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

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Cover Photo: Stormwater drain at Tanners Point

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Revision #	Reviewers
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Approved for publication by:

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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 be a risk to community health through transport of microbial pathogens and can contribute to nutrient enrichment of waterways. This investigation has focused on water quality adjacent to selected coastal and lakefront communities, which are either served by on-site wastewater treatment systems or have recently been reticulated.

Targeted monitoring of stormwater discharges, seepages and groundwater near those selected communities that do not have access, the sewage reticulation is necessary to assess whether OSET systems are having an adverse effect on water quality. The results can be used to determine appropriate options to manage OSET systems.

This report does not assess the effects of OSET systems on lake nutrient budgets. It also does not supersede more detailed location-based reports on OSET systems, such as Simonson (2017).

This report updates the findings for nine communities and provides results of ongoing monitoring of a reticulated area (Ōmokoroa). The findings for each are summarised below:

Community	What has been monitored	Monitoring results	Potentials effects of OSET
Lake Tarawera	Microbial water quality *(E.coli)* of the nearshore environment	Weak contamination of shallow groundwater. No conclusive microbial contamination of the nearshore lake receiving waters from septic tanks.	Reducing nutrient inputs to the lake from on-site wastewater systems is a key measure to reducing risk of algal blooms. The potential risk to human health from pathogens from on-site wastewater systems is low, based on faecal indicator bacteria results. Simonson (2017) found effective and sustainable on-site wastewater management is severely constrained by environmental conditions.
Tumoana – Lake Rotoiti	Microbial (*E.coli*) and nutrient (DRP) water quality of the nearshore environment	No microbial contamination associated with septic tanks detected in the nearshore lake receiving waters.	No contamination of near shore Tumoana community detected that could be associated with on-site wastewater systems discharges. Potential cumulative impact of nutrients on lake eutrophication.
Ngamotu – Lake Rotoma	Microbial (E.coli) and nutrient (DRP) water quality of the nearshore environment	No microbial contamination associated with septic tanks detected in the nearshore lake receiving waters.	Near shore monitoring of the waters adjacent to the Ngamotu community, did not detect any significant contamination that could be associated with on-site wastewater systems discharges. Potential cumulative impact of nutrients on lake eutrophication.
Lake Rotoehu – Otautu and Kennedy bays	Microbial (*E.coli*) water quality of the nearshore environment, and limited drain monitoring	No microbial contamination associated with septic tanks detected in the nearshore lake receiving waters.	Near shore monitoring of the waters adjacent to the Ngamotu community, did not detect any significant contamination that could be associated with on-site wastewater systems discharges. Potential cumulative impact of nutrients on lake eutrophication.

Community	What has been monitored	Monitoring results	Potentials effects of OSET
Mamaku	Microbial (*E.coli*) and nutrient water quality of drains. Faecal source tracking (FST)	Occasional elevated *E.coli* and nutrient levels indicating septic tank contamination. Confirmed by positive FST human markers.	Drain water quality can be above the recreational contact guideline; hence contact may be a health risk to the community. Agricultural sources are also likely to be contributing to microbial contamination.
Tanners Point	Microbial (*E.coli*) and nutrients water quality of drains and seepages and nearshore environment	Decreasing contaminant concentrations in drains and seepages.	Drain water quality has been occasionally above the recreational contact guideline as a likely result of septic tank wastewater. Swimming water quality of the local estuary remains good.
Ongare Point	Microbial (*E.coli*) and nutrients water quality of drains and seepages and nearshore environment. Faecal source tracking (FST)	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. Potu Street, drain tested positive for human faecal contamination.	Contact with contaminated drain water at the foreshore discharge points remains the greatest health risk to the community. Bathing surveillance monitoring of the estuary adjacent to the Ongare Point community shows that the water is suitable for contact recreation.
Te Puna West	Microbial (*E.coli*) and nutrients water quality of drains and seepages and nearshore environment. Faecal source tracking (FST)	Monitoring foreshore drains at Te Puna shows some contamination from septic tanks, generally at low levels. Waitui Drain tested positive for human faecal contamination.	Contact with contaminated drain water at the foreshore discharge points remains the greatest health risk to the community. Bathing surveillance monitoring of the estuary adjacent to the Te Puna community shows that the water is suitable for contact recreation. Community is to be reticulated in the near future.
Pukehina	Microbial (*E.coli*) and nutrients water quality of drains and seepages and nearshore environment. Faecal source tracking (FST)	Monitoring of the Pukehina foreshore seeps show some indications contamination from septic tank effluent. These have not been confirmed as human using FST techniques.	Some drains regularly exceed the contact recreational guideline for waters indicating a potential health risk. Flows from drains are of very limited extent, are unlikely to be used for contact recreation.
Matata	Microbial (*E.coli*) and nutrient water quality of drains, streams and lagoon. Faecal source tracking (FST)	Occasional elevated *E.coli* and nutrient levels indicating septic tank contamination. Confirmed by positive FST human markers.	Water quality can be above the recreational contact guideline; hence contact may be a health risk to the community. Agricultural sources are also likely to be contributing to microbial contamination in some waterways.

Community	What has been monitored	Monitoring results	Potentials effects of OSET
Bryans Beach	Microbial (*E.coli*) and nutrient water quality of drains. Faecal source tracking (FST).	Monitoring of drains shows some indications of contamination from septic tank effluent. These have not been confirmed as human using FST techniques.	Drains are occasionally contaminated with septic tank leachate at levels that may present a health risk, however, full immersion contact is unlikely in these small flows.

Lake Tarawera

Previous monitoring has shown some indication of contamination from on-site wastewater systems in shallow groundwater but this has not translated through to sample in near shore lake environment.

The potential risk to human health from pathogens from on-site wastewater systems is low, based on faecal indicator bacteria results. However, summer blooms of toxin forming cyanobacteria have occurred in the past few years and can be a risk to reactional water users. Reducing nutrient inputs to the lake is a key measure to reducing risk of algal blooms, including those from on-site wastewater systems.

Simonson (2017) found effective and sustainable on-site wastewater management is severely constrained by environmental conditions. It was also found that for many sites, it may not be possible to meet OSET Plan standards, while other sites would require significant upgrades to meet the standards.

Lake Rotoiti

Near shore monitoring of the waters adjacent to the Tumoana community, did not detect any significant contamination that could be associated with OSET discharges. Low occupancy and low housing density would seem to equate to a very low risk of environmental degradation of the lake environment from these contaminant sources.

Lake Rotomā

The microbiological water quality of Lake Rotomā adjacent to communities remains excellent and there is little evidence to suggest the flows from OSET systems pose a direct health risk to lake users. Recent monitoring of the waters adjacent to the Ngamotu community at Lake Rotomā, did not detect any significant contamination that could be associated with OSET discharges. Low occupancy and low housing density would seem to equate to a very low risk of environmental degradation of the lake environment from these contaminant sources.

Nutrient inputs from these systems of both nitrogen and phosphorous can contribute to lake eutrophication. Reticulating septic tanks has been identified as one of the easiest options to reduce nutrient input to the lake, to reduce this risk of degradation due to eutrophication.

Lake Rotoehu

Near shore monitoring of the waters adjacent to the Otautu and Kennedy Bay communities, did not detect any significant contamination that could be associated with OSET discharges. Low occupancy and low housing density would seem to equate to a very low risk of environmental degradation of the lake environment from these contaminant sources.

Mamaku

Elevated *E.coli* and nutrient levels have been found in a limited survey of drains at Mamaku. Faecal source tracking found human markers of contamination showing septic tank effluent, is contributing to contamination in the local drains. Agricultural sources may also be contributing in some drains as stock are present in fields adjacent to the drains. Examination of a potential palaeosol should be considered, to determine if this soil layer is an impediment to effluent drainage.

Tanners Point

Potential for contamination of receiving waters from septic tank effluent at Tanners Point, appears in two locations where drainage through colluvial soils occurs. Contaminant concentrations have decreased in the past few years showing an improved situation and this may, in part, be due to improvement in roadside stormwater and the requirement of regular pumping out of septic tanks.

The upgrade of the disposal field at the public toilet also appears to have reduced contamination in the drain adjacent to the boat ramp.

Ongare Point

Monitoring of drains that flow onto the foreshore at Ongare Point has shown that some contamination from septic tanks is occurring. 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 generally suitable for contact recreation. Contact with contaminated drain water at the foreshore discharge points remains the greatest health risk to the community.

Te Puna

Te Puna west drains continue to show high levels of bacteria and ammonium-nitrogen (NH_4-N), 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 nitrate-nitrite-nitrogen (NNN) to ammonium-nitrogen ratio. This higher ratio 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.

Faecal source tracking results have shown that drains on both side of the peninsula are contaminated with human faecal material.

Pukehina/Waihī Estuary

Monitoring of the Pukehina discharges adjacent to the foreshore show markers of contamination from septic tank effluent, but these have not been confirmed using PCR faecal source tracking techniques. Some drains regularly exceed the Microbiological Water Quality Guidelines red action mode, with most exceedances occurring at a small discharge onto the foreshore that flows most of the year round.

Swimming water quality is at times compromised in Waihī Estuary, usually as a result of rainfall runoff. While local drains will be adding to compromised swimming water quality, they are only a minor contributor compared to inputs from freshwater streams into the estuary. The risk to community health from septic tank effluent is from direct contact with contaminated drain waters. Contact with the water in these drains or where they discharge onto the foreshore should be avoided.

Matatā

Matatā currently has some septic tanks located in inappropriate soils and in a high water table, leading to contamination of Matatā’s local waterways. There are local hot spots of contamination in small and at times, ephemeral waterways, with contamination confirmed as human in one case by microbial source tracking.

The lagoon outlet on average has good bacterial water quality. Monitoring at the control structure in the eastern lagoon shows dissolved nutrients levels at concentrations similar to stream inflows, indicating that septic tank effluent may only have a minor impact on the lagoon nutrient status.

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 therefore these periods pose the highest risk to human health.

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

Ōkareka Post Reticulation Monitoring

Reticulation of Lake Ōkāreka has been undertaken to reduce nutrient inputs to the lake and to remove the risk of health risk from poorly managed and flood prone on-site wastewater treatment systems. As an action under the Lake Ōkāreka Catchment Management Plan (2004), reticulation has potentially removed 2.37 tN/yr and 0.02 tP/yr of nitrogen and phosphorus respectively. Comparison of nitrate concentrations in shallow groundwater entering the lake indicates that reticulation has reduced concentrations from the township. No change in phosphorus concentrations was noted.

Omokoroa Post Reticulation Monitoring

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.

Summary

Almost all of the waterfront areas monitored adjacent to communities with septic tanks, had water quality that consistently met bacterial guidelines for contact recreation. Of greater concern, particularly in the coastal environment, are discharges at the shoreline or foreshore from seepages, stormwater outlets and other drains. Some of these have been found to have elevated levels of faecal contaminants at levels that pose a risk to human health. Faecal source tracking in some communities identifies septic tanks as a source of contamination.

Nutrient contamination from septic tanks is potentially a greater problem in some areas than microbial contamination. This is particularly so in the Rotorua Lakes, where nutrient inputs are leading to lake eutrophication.

Recommendations

- Undertake a risk assessment approach to determine which unreticulated communities present a medium-high risk to water quality. Monitoring priorities would be set based on this analysis.
- Continued monitoring of western bay coastal communities: Tanners Point, Ongare Point and Te Puna West.
- Faecal source tracking to confirm contamination from on-site wastewater treatment systems at Pukehina, Bryans Beach.
- Look at emerging contaminant contamination from on-site wastewater systems in communities with issues of contamination of local waterways from effluent.

Contents

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 OSET systems with poor treatment and disposal. Adverse effects can include: odours, contamination of surface waters, addition of nutrients to water bodies, contamination of shellfish and foreshore environments, negative health effects of 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 water quality. 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 OSET discharges in the Bay of Plenty communities, to territorial authorities, hapu/iwi authorities, and health agencies.

To help guide the management of OSET systems, monitoring of stormwater discharges, seepages and groundwater in 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 recurring problems.

Monitoring of communities with on-site wastewater treatment systems was initiatived after reviews by Dr Ian Gunn in 2001, and Dr Mike Patrick in 2009.

The communities reviewed in this report are:

Coastal communities

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

Lake communities

- Tarawera
- Ōkāreka
- Rotoiti - Tumoana Point
- Rotomā – Ngamotu
- Rotoehu – Otautu and Kennedy bays
- Mamaku

There are other unreticulated communities in the Bay of Plenty region. However, these have not been included in this report as they are currently seen as low risk, or more specific monitoring has taken place and been reported separately.

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 (NH_4-N), 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, NO_3-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 or 'P' 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 one and eight 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, dependent on soil pH, moisture, temperature, and soil microbial population. If effluent comes into 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. Faecal source tracking (FST) is a technique in which *E. coli* or enterococci, are isolated from water samples. These isolates are then fingerprinted using either DNA-based or phenotypic/biochemical based-methods. Results can be compared to a library of DNA based markers to identify sources.

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.

Faecal source tracking, 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[1] (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^{o}C

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

Conductivity	APHA Method 2510B, EDTRE 387 Tx Meter	0.5 mS/m at 25°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 and Wastewaters (2005)	1 cfu/100 ml
Enterococci (Ent)	Method No 1600, USEPA 1986 EPA-821-R-97-004	1 cfu/100 ml

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 2013 census put the population for Tarawera at 1,437 people with an average household having 2.7 persons. Approximately 900 of these would reside near the lake. There are 393 occupied dwellings in the inner catchment with around 75% of these used holiday accommodation. Hence, permanent occupancy is around 20% over the autumn/winter months, but occupancy increases over spring/summer, particularly over the holiday period.

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

3.1.1 Previous monitoring

Bay of Plenty Regional Council has undertaken monitoring of shallow groundwaters, lake waters around the urban fringe and analysed shellfish samples, to examine potential health risks associated with septic tank contamination.

Previous results showed only weak evidence of septic tank contamination with some hotspots of increased nitrogen levels in shallow groundwater (see Scholes, 2011 for more details).

More recently a study on the impact of sewage reticulation on the Tarawera Catchment looked at drinking water testing, given that many residences extract drinking water from the lake (Dada et al, 2016). The study examined *E.coli* concentrations from drinking water samples collected from tap water extracted from the lake without any form of treatment. The New Zealand drinking water guidelines stipulate that every 100 ml of tested sample, must have faecal coliform counts less than one. The analysis concluded that no concrete evidence showed that septic tanks were the cause of *E.coli* levels above the New Zealand drinking water standard in drinking water taken from the lake. It was considered that there could be undetected sources of *E.coli* to the lake from septic systems, particularly given the existing soil properties and the number of poorly functioning infiltration fields.

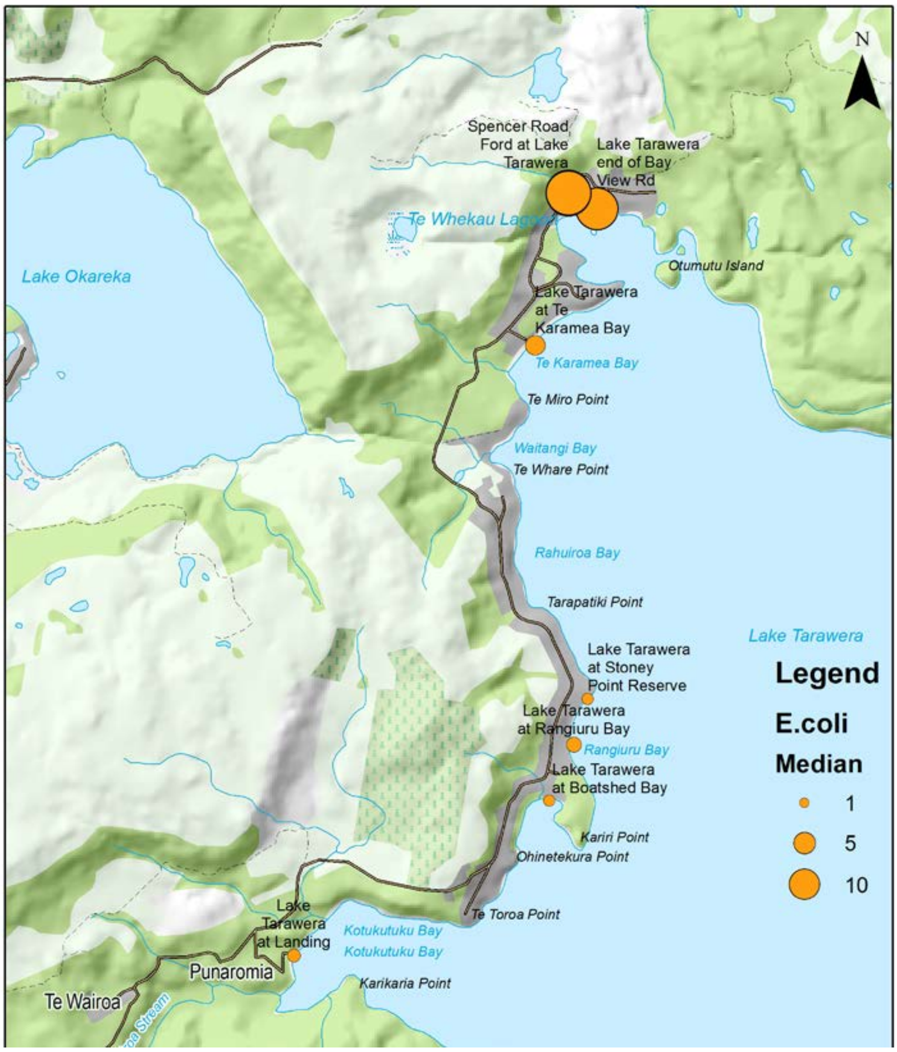


Figure 3.1.1 *Lake Tarawera monitoring site location map (and median E.coli concentrations (cfu/100 ml)).*

3.1.2 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 (mud) sandy loam. Recent tests showed this soil to be poorly drained classed to be Category 6 soils as outlined in the Australian/New Zealand Standard for On-site Domestic Wastewater Management (AS/NZS1547:2012). These are not considered suitable for use with conventional trench and bed soakage disposal systems (Simonson, 2017).

Mean annual rainfall measured at Whakarewarewa over the period 1981 to 2010 was 1424 mm.

3.1.3 Recent monitoring

A limited survey of lake *E.coli* concentrations around the lakeside community was undertaken over the 2016/2017 swimming season. This included the small stream at Spencer Road Ford.

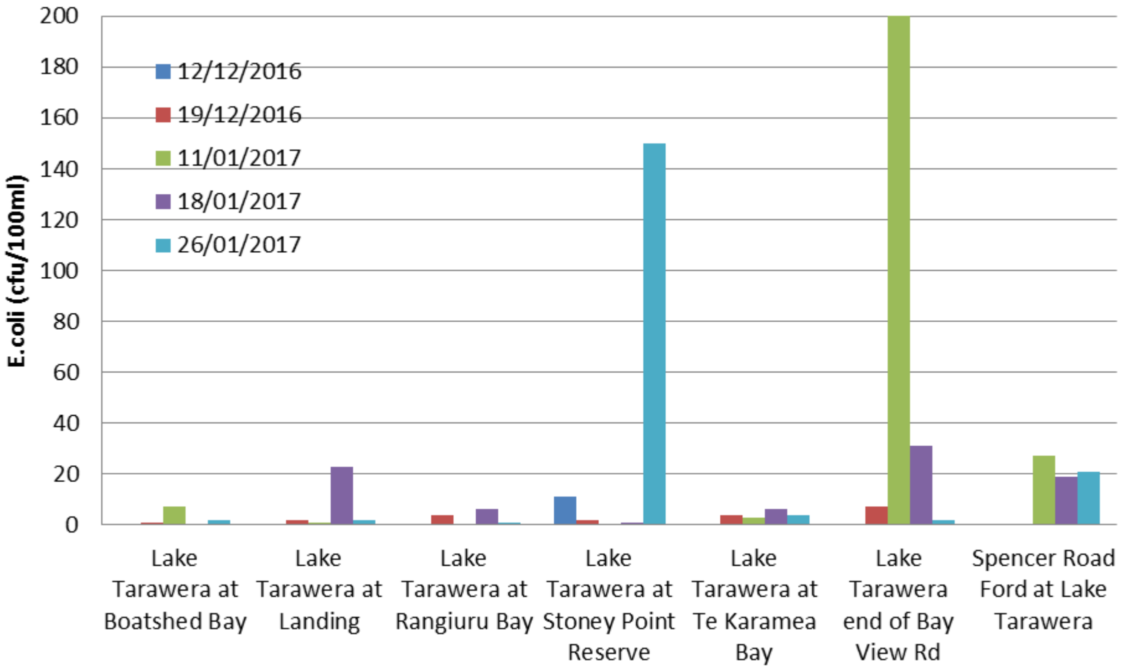


Figure 3.1.2 E.coli concentrations in lake Tarawera, 2016/17. For comparison microbiological water quality guideline, the orange alert guideline, is 260 cfu/100 ml.

E.coli concentrations in the lake over the summer were on the whole very low (see median results in Figure 3.1.2, with the exception of an elevated result at the lake at the end of Bay View Road. As no runoff due to rain or other sources was noted and the Spencer Road Ford stream was at a low *E.coli* concentration, it is likely that this sample was elevated due to inclusion of contamination from a recent wildfowl scat.

Weekly monitoring of *E.coli* concentrations is also undertaken at Stony Point Reserve. Results for the 2016/2017 season were all under 20 cfu/100 ml with the exception of one *E.coli* result at 150 cfu/100 ml.

E.coli results do indicate there is a very low risk of recreational users of lake from faecal contaminant sources, with potentially the greatest risk from avian sources rather than septic tanks. However, there is still concern over the nutrient load coming from septic tanks.

The Tarawera lakes Restoration Plan (2015) estimates nutrient loading from septic tank to be in the order of 8% and 5% for phosphorus and nitrogen respectively. Monitoring undertaken in the centre of the lake to establish information on the nutrient status, indicates an increasing trend in total and dissolved phosphorus concentrations. Blooms of toxin forming cyanobacteria have occurred in recent years in the lake and this is associated with rising nutrient levels.

3.1.4 Bathing surveillance monitoring

Bathing surveillance monitoring was undertaken at Stoney Point Reserve from October 2016 to March 2017. Samples are analysed for the indicator bacteria *E.coli*. Results indicate a very low level of faecal contamination is present and *E.coli* levels not exceeding contact recreation guidelines over the season. This is consistent with previous seasons, showing the water to be excellent for recreation purposes with respect to faecal contamination, but recommended to be treated for drinking water purposes.

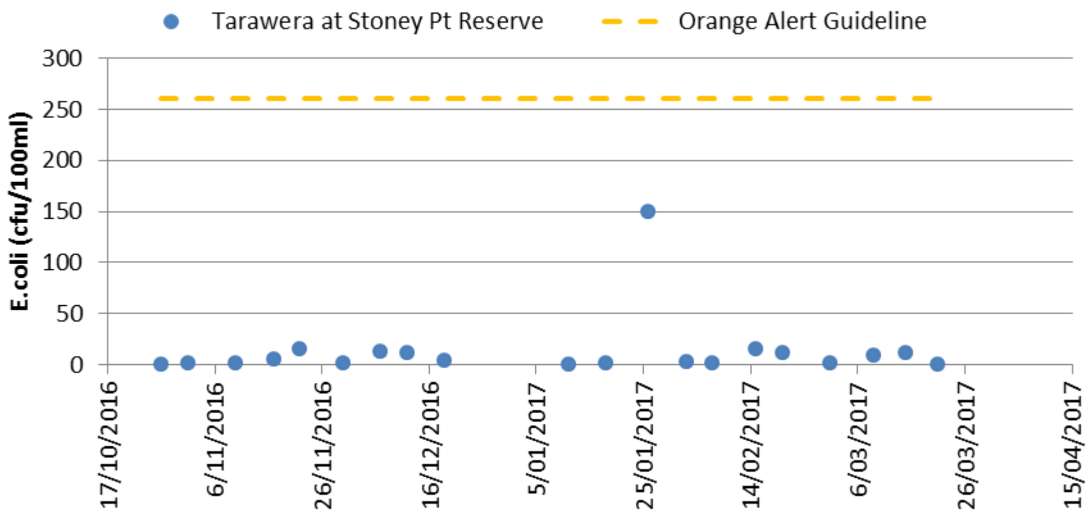


Figure 3.1.3 E.coli concentrations over the 2016/2017 bathing surviellance season.

Monitoring of blue-green algae (cyanobacteria) has found that toxin forming species have reached levels exceeding the contact recreation guidelines in the past three years, albeit for only short lived events in the past two years.

3.1.5 Discussion

Previous monitoring has shown some indication of septage signatures in shallow groundwater, but this has not translated through to sample in near shore lake environment. It is possible that sampling has missed peak groundwater concentrations that may have occurred from septic sources, peak concentrations occurring when occupancy rates are high in mid-summer, and could be explored further.

The potential risk to human health from pathogens is low, based on faecal indicator bacteria results. However, summer blooms of toxin forming cyanobacteria have occurred in the past few years and can be a risk to reactional water users. Dada et al (2016) concluded that Lake Tarawera is regionally unique in that the majority of its phosphorus (P) load and a substantial portion of its nitrogen (N) load appear to be derived from a combination of ‘tributary’ lakes and geothermal sources. Reducing nutrient inputs to the lake is a key measure to reducing risk of algal blooms.

A more specific compliance and risk report has been undertaken by Simonson (2017). The report found effective and sustainable on-site wastewater management is severely constrained by environmental conditions. It was also found that for many sites it may not be possible to meet OSET Plan standards, while other sites would require significant upgrades to meet the standards.

3.2 Lake Rotoiti – Tumoana Point

Tumoana Point community occupies a peninsula on the southern side of Lake Rotoiti occupying approximately 400 m of lake shore. There are around 22 dwellings within the community and many of these are used as holiday homes, remaining vacant for much of the year.

Sampling around the foreshore was undertaken to detect if on-site treatment systems were impacting lake water quality (Figure 3.2.1). Monitoring was undertaken for nine months from June 2016 to February 2017. Samples were analysed for *E.coli* and dissolved reactive phosphorus concentrations.

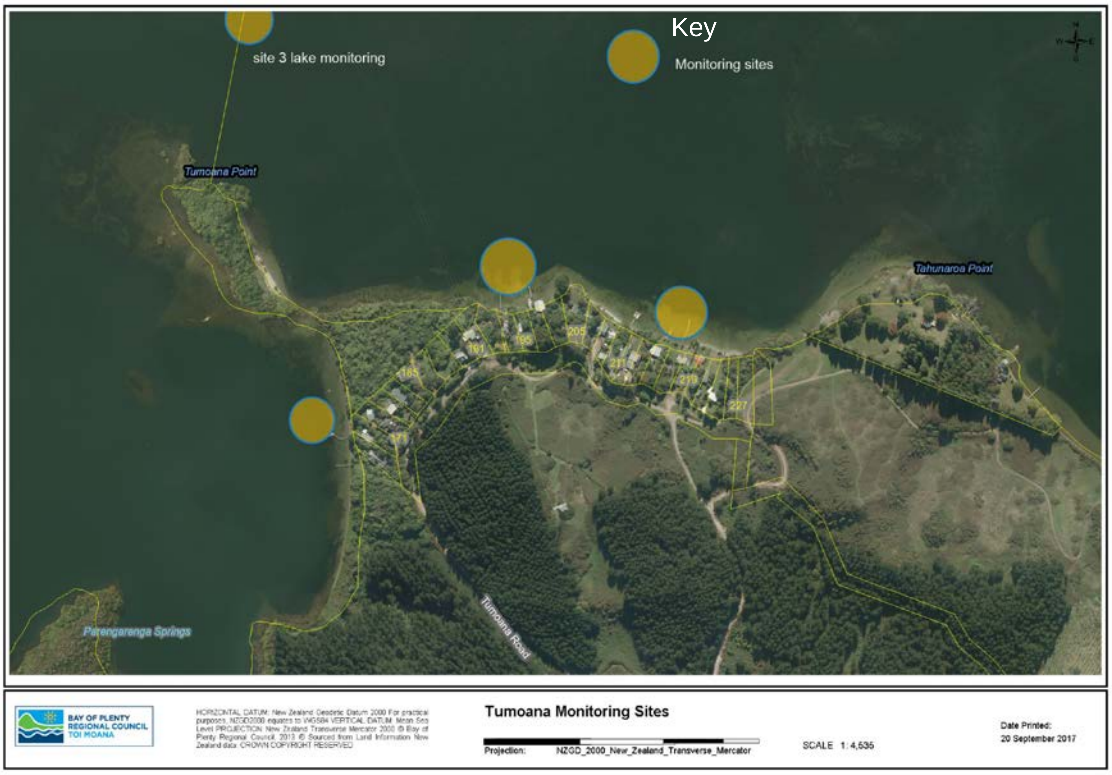


Figure 3.2.1 Monitoring foreshore locations around Tumoana community.

3.2.1 Results

E.coli concentrations around the foreshore were found to be low, with regards to recreational use water quality (Figure 3.2.2). The highest result of 17 cfu/100 ml is well below the first alert level of 260 cfu/100 ml for microbiological water quality guidelines.

Dissolved reactive phosphorus (DRP) was also analysed to observe if there were any increased fluxes as a result of leaching from septic tanks. Low DRP concentrations were observed (Figure 3.2.3) with concentrations similar and generally lower that those found at the adjacent lake monitoring sites (site 3).

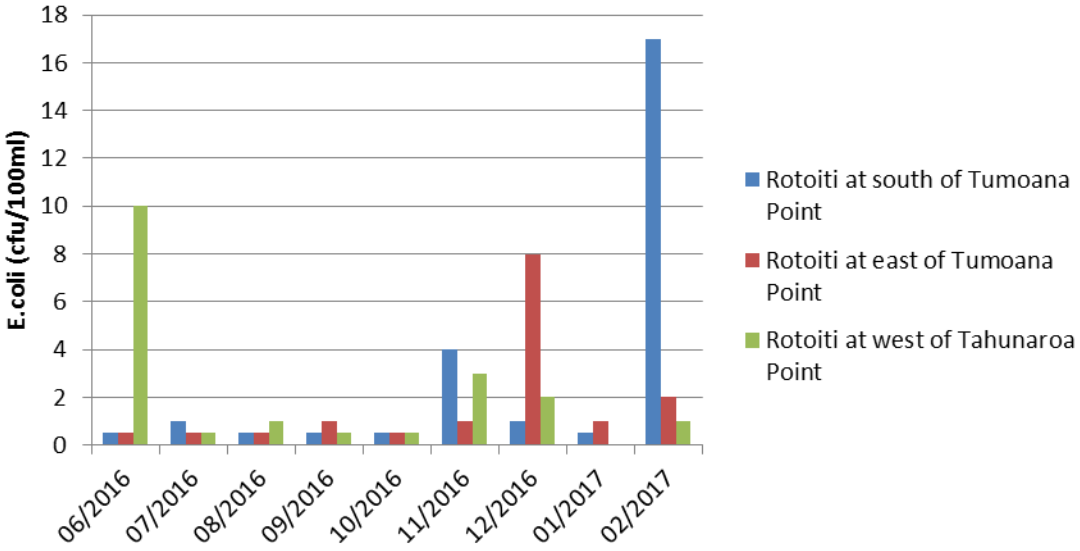


Figure 3.2.2 E.coli concentrations at Tumoana Point.

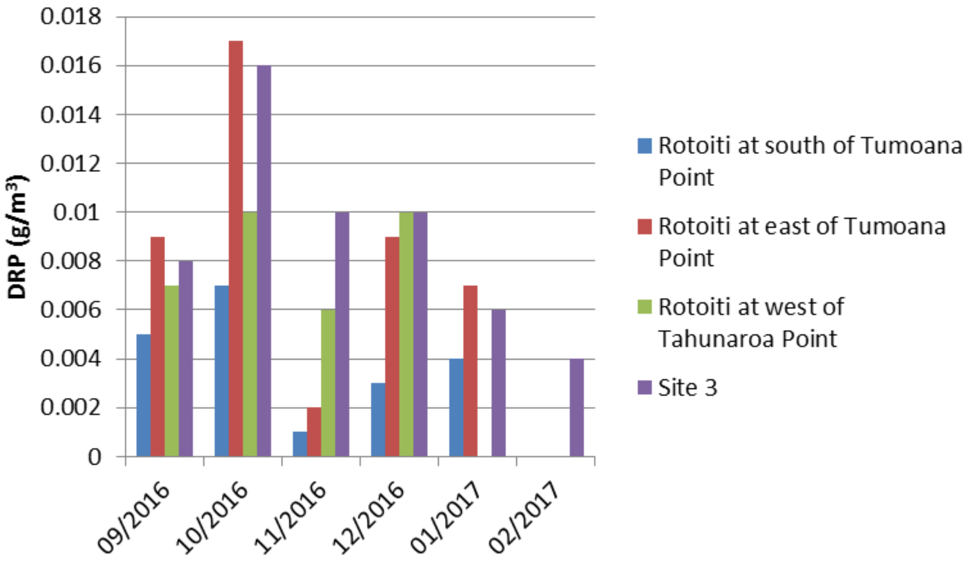


Figure 3.2.3 Dissolved reactive concentrations at Tumoana Point.

3.2.2 Discussion

Limited monitoring of the waters adjacent to the Tumoana community, did not detect any significant contamination that could be associated with on-site wastewater systems discharges. Low occupancy and low housing density would seem to equate to a very low risk of environmental degradation of the lake environment from these contaminant sources.

3.3 Lake Rotoma

Lake Rotoma is the eastern most lake of the Rotorua Lakes with community development on the south and south-western edges of the lake, and a number of dwellings form the Ngamotu community around the peninsula opposite Whangaroa Inlet (Figure 3.3.1). Rotomā's 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. Around 23 dwellings occupy the area around Okopua Point and this has been the target of recent monitoring, as the rest of the more accessible Rotomā community is due to be reticulated.

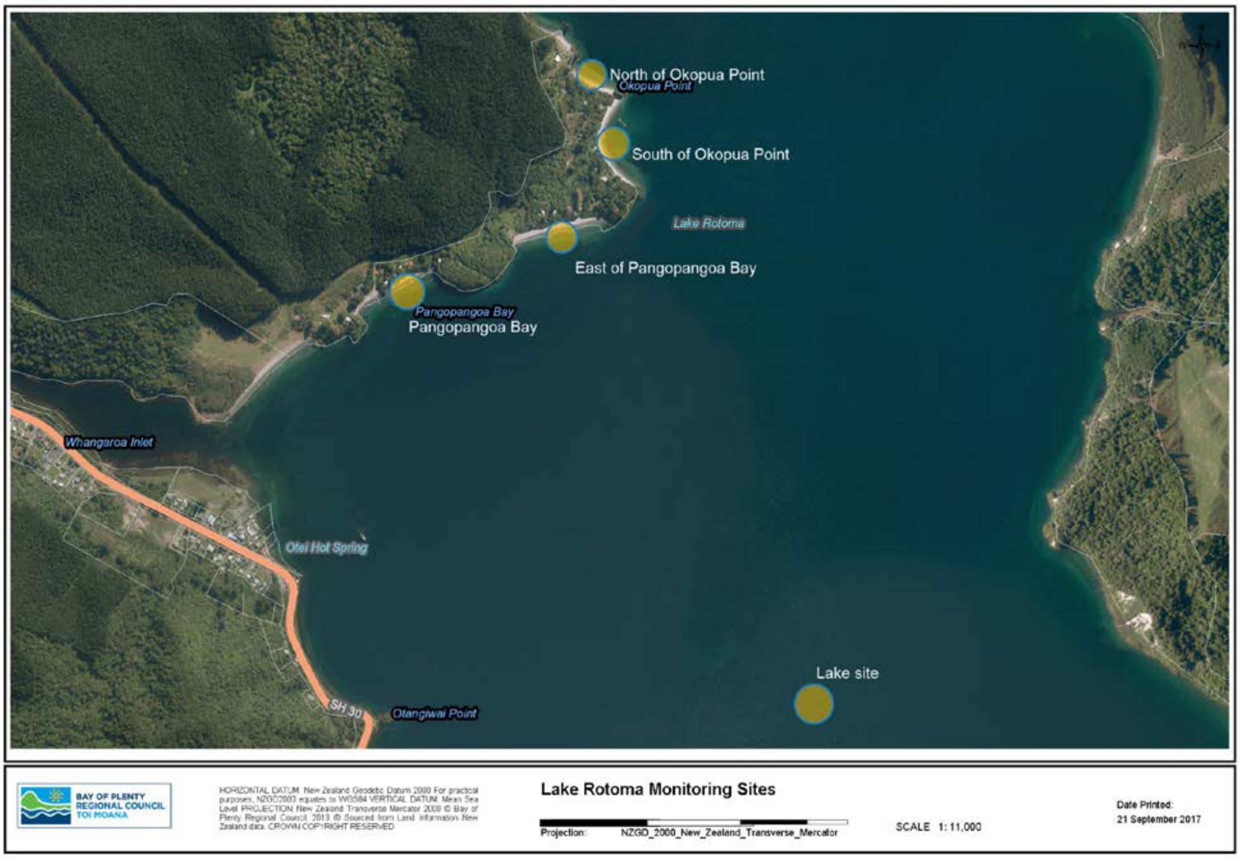


Figure 3.3.1 Lake Rotomā monitoring site location map.

3.3.1 Physical environment

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

Rainfall figures from Mangorewa at Kaharoa give an indication of rainfall in this area. Mean annual rainfall from 1986 to 2010 to be in the order of 1828 mm per year.

3.3.2 Previous monitoring

Shallow groundwater and monitoring of some the limited inflows around the settlement areas has been undertaken to potentially intercept effluent pathways from septic tanks. Sampling around Whangaroa Bay did show some elevated contaminant concentrations linked to elevated water table, however, on whole, contaminant levels were low.

More intensive daily monitoring of two shallow bores at Anaputa Bay did show a nitrate signature steadily rise on one occasion. This interception of a contaminant plume showed that septic tank signatures in the right environment could flux on a daily time scale.

The microbiological water quality of Lake Rotomā adjacent to communities remains excellent and there is little evidence to suggest the flows from on-site wastewater treatment systems pose a direct health risk to lake users. More of a concern is the nutrient input from these systems of both nitrogen and phosphorous.

The Lake Rotoma Action Plan identifies reticulation of the southern shore as a mechanism to reduce nutrients in the lake.

3.3.3 Recent results – Ngamotu

Sampling around the foreshore was undertaken to detect if on-site treatment systems were impacting lake water quality (Figures 3.2.1). Monitoring was undertaken for 13 months from May 2016 to May 2017. Samples were analysed for *E.coli* and dissolved reactive phosphorus concentrations.

E.coli concentrations around the foreshore were found to be low with regards to recreational use water quality (Figures 3.3.2 and 3.3.3). The highest *E.coli* result of 32 cfu/100 ml is well below the first alert level of 260 cfu100 ml for microbiological water quality guidelines.

Dissolved reactive phosphorus (DRP) was also analysed to observe if there were any increased fluxes as a result of leaching from septic tanks. Low DRP concentrations were observed (Figure 3.3.3) with concentrations similar and generally lower than those found at the lake monitoring site.

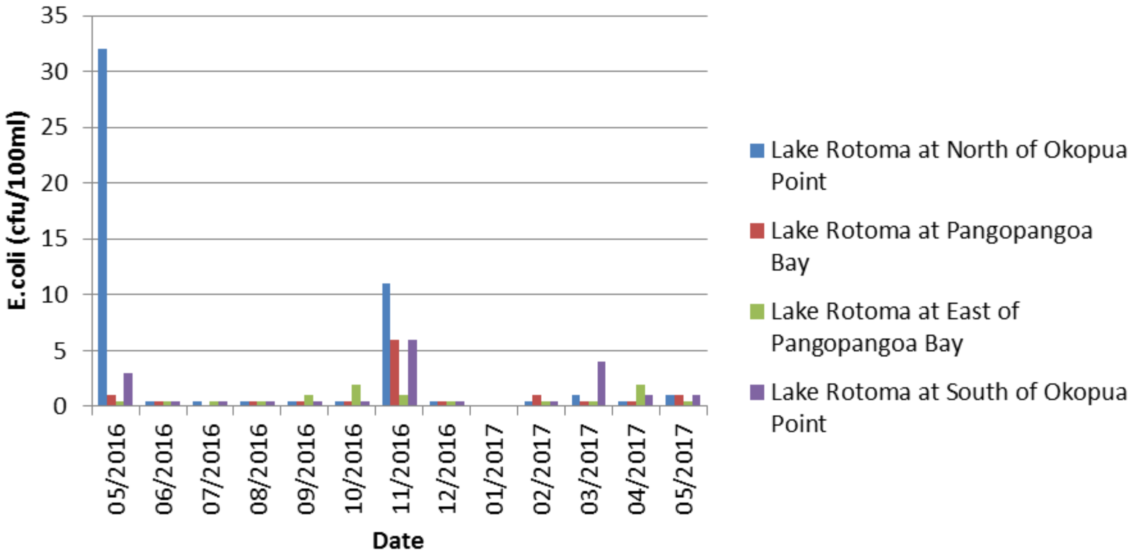


Figure 3.3.2 E.coli concentrations at Tumoana Point.

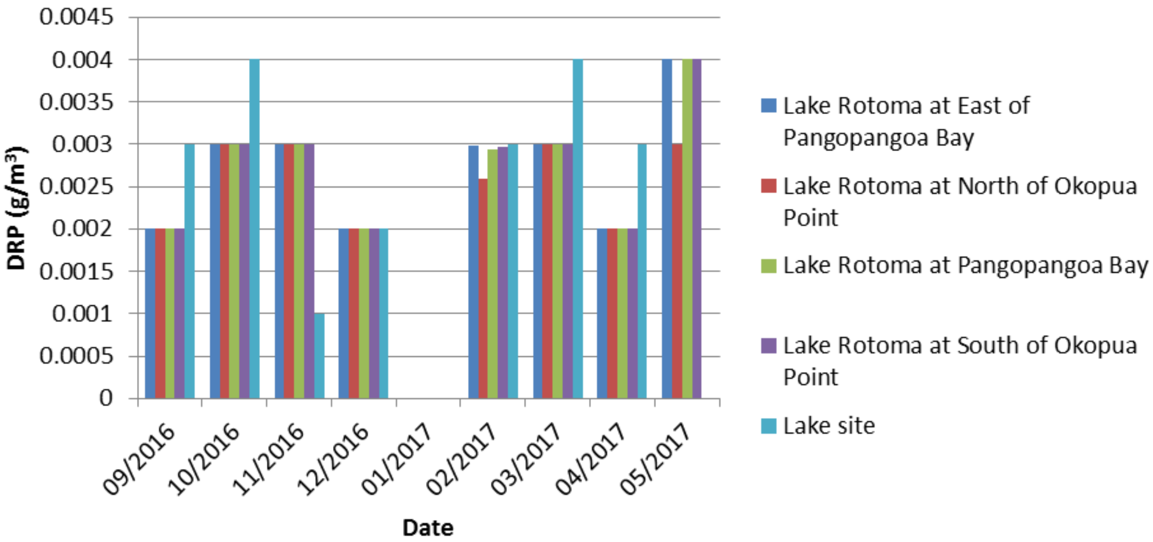


Figure 3.3.3 Dissolved reactive concentrations at Tumoana Point.

3.3.4 Discussion

Limited monitoring of the waters adjacent to the Ngamotu community at Lake Rotomā did not detect any significant contamination that could be associated with on-site wastewater systems discharges. Low occupancy and low housing density would seem to equate to a very low risk of environmental degradation of the lake from these contaminant sources.

3.4 Mamaku

Pollution Prevention staff outlined drainage areas in Mamaku that could possibly be impacted by septic tank leachate. These were initially centred around Umuroa Road with an additional site monitored at the corner of Turoa and Mamaku streets. Monitoring was undertaken over a six month period from April to September 2016.

3.4.1 Physical environment

The township is situated on relatively flat area of Mamaku plateau ignimbrite at around 580 m above sea level. Predominant soil type around the Mamaku township is described as Mamaku loamy sand, which is well drained with strong leaching potential and high phosphorus retention. Anecdotal evidence suggest there may be a palaesol that limits downward migration (and treatment) of septic tank effluent through the soil profile. This would need confirmation.

Rainfall is around 2000 mm per annum with highest rainfall occurring around the winter months.

The township has relatively large sections and a small population (690 inhabitants, 2013 census; 0.39 inhabitants per dwelling). Pastoral livestock species are observed on several sections and adjoining fields throughout the town.

Figure 3.4.1 Mamaku monitoring site location map.

3.4.2 Results

The drains have shown variable levels of *E.coli* concentrations (Figure 3.4.2). Initial results from April 2016 at the Ururoa Road drains were above the microbiological water quality guideline (MBWQ) red action mode, and this occurred on two other occasions during the six months of monitoring.

Nutrient concentrations would indicate the possibility of contamination of the drains from septic tanks at only a low-moderate level. Ammonium-nitrogen (NH_4-N) concentrations (Figure 3.4.2) are slightly elevated above what might be expected in these spring fed streams, but with only one sample in the drain opposite 20 Umuroa Road being more indicative of concentrations that might be emanating from septic tanks. Nitrate-nitrite-nitrogen (NNN) concentrations are generally higher than ammonium-nitrogen concentrations, possibly due to denitrification processes as septic effluent moves through the soils. Further evidence that the soils are treating effluent leaking into the drains is the low DRP, with the exception of one result which coincides with the highest NH_4-N result.

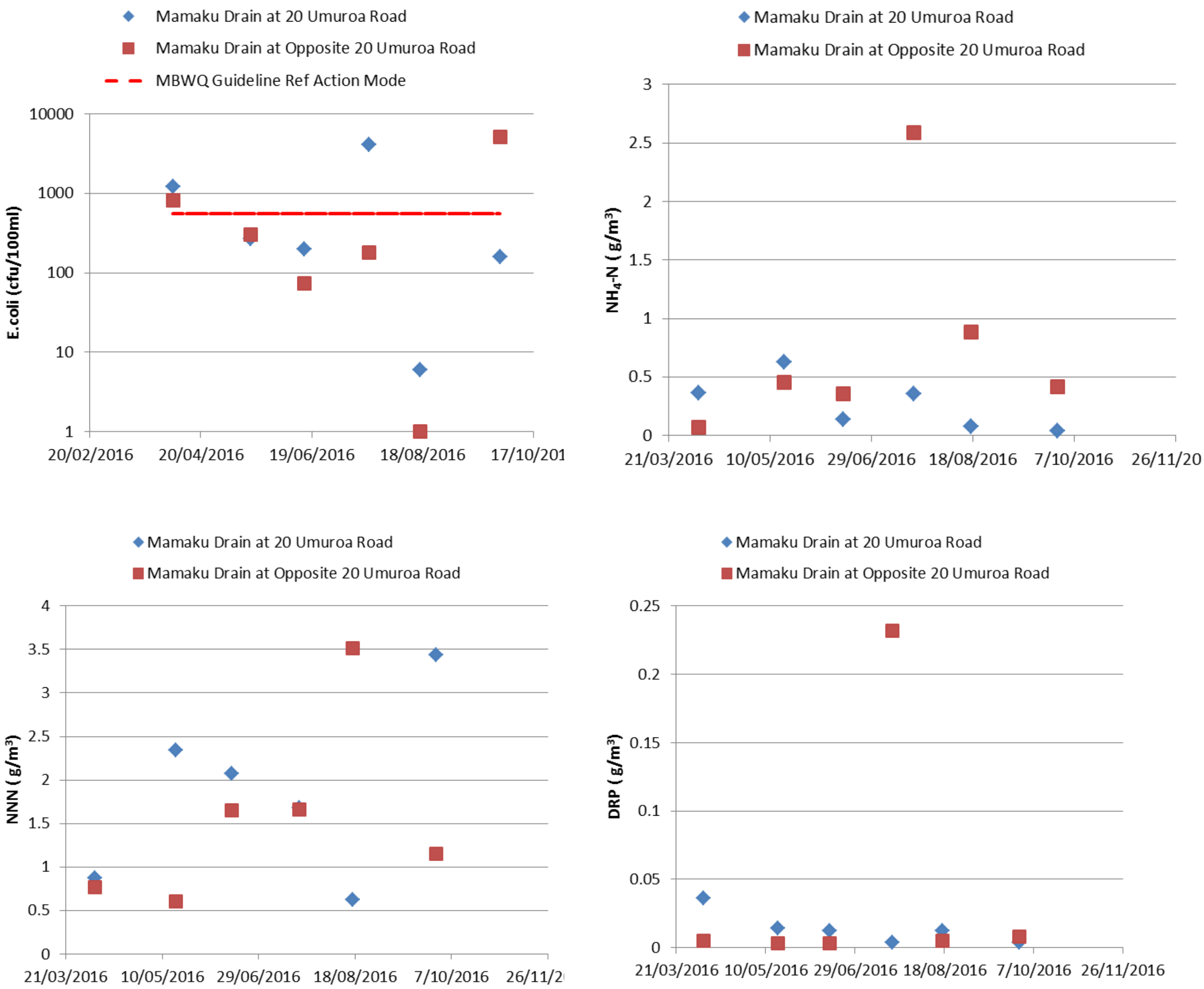


Figure 3.4.2 E.coli and Nutrient concentrations.

A one off sample was also taken from a drain at the corner of Turoa and Mamaku streets. Extremely high *E.coli* concentration (2,7000,00 cfu/100 ml) as well as ammonium-nitrogen (10.7 g/m^3) indicate a septic system is directly leaking to the stormwater drain in this location.

The three drains have been tested for the presence of human *E.coli* isolets. The drain opposite 20 Umuroa Road and the drain corner of Turoa and Mamaku streets tested positive for two human based isolets (Human BacH and Human BiADO) on April 2016 and January 2015. No human marker was detected in the drain at 20 Umuroa Road.

3.4.3 Discussion

Elevated *E.coli* and nutrient levels have been found in a limited survey of drains at Mamaku. Faecal source tracking found human markers of contamination showing septic tank effluent is contributing to contamination of one of the drains tested. Agricultural sources may also be contributing in some drains, as stock are present in fields adjacent to the drains.

One of the drains at Umuroa Road tested positive for a human source. This information together with elevated nutrient and *E.coli* levels found in the drains indicates some contamination from septic tanks, possibly only intermittently.

High level contamination is occurring at the drain corner of Turoa and Mamaku Streets. It is more than likely there is a poorly functioning septic tank at the property adjacent to this location directly discharging to the drain.

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 3.5.1). There are around a hundred dwellings within the community, many of which have permanent residents.

Figure 3.5.1 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 m. 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 2010 is on average 1907 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 3.5.2 shows that NNN results remain elevated, indicating that septic tank contamination is likely to be occurring as ammoniacal-nitrogen is converted to nitrate-nitrite-nitrogen. High NNN results have also been found in the waters emanating from the sub-surface drains. Ammoniacal-nitrogen does show a declining trend ($p<0.05$), however, dissolved reactive phosphorous (DRP) concentrations have an increasing trend ($p<0.05$) with minimum observed concertation increasing. This may be a sign that soils have become saturated with respect to phosphorous and are not readily adsorbing phosphorus.

The drain has occasional elevated *E.coli* levels at times above contact recreational limit of 550 cfu/100 ml. Concentrations of this faecal indicator bacteria have been declining possibly in part, due to an improved treatment system installed to service the public toilets.

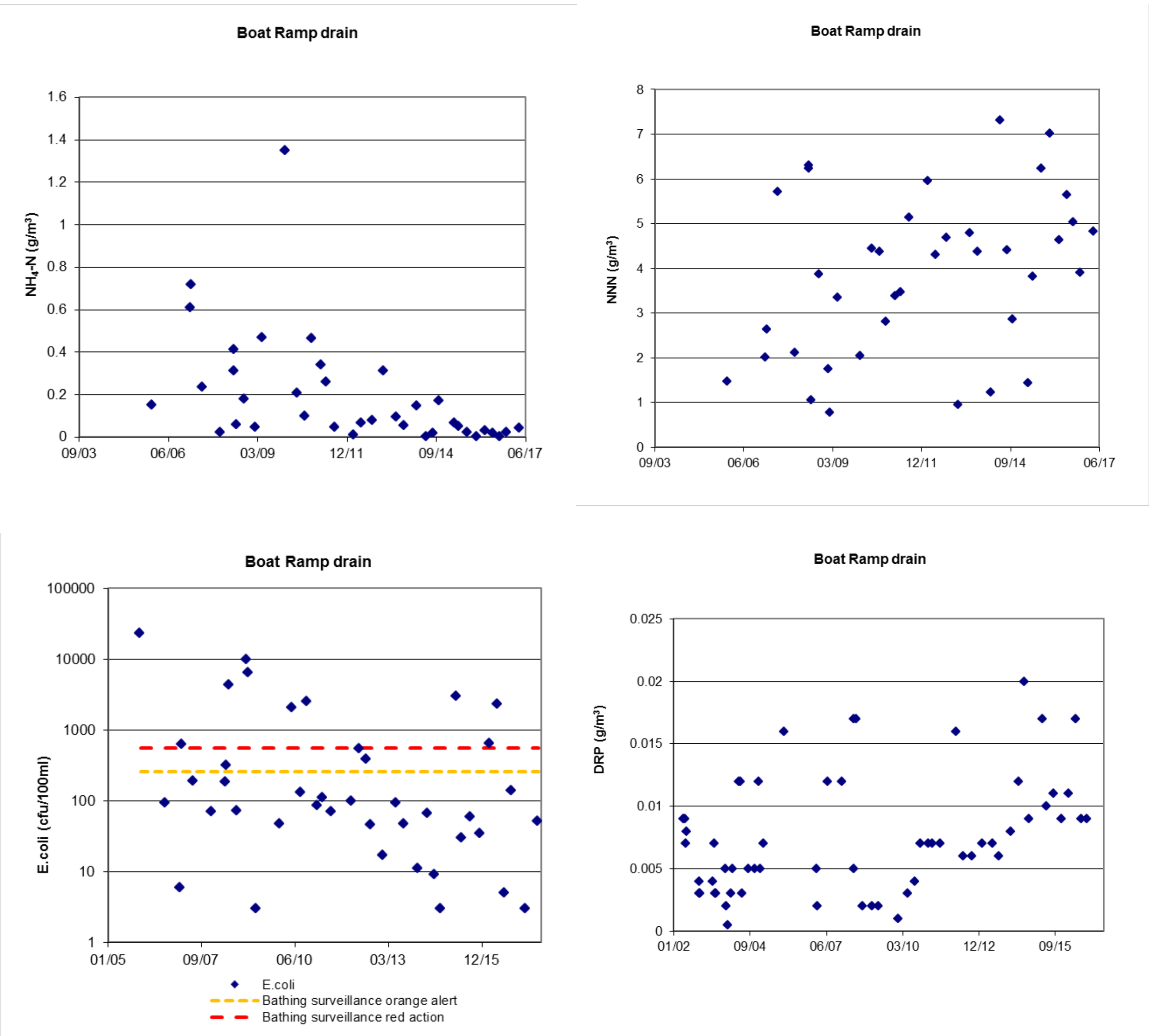


Figure 3.5.2 Faecal coliform and nutrient concentrations, Boat Ramp Drain, Tanners Point.

Figure 3.5.3 displays data for Boat Ramp Drain along with two other smaller drains that flow onto the foreshore. Sampling from twin pipe drain near the boat ramp has been sporadic as often there is no flow. 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.

Ammoniacal-nitrogen levels have remained relatively low in all drains potentially indicating better renovation of ammoniacal-nitrogen to nitrate-nitrite-nitrogen in the tanks and soils.

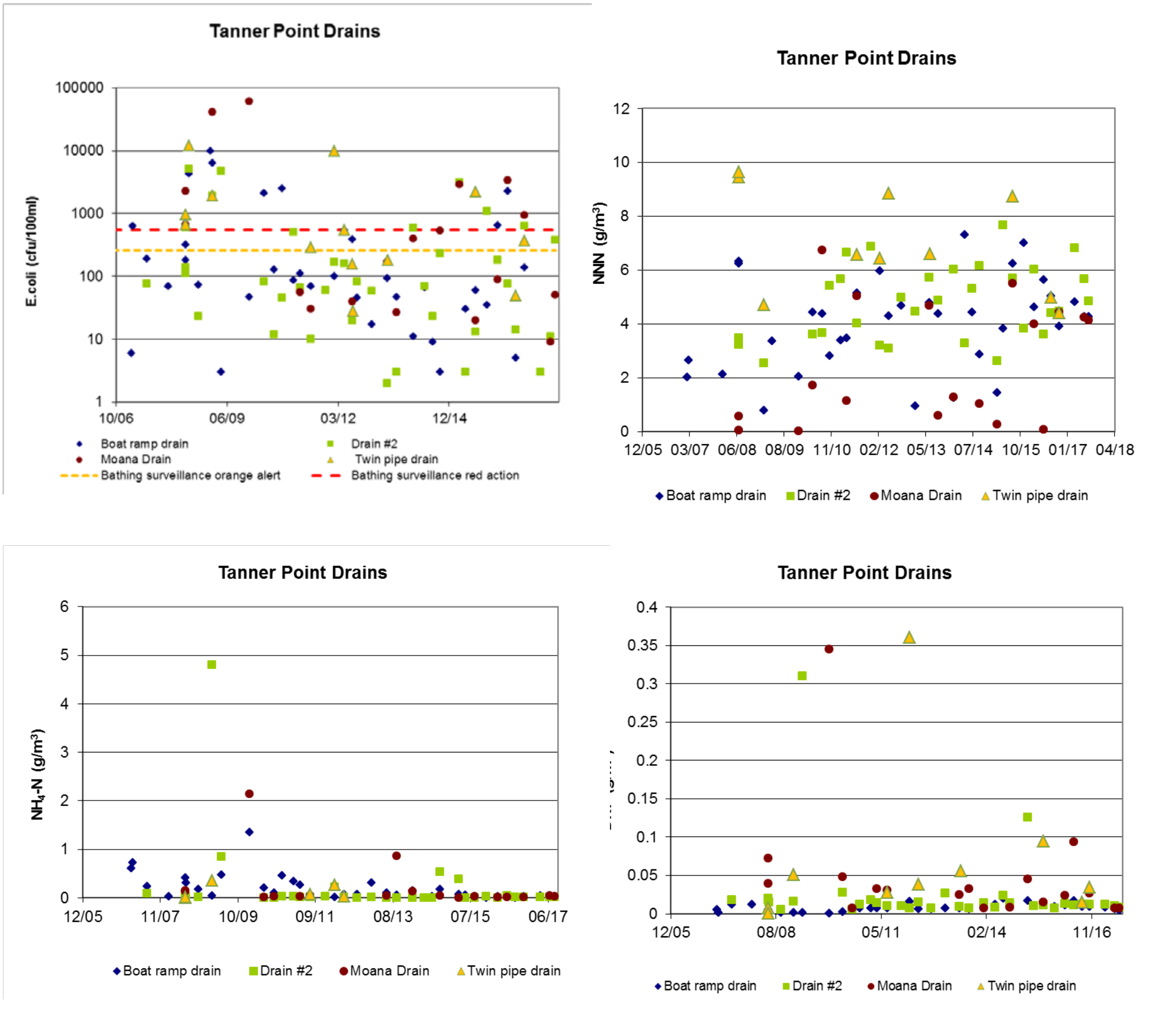


Figure 3.5.3 E.coli and nutrient concentrations, Tanners Point drains.

Bathing surveillance monitoring undertaken at the boat ramp in summer has shown an increase in concentrations over the past two seasons. Three results in the past two seasons have been over the red action guideline for swimming water quality, although these were driven by intensive rainfall events. Impact of septic tanks on such events has not been discriminated.

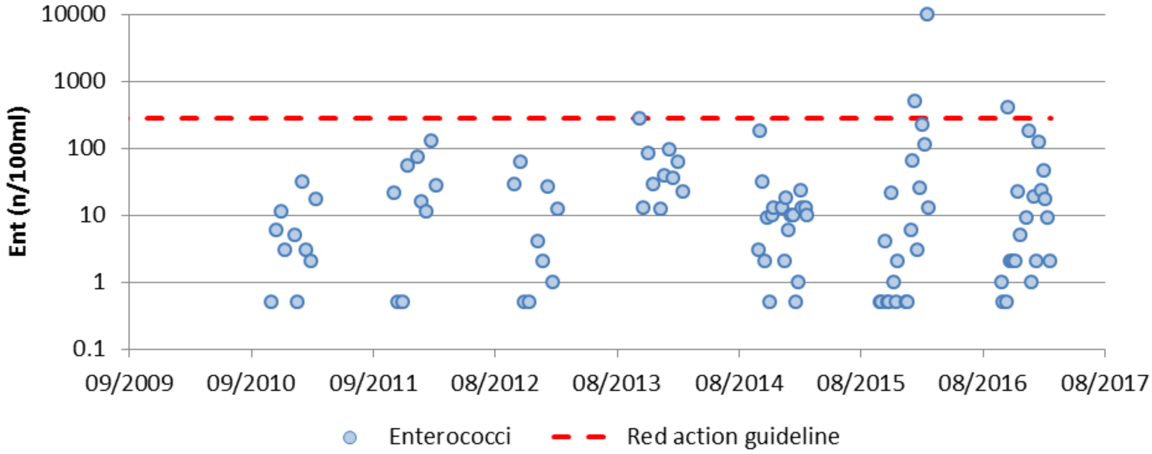


Figure 3.5.4 Indicator bacteria concentrations, Tanners Point Jetty.

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. Contaminant concentrations have decreased in the past few years, showing an improved situation and this may in part be due to improvement in roadside stormwater and the requirement of regular pumping out of septic tanks.

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.

The upgrade of the disposal field at the public toilet also appears to have reduced 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.

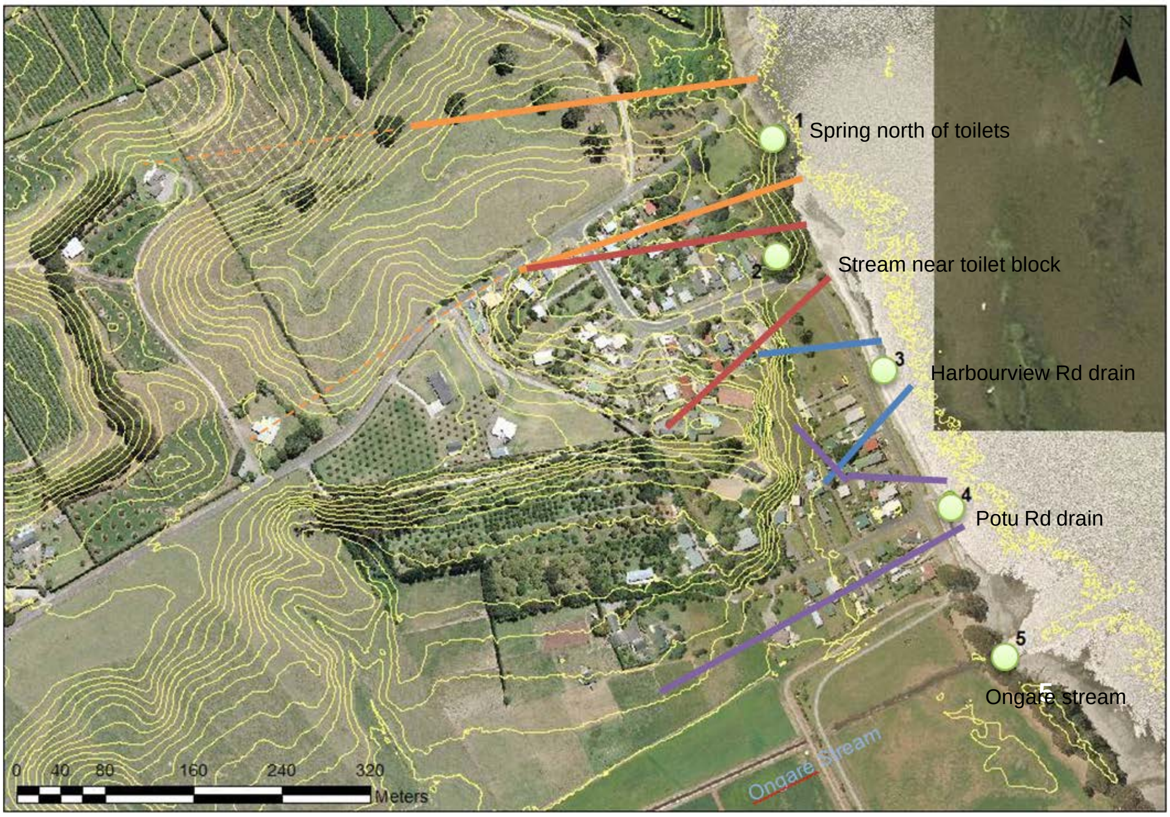


Figure 3.6.1 Ongare Point sample location map with approximations of subsurface drainage catchments relative to sample locations shown.

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 the communities' stormwater and groundwater (Figure 3.6.1). 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 harbour's 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 physio-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/100 ml).

Monitoring of drains that flow onto the foreshore at Ongare Point has been undertaken quarterly from 2008 to 2017. Results showed that some contamination from septic tanks is occurring. Drains 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.

3.6.3 Updated monitoring results

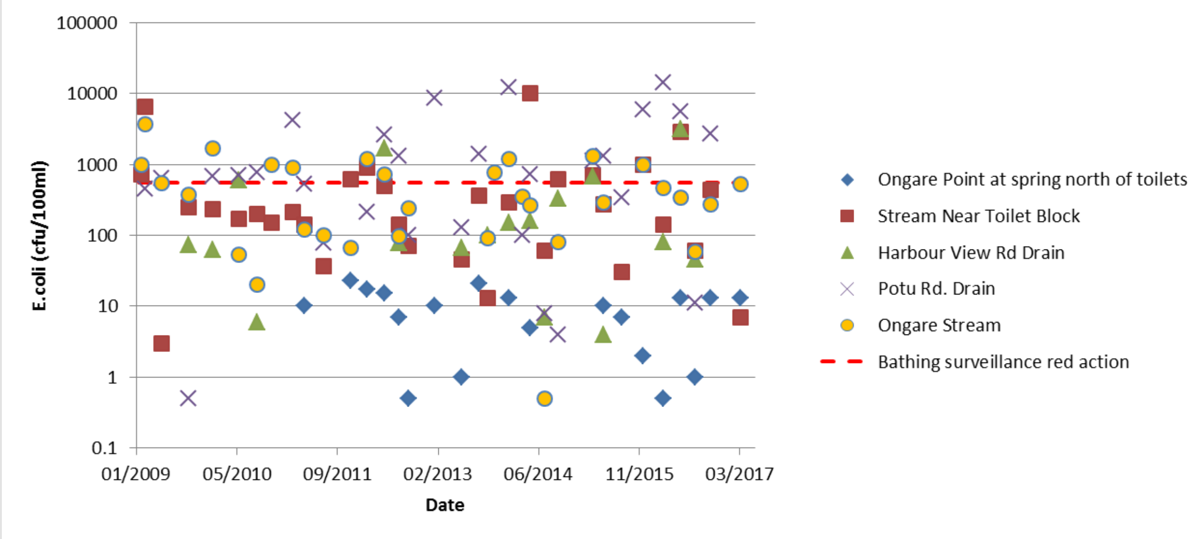
Monitoring has been undertaken over five foreshore flows that occur across the community (Figure 3.6.1), with analysis of water samples undertaken. Results for these were last reported in Scholes (2011), and community updates have also been posted in the Bay of Plenty Regional Council website.

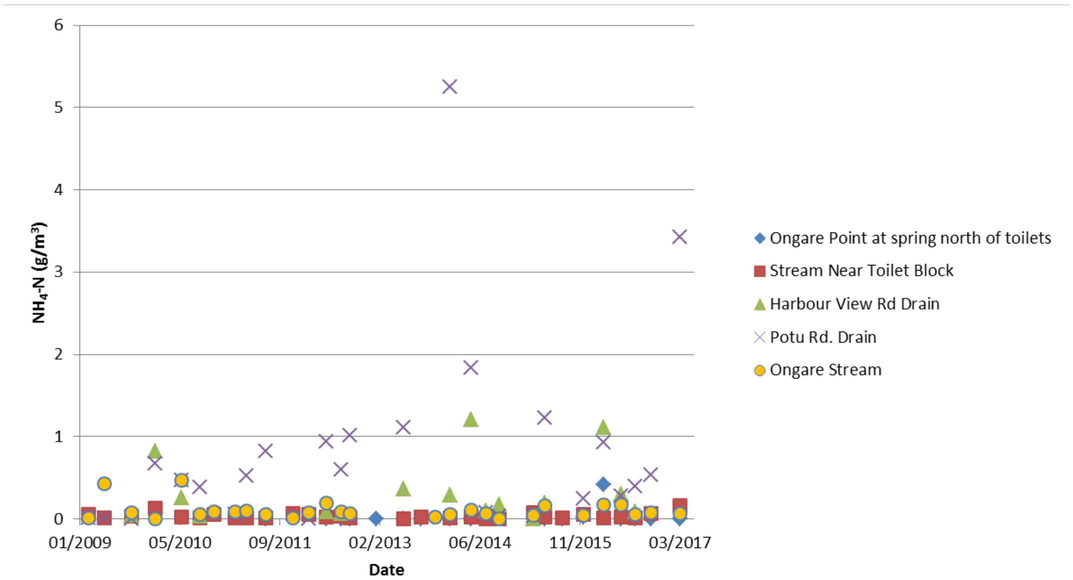
Bacterial water quality entering the foreshore is shown by Figure 3.6.2, and is represented by the indicator bacteria *E.coli*. The Potu Road drain shows the most consistently high *E.coli* results consistent with the low water table in the this area leading to problematic septage treatment in soils. This also shown by elevated DRP and NH_4-N concentrations (Figure 3.7.2), again indicating some contamination from septic tanks.

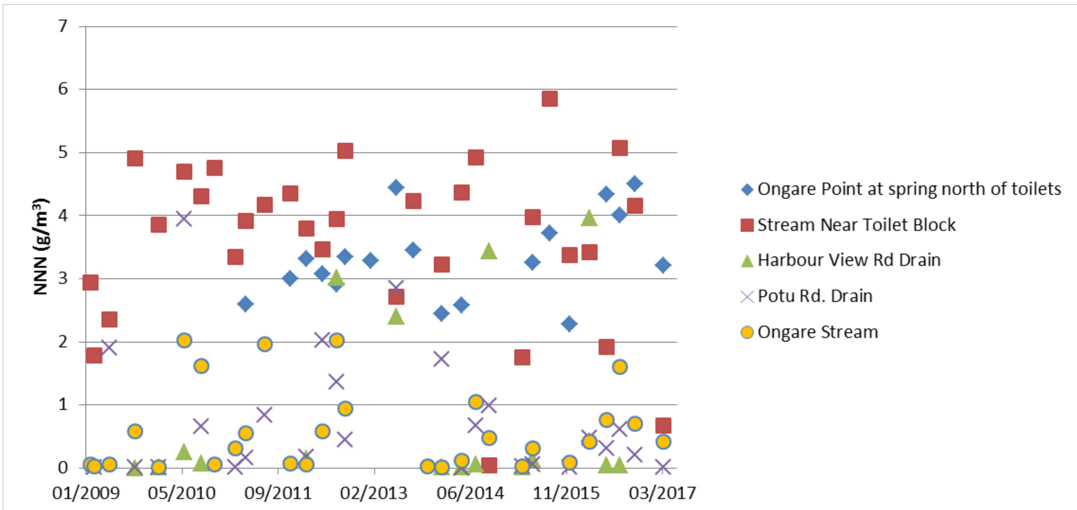
Harbour View Drain has to a lesser extent, also been found to have occasional higher levels of indicator bacteria and nutrients that would be expected in an uncontaminated stormwater seep. Flow from the Potu Road Drain is almost year round while the Harbour View drain experiences only intermittent flow and is therefore influenced by rainfall and water table levels.

Nitrate-nitrite-nitrogen (NNN) at the spring north of toilet block and the stream near the toilet block often have concentrations above 3 g/m^3. Similar concentration of these mobile nitrogen species through groundwater are also observed in the rurally influenced Site 1 (Figure 3.7.2), indicating nitrogen input from rural sources as well as from septic tanks. Other drains monitored have lower NNN concentrations on average but higher NNN to NH_4-N ratio.

Ongare Stream does show signs of contamination from rural sources and has predominantly cattle grazing around its lower extent. *E.coli* concentrations have been 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. This has dropped off recently with the installation of a new culvert.


100000
10000
1000
100
10
1
0.1
E.coli (cfu/100ml)
01/2009
05/2010
09/2011
02/2013
06/2014
11/2015
03/2017
Date
Ongare Point at spring north of toilets
Stream Near Toilet Block
Harbour View Rd Drain
Potu Rd. Drain
Ongare Stream
Bathing surveillance red action


6
5
4
3
2
1
0
NH_4-N (g/m³)
01/2009
05/2010
09/2011
02/2013
06/2014
11/2015
03/2017
Date
Ongare Point at spring north of toilets
Stream Near Toilet Block
Harbour View Rd Drain
Potu Rd. Drain
Ongare Stream


7
6
5
4
3
2
1
0
NNN (g/m³)
01/2009
05/2010
09/2011
02/2013
06/2014
11/2015
03/2017
Ongare Point at spring north of toilets
Stream Near Toilet Block
Harbour View Rd Drain
Potu Rd. Drain
Ongare Stream

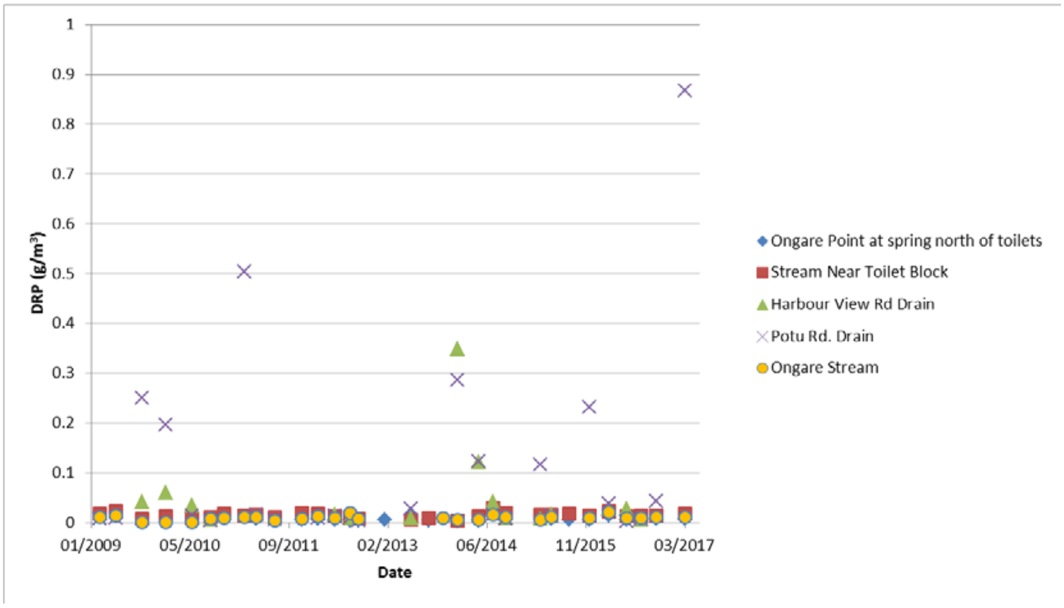


Figure 3.6.2 E.coli and nutrient concentrations, Ongare Point.

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 3.6.3 displays these loads as *E.coli* number per day.

The greatest contribution of faecal contamination to the harbour is from the stream, primarily due to its much greater flow. However, the input from the relatively small drain flows is not insignificant and represents a localised health risk to the foreshore if infectious material is present.

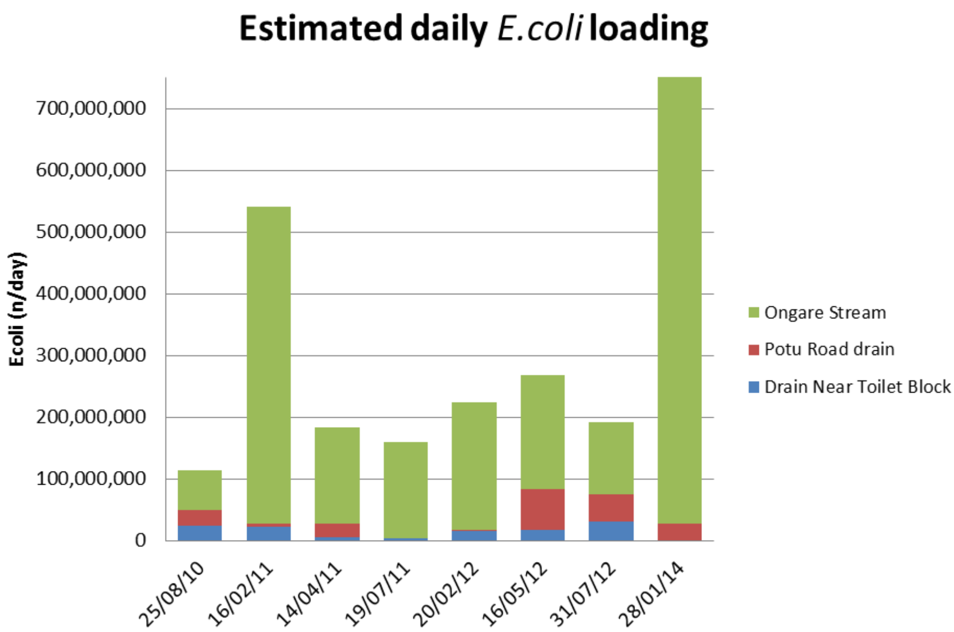


Figure 3.6.3 Percentage representation of E.coli loads to harbour (cfu/day) for Ongare Point drains and stream.

The technique of quantitative PCR (qPCR)-based feacal source tracking (FST) markers used for identifying the presence and relative contributions of human and ruminant sources of faecal pollution in waterways, has also been employed. Results have found faecal contamination from human sources in the Potu Street Drain (Site 4), but no evidence of human markers at Ongare Point stream (Site 5). No other sites were tested.

Bathing water quality around Ongare Point is generally good. Only once has the water quality exceeding the Microbiological Water Quality Guidelines (2003) red action mode of 260 enterococci per 100 ml (requires two consecutive samples to be over this threshold). Results of 1000 enterococci per 100 ml occurred in 2006 (Figure 3.7.4) and 2007, and a result of 10000 enterococci per 100 ml occurred in 2016. All of these samples were taken after substantial rain had fallen.

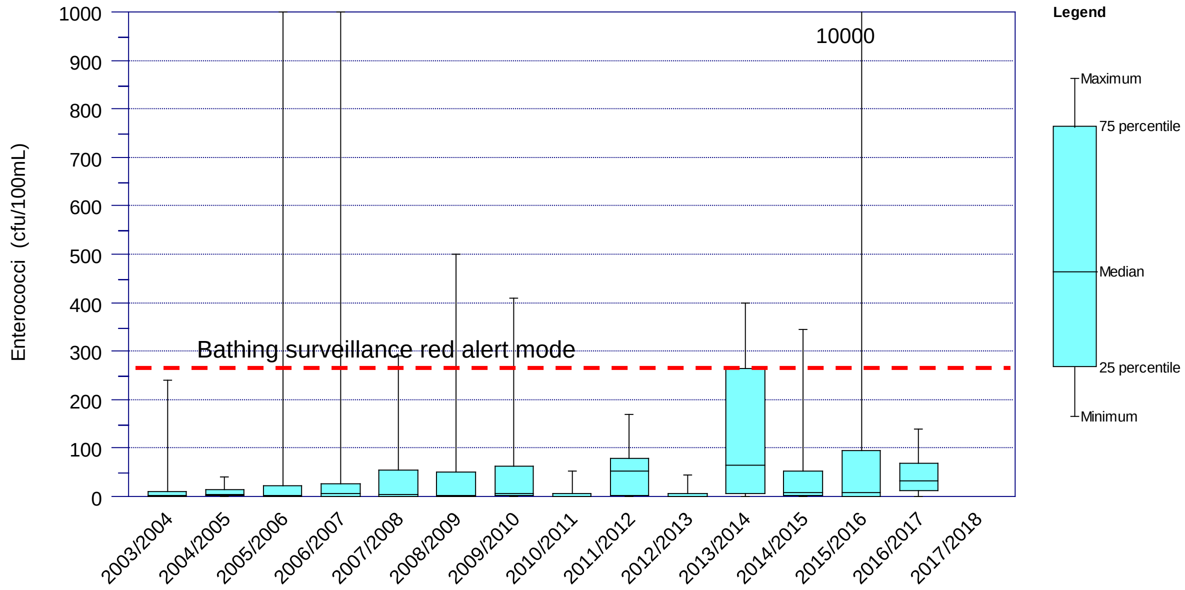


Figure 3.6.4 Bathing surveillance monitoring results, Enterococci, Ongare Point.

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. 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 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.

Ongare Point is due to be reticulated in the near future.

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.

Western Bay of Plenty District Council has installed a ‘holding tank’ at the public toilet in Te Puna which no longer discharges to the environment. The tank is pumped out as required.

Properties in Te Puna West are located in a ‘Maintenance zone’ as specified by Rule 1 of the On-site Effluent Treatment Regional Plan 2006 (OSET Plan). This specifies that septic tanks are subject to a regular pump out and inspection programme.

The OSET Plan specifies that septic tanks in Te Puna become discretionary in 1 December 2015. This means that at that time, a resource consent will need to be obtained or an advanced wastewater system installed, or (if available) the wastewater connected to a Council sewerage scheme. The Western Bay of Plenty District Council is reticulating the Te Puna West area, which will be connected to the Omokoroa-Tauranga sewer line.

There has been signage at the Waitui Reserve warning the public not to 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 Omokoroa is 1317 mm based on data from 1991 to 2010.

Figure 3.7.1 Te Puna monitoring site location map.

3.7.2 Previous studies

Gunn (2001) in his review of OSET 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.

Previous monitoring of the foreshore showed Te Puna west drains to high levels of indicator bacteria and ammoniacal-nitrogen, a sign of septic tank contamination. Drains to the east have occasional high indicator bacteria levels but are distinct form the western drains due to their much higher nitrate-nitrite-nitrogen (NNN) levels. Elevated NNN may be due to other catchment influences.

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, 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.

3.7.3 Monitoring results

Several drains show high bacterial contamination (Figure 3.7.2, 3.7.6) 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 action mode) occurred in one drain on the west side in data from 2010 to 2017. All drains have periodic results above the red action mode guideline with the exception of drain #10 and drain #7.

Several of these west side drains have elevated ammoniacal-nitrogen (NH_4-N) concentrations, indicating septage contamination. Drains on the eastern side have lower ammoniacal-nitrogen concentrations. Two drains on the eastern side have higher NNN concentrations than their western counterparts. This could be a result of nutrient renovation of septic tank effluent as well as rural land use impacts. High NNN concentrations at the two western drains also indicate influence of septic tanks. Elevated phosphorus levels on the eastern side also indicate some potential effluent influence (Figure 3.7.5).

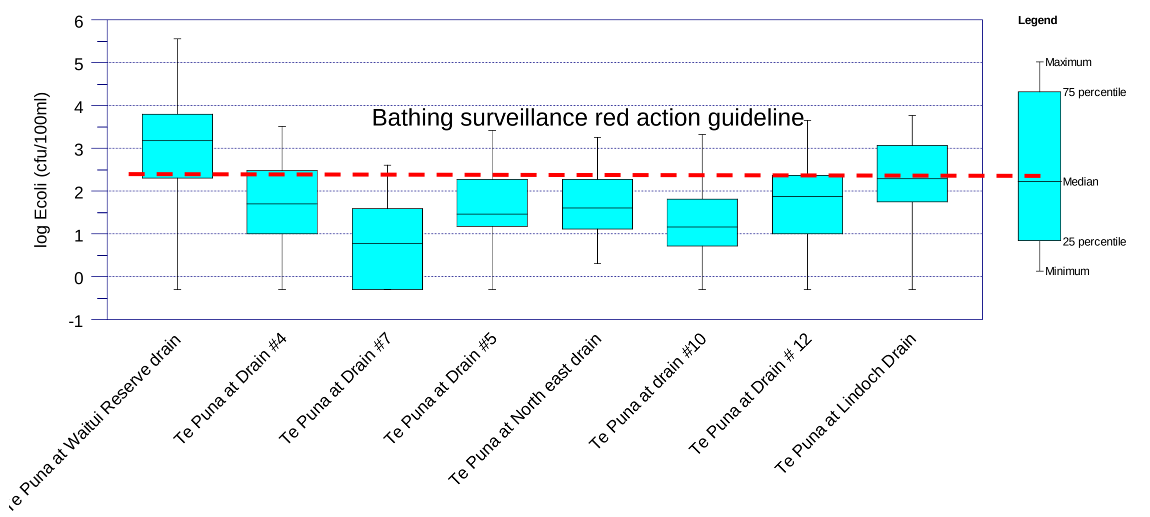


Figure 3.7.2 Box-whisker plots of E.coli concentrations, Te Puna drains, 2010 to 2017.

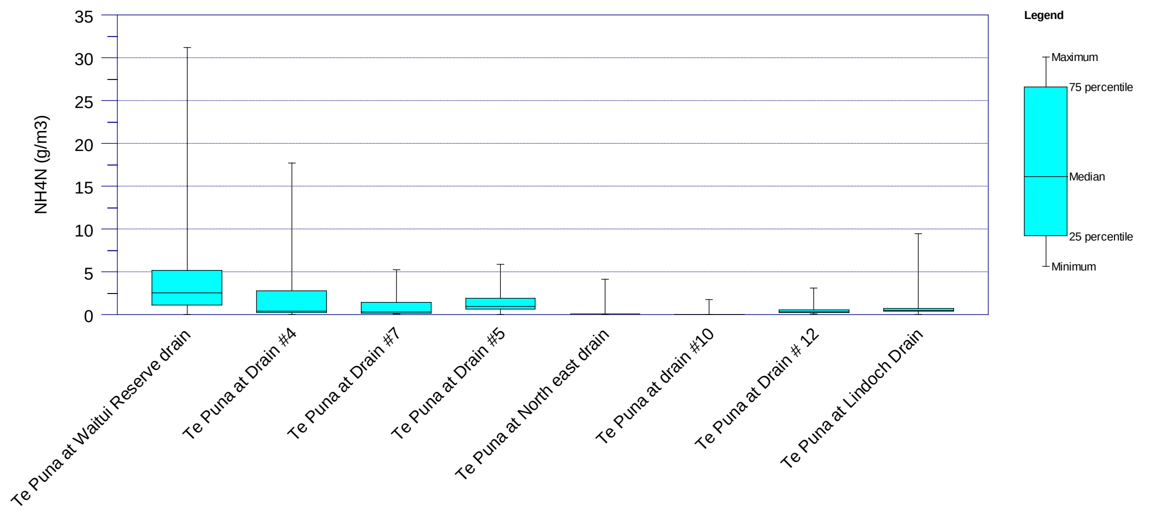


Figure 3.7.3 Box-whisker plots of NH_4-N concentrations, Te Puna drains, 2010 to 2017.

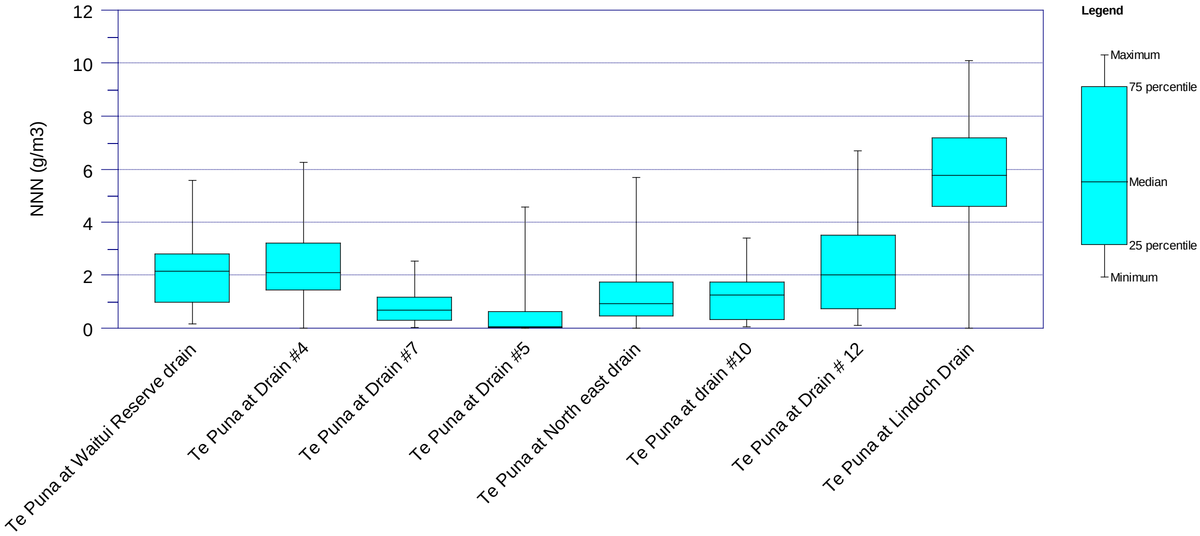


Figure 3.7.4 Box-whisker plots of NNN concentrations, Te Puna drains, 2010 to 2017.

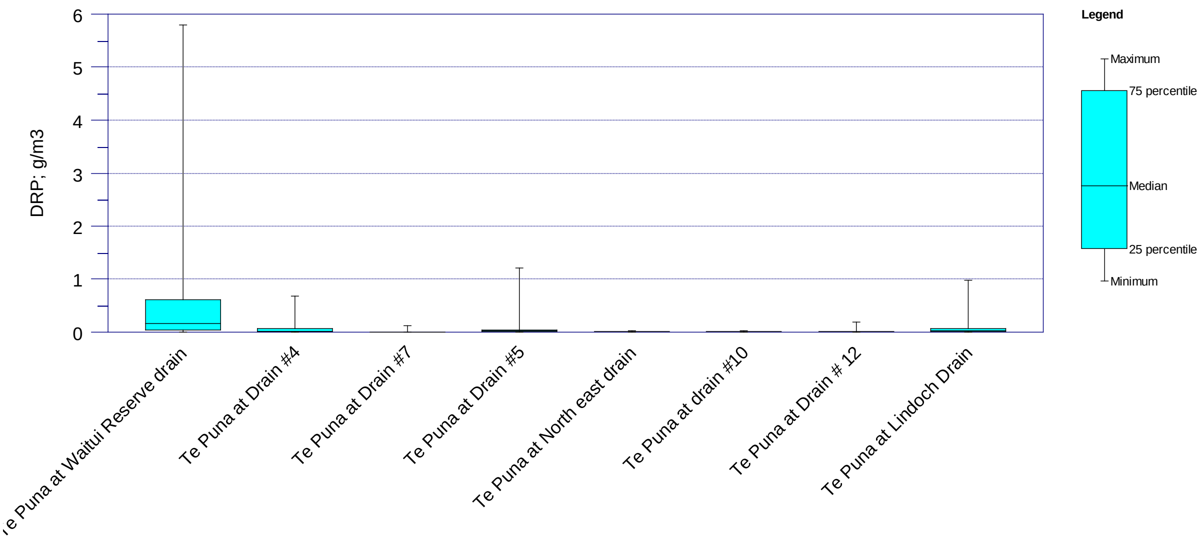


Figure 3.7.5 Box-whisker plots of DRP concentrations, Te Puna drains, 2010 to 2017.

The north-eastern drain show mixed results with a high *E.coli* concentration of 600 *E.coli*/100 ml in May 2012, a rain affected sample, and another elevated result (1800 cfu/100 ml) in May 2014 (Figure 3.7.6). A rain affected sample also occurred in October 2016. In January 2014, indicator bacteria faecal coliform and enterococci were both elevated indicating some contaminant source. Ammoniacal-nitrogen levels have remained consistently low (with one exception), but nitrate-nitrite-nitrogen has been elevated on occasion, but this could also be agriculturally influenced.

The standout contaminated drain is the Waitui Drain. This drain has not only high indicator bacterial levels but also elevated nutrient levels, indicating contamination from OSET systems. Consistent contamination by septic tank effluent is displayed in the drain outflow and has also been found with the presence of human faecal contamination markers.

Three drains have been tested for the presence of human *E.coli* isolets: Waitui Drain; Lindoch Drain; and NE Drain. Both Waitui Drain and Lindoch Drain have tested positive for two human based isolets (Human BacH and Human BiADO) on two separate sampling occasions: July 2014 and January 2015. No human marker was detected in the NE Drain.

The microbiological swimming water quality of the Te Puna Estuary is good, based on monitoring of the indicator bacteria enterococci (Figure 3.7.7). Only two results have been above the bathing surveillance red alert threshold (280 cfu/100 ml) over the past seven seasons.

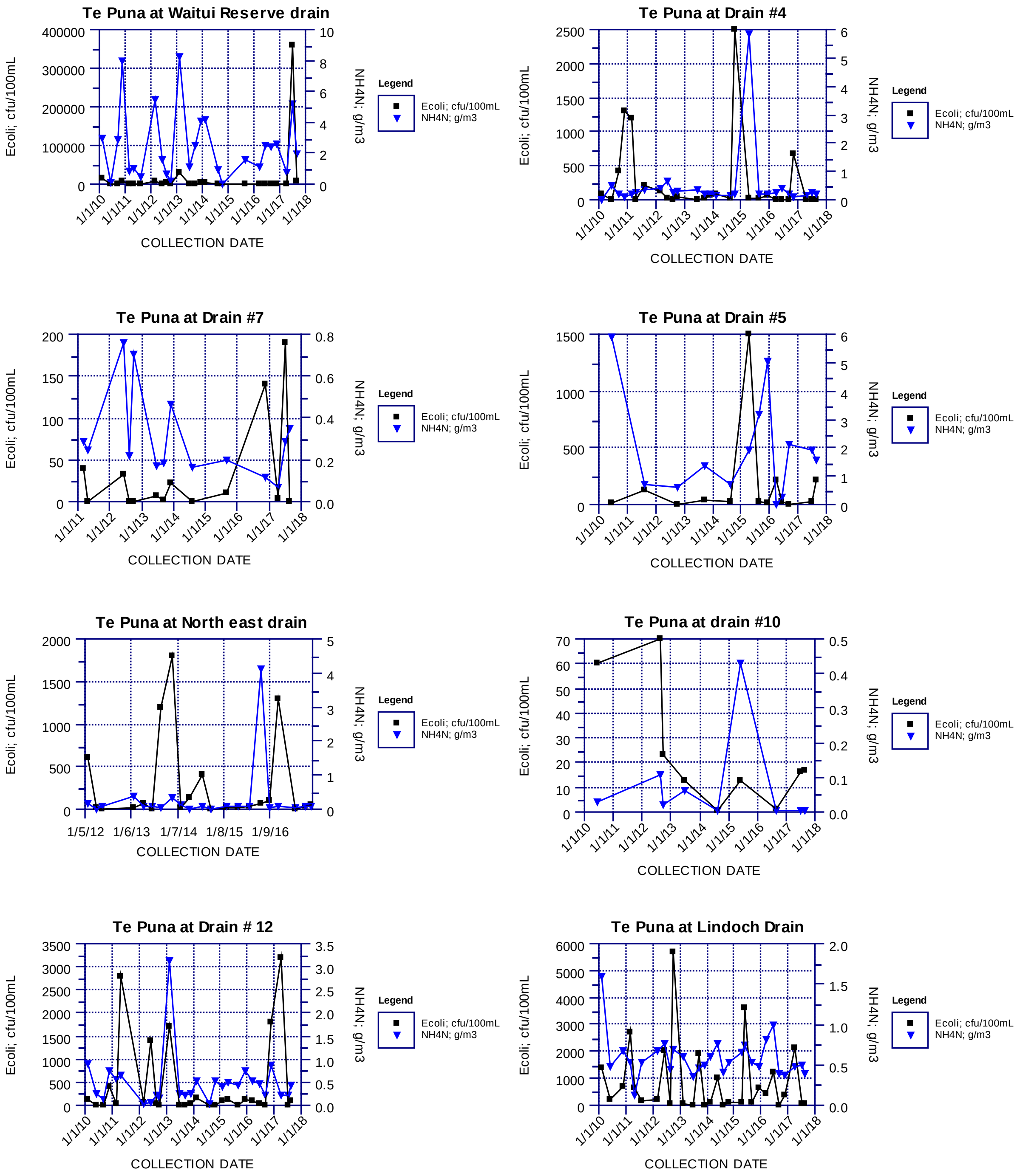


Figure 3.7.6 Te Puna Drain E.coli and NH_4-N concentrations, 2010 to 2017.

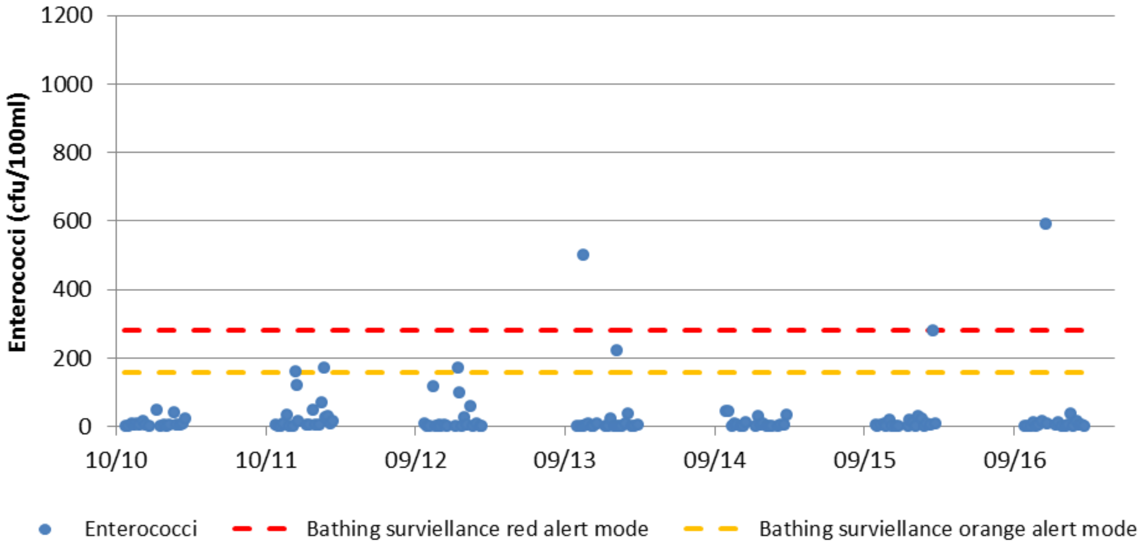


Figure 3.7.7 Bathing surveillance monitoring results, Enterococci, Te Puna.

3.7.4 Discussion

Te Puna west drains continue to show high levels of bacteria and ammonium-nitrogen (NH_4-N), 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 nitrate-nitrite-nitrogen (NNN) to ammoniacal-nitrogen ratio. This higher ratio 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.

New scientific methods are also emerging to help identify sources of faecal contamination. Faecal source tracking (FST) results have shown that Waitui and Lindoch drains are contaminated with human faecal material.

3.8 Pukehina/Waihī Estuary

Pukehina is a seaside community with a 5.3 km 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 2 kms of the community is adjacent to the Waihī Estuary.

The community relies on, 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 1298 mm over the period 1990 to 2010.

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

Figure 3.8.1 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 3.8.3). 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.

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 often at levels considered not 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, indicating some contamination is brought into the estuary during rainfall. Viral and F-RNA-bacteriophage analyses were also undertaken on the shellfish taken in February 2011 and were found to be negative for enteric viruses and FRNA phage (GI and GII). This shows at this time, no contamination from human sources was detected (see Scholes et al, 2009).

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 3.9.1). Results for these are displayed in Figure 3. Most seepages of drains are ephemeral with only the larger drain at site P6 having permanent flowing water, although the drain at Midway Park (site P5) always contains water. The drain near the access way of number 604 Pukehina Parade (site P1) has, on the odd occasion, not had any surface flow. These four sites have been monitored most consistently over the past few years, while other sites have had often little or no flow from which to obtain a sample from.

E.coli results above the Ministry of Heath's and Ministry of the Environment's recreation guideline red action have, for the most part, been sporadic for most sites with the exception of site P1 which has shown consistent elevated *E.coli* levels. The seepage at site P7 has previously also had elevated *E.coli* levels, but in the last two years, these have been below recreation guidelines. Sites P5 and P7 show a weak correlation between *E.coli* and ammonium (NH_4-N), indicating septic tank effluent as a probable source of contamination. Elevated ammonium has been most prevalent at sites P1 and P7 again the most likely source at these levels is septic tank effluent (Figure 3.8.3).

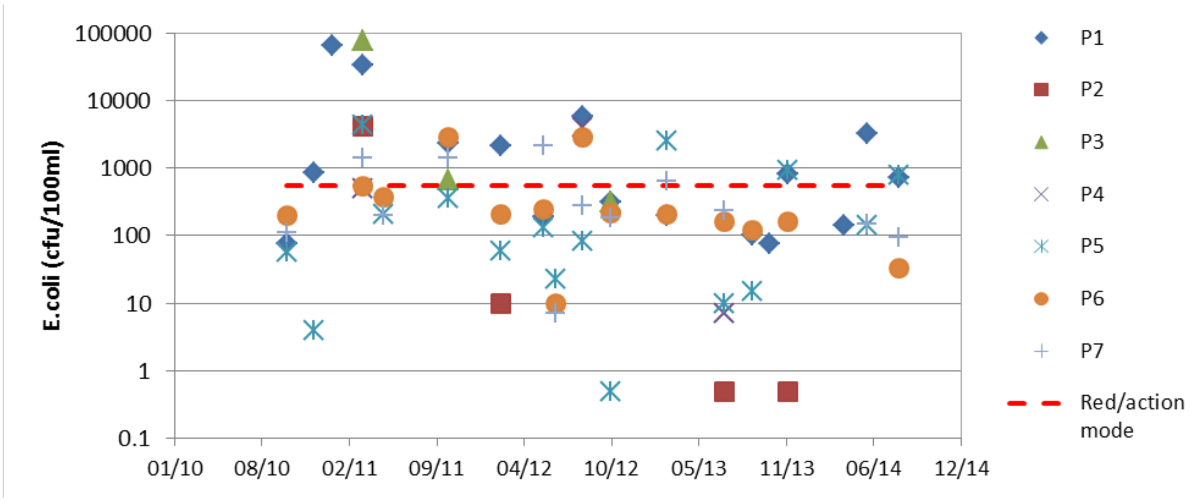


Figure 3.8.2 E.coli concentrations from seeps and drains, Pukehina.

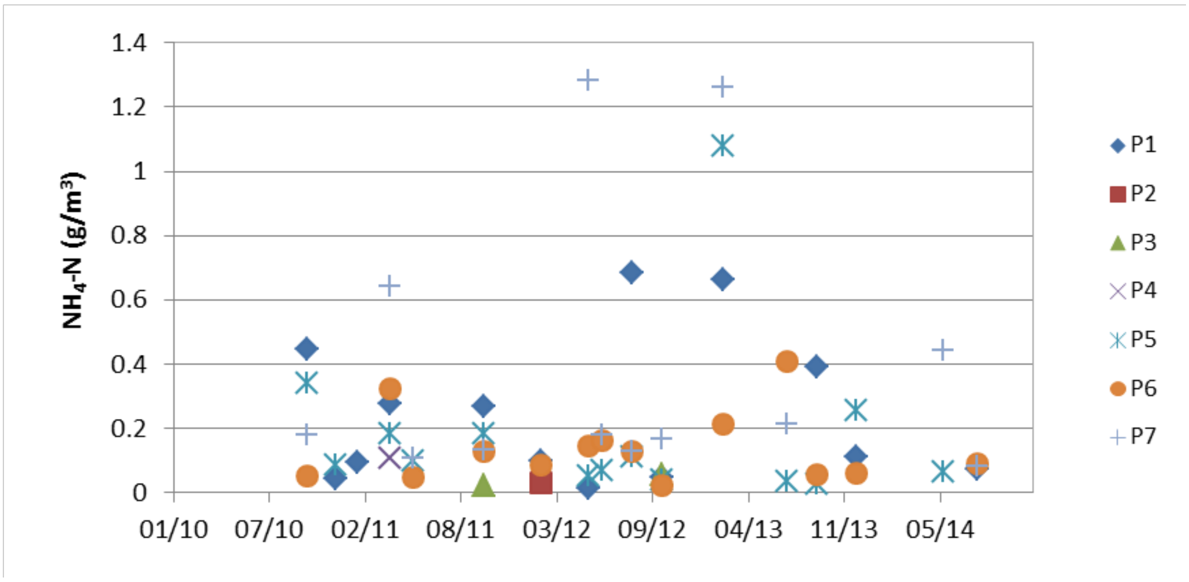
Dissolved reactive phosphorus can be elevated by washing products high in phosphate and hence an indicator of septic tank effluent pathways. In the Pukehina drains there has been one high result at the site P1 which also ties with elevated *E.coli* and ammonium at this site. However, for the most part with the exception of some elevated results at sites P6 and P7, results are for the most part unremarkable. A similar situation exists for nitrate-nitrite-nitrogen (NNN), although concentrations potentially indicate renovation of septic tank ammonium by the local soils before migrating to the harbour.

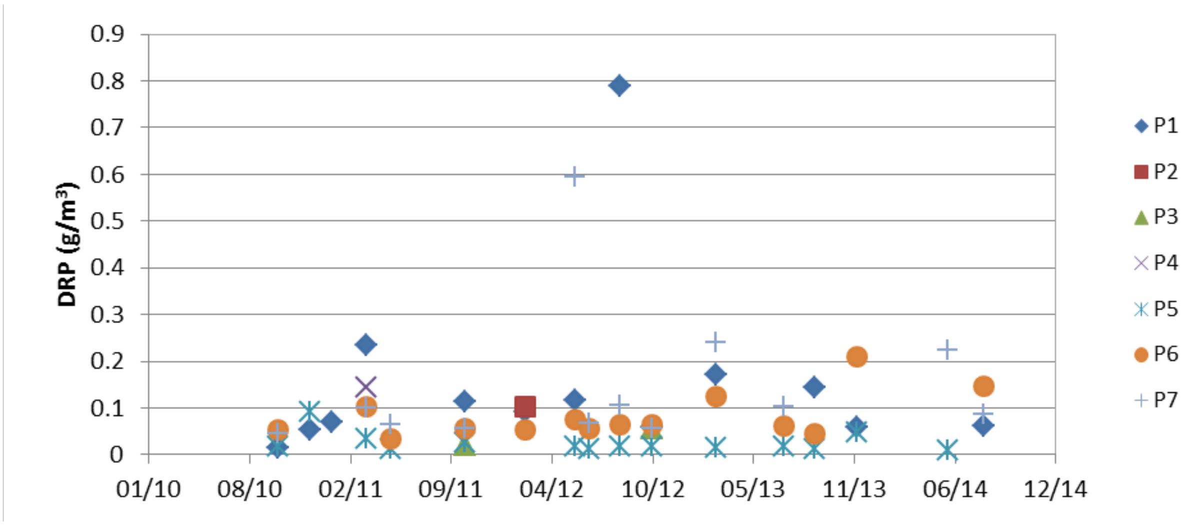
The technique of quantitative PCR (qPCR)-based faecal source tracking (FST) markers within for identifying the presence and relative contributions of human and ruminant sources of faecal pollution in waterways, has also been employed. Results of one off sampling round in May 2014 have found no evidence of faecal contamination from the three sites tested (Table 3.8.1).

Table 3.8.1 Results of PCR Analysis for faecal source tracking.

Site	E.coli (n/100 ml)	General GenBac	Overall conclusion
P1	>1000	Strong positive	No evidence of human source
P5	220	Very strong positive	No evidence of human source
P7	520	Strong positive	No evidence of human source

**GenBac = the general PCR marker used to define if other markers can be found. Where strong detection is found, source specific markers could be expected to be detected if present and contamination is recent.*





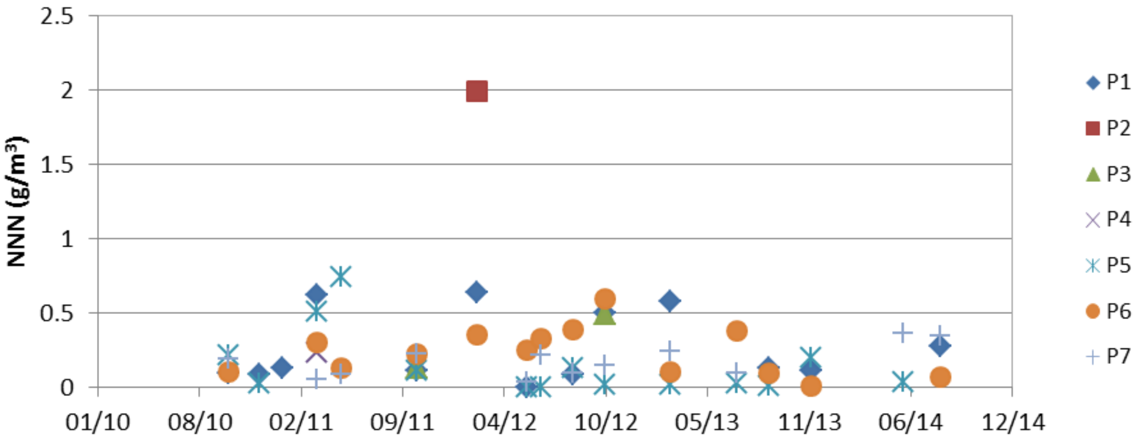


Figure 3.8.3 Nutrient concentrations from seeps and drains, Pukehina.

Bathing surveillance monitoring at Pukehina Beach (coastal waters), shows these waters to be excellent for contact recreation purposes. Waihī Estuary has lower water quality due predominantly to rural freshwater inputs. Only very small intermittent flows of some contaminants originate from the Pukehina community. Figure 3.8.4 shows monitoring results for the lower estuary from 2003 to 2017. Results are generally below bathing surveillance alert levels for marine waters, with four seasons in the last ten having had occasional results above the bathing surveillance red alert level.

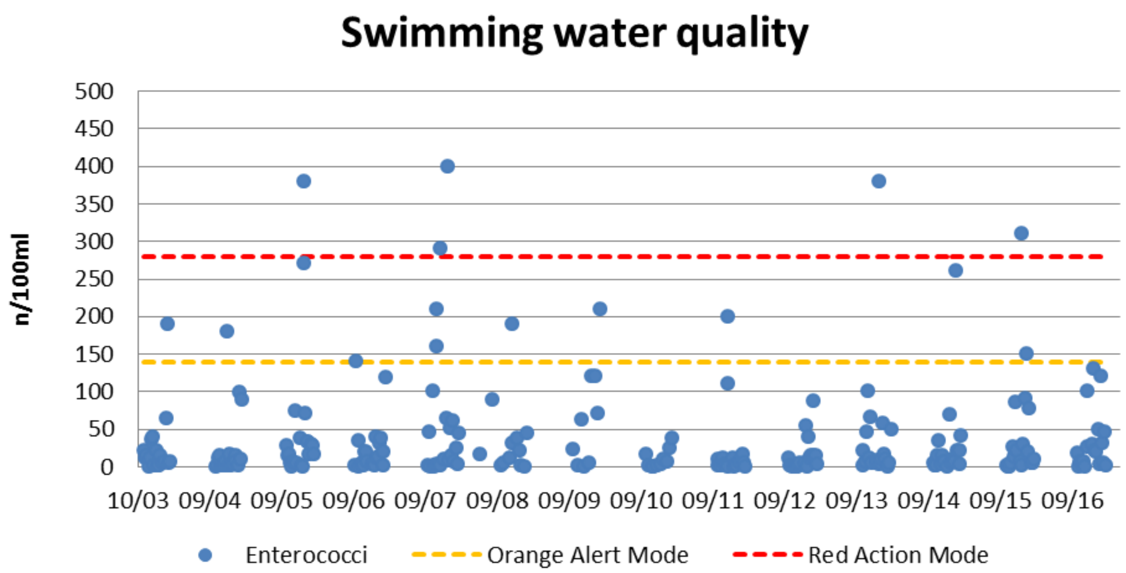


Figure 3.9.4 Swimming water quality and recreational guideline levels. Waihī Estuary.

Indicator bacteria results for shellfish waters in the Waihī Estuary have been variable, with some elevated faecal coliform results found in the water on occasion. These are usually associated with rainfall events. Faecal coliform results for main channel pipi indicate, that on occasion, pipi would not be considered not safe for human consumption. Results for shellfish waters over the past three years (Figure 3.8.5) show that in 2015/16 the two shellfish water guidelines were exceeded, showing shellfish water were unsafe for human consumption.

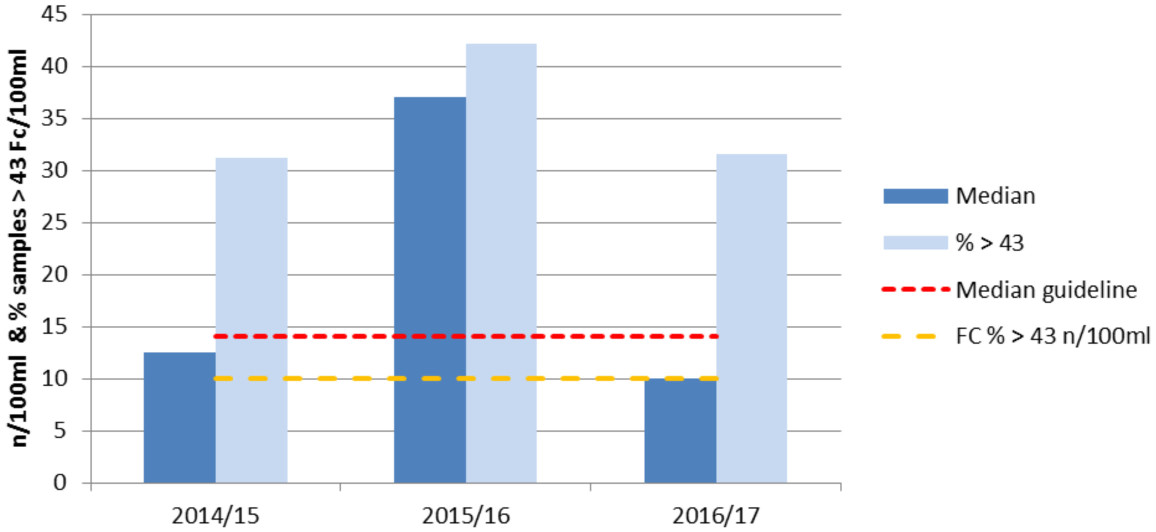


Figure 3.8.5 Shellfish water quality and shellfish water guideline levels based on faecal coliform concentrations. Waihī Estuary.

3.8.4 Discussion

Monitoring of the Pukehina discharges adjacent to the foreshore show markers of contamination from septic tank effluent, but these have not been confirmed using PCR faecal source tracking techniques. Some drains regularly exceed the Microbiological Water Quality Guidelines red action mode, with most exceedances occurring at site P1, a small discharge onto the foreshore that flows most of the year round.

Swimming water quality is at times compromised in Waihī Estuary, usually as a result of rainfall runoff. While local drains will be adding to compromised swimming water quality, they are only a minor contributor compared to inputs from freshwater streams into the estuary. The risk to community health from septic tank effluent is from direct contact with contaminated drain waters. Contact with the water in these drains or where they discharge onto the foreshore should be avoided.

3.9 Matatā

Matata is a small township located at the northern extent of the Rangitaiki Plains, Bay of Plenty. It has around 642 residents (2013 census) with around 237 households and 43 business locations. Whakatane District Council recently applied to move the community to a sewage scheme to replace individual household septic systems. The application was heard by the Environment Court but was denied due to the proposed location of the treatment plant.

3.9.1 Physical environment

Matata township is located predominantly on mainly well drained Opouriao fine sandy loams derived from greywacke and weathered volcanic ash. Also present is Kopeopeo loamy sand, a moderately well soil derived predominantly from ash pumice and dune sands.

The water table generally lies within 1 m of the surface in winter. The township has two perennial streams flowing through or near it, the Waitepuru and Awatarariki Streams, and a smaller ephemeral stream that flows as part of the drainage system through the town to the Matatā Lagoon (Figure 3.9.1). There are also stormwater drains draining road reserves and adjacent catchments.

The town is located on land sloping towards the lagoon with the lagoon being a sink for surface waters and possibly some groundwaters. The lagoon is surrounded by an extensive wetland margin except for the seaward side where the Matata Campground is located.

Mean annual rainfall measured at Thornton over the 1990 to 2010 period was 1257 mm.

Figure 3.9.1 Matatā monitoring locations.

3.9.2 Previous monitoring results

Monitoring of Matata drains and streams was undertaken intensively April/May 2012, and biannually in 2013 and 2014. A small rainfall event occurred 27 April 2012 (30 mm over 24 hours), with conditions being relatively dry prior to this. On 10 May 2012, another larger rain event occurred (over 75 mm in 14 hours) and sampling was undertaken the following day.

Indicator bacteria and nutrient results are listed in the tables below. The locations of monitoring sites are shown in Figure 3.9.1.

A number of springs located in freshly dug drainage channels were sampled north of SH 2 in April 2012. The springs varied in flow volume and almost none of the springs showed any faecal contamination. The exception is the cut of drain opposite the Matata Hotel, where a drainage pipe has historically shown elevated faecal indicator bacteria results (see Scholes 2005). However, there were only elevated faecal indicator bacteria results on one occasion in this recent sampling round. Elevated concentrations of nitrate-nitrogen, especially compared to other springs in the nearby cut-off drains, was found (Table 3.9.1). A high level of nitrate-nitrogen concentration suggests that this is sourced from septic tanks, but that good nitrification is occurring.

The indicator bacteria results for *E. coli* listed in table 3.9.1 are highlighted to show where the microbial water quality guidelines for recreational waters (MfE, 2003) have been exceeded. Where this occurs, there is the potential for human health concerns with emersion based contact.

E. coli results in the Waitepuru Stream show increasing concentrations as you move downstream. Four of the sampling occasions showed that the downstream sites had *E. coli* concentrations above the recommended recreational guideline (red action mode).

The Clark Road Drain has also shown elevated *E. coli* concentrations at the downstream site on many occasions. One sample taken on Clark Road downstream from the rugby grounds had lower *E. coli* levels and this may indicate contamination is fairly localised. Waimea Stream at Division Road had consistently elevated bacteria, although in 2014 there was no flow. Both of these streams potentially show contamination from septic tanks on some occasions.

Indicator bacteria results from the lagoon outlet generally show compliance with recreational water quality guidelines, with the exception of one sample taken after a larger rain event and the last sample taken in July 2014. This may indicate that the overall impact of any septic tank contamination via groundwater water or surface water source does not impact largely on the bacterial water quality of the lagoon.

Table 3.9.1 E.coli concentrations (cfu/100 ml). Matatā waterways. Orange results have exceeded the 2003 Micriobiological Water Quality orange alert mode, red results the red action mode.

Date	Waitepuru Stream Edgecumbe Road	Waitepuru Stream Heale Road	Waitepuru Stream below SH2	Waimea at Division Road	Clark Road Drain above SH2	Cutoff Drain Opp Matatā Hotel	Drain west of Matatā Hotel	Lagoon outlet	Awatarariki at Richmond
23/04/2012	40	180	120	140	2800	1100		130	
24/04/2012	26	470	1000	150	580	4		76	
27/04/2012	360	2700	3000	>10000	2800	<1		210	
30/04/2012	50	180	870	650	570	<1		60	
10/05/2012	90	170	280	130	1000		930	2700	
27/02/2013	1000	2500	1200	2600	140		140	34	
02/10/2013	270	550	360	3000	28		860	<1	
27/05/2014	170	2300	3900	No flow	520		93	83	
07/08/2014	2	1200	2	No flow	300		390	1400	
16/06/2016	52	390	240	No flow	57		100		34
07/07/2016	80	350	410	No flow	59		160		24

Ammoniacal-nitrogen was found to be elevated in the cut-off drain number one (Table 3.9.2), and although bacterial concentrations were found to be low, it is likely that this is sourced from septic tank effluent. In the surface waters, ammonium-nitrogen was found to be most concentrated in the Clark Road Drain above SH 2 where elevated bacteria levels were also found. Cut-off drains number one and two have shown consistently elevated nitrate-nitrogen and at times, slightly elevated ammonium-nitrogen and dissolved phosphorus. Again, this nutrient signature is likely to largely be the result of effluent from septic tanks mixing with groundwater.

Sampling after rainfall had mixed results. Surface waters sampled after the first moderate shorter duration rain event showed elevated indicator bacteria results in most surface water bodies. While after a longer more intense event, only the Clark Road Drain above SH 2 displayed elevated indicator bacteria levels.

Table 3.9.2 Dissolved nutrient concentrations (g/m^3), Matatā waterways.

Parameter	Date	Waitepuru Stream Edgecumbe Road	Waitepuru Stream Heale Road	Waitepuru Stream below SH2	Waimea at Division Road	Clark Road Drain above SH2	Cutoff Drain Opp Matatā Hotel	Drain west of Matatā Hotel	Lagoon outlet
DRP (g/m^3)	23/04/2012	0.019	0.017	0.017	0.022	0.015			0.007
DRP (g/m^3)	24/04/2012	0.018	0.017	0.017	0.023	0.012	0.019		0.008
DRP (g/m^3)	27/04/2012	0.019	0.049	0.031	0.029	0.025	0.081		0.008
DRP (g/m^3)	30/04/2012	0.018	0.016	0.016	0.026	0.01	0.104		0.009
DRP (g/m^3)	10/05/2012	0.012	0.012	0.021	0.015	0.019	0.009		0.01
DRP (g/m^3)	27/02/2013	0.027	0.018	0.019	0.142	0.02		0.055	0.014
DRP (g/m^3)	02/10/2013	0.02	0.019	0.018	0.033	0.019		0.026	0.012
DRP (g/m^3)	27/05/2014	0.026	0.018	0.015	No flow	0.008		0.021	0.008
DRP (g/m^3)	07/08/2014	0.039	0.039	0.033	No flow	0.031		0.06	0.025
NNN (g/m^3)	23/04/2012	0.109	0.064	0.077	0.019	0.176			0.005
NNN (g/m^3)	24/04/2012	0.104	0.064	0.077	0.014	0.171	1.75		0.012
NNN (g/m^3)	27/04/2012	0.1	0.093	0.107	0.024	0.167	3.28		0.002
NNN (g/m^3)	30/04/2012	0.099	0.066	0.079	0.016	0.122	3.43		0.001
NNN (g/m^3)	10/05/2012	0.095	0.094	0.27	0.09	0.092	0.134		0.086
NNN (g/m^3)	27/02/2013	0.058	0.003	0.05	1.19	0.528		0.011	0.007
NNN (g/m^3)	02/10/2013	0.05	0.051	0.084	0.09	1.1		0.154	0.005
NNN (g/m^3)	27/05/2014	0.047	0.029	0.103	No flow	0.666		0.983	0.004
NNN (g/m^3)	07/08/2014	0.059	0.053	0.141	No flow	1.01		1.41	0.001
NH_4-N (g/m^3)	23/04/2012	0.023	0.002	0.004	0.001	0.037			0.004
NH_4-N (g/m^3)	24/04/2012	0.017	0.004	0.009	0.001	0.035	0.004		0.005
NH_4-N (g/m^3)	27/04/2012	0.012	0.062	0.03	0.002	0.1191	0.058		0.004
NH_4-N (g/m^3)	30/04/2012	0.011	0.005	0.012	0.004	0.023	0.008		0.002
NH_4-N (g/m^3)	10/05/2012	0.017	0.016	0.03	0.024	0.025	0.037		0.023
NH_4-N (g/m^3)	27/02/2013	0.007	0.005	0.012		0.02		0.05	0.008
NH_4-N (g/m^3)	2/10/2013	0.008	0.008	0.015	0.024	0.096		0.008	0.006
NH_4-N (g/m^3)	27/05/2014	0.014	0.004	0.013	No flow	0.069		0.488	0.006
NH_4-N (g/m^3)	07/08/2014	0.006	0.005	0.016	No flow	0.255		0.413	0.002

Microbial source tracking was undertaken on three samples from May 2014. One sample, taken from the Clark Road Drain at SH 2, tested positive for two human PCR markers, indicating a strong presence of contamination from a human source.

3.9.3 Discussion

The last monitoring to take place in Matata was in 2016. *E.coli* concentrations were slightly improved on previous monitoring events, although those taken in 2014 were generally similar to previous results around Matatā reported by Scholes in 'Investigation of On-Site Effluent Disposal, Matatā', Environment Bay of Plenty Environmental Publication 2005/04, May 2005.

Matatā currently has some septic tanks located in inappropriate soils and in a high water table, leading to contamination of Matatā's local waterways. An ESR report (Gilpin and Lake, 2012) concluded that changing from a septic tank disposal system to a reticulated system with controlled application rate and effective pathogen removal will help reduce contamination of the local environment. A reticulated system would reduce the risk to public health in Matatā from exposure to faecal contaminants.

The Waitepuru Stream, Waimea Stream and Clark Road Drain show some contamination likely to be of septic tank origin. In the case of the water, Waitepuru Stream - there may be some additional influences from rural (or other) sources.

Groundwaters showed no indicator bacterial contamination from septic sources, with the exception of one location adjacent to the Matatā Hotel. This may indicate a preferential flow path or failing systems contributing to contamination. Elevated ammoniacal-nitrogen at this location confirms this.

Local hotspots of contamination have been shown around Clark Road Drain and Division Road, and these are mostly related to small flows near SH 2. This indicates localised contamination from the areas with elevated water tables.

The lagoon outlet currently displays good bacterial water quality, with the one exception being after a heavy rain event. In this case, the increased storm activity is likely to have stirred up lagoon sediments increasing the bacterial loading at this time. Nutrient loading to the lagoon is not examined in this report as water balance would be required to make a robust assessment. Monitoring at the control structure in the eastern lagoon shows dissolved nutrients levels at concentrations similar to stream inflows, indicating that septic tank effluent may only have a minor (if any) impact on the lagoon.

3.10 Bryans Beach

Until recently, the Bryans Beach community was dominated by seasonally occupied baches. 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.

3.10.1 Physical environment

Soils around Bryans Beach are dominated by Opotiki Hill soils, which are loams comprised of very thin Taupo Pumice on Whakatane, Rotoma, Waiohau and Rotorua Tephra, and tephric loess on weathered rhyolitic tephra. Beachfront properties also have a component of well drained Ohope sand.

Annual average rainfall measured at Opotiki is 1175 mm from 1998 to 2010.

Figure 3.10.1 Bryans Beach monitoring site location map.

3.10.2 Previous studies

The Bay of Plenty Regional Council and Opotiki 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.

More recent monitoring has correlated of *E.coli* with ammoniacal-nitrogen in the Bryans Beach Stream, a strong indicator that poorly treated effluent is entering the stream.

3.10.3 Monitoring results

Bryans Beach monitoring has been undertaken to compare upstream and downstream water quality of the stream that runs along Bryan Road and past Wagner Place. Water quality of a stormwater drain that enters the stream above Wagner Place and a drain that runs onto the beach area from a residential location are also monitored.

Comparison of upstream and downstream results of the stream show nutrient and indicator bacteria water quality parameters are higher downstream than upstream (Figures 3.10.2 and 3.10.3). Ammoniacal-nitrogen is notably elevated downstream in comparison to upstream of residential area. As ammoniacal-nitrogen is in high concentrations in septic tank effluent and generally adsorbs onto soil particles, except when contaminant sources overwhelm soil adsorption properties, it is a good marker of septic tank contamination. Together with elevated *E.coli* concentrations downstream, it can be concluded that septic tank effluent continues to reach the small stream.

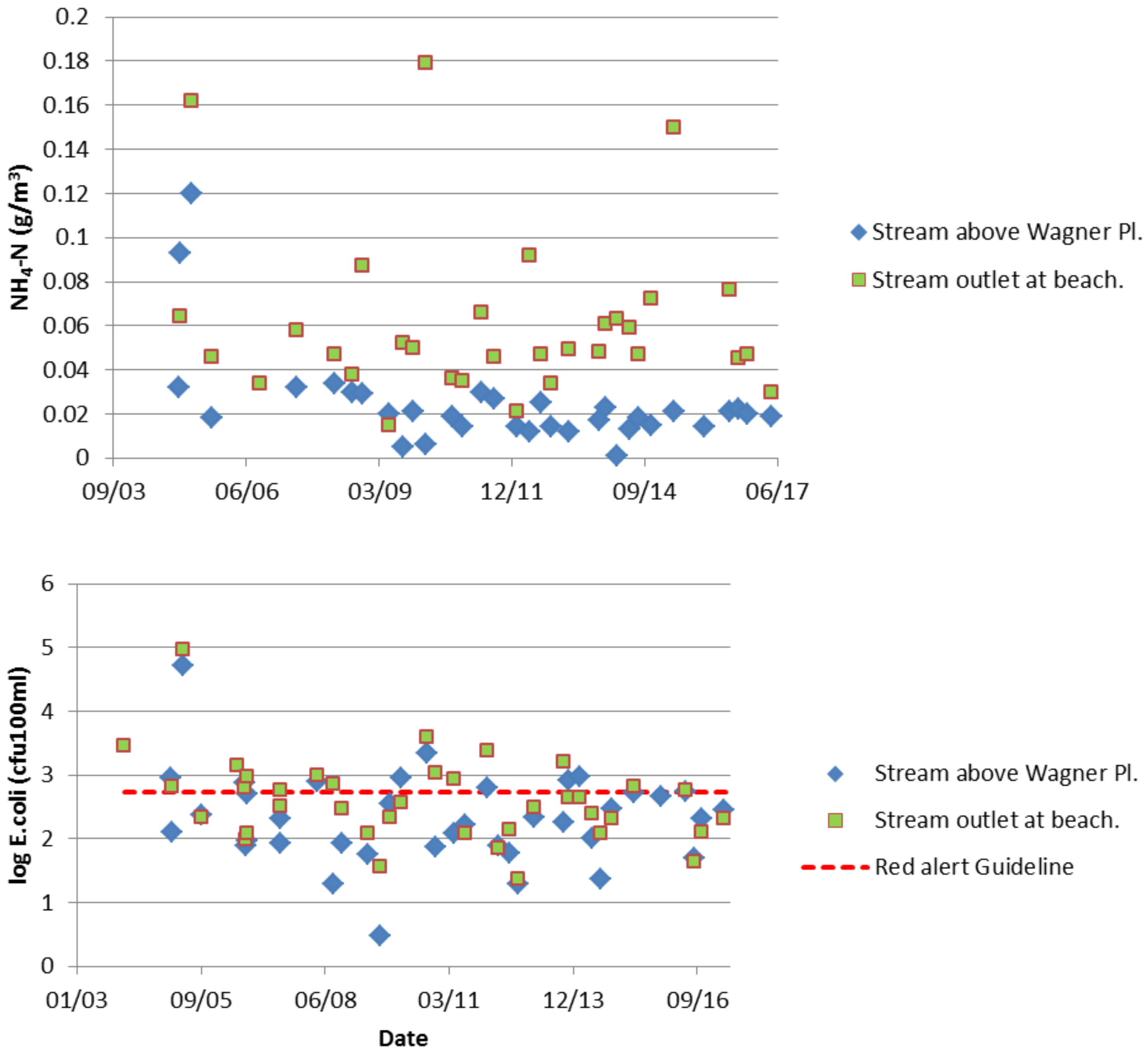


Figure 3.11.2 Ammoniacal-nitrogen and E.coli concentrations from stream sites, 2003 to 2017, Bryans Beach.

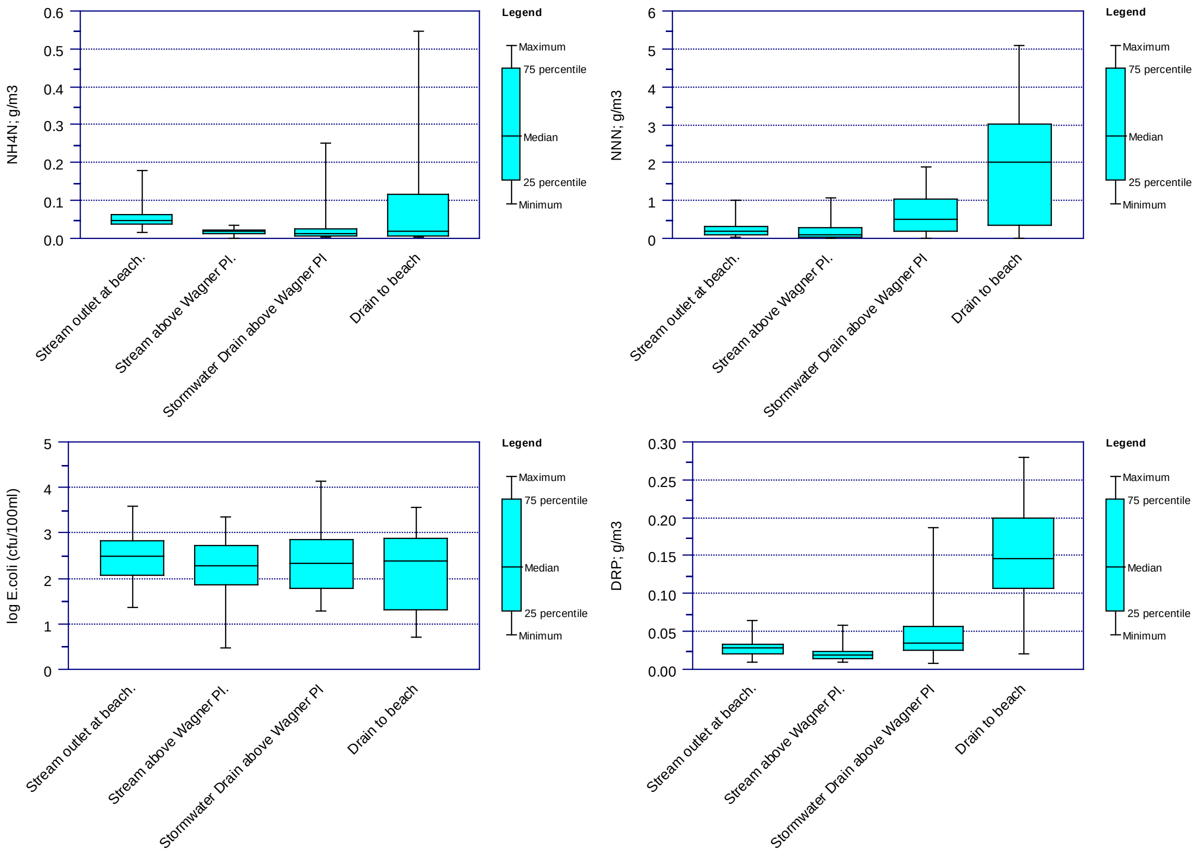


Figure 3.10.3 Box whisker plots of nutrient and E.coli concentrations from stream and drains, 2007 to 2017, Bryans Beach.

The *E.coli* data from the stream shows fewer results over the Microbiological Water Quality Guideline red alert level (Figure 3.10.2) in the past few years. *E.coli* concentrations from the stomwater drains have been higher than the stream results, with the drain to beach showing indications of a downward trend. The highest health risk to the community will be due to potential contact with the drain waters at the beach.

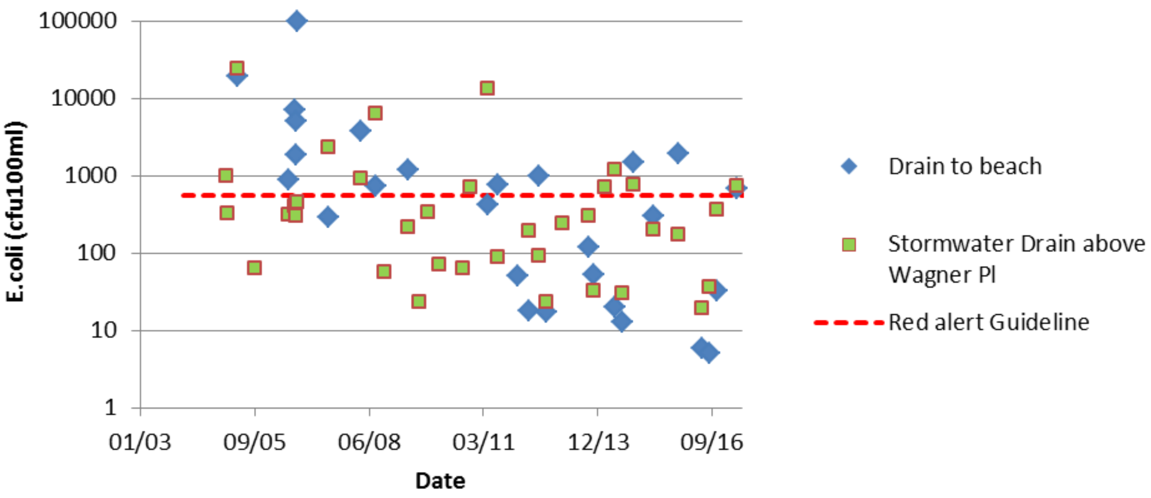


Figure 3.10.4 E.coli concentrations from stormwater drains, 2003 to 2017, Bryans Beach.

Drain to the beach continues to have occasionally elevated ammoniacal-nitrogen and nitrate-nitrite-nitrogen concentrations consistent with septic tank contamination. The stormwater drain above Wagner Place has much lower ammoniacal-nitrogen, but elevated nitrate-nitrite-nitrogen concentrations. Both drains have concentrations of dissolved reactive phosphorus above the steam concentrations. Nutrient data shows likely low level contamination form septic tank effluent to the stormwater drain above Wagner Place, with the drain to beach showing a much higher level of contamination.

The technique of quantitative PCR (qPCR)-based faecal source tracking (FST) markers within for identifying the presence and relative contributions of human and ruminant sources of faecal pollution in waterways, has also been employed. Results of one off sampling round in May 2014 at the site stream outlet to beach, found no evidence of faecal contamination from human markers. However, the sample only has low level bacterial concentrations (*E.coli* = 260 cfu/100 ml) which may not have been adequate to get a conclusive result.

3.10.4 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 therefore pose the highest risk to human health. Full immersion contact is unlikely in these small flows, but there is still a greater than 5% risk of infection from activities with occasional immersion and some ingestion (based on National Policy Statement for Freshwater secondary contact attribute, 2014).

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

3.11 Rotoehu

Cyanobacterial blooms occur at Lake Rotoehu predominantly during the summer months. To help reduce lake eutrophication and cyanobacteria blooms, Lake Rotoehu has an action plan which has as an action to remove nutrients inputs from wastewater to the lake. However, more recently monitoring has been undertaken to assess any faecal contamination risk to recreational users of the lake.

Lake Rotoehu has an estimated population of around 270 residents in summer and 147 in winter. There are around total of 94 properties around the lake shores, primarily based in two communities, Otuatu and Kennedy bays. These two communities have been in a Maintenance Zone since 2006. During this period, only 26 (30%) have ever been inspected. Of the few that have been inspected, only 8 (10%) have passed the criteria for septic tank requirements.

3.11.1 Physical environment

Kennedy Bay community is located on a rapidly increasing incline composed mostly of well drained Matahina sands. The top of Kennedy Bay community and Ōtautū Bay are located on a combination of Matahina sands and Matahina hill soils. These pumice soils are well drained. An ephemeral waterway occurs through the Ōtautū Bay community, but only tends to flow during moderate-high rainfall events.

Rainfall figures from Mangorewa at Kaharoa give an indication of rainfall in this area. Mean annual rainfall from 1986 to 2010 to be in the order of 1828 mm per year.

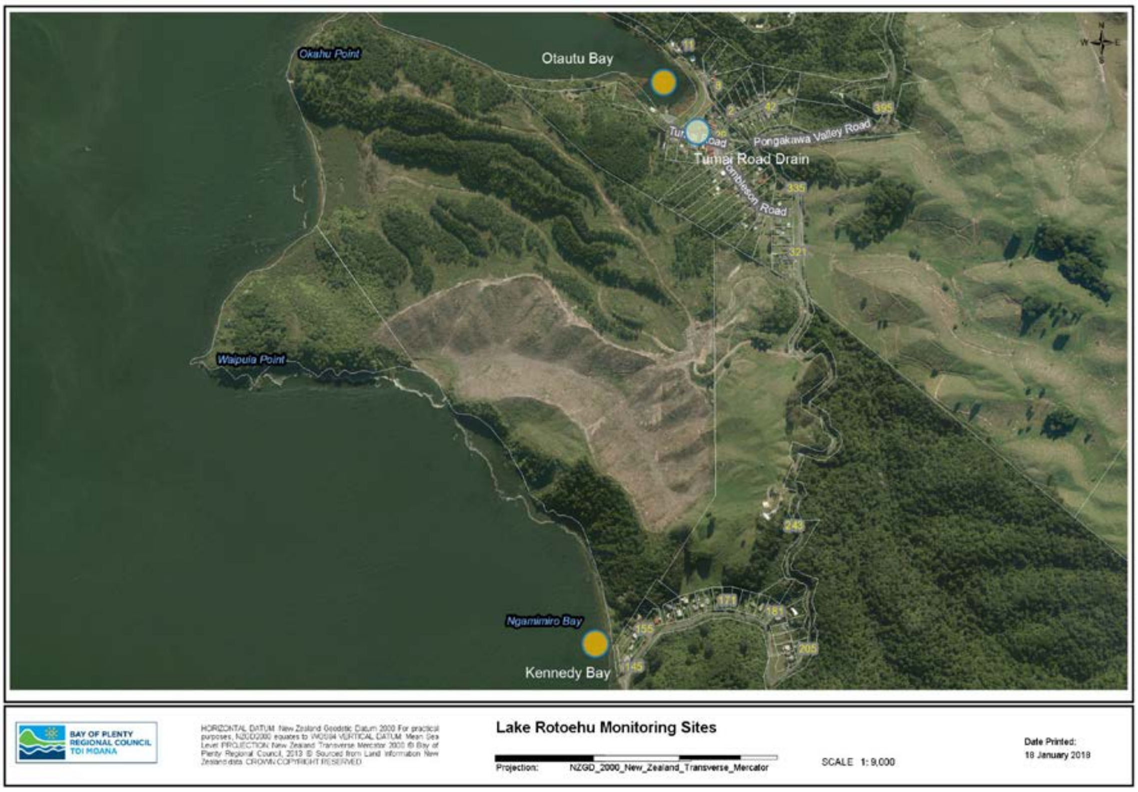


Figure 3.11.1 Monitoring site location map, Lake Rotoehu communities.

3.11.2 Monitoring results

Rotoehu has showed very little indication of contamination in the nearshore lake environment adjacent to the two communities as indicated by *E.coli* concentrations (Figure 3.11.2). Median *E.coli* concentrations over the 2013-14 monitoring period were both 1 *E.coli*/100 ml, well below the orange alert for swimming waters set at 260 *E.coli*/100 ml.

One drain has been sampled, but often has little or no flow. Tamai Road Drain at Ōtautū Bay has shown relatively low *E.coli* concentrations (less than 100 *E.coli*/100 ml), and some of this is likely to be contributed from the pastoral land above the residential area. Nutrient levels were also not usually elevated, although one nitrate-nitrite-nitrogen level was above background concentrations (2.29 gN/m^3). This result could be a mixture of pastoral and septic influences.

Nutrient loading has been estimated in the context of the lake loading budget at around 1% of the total nitrogen and phosphorus budget (Figure 3.12.3). Hence, the contribution and impact from septic tanks on lake eutrophication is very minor.

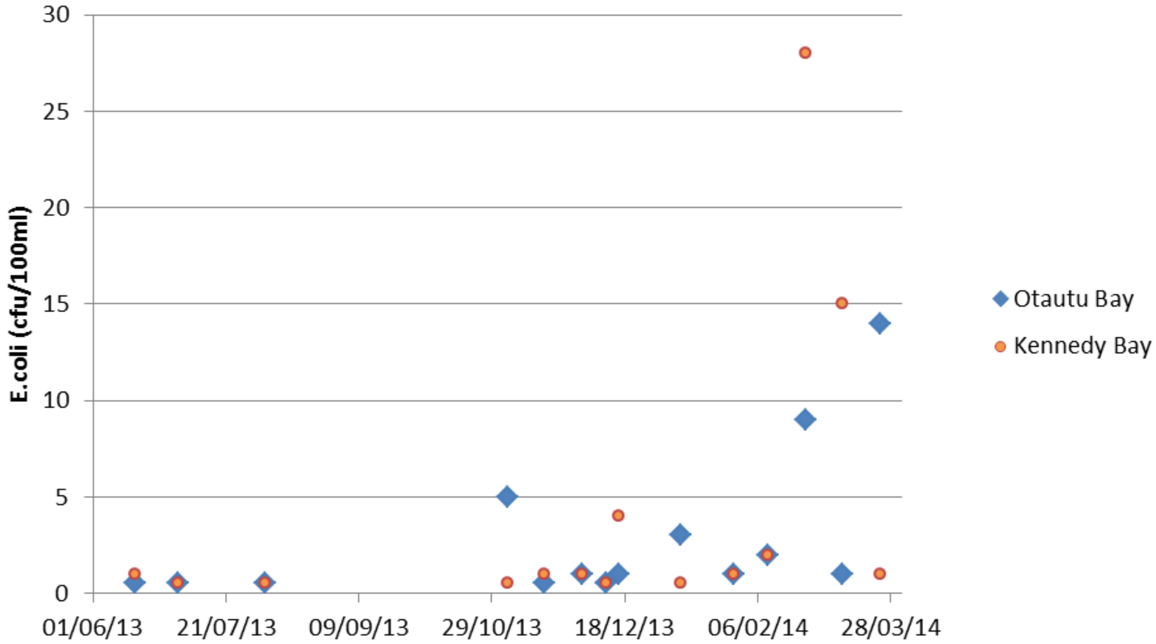


Figure 3.11.2 E.coli concentrations of Lake Rotoehu adjacent to the Otautu and Kennedy Bay communities.

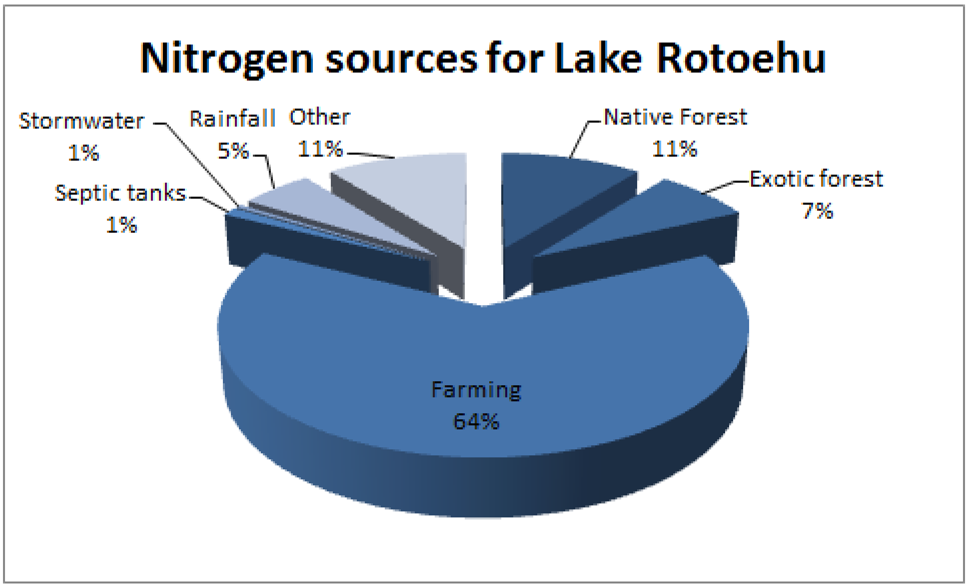


Figure 3.11.3 Nitrogen sources for Lake Rotoehu, from Lake Rotoehu Action Plan, 2007.

3.11.3 Discussion

Limited monitoring of the waters adjacent to the Otautu and Kennedy Bay communities at Lake Rotoehu did not detect any significant contamination that could be associated with on-site wastewater systems discharges. Low occupancy and low housing density would seem to equate to a very low risk of environmental degradation of the lake from these contaminant sources.

Part 4

Recently reticulated communities

4.1 Lake Ōkāreka

The Ōkāreka settlement is built on the western side of Lake Ōkāreka consisting of around 288 dwellings. Reticulation of the township along with Lake Tikitapu was completed in 2010. Since this time the nutrient status of the lake has not improved, but has remained stable. This section explores other physical evidence that reticulation has reduced the environmental impact of septic tank effluent potentially leaching to the lake.

4.1.1 Physical Environment

The settlement area is underlain by Mamaku Ignimbrite, which occurs from depths of about 11 m. The ignimbrite is overlain by a layer of pumiceous rhyolitic gravely sands. The upper *five* in of the soil profile consists of silty sands. Groundwater was generally encountered towards the base of the gravely sands overlying the ignimbrite (NIWA, 2001).

Lake margins are interspersed with wetlands and beaches, with one small permanent inflow to the lake in the township entering the lake near Acacia Road.

4.1.2 Previous and recent monitoring results

The National Institute of Water and Atmospheric Research (NIWA) undertook groundwater sampling November 1999. Samples were analysed for nitrate-nitrogen, ammoniacal-nitrogen, *E.coli* and fluorescing whitening agents (FWA). A similar survey was undertaken in April 2015 at or near the same locations. Results are presented in Figure 4.1.1 to 4.1.3.

Nitrate-nitrogen results from the 1999 NIWA study overall show higher concentrations from the sites sampled in the residential areas. Reduction of nitrate-nitrogen concentrations is likely to a direct result of removal of septic tank effluent discharges. There still remains the question of how much nitrogen has built up in the local soils over the years and how long it takes for this source to be utilised by soil microbes and plants or leached into the water table. The Boyles Beach area which is not residential returned low nitrate-nitrogen concentrations in both 1999 and 2015, with the exception of one result returning nitrate-nitrogen around 1.5 ppm (Figure 4.1.3).

Like the 1999 survey, 2015 ammoniacal-nitrogen concentrations result were at background levels. In the 1999 survey, two results around Steep Street were elevated indicating some influence of septic tank effluent, this was not seen in the 2015 survey.

E.coli concentrations were analysed in 1999 but concentrations were negligible and were not repeated in 2015. Dissolved Reactive Phosphorous (DRP) concentrations were also measured in both surveys. No appreciable difference in concentrations was found in between either surveys (Figure 4.3.4), which may indicate that phosphorous levels remain at background levels as most phosphorous is readily adsorbed to volcanic soils.

Figure 4.1.1 *Shallow groundwater nitrate-nitrogen concentrations, Acacia Road. Green bars are from NIWA study 1999, yellow bars are from 2015.*

Figure 4.1.2 *Shallow groundwater nitrate-nitrogen concentrations, Steep Street beach. Green bars are from NIWA study 1999, yellow bars are from 2015.*

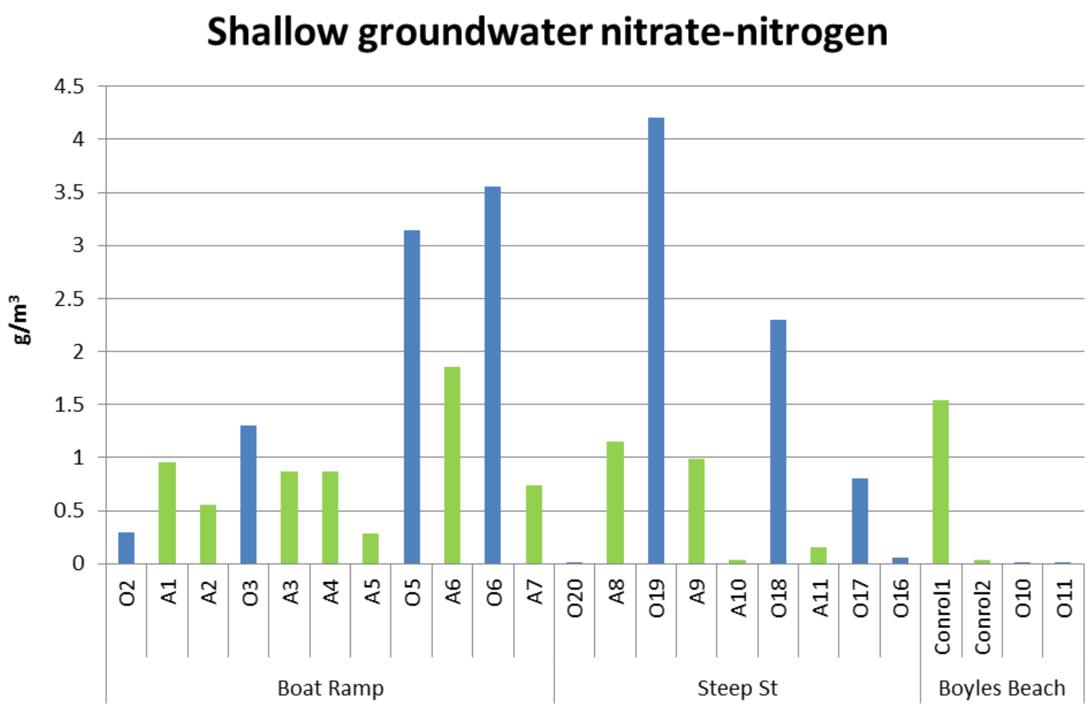


Figure 4.1.3 *Shallow groundwater nitrate-nitrogen concentrations, Lake Okareka. Blue bars ('O' sites) are from NIWA study 1999, green bars ('A' sites) are from 2015.*

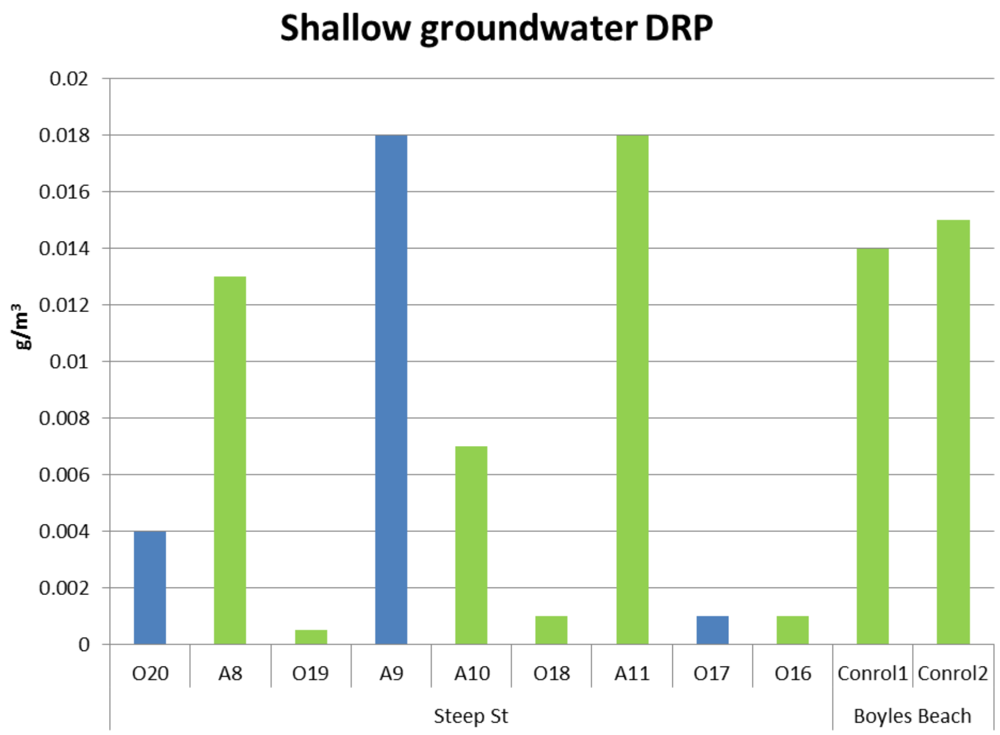


Figure 4.1.4 *Shallow groundwater nitrate-nitrogen concentrations, Lake Okareka. Blue bars ('O' sites) are from NIWA study 1999, green bars ('A' sites) are from 2015.*

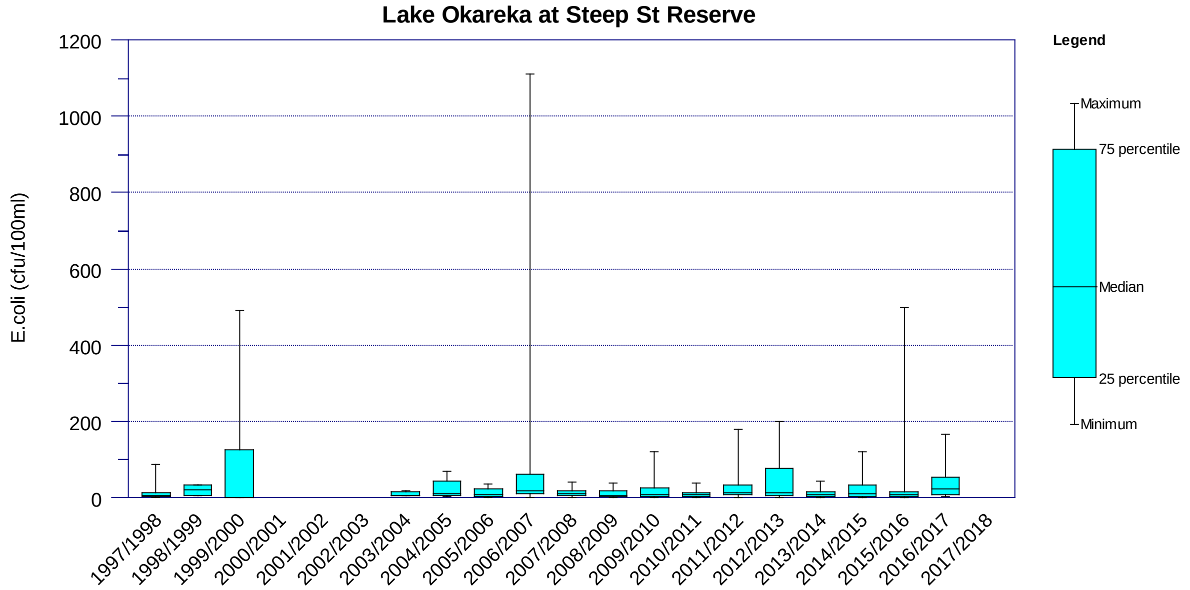


Figure 4.1.5 *Box whisker plot of annual E.coli concentrations, Lake Ōkāreka at Steep Street Reserve.*

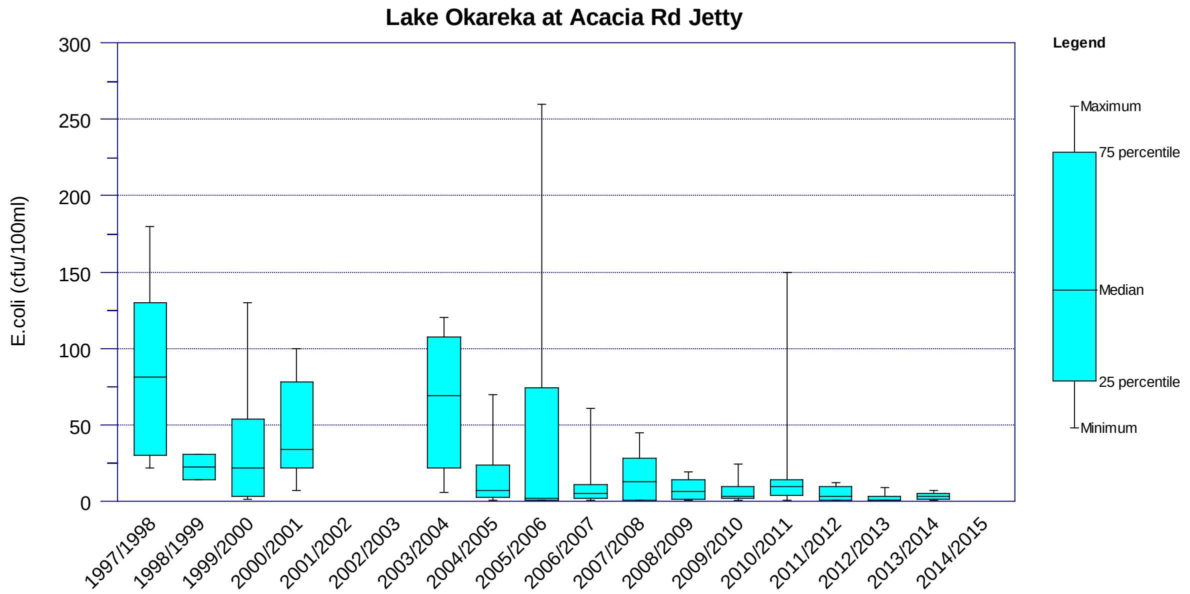


Figure 4.1.6 *Box whisker plot of annual E.coli concentrations, Lake Ōkāreka at Acacia Road Jetty.*

Recreational surveillance monitoring undertaken at Steep Street Reserve and from the jetty in Acacia Road indicates changes in near shore *E.coli* concentration over the past 20 years (Figures 4.1.5 and 4.1.6). No appreciable change in *E.coli* concentrations have been observed at the Steep Street Reserve site, compared to the more highly populated area around Acacia Road jetty, in which has had a strong trend of declining *E.coli* concentrations.

4.1.3 Discussion

Reticulation of Lake Ōkāreka has been undertaken to reduce nutrient inputs to the lake and to remove the risk of health risk from poorly managed and flood prone on-site wastewater treatment systems. As an action under the Lake Ōkāreka Catchment management Plan (2004) reticulation has potentially removed 2.37 tN/yr and 0.02 tP/yr of nitrogen and phosphorus respectively. Comparison of nitrate concentrations in shallow groundwater entering the lake indicates that reticulation has reduced concentrations from the township. No change in phosphorus concentrations was noted.

Risk of impacts from microbial pathogens from septic tanks was tested by Institute of Environmental Science and Research Limited (ESR) (Pang et al., 2001). The ESR study involved a combination of literature review, field trials, laboratory trials and computer modelling. The studies main aim was to establish a 'safe' setback distance from contaminated effluent sources likely to be entering the lake. Environmental Science and Research Limited decided to use two different targets in its assessment. One was the bathing guideline for *E.coli* (<126/100 mL), and the other, the New Zealand Drinking Water Standard of <1 pfu/100 mL for viruses. A setback distance of 16 m was required to meet the bathing guideline of <126 n/100 mL for *E.coli*, while a setback distance of 51 m is required to meet the NZDWS of <1 pfu/100 ml for viruses. This assessment assumed the worst-case scenario that the septic tank leachate would travel into the groundwater without any removal of pathogens.

E.coli concentrations were below detection or at very low levels in shallow groundwater in the 1999 survey, although viral contamination may still remain a risk due to the longevity of these organisms and the smaller size. Setback distance as recommended by the ESR report could not be achieved as lake front properties had been established prior to such recommendations, hence reticulation was warranted to reduce the microbial contamination risk to user of the lake from these properties. Bathing surveillance monitoring of adjacent to the community has observed a notable improvement in *E.coli* concentrations in the lakes nearshore environment since reticulation has occurred.

4.2 Omokoroa

Much of the sewage from Omokoroa 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 Omokoroa foreshore (see Figure 4.2.1) has been carried out since reticulation to document improvements. This monitoring is summarised here.

Figure 4.2.1 Ōmokoroa monitoring site location map.

4.2.1 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 4.4.2). 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, with the exception of one high result in July 2017 after heavy rain. Other drains and seeps are displaying a two or one log (10 to 100-fold) reduction, but these were generally not as highly contaminated as the Domain and Esplanade #1 drains.

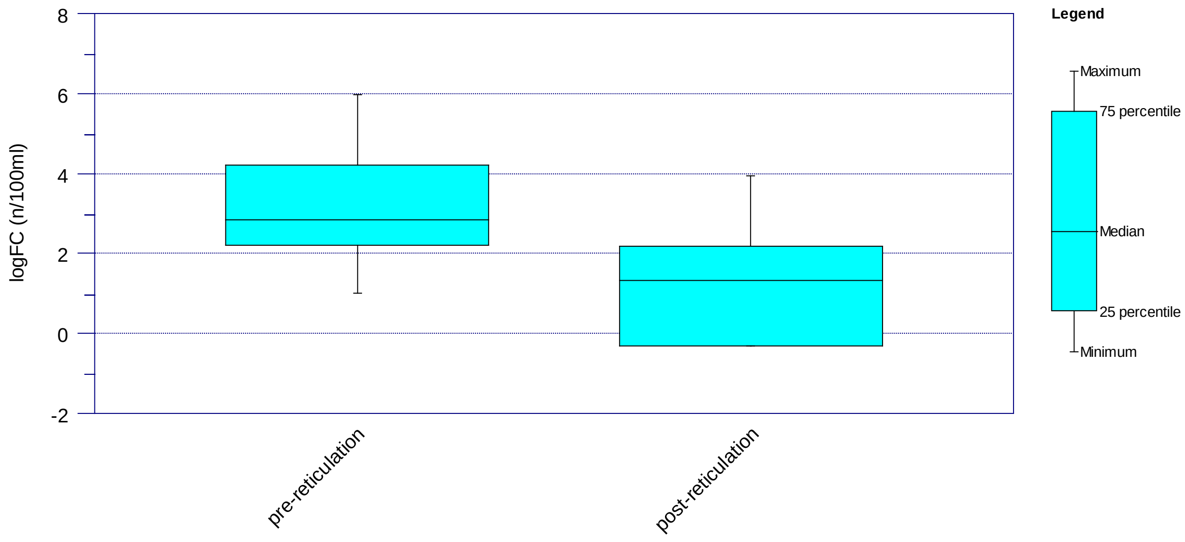


Figure 4.2.2 *Faecal coliform concentrations from drains and seeps, pre (1997-2003) and post-reticulation (2008-2017), Omokoroa. Note; the log scale in the graphs de-emphasises the significant reductions that occurred post-reticulation.*

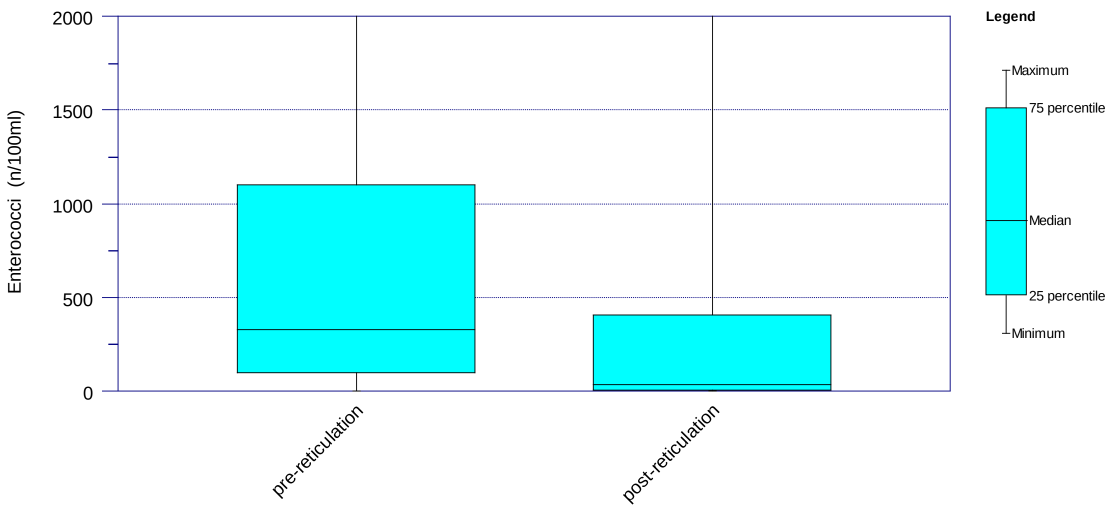


Figure 4.2.3 *Enterococci concentrations from drains and seeps, pre (1997-2003) and post-reticulation (2008-2010), Omokoroa.*

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 Espanade #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 ammoniacal-nitrogen (NH_4-N) and DRP concentrations in discharges to the foreshore. Nitrate-nitrite-nitrogen (NNN) show little change since reticulation (Figure 4.2.5) 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.

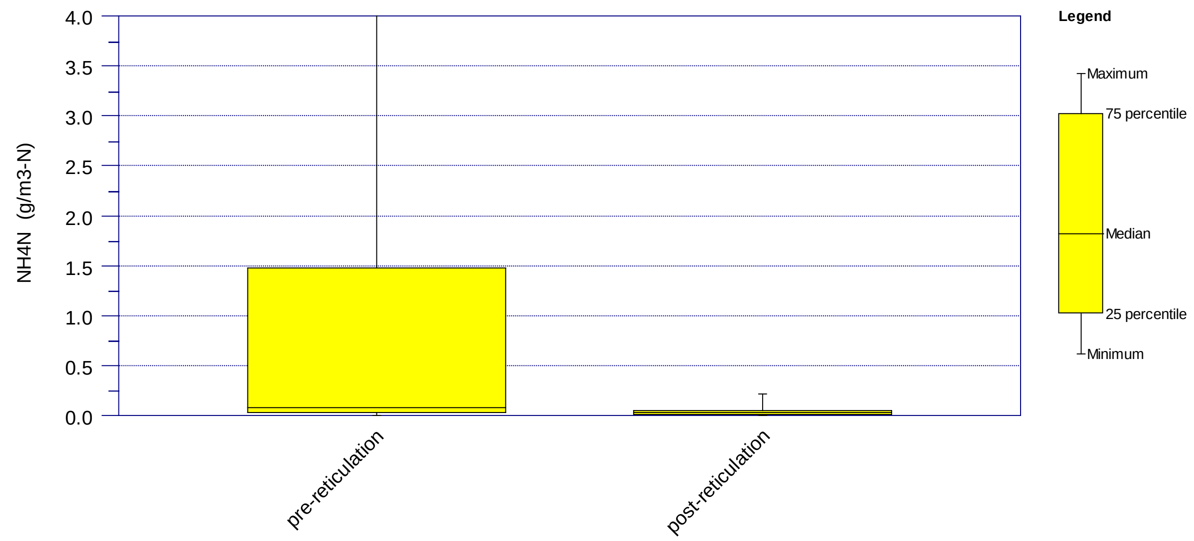


Figure 4.2.4 NH_4-N concentrations from drains and seeps, pre (1997-2003) and post-reticulation (2008-2017), Omokoroa.

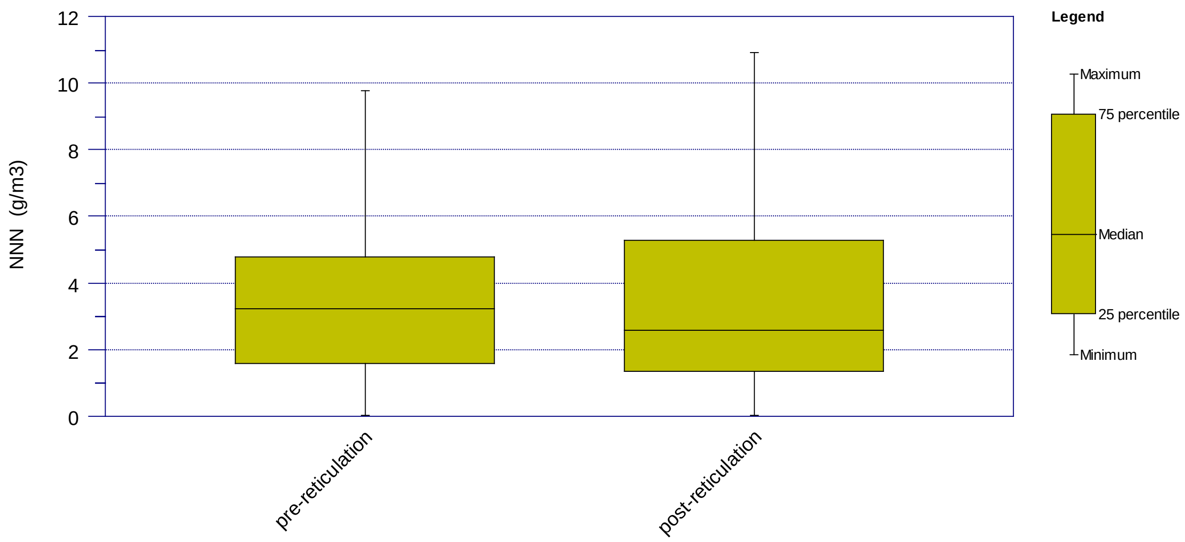


Figure 4.2.5 NNN concentrations from drains and seeps, pre (1997-2003) and post-reticulation (2008-2017), Omokoroa.

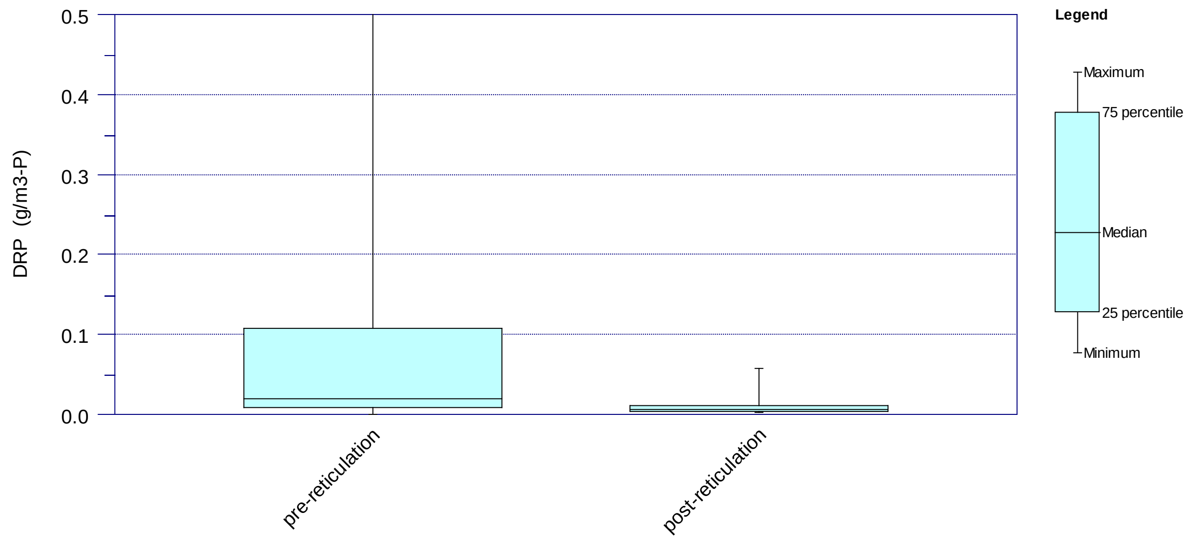


Figure 4.2.6 Dissolved Reactive Phosphorous concentrations from drains and seeps, pre (1997-2003) and post-reticulation (2008-2017), Ōmokoroa.

4.2.2 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

Summary and recommendations

5.1 Summary

Almost all of the waterfront areas 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. It is likely that there is a contribution from OSET systems on these occasions, but direct linkages to discharges from the adjacent communities is difficult to qualify. The greater risk to the community from these sources is foreshore discharge associated with OSET systems. Poor recreational water quality predominantly results from 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. An example of this is documented from Ongare Point.

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 are generally small, for example only 1% (of the total nitrogen and phosphorous load) for Lake Rotoiti. 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.

Surface discharges at the foreshore of the lakes are rare due to the highly permeable soils. Recent monitoring has focused on previously unmonitored communities of Tumoana, Lake Rotoiti and Doctors Point, Lake Rotomā. Monitored of the microbial water quality adjacent to these communities detected little or no contamination. This was also the case for the community adjacent to Lake Tarawera. While this would infer a very low risk to recreational users of the lake, it does not imply that water is suitable for drinking. Setback distances for septic tank discharges are recommended at be greater than 51 m to negate viral infection risk (Pang et al, 2001).

Elevated nutrient levels, particularly nitrate-nitrogen, 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 diversion wall). As already discussed, this can also be seen in the discharges around the Omokoroa foreshore.

The advent of microbial or faecal source tracking using DNA-based or phenotypic/biochemical based techniques to identify sources bacterial gut markers, has helped confirm septic tanks as the source of microbial contamination in many of the communities surveyed. Human faecal contamination has been confirmed in two coastal communities, Te Puna, Ongare Point and also at Mamaku township.

5.2 Recommendations

- Undertake a risk assessment approach to determine which unreticulated communities present a medium-high risk to water quality. Monitoring priorities would be set based on this analysis.
- Continued monitoring of western bay coastal communities: Tanners Point; Ongare Point; and Te Puna West.
- Faecal source tracking to confirm contamination from on-site wastewater treatment systems at Pukehina, Bryans Beach.
- Look at emerging contaminant contamination from on-site wastewater systems in communities with issues of contamination of local waterways from effluent.

Part 6

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