Monitoring impacts of on-site wastewater treatment systems - Bay of Plenty

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Bay of Plenty Regional Council
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Cover Photo: Sign at Omokoroa

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Executive Summary

Many Bay of Plenty communities rely on on-site wastewater treatment systems and these generally function effectively with little environmental impact. However, in some cases these systems can create community health risks and contribute to nutrient enrichment of waterways. This investigation has focused on water and shellfish quality adjacent to waterfront communities served by on-site wastewater treatment systems.

Targeted monitoring of stormwater discharges, seepages and groundwater near waterfront communities that do not have access to sewage reticulation is necessary to assess whether the objectives of the On-site Effluent Treatment (OSET) Regional Plan are being met. The results can be used to assess the effectiveness of initiatives, such as reticulation or improved system maintenance, or to monitor for new or recurring issues.

This report updates the findings for nine communities and presents a case study for a recently reticulated area (Ōmokoroa). The findings for each are summarised below.

Lake Tarawera

There continues to be localised evidence suggesting that septic tanks are causing some groundwater contamination. High nitrate, elevated faecal bacteria and conductivity around Tarapatiki Point and Rangiuru Bay have been intermittently found, however bathing water quality remains good. Freshwater shellfish do indicate that faecal contamination is present adjacent to the lakeside community, although it is unclear if this contamination comes from septic tanks or other sources such as waterfowl. It is likely that the health risk to the community from septic tanks is low, but nutrient inputs will continue to be a potential issue for the lake.

Lake Rotoiti

Monitoring at Gisborne Point indicates some contamination is occurring from septic tanks, but it is only detected at low levels in shallow groundwater and the near-lake environment. Faecal bacteria levels in shellfish show some contamination is occurring but this may be sourced from waterfowl as well on-site wastewater systems.

Any faecal contamination arising from septic tank effluent from the Hinehopu community appears to have little effect on the bathing quality of the adjacent waters, but may affect shellfish. Two surface water inflows show low level contamination which is likely to emanate from on-site wastewater systems. Nutrient concentrations from surface inflows are at low levels compared to other Lake Rotoiti inflows.

Lake Rotomā

The water quality of Lake Rotomā adjacent to lakefront communities remains excellent, however the lake has been showing signs of increasing nutrient loading. Reticulating septic tanks has been identified as one of the options to reduce nutrient input to the lake.

Tanners Point

A permanent flowing drain and a small seepage on the boat ramp both show signs of contamination which is likely to come from septic tank effluent. However, indicator bacteria levels in the adjacent estuary area are for the most part below water quality guidelines for contact recreation.

A public toilet is also located in the boat ramp sub-catchment. A recent upgrade of the disposal field at this facility may reduce contamination in the boat ramp drain. On the northern side of the Tanners Point peninsula the drain from Moana Drive has been modified, reducing flow onto the beach and this should also reduce the potential health hazard.

Ongare Point

Monitoring of drains that flow onto the foreshore at Ongare Point has shown that some contamination from septic tanks is occurring but generally at low levels. Drains do show elevated indicator bacteria levels after rainfall, but only the Potu Street stormwater drain consistently has levels above the red alert mode microbiological water quality guideline. Pathogen loading from the contaminated drains is far less than from the local stream, primarily due to the much greater flow coming from the stream.

Bathing surveillance monitoring of the estuary adjacent to the Ongare Point community shows that the water is suitable for contact recreation. Contact with contaminated drain water at the foreshore discharge points remains the greatest health risk to the community.

Te Puna

The Te Puna west drains show the highest level of indicator bacteria and ammonium-nitrogen, a sign of septic tank contamination. Drains to the east have occasional high indicator bacteria levels.

Contact recreation water quality in the estuary remains good despite the high level of bacterial contamination in some drains. The main risk to beach users is the contamination of the foreshore adjacent to contaminated drains.

Little viral contamination of shellfish has been found in Te Puna estuary compared to other shellfish beds in the southern end of Tauranga Harbour. During two storm events in 2008 positive F- RNA bacteriophage typical of both animal and human sources were detected in shellfish, indicating that contamination from rural sources and septic tanks is occurring.

Pukehina/Waihī Estuary

Waihī estuary generally has water acceptable for contact recreation purposes under current guidelines but shellfish are impacted by faecal contamination particularly after rainfall. Shellfish have also revealed positive results for human faecal contamination after moderate to heavy rainfall. Human faecal contamination could be sourced from the Little Waihī and/or Pukehina communities.

Seepage monitoring to date around the Pukehina community has revealed some contamination, but contamination from seepages and drains is small in magnitude due to the small flows. Some drains do present a potential health risk to users who come in contact with these waters. The likelihood that shellfish are contaminated from drains or seepages from Pukehina is low, but the magnitude of transfer of pathogens via groundwater transport routes directly to the estuary or ocean is unknown.

Little Waihī is expected to be reticulated in the future and monitoring of shellfish should be continued to assess any improvements in the levels of human faecal contamination.

Bryans Beach

Small flows from the Bryans Beach community to the beach are occasionally contaminated with septic tank leachate at levels that may present a health risk. Flows are generally short lived disappearing into the porous sand dunes except during stormy periods when the stream discharges directly to the sea. Elevated contaminant levels often occur after moderate to high rainfall events and these periods pose the highest risk to human health.

The positive correlation of *E.coli* with ammonium-nitrogen in the Bryans Beach stream is a strong indicator that poorly treated effluent is entering the stream.

Ōmokoroa Case Study

A marked reduction in indicator bacteria levels (up to 10,000 fold) has occurred in a number of Ōmokoroa drains and seeps since sewage reticulation in mid-2007. Both nutrients and indicator bacteria have been reduced, however oxides of nitrogen have shown no improvement. This nutrient species is highly mobile in groundwater and this may indicate reservoirs of waste material that are still leaching, or contributions from other sources.

Conclusions

Almost all of the water bodies monitored adjacent to communities with septic tanks had water quality that consistently met bacterial guidelines for contact recreation. However, a number of discharges at the shoreline or foreshore from seepages, stormwater outlets and other drains were found to have elevated levels of faecal contaminants at levels that pose a risk to human health. These were most prevalent in the coastal environment. In the Rotorua Lakes, nutrient contamination from septic tanks (which can contribute to poor lake water quality) is potentially a greater problem than microbial contamination.

Future Monitoring

The monitoring programme will continue with the following refinements:

1 Lake Tarawera community – groundwater monitoring should be intensified at identified 'hotspots' during or after peak occupancy.

2 Microbial source tracking and viral testing – greater use of these techniques is recommended to determine the sources of shellfish contamination, particularly in lakes.

3 Recently reticulated communities - continue monitoring after reticulation to document water quality trends, particularly in shellfish. A good case study will be Little Waihī, which is known to have a poor standard of on-site wastewater treatment and has been linked to human faecal contamination of shellfish in the Waihī Estuary.

Contents

Tables and Figures

Part 1: Introduction

Many of the Bay of Plenty's more isolated communities are served by on-site wastewater disposal and/or treatment systems. In areas of more concentrated dwellings located near sensitive water bodies or in areas utilised by the public, there is the potential for adverse environmental effects from on-site effluent treatment systems with poor treatment and disposal. Adverse effects can include odours, contamination of surface waters, nutrient enrichment, contamination of shellfish and foreshore environments, negative health effects on water body users, and negative impacts on the physical and cultural resources of Maori.

The on-site effluent monitoring programme (OSEM) has been initiated to help ascertain the impacts of communities with on-site wastewater disposal systems on the wider environment and to monitor and guide the On-site Effluent Treatment Regional Plan. Hence the objective of this report is:

> *To reduce the impact of on-site domestic sewage treatment systems on the environment by making available good quality data and analyses from monitoring of on-site effluent treatment discharges in the Bay of Plenty communities, to Territorial Authorities, Hapu/Iwi Authorities, and Health Agencies.*

To help monitor the policies and objectives of the On-site Effluent Treatment Regional Plan (OSET Plan) monitoring of stormwater discharges, seepages[1] and groundwater near specific unsewered communities for contamination is undertaken. Results are used to chart the progress of intiatives to reduce septic tank contamination in communties and to investigate new or re-occurring problems.

A review of the OSET Plan was undertaken by Resource and Environmental Consultants (Dr Mike Patrick) in 2009. Monitoring near communities with on-site wastewater treatment systems is recommended in the review, as is concentrating on communities within the current maintenance programme instigated by a 2001 review undertaken by Dr Ian Gunn.

The areas covered in this report are:

1.1 Coastal communities

- Tanners Point
- Ongare Point
- Ōmokoroa
- Te Puna
- Bryans Beach

1.2 Lake communities

- Tarawera
- Ōkāreka
- Rotoiti - Gisborne Point
- Rotoiti - Hinehopu
- Rotomā

[1] Seepages may be a small spring or a place where water has oozed through the ground.

Part 2: Methods

2.1 Introduction

Almost all domestic septic tank systems deliver their effluent to land to utilise the topsoil or similar media to treat effluent through natural physical, chemical and biological processes. If soil type is unsuitable, the drainage field is incorrectly installed, or the system is overloaded, failure of effluent treatment can result. Failure can lead to contamination of ground and/or surface waters with nitrogen, phosphorus and pathogens. Environmental monitoring attempts to detect if contamination is occurring and where possible quantify contamination of ground and/or surface waters.

The methods employed to detect contamination in the environment involve surveying surface waters (drains, seepages, streams etc.) and groundwater and using analytical and microbiological techniques to determine contaminant concentrations and/or loadings. Water samples are commonly analysed for conductivity, nitrogen, phosphorus and indicator bacteria (Escherichia coli or 'E.coli'), faecal coliforms, and enterococci). Similarly, lake or harbour waters are also monitored for indicator bacteria as a potential symptom of contamination, and likewise shellfish in these environments can also indicate contamination.

Nitrogen discharged in sewage effluent to a disposal field will potentially undergo a number of transformations such as volatilisation, nitrification, denitrification, uptake by vegetation, and adsorption by soil matter. Two forms of nitrogen are used to help detect the presence of septage in water paths, ammonia and nitrate.

Ammonia, commonly tested for as ammonium-nitrogen (NH4N), is not only potentially toxic to aquatic organisms but is representative of poorly treated effluent disposal fields with high ground water levels or clogged and not effectively functioning disposal fields. Most conventional septic tank system will have a very high ratio of ammonia to nitrate in effluent. Aerobic bacteria convert ammonia to nitrite then to nitrate. Nitrate (nitrate-nitrogen, NO3-N) can be taken up by plants and further reduced to nitrogen gas and released to the atmosphere. However, nitrate is a very mobile species in soil and some leaching occurs to groundwater.

Phosphorus is less likely to be present in elevated levels in seepages, drains or groundwater as a result of septic tank effluent contamination due to the adsorption characteristics of soil. Rotorua soils have been estimated to be capable of removing 98% of phosphorus from septic tank effluent compared to 35% for nitrogen (Hoare, 1984). Phosphorus concentrations are also typically one tenth to one fifth of nitrogen concentrations in effluent. Thus elevated levels of phosphorus detected in the environment are indicative of very poor disposal field conditions and rapid transfer of effluent to preferential water pathways. The ability of the soil to remove P appears to be limited to between 1 and 8 years (Geary 2005, Gerritse *et al.,* 1995), and P can readily move through to the water table (Geary 2005, Gerritse *et al.,* 1995, Whelan *et al.,* 1981) on sandy soils.

Such conditions can also be responsible for transport of faecal micro-organisms in effluent into surface and groundwater drainage systems. Micro-organisms such as bacteria, protozoa and viruses are typically removed from septic tank effluent in the top soil layers, dependant on soil pH, moisture, temperature, and soil microbial population. If effluent comes in contact with a saturated zone connected to surface drainage then faecal micro-organisms can be readily transported into the environment.

As well as making use of data from monitoring of nitrogen, other constituents such as phosphorus and indicator bacteria concentrations and surface and groundwater conductivity can also be used to trace contamination. Conductivity is a measure of a waters ability to conduct electricity, where generally the higher the concentration of mineral salts in the water the higher the conductivity. An elevated conductivity can be the result of effluent contamination.

None of these indicators of septic tank contamination uniquely indicate septic tank effluent as a contaminant source. However, in many cases where monitoring has occurred adjacent to dense populations served by septic systems there can be little doubt the source of contamination is septic tank effluent.

Other technologies have become more readily available in sourcing faecal contamination. RNA genome detection techniques that can be used to detect human viruses as well as F-RNA bacteriophages, which are bacterial viruses that can be derived from both human and animal sources, have both been used as an indicator of on-site wastewater contamination.

2.2 Sampling and analysis

Sampling and analyses were performed in accordance with established internal protocols. Most analyses were performed by the Bay of Plenty Regional Council laboratory (which holds IANZ accreditation) or Hills Laboratory, Hamilton.

Water quality analyses were completed using the methods in Table 2.1. All samples for chemical analysis were stored and returned within the time period stipulated by the methods.

Viral and F-RNA bacteriophage analyses were undertaken by the Institute of Environmental Science and Research (ESR) using two step real-time polymerase chain digestion (RT-PCR) assays. F-RNA bacteriophage were identified and genotyped using semi-quantitative multiplex real-time RT-PCR assay.

Table 2.1 Methods used for chemical/biological analysis of water samples.

Parameter (abbreviation)	Method	Detection Limit/ Units
Ammonium Nitrogen (NH_4-N)	NWASCO Misc. Pub. No. 38, 1982. Phenolhypochlorite colorimetry	1 mg/m^3
Total Oxidised Nitrogen (Nitrate-Nitrite, NNN)	Flow injection analyser, APHA 4500 NO3-I	1 mg/m^3
Total Kjeldahl Nitrogen[2] (TKN)	APHA Method 4500B NIWA mod., Oct 1990	90 mg/m^3
Total Phosphorus (TP)	NWASCO Misc. Pub. No. 38, 1982. Acid persulphate digestion.	8 mg/m^3
Dissolved Reactive Phosphorus (DRP)	NWASCO Misc. Pub. No. 38, 1982. Antimony – phosphate – molybdate.	4 mg/m^3
pH	APHA method 4500-H+ measurement at 25^{o}C	
Temperature	YSI or Hach DO Meter	0.1 deg C
Conductivity	APHA Method 2510B, EDTRE 387 Tx Meter	0.5 mS/m at 25 deg C
Suspended Solids (SS)	APHA Method 2540D	0.5 g/m^3
Escherichia coli (E.coli) **Faecal coliform (FC)**	Membrane filtration, Standard Methods for the Examination of Water & Wastewaters (2005)	1 cfu/100ml
Enterococci (Ent)	Method No 1600, USEPA 1986 EPA-821-R-97-004	1 cfu/100ml

[2] Total nitrogen (TN) is derived from TKN and NNN.

Part 3: Results and Discussion

3.1 Lake Tarawera

The Tarawera lakeside community is a relatively well spread community along the western side of the lake. The 2006 census put the declining population for Tarawera at 1395 people with an average household having 2.7 persons. Approximately 900 of these would reside near the lake. Permanent occupancy is around 20% over the autumn/winter months, but increases over spring/summer.

Many sections are built on steep sloping sections around the lake and because of this soak holes are the dominant disposal option.

Bay of Plenty Regional Council has been undertaking environmental monitoring to examine potential health risks in associated with septic tank contamination and to ascertain if contamination from septic systems is occurring and if so on what scale.

Figure 3.1 Lake Tarawera monitoring site location map

3.1.1 Physical environment

The Lake Tarawera environs around the western side of the lake where most residential properties are located is a combination of urban dwellings surrounding the lake, pastoral farming and native bush on the higher slopes. As part of the Haroharo caldera subsurface flows drain through porous ignimbrite, tephra and ash deposits. On this western margin Lake Okareka drains through the Waitangi Spring.

The predominant soil around the western lake margin is Rotomahana sandy loam. This moderately well drained to very well drained soil type is classed to have a moderate septic tank effluent field limitation due to its medium to slow internal drainage. Rotomahana hill soils are more commonly found on the upper slopes of western Tarawera and while this soil has similar drainage properties as the Rotomahana sandy loam its septic tank field limitations are slight, particularly if beneath Rotomahana mud.

Mean annual rainfall measured at Whakarewarewa over the period 1900 to 2005 was 1428 mm.

3.1.2 Previous studies

Inspection of Tarawera septic systems before July 2001 showed that approximately 65% failed the standards of the day. Failed systems were evenly distributed throughout the community, and over 75% of systems have soak holes for disposal. Disposal field conditions are relatively good although inspections failed to locate many of the fields. This is likely to be because of the difficult topography associated with properties located on steep ground.

An independent survey by the University of Waikato of shallow groundwater around the lake found three elevated nitrate-nitrogen results at Rangiuru Bay (2.4 g/m^3), Stoney Point (3.4 g/m^3) and Tarapatiki Point (1.1 g/m^3). It was concluded that these elevated concentrations of nitrate-nitrogen are a direct results of septic tank effluent contamination. Obvious signs of septic tank leakage were also observed. These nitrate-nitrogen results are generally several orders of magnitude higher than the survey carried out by Bay of Plenty Regional Council (Table 2.1), with the exception of sampling at Boatshed Bay. The University of Waikato may have intercepted preferential flow paths for septage contamination where the Bay of Plenty Regional Council sites have largely missed such flow paths, or septic contamination is not occurring or obvious at those sample locations.

3.1.3 Groundwater monitoring

Five shallow wells were installed around the shoreline of residential areas of Lake Tarawera at the start of 2003 (see Figure 3.1 for locations). The wells are designed to intercept shallow groundwater with the intention of detecting any effluent plumes that may result from septage. Sampling started in March 2003 and results for key dissolved nutrients and indicator bacteria are presented in Figure 3.1. The Boatshed Bay well was destroyed in late 2005 and so no new data has been collected from this site since.

The Bayview Road site shows little confirmation of contamination by septage. DRP is elevated and on occasion faecal levels are also elevated which could be an artefact of the high water fowl numbers in this area.

Of the five sites monitored Cliff Road has on average the highest level of faecal contamination (faecal coliform and enterococci). After Boatshed Bay, Cliff Road also has the higher nitrate-nitrogen concentrations, but other parameters are generally at low levels.

Conductivity measured in groundwater samples at Tarapatiki Point is on average much higher than for other groundwater sample locations (Figure 3.2). The sulphurous odour of the samples may indicate geothermal influences, although the Bayview Road site also has this feature with a much lower conductivity. Tarapatiki Point also has had some elevated ammonium concentrations with conductivity and ammonium correlating well (Pearson $r = -0.630$, $p=0.05$). The negative correlation could indicate that ammonium is flushed out with rain diluted groundwater, and this may occur for dissolved reactive phosphorous (DRP) also.

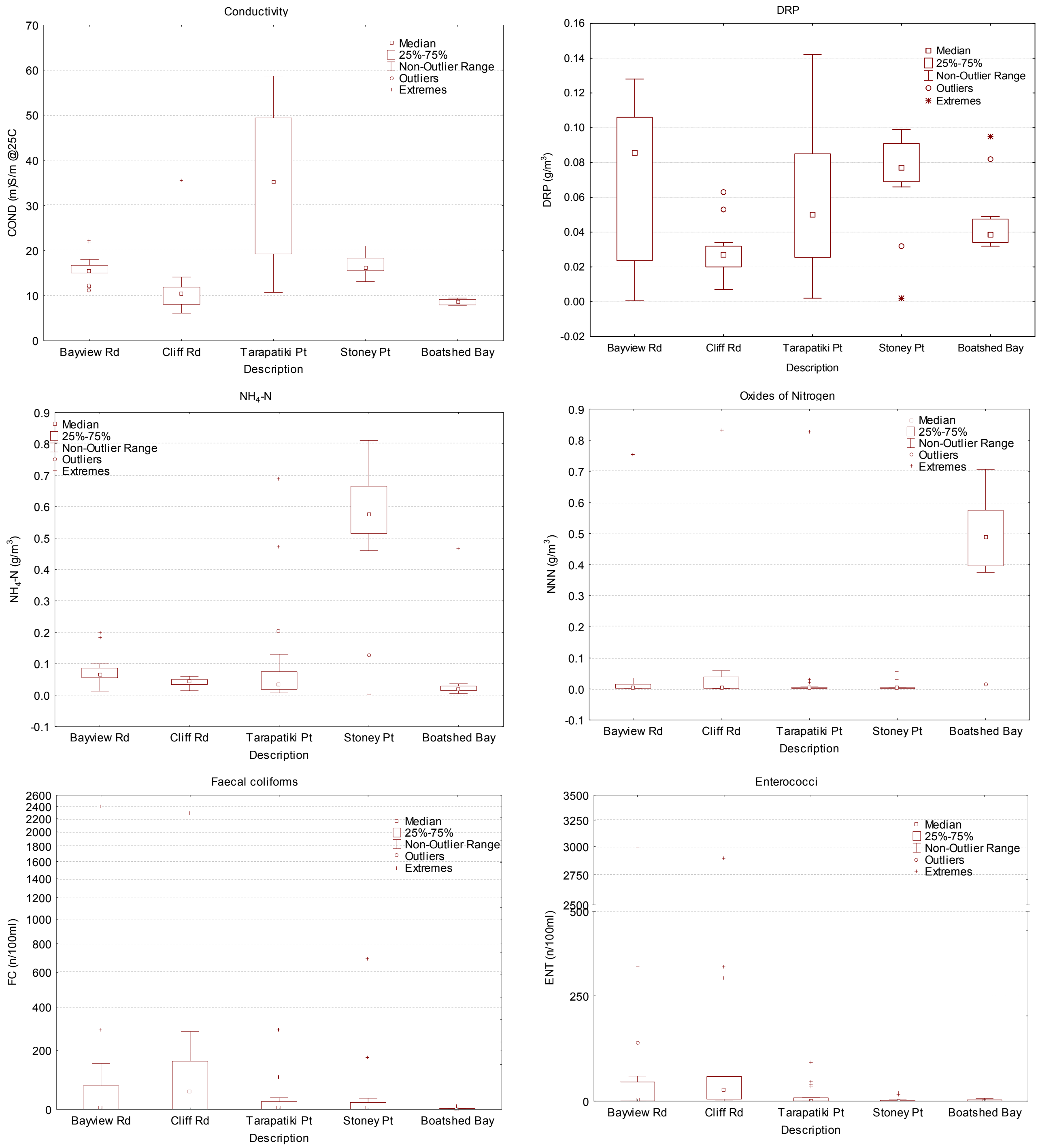


Figure 3.2 Box whisker plots of several water quality parameters from shallow groundwater sites around the Lake Tarawera community.

Ammonium-nitrogen (NH_4-N) levels are for the most part reasonably low with only the Stoney Point Reserve sample point displaying elevated levels (Figure 3.2). Elevated ammonium-nitrogen levels can be a result of contamination from poorly treated effluent, however there is no correlation of ammonium-nitrogen with faecal coliform data. If groundwater at Stoney Point is contaminated from a septic source, effluent is achieving microbiological decontamination in the ground. The level of ammonium-nitrogen found at this site is consistent with concentrations found in a similar study at Lake Okareka where it was thought that groundwater flows were not sufficient to dilute ammonium-nitrogen concentrations (NIWA, 2000).

Boatshed Bay sample point had median nitrate-nitrogen levels elevated compared to the other sample points. Other parameters are at low levels at this site. Comparison of nitrate-nitrogen levels monitored in this monitoring programme to a similar sampling programme on the shores of Lake Okareka shows levels observed to be much lower at Tarawera and as such may be a result of only low level contamination from septage and/or nitrate-nitrogen (NNN) from other catchment sources.

3.1.4 Bathing surveillance monitoring and shellfish

Three sites have been monitored as a part of the bathing surveillance monitoring programme: Tarapatiki Point, Rangiuru Bay, and more recently Te Karamea Bay (Cliff Road beach).

Bathing surveillance results indicate good water quality with only low level of contamination well below recommended contact recreation guidelines (Figure 3.3). Only one result has been above the orange alert level at Te Karamea Bay in 2009 which occurred during rainfall and high wave action in the lake.

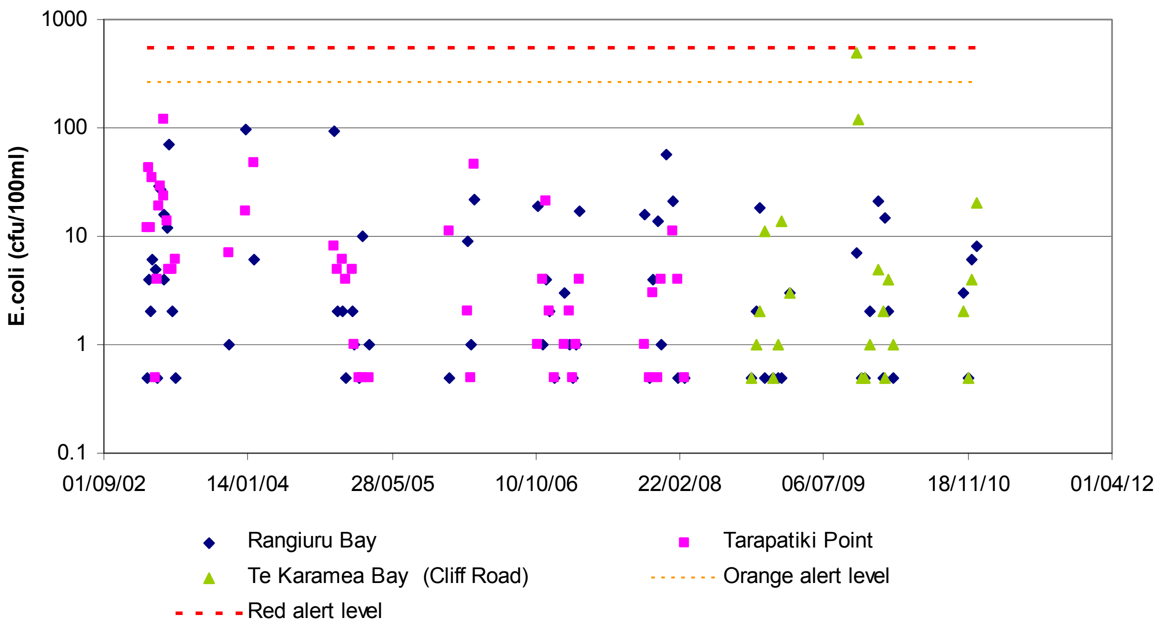
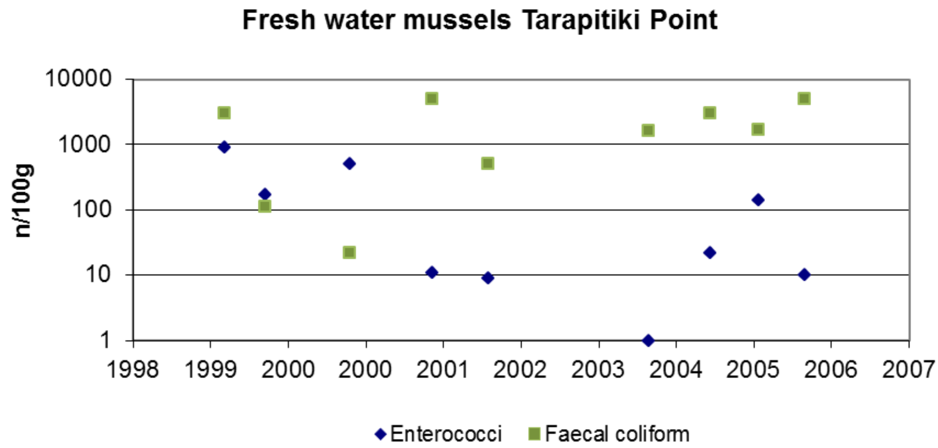


Figure 3.3 Bathing surveillance monitoring results, 2003 to 2011, Lake Tarawera.

Freshwater mussels have been monitored on several occasions for indicator bacteria (Figure 3.4) within the near shore environment of the lake at two locations, Bay Road and Tarapatiki Point. Both sites have recorded concentrations of faecal coliforms above 1,000 faecal coliform/100g of flesh on several occasions. At such levels of contamination, shellfish are unlikely to be suitable for consumption by humans.

The enterococci to faecal coliform ratio of shellfish monitored at Bay Road shows much less variance than shellfish monitored at Tarapatiki Point (Figure 3.4). This variance could indicate the difference between a constant source of bacteria from water fowl, and stream inflows, versus bacteria from a variable source such as septage. There are no obvious long term trends in the shellfish monitoring data apart from a general decrease in enterococci levels at Tarapatiki Point over the past few years. Salmonella was analysed for in one month and not detected but low levels of *Clostridium perfringes* were detected. This may suggest septage rather than water fowl.



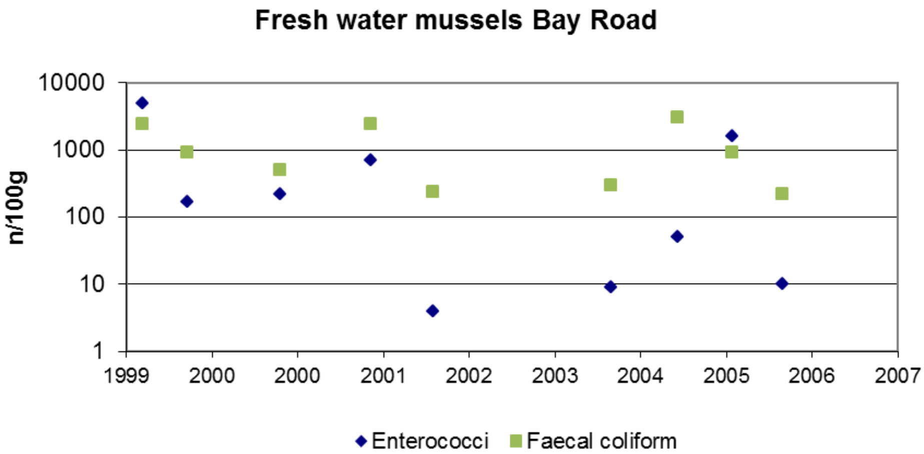


Figure 3.4 Freshwater mussel monitoring results, 1999 to 2007, Lake Tarawera.

3.1.5 Discussion

Groundwater sampling has shown elevated nitrate-nitrogen concentrations at one site, however these levels are similar to levels found in spring fed surface waters and may be representative of catchment concentrations rather than distinctive contamination signatures representative of septic tank effluent.

Other nutrients monitored in groundwater displayed some elevated results, but like nitrate-nitrogen they showed no correlation with indicator bacteria monitoring. This may be due to bacterial die-off and adsorption in the porous soils.

Tarapatiki Point displayed the greatest possibility of contamination from septage. As well as an elevated nitrate-nitrogen result monitored in the groundwater, groundwater generally had a higher conductivity than other sites and the analysis of bacterial monitoring in shellfish displays a variance more typical of an erratic contaminant source, such as contaminated groundwater.

It is possible that sampling has missed peak groundwater concentrations that may have occurred form septic sources, peak concentrations occurring when occupancy rates are high in mid-summer.

If monitoring continues into the future, there should be a greater focus on groundwater at localised hotspots identified in this study and the University of Waikato survey. Surveys should occur during or after peak occupancy.

3.2 Lake Rotoiti – Gisborne Point

Gisborne Point community occupies a peninsula on the southern side of Lake Rotoiti occupying approximately 1,445 metres of lake shore. There are around 120 dwellings within the community and many of these are used as holiday homes, remaining vacant for much of the year.

3.2.1 Physical environment

Gisborne Point is a gentle sloping fan composed of 10 metre thick tephra with a fluctuating water table, which is moderately permeable to a depth of 1 metre. The fans fringes are low lying and as such have a higher water table which may be unsuitable for some disposal systems.

Mean annual rainfall measured at Kaharoa Link station is 1,794 mm over the period 1986 to 2005.

3.2.2 Previous studies

A review of septic tanks systems (Gunn, 2001) found that 77% of systems failed to meet inspection criteria. The biggest problem was tank size, however it was recognised that groundwater clearance was a limiting factor for around a quarter of the systems inspected.

Figure 3.5 Lake Rotoiti - Gisborne Point monitoring site location map

3.2.3 Groundwater monitoring

Five groundwater sampling wells have been monitored on the lake fringes since the beginning of 2003 (Figure 3.5). An additional well has been monitored as part of a study on septic tank performance.

Oxides of nitrogen (NNN) levels were relatively low in all wells. Only well GP101 displayed a correlation between NNN concentrations and faecal coliform concentrations (also for E.coli) (Spearman $r=0.779$, $p<0.05$, $n=18$), indicating a preferential septage path was found. This well also displayed the highest median ammonium-nitrogen and dissolved reactive phosphorus concentrations (Table 4.1, Figure 4.7). DRP also had a correlation with conductivity (Spearman $r=0.475$, $p=0.05$, $n=19$) potentially indicating contamination of groundwater with phosphate.

Like well GP101, there is an elevated median concentration of ammonium-nitrogen in well GP113. Such results may indicate poor disposal field treatment. Correlation of ammonium-nitrogen with phosphorous and conductivity suggested this is the case.

Well GP-LR located downstream of an advanced on-site effluent system shows higher NNN levels than the other wells. Greater conversion of ammonium-nitrogen to nitrate-nitrogen by the advanced system and intermittent loading may explain this.

Faecal indicator species have been elevated at times for all wells but at levels below contact recreational guidelines.

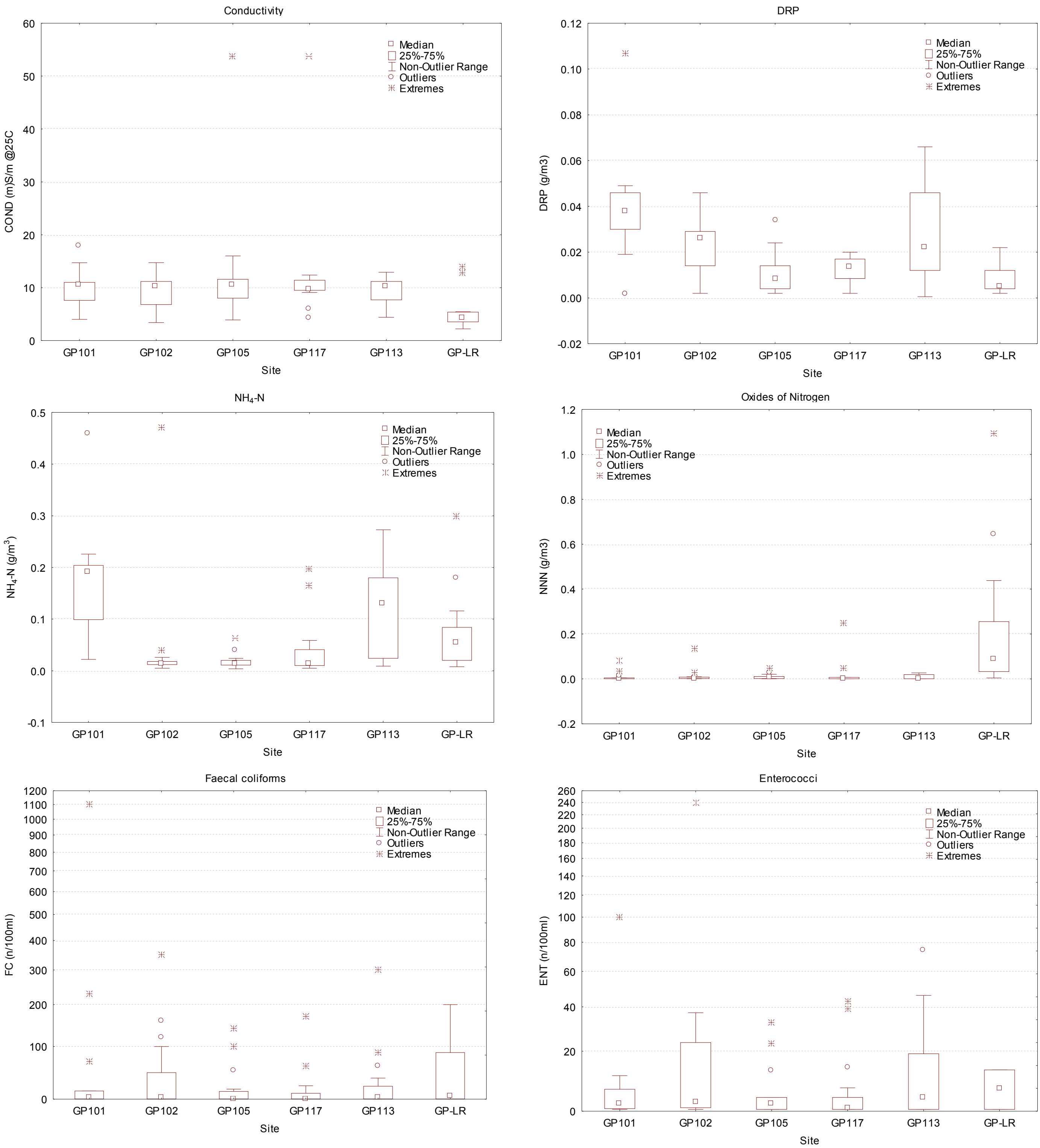


Figure 3.6 Box whisker plots of several water quality parameters from shallow groundwater sites around the Gisborne Point community, Lake Rotoiti.

3.2.4 Bathing surveillance monitoring and shellfish

The Gisborne Point boat ramp is the site for bathing beach and shellfish monitoring. Figure 3.7 shows the bathing water quality results from 2003 to 2010. Bathing water quality is generally good with almost no exceedances. Analyses of freshwater mussels show relatively high concentration of faecal coliform, above safe consumption guidelines. Enterococci, another indicator organism of faecal contamination, are generally low (Figure 3.8).

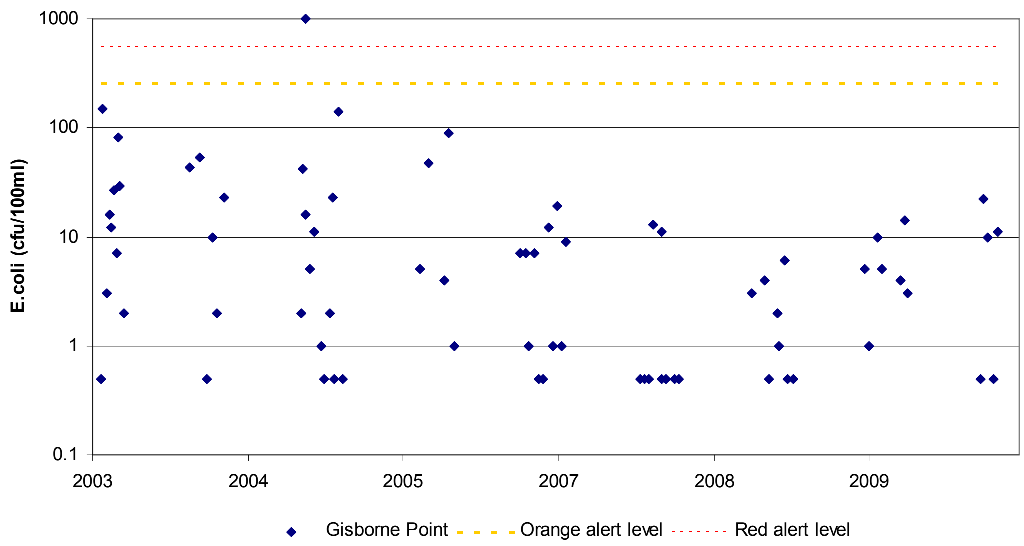


Figure 3.7 Bathing surveillance monitoring results, 2003 to 2011. Gisborne Point, Lake Rotoiti.

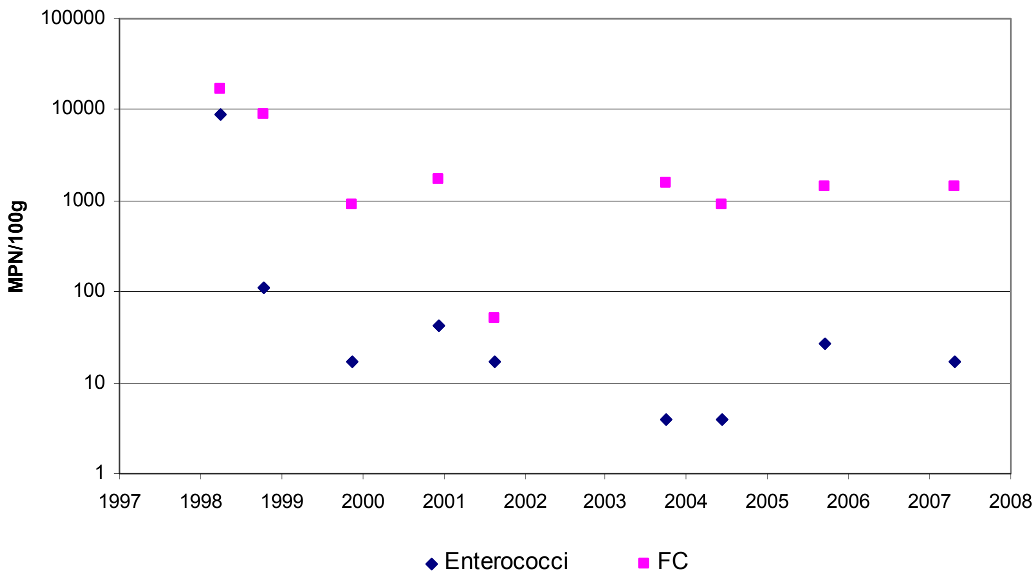


Figure 3.8 Freshwater mussel monitoring results, 1999 to 2008. Gisborne Point, Lake Rotoiti.

3.2.5 Discussion

Monitoring of the Gisborne Point community does indicate some contamination is occurring from septic tanks, but is only detected at low levels in shallow groundwater and the near-lake environment. Faecal indicator bacteria levels in shellfish show some contamination is occurring but this may be sourced from waterfowl as well on-site wastewater treatment systems.

3.3 Lake Rotoiti – Hinehopu

Located at the eastern edge of Lake Rotoiti (Figure 3.9), the Hinehopu community is composed of holiday and permanent homes formed in a ribbon development along the lake edge to the north, and in several clusters near a marae to the south. The community is made up of around 50 dwellings.

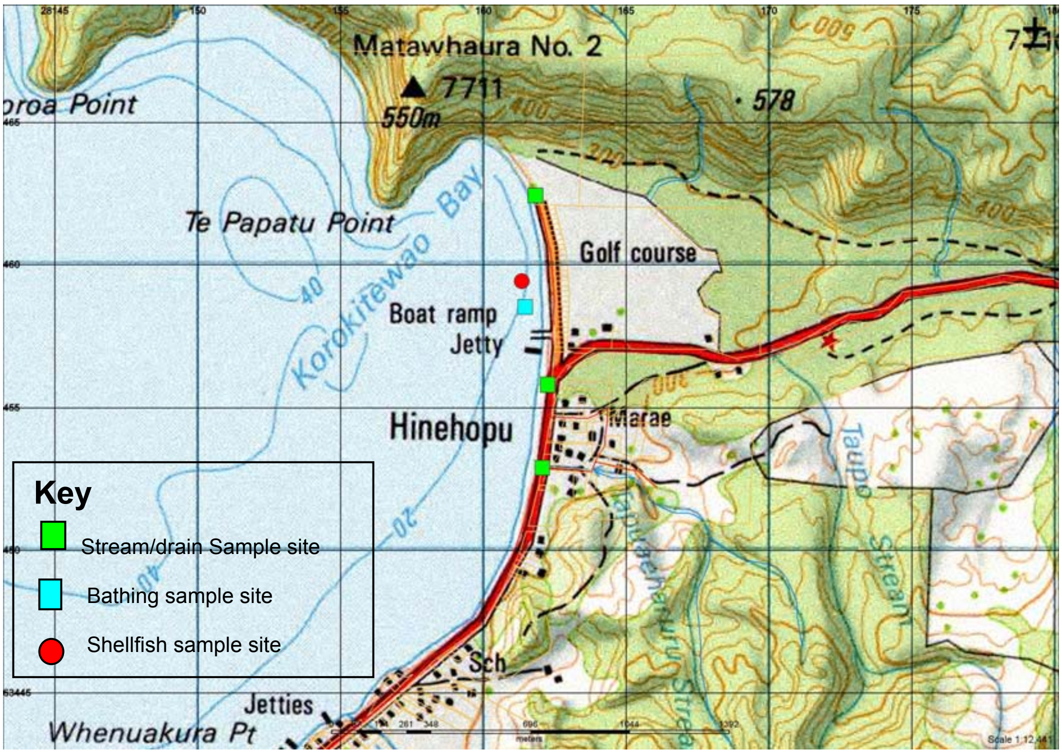


Figure 3.9 Lake Rotoiti – Hinehopu monitoring site location map.

3.3.1 Physical environment

The subsoils of Hinehopu have been described as coarse volcanic sands (NIWA, 2000). Soils are likely to have come from a permeable airfall tephra up to 10 metres thick, with some lacustrine and deltaic deposits (Pullar, 1981).

Groundwater is thought to flow from Lake Rotoehu to Lake Rotoiti potentially driving septic tank effluent toward Lake Rotoiti. However, a NIWA study found that septic tank plumes from the Tamatea Street community appeared to flow away from the lake towards a surface drain at the rear of the houses.

3.3.2 **Previous studies**

Inspections of septic tanks at Hinehopu, reported in 2001, found 77% of tanks failed to meet the inspection criteria. The worst criteria failed were ‘tank below size’, 94% and ‘groundwater clearance’, 48%

Both the 1992, “Investigation of Septic Tank Effluent Disposal in the Bay of Plenty”, and the NIWA Report (2000) found that contamination of the drain behind the Tamatea Street houses by septic effluent was occurring. The NIWA study also implied there was a health risk to contact recreational use near the outlet to this drain.

3.3.3 **Surface water inflows**

Three surface inflows have been monitored (Figure 4.9) and results are tabulated in Table 3.1. The Tapuaeharuru Stream has high nitrate-nitrite-nitrogen and *E.coli* concentrations compared to the control stream, the Taupo Stream, which has fairly low indicator bacteria concentrations and little contact with the local community.

Tapuaeharuru Stream	DRP (g/m^3)	NH_4-N (g/m^3)	NNN (g/m^3)	Enterococci (cfu/100mls)	*E.coli* (cfu/100mls)
Median	0.04	0.009	0.114	78	310
Average	0.039	0.012	0.113	101	312
Maximum	0.054	0.067	0.322	240	470
Minimum	0.011	0.005	0.0073	7	140
n	19	19	17	5	5

Taupo Stream	DRP (g/m^3)	NH_4-N (g/m^3)	NNN (g/m^3)	Enterococci (cfu/100mls)	*E.coli* (cfu/100mls)
Median	0.031	0.006	0.022	83	87
Average	0.028	0.011	0.026	88.9	96.6
Maximum	0.059	0.052	0.075	220	180
Minimum	0.003	0.0005	0.0005	8	17
n	31	31	28	9	9

Tamatea Drain	DRP (g/m^3)	NH_4-N (g/m^3)	NNN (g/m^3)	Enterococci (cfu/100mls)	*E.coli* (cfu/100mls)
Median	0.008	0.011	0.017	104	110
Average	0.01	0.01	0.04	157	248
Maximum	0.029	0.032	0.252	420	970
Minimum	0.0005	0.004	0.0005	2	1
n	31	19	29	22	25

Table 3.1 Summary of monitoring results from Hinehopu surface inflows to Lake Rotoiti, 2001 to 2010.

The Tamatea drain drains the back of dwellings on Tamatea Street and has been indicated by a NIWA groundwater survey to receive groundwater flow from properties in that area. However, nutrient levels remain near background levels but faecal indicators do show occasional elevated levels.

3.3.4 Bathing surveillance monitoring and shellfish

Even with sporadic elevated indicator bacteria levels coming from the Tamatea drain the bathing water quality of the Hinehopu area remains excellent (Figure 3.10). Surface water inflows to the area are of small volume so faecal loading from these sources is likely to be low.

Faecal coliform levels in freshwater mussels have on occasion been at levels not considered safe for human consumption (Figure 3.11). Enterococci levels are at a low level in the shellfish which may indicate a terrestrial source rather than water fowl.

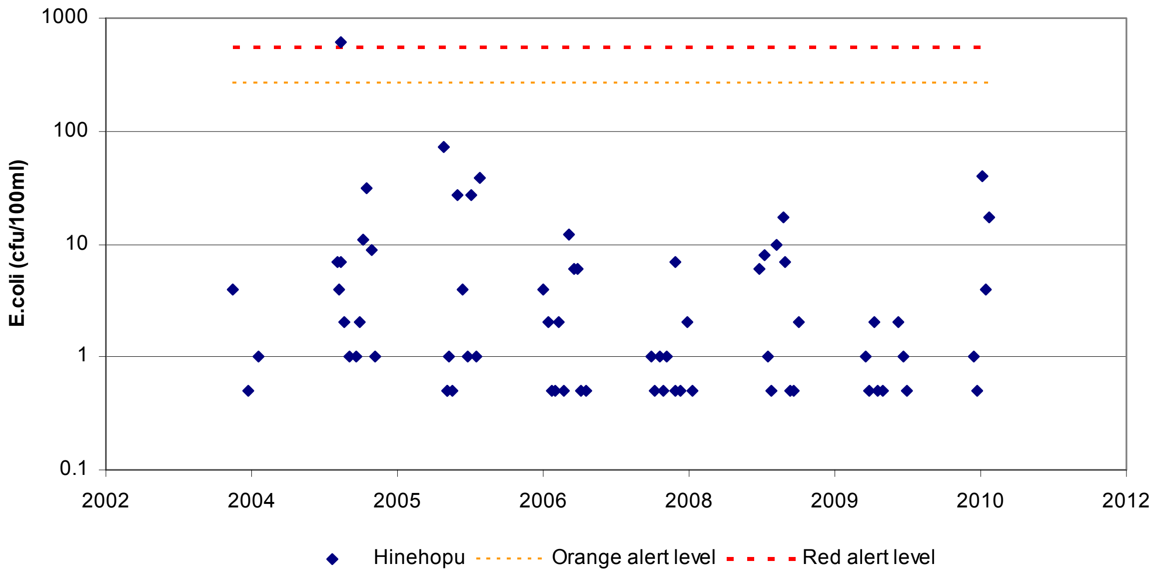


Figure 3.10 Bathing surveillance monitoring results, 2003 to 2011. Hinehopu.

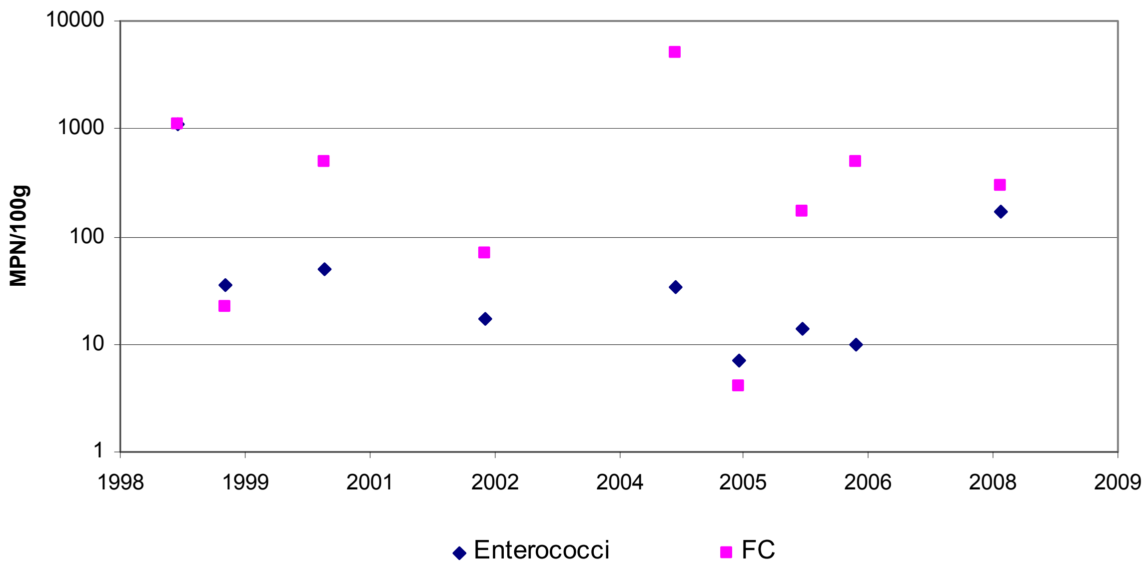


Figure 3.11 Freshwater mussel monitoring results, 1999 to 2009. Hinehopu, Lake Rotoiti.

3.3.5 **Discussion**

Any faecal contamination arising from septic tank effluent from the Hinehopu community appears to have little effect on the bathing quality of the adjacent waters, but may affect shellfish. Two surface water inflows show low level contamination which is likely to emanate from on-site wastewater systems. Nutrients from surface inflows are at low levels compared to other Lake Rotoiti inflows.

3.4 Lake Rotomā

Lake Rotomā is the eastern most lake of the Rotorua Lakes with community development on the south and south-western edges of the lake (Figure 3.12). This ribbon development is composed of a mixture of permanent and holiday homes with a total of approximately 188 dwellings. There is also a motor camp and two public toilet blocks meeting the needs of this popular recreational lake.

Figure 3.12 Lake Rotomā monitoring site location map.

3.4.1 **Physical environment**

Kaharoa ash underlain by Rotokawau, Mamaku and Rotomā ash surround Lake Rotomā. Rotoiti and Oropi soils dominate the topsoil formed from Kaharoa ash with free draining alluvial and colluvial soils in the Anaputa area and thicker airfall tephra assemblages adjacent to Whangaroa.

Manual rainfall figures from A.B. Wright show mean annual rainfall from 1964 to 2003 to be in the order of 2131 mm per year.

3.4.2 Groundwater monitoring

Due to the pervious nature of the soils around Lake Rotomā shallow groundwater is potentially the best indicator of any trace of contamination by septic tanks. Figure 3.13 displays nutrient indicators and *E.coli* concentrations in two shallow monitoring wells located around the most densely built up part of the Rotomā community, the Whangaroa settlement.

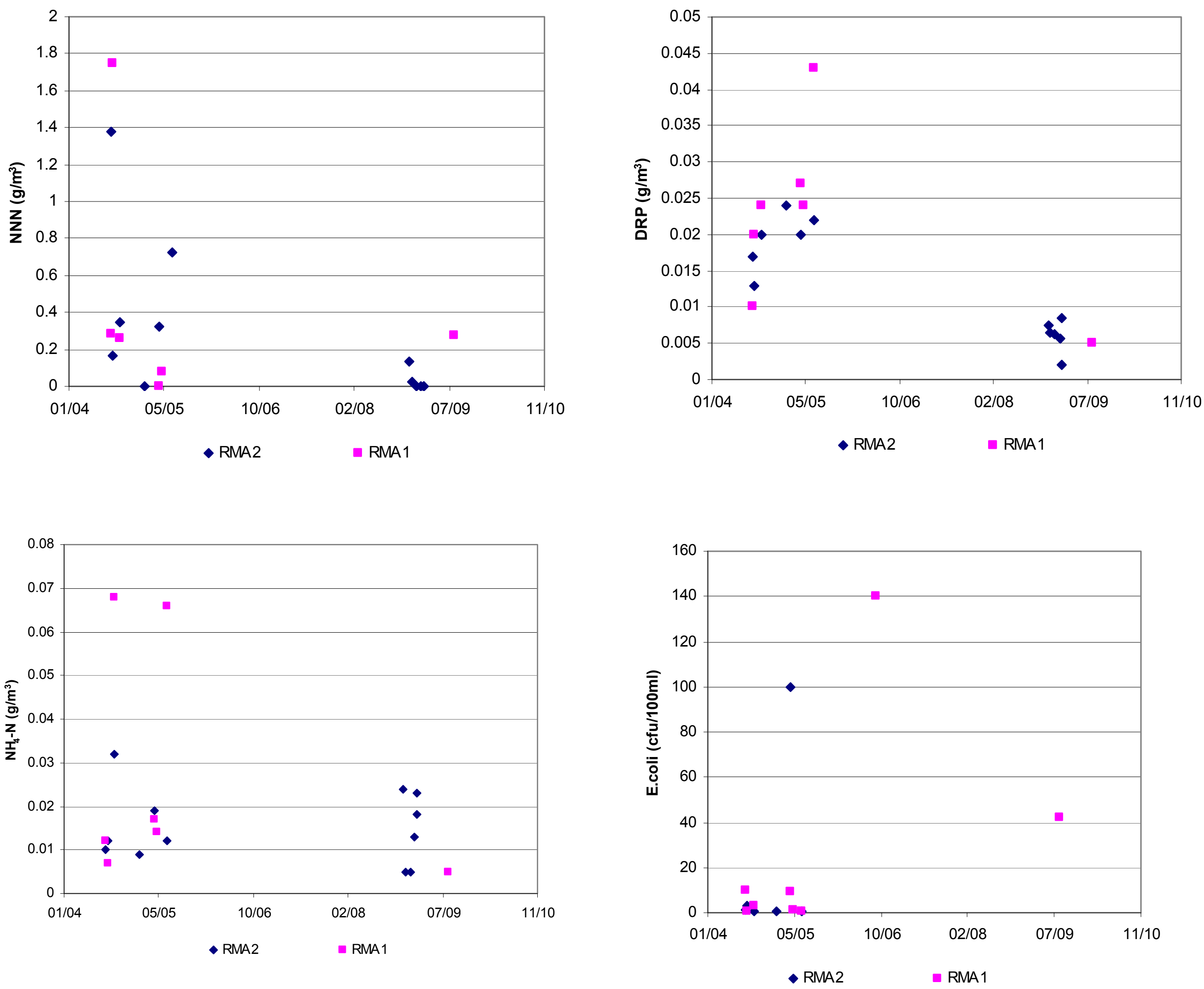


Figure 3.13 Nutrient and E.coli concentrations in shallow wells, Lake Rotomā.

Nutrient levels decreased between 2004/2005 and 2008/2009. This is probably climatically driven with lower rainfall reducing flushing and dilution of nutrients in some years. NNN levels are elevated compared to shallow groundwater monitoring at other lakes but are generally similar to those found in the Rere Stream (average NNN = 0.238 g/m^3). Concentrations above this surface water average have occurred on three occasions (Figure 3.13). Both DRP and NH4-N concentrations tell a similar story with only one or two samples above background concentrations.

Elevated E.coli concentrations have occurred on three occasions in the two shallow wells indicating that some low level faecal contamination is occurring.

Sampling of two shallow wells around Anaputu Bay on several occasions has also yielded some interesting results. Figure 3.14 shows NNN concentrations taken on different days but with multiple samples being taken within a short time of each other. Site 5 (Figure 3.14) has low NNN levels compared to other shallow wells sampled, but on one occasion an increasing plume is detected. For Site 7 NNN levels are at quite different concentrations on two different sampling days, potentially indicating the arrival of a plume on one of the days due to a contamination source.

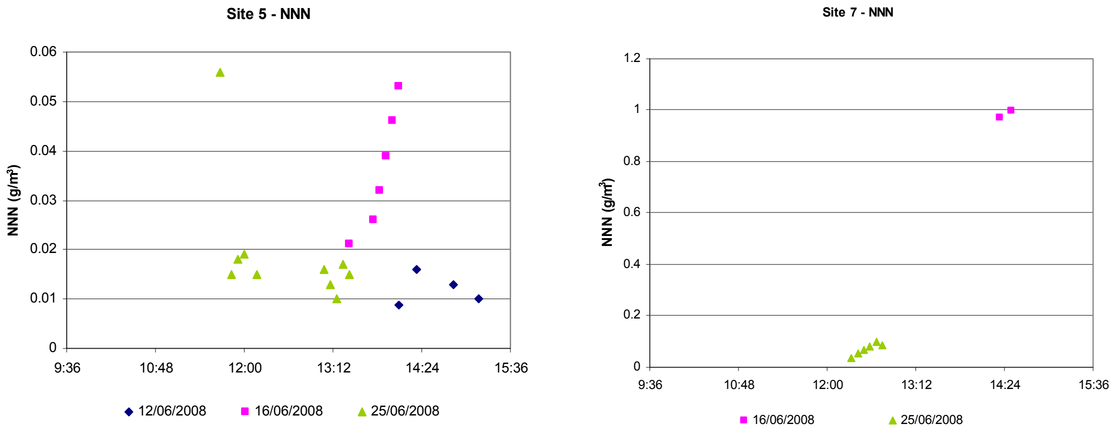


Figure 3.14 NNN concentrations in shallow water wells, Anaputu Bay, Lake Rotomā.

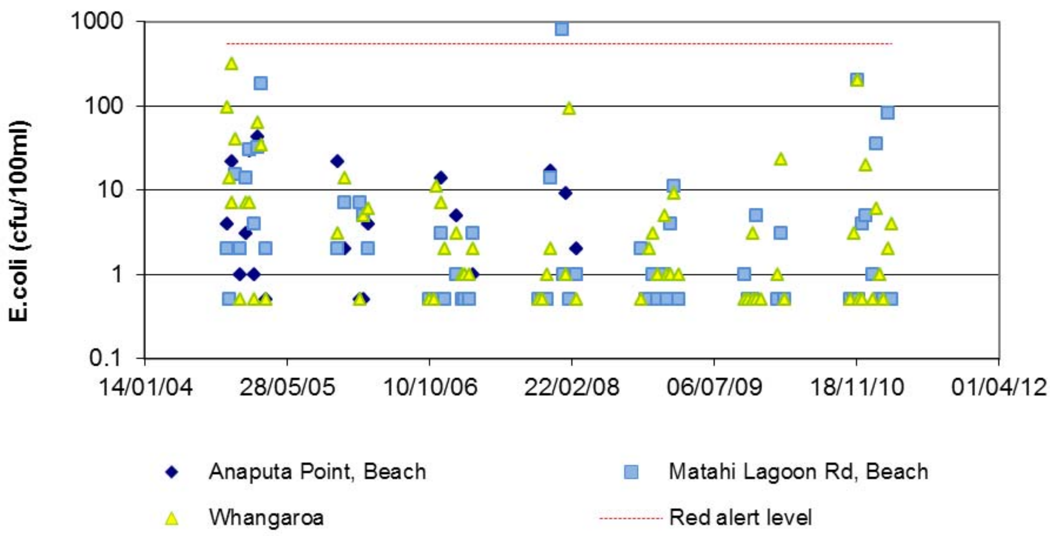


Figure 3.15 Bathing surveillance monitoring, Lake Rotomā.

Bathing surveillance monitoring of the Lake Rotomā waters adjacent to the built up communities reveals the lake to be in excellent condition for recreational pursuits. In the last seven seasons only one sample has exceeded the microbiological guideline red alert mode, and this may be an anomaly (e.g. sample potentially contained water fowl faeces). Although only a few freshwater mussel samples have been analysed from near Matahī Beach in the past few years, there were no results to indicate any contamination issues.

3.4.3 Discussion

The water quality of Lake Rotomā adjacent to lakefront communities remains excellent, however the lake has been showing signs of increasing nutrient loading. Reticulating septic tanks has been identified as one of the options to reduce nutrient input to the lake (see the Lake Rotomā Action Plan, 2009).

3.5 Tanners Point

The Tanners Point community is located on the tip of the Tanners Point peninsula which extends into the northern extent of Tauranga Harbour (Figure 3.16). There are around a hundred dwellings within the community, many of which have permanent residents.

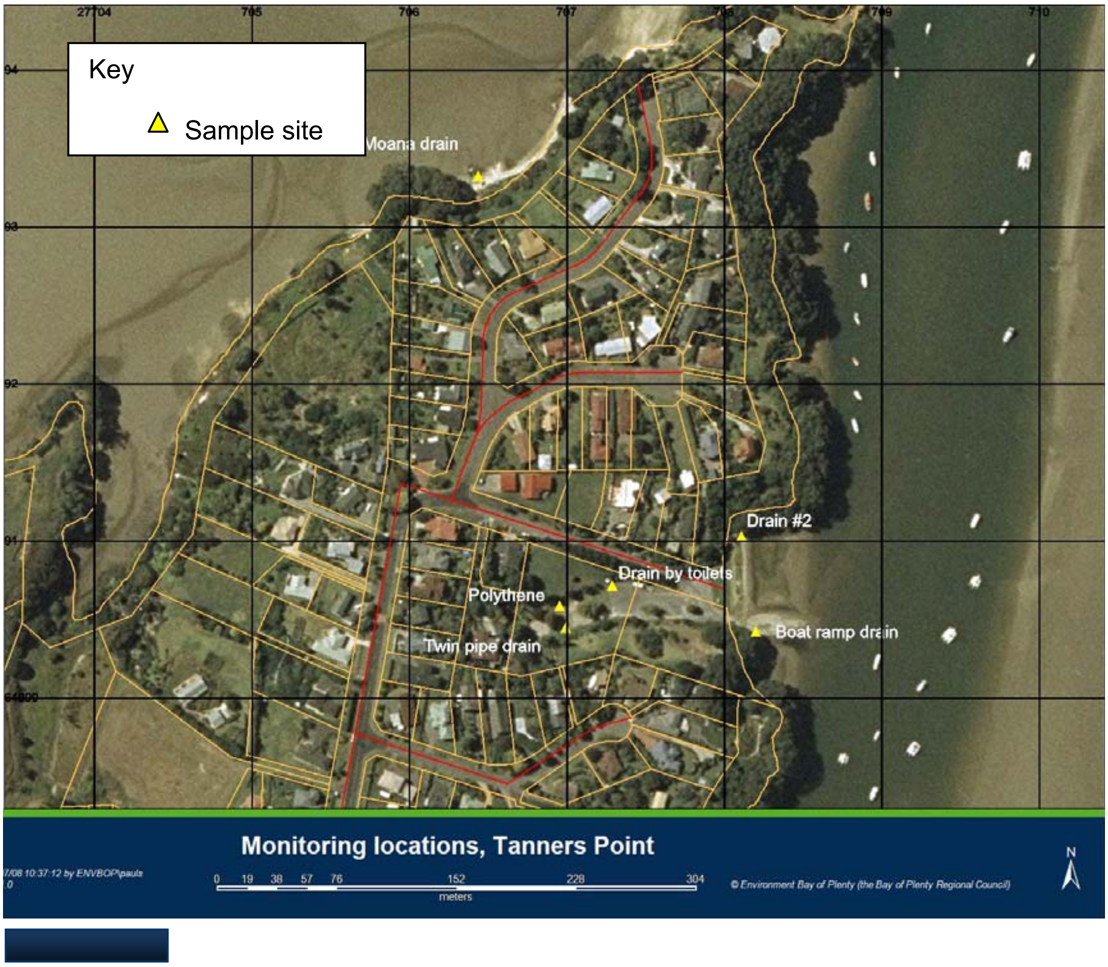


Figure 3.16 Tanners Point monitoring site location map

3.5.1 Physical environment

The Tanners Point Peninsula rises quickly from sea-level to a height of 28 metres. Soil type is Katikati sandy loam which is derived from thin rhyolitic tephra (Taupo Pumice and Tuhua Tephra) on weathered tephra and loess. It is generally well drained.

Rainfall measured from 1994 to 2005 is on average 1892 mm per year, as measured at the Tuapiro rainfall gauge.

3.5.2 Monitoring results

The Tanners Point boat ramp area provides most of the focus for monitoring. This area has a permanently flowing drain and a small seepage at the harbours edge, as well as several subsurface drains that flow into a water table drain located at the landward side of the reserve. Moana Drive also has an ephemeral stormwater drain that flows towards the northern beach.

The permanently flowing drain adjacent to the boat ramp at Tanners Point has been the most often sampled flow on the peninsula. Figure 3.17 shows that the drain has elevated faecal coliforms. *E.coli* levels have also been monitored and have a median level of 183 cfu/100ml over the period 2004 to 2011. This is below the contact recreational limit of 550 cfu/100ml.

NNN results are also high, indicating that septic tank contamination is likely to be occurring. High NNN results have also been found in the waters emanating from the sub-surface drains. Ammonium-nitrogen and dissolved reactive phosphorous concentrations also have at times been at levels that suggest a contamination source.

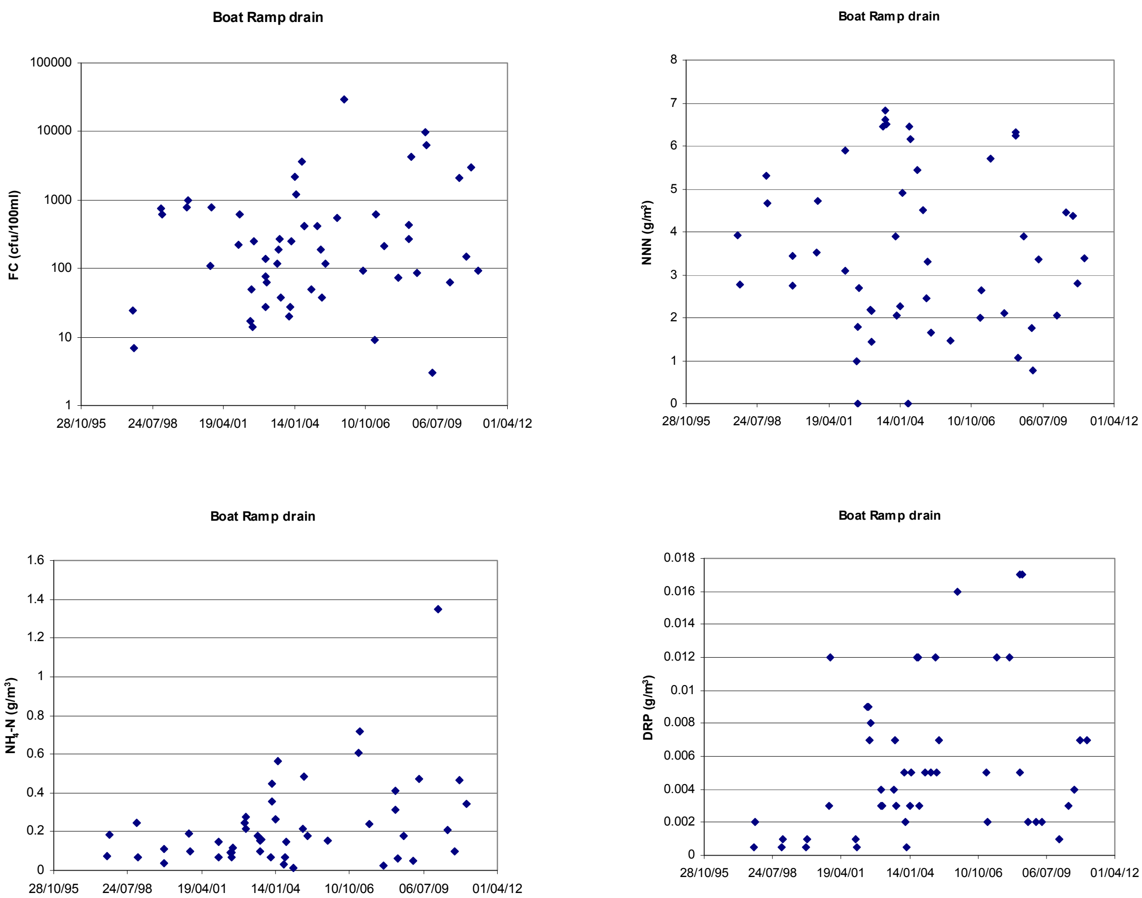


Figure 3.17 Faecal coliform and nutrient concentrations, Boat Ramp drain, Tanners Point.

Figure 3.18 displays data for Boat Ramp drain along with two other smaller drains that flow onto the foreshore. Both the other drains display similar, if not at times higher, levels of nutrient and indicator bacteria. Elevated levels of dissolved nutrients and *E.coli* indicate that both these drains at times are contaminated by septage.

Monitoring of Tanners Point drains in June 2008 over three days after intensive rainfall occurred showed elevated concentrations of *E.coli* and oxides of nitrogen with the highest levels emanating from the sub-surface drains at the bottom of the small boat ramp sub-catchment. Waterlogged soakage fields and increased rainfall is likely to have contributed to leaching of septage into the lower drains and to the foreshore.

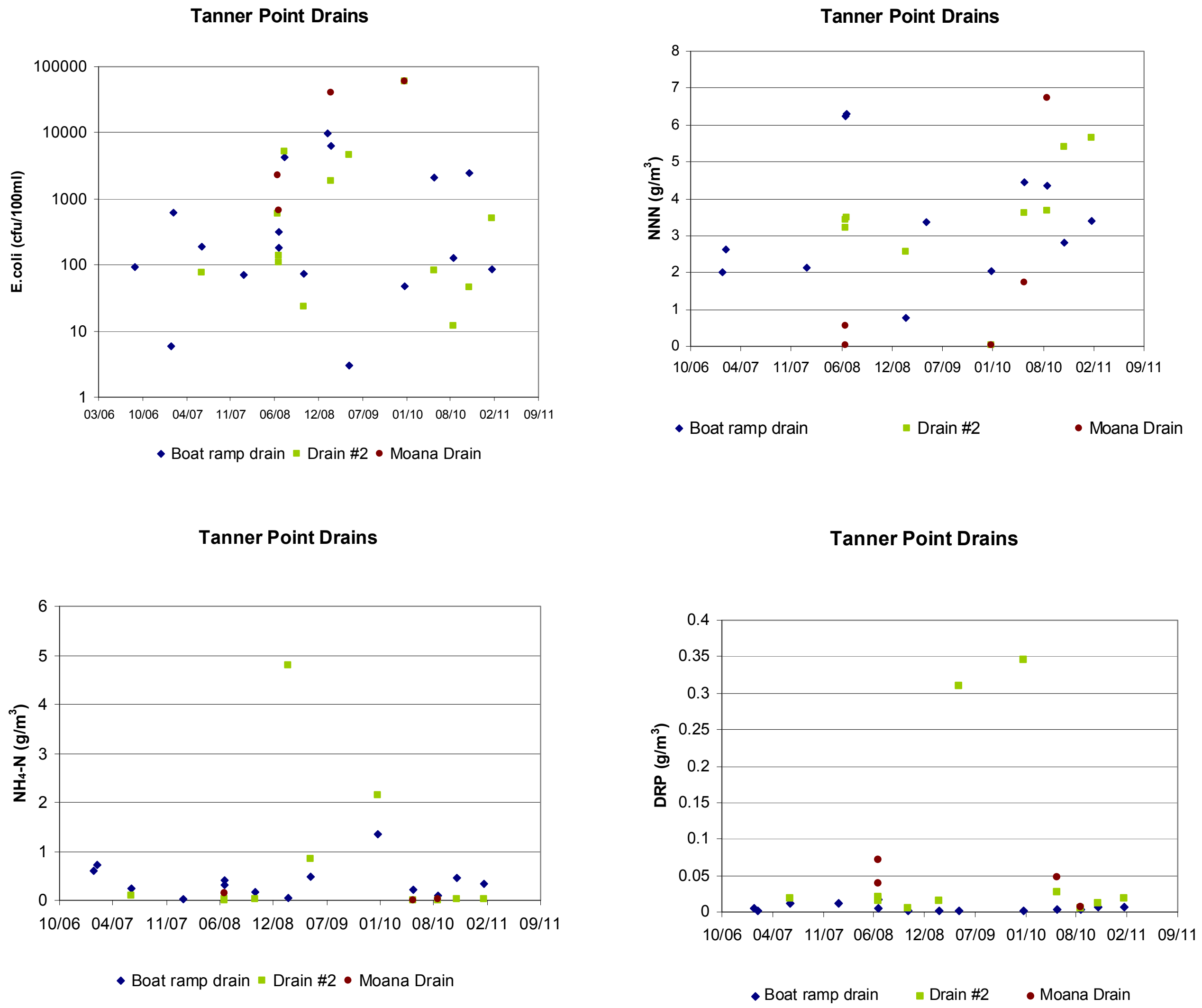


Figure 3.18 Faecal coliform and nutrient concentrations, Boat Ramp drain, Tanners Point.

Indicator bacteria results taken from the jetty near the boat ramp at Tanners Point are at consistently low levels (Figure 3.19). Similarly bathing surveillance monitoring undertaken at the boat ramp in summer has only recorded one value over the microbiological water quality guidelines (2003) in eight seasons. This exceedance may have been the result of an illegal boat discharge, flow from the Tuapiro River or water fowl rather than a land based discharge from Tanner Point.

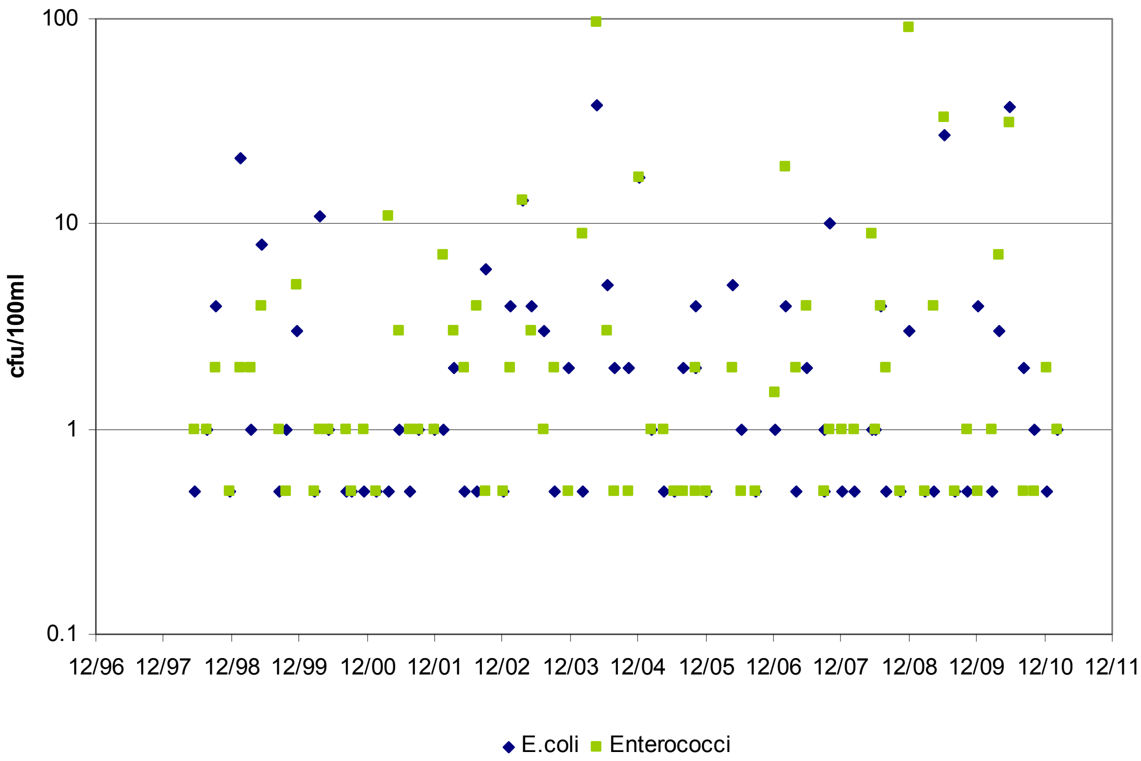


Figure 3.19 Indicator bacteria concentrations, Tanners Point Jetty.

3.5.3 Discussion

Potential for contamination of receiving waters from septic tank effluent at Tanners Point appears in two locations where drainage through colluvial soils occurs.

On the northern side of the Tanners Point peninsula the drain from Moana Drive has been modified, reducing flow onto the beach and this should also reduce the potential health hazard.

A permanent flowing drain and a small seepage on the boat ramp both show signs of contamination which is likely to come from septic tank effluent. However, indicator bacteria levels in the adjacent estuary area are for the most part below water quality guidelines for contact recreation.

A public toilet is also located in the boat ramp sub-catchment. A recent upgrade of the disposal field at this facility may reduce contamination in the boat ramp drain.

3.6 Ongare Point

Ongare Point is a small community located adjacent to Tauranga Harbour north of Katikati. It has around 130 residents with 51 households each of which operates a septic tank system.

Figure 3.20 Ongare Point monitoring site location map.

3.6.1 Physical environment

The Ongare Point community is located on a mixture of well drained Katikati sandy loam and poorly drained Te Puna loam on the elevated sites and poorly drained Wharere loamy coarse sand on the low lying areas.

Four drains provide the drainage conduits for stormwater and groundwater (Figure 3.20). During summer these drains can have little or no flow. There is also a stream to the south of the town being fed by a rural catchment of mixed orchards and pastoral farming. A small drain from Potu Street south dwellings enters the stream above the culvert at the stream mouth. The spring south of the boat damp was displaced by tidal influences in 2008 and has not been monitored since this time.

The town is located on land sloping towards the harbour with the harbour being a sink for surface waters and some groundwater. The harbours edge is predominantly vegetated by exotic grasses with some Pohutukawa trees and sedges to the north of the public toilets.

Mean annual rainfall measured at Kauri Point Road over the 1963 to 2005 period was 1595 mm.

3.6.2 Previous studies

Ongare Point had not been included in the on-site effluent monitoring programme and so the actual state of septic tank systems is unknown. A few residents have voluntarily had their systems inspected and this has shown that tanks are undersized for the volume of effluent being treated.

Surface water sampling has been undertaken at a small drain near the public toilets at the reserve. The drain was found to be clear flowing with no evidence of chronic environmental effects (Gunn, 2001). Bacterial and nitrate-nitrogen levels have indicated some contamination by septic tank effluent (Environment Bay of Plenty, 2001), but in Gunn (2001) it was concluded that the present data did not "indicate consistent levels of contamination due to septic tank effluent".

Initial monitoring of Ongare Point surface waters was carried out in 1991 and 1992. Sampling occurred predominantly in the drain near the toilet block on Harbour View Road. Samples were tested for indicator bacteria and physico-chemical parameters.

The drain at that time displayed consistently high nitrate-nitrogen (NO_3-N) results and its median enterococci concentration for that time is over the current marine red alert level for bathing water quality guidelines (280 enterococci/100ml).

3.6.3 Monitoring results

Much of the monitoring has occurred in the small drain near the Harbour View Road toilet block due to its constant flow and proximity to many of the residences. Figure 3.21 shows occasions where high *E.coli* levels have occurred over the 550 cfu/100ml contact recreation limit, although this has generally occurred after rainfall (see Figure 3.22). Recent *E.coli* levels have remained at a consistent level, below the contact recreation limit. Sampling has been undertaken upstream of the toilet block.

Oxides of nitrogen (NNN) show an increasing trend with recent concentrations above 3 g/m^3. Nitrate-nitrogen is the more mobile nitrogen species through groundwater and at such high levels it is likely that part of this loading is from septic tanks. NNN concentrations in the drain near the toilet block are similar to concentrations in the spring south of the boat ramp (Figure 3.22). Other drains monitored have lower NNN concentrations on average but higher NNN to NH_4-N ratio. There may be an influence of rural groundwater in the spring waters of the drain near the toilet block and the spring south of the boat ramp.

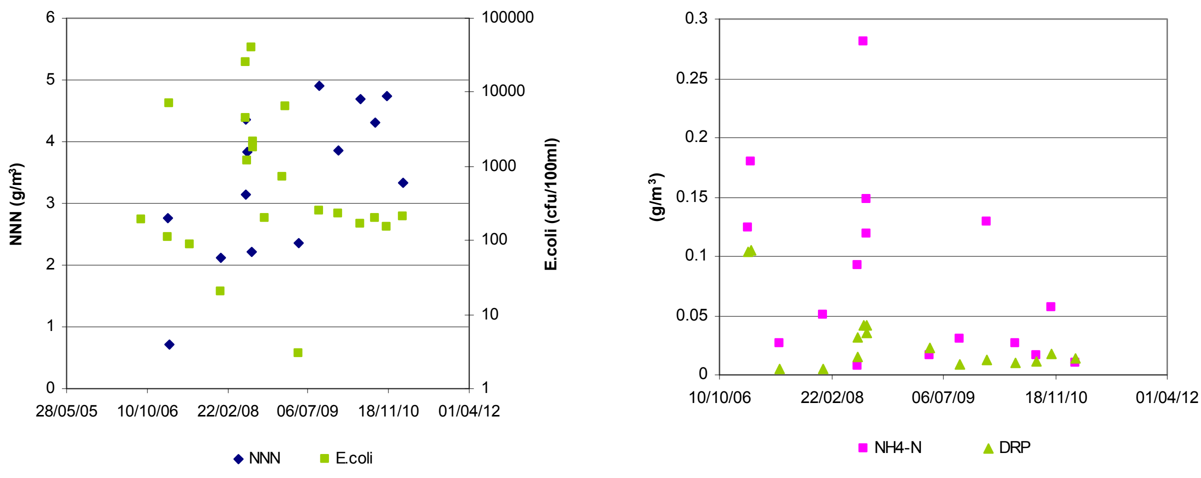


Figure 3.21 E.coli and nutrient concentrations, drain near toilet block, Ongare Point.

A rainfall event was monitored over consecutive days in June 2008 (Figure 3.22). A rise in indicator bacteria levels occurred in all drains except for the spring south of the boat ramp. Nutrient species also displayed a similar increase, most probably as a result of the high groundwater and the consequent impact on drainage fields.

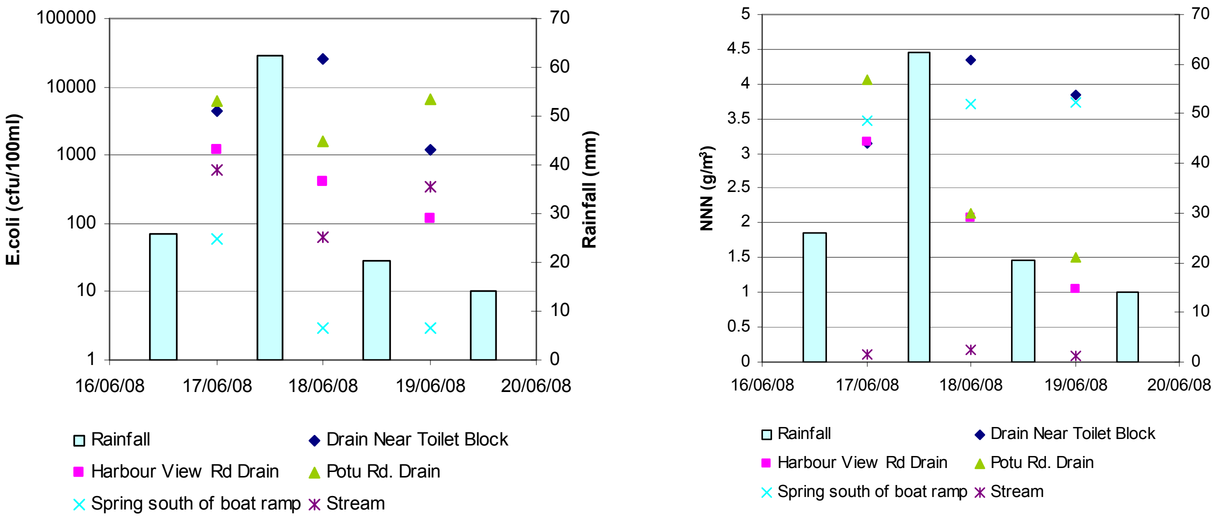


Figure 3.22 Daily total rainfall, E.coli and NNN concentrations, June 2008, Ongare Point.

The Potu Road drain at times shows elevated *E.coli*, DRP and NH_4-N concentrations (Figure 3.23). These elevated levels indicate some contamination from septic tanks. Harbour View drain has to a lesser extent also been found to have occasional higher levels of indicator bacteria and nutrients that would be expected in an uncontaminated stormwater seep. Flow from the Potu Road drain is almost year round while the Harbour View drain experiences only intermittent flow and is therefore influenced by rainfall and water table levels.

Figure 3.23 also shows *E.coli* and nutrient data from the local stream. Some monitoring has been undertaken above and below a subsurface drain that enters the stream from the Potu Road residences. This drain has shown very little flow and no marked difference in the water quality of the stream has been observed due to its input. The stream does however show signs of contamination from rural sources and has predominantly cattle grazing around its lower extent. *E.coli* concentrations are often above the contact recreational guideline and elevated NH_4-N concentrations have been recorded. High NH_4-N concentrations may have been a result of reduced flow and stagnation caused by the build-up of sea lettuce and the configuration of the culverts. A new culvert recently installed will alleviate some of this build up.

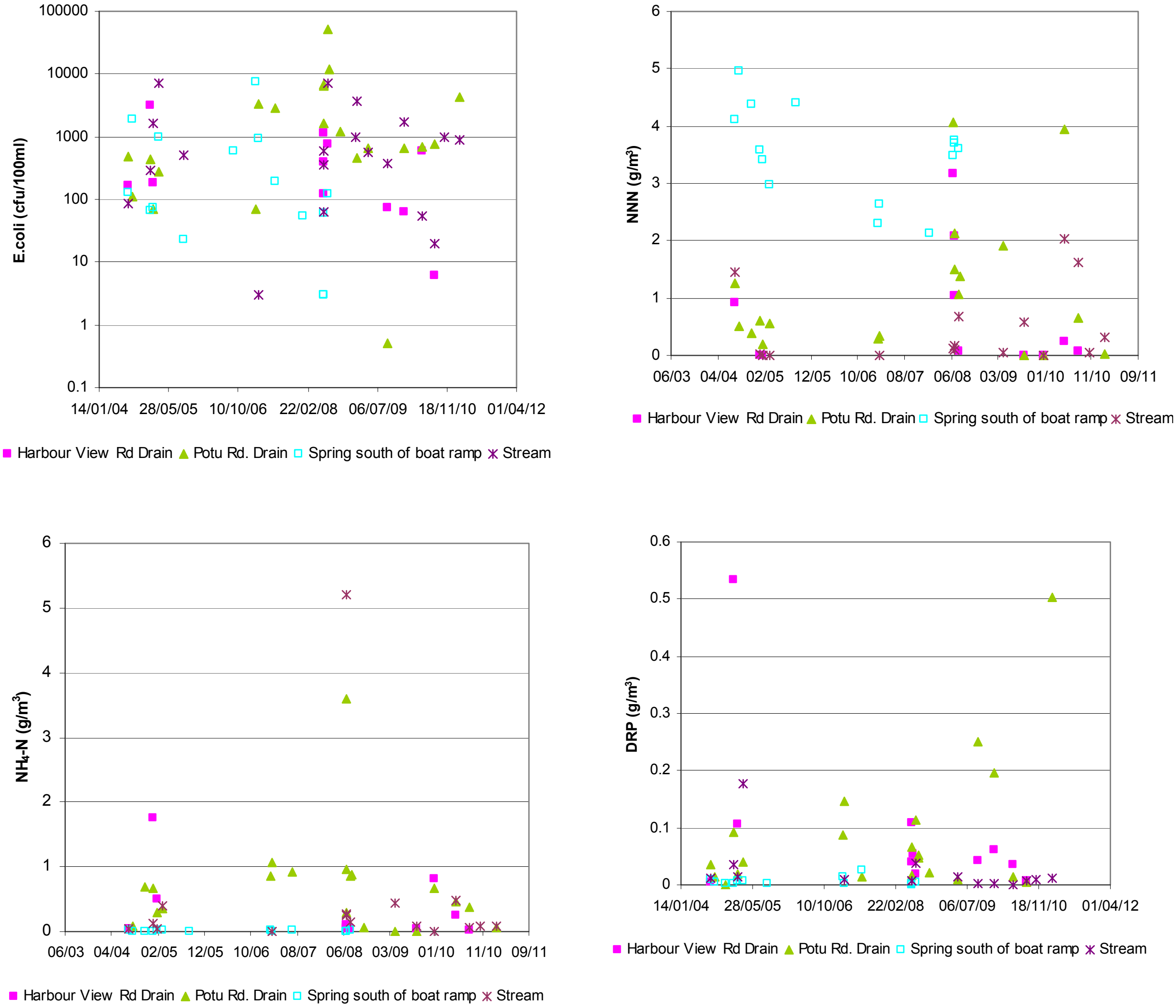


Figure 3.23 E.coli and nutrient concentrations, Ongare Point.

Estimates of flow from the drains and the stream have been made and used to estimate the daily *E.coli* load transported into the harbour from these sources. Figure 3.24 displays these loads as a percentage of the total load from all the drains and the stream. Winter and summer samples are represented.

It can be seen that in winter the drain near the toilet block can have a higher bacterial load than the higher flowing stream, but in the summer of 2011 the stream is the dominant bacteria source. *E.coli* concentrations in the winter do fluctuate and are on average likely to be higher than represented in the winter example in Figure 3.24.

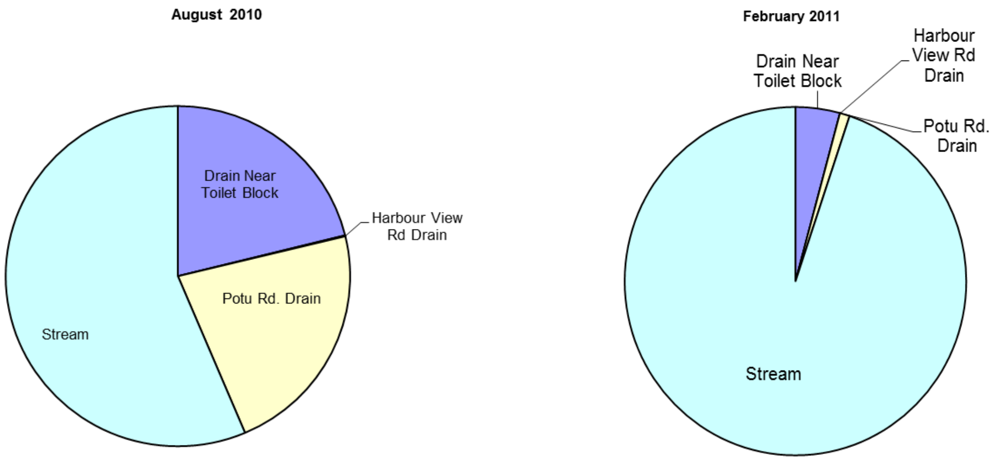


Figure 3.24 Percentage representation of E.coli loads to harbour (cfu/day) for Ongare Point drains and Stream.

Bathing water quality around Ongare Point is generally good with only ten samples exceeding the Microbiological Water Quality Guidelines (2003) orange alert mode of 140 enterococci per 100ml. Results of 1000 enterococci per 100ml occurred in 2006 and 2007. Both samples were taken after substantial rain had fallen

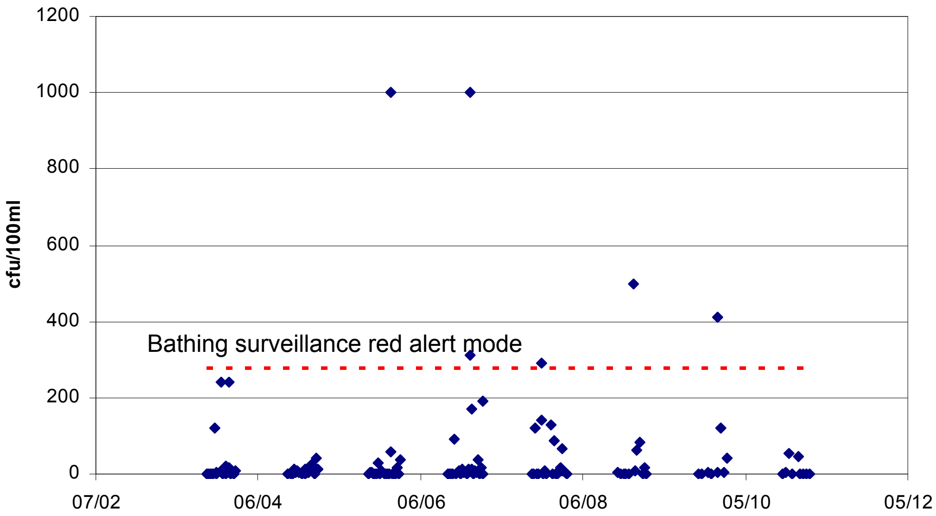


Figure 3.25 Bathing surveillance monitoring results, Enterococci, Ongare Point.

3.6.4 Discussion

Monitoring of drains that flow onto the foreshore at Ongare Point has shown that some contamination from septic tanks is occurring but generally at low levels. Drains do show elevated indicator bacteria levels after rainfall, but only the Potu Street stormwater drain consistently has levels above the red alert mode microbiological water quality guideline. Pathogen loading as shown by indicator bacteria from the contaminated drains is far less than from the local stream, primarily due to the much greater flow coming from the stream. Concentrations of indicator bacteria in the drains can still be high.

Bathing surveillance monitoring of the estuary adjacent to the Ongare Point community shows that the water is suitable for contact recreation. Contact with contaminated drain water at the foreshore discharge points remains the greatest health risk to the community.

3.7 Te Puna

The Te Puna community is located west of Tauranga City on a small peninsula on the Tauranga Harbour. Over 130 dwellings make up the community and these are predominantly grouped to the north and north-east of the peninsula.

The Bay of Plenty Regional Council administers a septic tank maintenance programme that requires regular cleaning and inspection of systems and the Te Puna community agreed to join this programme in December 2002.

There has been signage at the Waitui Reserve warning the public not take shellfish from this area due to potential contamination from septic tank effluent.

3.7.1 Physical environment

The Te Puna peninsula consists of flat to gentle rolling tablelands predominantly elevated 10 meters or greater above sea level. There are residential areas on lower lying land around Lindoch Avenue and Waitui Reserve and these areas tend to have less permeable soils and a higher water table. Rijkse (2003) describes the parent soil material as thin rhyolitic tephra (Taupo Pumice, on Tuhua Tephra) on loess and weathered Rotorua Ash. Soil cover is predominantly well drained Katikati sandy loam, but the lower lying areas are likely to be pockets poorly drained silt loam derived from estuarine sandy sediments.

Mean annual rainfall measured at Te Puna is 1330 mm based on data from 1991 to 2005.

Figure 3.26 Te Puna monitoring site location map

3.7.2 Previous studies

Gunn (2001) in his review of on-site effluent treatment communities noted that contamination levels at Te Puna were of concern and recommended that the community should join the inspection and monitoring programme. He also commented that environmental monitoring should better identify effects due to seepages from disposal fields.

Results of the maintenance programme for Te Puna and impact monitoring were reported on in 2003 (Futter, 2003). Of the 52 residences surveyed 55% of systems failed maintenance programme criteria of which 20% of systems have a soakage field/hole failure.

3.7.3 Monitoring results

Several drains show high bacterial contamination (Figure 3.27, 3.28) typical of poorly treated septic tank effluent. The highest bacterial contamination occurs on the western side of Te Puna where a number of dwellings are located on flat low lying land. Median *E.coli* levels above the microbiological water quality guideline (red alert mode) occur in two of the drains on the east side and one on the west side (Figure 3.27). This is similar to results reported in 2006 (see Scholes, 2007).

Several of these west side drains as well as two of the drains on the north side of the Waitui Reserve have elevated ammonium-nitrogen (NH_4-N) concentrations. Drains on the eastern side have lower ammonium-nitrogen concentrations. Conversely, drains on the eastern side have higher NNN concentrations than their western counterparts.

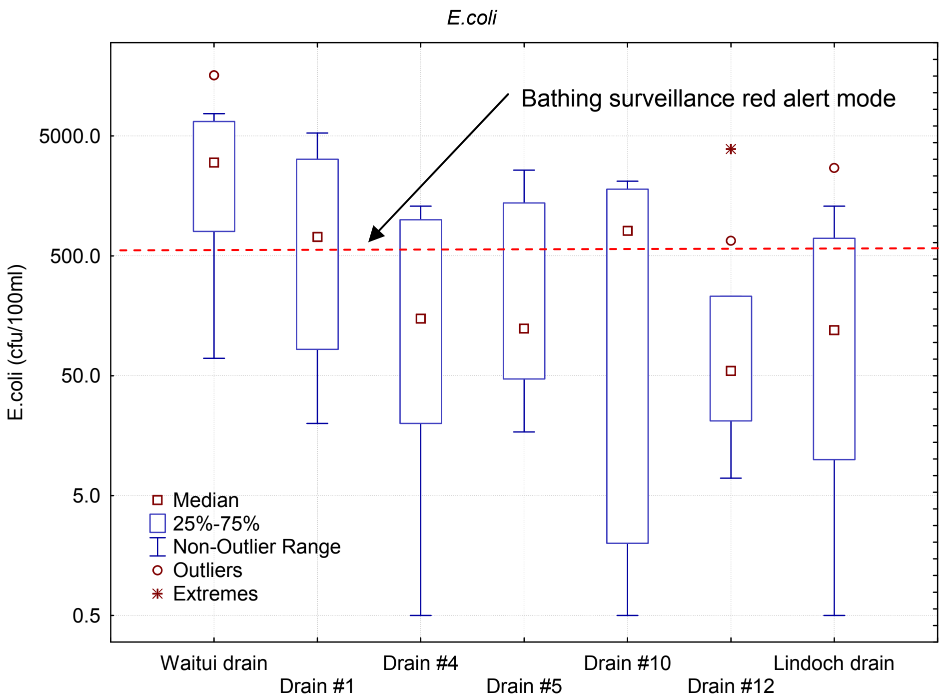


Figure 3.27 Box-whisker plots of E.coli concentrations, Te Puna drains, 2006 to 2011.

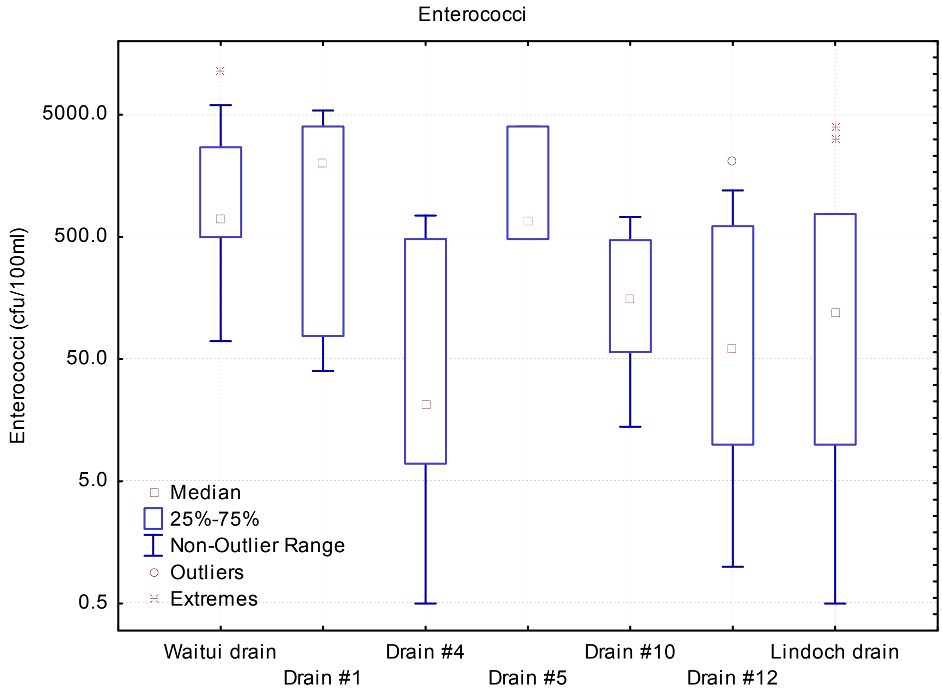


Figure 3.28 Box-whisker plots of enterococci concentrations, Te Puna drains, 2006 to 2011.

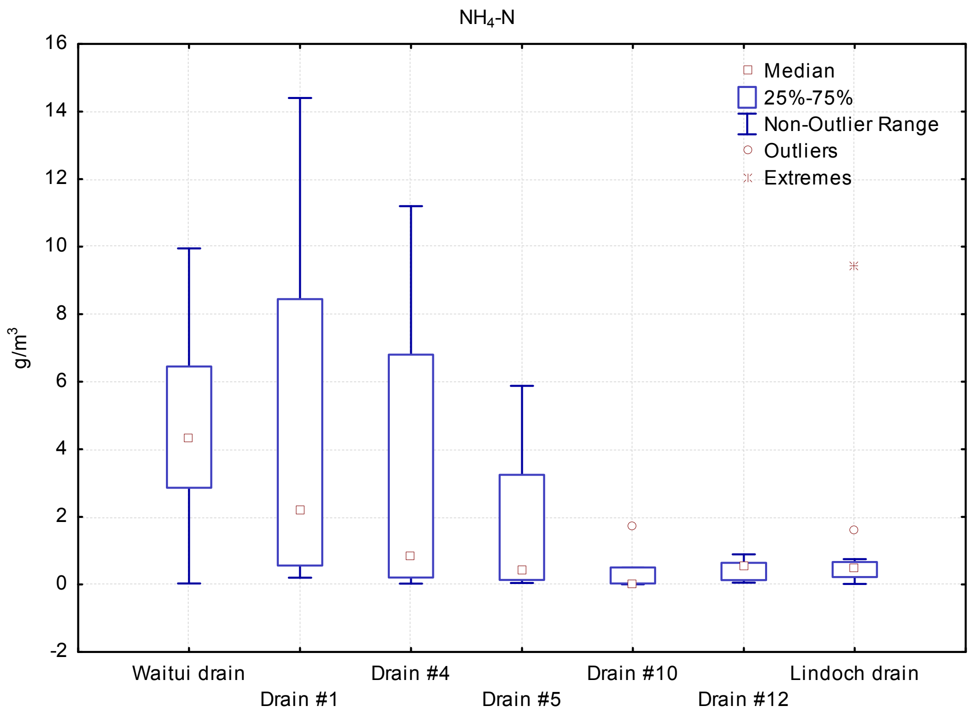


Figure 3.29 Box-whisker plots of NH_4-N concentrations, Te Puna drains, 2006 to 2011.

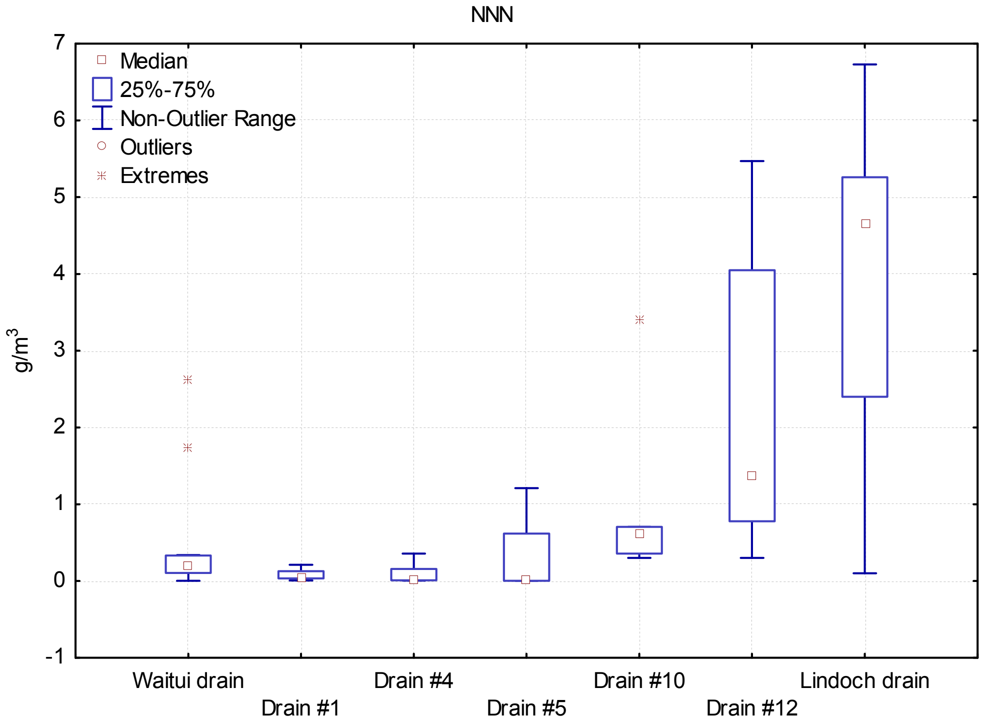


Figure 3.30 Box-whisker plots of NNN concentrations, Te Puna drains, 2006 to 2011.

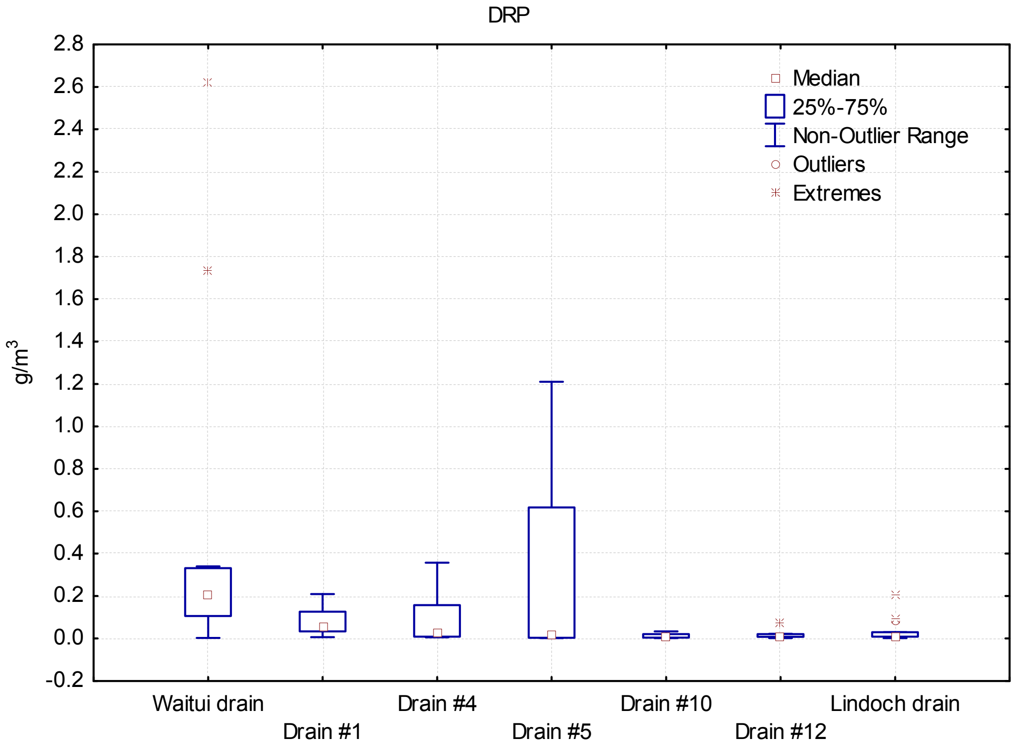


Figure 3.31 Box-whisker plots of DRP concentrations, Te Puna drains, 2006 to 2011.

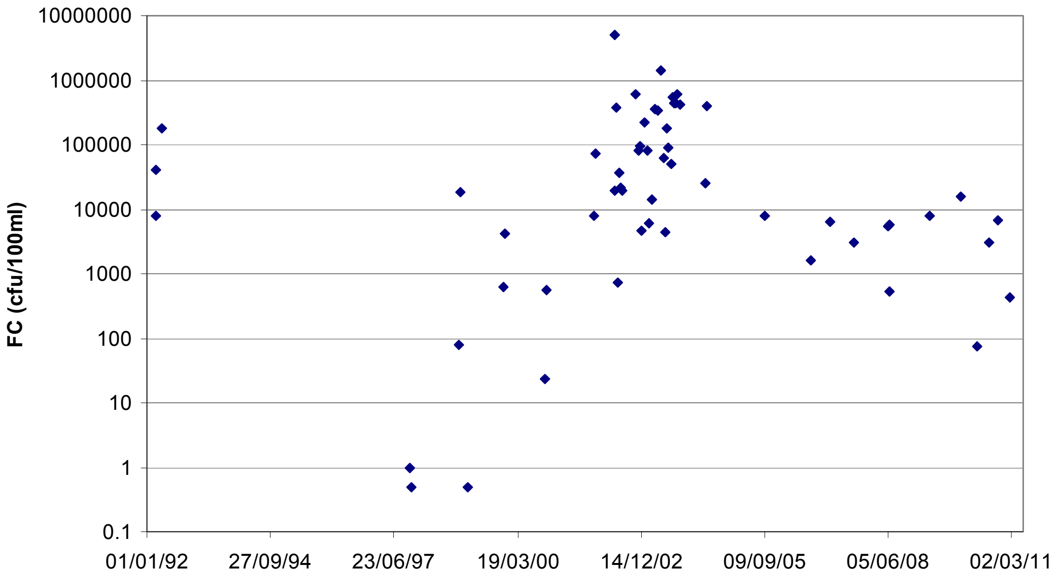


Figure 3.32 Waitui drain faecal coliform concentrations.

One of the main stormwater drains, the Waitui drain, has not only high indicator bacterial levels but also elevated nutrient levels, indicating contamination from on-site effluent treatment systems. Figure 3.32 indicates that faecal contamination was high in 1992 but showed low results in 1997 elevating to extremely high results in 2002, 2003. This has returned to a more moderate contamination level in recent times possibly due to septic system servicing.

The microbiological swimming water quality of the Te Puna estuary is good based on monitoring of the indicator bacteria enterococci (Figure 3.33). Only four results have been above the bathing surveillance red alert threshold (280 cfu/100ml) over the past eight seasons.

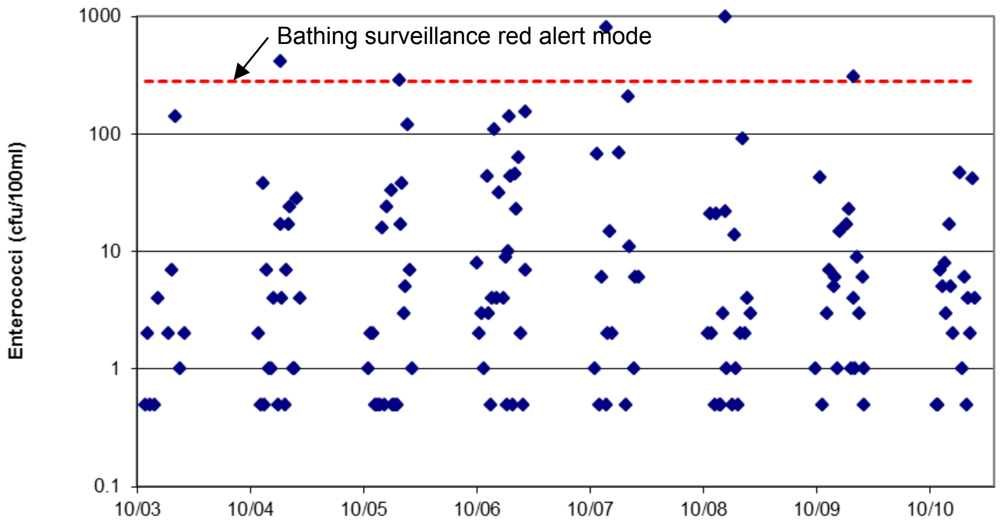


Figure 3.33 Bathing surveillance monitoring results, Enterococci, Te Puna.

Monthly testing of Te Puna estuary oysters for one year in 2007/2008 was undertaken as part of a Tauranga Harbour wide shellfish survey. Oysters were analysed for indicator bacteria, two common viruses commonly excreted by humans and F-specific RNA bacteriophage.

Indicator bacteria results are shown in Figure 3.34 over the 12 months of sampling. *E.coli* results were over the level considered safe for human consumption (what is the level?) three times over the 12 months (monthly monitoring). Two of these elevated *E.coli* concentrations occurred after rainfall. Only one positive virus detection (adenovirus) occurred in the 12 months. Human and animal F-specific RNA bacteriophage were also detected.

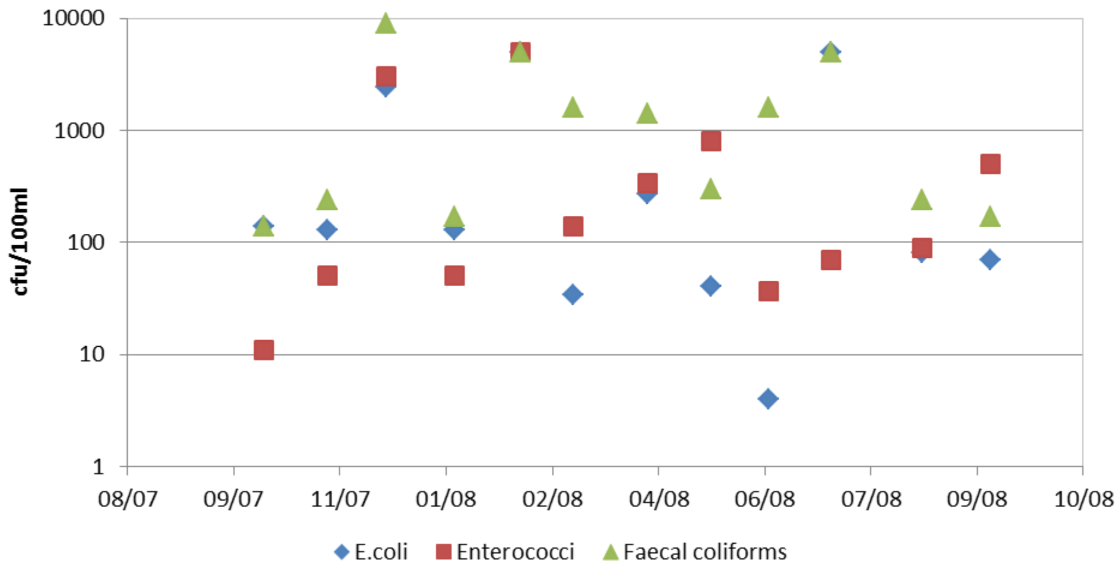


Figure 3.34 Indicator bacterial results for Te Puna estuary oysters, 2007/2008.

Shellfish sampling and analysis of the oyster beds also occurred after two moderate rainfall events (Table 3.2). Elevated *E.coli* and faecal coliform results occurred immediately following rainfall and only on one of the events were these at levels considered unsafe for human consumption. Concentrations of both these thermo tolerant bacteria reduced in shellfish a week after the event. No viruses were detected but both events picked up positive results for animal and human F-specific RNA bacteriophage.

Table 3.2 Indicator bacterial, viral and F-specific RNA phage results for Te Puna estuary oysters after rainfall events, 2008.

Date Sampled	**E.coli**	**Enterococci**	**Faecal Coliforms**	**Norovirus**		**Adeno-virus**	**F-specific RNA phage**			
	n/100g	n/100g	n/100g	Group I	Group II		Group I	Group II	Group III	Group IV
							Animal	Human	Human	Animal
17-Apr-08	3500	2400	5400	Neg	Neg	Neg	Neg	Neg	Neg	Neg
18-Apr-08	1300	490	2400	Neg	Neg	Neg	Positive	Neg	Neg	Neg
21-Apr-08	300	2400	300	Neg	Neg	Neg	Neg	Positive	Neg	Neg
23-Apr-08	110	78	330	Neg	Neg	Neg	Neg	Positive	Neg	Neg
1-May-08	240	37	140	Neg	Neg	Neg	Positive	Positive	Neg	Neg
7-May-08	40	800	300	Neg	Neg	Neg	Positive	Positive	Positive	Neg
15-May-08	22	220	50	Neg	Neg	Neg	Positive	Neg	Neg	Neg
21-May-08	12	220	170	Neg	Neg	Neg	Neg	Positive	Neg	Neg

3.7.4 Discussion

The Te Puna west drains continue to show high levels of bacteria and ammonium-nitrogen, a sign of septic tank contamination. Drains to the east have occasional high indicator bacteria levels but are distinct from the western drains due to their much higher NNN to NH4-N ratio. This higher ration may be due to other catchment influences and transformations of nitrogen from septic tank effluent.

Contact recreation water quality in the estuary remains good despite the high level of bacterial contamination in some drains. The main risk to beach users is the contamination of the foreshore adjacent to contaminated drains.

An intensive survey of oysters on the opposite side of the estuary to the contaminated drains displayed little viral contamination compared to other shellfish beds in the southern end of Tauranga Harbour. During two storm events in 2008 positive F- RNA bacteriophage typical of both animal and human sources were detected. This indicates that contamination from rural sources and septic tanks is occurring.

3.8 Pukehina/Waihī Estuary

Pukehina is a seaside community with a 5.3 kilometre ribbon development encompassing the Pukehina-Waihī Estuary spit and containing almost 700 dwellings. The number of permanent residents has been increasing although a large number of the population are seasonal. Only two kilometres of the community is adjacent to the Waihī Estuary.

The community relies in on-site wastewater treatment systems for sewage disposal but the area has not been previously identified as having contamination issues due to wastewater disposal.

3.8.1 Physical environment

The Pukehina community is located on coastal dunes forming the Waihī-Pukehina spit with some southern dwellings on Wharepaina silt loam. Coastal sands have very good drainage unlike silt loam which has poor drainage properties. The nearest rain gauge is located near Te Puke at Te Matai and has a mean annual rainfall of 1313 millimetres over the period 1990 to 2005.

Stormwater is directed back to the estuary side of the community from the existing stormwater network.

Figure 3.35 Pukehina/Waihī Estuary monitoring site location map.

3.8.2 Previous studies

A survey of septic tank contamination primarily of the Little Waihī community was undertaken in the early 1990s and included bathing suitability surveys and shellfish monitoring results. Bathing survey results showed Waihī Estuary and Pukehina Beach at the surf club were well with guideline limits on a median seasonal basis. No viral pathogens were found in shellfish or sediment in Waihī Estuary, but F-specific bacteriophage were present in sediment and shellfish (McIntosh, 1992). The source of the F-specific bacteriophage was not determined.

The 2001 report *Monitoring of the On-site Effluent Regional Plan* also showed that bathing survey results remained within guideline limits on a median seasonal basis, but would sometimes exceed the guideline in the estuary. Shellfish were often found to be contaminated especially adjacent to the Little Waihī community.

The report also lists the results of seepage monitoring around Pukehina conducted by Western Bay of Plenty District Council (McIntosh *et al*., 2001). Only one seep displayed consistently elevated faecal coliform results (9P) and one seep had occasionally elevated results (2P) (Figure 3.36). Both these sites are located at the south end of the community. The site 10P (eastern drain) and 4P (Midpark drain) also had some elevated results. These results indicated some local scale contamination and/or contamination hotspots, but at locations that are of low risk to public health.

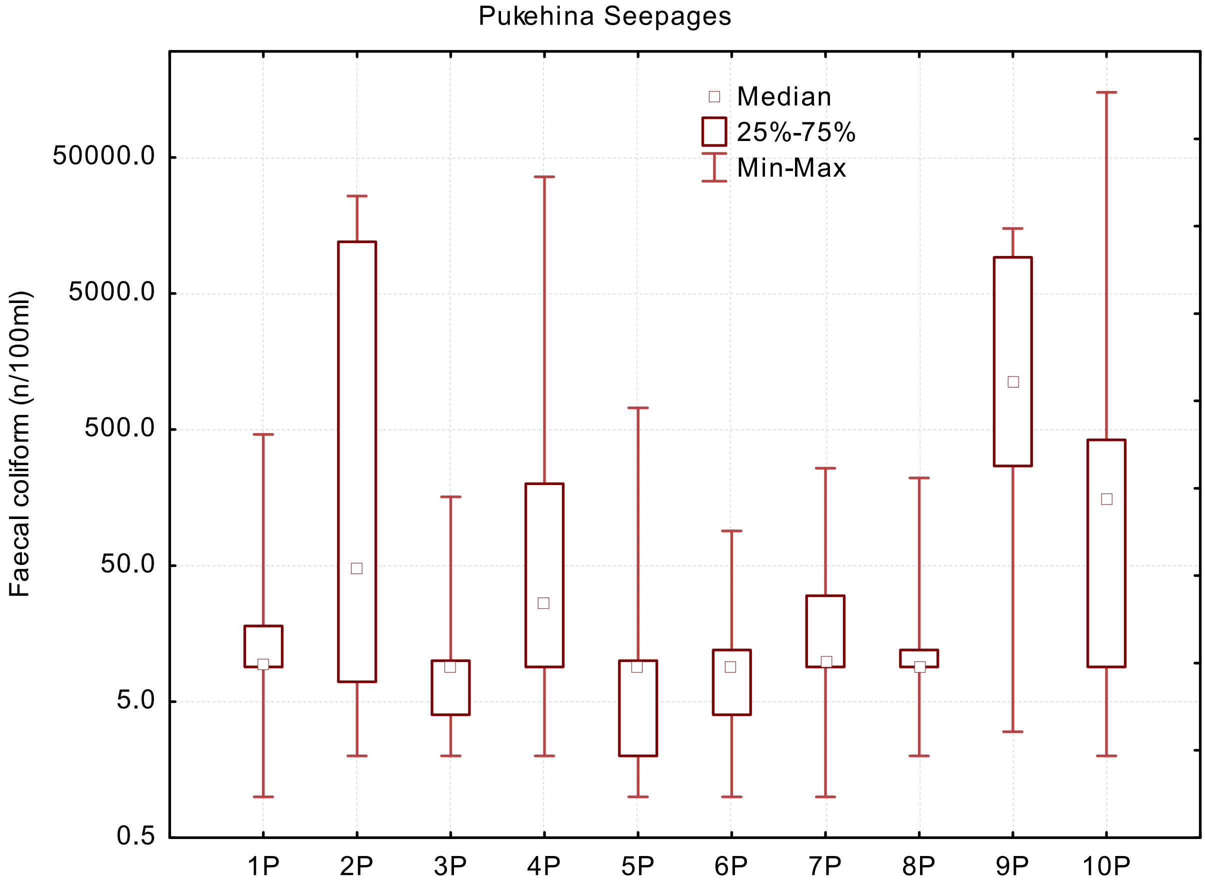


Figure 3.36 Faecal coliform concentrations (n=22-27), Pukehina seepages, 1999 to 2001.

3.8.3 Monitoring results

Several small seepages and drains have been monitored from the end of 2010 predominantly around the Waihī Estuary foreshore (see Figure 3.35). Results for these are displayed in Figure 3.37.

The initial survey in spring found very low flows and low *E.coli* levels. Two drains had slightly elevated ammonium-nitrogen (NH_4-N) levels but these levels did not increase with subsequent sampling. However, *E.coli* levels did increase for most drains over the summer with high contamination levels found in two drains (P1 and P3). Dissolved reactive phosphorous (DRP) and NH_4-N levels increased over the summer in P1 and also in P6, the eastern main drain. However, nutrient levels have not reached levels as high as other beachside communities showing contamination from septic tanks.

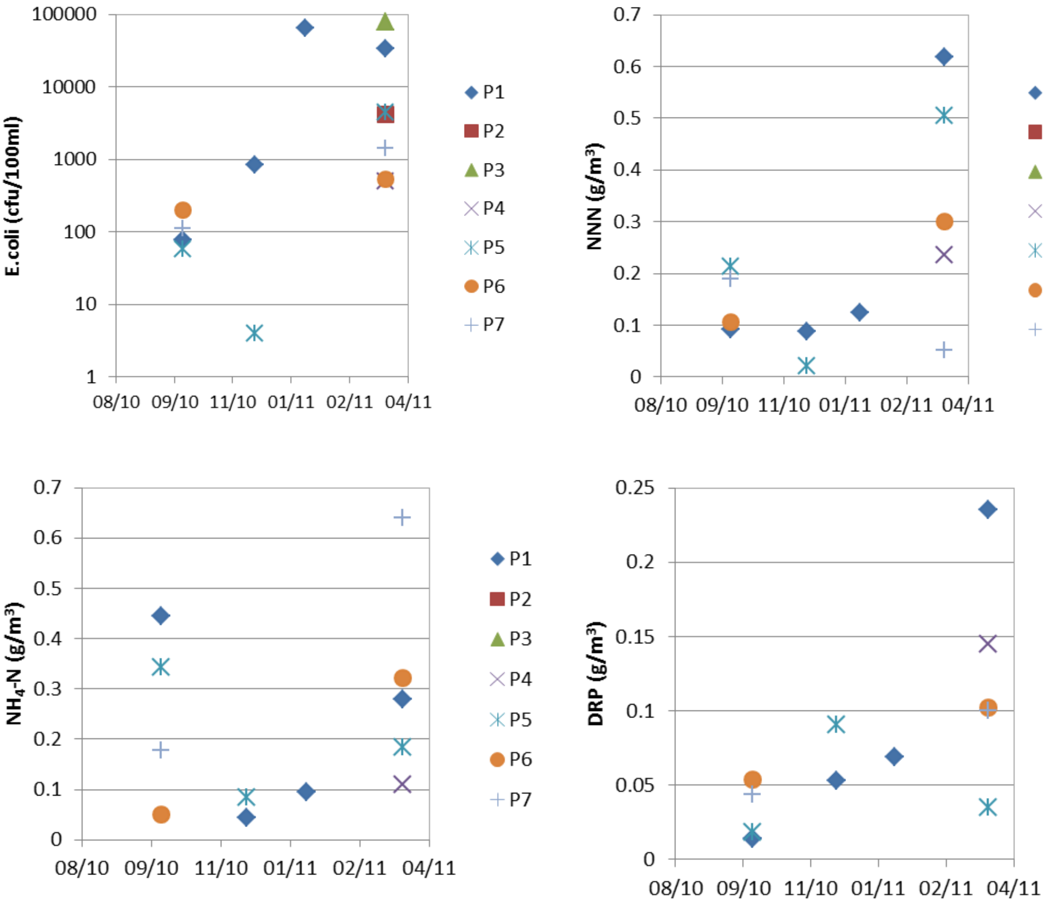


Figure 3.37 Nutrient and E.coli concentrations from seeps and drains, Pukehina.

Bathing surveillance monitoring at Pukehina beach shows these waters to be excellent for contact recreation purposes. Waihī Estuary has lower water quality due to rural freshwater inputs, local contamination from the Little Waihī community and potentially from Pukehina. Figure 3.38 shows monitoring results for the lower estuary from 2003 to 2011. Apart from the 2009/2010 season results have been under 50 enterococci/100ml, well below the bathing surveillance alert levels for marine waters. Only three seasons in the last eight have had occasional results above the bathing surveillance red alert level.

Indicator bacteria results for shellfish in the Waihī Estuary have been variable, with some very high faecal coliform results found in cockles adjacent to the Little Waihī community in 2003. Faecal coliform results for main channel Pipi are generally of lower concentrations and are often at levels safe for human consumption. A monthly survey undertaken of Pipi in the estuary over a year in 2007/2008 showed elevated indicator bacteria results with moderate rainfall events (Figure 3.39), indicating some contamination is brought into the estuary during rainfall.

To help determine the origins of the contamination viral and F-RNA-bacteriophage analyses were undertaken. One sample in the 12 months of sampling tested positive for both norovirus (GII) and adenovirus. F-RNA-bacteriophage analyses was only undertaken after storm events and while no positive viral results were encountered over this sampling period, six of the eight samples tested positive for FRNA phage G2 (GII) which is characteristic of human faecal contamination (see Scholes et al, 2009). Viral and F-RNA-bacteriophage analyses were also undertaken on the sample taken in February 2011 and were found to be negative for enteric viruses but positive for FRNA phage (GI and GII).

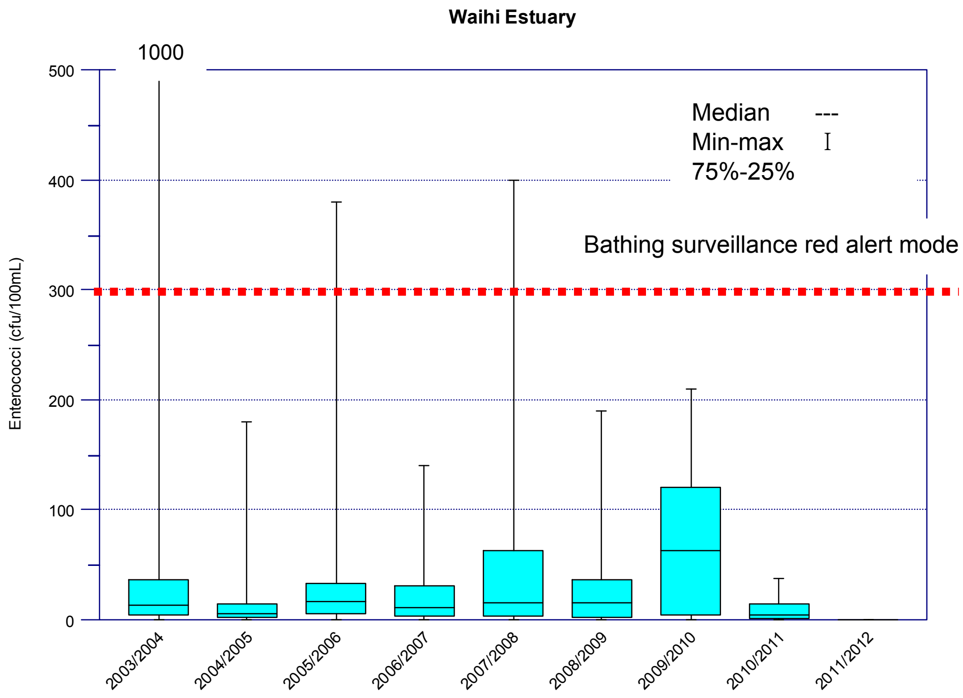


Figure 3.38 Bathing surveillance results, Waihī Estuary.

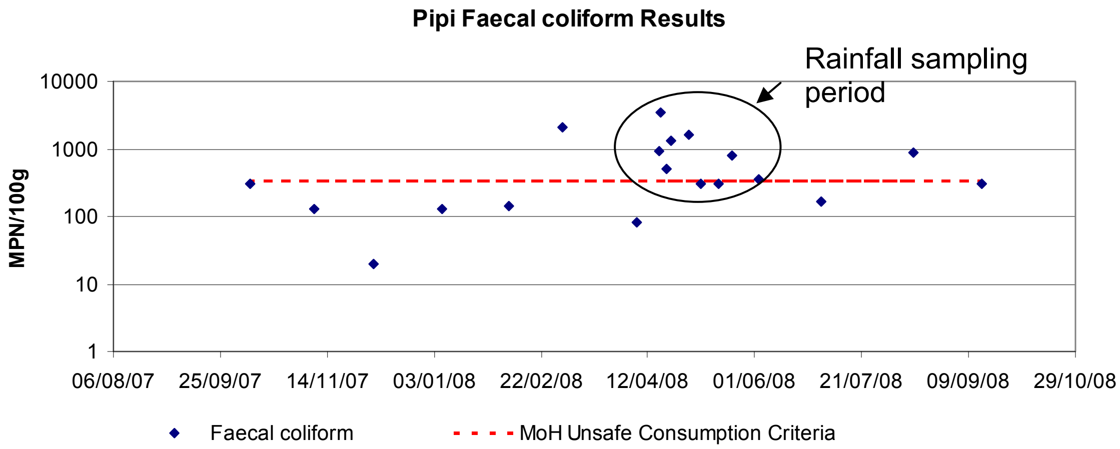


Figure 3.39 Faecal coliform concentrations, Pipi, Waihī Estuary.

There have been only a few shellfish samples taken from the Pukehina coastal area. Tuatua results for Pukehina are shown in Figure 3.40 with one result showing elevated faecal coliform and enterococci concentrations although low *E.coli*. Viral and F-RNA-bacteriophage analyses were also undertaken on the sample taken in February 2011 and were found to be negative for enteric viruses and FRNA phage (GI and GII).

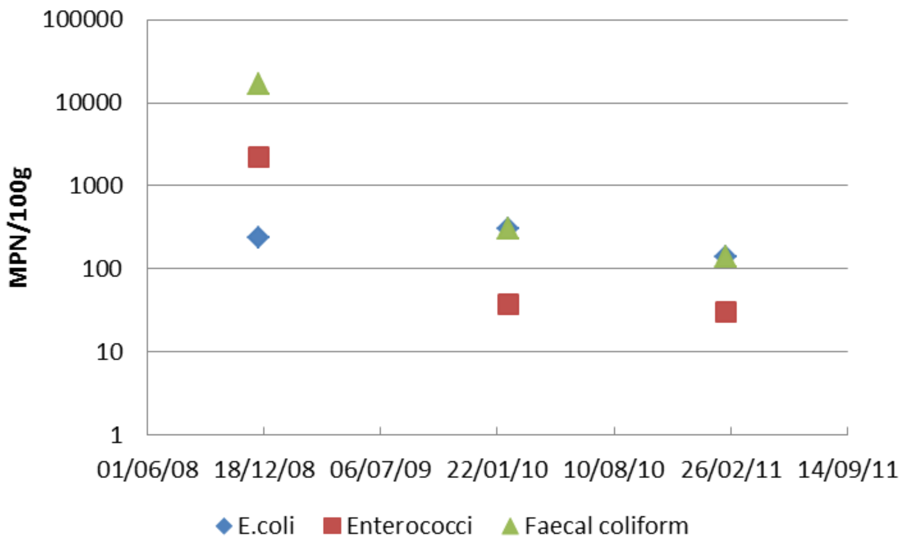


Figure 3.40 Indicator bacteria concentrations in Pukehina shellfish.

3.8.4 Discussion

Waihī estuary generally has water acceptable for contact recreation purposes under current guidelines but shellfish are impacted by faecal contamination particularly after rainfall. Rainfall impacted shellfish have also revealed positive results for human faecal contamination. Human faecal contamination could be sourced from the Little Waihī and/or Pukehina communities.

Seepage monitoring to date around the Pukehina community has revealed some contamination, but contamination from seepages and drains is small in magnitude due to the small flows. Some drains do present a potential health risk to users who come in contact with these waters. The likelihood that shellfish are contaminated from drains or seepages from Pukehina is low, but the magnitude of transfer of pathogens via groundwater transport routes directly to the estuary or ocean is unknown.

Little Waihī is expected to be reticulated in the future and monitoring of shellfish should be continued to assess any improvements in the levels of human faecal contamination.

3.9 Bryans Beach

Until recently the Bryans Beach community was dominated by holiday dwellings. With around 50 dwellings, the growing permanent residential population means that a greater quantity of septic tank effluent is being discharged to the environment. One small channelised stream flows through the densest part of the community and as such it is susceptible to contamination from septic tank effluent.

3.9.1 Physical environment

Soils around Bryans Beach are dominated by Ōpōtiki Hill soils. These are loams comprised of very thin Taupo Pumice on Whakatāne, Rotomā, Waiohau and Rotorua Tephra, and tephric loess on weathered rhyolitic tephra. Beach front properties also have a component of well drained Ohope sand.

Annual average rainfall measured at Ōpōtiki is 1175 mm from 1997 to 2005.

Figure 3.41 Bryans Beach monitoring site location map.

3.9.2 Previous studies

The Bay of Plenty Regional Council and Ōpōtiki District Council responded to community concerns over contamination from septic tank effluent in 2000/2001. Dye testing of individual septic systems and sampling of the Wagner Street stream revealed significant contamination from septage. Action was undertaken by owners of the properties that were identified as contributing to the contamination. Community members were alerted to the problems and it was suggested that their septic systems be upgraded where necessary and regularly cleaned out.

Gunn (2001) after surveying the investigation results has suggested that adverse environmental effects will continue due to the proximity of the watercourse to the communities sewage systems, the high groundwater table and soil type, and the increasing permanent population. He suggests that a long-term solution is to work towards a communal effluent collection, treatment land application system.

Monitoring of potential contamination from septic tank effluent has occurred since 2000. In 2000 a series of samples was taken in the Wagner Street stream and tested for fluorescence whitening agents as an indicator of septage contamination. Results were inconclusive.

3.9.3 Monitoring results

Bryans Beach monitoring has been undertaken to compare the Wagner Street stream outlet with the water quality upstream of a stormwater drain and in two drains that enter the stream.

Nutrients have only been elevated on some occasions, mainly in a small drain to the beach and in the Wagner Street stormwater drain (Figure 3.42). DRP has a correlation with *E.coli* for both the Wagner Street drain and the stream outlet (Pearson r=0.678 & 0.651 respectively, $p<0.05$) and the stream outlet *E.coli* data also correlate with ammonium-nitrogen data (Pearson r=0.660, $p<0.05$). Such a correlation would suggest the source of bacterial contamination is septic tank effluent, particularly as ammonium nitrogen in the stream outlet is higher than the upstream site.

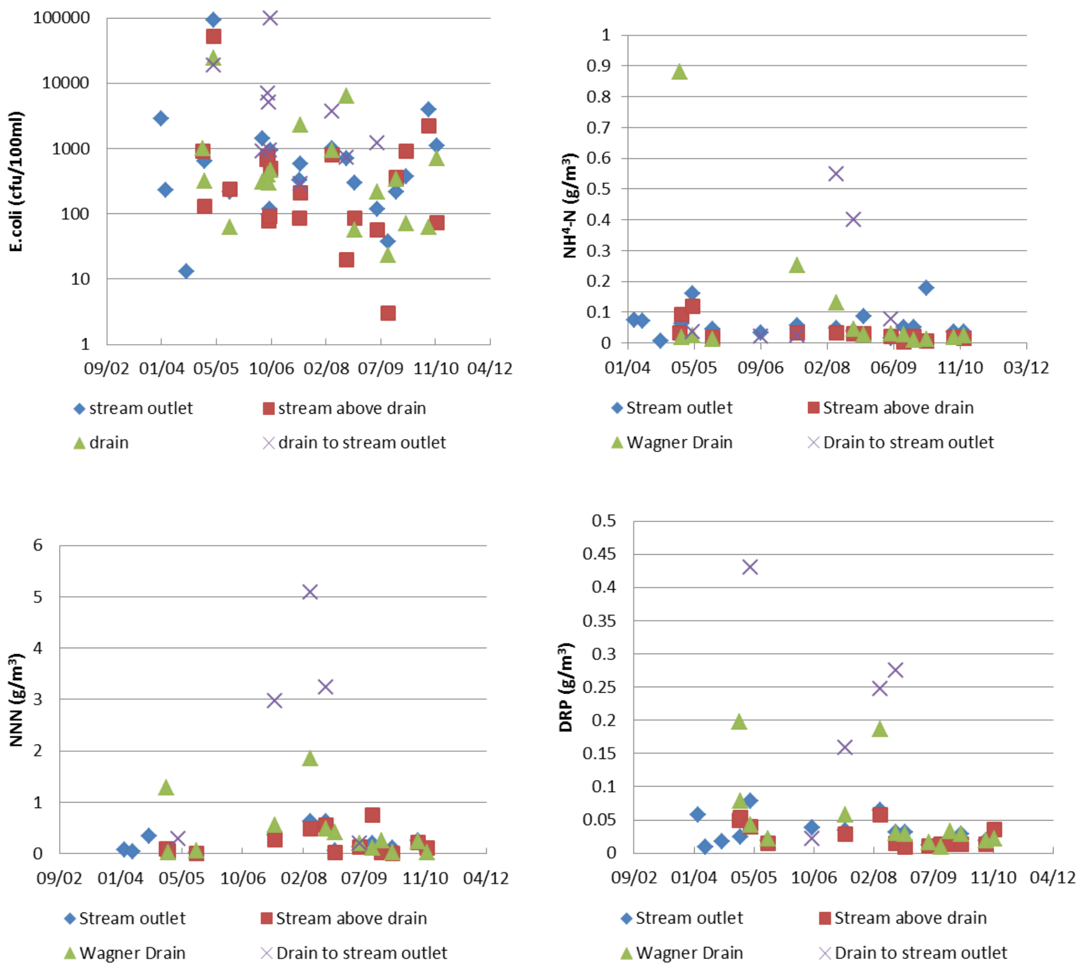


Figure 3.42 Nutrient and E.coli concentrations from stream and drains, Bryans Beach.

The *E.coli* data for the stream is more variable with only five of the 18 sample points for the upstream sampling site being an order of magnitude higher than in the downstream. This suggests contamination as indicated by *E.coli* is intermittent and that there is a bacterial loading from the rural source as well as septic tanks. The concentrations of *E.coli* and other indicator bacteria are high in the drain to stream outlet showing contamination must be from septic tanks.

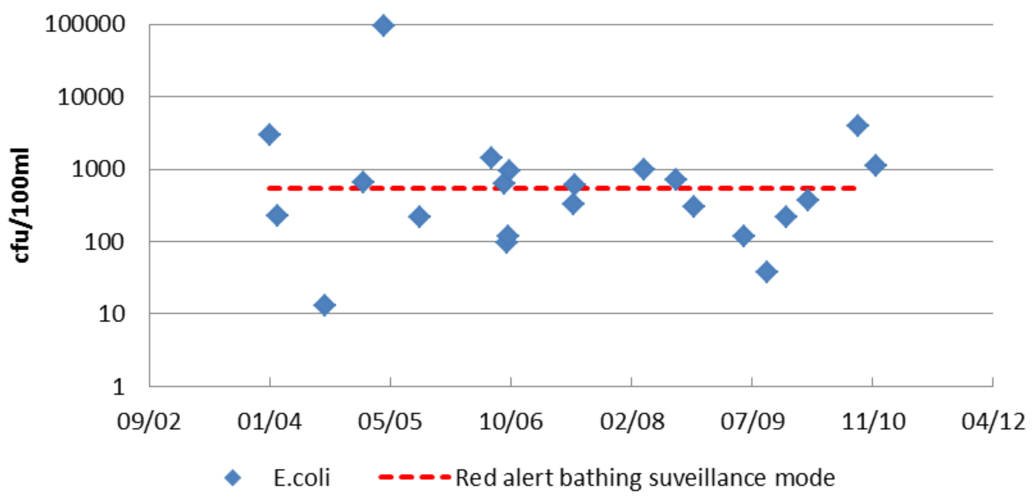


Figure 3.43 E.coli concentrations, Stream outlet, Bryans Beach.

The highest health risk to the community will be due to potential contact with the drain waters at the beach. Figure 3.43 shows that the stream outlet was above the guideline for bathing microbiological water quality around 50% of the time during the period of sampling.

3.9.4 Discussion

Small flows from the Bryans Beach community to the beach are occasionally contaminated with septic tank leachate at levels that may present a health risk. Flows are generally short lived disappearing into the porous sand dunes except during stormy periods when the stream discharges directly to the sea. Elevated contaminant levels often occur after moderate to high rainfall events and these periods pose the highest risk to human health.

The positive correlation of *E.coli* with ammonium-nitrogen in the Bryans Beach stream is a strong indicator that poorly treated effluent is entering the stream.

Part 4: Ōmokoroa – The Case for Reticulation

4.1 Introduction

Much of the sewage from Ōmokoroa was reticulated to the Tauranga City Council wastewater treatment plant in mid-2007. This was necessary due to increasing development pressure and strong evidence of foreshore contamination from on-site wastewater treatment systems.

Targeted monitoring of drains and seepages on the Ōmokoroa foreshore (see Figure 3.44) has been carried out since reticulation to document improvements. This monitoring is summarised here.

Figure 3.44 Ōmokoroa monitoring site location map.

4.2 Results

Drains and seeps show an overall improvement in indicator bacteria concentrations since reticulation. The most dramatic improvements appear in the faecal coliform results (Figure 3.45). The highly contaminated drains (Domain and Esplanade #1) have shown around a 3 log order reduction (1,000 to 10,000-fold) in faecal coliform levels. Other drains and seeps are displaying a 2 or 1 log (10 to 100-fold) reduction, but these were generally not as highly contaminated as the Domain and Esplanade No. 1 drains.

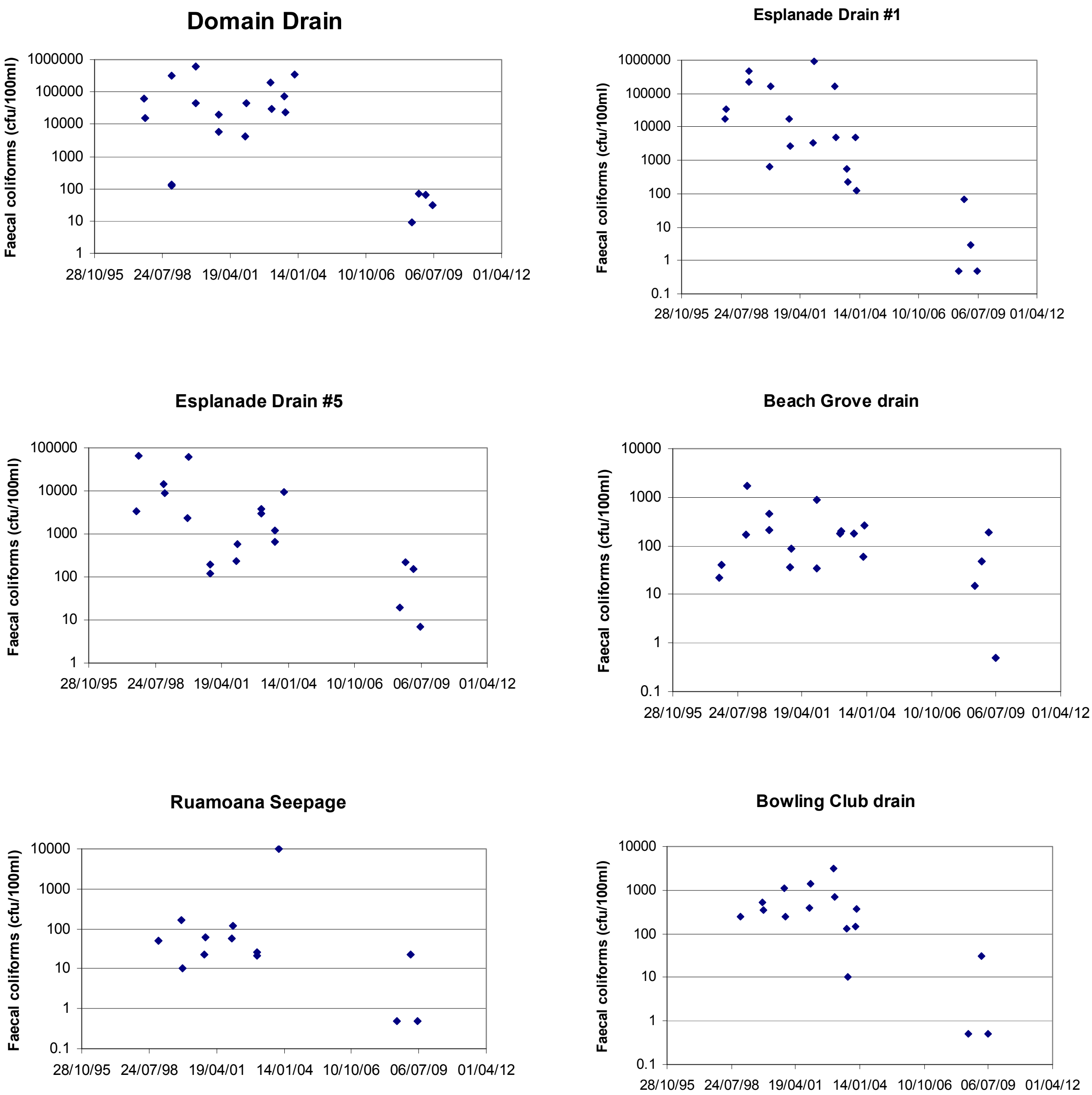


Figure 3.45 Faecal coliform concentrations in drains and seeps, Ōmokoroa. Note: the Log scale in the graphs de-emphasises the significant reductions that occurred post-reticulation.

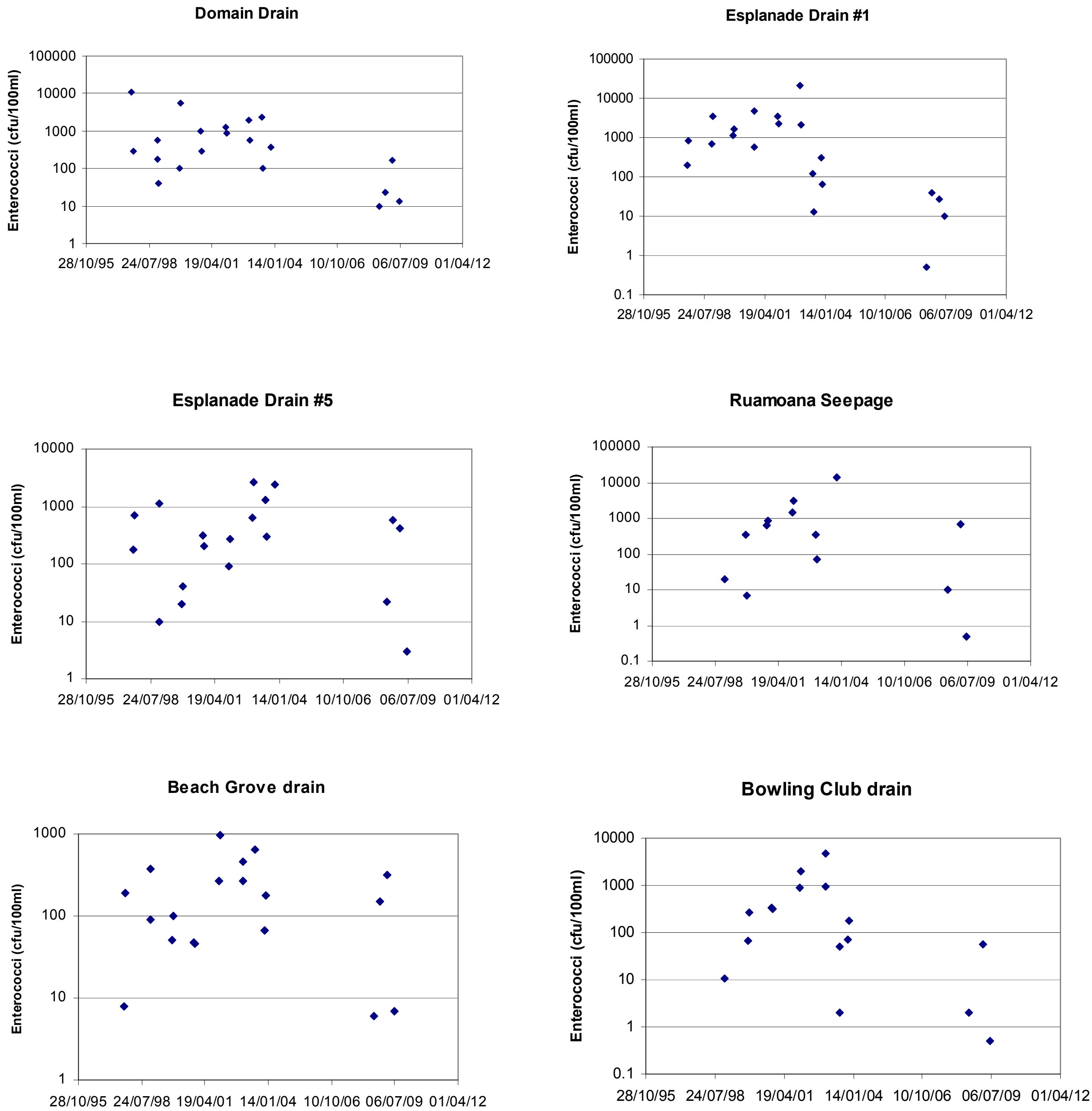


Figure 3.46 Enterococci concentrations in drains and seeps, Omokoroa. Note: the Log scale in the graphs de-emphasises the significant reductions that occurred post-reticulation.

The enterococci results are not as conclusive as the faecal coliform results, with a one to two log order improvement in concentrations in the Domain and Esplanade #1 drains. However, results from other communities tend to show faecal coliform or *E.coli* as the better indicator of contamination from on-site wastewater treatment sources (see Scholes, 2007). Enterococcus species also come from a variety of vegetative sources and may not be exclusively from a faecal source.

The nutrient results indicate an improvement in ammonium (NH_4-N) and dissolved reactive phosphorus (DRP) concentrations in discharges to the foreshore. Oxides of nitrogen show little change since reticulation indicating a pool of organic nitrogen that is continuing to oxidise and leach into groundwater. These concentrations may also be due to high background concentrations and/or slow leakage of existing on-site wastewater treatment tanks through anaerobic soils.

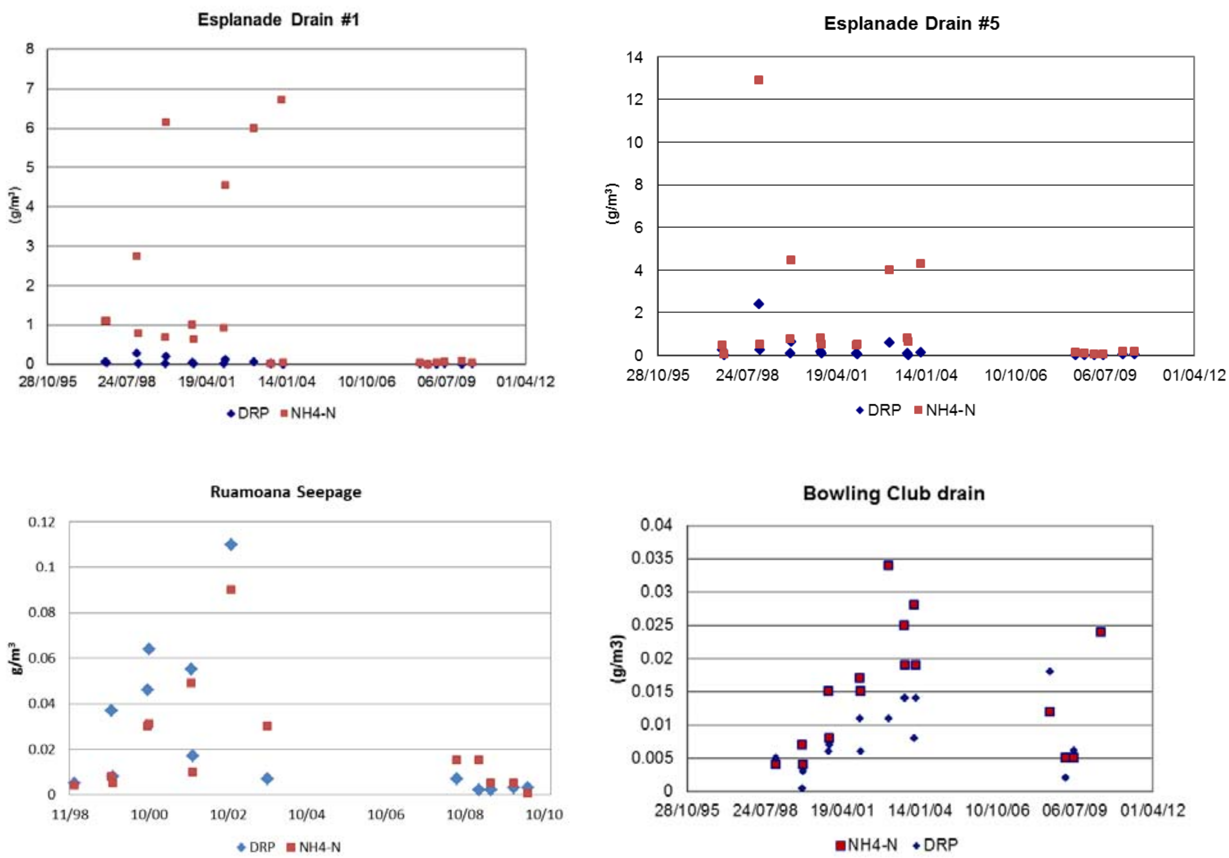


Figure 3.47 DRP and NH_4-N concentrations in drains and seeps, Omokoroa.

4.3 Conclusions

A marked reduction in contaminant levels (up to 10,000 fold) has occurred in a number of Omokoroa drains and seeps since sewage reticulation in mid-2007. Both nutrients and indicator bacteria have been reduced, however oxides of nitrogen have shown no improvement. This nutrient species is highly mobile in groundwater and this may indicate reservoirs of waste material that are still leaching, or contributions from other sources.

Part 5: Conclusions and Future Monitoring

5.1 Conclusions

Many Bay of Plenty communities rely on on-site wastewater treatment systems and these generally function effectively with little environmental impact. However, in some cases these systems can create community health risks and contribute to nutrient enrichment of waterways. This investigation has focused on water and shellfish quality adjacent to waterfront communities served by on-site wastewater treatment systems.

Almost all of the water bodies monitored adjacent to communities with septic tanks had water quality that consistently met bacterial guidelines for contact recreation. Occasionally water quality in coastal locations does not meet recreational water quality guidelines. No link to discharges from the adjacent communities has been made when this occurs. Poor recreational water quality can be the result of adverse weather conditions and rural runoff. Heavy rainfall and high winds can result in increased faecal loading into estuaries, which stem from multiple sources, predominantly via river systems.

Nutrient contamination of the wider receiving waters is potentially a greater problem in some areas than microbial contamination from communities with on-site wastewater treatment. This is particularly so in the Rotorua Lakes, where nutrient inputs are leading to lake eutrophication. Nutrient contributions from on-site wastewater systems are documented in 'Action Plans' for several of the lakes. These contributions can range from as little as 1% (of the total nitrogen and phosphorous load), as is the case for Lake Rotoiti, to over 50%, as is the case for phosphorous in Lake Tikitapu. Estuaries are generally well flushed and therefore the effects of nutrients are not as acute, although elevated nutrient concentrations are associated with muddier deltaic sediments in estuarine inlets.

Of greater concern in the coastal environment are discharges at the shoreline or foreshore. Discharges from seepages, stormwater outlets and other drains have been found to have elevated levels of faecal contaminants and nutrients at all of the coastal communities surveyed. All of these areas had at least one discharge to the near shore environment that poses a potential health risk. In these communities the source of bacteria and nutrients is most likely to be from septic tanks. At Pukehina human faecal contamination has been identified in shellfish and to a lesser degree at Te Puna, although the greatest pathogenic risk in shellfish is generally from rural sources.

Surface discharges at the foreshore of the lakes are rare due to the highly permeable soils and therefore monitoring has focussed on permanent flowing waterways or groundwater. Monitoring of streams at Hinehopu shows that some contamination from septic tanks is occurring at a low level. In general, groundwater monitoring around the lakes has shown low levels of faecal contamination.

Elevated nutrient levels, particularly nitrate-nitrogen, do suggest septic tank sourced contamination. However, there are other sources of nitrate present in the lake catchments including agriculture and geothermal activity. Many of the lake communities have reticulation planned or completed (e.g. Lakes Okareka and Tikitapu) and the benefits of reticulation have been recently seen at Okawa Bay, Lake Rotoiti, where a rapid improvement in water quality followed reticulation (improvements following this are also in part due to the installation of the Ohau Channel diversion wall). As already discussed, this can also be seen in the discharges around the Omokoroa foreshore.

5.2 Future Monitoring

The monitoring programme will continue with the following refinements:

1 Lake Tarawera community – groundwater monitoring should be intensified at identified 'hotspots' during or after peak occupancy.

2 Microbial source tracking and viral testing – greater use of these techniques is recommended to determine the sources of shellfish contamination, particularly in lakes.

3 Recently reticulated communities - continue monitoring after reticulation to document water quality trends, particularly in shellfish. A good case study will be Little Waihī, which is known to have a poor standard of on-site wastewater treatment and has been linked to human faecal contamination of shellfish in the Waihī Estuary.

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