**Title:** Water quality and ecological health in Te Awarua-o-Porirua Whaitua

**Purpose:** To provide information on current water quality and ecological health throughout Te Awarua-o-Porirua Whaitua

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# Water quality and ecological health in Te Awarua-o-Porirua Whaitua

## Contents

# 1. Executive Summary

Greater Wellington Regional Council routinely undertakes a range of water quality and ecological monitoring in the Harbour and three largest sub-catchments in Te Awarua-o-Porirua Whaitua, as well as targeted monitoring in response to specific environmental issues. Wellington Water Limited, on behalf of Wellington City Council and Porirua City Council, also carries out water quality monitoring to understand the effects of discharges from sewer and stormwater infrastructure.

Water bodies in the Whaitua are monitored to assess their suitability for two main purposes: supporting aquatic life (commonly referred to as ecosystem health) and human uses such as swimming and food gathering (commonly referred to as recreational water quality).

Streams in the Whaitua support a range of native fish species. Aquatic invertebrate sample results suggest that stream ecosystem health ranges from 'poor' to 'good'. There are a number of key factors affecting ecosystem health in streams in the Whaitua including channelisation of natural stream form, streambank erosion, elevated toxic contaminants from urban stormwater, elevated nutrient levels from sewer/stormwater discharges and other urban and rural sources.

Analysis of water quality data from GWRC's four long-term stream monitoring sites shows the following trends over the past nine years:

- Decreasing levels of soluble and total nitrogen at the two routinely monitored sites in the Porirua Stream (Glenside and Wall Park)
- Decreasing levels of phosphorus at Porirua Stream at Wall Park
- Stable but elevated median levels of dissolved copper and zinc at both Porirua Stream sites
- Decreasing levels of phosphorus at Pauatahanui Stream
- Increasing levels of nitrogen levels in the Horokiri Stream
- Increasing levels of *E. coli* at all four sites.

Some stream sites in the Whaitua are unlikely to meet the National Policy Statement for Freshwater Management (NPS-FM) secondary contact recreation bottom line of a median of 1000 *E. coli*/100mL. These include Porirua Stream at Wall Park, the lower reaches of the Kenepuru Stream and the lower reaches of Browns Stream.

Overall, water quality in the Whaitua is moderate with contamination from sewer leaks/faults and overflows in the Whaitua a major concern. Inputs of sediment from various activities continue to accumulate in the Harbour. Several sites are not suitable for recreational activities, particularly swimming, with three sites consistently given a 'poor' Suitability for Recreation Grade.

# 2. Background

The Government has set out a National Objectives Framework (NOF) within the National Policy Statement for Freshwater Management (NPS-FM) to support and guide the setting of freshwater objectives in regional plans. Two compulsory national values have been set:

- Ecosystem health - the freshwater management unit supports a healthy ecosystem appropriate to that freshwater body type (river, lake, wetland, or aquifer). In a healthy freshwater ecosystem ecological processes are maintained, there is a range and diversity of indigenous flora and fauna, and there is resilience to change, and

- Human health for recreation - as a minimum, the freshwater management unit will present no more than a moderate risk of infection to people when they are wading or boating or involved in similar activities that involve only occasional immersion in the water. Other contaminants or toxins, such as toxic algae, would not be present in such quantities that they would harm people's health.

Note that a freshwater management unit is defined as either a water body, multiple water bodies or a part of a water body, depending on the appropriate spatial scale. The implication is that water quality over the whole unit can be aggregated, allowing for decline in some parts and improvement in others (AndersonLloyd 2014).

National bottom lines have been outlined; no council can set a freshwater objective below these bottom lines. The Government has set quality bands for the physical attributes of waterways for different values. For example, bands for the value ecosystem health and its attribute dissolved oxygen (DO) are:

- A – no stress caused by low DO on any aquatic organism
- B – occasional minor stress on sensitive organisms caused by short periods of low DO
- C – moderate stress on a number of aquatic organisms
- D – significant, persistent stress on a range of aquatic organisms.

Band D is unacceptable. That is the national bottom line. Councils can maintain waterways at bands A-C, seek to improve them, but cannot go backwards and cannot choose D unless there are exceptional circumstances.

The NOF is continually evolving; more requirements covering different values and different water body types will be added as information becomes available. Councils can also add optional values (e.g. trout spawning). For more information on the NPS-FM refer to the report titled Overview of the NPS-FM 2014 (Vujcich 2015).

# 3. Why measure water quality and ecosystem health?

Water bodies in the Whaitua are monitored as part of GWRC's State of Environment and Recreational Water Quality programmes to assess their suitability for two main purposes:

- Supporting aquatic life which is commonly referred to as ecosystem health. Monitoring of ecosystem health involves measuring biological indicators such as algae, invertebrates and fish as well as assessment of water, sediment and habitat quality.

- Human uses such as swimming and food gathering which is commonly referred to as recreational water quality. Recreational water quality monitoring focusses on measurement of faecal indicator bacteria which represent pathogens that can make people sick.

Monitoring of water quality provides information used by a variety of people and organisations to help protect water bodies, and is a fundamental tool in the management of freshwater resources. There are many ways to measure water quality and it will depend on what the purpose of the monitoring is as to which method, timeframe/data set size is used. This will also influence interpretation of the data. Data can be used:

- to inform national and regional policy and plans
- to observe long-term trends
- to recognise areas where there are contamination problems
- to manage land issues
- to understand impacts of water takes and discharges.

Currently, each Regional Council must determine the measureable objectives, or water quality and quantity attributes that should be used to provide for freshwater values. The NPS-FM includes a NOF which contains minimum levels (bottom lines) below which a regional council cannot set a numeric objective. The national bottom lines only come into play when the existing state of a waterbody is below the line. Elsewhere the "*maintain and improve*" requirement is the main constraint in the setting of objectives.

Water quality is strongly related to land use so this must be taken into consideration. For example, undisturbed land with indigenous vegetation cover generally results in good water quality while disturbed land lacking vegetation often results in degraded water quality. New Zealand's fresh waters are under increasing pressure through agricultural intensification, urbanisation, invasion of exotic species, and climate change (Joy & Death 2013).

# 4. Current status of water quality and ecosystem health

*New Zealand has made good progress in clearing up point source pollution over the last twenty years, but monitoring shows that our water quality is declining in many places, particularly in lowland waterbodies. Also, urban waterways remain highly polluted, including on account of sewage leakages, stormwater run-off and discharges from processing factories. Declining water quality impacts on biodiversity, aquatic ecosystems and instream uses. It can affect human and animal health*.

Land & Water Forum, 2010

Greater Wellington Regional Council (GWRC) routinely undertakes a range of water quality and ecological monitoring in the Harbour and three largest sub-catchments in the Whaitua (Horokiri, Pauatahanui and Porirua streams) as well as targeted monitoring in response to specific environmental issues. Monitoring of water quality at coastal sites popular for swimming and other types of recreation is jointly carried out by GWRC and Porirua City Council (PCC). Wellington Water, on behalf of Wellington

City Council (WCC) and PCC, also carries out some water quality monitoring to assess the effects of sewer and stormwater infrastructure.

## 4.1. Ecosystem health

Ecosystem health is the term used to describe the condition of an ecosystem (a community of organisms interacting with their environment). A variety of information is used to assess ecosystem health, including measures of the biological indicators such as invertebrates, and physical and chemical factors (e.g. temperature and contaminant concentrations) that influence their health (see Appendix A for detailed list).

### 4.1.1. Freshwater

The Whaitua has a large number of streams and tributaries, most of which flow into the Harbour.

Streams in the Whaitua support a range of native fish species. According to the GWRC Proposed Natural Resources Plan (2015a) Porirua, Pauatahanui, Horokiri, Kakaho and Taupo streams as well as Duck Creek support significant indigenous ecosystems including habitat for threatened native fish species, six or more migratory indigenous fish species and inanga spawning sites.

Aquatic invertebrate samples from the Whaitua suggest that ecosystem health of streams ranges from 'good' to 'poor'. Streams with good health tend to be hill country streams outside of the urban area while 'poor' sites are more common in stream reaches with highly urbanised catchments such as some parts of the Porirua and Kenepuru streams (Fig. 1).

Algae, which occurs naturally, can bloom under the right conditions (lack of stream shade, low flows, elevated nutrients) and become a problem in streams in the Whaitua however, frequent flushing from rainfall in the catchment reduces the risk of this. It is likely that none of the stream sites monitored in the Whaitua have levels of algal growth that will exceed the NPS-FM national bottom line (Appendix B).

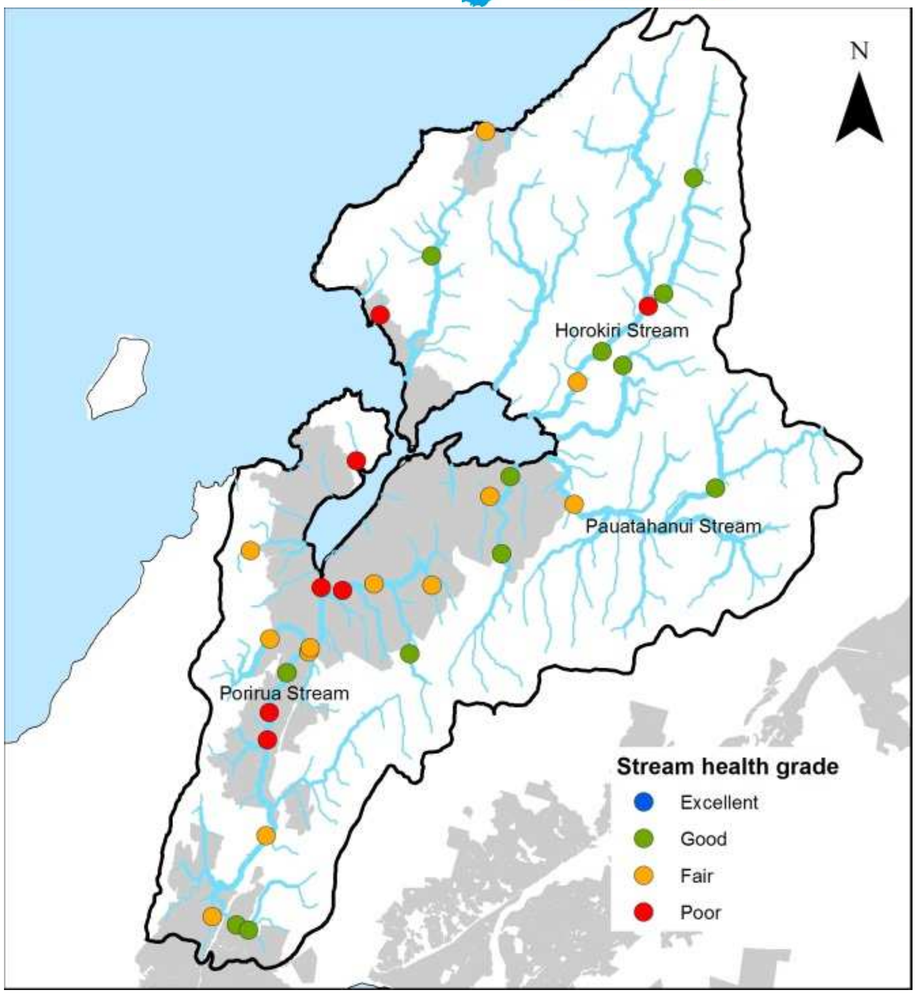


**Figure 1: Map showing invertebrate sampling sites and associated stream health in the Te Awarua-o-Porirua Whaitua based on invertebrate community composition between 2001 and 2014.**

Key factors affecting ecosystem health in streams in the Whaitua are:

- Elevated levels of metals and other toxic contaminants in urban stream water and bed sediment. For example, Porirua Stream at Wall Park has elevated levels of dissolved copper and zinc (e.g. Perrie et al. 2012, Heath et al. 2014) while Kenepuru Stream has high levels of heavy metals, PAHs and DDT (Milne & Watts 2008).
- Reduced habitat quality due to channelisation, lack of riparian vegetation and barriers to fish passage (e.g. perched culverts). Poor habitat quality is particularly an issue in urban streams. Anecdotal evidence suggests that inanga are present only in low numbers because their spawning and rearing habitat has been reduced (Forsyth & Todd 2012). Porirua Stream at Wall Park also has poor habitat quality due to channel straightening and lack of shade from riparian vegetation (Heath et al. 2014).
- Instream sedimentation from stream bank erosion. For example, the bed of the Pauatahanui Stream at Elmwood Bridge has high coverage of deposited sediment (Heath

et al. 2014) which can reduce habitat quality for stream life. Kenepuru Stream also has streambank erosion issues.

- Elevated nutrient levels from sewer/stormwater discharges and other sources. Porirua Stream at Wall Park has elevated levels of nutrients (Perrie et al. 2012) as does Kenepuru Stream (Milne & Morar *in prep*.) which can contribute to algal blooms.

None of the streams monitored in the Whaitua exceed the NPS-FM national bottom lines for nitrate toxicity (Appendix B).

Preliminary analysis of water quality data between July 2006 and June 2015 from the four GWRC monitoring sites shows the following key trends:

- Decreasing levels of soluble and total nitrogen by 2–3% per year at both Porirua Stream sites (Glenside and Walk Park)
- Decreasing levels of phosphorus by 2–3% per year at Porirua Stream at Wall Park and by 3–4% at Pauatahanui Stream at Elmwood Rd Bridge
- Stable but elevated median levels of dissolved copper and zinc at both Porirua Stream sites
- Increasing levels of nitrogen levels by 2–4% per year in the lower Horokiri Stream.

In almost all cases, the trends were evident in both the raw data and data that have been 'adjusted' to take into account variations in stream flow.

Continuous turbidity monitoring stations are located in the lower reaches of Horokiri, Pauatahanui and Porirua streams as they have been identified as delivering the most sediment to the harbour (Green et al. 2014). Although there are spikes in turbidity during dry weather, related to, for example, streambank lawn mowing, the greatest amount of sediment entering the streams typically occurs during wet weather events. During the May 2015 flooding event the three main sub-catchments (Horokiri, Porirua and Pauatahanui) delivered more sediment than recorded in both 2013 and 2014 combined. The Horokiri Stream alone delivered approximately 3,400 tonnes of sediment into the Harbour while Pauatahanui catchment delivered approximately 2,500 tonnes of sediment (GWRC unpublished data).

Water quality is linked to upstream catchment landcover and land use (Perrie et al. 2012). The predominant landcover at GWRC's Horokiri and Pauatahanui stream monitoring sites is pasture while urban land use surrounds both Porirua Stream monitoring sites. A considerable amount of stream piping and reclamation associated with residential and roading development has occurred in urban areas of Porirua in recent years (Perrie et al. 2012). Both Kenepuru and Porirua Stream are impacted periodically by sewer/stormwater discharges and/or faults (such as cross connections).

### 4.1.2. Marine

The Harbour comprises two estuaries and as such, there is a regular exchange of water. Ecosystem health monitoring has, therefore, been largely focussed on aspects of sediment quality because it is in the sediment that contaminants accumulate and the effects of poor ecosystem health will be most evident. GWRC's Coastal State of Environment programme monitors the condition, or health, of intertidal and subtidal sites within the harbour. Monitoring includes measures of sediment quality (including contaminants) and benthic (sea bed) ecology, general water quality (turbidity, nutrients, and suspended solids), the type and extent of habitats (e.g. seagrass, saltmarsh) and substrate (e.g.

mud vs sand vs gravel). Permanent sediment plates are also in place at a number of sites to measure the rates of sediment deposition.

The Harbour is considered to be in 'moderate' health although there is localised contamination of sediments in the Harbour, particularly at the southern end of Onepoto Arm (Sorensen & Milne 2009, Oliver & Milne 2012). The overall ecological health is worse in the Onepoto Arm compared with the Pauatahanui Arm. This reflects the combined influence of higher mud content, nutrients, and stormwater contaminants. Subtidal sediments show levels of heavy metals, PAHs and DDT above Australia and New Zealand Environment and Conservation Council (ANZECC) and Auckland Regional Council (ARC) 'early warning' guidelines (Oliver & Milne 2012).

Limited water quality monitoring within the harbour has found that water quality varies greatly in inner harbour areas where the influence of streams and stormwater inputs are greatest. The inner Onepoto Arm has the poorest and most varied water quality.

Valuable habitat forming species such as seagrass provide nursery and feeding habitats for a range of marine animals. The cover and extent of seagrass has declined by an estimated 40% since the 1980s, largely as a result of reduced water clarity and smothering by sediment. Elevated nitrogen concentrations (e.g. from stormwater and wastewater networks) may also be a factor in reducing seagrass cover (Matheson & Wadhwa 2012). The same elevated nutrients also promote the growth and persistence of large algal species, such as the green sea lettuce which smother other organisms and deplete sediment oxygenation as it decays. At times this can result in the release of unpleasant sulphide ('rotten egg') odours.

## 4.2. Human health

When human health is the focus, the amount of faecal indicator bacteria in the water is measured to determine the suitability of a water body for recreational activities, such as swimming.

### 4.2.1. Freshwater

High levels of the faecal indicator bacteria *E. coli* are a problem in some urban streams in the Whaitua due to sewer/stormwater discharges and/or faults (such as cross connections). This contamination is present in both dry and wet weather but is worse during wet weather. Monitoring of the Porirua Stream at Wall Park between 2012/13 and 2014/15 shows that this site does not meet the NPS-FM national bottom line for secondary contact recreation (median of 1000 *E. coli*/100mL; Appendix B). In addition, monitoring by PCC and Wellington Water indicates that the lower reaches of the Kenepuru and Browns streams are also unlikely to meet the NPS-FM bottom line.

Preliminary analysis of water quality data between July 2006 and June 2015 from GWRC's four monitoring sites shows *E. coli* have increased by 6–14% per year across all four sites.

Cyanobacteria (commonly known as toxic algae) which can also be a risk to human (and animal) health are not known to be an issue in streams in the Whaitua.

### 4.2.2. Marine

Recreational water quality is measured weekly over the summer swimming months and monthly over winter to inform people of the risk to their health from disease causing organisms (Fig. 2). One site within the harbour, the Rowing Club, is consistently graded poor. Plimmerton South Beach and the south end of Titahi Bay are also consistently graded poor.

Modelling of faecal indicator bacteria in the harbour suggests that the plume from the Porirua Stream strongly affects water quality at the rowing club site following heavy rainfall events, with Kenepuru Stream a significant secondary source of faecal contamination (Tuckey 2015 a & b). This modelling also found that wind, rather than tide, drives water movement throughout both arms of the Harbour, and can cause eddies to develop in the main basin trapping faecal contaminants in the Harbour.

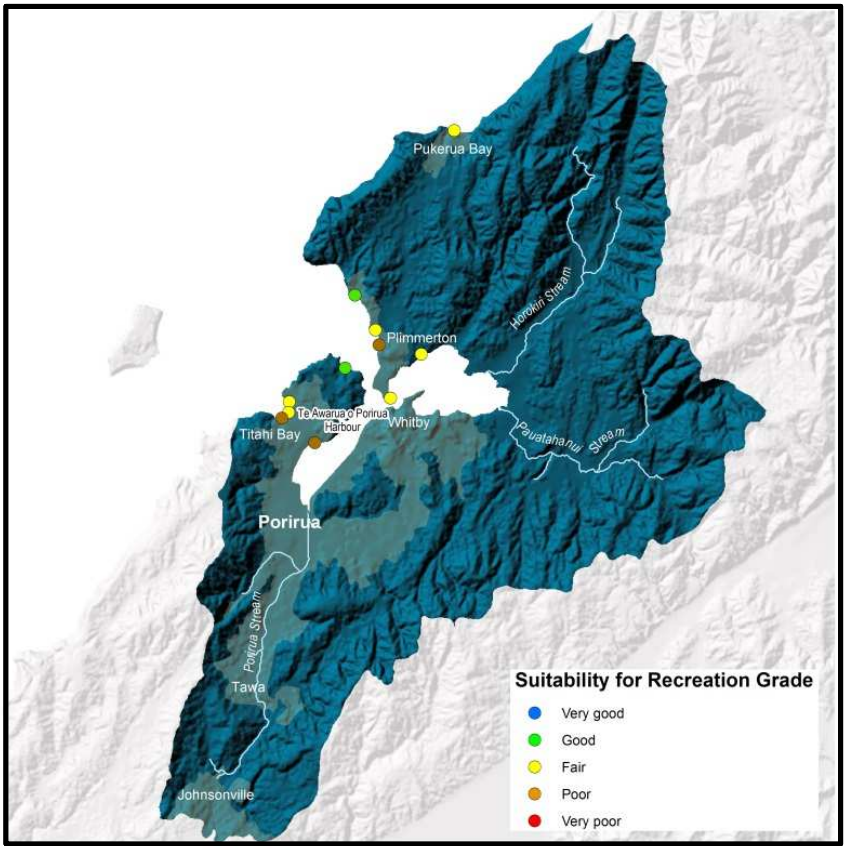


**Figure 2: Map showing coastal recreational water quality sites and Suitability for Recreation Grades as at June 2015.**

# 5. Where and what is measured in the whaitua

All monitoring carried out in the Whaitua by GWRC contributes to the State of Environment (SoE) reports and recreational water quality reports of the Wellington region as well as summary cards for each sub-region such as Porirua. Much of the data can be found on GWRC and the Land, Air Water Aotearoa (LAWA) websites.

## 5.1. River and stream ecosystem health and water quality

GWRC measures many aspects of surface water quality in streams ranging from pH and turbidity to faecal indicator bacteria, nutrients, suspended sediment and heavy metals (copper and zinc). Stream biological monitoring includes measurements of streambed algae (periphyton) and the number of small animals, known as macroinvertebrates, present. These are measured for a variety of reasons such as being a requirement for aquatic life or as an indicator of habitat or water quality. Appendix A lists the key stream monitoring variables and why they are measured.

Water quality variables are measured monthly while most biological indictors are measured annually. Four sites (Horokiri Stream at Snodgrass, Pauatahanui Stream at Elmwood Br, Porirua Stream at Glenside and at Wall Park) are monitored in the Whaitua as part of GWRC's Rivers SoE programme.

## 5.2. Coastal water quality

GWRC monitors the health of Wellington region's near-shore coastal environment, including sites in the Whaitua, which contain significant habitats for a variety of plants and animals, and provides for a diverse range of human activities (Oliver & Milne 2012).

'Broad scale' (essentially percentage cover) aspects of estuary health (algal, seagrass and saltmarsh cover, and substrate type [sand, mud, etc.]) are monitored between high and low tide (intertidal) either on an annual or five-yearly basis.

Indicators of ecological health and sediment quality are monitored both above (intertidal) and below (subtidal) low tide. Monitoring includes measures of benthic invertebrate communities, sediment mud content, organic carbon content, nutrients, DDT, hydrocarbons and heavy metals, with sampling carried out at annual or five-yearly intervals. Rates of sedimentation are also measured annually at 18 sites using buried sediment plates.

## 5.3. Recreational water quality

Recreational water quality at popular coastal sites is measured weekly over the summer swimming months, and monthly over winter, to inform people of the risks to their health from disease causing organisms. This monitoring is a joint effort between GWRC and PCC. Water contaminated by human or animal excreta may contain a diverse range of pathogenic (disease causing) micro-organisms such as bacteria, viruses and protozoa (e.g. salmonella, campylobacter, cryptosporidium, giardia). These organisms may pose a health hazard when the water is used for recreational activities such as swimming. The most common illness from swimming in contaminated water is gastroenteritis, but respiratory illness and skin infections are also quite common.

Enterococci are the faecal indicator bacteria measured in coastal waters. Monitoring focuses on sites where people are most likely to swim. Sites are given one of five "suitability for recreational grades" (SFRG; more detail in Appendix C) that range from 'very good' to 'very poor'. An SFRG is an overall water quality grade based on long-term information on both water quality and catchment faecal contamination risk. All recreational water quality variables measured are compared to the national guidelines for recreation.

Note that recreational water quality monitoring in streams in the Whaitua is focussed on secondary contact recreation only and involves monthly measures of *E. coli* at GWRC's four Rivers SoE sites.

## 5.4. Other Monitoring

A wide range of ecosystem health and water quality information is also collected by other departments at GWRC as part of environmental impact assessments and monitoring for resource consents. Wellington and Porirua City Council's also run water quality monitoring programmes in the Whaitua that are managed by Wellington Water Limited (WWL). The focus of these programmes is on microbiological water quality.

### 5.4.1. Porirua City Council (PCC)

In November 2011, PCC staff implemented a water quality monitoring programme at selected stream and stormwater sites focussed on identifying potential 'hotspots' within Porirua City's wastewater and stormwater network. Sites were sampled at approximately monthly intervals, with some targeted sampling (on GWRC's advice) to capture wet weather events. Some changes were necessary to monitoring sites within the first few months due to saline influences (e.g. the Duck Creek site was moved further upstream). Some sites were also changed by PCC following an interim review of the results with GWRC in July 2012. In May 2013, the programme was further scaled back to a handful of sites and a microbiological water quality focus (Milne & Morar *in prep*.).

In late 2014, WWL established a new programme after looking at the earlier monitoring. This programme involves monthly water quality sampling at nine sites within Porirua (mostly stream mouths and two stormwater outfalls (Te Hiko Street and Semple Street outfalls). Water samples are tested for *E. coli* indicator bacteria and the results compared against the NPS-FM bottom line of 1,000 *E. coli*/100mL.

### 5.4.2 Wellington City Council (WCC)

Each fortnight water samples are collected from five sites in the Porirua Stream catchment as part of WCC's much larger Beaches and Streams programme that covers a number of beaches, streams and stormwater outlets across Wellington City. This ongoing monitoring programme dates back to the early 1990s and the implementation of WCC's Sewage Pollution Elimination (SPE) Programme seeking to identify and address pollution from the sewer and stormwater network entering the city's beaches and streams. Water samples are mostly tested for *E. coli* and faecal coliform indicator bacteria.

# 6. What affects water quality and Ecosystem Health?

The landscape of the Whaitua has been greatly modified by settlement. Reclamation of parts of the Harbour (mainly in the Onepoto arm) and streams for transport infrastructure and urban development, modification of stream channels for flood protection and removal of native vegetation cover have resulted in the greatest changes to the landscape (Ammundsen 2015).

## 6.1. Natural influences

Water quality can vary naturally between catchments and sub-catchments as a result of differences in geology, topography and climate. The Whaitua has a base of greywacke overlain with loess (windblown silt) which contributes to sedimentation. This can be exacerbated by changes in land cover and use. Sub-catchments of the Porirua Stream have little vegetation cover other than pasture grass or residential gardens and an increase in the area of hard surfaces (e.g. asphalt) leading to an increase in sediment and contaminant-laden runoff. In comparison the Pauatahanui Inlet catchment, and associated sub-catchments, have more vegetation, plantation forestry and less urban development; this means water quality is generally better in this part of the Whaitua.

Rainfall can have a significant impact on water quality, as runoff from rural or urban land containing sediment and other contaminants washes into streams and to the coast. The mean annual rainfall varies across the Whaitua ranges from 1,000–1,200mm in the west to 1,200–1,400mm in the east (GWRC hydrology paper, 2015b). Streams in the west areas may be more prone to low flows and therefore more likely to incur higher temperatures and possible increases in algal growth.

Tides and currents may influence water quality at coastal sites, stirring up sediments and carrying contaminated freshwater to sheltered areas. However, wind direction has been found to be the more significant influence on the dispersal of (faecal) contaminants throughout the Harbour (Tuckey 2015 a & b). Eddies created by windy conditions retain material originating from the freshwater streams in localised areas of each arm of the Harbour. Waves also re-suspend sediments and other contaminants in the water column thereby reducing water quality through increased turbidity.

## 6.2. Land Use

Catchment land cover and land use can significantly affect stream health. Loss of natural vegetation cover can lead to direct effects on water quality, such as increased light penetration and water temperatures, and indirect effects such as increased runoff.

Land use has influenced water quality in a number of ways. Runoff from agricultural land can adversely affect river and stream water quality and ecological health by adding sediment, faecal material and nutrients to the waterways. Direct stock access to rivers and streams can add to the degradation through direct deposit of faecal matter and urine into the water and damage to stream banks, degrading riparian habitat and adding sediment to the waterway.

In urban areas water quality is affected primarily from stormwater (originating from rainfall and domestic sources such as car washing) and sewer leaks/faults/overflows. Stormwater flows from impervious surfaces (e.g. roofs, roads) through the stormwater system, picking up sediment, rubbish, animal faeces and other contaminants (e.g. heavy metals), along way before exiting to streams or the coast. Heavy or prolonged rainfall may result in untreated sewage from sewage pump station failures or pipe overflows discharging into streams or the coast.

Urban land use can also adversely impact ecological health through the loss of instream or riparian habitat, due to stream piping or artificial channelisation.

## 6.3. Other Stressors

As mentioned in Section 4 and Appendix A, ecological health is affected by various other stressors (biological, chemical and physical). The sites in poorest condition usually have one or more of the following stressors: nutrient enrichment, poor clarity, toxicity, microbiological contamination, and/or habitat degradation.

- Nutrient enrichment occurs from stormwater/sewer discharges and rural run-off. High nutrient levels can contribute to increased algae growth (periphyton and macrophyte growth).

- Poor water clarity prevents light thereby reducing algal growth but also affecting the ability of sight-feeding animals (e.g. fish) to locate food. It also reduces recreational and aesthetic appeal for human activities.

- Sediments can smother invertebrates living on the stream/harbour bottom, clog the gills of filter feeding animals, degrade fish spawning habitat, increase sediment deposition on the streambed and accumulate other contaminants.

- Microbiological contamination, typically of faecal matter, occurs often after rainfall and is linked to sewer/stormwater overflows and faults and animal fouling.

- Habitat degradation is linked with degraded instream and/or riparian habitat. The streams with poorest macroinvertebrate health tend to have a lack of riparianvegetation and a high amount of fine sediment on the streambed.

*"If we've got a dirty river let's understand why it's dirty and what science can tell us about fixing it…"*

Bruce Willis (then President Federated Farmers), 2011

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# 8. Acknowledgements

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# APPENDICES

## A. MONITORING VARIABLES

Core water quality and biological variables measured as part of GWRC's River State of Environment (RSoE) monitoring programme including a brief description of relevance to surface water quality (table adapted from Perrie et al 2012).

| Variable | Explanation/relevance |
|---|---|
| Water temperature | • Indicator of biological activity – temperature affects the functioning of aquatic ecosystems and the physiology of biota, including cell function, enzyme activity, bacteriological reproduction rates, and plant growth rates.<br>• Requirement for aquatic life (e.g. temperatures >19°C can stress trout).<br>• Influences dissolved oxygen concentrations (the higher the temperature, the lower the oxygen concentration) and can affect the toxicity of certain pollutants such as ammonia. |
| Dissolved oxygen (DO) | • Essential for aquatic life – concentrations less than 5 mg/L adversely affect trout and concentrations of 2–3 mg/L may result in fish kills.<br>• Indicator of organic pollution (e.g. sewage) – DO concentrations are reduced as bacteria require oxygen to break organic matter down.<br>• Indicator of photosynthesis (plant growth). |
| pH | • Protection of aquatic life – particularly high (alkaline) or low (acidic) pH levels may adversely impact on aquatic biota. Alkaline conditions may also increase the toxicity of certain pollutants such as ammonia.<br>• Indicator of industrial discharges. |
| Conductivity | • Indicator of total salts/mineral content – the lower the value, the purer the water is. Wastewater/effluents therefore have higher concentrations of minerals than natural water and a large increase in the conductivity in a water body can often be traced back to wastewater discharges. However, considerable natural variation exists and some rivers and streams may have naturally elevated conductivity concentrations. |
| Visual clarity, turbidity and suspended solids | • Aesthetic appearance.<br>• Aquatic life protection – differences in water clarity affect the ability of sight-feeding predators (e.g., fish, birds) to locate prey and the ability of algae to photosynthesise and hence provide food for animals further up the food chain.<br>• Indicator of light availability for excessive plant growth.<br>• Indicator of catchment condition, land use.<br>• Suspended sediment in the water column can clog the gills of invertebrates and fish.<br>• Excessive deposition of sediment on the streambed can block and seal off interstitial spaces (the spaces between cobbles/stones where most fauna live or rest), reduce water flow to the hyporheic zone (water under the streambed) where some stream animals live, degrade fish spawning habitat and encourage the growth of nuisance aquatic plants. |
| Total organic carbon | • Indicator of organic carbon content of a water body – provides a quick and convenient way of determining the degree of organic contamination (e.g., as a result of wastewater discharges). |

Te Awarua-o-Porirua Whaitua Committee

greater WELLINGTON REGIONAL COUNCIL Te Pane Matua Taiao

| Variable | Explanation/relevance |
|---|---|
| Nutrients<br>- Nitrogen<br>- Phosphorus | • Vital elements for aquatic plant and algal growth – may be limiting factors in plant growth when in short supply but in sufficient quantities they may also promote unsightly algal blooms and nuisance plant growth. Dissolved inorganic nutrient concentrations (ammoniacal nitrogen, nitrite-nitrate nitrogen and dissolved reactive phosphorus) are most relevant for predicting the potential for nuisance plant growth as they are the principal forms available to plants (ie, soluble). Total nutrient concentrations are also relevant in surface waters, because particulate matter can settle out in quiescent areas and become biologically available to plants via mineralisation.<br>• Nitrate, in sufficient concentrations, is harmful to livestock and humans, and toxic to aquatic life.<br>• Ammoniacal nitrogen comprises ammonium ($NH_{4+}$) and unionised ammonia ($NH_3$). Ammonia is rarely found in any significant amounts in natural waters and its presence most commonly indicates the presence of domestic, agricultural or industrial effluent. Ammonia is very soluble in water and can be toxic to aquatic life, especially fish. Toxicity is a function of both temperature and pH, with toxicity increasing with increasing water temperature and alkalinity. |
| *E. coli* | • Indicator of pollution with faecal matter, useful for determining the suitability of waters for contact recreation and stock drinking – presence in water may indicate the presence of harmful pathogens that can cause eye, ear, nose and throat infections, skin diseases, and gastrointestinal disorders – a number of parasites and pathogens can also be transmitted by contaminated water to livestock and affect their health.<br>• *E. coli* is the most specific indicator of faecal contamination and is nearly always found in high numbers in the gut of humans and warm blooded animals. *E. coli* is the preferred microbiological indicator for faecal contamination and health effects in fresh waters. |
| Heavy metals | • Natural elements of which some (eg, copper and zinc) are essential for metabolism. Can be toxic to aquatic life at higher concentrations and tend to bioaccumulate. Toxicity can vary depending on many factors, including water temperature, pH and hardness. |
| Periphyton | • Periphyton is the slimy material attached to the surfaces of rocks and other bottom substrate in rivers and streams. It comprises algae, diatoms, bacteria, and fungi and plays a key role in aquatic food webs because it is the main source of food for benthic invertebrates, which in turn are an important food source for fish.<br>• Excessive periphyton growths may block intake screens for water supply, and reduce the aesthetic, recreational and ecosystem values of rivers and streams. |

| Variable | Explanation/relevance |
|---|---|
| Macroinvertebrates | • Macroinvertebrates are organisms that lack a backbone and are larger than 250 microns in size. Four major groups of macroinvertebrates exist: *insects* such as mayflies, caddisflies and dragonflies; *molluscs* such as snails and mussels; *crustaceans* such as freshwater shrimps and amphipods; and *oligochaetes*, aquatic worm species that live in muddy streambeds.<br>• Different macroinvertebrate species have different tolerances to environmental factors such as dissolved oxygen, nutrients and fine sediment, such that the presence or absence of different species in an environment may indicate changes in water quality.<br>• Macroinvertebrates indicate long-term water quality conditions compared with spot physico-chemical samples which only represent water quality at time of sampling. |
| Fish | • Fish are a key component of river and stream ecosystems and a very useful indicator of ecosystem health because they respond to both local and catchment-scale impacts. The majority of indigenous fish species are diadromous (migratory) so require connectivity to and from the sea. A healthy indigenous fish community is also dependent on water quality and habitat quality. Some introduced fish species can negatively impact indigenous fish communities (eg, through direct predation and competition and indirectly through affecting food webs, water quality and habitat). |
| Deposited sediment | • The degree of fine sediment cover of a river or stream bed alters the physical habitat by clogging interstitial spaces used as refugia by benthic invertebrates and fish, by altering food resources and by removing sites used for egg laying. |
| Habitat | • Habitat quality is a strong driver of ecological health in rivers and streams. Generally speaking, ecological health is highest when there is a diversity of stream substrate, flow (runs, riffles and pools) and good riparian vegetation to stabilise stream banks and provide instream shade/cover. |

## B. NATIONAL OBJECTIVE FRAMEWORK (NOF) TABLE

Assessment of NPS-FM nitrate toxicity, *E. coli* and periphyton attributes for streams in the Te Awarua-o-Porirua Whaitua was based on data from the Rivers State of the Environment monitoring programme. As outlined in the NPS-FM, assessment of the nitrate toxicity attribute has been based on a median (i.e. the value below which 50% of results are found) and a 95th percentile (i.e. the value below which 95% of results are found) nitrate-nitrogen concentration. Calculation of median and 95th percentile nitrate-nitrogen concentration and median *E. coli* concentration was based on monthly measurements collected between July 2013 and June 2015 (36 results).

Assessment of the periphyton attribute is indicative only. This is because the NPS-FM requires monthly assessment of periphyton biomass as opposed to the annual measurements that are currently undertaken. Annual data collected during summer/autumn between 2004 and 2015 (11 results) have been compared to the bottom line (200 $mg/m^2$) to provide an indicative assessment. Sites with two or less results within 80% or greater of 200 $mg/m^2$ were identified as likely to meet the bottom line. Sites with more than two results within 80% or greater of 200 $mg/m^2$ were identified as unlikely to meet the bottom line (Table 1). An indicative periphyton attribute band based on a rough qualitative assessment has also been provided.

Note that ammonia toxicity and dissolved oxygen attributes have not been assessed due to lack of guidance from MfE as to their application and, in the case of the dissolved oxygen attribute, lack of data from below point source discharges.

**Table 1: Assessment of data from Rivers State of the Environment monitoring sites in the Te Awarua-o-Porirua Whaitua against National Policy Statement for Freshwater Management nitrate toxicity, *E. coli* and periphyton attributes**

| Site Code | Site Name | Median nitrate-N NOF band | 95th percentile nitrate-N band | *E. coli* - secondary contact band | Periphyton bottom line likely to be met? | Likely periphyton band |
|---|---|---|---|---|---|---|
| RS13 | Horokiri Stream at Snodgrass | A | A | B | Likely | A/B |
| RS14 | Pauatahanui Stream at Elmwood Bridge | A | A | B | Likely | B/C |
| RS15 | Porirua Stream at Glenside Overhead Cables | A | B | B | Likely | A/B |
| RS16 | Porirua Stream at Milk Depot | A | A | D | Likely | A/B |

## C. SUITABILITY FOR RECREATION GRADE

Information below taken from GWRC website: http://www.gw.govt.nz/water-quality-faqs/#Suitability for Recreation Grades.

**What is Suitability for Recreation Grade (SFRG)?**

Suitability for Recreation Grade (SFRG) describes the likely health risk from direct contact with the water at any one time. It only relates to health risk from faecal contamination of water from disease causing organisms (ie, it doesn't include health risk from toxic algae) and is made up of two components: assessment of the catchment area for sources of faecal contamination (ie, farmland runoff, stormwater discharges or large waterfowl populations) and faecal indicator bacteria results from the previous five summers.

**What do the grades mean?**

There are five SFRGs, ranging from 'very good' to 'very poor'. The potential risk of becoming sick from contact with the water at a site increases as the grading shifts from 'very good' to 'very poor'.

**Table 1: Suitability for Recreation Grade and description**

| Grade | Description |
|---|---|
| Very good | The site has generally excellent water quality and very few potential sources of faecal pollution. Water is considered suitable for swimming for almost all of the time |
| Good | The site is considered suitable for swimming for most of the time. Swimming should be avoided during or following heavy rain |
| Fair | The site is generally suitable for swimming, but because of the presence of significant sources of faecal contamination, extra care should be taken to avoid swimming during or following rainfall or if there are signs of pollution such as discoloured water, odour, or debris in the water |
| Poor | The site is susceptible to faecal pollution and water quality is not always suitable for swimming. During dry weather conditions, ensure that the swimming location is free of signs of pollution, such as discoloured water, odour or debris in the water, and avoid swimming at all times during and for up to two days following rainfall |
| Very poor | The site is very susceptible to faecal pollution and water quality may often be unsuitable for swimming. It is generally recommended to avoid swimming at these sites |