Northland REGIONAL COUNCIL
Te Kaunihera ā rohe o Te Taitokerau

River water quality and ecology in Northland

Te kounga wai i ngā awa me te hauropi i roto i Te Taitokerau

State and trends 2012–2016

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Executive summary

This report provides a snapshot on the current state and trends of water quality and ecological health at 34 Northland River Water Quality Monitoring Network (RWQMN) sites from January 2012–December 2016. It is the second in a series of reports initiated in 2007 to provide 5-yearly updates of current water quality and ecological health in Northland waterways.

As well as physical and nutrient data, *Escherichia coli* (bacterial indicator, *E. coli*), habitat, periphyton and macroinvertebrate data is presented to provide an overall indication of water quality and ecological health. Score cards on pages 28-44 provide an overall summary of water quality and ecological health for sites grouped according to their coastal receiving environments.

When compared with natural state (reference sites) draining almost exclusively native forest, key issues identified with water quality in Northland are elevated nutrient levels as well as degraded habitat quality and ecological health (based on MCI). On a national scale, our rivers compare poorly for phosphorus, ammoniacal nitrogen, faecal contamination, turbidity, and visual clarity. Results from reference sites suggest that turbidity and *E. coli* are naturally elevated in Northland rivers while nutrient levels are naturally low. Both issues of high *E. coli* and poor visual clarity may relate to deeply weathered clay soils common in Northland, which are characterised by rapid runoff and slow or restricted infiltration (Collins *et al.* 2007). These clay soils yield very fine plate-shaped particles that settle extremely slowly, staying suspended in rivers for a prolonged period of time and resulting in turbid and cloudy rivers. Microbial Source Tracking at a selection of river sites has shown that 66% returned positive markers for ruminant contamination, 24% for wildfowl, 7% for plant decay, 2% returned indeterminate results and 1% for human contamination.

Looking at the receiving environment, the monitored catchments feeding into the West Coast and Whangaroa Harbour have the best results for water quality and ecological indicators. The harbours/bay catchments with the poorest water quality/ecological results are those with predominantly pastoral/urban influences such as Bream Bay, Rangaunu Harbour, Kaipara and Whangārei. Results from the coastal water quality monitoring programme reflect this with long term monitoring sites in the Kaipara Harbour exceeding guidelines for nutrients as do the Bay of Islands and Whangārei Harbour.

Those sites with the poorest water quality (Manganui, Waiotu, Waipao, Mangere, and Wairua (Kaipara Harbour), Awanui (Rangaunu Harbour), Waiharakeke (Bay of Islands), Utakura (Hokianga Harbour), and Ruakaka (Bream Bay)) tend to have poor ecological health, poor habitat quality and degraded macroinvertebrate communities, and are exclusively soft bottom sites where the surrounding land use is predominantly pastoral. This aligns with national findings that pastoral land use degrades water quality (Ballantine *et al.* 2010; Ballantine and Davies-Colley 2013; Larned *et al.* 2004). With the exception of the Ruakaka River, all these sites feed into harbours/bays where contaminants may persist for some time because of the sheltered nature of the environment. In common with most harbours in New Zealand, studies have shown that sediment has been accumulating in these receiving

Soft bottom stream: stream/river bed consists of more than 50% silt/sand
Hard bottom stream: stream/river bed consists of more than 50% gravel/cobble/boulder/bed rock

Front & inside cover photos:
Te Papa Stream

environments at an exponentially greater rate since human settlement. Analysis indicates that pastoral farming could be the source of more than 60% of the sediment entering the Bay of Islands (Swales *et al.* 2010). Stream bank erosion, gullying and slips are the major sources of sediment in the Whangārei Harbour (Swales *et al.* 2013).

Trend analysis indicates several improving trends in water quality over the 10 years from January 2007–December 2016 particularly in nitrogen and turbidity. There are also several improving trends in the five years from January 2012–December 2016. These improvements would suggest improving land management practices such as improved farm dairy effluent management, nutrient management, and stock exclusion from waterways. However, 13 sites' results show degrading levels of phosphorus in the five-year trends, and ecological health has deteriorated at five sites over the ten-year period.

Conclusions

The majority of RWQMN sites (67%) are in a degraded condition and, while ten-year trend analysis indicate improvements in a number of parameters, five-year trends between January 2012–December 2016 show an increase in dissolved reactive phosphorus levels across the monitoring network. Ecological health is degraded with 42% of MCI scores and 57% of habitat scores being within degraded categories. Reference site data indicates that *E. coli*, turbidity and dissolved oxygen levels are naturally elevated and nutrient levels are naturally low. These results highlight the sensitivity of Northland rivers to land use activities and the need for strategic, targeted land management initiatives to maintain/enhance water quality and ecological health.

Recommendations

To help improve the monitoring of Northland's rivers the following actions are recommended:

- Review of the existing network and associated monitoring programmes to ensure regional representativeness and comprehensive integration with other scientific monitoring programmes.
- Incorporate Mātauranga Māori into monitoring plans.
- Further develop regional water quality and MCI guidelines incorporating reference data from the newly established reference sites.
- Include continuous monitoring of dissolved oxygen and temperature particularly during summer low flows.
- Increase flood event monitoring (sediment, microbes).
- Further develop council's fish, periphyton and sedimentation monitoring programmes including deposited sediment.
- Foster community monitoring by further developing the Northland Regional Council Citizen Science Programme which offers advice, training and data management support to community groups.

Waipoua River

Introduction

Northland Regional Council has a responsibility to manage the rivers and streams of Northland to ensure they remain clean and healthy for recreation, mahinga kai and aquatic biodiversity. To assess how well rules and policies achieve this several physical, chemical and ecological parameters are regularly monitored at river sites throughout Northland.

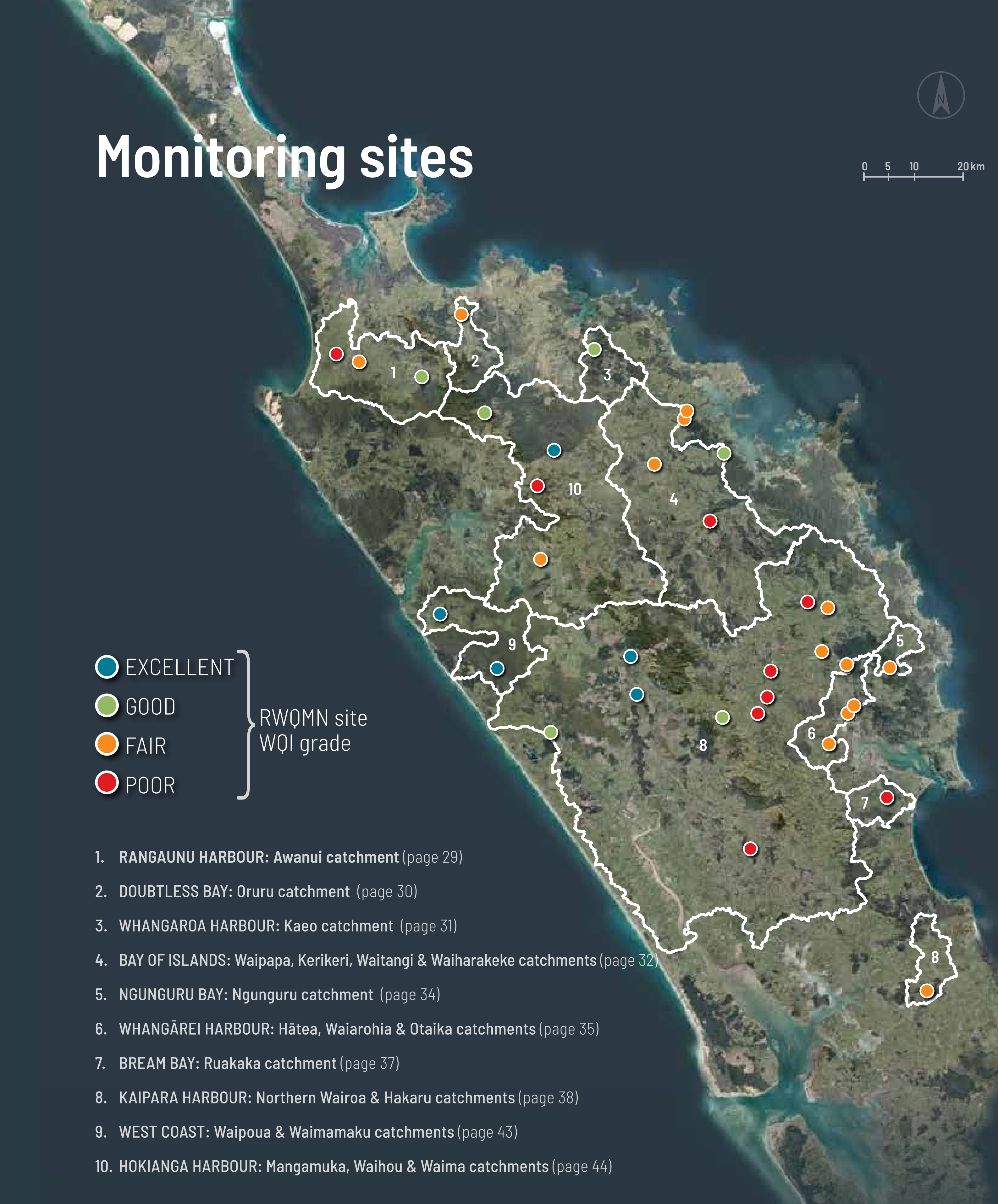
Because of the region's narrow land mass, most rivers in Northland are relatively short with small catchments which flow into harbours and estuaries rather than directly to the open coast. Estuaries are located at the end of the freshwater drainage system, which means that these systems are influenced by activities and processes that occur within their catchments. In addition, due to the chemical reactivity of most contaminants, estuaries rather than the open coast are often the ultimate sink for most contaminants (Clark 1992). The Northern Wairoa River is Northland's largest river, draining a catchment area of 3,650 square kilometers, or 29% of Northland's land area. It flows into the Kaipara Harbour, which is a large, enclosed harbour estuary complex, covering 947 square kilometers. In this report, we have grouped monitoring sites/catchments according to their receiving environments to compare water quality.

Northland is prone to both droughts and floods. River flows vary considerably with rainfall, with high intensity storms causing flash floods, while prolonged dry spells may lead to very low flows. Because Northland is dominated by deeply weathered geology and fine clay soils it is common to observe slow flowing and 'cloudy' (with poor visual clarity) rivers.

Northland's River Water Quality Monitoring Network (RWQMN) was established in September 1996 for State of the Environment (SoE) monitoring and initially included nine river sites throughout Northland. Since 1996 a further 29 sites have been added to the network. Two Northland sites monitored through the National Institute of Water and Atmospheric Research (NIWA) National River Water Quality Network are also incorporated into the regional network. In total 38 sites are monitored monthly throughout Northland for water quality/ecological health (as shown on the map on page 5). Four of these sites are new reference sites and have not been included in this report as insufficient data has been collected to undertake meaningful analyses. Monitoring the state of the environment is a specific requirement for regional councils under section 35(2)(a) of the Resource Management Act (RMA) 1991.

Coastal water quality is monitored in the Whangārei Harbour, the Bay of Islands and the Kaipara Harbour. 17 sites are monitored in the Whangārei Harbour, 16 sites in the Bay of Islands and nine sites in the Kaipara Harbour. In addition, the council undertook a survey of water quality of the Far North harbours in 2013. This was a repeat of a study undertaken in 2004. This survey included Whangaroa Harbour, Mangonui Harbour, Taipa River, Rangaunu Harbour, Houhora Harbour, Parengarenga Harbour and Hokianga Harbour. Recently routine monitoring has begun in Doubtless Bay and Ruakaka/Bream Bay.

Monitoring sites



1. **RANGAUNU HARBOUR: Awanui catchment** (page 29)
2. **DOUBTLESS BAY: Oruru catchment** (page 30)
3. **WHANGAROA HARBOUR: Kaeo catchment** (page 31)
4. **BAY OF ISLANDS: Waipapa, Kerikeri, Waitangi & Waiharakeke catchments** (page 32)
5. **NGUNGURU BAY: Ngunguru catchment** (page 34)
6. **WHANGĀREI HARBOUR: Hātea, Waiarohia & Otaika catchments** (page 35)
7. **BREAM BAY: Ruakaka catchment** (page 37)
8. **KAIPARA HARBOUR: Northern Wairoa & Hakaru catchments** (page 38)
9. **WEST COAST: Waipoua & Waimamaku catchments** (page 43)
10. **HOKIANGA HARBOUR: Mangamuka, Waihou & Waima catchments** (page 44)

Shows the 34 Regional Water Quality Monitoring Network (RWQMN) sites and their Water Quality Index (WQI) results. The white outlines indicate the catchment/s feeding into the coastal receiving environments listed above. Water quality within these catchments is examined in the Report Cards section of this report.

Report purpose and scope

The key questions this report seeks to answer:

- How clean and healthy are Northland rivers?
- How does Northland water quality compare to the rest of New Zealand?
- Where is river water quality and ecological health degraded in Northland?
- Are water quality and ecological health improving in Northland rivers?

This information allows us to understand and assess whether existing policies and management initiatives are effective and achieve expected outcomes for protecting our rivers as well as identifying areas where they are unhealthy and where further investigation is required. Lake water quality and ecological health are covered by a similar report which presents results for the Lake Water Quality Monitoring Network (LWQMN).

In this report, the water quality and ecological health assessments focus on RWQMN data, assessing water quality and ecological monitoring results for sites impacted by human activities including forestry, farming or urban development, against those draining predominantly native forest (called reference sites).

These reference sites provide an indication of what river water quality should be like without the influence of human activity. This differs from previous reports which have compared results to national guidelines/standards. This provides us with a more realistic picture of what Northland water quality should look like. We are measuring against standards specific to Northland and its unique climate and geology. For completeness, results are also measured against the National Policy Statement for Freshwater Management, NPS-FM (2014, updated 2017).

Overview of river monitoring in Northland

Monitoring objectives

The aim of the council's (RWQMN) and ecological monitoring programmes:

1. Find out if our rivers are clean and ecologically healthy for aesthetics and recreational activities such as swimming and fishing.
2. Detect changes in water quality and ecological health both within catchments and over time.
3. Assess the effectiveness of our regional policies, plans and land management initiatives in keeping our rivers clean and healthy.
4. Highlight places where water quality and health are degraded so that we can investigate the causes and make changes to improve the state and health of those rivers.

Monitoring variables

A number of physical, chemical and ecological parameters are measured at each of the 34 SoE sites and results are compared to objective values derived from reference site results.

Physical and chemical variables

Physical, chemical, and microbiological data is collected monthly. This includes up to 12 water quality parameters: dissolved oxygen (DO), conductivity, *Escherichia coli* (*E. coli*), water clarity, turbidity (TURB), temperature, pH, ammoniacal nitrogen (NH_4), Total oxidised nitrogen (TON), total nitrogen (TN), dissolved reactive phosphorus (DRP), total phosphorus (TP) and flow.

Dissolved oxygen

Dissolved oxygen is the amount of oxygen gas dissolved in the water. Oxygen is vital to fish, other aquatic animals, micro-organisms and plants which depend on it to be able to respire or breath. The level of dissolved oxygen is a useful indicator of water quality. It can indicate the presence of certain pollutants, particularly organic matter. Sewage effluent, decaying aquatic vegetation and animal manures reduce dissolved oxygen levels as they are decomposed by micro-organisms. Dissolved oxygen levels naturally fluctuate in water. Aquatic plants and algae release oxygen into the water during the day as they photosynthesise so peak levels occur in early afternoon and minimum levels at night when no photosynthesis is occurring.

Conductivity

Conductivity is a parameter of water's capability to conduct electricity. This ability is directly related to the concentration of ions in the water. Conductive ions come from dissolved salts and inorganic materials such as alkalis, chlorides, sulphides and carbonate compounds. Naturally occurring and artificially introduced chemicals may end up in water as it filters through soils or rocks, changing its chemistry. Conductivity is one way of measuring the amount of substances such as calcium, bicarbonate, nitrogen, phosphorus, iron, or sulphur dissolved in water. Elevated levels of dissolved minerals may affect how suitable the stream water is for some uses such as drinking and habitat for certain aquatic plants and animals.

E. coli

E. coli is a group of bacteria commonly found in the intestines of warm-blooded animals. *E. coli* in freshwater can indicate the presence of pathogens (disease-causing organisms) from animal or human faeces. Although not usually harmful to ecological health, it is a concern for human health as pathogens can cause illness for anyone who ingests them. *Campylobacter* is one of the most common pathogens associated with animal and human faeces (McBride, 2017) but is difficult to measure. *E. coli* concentration is measured to infer the presence of pathogens in the water.

Water clarity

Water clarity is an indirect measurement of the amount of suspended soil particles/organic matter in a water column or the murkiness of water. Suspended solids in streams can affect habitat for fish and other aquatic life. The suspended material prevents light passing through the water column which in turn affects ecological communities reducing visibility for feeding and preventing plant growth.

Turbidity

Turbidity is another parameter of water clarity. It is the cloudiness or discoloration caused by individual particles of sediment and other material suspended in the water column that are generally invisible to the naked eye, similar to smoke in air.

Temperature

Many of the physical, chemical and ecological characteristics of streams are directly affected by temperature. In particular, temperature affects the amount of oxygen water can hold (warm water holds less than cold water) and will influence the ecological communities that live there. Many fish and invertebrates are sensitive to high water temperatures.

pH

The pH of water is a measure of how acidic or alkaline (basic) the water is on a scale of 0–14.

pH values less than 7 indicate the water is acidic and parameters from 7 to 14 indicate it is alkaline. The pH of fresh water is usually 6.5 to 8.2, although wide variations can occur because of catchment geology. The pH of water will impact on what lives in a stream. Even under natural conditions, the animal and plant communities of acidic streams contain different species to those in alkaline streams. Changes in pH outside the normal range will cause more sensitive species to die.

Nitrogen

Nitrogen is a mineral nutrient, essential to all forms of life. It is found in proteins, including enzymes, DNA and many of the other building blocks of life. Ammoniacal nitrogen and nitrate-nitrogen are different forms of nitrogen. The balance of an ecosystem can be upset when nitrogen levels become too high. This can cause aquatic weeds and algae to grow too fast. This increased plant growth can increase oxygen demand at night and when dead plant material decomposes, and thus pose a threat to aquatic life. Nitrite-nitrogen and ammoniacal nitrogen become toxic at high concentrations, particularly under certain temperature and pH conditions. This can cause direct harm to fish and macroinvertebrates.

Phosphorus

Dissolved reactive phosphorus is a form of phosphorus. Phosphorus is a plant nutrient needed for growth and is important for life processes in plant and animal cells. In most waterways, phosphorus limits growth because it is present in very low concentrations. Too much phosphorus in water stimulates plant growth, resulting in problems such as algal blooms and growths which are unsightly and can choke the stream and cause long term damage.

Flow

The flow rate of a stream will influence water temperature, the concentration of dissolved oxygen and how many solids can be kept in suspension. It is also a key factor in determining what plants and animals will find suitable habitat. Rainfall, geology, soil type, catchment slope and land cover all influence the flow and its effects on stream habitat. For instance, where there is unstable geology flood events are far more likely to cause sediment to be carried into a stream through erosion processes.

Ecological variables

Ecological data is also collected at each RWQMN site. Periphyton is sampled once a month at wadeable sites and macroinvertebrates are sampled once a year along with habitat assessments.

Macroinvertebrates

Macroinvertebrates are aquatic invertebrates which live in our freshwater such as mayfly larvae, fly larvae, and snails. Because they have different tolerances to water quality and live in freshwater for an extended period, assessing the macroinvertebrate community can tell us a lot about how clean and healthy our rivers are.

Habitat assessments

Good habitat is vital to support healthy aquatic communities. The variety of habitat available in a stream will directly affect the number of plants and animals living there. Winding, shady rivers with a mixture of slow and fast-moving water (pools and riffles), in-stream debris, and different substrate types such as boulders, cobbles and sand will support a greater diversity of aquatic plants and animals than a slow flowing channelised stream with no shade and a bed comprised of only fine sediment.

Periphyton

Periphyton is the algae and bacteria that grow on river substrate. It is naturally occurring and important for sustaining life (Biggs 2000). However, it can sometimes form thick growths in response to a range of influencing factors such as elevated nutrient levels, high light availability and stable flows. These growths can look unsightly, alter the types of macroinvertebrates and fish which live in a river, occasionally be toxic and make things unpleasant for recreational activities such as swimming and fishing.

Measuring water quality

Water Quality Index (WQI)

Communicating water quality is a challenge because of the size and complexity of the data collected. A WQI (Perrie *et al.* 2012; Ozane 2012) helps to solve this problem by summing up all the data and enabling us to compare results within catchments and across the region. The WQI we have used in this report is calculated using the median values for the six parameters: DO (% saturation), DRP, *E. coli*, NH_4, TON and TURB assessed against an NRC Objective value (as shown in the table below).

NRC Objective values are the 92nd or 8th percentile values calculated using the results from two long-term Northland reference sites (Waipapa River at Forest Ranger and Waipoua River at SH12). In other words, the objective value to which other sites are compared is based on some of the poorest results from the most pristine sites in the network. Both Waipapa River at Forest Ranger and Waipoua River at SH12 have a minor amount of forestry and farming respectively in their upper catchments. A further four true reference sites draining 100% native forest were added to our network in mid-2016. Once sufficient data from these sites has been collected it will be used to further refine water quality objectives for future reporting. Reference sites give an indication of the natural state of Northland rivers and allows us to compare results from other sites in the RWQMN to measure how much water quality has been impacted by various land use activities.

NRC Objective values used to calculate the WQI for Northland RWQMN sites. The objectives are calculated using the 92nd or 8th percentile of combined results from two Northland reference sites (Waipapa River at Forest Ranger and Waipoua River at SH12) from January 2012–December 2016:

Parameter	Abbreviation	Measure	NRC Objective value	National standards guidelines/triggers
Dissolved oxygen	DO	% saturation	≥94%	≤80% RMA 1991
Dissolved reactive phosphorus	DRP	mg/L	≤0.008	≤0.010 ANZECC 2000 – lowland
Escherichia coli	*E. coli*	cfu/100mL	≤505	≤100 ANZECC 2000 – livestock drinking water
Ammoniacal nitrogen	NH_4	mg/L	≤0.011	≤0.021 ANZECC 2000 – lowland
Total oxidised nitrogen	TON	mg/L	≤0.07	≤0.444 ANZECC 2000 – lowland
Turbidity	TURB	NTU	≤6.2	≤5.6 ANZECC 2000 – lowland

The WQI grades sites into different 'classes' according to their score:

- **EXCELLENT**: median values for all six variables are within objective values.
- **GOOD**: median values for five of the variables are within objective values.
- **FAIR**: median values for three or four of the variables are within objective values.
- **POOR**: median values for less than three of the six variables comply with objective values.

Sites with a grade of **GOOD**, **FAIR** or **POOR** represent sites with at least some water quality problems as the median value of at least one of the six key water quality variables does not meet its objective. The degree of degradation is relative, with sites graded as **GOOD** having just slightly degraded water quality and **POOR** sites the most degraded water quality.

Previous NRC reports have used national standards and guidelines (e.g., ANZECC 2000 and RMA 1991) as a benchmark. By using local reference sites to determine what water quality should look like, we get an indication of the natural state of water quality specific to Northland and its unique climate and geology. The NRC objective values for DO, *E. coli* and turbidity are higher, while nutrient levels are lower than ANZECC/RMA standards and guidelines (as shown in the table on page 10). This would suggest that DO, *E. coli* and TURB levels are naturally high and nutrients are naturally low in Northland rivers. These results are consistent with the fact that Northland soils are predominantly low in nutrients and the findings of McDowell *et al.* 2013 who found that in warm, wet humid climates *E. coli* levels tend to be naturally high.

Waipapa River

Ecological health

While clean water is important for human health for drinking, swimming, food gathering and aesthetics, another vital role of water is its capacity to support healthy ecological communities or mauri (life and wellbeing sustaining capacity). Healthy rivers have clean water, support a diverse number of aquatic plant and animals and are aesthetically pleasing, winding through the landscape with a variety of habitat types such as deep pools, riffles and runs and areas of shade from overhanging vegetation or trees. Just like water quality, ecological health is extremely complex and difficult to parameter but periphyton, macroinvertebrates and habitat assessments provide tools to determine the ecological health of our waterways.

Macroinvertebrate Community Index (MCI) scores

MCI monitoring is undertaken each year by the council during summer low flows when macroinvertebrates are at their most abundant and easiest to collect. Each species has a 'tolerance score', which is used to calculate a Macroinvertebrate Community Index (MCI). The higher the score, the better the water quality. Macroinvertebrate monitoring began in New Zealand in the mid 1980's (Stark 1985) and has been revised several times (Stark 1993; Stark 1998; and Stark *et al.* 2001). In 2014 Stark developed a Northland specific MCI (Stark 2014) to account for its unique climate and geology.

Quality class		MCI & MCI-sb
EXCELLENT	★★★	≥120
GOOD	★★☆	100–119
FAIR	★☆☆	80–99
POOR	☆☆☆	<80

Habitat quality scores

Since 2014, Rapid Habitat Assessments (RHA)(Clapcott, 2015) have been undertaken at each RWQMN site alongside the macroinvertebrate monitoring. The habitat assessment involves assigning scores to 10 stream characteristics including deposited sediment, aquatic habitat abundance, aquatic habitat diversity, bank stability, channel shade, and riparian vegetation. The sum of the 10 scores provides a habitat quality score. The higher the score the better the habitat. The RHA scores are then compared to the average score from reference sites (Waipoua at SH12 and Waipapa at Forest Ranger, summer 2014–2015) to provide a Habitat Quality Score.

Quality class		HQS%
EXCELLENT	★★★	≥90
GOOD	★★☆	70–89
FAIR	★☆☆	50–69
POOR	☆☆☆	<50

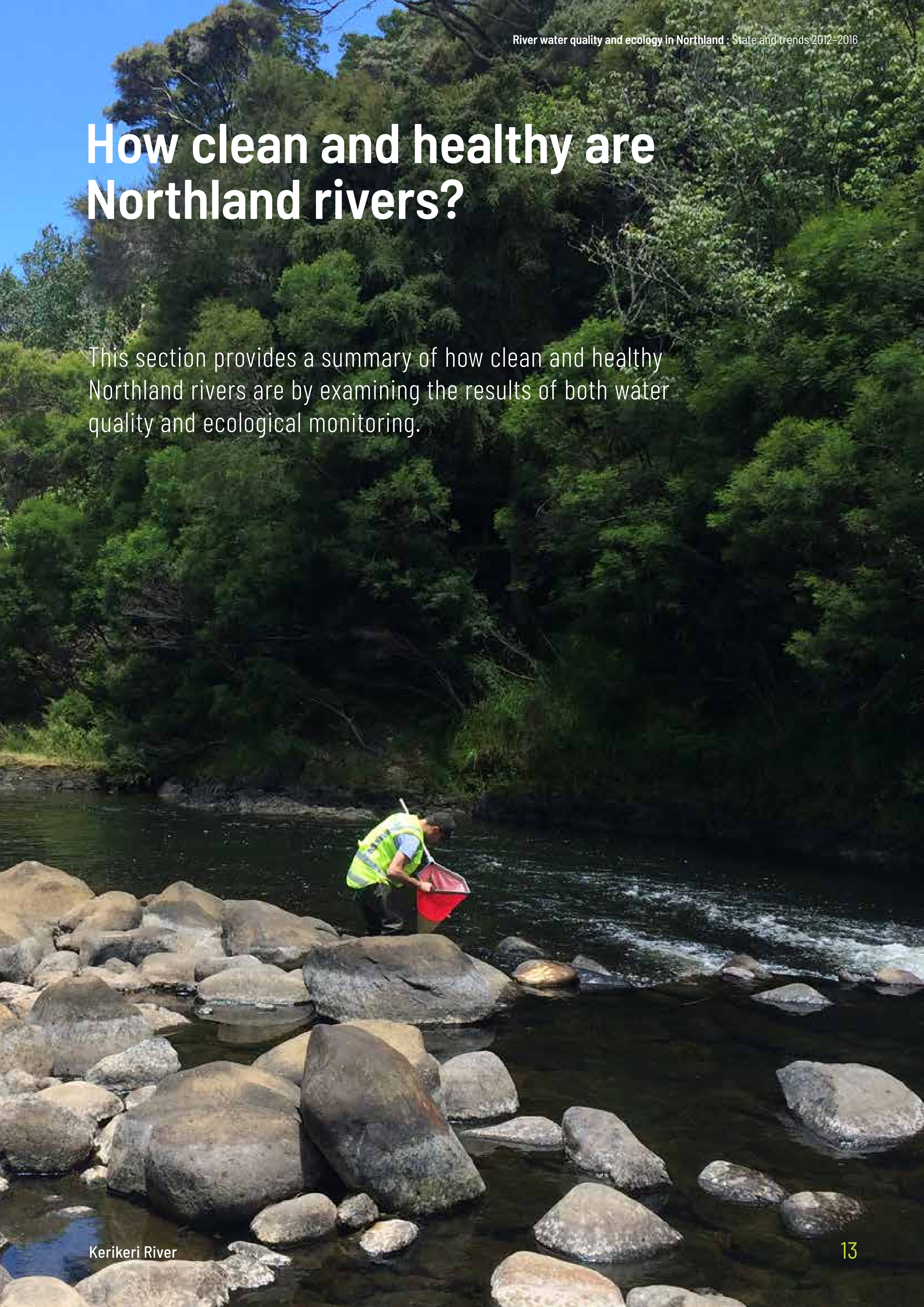
Periphyton scores

Periphyton is sampled monthly throughout the year at all suitable sites. Samples are analysed for chlorophyll *a* (Chla) as a parameter of biomass. A difficulty with the sampling protocol is that it is only suitable for wadeable streams with reasonable water clarity and a hard substrate. Unfortunately, as many Northland streams are deep, slow flowing and soft bottomed, and often have poor water clarity, almost one third of our SoE sites are unsuitable for sampling. Many of these sites will not support periphyton growth because they lack a stable substrate for periphyton to grow on. However, others have been observed to have periphyton growing on instream debris (epiphytic periphyton). Soft bottom streams are often slow flowing and support macrophyte (aquatic plant) growth which can also reach nuisance levels, clogging the stream and impacting both water quality and ecological health. Macrophytes are currently not included in Council's monitoring programmes due to a lack of resources. Sites suitable for periphyton sampling, have been graded according to the National Objectives Framework – FW (2014).

Quality class		Chla (mg/m^2)
EXCELLENT	★★★	≤50
GOOD	★★☆	>50 to ≤120
FAIR	★☆☆	120 to ≤200
POOR	☆☆☆	>200

How clean and healthy are Northland rivers?

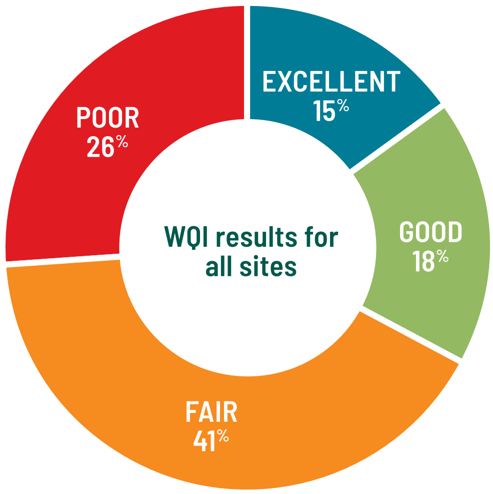
This section provides a summary of how clean and healthy Northland rivers are by examining the results of both water quality and ecological monitoring.



Kerikeri River

Water quality results

The results show that water quality is degraded at the majority of the sites in Northland with two thirds of our RWQMN SoE monitoring sites being moderately to severely degraded. The pie chart below and Appendices A and B show the WQI results for the 34 RWQMN sites from data collected from January 2012–December 2016. Just 11 sites (33%) are graded as **GOOD** or **EXCELLENT** using the WQI. The remaining 23 sites (67%) are graded as **FAIR** or **POOR**.

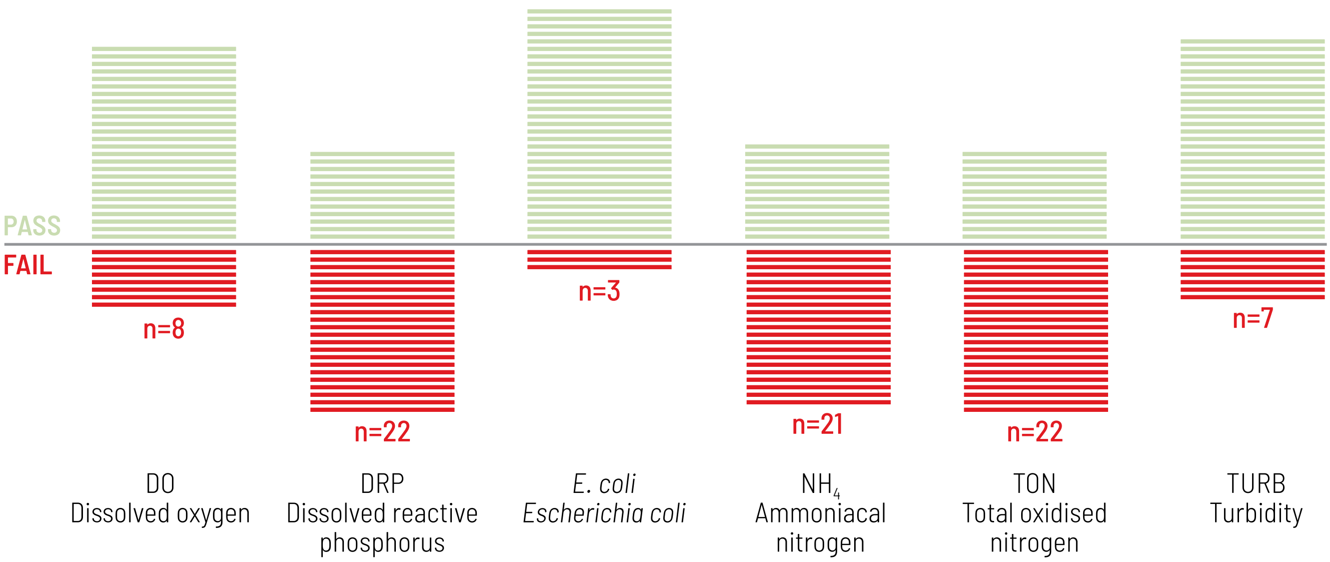


Previous NRC reports, which have used national standards and guidelines as a benchmark, have identified dissolved reactive phosphorus, *E. coli* and turbidity as the main water quality parameters of concern. Using local reference sites to calculate what water quality should look like in Northland provides quite a different picture. The results in the diagram below suggest that the main concerns are nutrients, with a high proportion of sites failing to meet the NRC objective values for dissolved reactive phosphorus, ammoniacal nitrogen and total oxidised nitrogen (65%, 62% and 65% respectively). In contrast, dissolved oxygen, *E. coli* and turbidity objectives are met at most sites. This would suggest that *E. coli* and turbidity levels are naturally elevated and nutrient levels are naturally low in Northland rivers. These results are consistent with the fact that Northland soils are predominantly low in nutrients (only three percent are classed as highly productive (NRC SoE report 2015)) and the findings of McDowell *et al.* 2013 that in warm, wet humid climates *E. coli* levels tend to be naturally high.

Nutrients are transported from the land to the rivers and then to the sea. The NRC soil monitoring programme has identified high levels of nitrogen in some of our pastoral soils which can be from a variety of sources such as fertiliser and animal effluent. Nutrient levels above national guidelines have also been recorded at coastal monitoring sites. In the Bay of Islands more than 80% of DRP samples failed guideline standards whilst in the Whangārei Harbour more than 50% of NH_4 samples and 80% of TON samples failed (SoE report 2015).

Number of NRC sites that failed water quality parameters in Northland, 2012–2016:

n = number of sites that failed from the total 34 sites



Fine sediment and water clarity issues in Northland

The erosion of soil and its transport as sediment through rivers and streams to the coast is a natural process. However, the rate at which this is now occurring has been accelerated by land clearance for agriculture, forestry and urban development. Increased sediment in our rivers and coastal environment can have adverse impacts on both human and ecological values. Cloudy rivers are not attractive, and fine sediment causes degradation of aquatic habitat for invertebrates and fish, smothering food sources and river beds so that habitat in spaces between river cobbles is no longer available. Sediment suspended in water also impacts light available for aquatic plant growth and the ability of animals to find prey and avoid predators (Clapcott *et al.* 2011). Out in the harbours and estuaries sediment has a similar impact, smothering marine plants and animals and causing a shift from sandy environments to shallow, turbid, muddy environments.

Our results suggest that turbidity, an indicator of how much sediment there is in our streams, is not elevated in Northland. However, because samples are collected monthly and only occasionally during/after heavy rain when most of the sediment is being washed into rivers, the results are unrepresentative of real sediment loads in our rivers. Globally, increasing sediments loads are recognised as a threat to estuarine and coastal marine ecosystems. Although sediment input and deposition in these receiving environments is a natural process, the rate at which this is now occurring is higher than before human activities disturbed the natural land cover (Thrush *et al.* 2004). In New Zealand, increases in sediment loads to estuaries and coastal ecosystems coincide with large-scale deforestation, which followed the arrival of people about 700 years ago (Wilmshurst *et al.* 2008). Sediment has been accumulating in Northland harbours and estuaries at rates of between 2.4 mm and 6.4 mm per year over the last 100 years (Swales *et al.* 2010, 2013). This is compared to average sediment accumulation rates of 0.23 mm per year during the last 10,000 years prior to deforestation by people (estimated from radio carbon dating of cores collected from the Bay of Islands). This order of magnitude increase in sedimentation is consistent with increased soil erosion following large-scale deforestation and indicates a major shift in the sedimentary regime of Northland's rivers and estuaries.

The studies also identified the current sources of sediment being deposited in these systems using the compound-specific stable isotope method. Analysis indicates that pastoral farming is the source of more than 60% of the sediment entering the Bay of Islands from all the major rivers except the Waikare, which is dominated by native forest and kānuka scrub. In Whangārei Harbour stream bank erosion, gullying and slips are major sources of sediment.

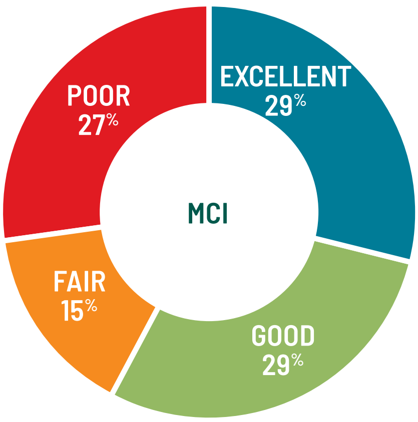
Approximately one third or our RWQMN sites have substrates that are composed entirely of sediment. It is not clear if this is their natural state or the result of considerable increases in sediment loads since human settlement. Most of these sites are in areas where the underlying geology is deeply weathered soft sediments and very prone to erosion. The unstable nature of the geology combined with Northland's high rainfall means that many are very vulnerable to erosion issues brought about by human activities. These rivers are often deep, slow flowing with unstable banks which frequently slump sediment into the river (see the photo on page 16). Bank slumping can 'bleed' fine sediment even at low flows. While the modelled sediment loads in Northland are only modest by national standards (Hicks *et al.* 2011), most of the sediment is layer clays which are intensely light-scattering. When surface runoff carries these clay particles into water, the colloidal nature of the particles can result in their remaining in suspension for extended periods, and even in low concentrations can cause major discoloration. Poor water clarity can impact aquatic organisms in many ways such as impacting on feeding ability, clogging gills and reducing light availability and hence the growth of aquatic plants. Non-colloidal sediment can drop out of suspension, particularly in slow flowing low energy streams, smothering stream beds along with habitat for aquatic macroinvertebrates and fish.

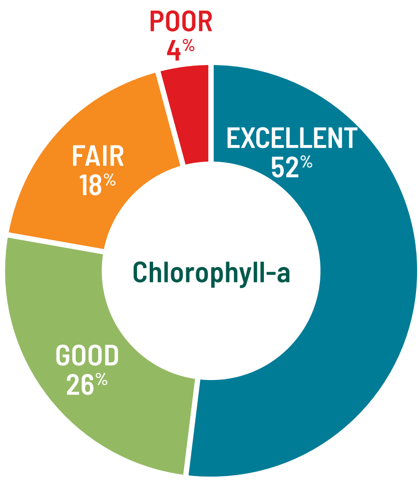
Ecological results

Ecological measures used in this report include:

- **Macroinvertebrate Community Index (MCI):** an index derived from macroinvertebrates taxa present in a stream and their tolerance to pollution.
- **Chlorophyll-a:** a measure of the biomass of periphyton (algae, fungi, and bacteria which grow on the beds of rivers and streams).
- **Habitat:** the condition, complexity and characteristics of the stream which provides the living space for all in-stream flora and fauna.

The pie charts below and Appendix B show the ecological results from data collected at 34 RWQMN sites from January 2012–December 2016. The ecological results are slightly better than for water quality, with almost 60% and 52% of sites scoring **GOOD** or **EXCELLENT** for MCI and chlorophyll-a respectively but still a considerable number of sites scoring either **FAIR** or **POOR**. More than half of sites (57%) scored **POOR** for habitat.





How does Northland water quality compare to the rest of New Zealand?

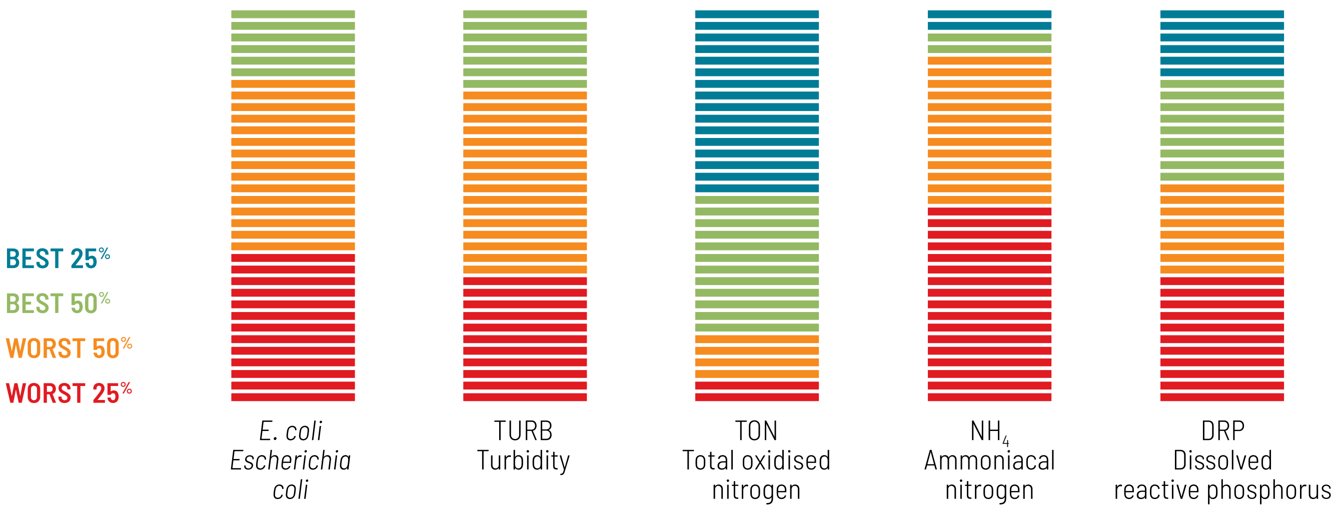
The website, Land, Air, Water Aotearoa (LAWA) www.lawa.org.nz, is a partnership between New Zealand's 16 regional and unitary councils, the Ministry for the Environment (MfE), Cawthron Institute and Massey University. LAWA displays water quality state and trend information for more than 1100 freshwater monitoring sites throughout New Zealand. The website gives us the opportunity to compare Northland water quality results to the rest of New Zealand.

On a national scale, we can see that water quality in Northland is not particularly good (see graph below) Most of our sites are in the worst 50–25% of parameters for *E. coli*, black disc, turbidity and ammoniacal nitrogen and just over half of our results are in the worst 50–25% for dissolved reactive phosphorus and total phosphorus. However, nitrogen levels compare well to the rest of New Zealand, with most of our sites in the best 25–50% category.

It is interesting that results are quite different to our WQI results where we saw that nitrogen levels were quite elevated compared to our objectives based on local conditions (reference sites) whereas *E. coli* and turbidity mostly met objective values. These results reflect the unique geography and climate of Northland and the influence these have on the region's water quality.

Comparison of Northland water quality results with the rest of New Zealand:

Based on data from LAWA. Each site was compared to similar sites with matching land use and gradient. Each bar represents one of the 34 sites.



Where is river water quality and ecological health poor in Northland?

All land use impacts on water quality and ecological health to some extent but pastoral land use is associated with the poorest water quality in Northland. This can be seen by comparing WQI and MCI results to land use classes according to the River Environment Classification (REC) (Snelder *et al.* 2010). From the map on page 5 and graphs below we can see the link between land use and how clean and healthy our rivers are. (Note there are very few sites in the urban and exotic forest categories so these results need to be viewed with caution.) Sites with a predominance of native forest in the catchment tend to have the best water quality (WQI) and MCI. When the land use becomes dominated by exotic forestry, pasture or urban development, water quality and MCI results tends to degrade. All the sites graded as **POOR** are sites where the predominant land cover is pastoral. Conversely almost all sites graded as **EXCELLENT** for water quality have catchments dominated by native or exotic forest. These patterns are also reported nationally (Davies-Colley, 2013). Urban water quality in Northland is **FAIR** with **GOOD**–**FAIR** ecological health.

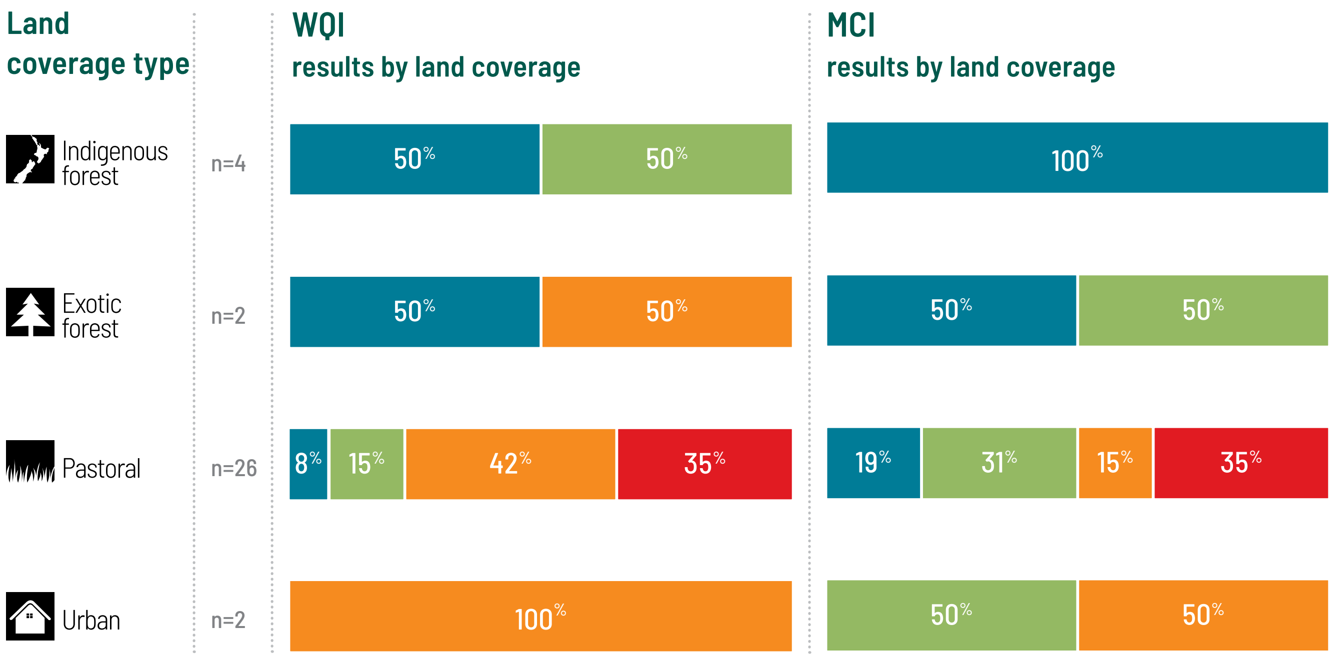
Appendix D shows meaningful correlation results for percentage of pasture in a catchment and nutrient and turbidity levels measured by the WQI. Pastoral land tends to have higher nutrients and turbidity. Ecological health can be influenced by many factors. The results show meaningful correlation between habitat quality, ammoniacal nitrogen, dissolved oxygen and turbidity levels. Better habitat and good levels of dissolved oxygen support healthy macroinvertebrate communities whilst elevated ammoniacal nitrogen and turbidity levels are factors associated with poor ecological health.

Northland's harbours and estuaries are important economic, social and cultural assets, with harbour and estuarine systems such as the Whangārei Harbour and the Bay of Islands significantly contributing to Northland's economy and the environment. However, because estuaries and harbours are located at the end of the freshwater drainage system, they can be vulnerable to land-based activities and processes that occur within their catchments.

Results compared to land coverage classes:

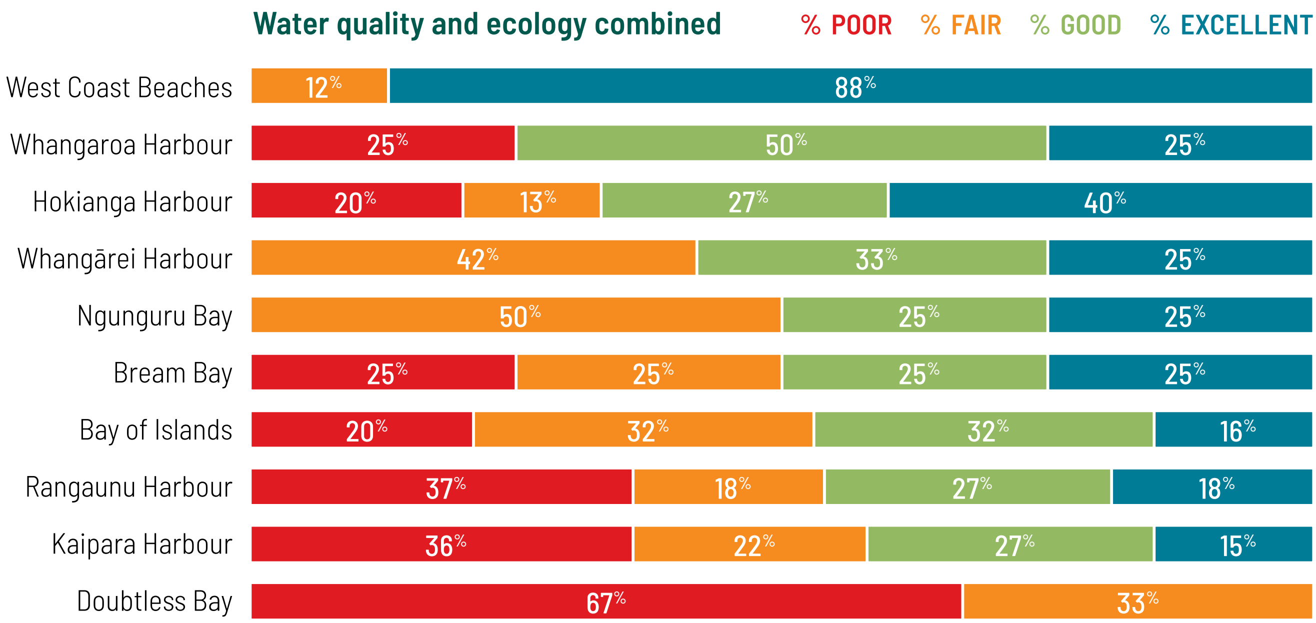
n = number of sites

% EXCELLENT % GOOD % FAIR % POOR



See pages 28–45 for report cards summarising water quality and ecological health for each of the RWQMN catchments according to the harbour, bays and beaches they feed into. Results are summarised in the graphs below. Looking at the receiving environment, the monitored catchments feeding into the West Coast and Whangaroa harbour have the best results for water quality and ecological indicators. The harbours/bays receiving the poorest water quality/ecological results are those with predominantly pastoral/urban influences such as Bream Bay, Rangaunu Harbour, Kaipara and Whangārei. Results from the coastal water quality monitoring programme reflect this with long term monitoring sites in the Kaipara harbour exceeding guidelines for nutrients as do the Bay of Islands and Whangārei Harbour.

Catchment results per receiving environment, 2012–16:



Are water quality and ecological health improving in Northland?

Summary trend data for water quality/ecological health (as shown in the graphs below) shows that there are several improving trends in water quality over the 10 years from January 2007 to December 2016 particularly in ammoniacal nitrogen, nitrogen (TON) and turbidity. There are also many positive improvements in the 5 years from January 2012–December 2016. However, a considerable number of sites are showing increasing levels of phosphorus (degrading) (DRP) in the 5-year trends.

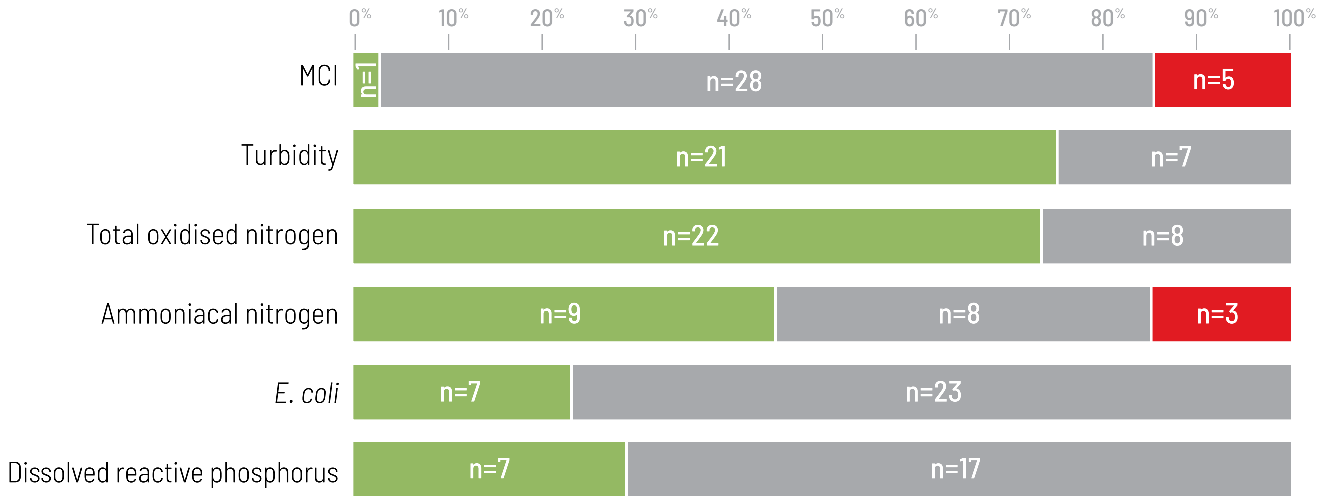
The reference sites act as a bench mark to compare trend data with. It is possible that these trends could be associated with natural impacts such as drought, El Nino, climate change etc. The reference site at Waipoua River shows a degrading trend in DRP, while the Waipapa River reference site has improving trends in DRP, ammoniacal nitrogen and turbidity. This suggests that while some of these changes are due to human activity (both positive and negative) others may be due to natural causes.

Water quality/ecologocial health trends:

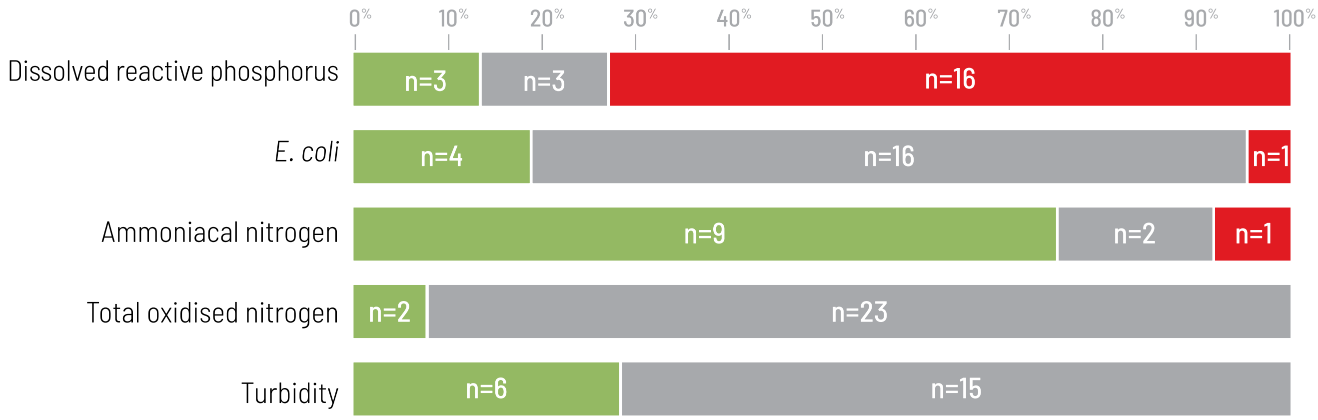
n = number of sites

IMPROVEMENT INDETERMINATE DEGRADATION

10-year water quality trends, 2007–2016

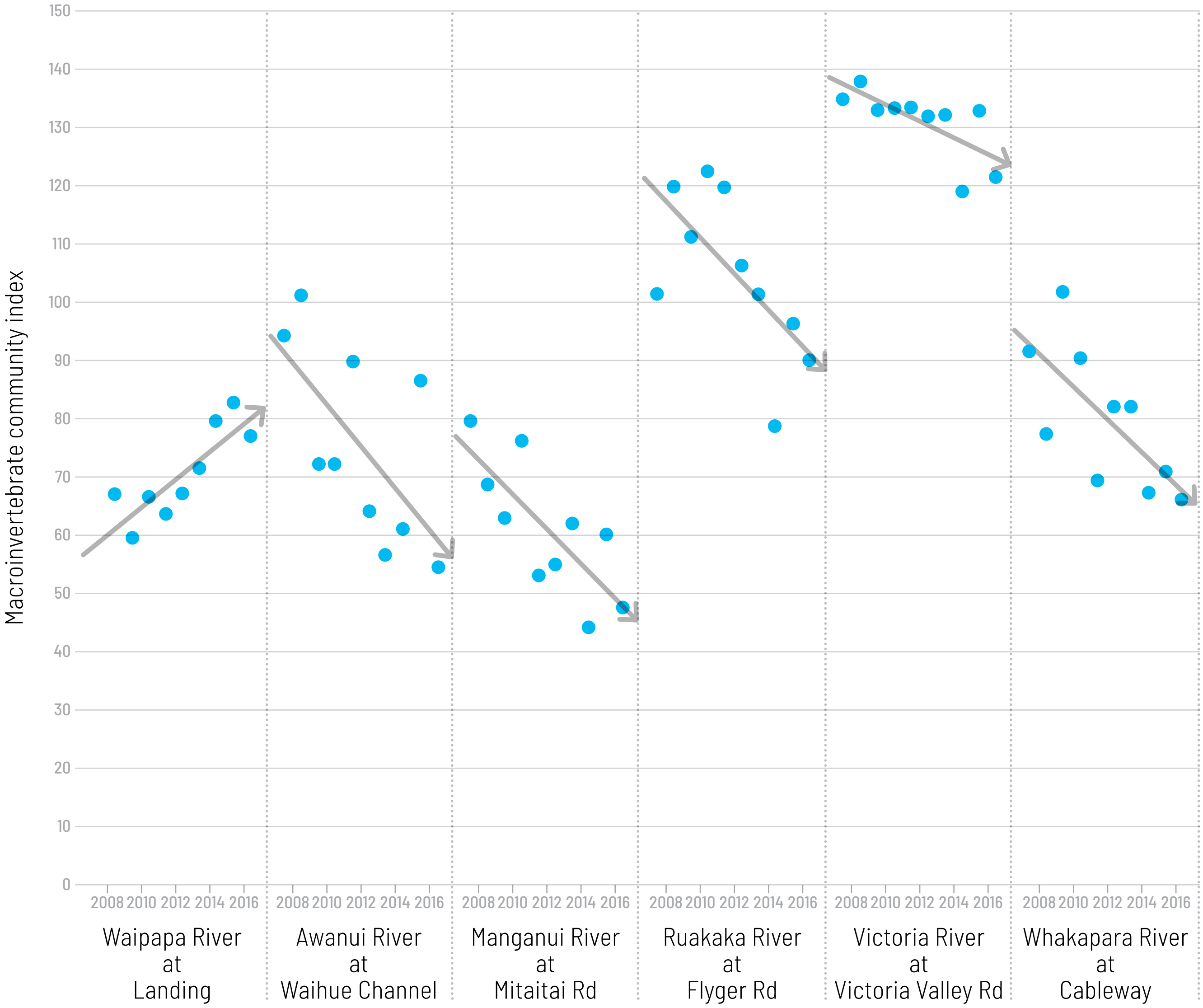


5-year water quality trends, 2012–2016



Because MCI data is only collected once a year there is insufficient data for 5 year trend analysis to cover the time period of this report. 10 year trend analysis from January 2012–December 2016 (as shown in the graph below) shows that at the majority of sites there has been no real change in ecological health. Just one site has shown any meaningful improvement and 5 have degraded. Results for both reference sites indicate no meaningful change. These results require further investigation. More degrading than improving trends would indicate that work needs to be done to improve the ecological health of waterways in Northland.

Meaningful 10-year MCI result trends at Northland RWQMN sites, 2012–2016:



Swimming water quality

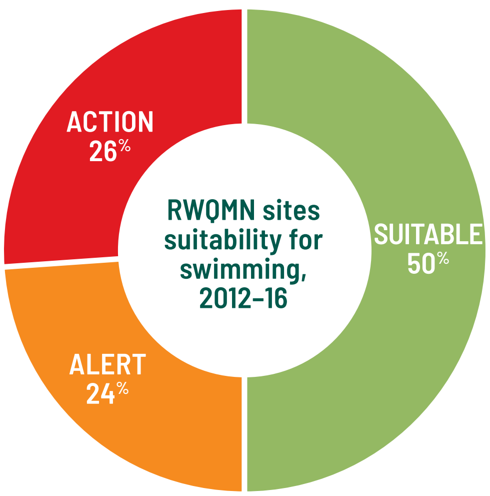
Most of the sites in Northland meet our objectives based on reference sites for *E. coli*; does this mean that most of our rivers are suitable for swimming? Data is measured against the *National Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas* released by the Ministry for the Environment and the Ministry of Health in June 2003 (see the table below).

www.mfe.govt.nz/publications/water/microbiologicalecological-quality-jun03

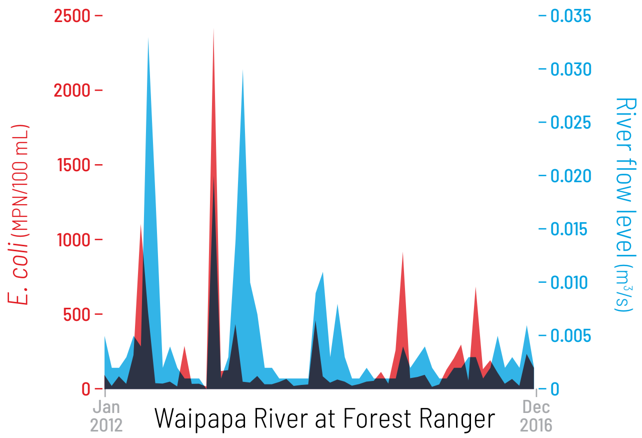
The pie chart below and Appendix F show *E. coli* results for Northland RWQMN sites from January 2012–December 2016. 74% of the time the RWQMN sites were suitable for swimming. For almost a quarter of the time however they were at alert level with slightly elevated levels of *E. coli* and just over a quarter of the time they were at action levels unsuitable for swimming. Even our reference sites (Waipoua at SH12 and Waipapa at Forest Ranger) draining almost entirely native catchments have occasional results in the alert/action grades (Appendix C). Rivers are sampled on a monthly basis regardless of the weather or flow. During high rainfall events *E. coli* (along with nutrients and sediment) is flushed into rivers along with overland flow and can lead to a temporary rise in *E. coli* levels. The graphs below show how the amount of *E. coli* in our rivers roughly mirrors flow, with flow and *E. coli* levels peaking in autumn and spring. During times of low rainfall/low flows sources of *E. coli* are likely to be from direct discharges to water or from stock that have access to unfenced streams.

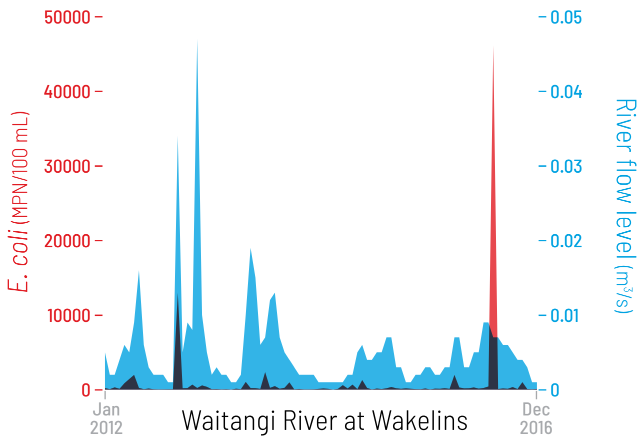
MfE and MoH single sample guidelines for freshwater sites, 2003:

E. coli concentration	Category	Suggested response
sample ≤260/100 mL	SUITABLE	No response necessary – continue weekly sampling.
260< sample ≤550/100 mL	ALERT	Undertake catchment assessment and sanitary survey where applicable to isolate source of faecal contamination.
sample >550/100 mL	ACTION	- Collect follow-up sample. - Undertake sanitary survey when applicable. - Erect warning signs. - Inform public through the media that a public health risk exists.



Comparison of flow vs. *E. coli* levels at two Northland RWQMN/NIWA sites, 2012–2017:





* NOTE: the large difference in the *E. coli* numbers on the y-axis (vertical) between these two graphs. More red area on the top graph is not an indication it has higher *E. coli* recordings. These graphs are designed to show a relationship trend.

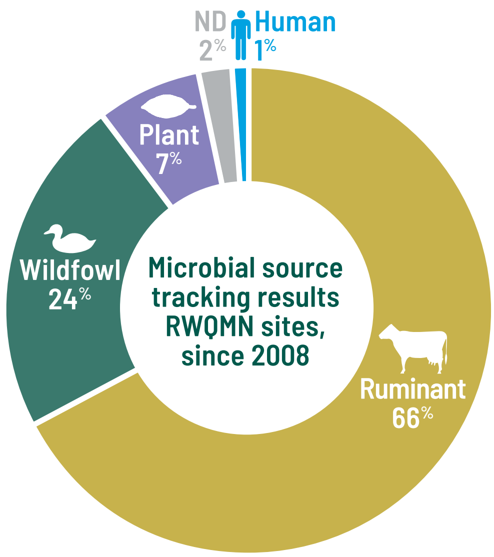
Microbial source tracking

Microbial source tracking (MST) uses scientific techniques to identify the source of bacterial contamination in water, including: faecal sterol ratio (FSR) analysis, fluorescent whitening agents (FWAs) and polymerase chain reaction (PCR) markers. The source of contamination is determined by combining the results from the above analyses. Markers for the following host groups have been developed – human, wildfowl (ducks and/or gulls), ruminants (includes sheep, cattle, deer and goats), possums and pigs – as well as a general indicator for faecal contamination.

Since 2008 a total of 93 samples have been analysed from rivers in the RWQMN. Of those samples, 61 (66%) returned positive markers for ruminant contamination, 22 (24%) wildfowl, 7 (7%) plant decay, 1 (1%) human, and 2 (2%) were not determined (ND) (see the graph on the right). Often a result will indicate faecal contamination from multiple sources, such as at Whangārei Falls on the Hātea River. However, based on MST results the majority of faecal contamination appears to be coming from ruminants.

It has now been established that *E. coli* can persist and in some cases multiply in the environment away from their natural habitat in the animal gut. This type of *E. coli* isolated in the environment is called 'naturalised'. It has been investigated by Southland and West Coast Regional Councils (Devane, 2017) and recently Northland Regional Council has commissioned the Institute of Environmental Science and Research (ESR) to investigate its occurrence in Northland. This may help to explain some of the sources of elevated *E. coli* results in Northland.

In a separate programme NRC does regular weekly swimming water quality monitoring in summer months at popular coastal and freshwater swimming sites. Results can be seen in the annual reports on the NRC website and in weekly updates on the LAWA website throughout summer.




Cows in an unfenced Northland stream

Does our water meet national standards?

The Government has imposed compulsory parameters and grades which apply to various uses of water through the National Policy Statement for Fresh Water Management (NPS-FM). These include values to protect ecological health and human health for contact recreation. The parameters to protect ecological health include periphyton (a parameter of trophic state/nutrient enrichment) and parameters for nitrogen toxicity. *E. coli* is used as a parameter for human health for contact recreation/swimming as although it is not always harmful to human health itself it indicates faecal contamination.

Grades 'A', 'B' and 'C' indicate quality from best to acceptable; 'D' is unacceptable and improvement in water quality is required. Results are presented in Appendix E.

Despite having poor results according to the WQI, results indicate that none of our sites have nitrogen levels which are considered excessively toxic under the NPS-FM and only one site (Hakaru at Topuni) fails the bottom line for chlorophyll-a (a measure of periphyton biomass). In contrast only two sites (6%) (Waipapa at Forest Ranger and Manganui at Mititai) meet the contact recreation/swimming grade and none have an 'A' attribute state. The very poor swimming results may reflect the findings of McDowell *et al*. 2013 that in warm, wet humid climates *E. coli* levels tend to be naturally high, exacerbated by land use impacts.

Monitoring limitations and knowledge gaps

NRC's State of the Environment monitoring programme provides a significant amount of information on the health of waterways in the Northland region. However, as understanding of the issues surrounding freshwater ecological health and its monitoring have developed, some limitations and knowledge gaps have become apparent:

- There is a lack of liaison with local iwi in implementing monitoring plans for water quality at NRC. Partnerships with local iwi should be promoted to develop mātauranga Māori; kawa (cultural practices) and tikanga (cultural principles) to help examine, analyse and understand water quality in Northland.
- The RWQMN has historically had a lack of reference sites to enable comparisons of similar types of streams. Until recently there have been only two sites sampled that drain unmodified catchments of at least 85% native forest (Collier *et al.* 2005). Four new reference sites were added in 2016 and will help assessing Northland's river water quality against natural state.
- About one third of Northland streams cannot be sampled for periphyton to assess nutrient enrichment as they are unsuitable for current methods. Often these soft bottom streams do not support periphyton growth however it is still important to assess these streams as they may have excessive macrophyte (aquatic plant) growth. They may also put downstream sites with hard substrate at risk of periphyton blooms and may cause eutrophication problems in downstream environments like lakes, estuaries and coastal waters. Methods should be explored to include nutrient enrichment/periphyton monitoring of soft bottom streams including the use of artificial substrates.
- Current monitoring of river water quality is almost exclusively based on spot samples. Continuous monitoring, especially during low flow conditions, would provide valuable information for peaks and troughs in parameters such as dissolved oxygen and water temperature which fluctuate markedly during the day and night. Diurnal ranges of nutrients should also be measured using auto samplers.
- Better integration of river, lake, coastal, and ground water quality monitoring programmes along with water quantity/water allocation programmes is needed to improve understanding of water quality issues in Northland.

- The RWQMN network was established over 20 years ago. While a number of sites have been added over the years there are still many catchments that have no, or very little, monitoring data. With significant advances in water quality science over the years and our increased understanding of freshwater dynamics the current network should be reviewed to ensure it is fit for purpose and provides relevant information about the general state and trends of river water quality in Northland.
- Some important aspects of stream health have not been monitored. These include fish community condition, macrophyte cover and composition, and deposited sediment. This lack of information limits the effectiveness of the SoE monitoring programmed to assess both the water quality and ecological health of Northland waters.
- Communities are becoming motivated to try and improve water quality in Northland. At the same time, the council has a need for further monitoring data to inform management decisions.
  A number of community groups have recently begun monitoring in partnership with NRC. Community monitoring (citizen science) including mātauranga Māori should be encouraged and promoted where practicable.

Kenana River

Recommendations

We have seen that there are a number of issues with water quality in Northland, in particular elevated nutrients at a regional level. Problems with sediment are also apparent, turbidity is elevated at some sites and the accumulation of sediment in the coastal environment from land sources is well documented (Thrush, 2004; Wilmhurst, 2008; Swales, 2010 & 2013). *E. coli*, water clarity, ammoniacal nitrogen and phosphorus compare poorly on a national scale. Poor habitat quality/ecological health is also an issue at many sites. Trend data shows some encouraging changes however, with climate change, the challenges of maintaining and improving water quality are likely to be even greater with influences such as warmer temperatures, droughts, and heavy rainfall events.

A number of measures are already in place to improve water quality including:

- The Draft Regional Plan (2016) has put forward a number of new rules to help reduce the impact of land use on river water quality including the exclusion of dairy cattle and pigs from all permanently flowing waterways from the 1st of January 2025. All beef cattle, dairy support cattle and deer are excluded from permanently flowing waterways from 1st of January 2030.
- Land management initiatives have been implemented to control the erosion of highly erodible land, put farm water quality improvement plans in place and the environment fund provides help with fencing and planting.
- Waiora Northland catchment groups in the four priority catchments Doubtless Bay, Waitangi, Whangārei Harbour and Mangere have all developed catchment management plans, including both regulatory and non-regulatory measures, to improve water quality.
- The Northern Wairoa (the largest catchment in Northland) is one of a number of waterways in New Zealand to have been allocated government funding from the Freshwater Improvement Fund to improve freshwater quality, a collaboration between our council, local iwi and the primary sector.
- Many community groups are working hard to improve water quality in Northland by fencing and planting waterways and restoring wetlands.

Some other land management and regulatory approaches that would help to improve fresh water quality include:

- Targeting farm water quality improvement plans to catchments/sub catchments identified as having poor water quality and ecological health.
- Nutrient management plans for highly productive land uses.
- Mandatory setback for stream fencing (fencing right on the stream edge does little to help water quality).
- Mandatory setbacks for forestry harvesting to protect waterways from sedimentation, and the high nutrient inputs and increased oxygen demand that result from rotting instream debris along with increased temperatures resulting from a loss of shading.
- Native riparian planting of waterways has numerous benefits including the trapping of nutrients and sediment and providing shade which in turn reduces water temperature and improves dissolved oxygen levels. Riparian planting provides habitat for terrestrial as well as aquatic species in the form of overhanging vegetation. Overhanging vegetation is also a source of food for many aquatic species as plant matter and terrestrial insects form a part of the diet of many fish and macroinvertebrates. Plantings can also form connective corridors between patches of native bush to help the dispersal of native terrestrial species, both plant and animal.
- Encouraging diversification into land uses which have less impact on water quality.

Report cards for Northland harbour catchments

The following section provides a score card displaying the water quality status according to the Water Quality Index and ecological results for harbour catchments in Northland. A brief summary of water quality results is presented alongside site descriptions, land use class and ecological information.

Your guide to the information on the following report cards:

- EXCELLENT
- GOOD
- FAIR
- POOR

River Water Quality Monitoring Network (RWQMN) site Water Quality Index (WQI) result

- Waterway
- Catchment boundary
- Monitoring site catchment boundary (if smaller area of the main catchment boundary)
- RWQMN and Waiora Northland Water (WNW) priority catchment boundary
- RWQMN and WNW priority catchment site

PHYSICAL and CHEMICAL	DO	Dissolved oxygen (% saturation)
	DRP	Dissolved reactive phosphorus (mg/L)
	E. coli	*Escherichia coli* (cfu/100mL)
	NH_4	Ammoniacal nitrogen (mg/L)
	TON	Total oxidised nitrogen (mg/L)
	TURB	Turbidity (NTU)
	Passes	Number of times site measured under threshold

ECOLOGICAL	MCI	MCI result indicated as
	Periphyton	Periphyton result indicated as
	Habitat	Habitat result indicated as

EXCELLENT ★★★
GOOD ★★☆
FAIR ★☆☆
POOR ☆☆☆

ND No data

Indicates an IMPROVING trend

Indicates a DETERIORATING trend

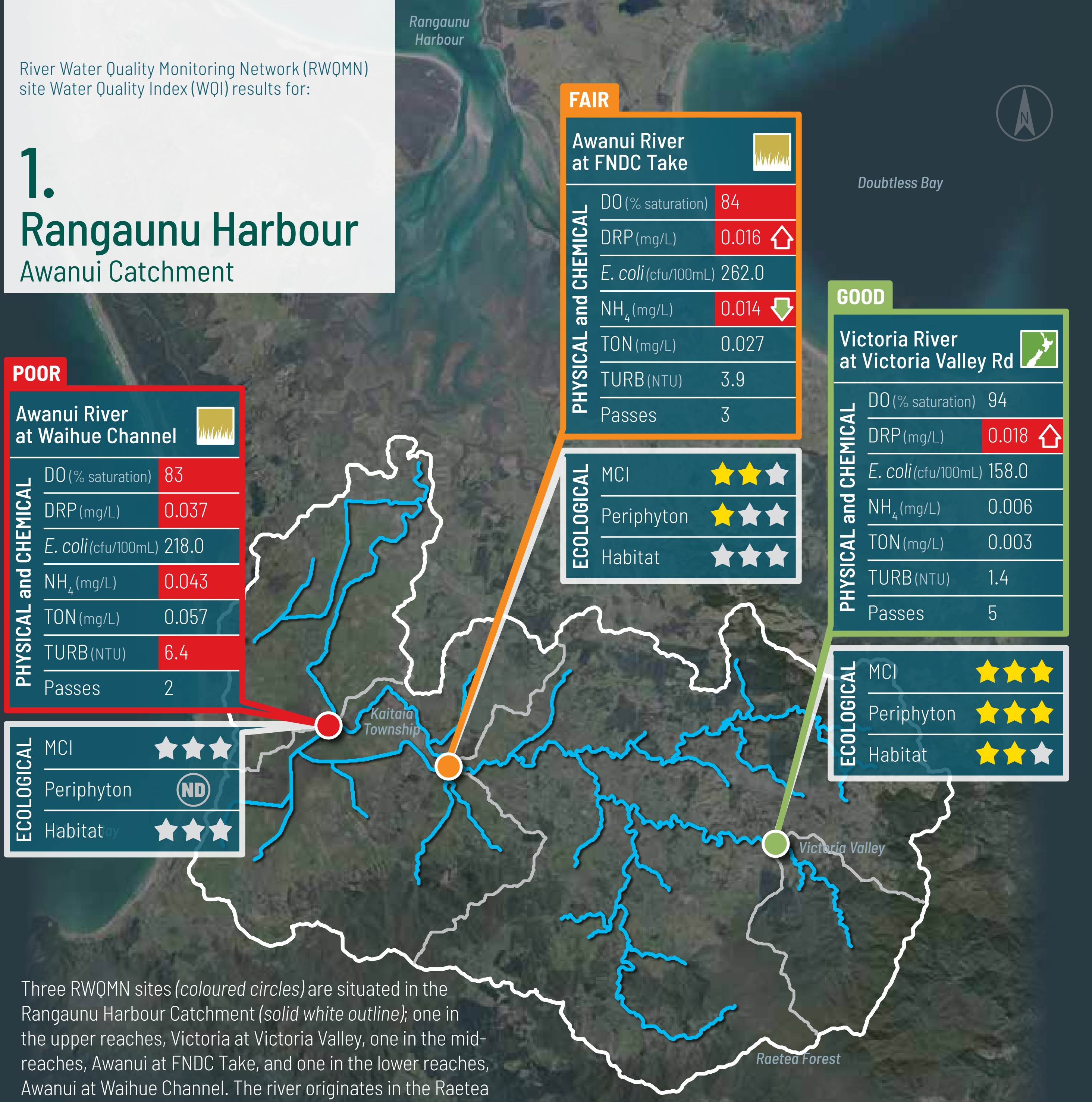
CATCHMENT LAND COVER

Pastoral | Exotic forest | Indigenous forest | Urban

River Water Quality Monitoring Network (RWQMN) site Water Quality Index (WQI) results for:

1. Rangaunu Harbour

Awanui Catchment



POOR

Awanui River at Waihue Channel

PHYSICAL and CHEMICAL	
DO (% saturation)	83
DRP (mg/L)	0.037
E. coli (cfu/100mL)	218.0
NH_4 (mg/L)	0.043
TON (mg/L)	0.057
TURB (NTU)	6.4
Passes	2

ECOLOGICAL	
MCI	★★★
Periphyton	ND
Habitat	★★★

FAIR

Awanui River at FNDC Take

PHYSICAL and CHEMICAL	
DO (% saturation)	84
DRP (mg/L)	0.016 ↑
E. coli (cfu/100mL)	262.0
NH_4 (mg/L)	0.014 ↓
TON (mg/L)	0.027
TURB (NTU)	3.9
Passes	3

ECOLOGICAL	
MCI	★★★
Periphyton	★★★
Habitat	★★★

GOOD

Victoria River at Victoria Valley Rd

PHYSICAL and CHEMICAL	
DO (% saturation)	94
DRP (mg/L)	0.018 ↑
E. coli (cfu/100mL)	158.0
NH_4 (mg/L)	0.006
TON (mg/L)	0.003
TURB (NTU)	1.4
Passes	5

ECOLOGICAL	
MCI	★★★
Periphyton	★★★
Habitat	★★★

Three RWQMN sites *(coloured circles)* are situated in the Rangaunu Harbour Catchment *(solid white outline)*; one in the upper reaches, Victoria at Victoria Valley, one in the mid-reaches, Awanui at FNDC Take, and one in the lower reaches, Awanui at Waihue Channel. The river originates in the Raetea Forest (in the Mangamuka ranges) and meanders north for a significant distance through pasture and the Kaitaia Township, eventually flowing into the Rangaunu Harbour. While the upper catchment is dominated by native forest, the main land use in the catchment is farmland with the lowest site (at Waihue Channel) having urban influences including the discharge from the Kaitaia sewage treatment plant.

In the upper reaches, where the upstream land cover in the catchment is predominantly indigenous forest, the Victoria River's water quality and ecological health are good, but results deteriorate downstream where the catchment is predominantly pasture and urban. By the time the Awanui River has passed through the Kaitaia township water quality and ecological health are severely degraded. The Awanui at Waihue Channel is amongst the worst RWQMN sites for water quality and ecological health. The main contaminants in the lower catchment are elevated dissolved reactive phosphorus, ammoniacal nitrogen and sediment (turbidity). These contaminants result in periphyton blooms, low levels of dissolved oxygen and alongside poor habitat quality contribute to a low scoring macroinvertebrate community in the lower catchment. Trend data between 2012–2016 indicates that dissolved reactive phosphorus levels at the Awanui at FNDC and Victoria at Victoria Valley sites are deteriorating (increasing) but ammoniacal nitrogen levels are improving (decreasing) in the Awanui at FNDC.

The Awanui feeds into the Rangaunu Harbour. The Rangaunu Harbour is not a regular coastal monitoring site but studies in the Far North harbours in 2004 and 2013 (Far North Harbour Study, 2013), are consistent with the fresh water quality results and suggest that bacterial levels meet guidelines but nutrient levels can sometimes exceed.

RWQMN site WQI results for:

2. Doubtless Bay

Oruru Catchment

FAIR

Oruru River at Oruru Rd

PHYSICAL and CHEMICAL		
	DO (% saturation)	84
	DRP (mg/L)	0.022 ↑
	E. coli (cfu/100mL)	202.0
	NH_4 (mg/L)	0.012
	TON (mg/L)	0.012
	TURB (NTU)	3.4
	Passes	3

ECOLOGICAL		
	MCI	★★★
	Periphyton	ND
	Habitat	★★★

The Oruru originates in the Maungataniwha/Otangaroa forest and flows north through native forest and scrub.

In the lower catchment, the river meanders through pastoral dominated land eventually flowing out into the Taipa River and then on into Doubtless Bay. Underlying geology is dominated by volcanic acidic rock, with some areas of soft sediments.

The long term RWQMN site *(coloured circle)* is towards the bottom of the Oruru catchment *(solid white outline)*. The main contaminants in this catchment are dissolved reactive phosphorus and ammoniacal nitrogen. Low dissolved oxygen alongside high nutrients and poor habitat quality contribute to a low scoring macroinvertebrate community. Trend data between 2012–2016 indicate that dissolved reactive phosphorus levels in the Oruru river are deteriorating (increasing).

The Oruru Catchment is just one of a number of catchments which feed into the Doubtless Bay harbour. A further nine sites spread between three main sub-catchments *(pale tinted area)*; Mangonui Harbour, Taipa River and Awapoko River have been monitored since July 2014 as part of the Waiora Northland Water (WNW) programme. Further details are provided in the 'Doubtless Bay Water Quality Update' 2016. Main findings from these sites have been:

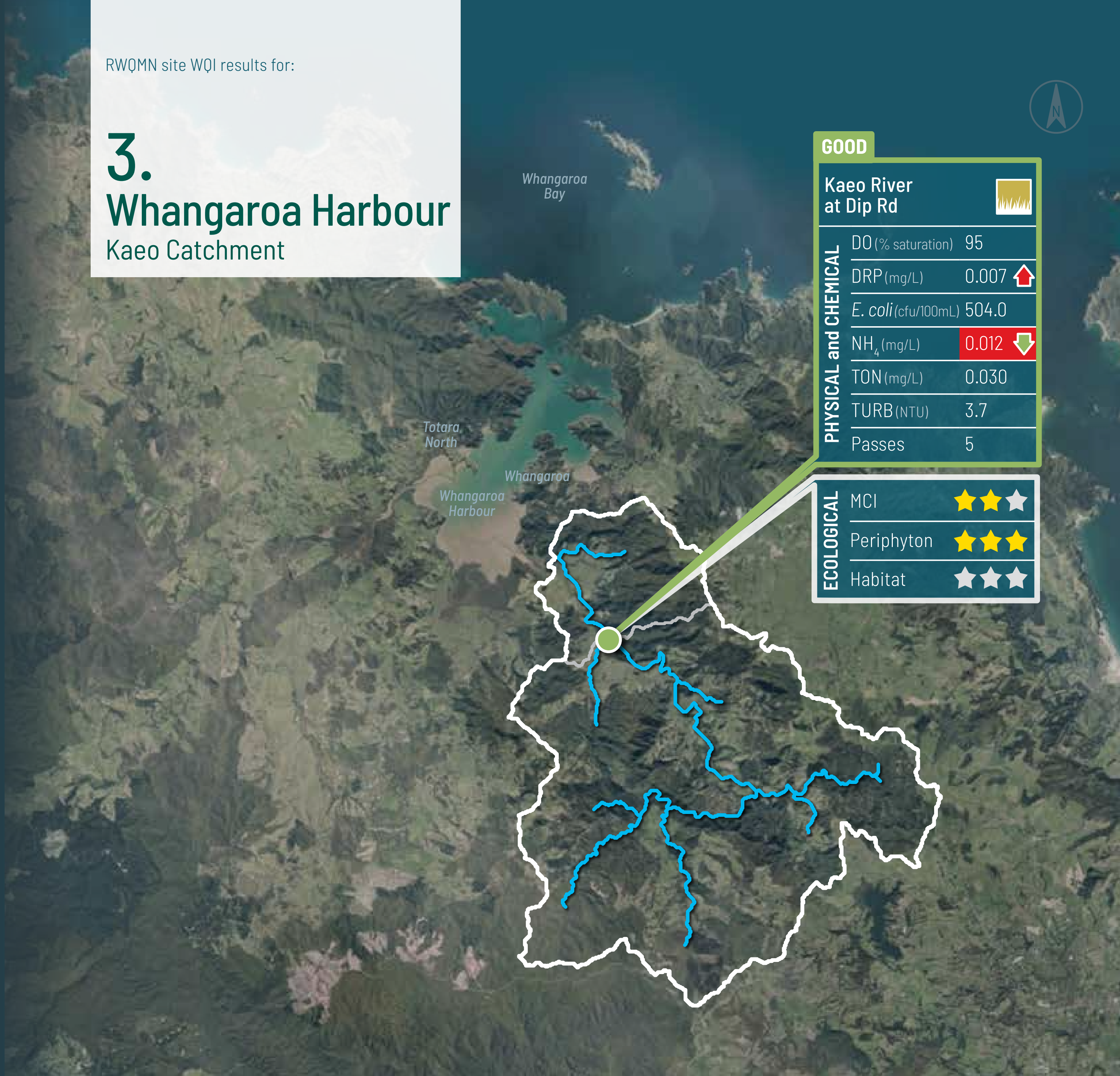
- dissolved reactive phosphorus levels are naturally elevated within the catchment related to geology
- the Aurere sub-catchment has a number of water quality and ecological issues including elevated dissolved reactive phosphorus, high turbidity (sediment), low dissolved oxygen levels, and poor habitat and MCI results
- ecological health is generally poor within the Doubtless Bay catchment as a whole with six out of ten sites scoring fair or poor MCI grades and five out of ten scoring poorly for habitat.

The Oruru feeds into Doubtless Bay. Regular coastal monitoring has only recently begun in Doubtless Bay but studies in the Far North harbours in 2004 and 2013 (Far North Harbour Study, 2013), are consistent with the fresh water quality results and suggest that bacterial levels meet guidelines but nutrient levels can sometimes exceed ANZECC guidelines.

RWQMN site WQI results for:

3. Whangaroa Harbour

Kaeo Catchment



GOOD

Kaeo River at Dip Rd

PHYSICAL and CHEMICAL		
DO (% saturation)	95	
DRP (mg/L)	0.007	↑
E. coli (cfu/100mL)	504.0	
NH_4 (mg/L)	0.012	↓
TON (mg/L)	0.030	
TURB (NTU)	3.7	
Passes	5	

ECOLOGICAL	
MCI	★★☆
Periphyton	★★★
Habitat	☆☆☆

The Kaeo River begins north of Waipapa and flows north into the Whangaroa Harbour. The catchment *(solid white outline)* is predominantly pastoral with native forest, and pine forest in the upper catchment. The underlying geology of the river is soft sediments.

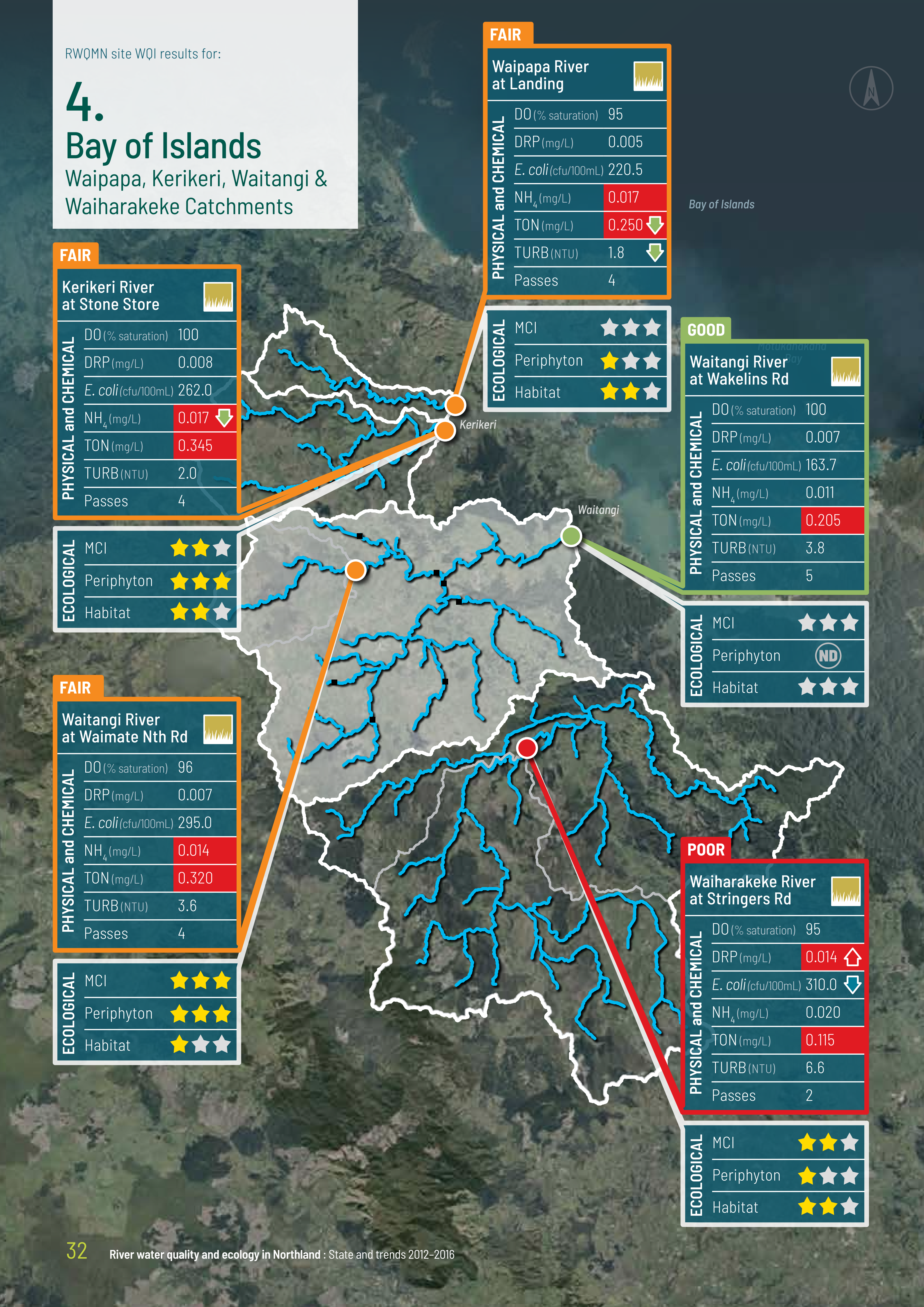
The long term RWQMN site *(coloured circle)* is towards the bottom of the Kaeo catchment below the discharge from the Kaeo sewage treatment plant. Ammoniacal nitrogen levels can be elevated but water quality is good. This is reflected in low periphyton growth and a healthy macroinvertebrate community despite poor habitat quality at the monitoring site. Trend data between 2012-2016 indicate that dissolved reactive phosphorus levels at in the Kaeo River are deteriorating (increasing) however ammoniacal nitrogen levels are improving (decreasing). Limited monitoring in the harbour suggests that water quality is good with the exception of elevated dissolved reactive phosphorus levels.

The Whangaroa Harbour is not routinely surveyed for water quality however an investigation was carried out from 2007-2010 as bacterial contamination was threatening the operating classification for growing commercial oysters. Faecal contamination was found to be low but turbidity levels exceeded ANZECC guidelines on occasions.

RWQMN site WQI results for:

4. Bay of Islands

Waipapa, Kerikeri, Waitangi & Waiharakeke Catchments



FAIR

Waipapa River at Landing

PHYSICAL and CHEMICAL		
DO (% saturation)	95	
DRP (mg/L)	0.005	
E. coli (cfu/100mL)	220.5	
NH_4 (mg/L)	0.017	
TON (mg/L)	0.250	↓
TURB (NTU)	1.8	↓
Passes	4	

ECOLOGICAL	
MCI	☆☆☆
Periphyton	★☆☆
Habitat	★★☆

FAIR

Kerikeri River at Stone Store

PHYSICAL and CHEMICAL		
DO (% saturation)	100	
DRP (mg/L)	0.008	
E. coli (cfu/100mL)	262.0	
NH_4 (mg/L)	0.017	↓
TON (mg/L)	0.345	
TURB (NTU)	2.0	
Passes	4	

ECOLOGICAL	
MCI	★★☆
Periphyton	★★★
Habitat	★★☆

GOOD

Waitangi River at Wakelins Rd

PHYSICAL and CHEMICAL	
DO (% saturation)	100
DRP (mg/L)	0.007
E. coli (cfu/100mL)	163.7
NH_4 (mg/L)	0.011
TON (mg/L)	0.205
TURB (NTU)	3.8
Passes	5

ECOLOGICAL	
MCI	☆☆☆
Periphyton	ND
Habitat	☆☆☆

FAIR

Waitangi River at Waimate Nth Rd

PHYSICAL and CHEMICAL	
DO (% saturation)	96
DRP (mg/L)	0.007
E. coli (cfu/100mL)	295.0
NH_4 (mg/L)	0.014
TON (mg/L)	0.320
TURB (NTU)	3.6
Passes	4

ECOLOGICAL	
MCI	★★★
Periphyton	★★★
Habitat	★☆☆

POOR

Waiharakeke River at Stringers Rd

PHYSICAL and CHEMICAL		
DO (% saturation)	95	
DRP (mg/L)	0.014	↑
E. coli (cfu/100mL)	310.0	↓
NH_4 (mg/L)	0.020	
TON (mg/L)	0.115	
TURB (NTU)	6.6	
Passes	2	

ECOLOGICAL	
MCI	★★☆
Periphyton	★☆☆
Habitat	★★☆

Five RWQMN sites feed into the Bay of Islands as shown on the map on page 32; the Kerikeri at Stone Store, Waipapa at Landing, Waitangi at Waimate North, Waitangi at Wakelins and Waiharakeke at Stringers. The Kerikeri River originates in the Puketi Forest whilst the Waipapa is further north and fed by Lake Manuwai. The Waitangi River originates in the middle of Northland and flows east, where it joins the coast at Waitangi. The Waiharakeke Stream is a major tributary of the Kawakawa River, which flows into the Waikare Inlet. Land use in the catchment is predominantly pastoral but also includes horticulture (orchards), agriculture (crops), forestry (pine plantations) and lifestyle blocks. The underlying geology in the area is predominantly acidic volcanic.

Water quality in the Bay of Islands is predominantly fair with the main contaminant in the catchment being nitrogen in the form of both ammoniacal nitrogen and total oxidised nitrogen. The Waiharakeke catchment has the poorest water quality results with elevated nutrients and turbidity and is amongst the worst sites for water quality in the RWQMN network. Ecological results are mixed with a range of scores from **EXCELLENT** to **POOR**. Trend data between 2012–2016 indicats several improving trends in the catchment; turbidity and nitrate levels are improving (decreasing) in the Waipapa and Kerikeri rivers, turbidity is improving in the Kerikeri River and *E. coli* in the Waiharakeke river. Dissolved reactive phosphorus levels are increasing (deteriorating) in the Waiharakeke River.

Coastal monitoring in the Bay of Islands shows a similar pattern. Most samples are within guidelines for turbidity and enterococci (faecal indicator for salt water) but nutrient levels can sometimes exceed (although they show improving trends). The Waiharakeke feeds into the Kawakawa River, which has the highest levels of turbidity and has been identified as a major source of sediment in the Bay of Islands.

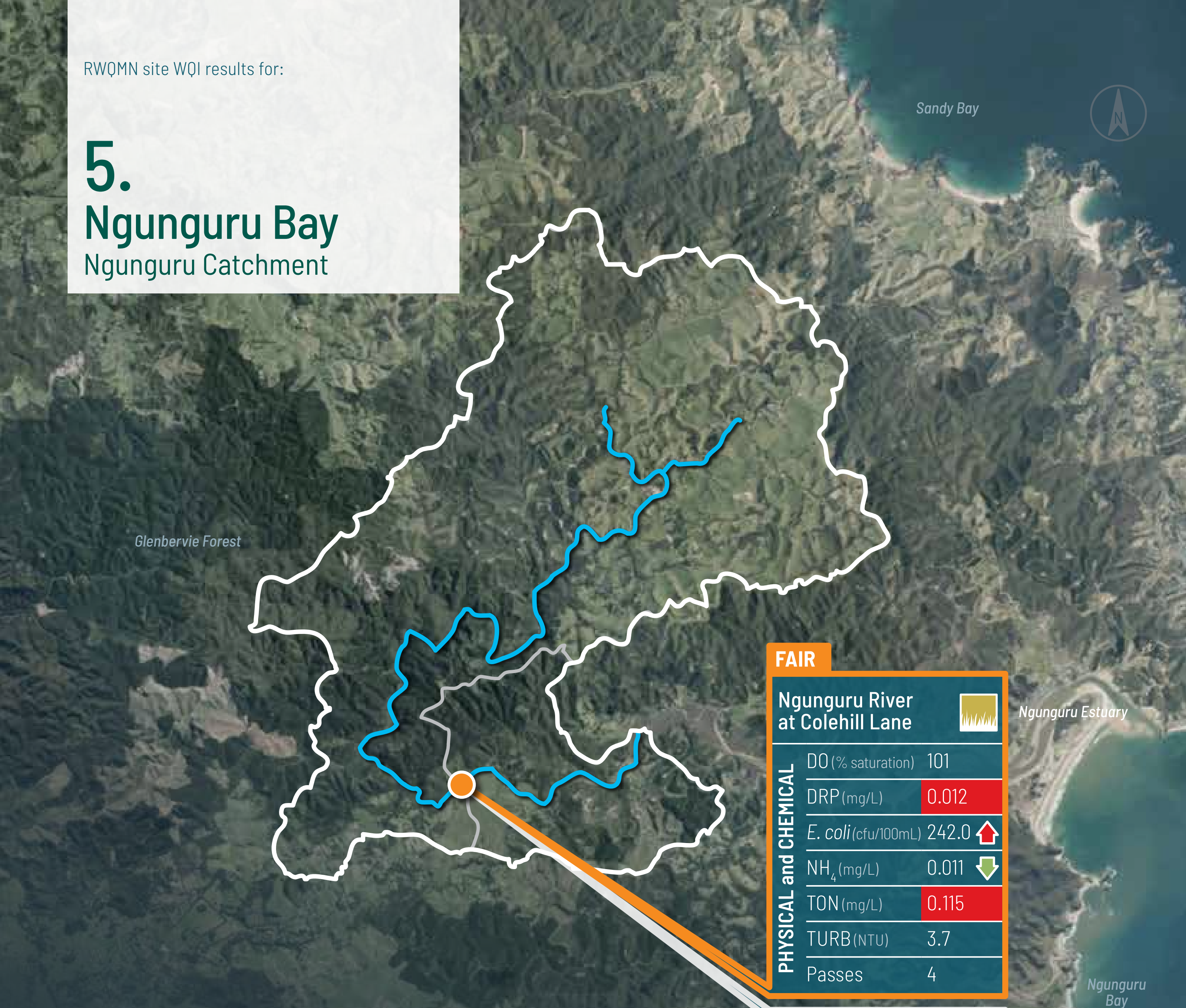
A further seven sites are spread between two main sub-catchments: Waitangi River and Wairohia River have been monitored since July 2014 as part of the Waiora Northland Water (WNW) programme. Further details are provided in the 'Waitangi Catchment Water Quality Update 2016'. Main findings from these sites have been:

- Water quality generally meets most current national standards/guideline values in the Waitangi catchment. However, national comparison (LAWA website) shows results for *E. coli*, turbidity, and nitrogen rank amongst the worst 50 percent of similar sites in New Zealand at the RWQMN sites. *E. coli* levels at the Waitangi at Waimate North Road site are amongst the worst 25 percent.
- All three Waitangi catchment sites, i.e., Waimate North Road, SH10 and Wakelins, exhibit occasional elevated turbidity levels and spikes in *E. coli* levels possibly associated with land run-offs during high rainfall events. While this in part may be linked to erosion issues occurring in its tributary, the Whangai Stream, all three sites have serious issues with slumping banks.
- The Mania Stream is a low energy meandering stream and has a number of water quality and ecological issues including elevated dissolved reactive phosphorus levels, low dissolved oxygen levels, poor habitat quality, and the lowest MCI score (61) in the Waitangi catchment.
- The three sites with the highest total oxidised nitrogen levels, i.e., Watercress, Waiaruhe D/S of Mangamutu and Pekepeka at Ohaeawai show some signs of nutrient enrichment with occasional periphyton blooms. The Watercress site has particularly high dissolved reactive phosphorus levels and the Waiaruhe D/S Mangamutu confluence has spikes in ammoniacal nitrogen toxicity as well as relatively high total oxidised nitrogen levels compared to other sites in the catchment.
- In general, the monitored swimming spots at Lily pond and Waitangi Bridge are suitable for swimming most of the time but can occasionally exceed the suitability for swimming guideline.

RWQMN site WQI results for:

5. Ngunguru Bay

Ngunguru Catchment



FAIR

Ngunguru River at Colehill Lane

PHYSICAL and CHEMICAL	DO (% saturation)	101
	DRP (mg/L)	0.012
	E. coli (cfu/100mL)	242.0
	NH_4 (mg/L)	0.011
	TON (mg/L)	0.115
	TURB (NTU)	3.7
	Passes	4
ECOLOGICAL	MCI	★★★
	Periphyton	★★☆
	Habitat	★☆☆

The Ngunguru River originates in Waipaipai to the west of the Tutukaka coast and flows through the Glenbervie forest out into the Ngunguru Estuary. The sampling site *(coloured circle)* is situated in the lower reaches of the river before it becomes saline. The catchment *(gray outline)* is predominantly pastoral with a mixture of *Pinus radiata* and native forest in the upper catchment.

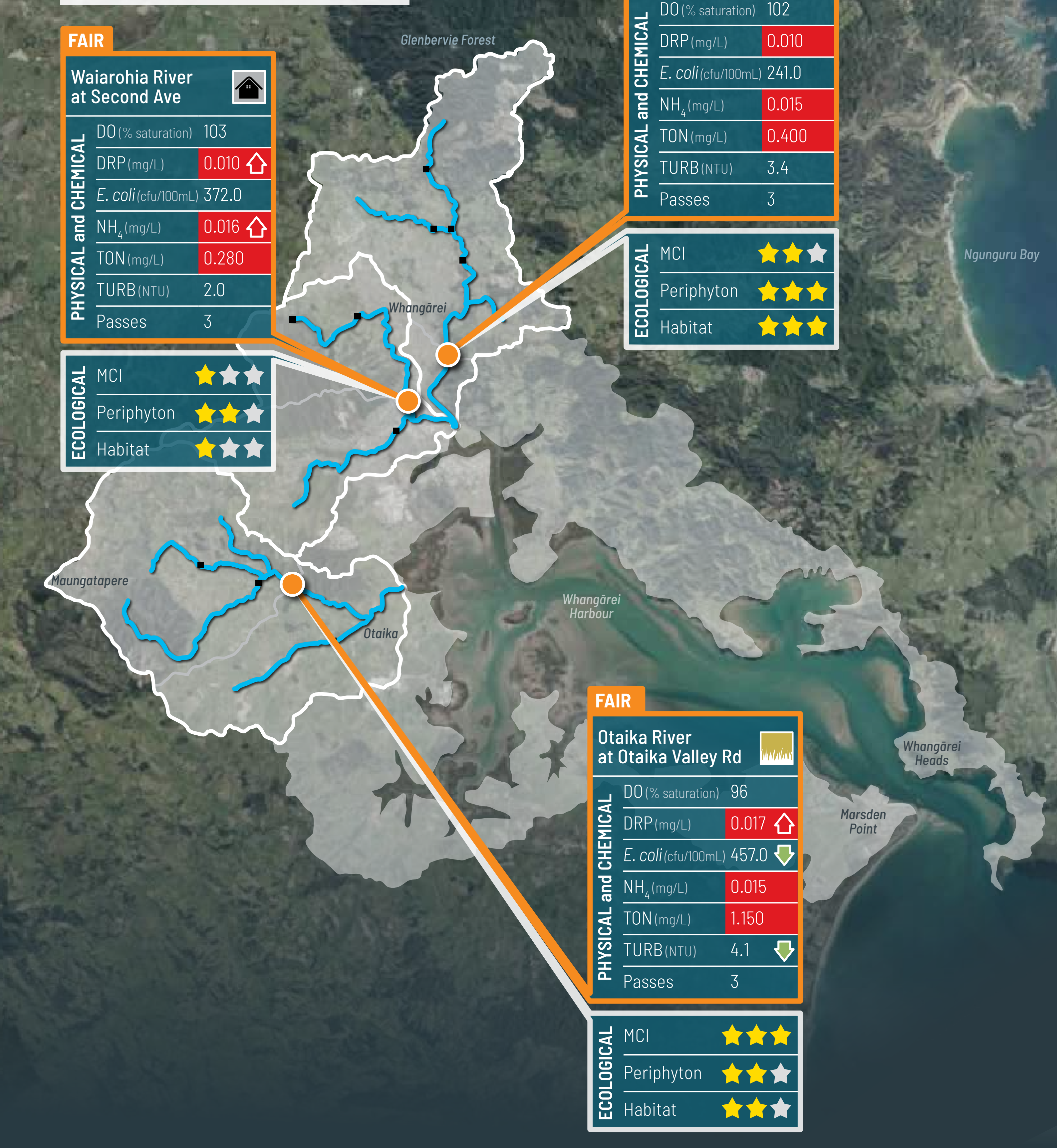
Water quality at the Ngunguru River site is fair, with high levels of dissolved reactive phosphorus and nitrate. These high nutrient levels are reflected in high periphyton growth (algal blooms). Despite only fair water quality, high periphyton growth and only fair habitat quality the site supports a healthy macroinvertebrate community. Trend data between 2012-2016 indicate that DRP levels in the Ngunguru River are deteriorating (increasing) however ammoniacal nitrogen levels are improving.

Coastal water quality sampling is not carried out in Ngunguru Bay.

RWQMN site WQI results for:

6. Whangārei Harbour

Hātea, Waiarohia & Otaika Catchments



FAIR

Waiarohia River at Second Ave

PHYSICAL and CHEMICAL	
DO (% saturation)	103
DRP (mg/L)	0.010 ↑
E. coli (cfu/100mL)	372.0
NH_4 (mg/L)	0.016 ↑
TON (mg/L)	0.280
TURB (NTU)	2.0
Passes	3

ECOLOGICAL	
MCI	★☆☆
Periphyton	★★☆
Habitat	★☆☆

FAIR

Hatea River at Mair Park

PHYSICAL and CHEMICAL	
DO (% saturation)	102
DRP (mg/L)	0.010
E. coli (cfu/100mL)	241.0
NH_4 (mg/L)	0.015
TON (mg/L)	0.400
TURB (NTU)	3.4
Passes	3

ECOLOGICAL	
MCI	★★☆
Periphyton	★★★
Habitat	★★★

FAIR

Otaika River at Otaika Valley Rd

PHYSICAL and CHEMICAL	
DO (% saturation)	96
DRP (mg/L)	0.017 ↑
E. coli (cfu/100mL)	457.0 ↓
NH_4 (mg/L)	0.015
TON (mg/L)	1.150
TURB (NTU)	4.1 ↓
Passes	3

ECOLOGICAL	
MCI	★★★
Periphyton	★★☆
Habitat	★★☆

Three RWQMN sites feed into the Whangārei Harbour (coloured circles); Hātea at Mair Park with headwaters to the north of Whangārei in the Glenbervie Forest, Waiarohia at Second Avenue originating from the Pukenui Forest and Otaika at Otaika Valley originating south of Whangārei near the township of Maungatepere. The predominant land use in the wider catchment is pastoral but there is also a mixture of native and exotic forest, lifestyle blocks and in the case of the Hātea and Waiarohia urban influences as they flow through residential housing and the central business area of Whangārei before entering the harbour. The Hātea site is downstream of a sewage discharge. Geology in the area is a mixture of volcanic acidic and hard sedimentary.

Water quality in the Whangārei Harbour catchment is fair. While *E. coli* and turbidity level meet objectives there are elevated levels of dissolved reactive phosphorus and nitrogen at all three sites. These high nutrient levels are reflected in high periphyton growth (algal blooms) in the Otaika and Waiarohia rivers. Despite only fair water quality, good habitat is supporting a healthy macroinvertebrate community at both the Hātea and Otaika sites. Trend data between 2012–2016 indicates that nutrient levels are increasing (deteriorating) at some sites but *E. coli* and turbidity levels are improving in the Otaika.

Coastal monitoring in the Whangārei Harbour shows a similar pattern. Most samples are within guidelines for turbidity and enterococci (faecal indicator for salt water) but nutrient levels can exceed ANZECC guidelines (although they are showing improving trends). The heavy metals copper, zinc and lead are also elevated in some areas of the Hātea and Waiarohia at levels which have the potential to cause adverse effects on marine ecosystems and may account for the fair macroinvertebrate results in the Waiarohia Stream.

A further nine sites spread between the Hātea, Waiarohia and Otaika-catchments have been monitored since July 2014 as part of the Waiora Northland Water (WNW) programme (small black squares). Further details are provided in the 'Whangārei Harbour Water Quality Update 2016'. Main findings from these sites have been:

- Total oxidised nitrogen and ammoniacal nitrogen levels are particularly high at the Puwera at Bennet's site with levels representing an acute risk of death for sensitive species inhabiting the stream.
- Total oxidised nitrogen median levels recorded at five sites in particular, i.e., Waitaua at Vinegar Hill Road, Waiarohia at Whau Valley, Raumanga at Bernard Street, Otaika at Cemetery Road and Otaika at Otaika Valley Road are elevated.
- Phosphorus levels are particularly elevated at three sites, Otaika at Cemetery Road, Otaika at Otaika Valley Road and Puwera at Bennet's Farm.
- Five sites, i.e., Mangakino at Mangakino Lane, Mangakino U/S Waitaua confluence, Otaika at Cemetery Road, Otakaranga at Otaika Valley Road and Puwera at Bennett's recorded elevated turbidity, possibly highlighting the influence of the two main land uses occurring within the upper Hātea and the Otaika catchments, i.e., forestry and pastoral activities respectively.
- *E. coli* levels at the popular swimming site Hātea at Whangārei Falls frequently fail guidelines for swimming.
- MCI and habitat health recorded are generally poor within the catchment compared to the reference site.
- The most impacted sites were those located in the Otaika sub-catchment as well as the Waitaua at Vinegar Hill Road site. All these sites currently have stock access.

RWQMN site WQI results for:

7. Bream Bay
Ruakaka Catchment

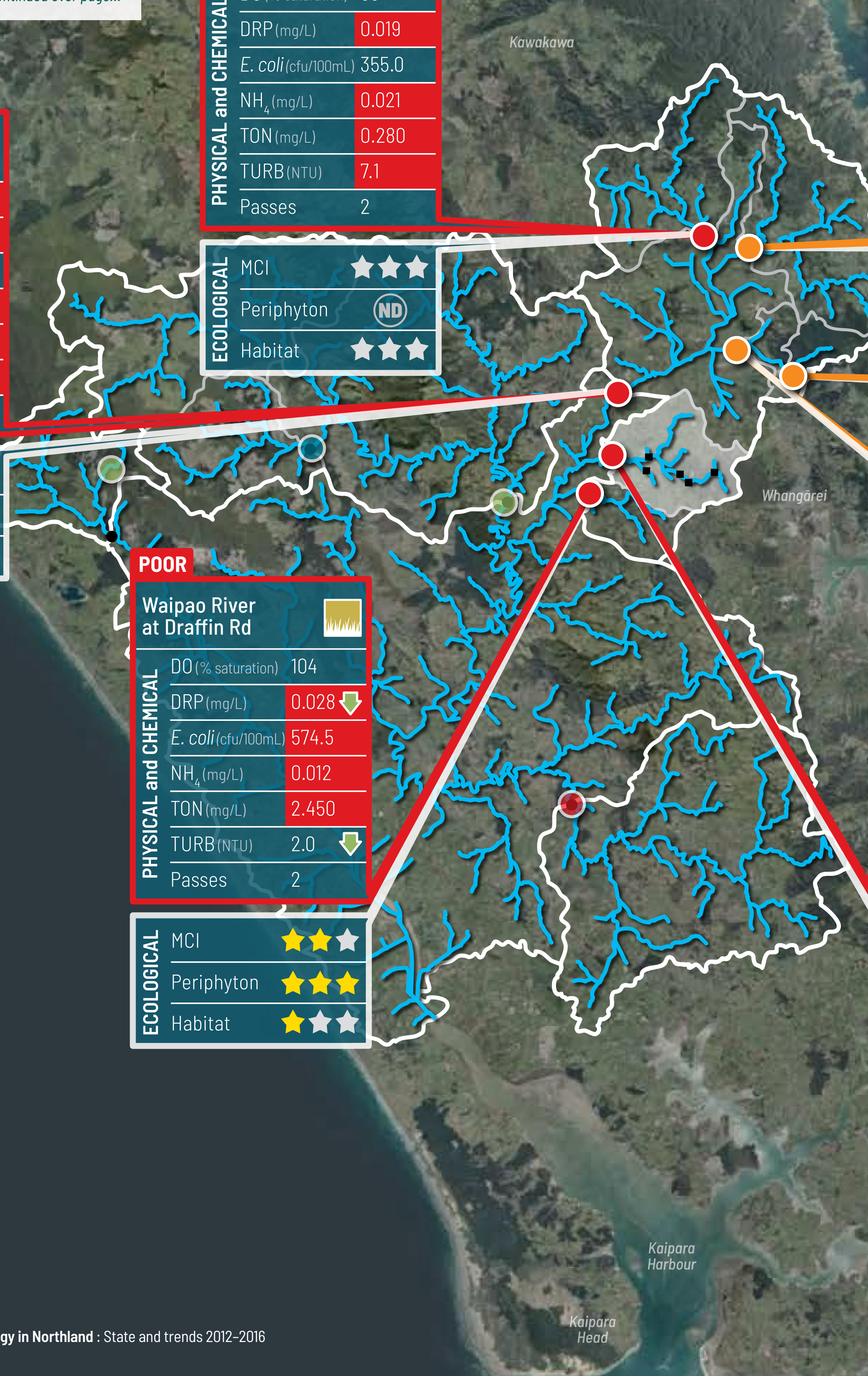
The Ruakaka River catchment *(solid white outline)* is relatively small and runs east from Ruakaka forest to Bream Bay. The catchment is dominated by pastoral land with areas of the upper catchment in native bush. The underlying geology at the site is mainly soft sediments.

Water quality in the Ruakaka River is very poor. The site fails objectives for all WQI parameters and has the worst results of all RWQMN sites. The sampling site *(coloured circle)* is within a patch of native bush so habitat quality is good and because the site is heavily shaded periphyton growth is restricted by low light conditions. Despite this phormidium is often recorded at this site (a form of periphyton/bacteria which can produce toxins). Although habitat quality is good the macroinvertebrate community is in only fair condition. Trend data between 2012–2016 indicate *E. coli* levels are improving (decreasing) at the site.

The Ruakaka River feeds into the Ruakaka estuary which is an ecologically significant habitat and an important feeding ground for numerous seabird species. Coastal monitoring began recently in the area but doesn't cover the time period for this report.

RWQMN site WQI results for:

8.
Kaipara Harbour
Wairua Catchment *...continued over page...*



POOR

Waiotu River at SH1

PHYSICAL and CHEMICAL	
DO (% saturation)	93
DRP (mg/L)	0.019
E. coli (cfu/100mL)	355.0
NH_4 (mg/L)	0.021
TON (mg/L)	0.280
TURB (NTU)	7.1
Passes	2

ECOLOGICAL	
MCI	☆☆☆
Periphyton	ND
Habitat	☆☆☆

POOR

Wairua River at Purua

PHYSICAL and CHEMICAL	
DO (% saturation)	92
DRP (mg/L)	0.017
E. coli (cfu/100mL)	92.1
NH_4 (mg/L)	0.018
TON (mg/L)	0.328
TURB (NTU)	9.0 ↓
Passes	1

ECOLOGICAL	
MCI	☆☆☆
Periphyton	ND
Habitat	☆☆☆

POOR

Waipao River at Draffin Rd

PHYSICAL and CHEMICAL	
DO (% saturation)	104
DRP (mg/L)	0.028 ↓
E. coli (cfu/100mL)	574.5
NH_4 (mg/L)	0.012
TON (mg/L)	2.450
TURB (NTU)	2.0 ↓
Passes	2

ECOLOGICAL	
MCI	★★☆
Periphyton	★★★
Habitat	★☆☆

FAIR

Whakapara River at Cableway

PHYSICAL and CHEMICAL	
DO (% saturation)	96
DRP (mg/L)	0.023 ↑
E. coli (cfu/100mL)	224.5
NH_4 (mg/L)	0.010 ↓
TON (mg/L)	0.250
TURB (NTU)	5.2 ↓
Passes	4

ECOLOGICAL	
MCI	☆☆☆
Periphyton	ND
Habitat	☆☆☆

FAIR

Mangahahuru River at Main Rd

PHYSICAL and CHEMICAL	
DO (% saturation)	96
DRP (mg/L)	0.011 ↑
E. coli (cfu/100mL)	327.5 ↑
NH_4 (mg/L)	0.011 ↓
TON (mg/L)	0.135
TURB (NTU)	6.2
Passes	4

ECOLOGICAL	
MCI	★★★
Periphyton	★★★
Habitat	★★☆

FAIR

Mangahahuru River at Apotu Rd

PHYSICAL and CHEMICAL	
DO (% saturation)	94
DRP (mg/L)	0.022 ↑
E. coli (cfu/100mL)	380.5
NH_4 (mg/L)	0.017 ↓
TON (mg/L)	0.280
TURB (NTU)	6.0
Passes	3

ECOLOGICAL	
MCI	★☆☆
Periphyton	ND
Habitat	☆☆☆

POOR

Mangare River at Knight Rd

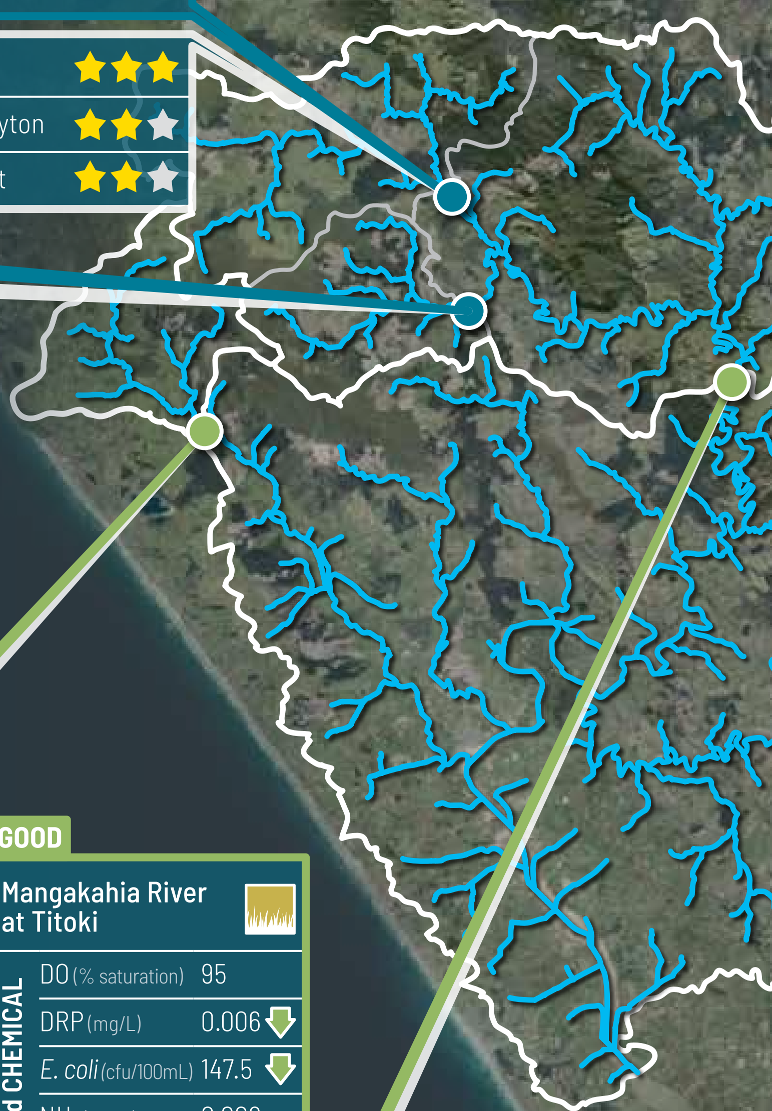
PHYSICAL and CHEMICAL	
DO (% saturation)	86
DRP (mg/L)	0.039 ↑
E. coli (cfu/100mL)	555.0
NH_4 (mg/L)	0.033
TON (mg/L)	0.455
TURB (NTU)	6.0 ↓
Passes	1

ECOLOGICAL	
MCI	★☆☆
Periphyton	ND
Habitat	☆☆☆

Wellsford

Kaipara Harbour

Mangakahia, Kaihu, Manganui & Hakaru Catchments



EXCELLENT

Opouteke River at Suspension Bridge

PHYSICAL and CHEMICAL	
DO (% saturation)	107
DRP (mg/L)	0.008
E. coli (cfu/100mL)	159.0
NH_4 (mg/L)	0.008
TON (mg/L)	0.043
TURB (NTU)	3.1
Passes	6

ECOLOGICAL	
MCI	★★☆
Periphyton	★☆☆
Habitat	★★☆

EXCELLENT

Mangakahia River at Twin Bridges

PHYSICAL and CHEMICAL	
DO (% saturation)	109
DRP (mg/L)	0.008
E. coli (cfu/100mL)	174.0
NH_4 (mg/L)	0.007
TON (mg/L)	0.037
TURB (NTU)	3.6
Passes	6

ECOLOGICAL	
MCI	★★★
Periphyton	★★☆
Habitat	★★☆

GOOD

Kaihu River at Gorge

PHYSICAL and CHEMICAL	
DO (% saturation)	101
DRP (mg/L)	0.007 ↑
E. coli (cfu/100mL)	187.0
NH_4 (mg/L)	0.008 ↓
TON (mg/L)	0.215
TURB (NTU)	2.9
Passes	5

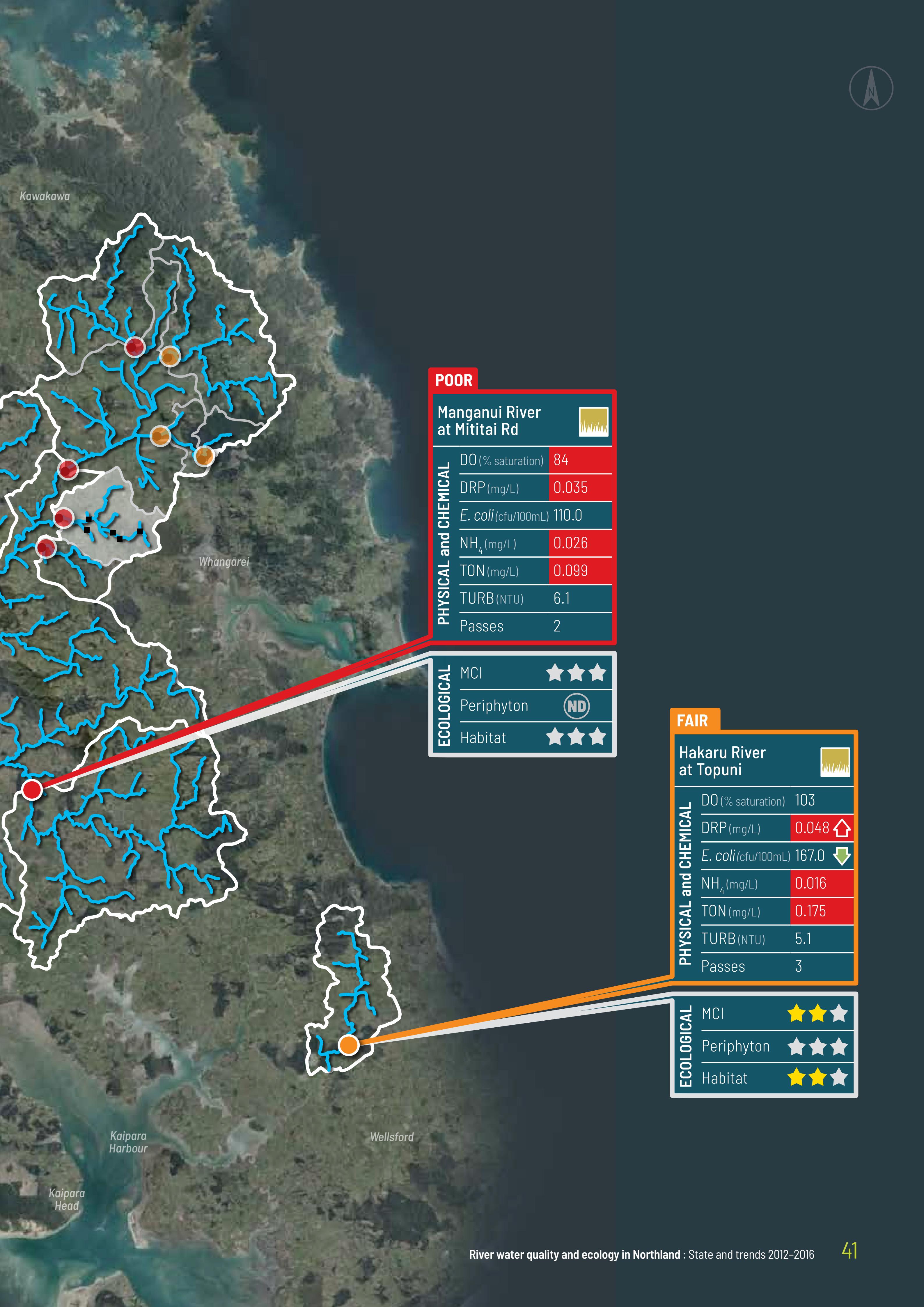
ECOLOGICAL	
MCI	★★☆
Periphyton	★★☆
Habitat	★★★

GOOD

Mangakahia River at Titoki

PHYSICAL and CHEMICAL	
DO (% saturation)	95
DRP (mg/L)	0.006 ↓
E. coli (cfu/100mL)	147.5 ↓
NH_4 (mg/L)	0.008
TON (mg/L)	0.042
TURB (NTU)	6.3
Passes	5

ECOLOGICAL	
MCI	★☆☆
Periphyton	ND
Habitat	★☆☆



POOR

Manganui River at Mititai Rd

PHYSICAL and CHEMICAL	
DO (% saturation)	84
DRP (mg/L)	0.035
E. coli (cfu/100mL)	110.0
NH_4 (mg/L)	0.026
TON (mg/L)	0.099
TURB (NTU)	6.1
Passes	2

ECOLOGICAL	
MCI	★★★
Periphyton	ND
Habitat	★★★

FAIR

Hakaru River at Topuni

PHYSICAL and CHEMICAL	
DO (% saturation)	103
DRP (mg/L)	0.048 ⇧
E. coli (cfu/100mL)	167.0 ⇩
NH_4 (mg/L)	0.016
TON (mg/L)	0.175
TURB (NTU)	5.1
Passes	3

ECOLOGICAL	
MCI	★★★
Periphyton	★★★
Habitat	★★★

Kaipara Harbour is the largest estuary in New Zealand covering 947 square kilometres. Recent state of the environment reports have documented a decline in the harbour ecosystem, with loss of habitat, decline in fisheries and shellfisheries, spread of mangroves and the accumulation of mud in previously sandy areas. NIWA studies have shown the current annual-average sediment load into the harbour is about 700,000 tonnes per year, compared to 120,000 tonnes per year in pre-human times.

The main catchment feeding into the Northern Kaipara is the Northern Wairoa which is Northland's largest river, draining most of Southern Northland and almost 30 percent of Northland's total land area. It is fed by three major rivers: the Wairua draining the eastern ranges between Whangārei and Kawakawa, and the Mangakahia and Kaihu Rivers draining central and western ranges. The Mangahahuru at Apotu Road site is downstream of the Fonterra Dairy Factory oxidation pond discharge just north of Whangārei. These river catchments all quickly turn from native/exotic forest to pastoral land, before flowing into the harbour. The Hakaru River originates further south in the Brynderwyn hills flowing south through native bush and pine forestry then farmland until it reaches the Topuni River and an eastern arm of the Kaipara Harbour. The underlying geology in the catchment is a mixture of volcanic acidic, and hard and soft sedimentary rock. The main land use in the Northern Kaipara is pasture, with native and exotic forestry in the upper catchment. Twelve sites, over a third of RWQMN sites, are situated within the wider Northern Kaipara Catchment.

Water quality at the Northern Wairoa and Hakaru catchment sites is good in the western upper reaches but degraded at all other sites. Currently a shortfall of the SoE monitoring network is a lack of monitoring sites lower in the Wairoa catchment, which would better reflect the water quality of the catchment. Data from current sites show that the main contaminants in the catchment are dissolved reactive phosphorus and nitrates, with elevated turbidity and *E. coli* levels at some sites. These results, as well as low levels of dissolved oxygen and poor habitat quality, contribute to a low scoring macroinvertebrate community particularly in the Wairua catchment.

The Wairua and Manganui catchments stand out for poor water quality and ecological health. Together they include five of the most impacted sites in the RWQMN network. In the Wairua catchment, the Waipao Stream fed from Poroti springs has elevated nitrogen compared to all other sites in Northland. This is currently under investigation. The Mangakahia and Kaihu sites have good water quality and ecological health although below the Kaihu at Gorge site, which is in the forested upper reaches, the river becomes degraded with pastoral land use. Most of the sites in the wider catchment are not suitable for periphyton monitoring being too deep to sample. The Hakaru at Topuni site has high nutrient levels and is the only RWQMN site to fail the periphyton National Objectives Framework- FW (2014) standard. Despite this the site has good habitat quality and supports a healthy macroinvertebrate community. Trend data between 2012–2016 indicates that DRP levels are deteriorating (increasing) at some sites but ammoniacal nitrogen and turbidity levels are improving (decreasing) at many sites. Both dissolved reactive phosphorus and *E. coli* are improving in the Mangakahia catchment.

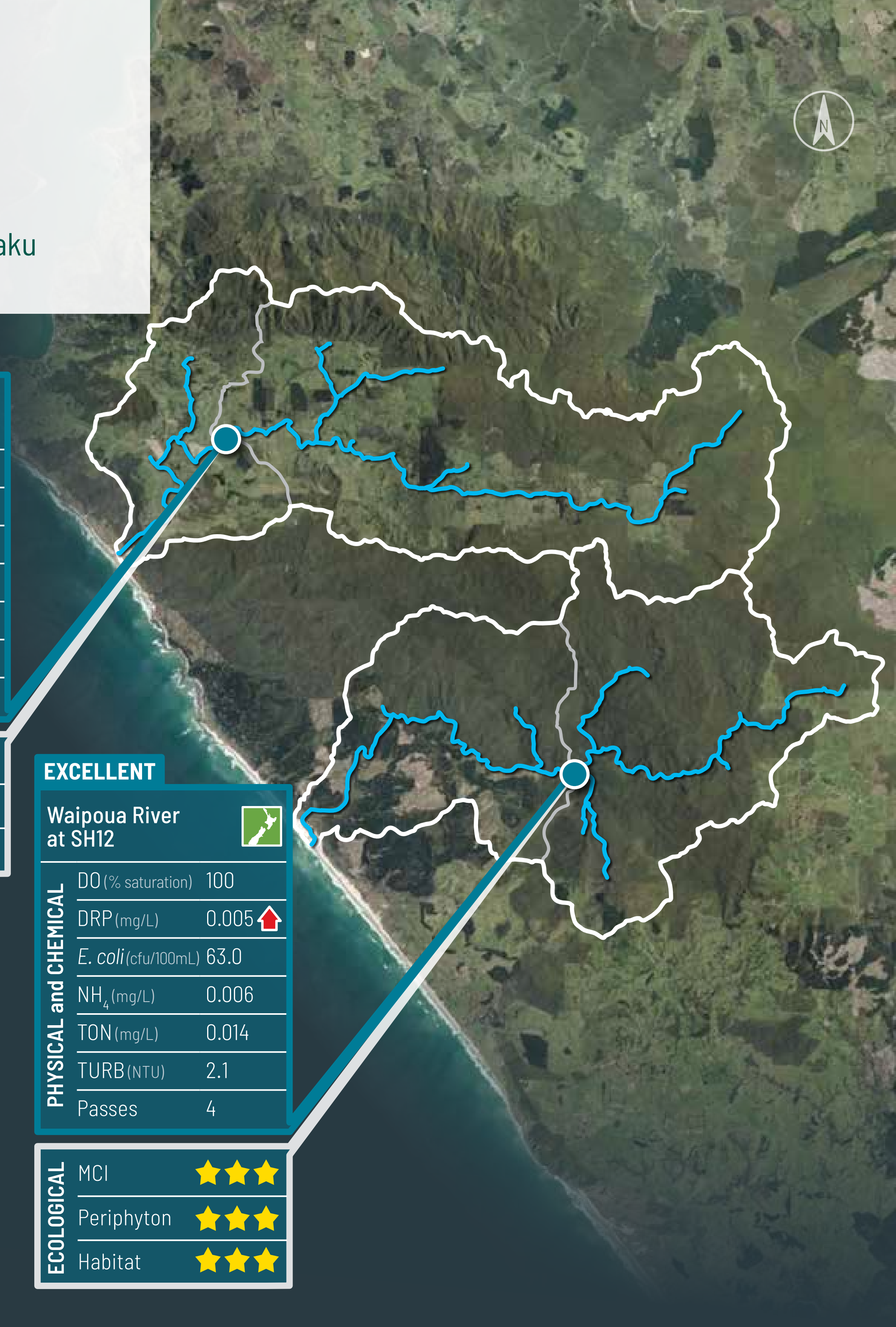
Coastal monitoring in the Kaipara Harbour shows a similar pattern. Most samples are within guidelines for turbidity and enterococci (faecal indicator for salt water) but nutrient levels often exceed ANZECC guidelines (although showing improving trends).

In the north-east section of the catchment, near Whangārei, a further six sites have been monitored in the Mangere sub-catchment (an intensive dairying area) since July 2014 as part of the Waiora Northland Water (WNW) programme. Further details are provided in the 'Mangere Water Quality Update 2016'. The main water quality issues in the Mangere include elevated nutrients and *E. coli* as well as low dissolved oxygen levels and moderate ecological health. The Mangapiu at Kokopu Road site stands out as having degraded water quality.

RWQMN site WQI results for:

9. West Coast

Waipoua & Waimamaku Catchments



EXCELLENT

Waimamaku River at SH12

PHYSICAL and CHEMICAL	
DO (% saturation)	100
DRP (mg/L)	0.006 ↓
E. coli (cfu/100mL)	285.5
NH_4 (mg/L)	0.008 ↓
TON (mg/L)	0.003
TURB (NTU)	3.3
Passes	6

ECOLOGICAL	
MCI	★★★
Periphyton	★★★
Habitat	★☆☆

EXCELLENT

Waipoua River at SH12

PHYSICAL and CHEMICAL	
DO (% saturation)	100
DRP (mg/L)	0.005 ↑
E. coli (cfu/100mL)	63.0
NH_4 (mg/L)	0.006
TON (mg/L)	0.014
TURB (NTU)	2.1
Passes	4

ECOLOGICAL	
MCI	★★★
Periphyton	★★★
Habitat	★★★

The Waipoua River originates in the Waipoua Forest, on the West Coast of Northland while the Waimamaku River begins just north of the Waipoua forest and flows west through Waimamaku township, eventually reaching the West Coast south of the Hokianga Harbour. The Waipoua catchment is dominated by native forest with exotic forest in the lower reaches, while the Waimamaku catchment is mainly pastoral *(catchments shown by solid white outlines).*

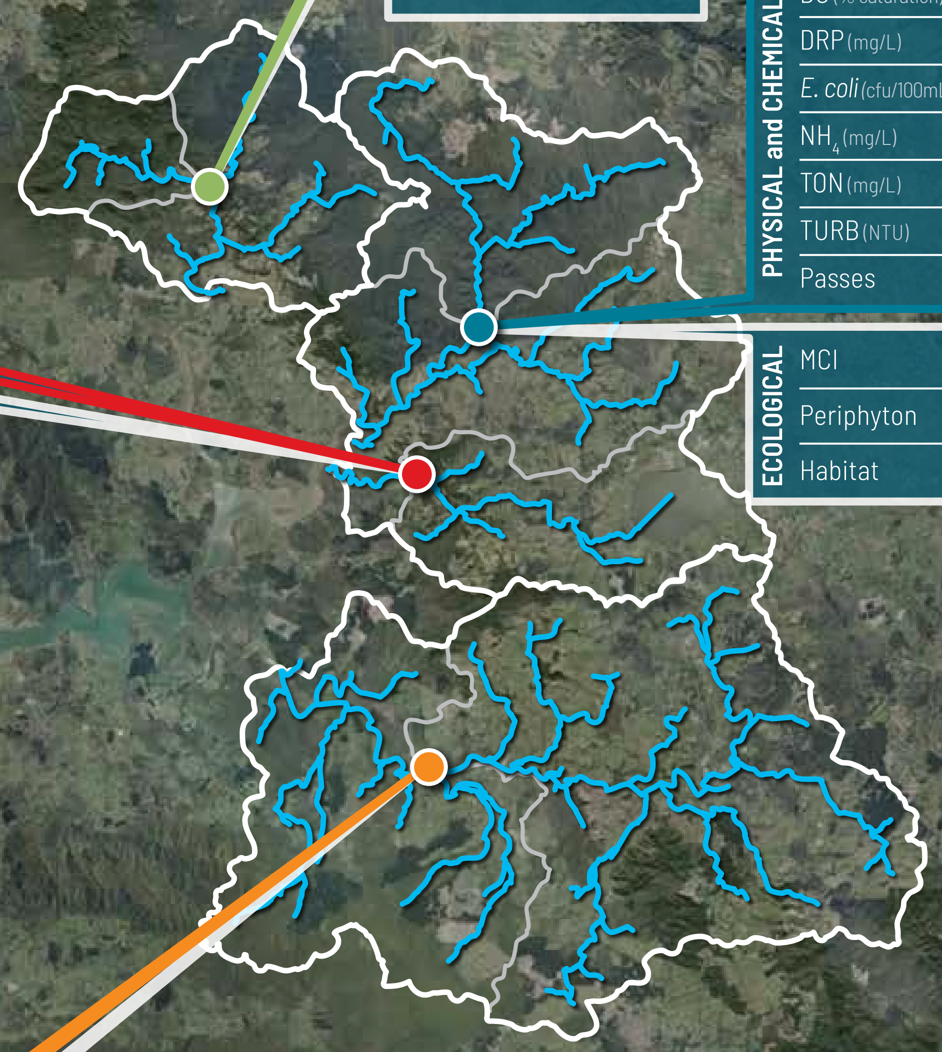
Water quality in the Waipoua and Waimamaku catchment is **EXCELLENT**. All WQI objectives are met and both sites *(coloured circles)* support healthy macroinvertebrate communities reflecting the dominance of forested land use in the catchment. The fair habitat assessment at Waimamaku is due to the site being on an unfenced pastoral site. Trend data between 2012-2016 indicate improving trends in ammoniacal nitrogen and turbidity at the Waimamaku site but increasing dissolved reactive phosphorus levels at the reference site in the Waipoua.

No coastal water quality sampling is currently undertaken in the area.

RWQMN site WQI results for:

10. Hokianga Harbour

Mangamuka, Waihou & Waima Catchments



GOOD

Mangamuka River at Iwitaua Rd

PHYSICAL and CHEMICAL	
DO (% saturation)	93
DRP (mg/L)	0.029 ↑
E. coli (cfu/100mL)	331.0
NH_4 (mg/L)	0.005
TON (mg/L)	0.005
TURB (NTU)	1.5
Passes	5

ECOLOGICAL	
MCI	★★★
Periphyton	★★★
Habitat	★☆☆

EXCELLENT

Waipapa River at Forest Ranger

PHYSICAL and CHEMICAL	
DO (% saturation)	97
DRP (mg/L)	0.005 ↓
E. coli (cfu/100mL)	66.4
NH_4 (mg/L)	0.003 ↓
TON (mg/L)	0.008
TURB (NTU)	1.6 ↓
Passes	6

ECOLOGICAL	
MCI	★★★
Periphyton	★★★
Habitat	★★★

POOR

Utakura River at Okaka Rd

PHYSICAL and CHEMICAL	
DO (% saturation)	92
DRP (mg/L)	0.011
E. coli (cfu/100mL)	201.0
NH_4 (mg/L)	0.014 ↓
TON (mg/L)	0.125
TURB (NTU)	6.6
Passes	1

ECOLOGICAL	
MCI	☆☆☆
Periphyton	ND
Habitat	☆☆☆

FAIR

Punakitere River at Taheke

PHYSICAL and CHEMICAL	
DO (% saturation)	99
DRP (mg/L)	0.017
E. coli (cfu/100mL)	329.0
NH_4 (mg/L)	0.014
TON (mg/L)	0.380
TURB (NTU)	4.7
Passes	3

ECOLOGICAL	
MCI	★★☆
Periphyton	★★☆
Habitat	★★☆

The Mangamuka, Waihou and Waima rivers are all located in central Northland and feed into the Upper Hokianga harbour. The Mangamuka and Waihou originate in native forest whilst the Waima originates from a wetland to the southwest of Kaikohe and drains mainly pastoral land. The catchment is dominated by native forest. From their respective sources, the rivers meander through farmland until they reach the harbour. Four RWQMN sites *(coloured circles)* are situated in this area; Mangamuka at Iwitaua Road (Mangamuka catchment), Waipapa at Forest Ranger and Utakura at Okaka Road (Waihou catchment) and Punakitere at Taheke (Waima catchment) *(catchments indicated by solid white outlines)*. Waipapa at Forest Ranger is a pristine 'reference' site situated in the Puketi forest. The Waipapa at Forest Ranger site is one of two sites in Northland which are part of the National River Water Quality Network (NRWQN) operated by NIWA.

Water quality in the Upper Hokianga harbour ranges from **EXCELLENT** to **POOR** with the main contaminants in the catchment being dissolved reactive phosphorus and nitrogen in the form of both ammoniacal nitrogen and total oxidised nitrogen. The sites in the upper catchment (Waipapa and Mangamuka) dominated by forestry both exhibit good water quality, low periphyton growth and healthy macroinvertebrate communities. The Punakitere and Utakura sites, both draining predominantly pastoral land, have the worst water quality results with turbidity (sediment) levels also elevated at the Utakura site. These contaminants are likely to be contributing to periphyton blooms/low scoring macroinvertebrate communities and low dissolved oxygen levels. The Utakura (draining Lake Omapere) is amongst the most degraded sites in the RWQMN. Trend data between 2012–2016 indicates dissolved reactive phosphorus levels are increasing (degrading) at the Mangamuka site. There are a number of improving trends in the Waipapa site including dissolved reactive phosphorus, ammoniacal nitrogen and turbidity.

Coastal water quality sampling was carried out in the Hokianga harbour for a year between June 2009–June 2010. Most samples were within guidelines for turbidity and enterococci (faecal indicator for salt water) but nutrient levels sometimes exceeded ANZECC guidelines, particularly in the upper harbour.

Mangamuka River

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Paranui River

Appendices

Appendix A: Water quality results summary

WQI grades and trends for RWQMN sites sampled at monthly intervals over the period 2012–2016. The index is based on comparisons of median values with objective values for six key variables (see table on page 10). Red numbers indicate the median does not meet the objective. Reference sites (draining almost 100% native forest) are shaded pale green. The WQI grade is based on how many of the six variables fail the objective. 0 = **EXCELLENT** / 1 = **GOOD** / 2–3 = **FAIR** / 4–6 = **POOR**.

CATCHMENT LAND COVER:

Pastoral Exotic forest Indigenous forest Urban

TREND:

↓ Improving ↑ Deteriorating

Water quality results for RWQMN sites sampled over the period, 2012-2016:

Site	Land cover	DO	DRP	*E. coli*	NH_4	TON	TURB	PASS	WQI Grade
1. Rangaunu Harbour									
Awanui Catchment									
Victoria River at Victoria Valley Rd		94	0.018 ↑	158.0	0.006	0.003	1.4	5	GOOD
Awanui River at FNDC		84	0.016 ↑	262.0	0.014 ↓	0.027	3.9	3	FAIR
Awanui River at Waihue Channel		83	0.037	218.0	0.043	0.057	6.4	2	POOR
2. Doubtless Bay									
Oruru Catchment									
Oruru River at Oruru Rd		84	0.022 ↑	202.0	0.012	0.012	3.4	3	FAIR
3. Whangaroa Harbour									
Kaeo Catchment									
Kaeo River at Dip Rd		95	0.007 ↑	504.0	0.012 ↓	0.030	3.7	5	GOOD
4. Bay of Islands									
Waipapa Catchment									
Waipapa River at Landing		95	0.005	220.5	0.017	0.250 ↓	1.8 ↓	4	FAIR
Kerikeri Catchment									
Kerikeri River at Stone Store		100	0.008	262.0	0.017	0.345 ↓	2.0	4	FAIR
Waiharakeke Catchment									
Waiharakeke River at Stringers Rd		95	0.014 ↑	310.0 ↓	0.020	0.115	6.6	2	POOR
Waitangi Catchment									
Waitangi River at Waimate North Rd		96	0.007	295.0	0.014	0.320	3.6	4	FAIR
Waitangi River at Wakelins		100	0.007	163.7	0.011	0.205	3.8	5	GOOD

Site	LC	DO	DRP	*E. coli*	NH_4	TON	TURB	PASS	WQI
5. Ngunguru Bay									
Ngunguru Catchment									
Ngunguru River at Coalhill Lane		101	0.012	242.0 ↑	0.011 ↓	0.115	3.7	4	FAIR
6. Whangārei Harbour									
Waiarohia Catchment									
Waiarohia River at Second Ave		103	0.010 ↑	372.0	0.016 ↑	0.280	2.0	3	FAIR
Hātea Catchment									
Hatea River at Mair Park		102	0.010	241.0	0.015	0.400	3.4	3	FAIR
Otaika Catchment									
Otaika River at Otaika Valley Rd		96	0.017 ↑	457.0	0.015	1.150	4.1 ↓	3	FAIR
7. Bream Bay									
Ruakaka Catchment									
Ruakaka River at Flyger Road		83	0.094	603.5 ↓	0.041	0.335	8.4	0	POOR
8. Kaipara Harbour									
Wairua Catchment									
Mangahahuru River at Main Rd		96	0.011 ↑	327.5 ↑	0.011 ↓	0.135	6.2	4	FAIR
Whakapara River at Cableway		96	0.023 ↑	224.5	0.010 ↓	0.250	5.2 ↓	4	FAIR
Mangahahuru River at Apotu Rd		94	0.022 ↑	380.5	0.017 ↓	0.280	6.0	3	FAIR
Waiotu River at SH1		93	0.019	355.0	0.021	0.280	7.1	2	POOR
Waipao River at Draffin Rd		104	0.028	574.5	0.012 ↓	2.450	2.0 ↓	2	POOR
Mangere River at Knight Rd		86	0.039 ↑	555.0	0.033	0.455	6.0 ↓	1	POOR
Wairua River at Purua		92	0.017	92.1	0.018	0.328	9.0 ↓	1	POOR
Mangakahia Catchment									
Mangakahia River at Twin Bridges		109	0.008	174.0	0.007	0.037	3.6	6	EXCELLENT
Mangakahia River at Titoki		95	0.006 ↓	147.5 ↓	0.008	0.042	6.3	5	GOOD
Opouteke River at Suspension Bridge		107	0.008	159.0	0.008	0.043	3.1	6	EXCELLENT
Kaihu Catchment									
Kaihu River at Gorge		101	0.007 ↑	187.0	0.008 ↓	0.215	2.9	5	GOOD
Manganui Catchment									
Manganui River at Mititai Rd		84	0.035	110.0	0.026	0.099	6.1	2	POOR
Hakaru Catchment									
Hakaru River at Topuni		103	0.048 ↑	167.0 ↓	0.016	0.175	5.1	3	FAIR

continued over page...

Site	LC	DO	DRP	*E. coli*	NH_4	TON	TURB	PASS	WQI
9. West Coast									
Waipoua Catchment									
Waipoua River at SH12		100	0.005 ↑	63.0	0.006	0.014	2.1	6	EXCELLENT
Waimamaku Catchment									
Waimamaku River at SH12		100	0.006 ↓	285.5	0.008 ↓	0.003	3.3	6	EXCELLENT
10. Hokianga Harbour									
Mangamuka Catchment									
Mangamuka River at Iwitaua Rd		93	0.029 ↑	331.0	0.005	0.005	1.5	5	GOOD
Waihou Catchment									
Waipapa River at Forest Ranger		97	0.005 ↓	66.4	0.003 ↓	0.008	1.6 ↓	6	EXCELLENT
Utakura River at Okaka Rd		92	0.011	201.0	0.014	0.125	6.6	1	POOR
Waima Catchment									
Punakitere River at Taheke		99	0.017	329.0	0.014	0.380	4.7	3	FAIR

Appendix B: Summary of water and ecological results

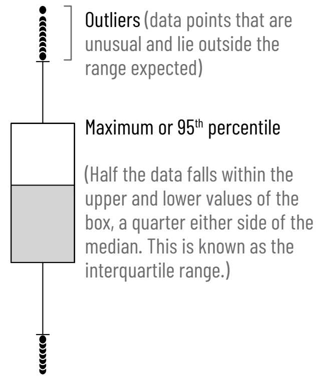
Water quality and ecological grades/results for RWQMN sites sampled over the period, 2012-2016:

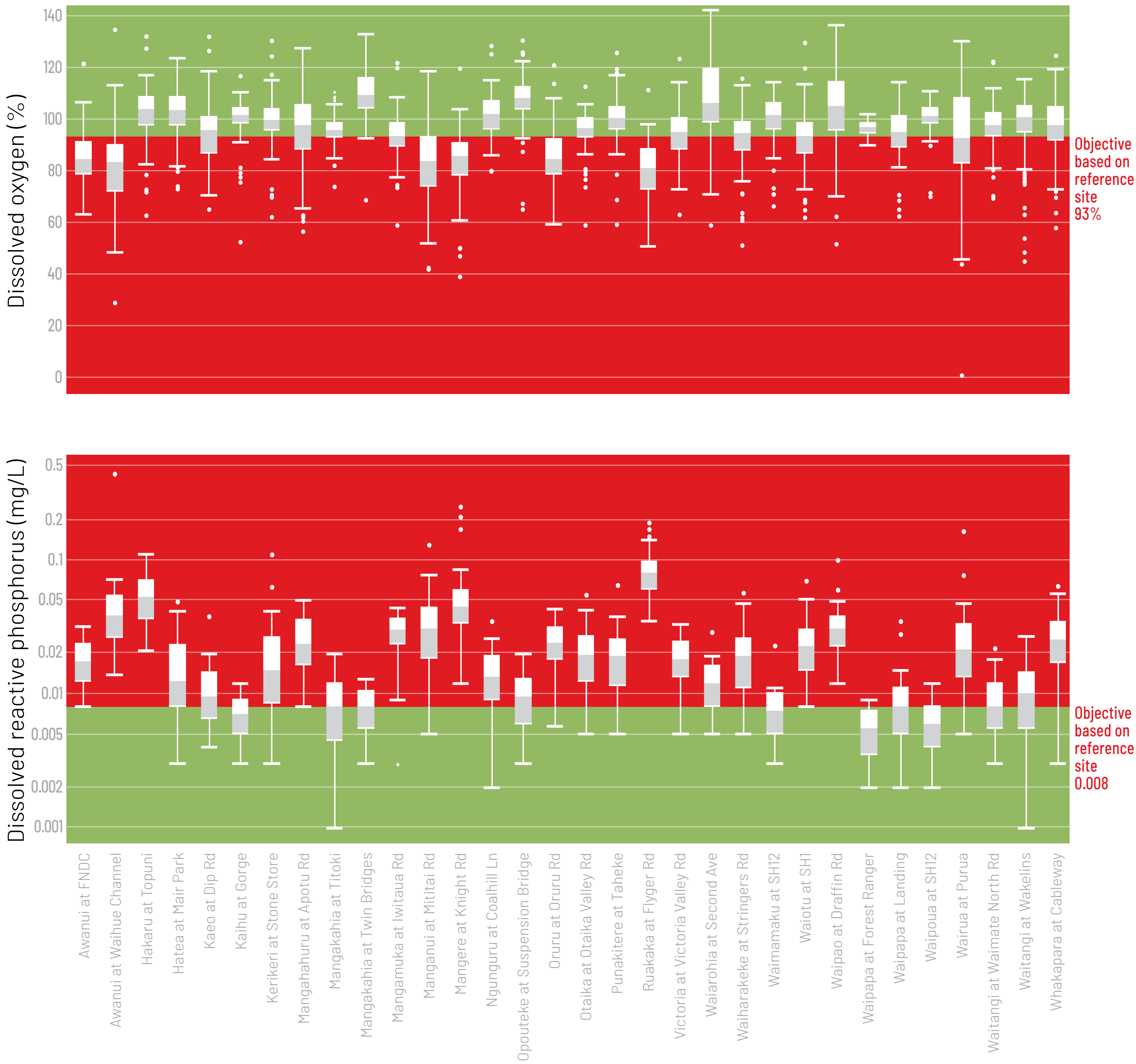
Site	WQI grade	MCI	Periphyton	Habitat
Waipapa at Forest Ranger ★★★	EXCELLENT	EXCELLENT	EXCELLENT	EXCELLENT
Waipoua at SH12 ★★★	EXCELLENT	EXCELLENT	EXCELLENT	EXCELLENT
Mangakahia at Twin Bridges	EXCELLENT	EXCELLENT	GOOD	GOOD
Opouteke at Suspension Bridge	EXCELLENT	GOOD	FAIR	GOOD
Waimamaku at SH12	EXCELLENT	EXCELLENT	EXCELLENT	FAIR
Kaeo at Dip Road	GOOD	GOOD	EXCELLENT	POOR
Kaihu at Gorge	GOOD	GOOD	GOOD	EXCELLENT
Mangakahia at Titoki	GOOD	FAIR	ND	FAIR
Mangamuka at Iwitaua Road	GOOD	EXCELLENT	EXCELLENT	FAIR
Victoria at Victoria Valley Road	GOOD	EXCELLENT	EXCELLENT	GOOD
Waitangi at Wakelins	GOOD	POOR	ND	POOR
Awanui at FNDC	FAIR	GOOD	FAIR	POOR
Hakaru at Topuni	FAIR	GOOD	POOR	GOOD
Hatea at Mair Park	FAIR	GOOD	EXCELLENT	EXCELLENT
Kerikeri at Stone Store	FAIR	GOOD	EXCELLENT	GOOD
Mangahahuru at Apotu Road	FAIR	FAIR	ND	POOR
Mangahahuru at Main Road	FAIR	EXCELLENT	EXCELLENT	GOOD
Ngunguru at Coalhill Lane	FAIR	EXCELLENT	GOOD	FAIR
Oruru at Oruru Road	FAIR	POOR	ND	POOR
Otaika at Otaika Valley Road	FAIR	EXCELLENT	GOOD	GOOD
Punakitere at Taheke	FAIR	GOOD	GOOD	GOOD
Waiarohia at Second Avenue	FAIR	FAIR	GOOD	FAIR
Waipapa at Landing	FAIR	POOR	FAIR	GOOD
Waitangi at Waimate North Road	FAIR	EXCELLENT	EXCELLENT	FAIR
Whakapara at Cableway	FAIR	POOR	ND	POOR
Awanui at Waihue Channel	POOR	POOR	ND	POOR
Manganui at Mititai Road	POOR	POOR	ND	POOR
Mangere at Knight Road	POOR	FAIR	ND	POOR
Ruakaka at Flyger Road	POOR	FAIR	EXCELLENT	GOOD
Utakura at Okaka Road	POOR	POOR	ND	POOR
Waiharakeke at Stringers Road	POOR	GOOD	FAIR	GOOD
Waiotu at SH1	POOR	POOR	ND	POOR
Waipao at Draffin Road	POOR	GOOD	EXCELLENT	FAIR
Wairua at Purua	POOR	POOR	ND	POOR

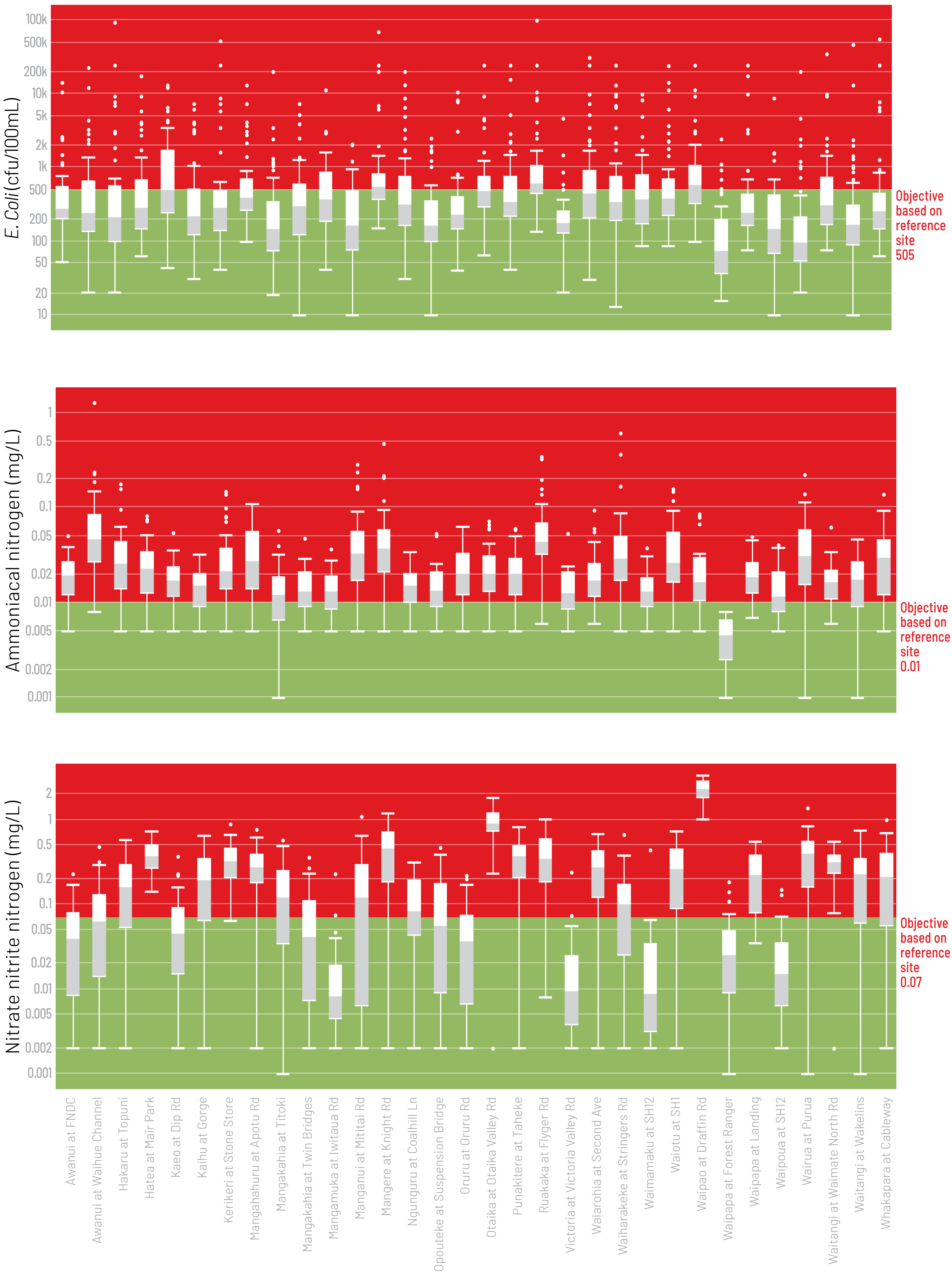
ND = No data

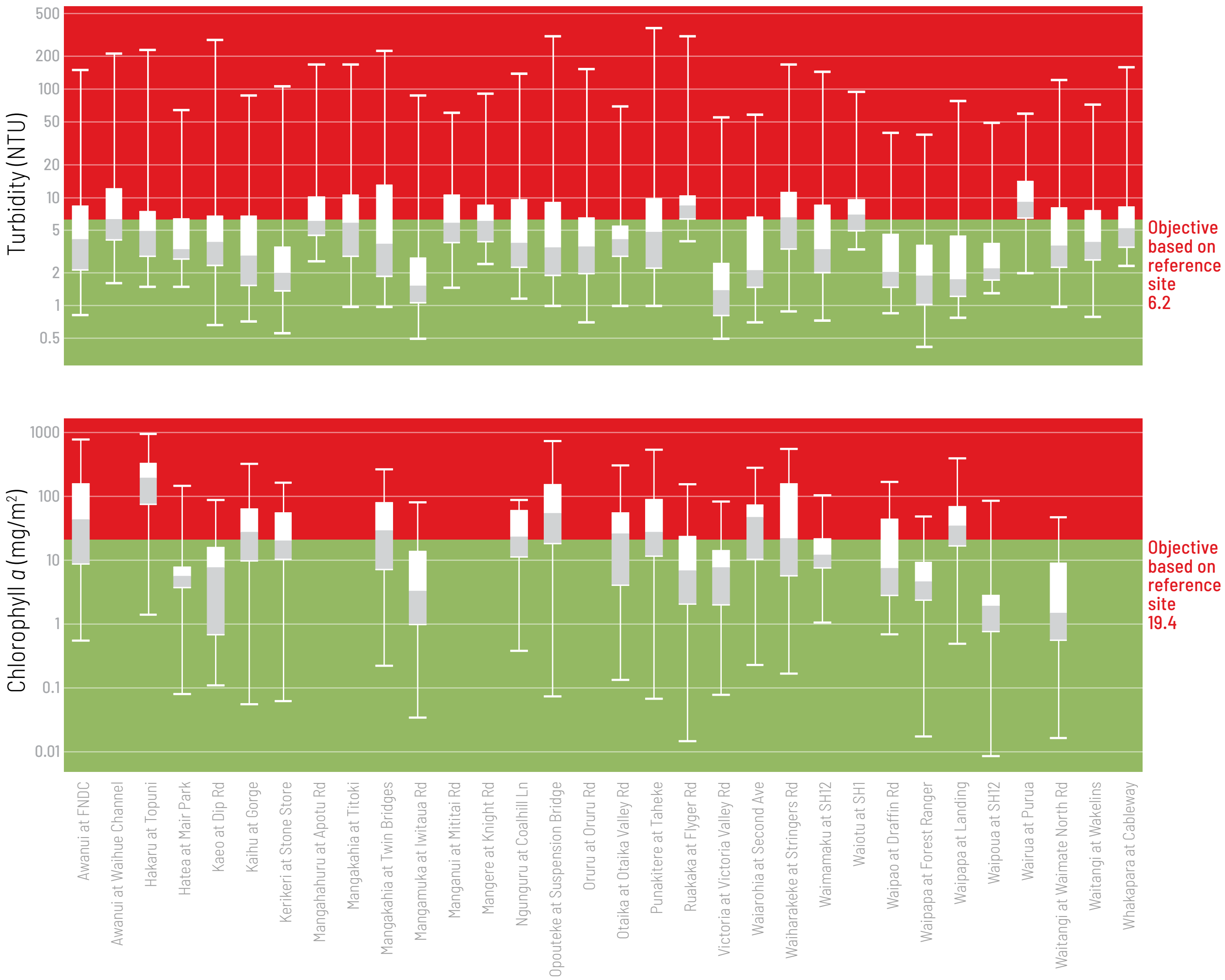
Appendix C: Water quality/ecological box plots

This describes water quality and ecological results in the Northland region using box and whisker plots to graphically display the distribution of water quality data based on a five value summary: the minimum value, first quartile, median, third quartile, and maximum. The central rectangle spans the first quartile to the third quartile (the inter-quartile range or IQR) covering the middle 50% of data. A segment inside the rectangle shows the median, and "whiskers" above and below the box show the minimum and maximum values, or the 95th percentile values, depending on the parameter being measured (see the diagram on the right). The water quality measures shown are those used to calculate the water quality index (WQI). The **GREEN** area represents values that pass the objective, **RED** represents values that fail.

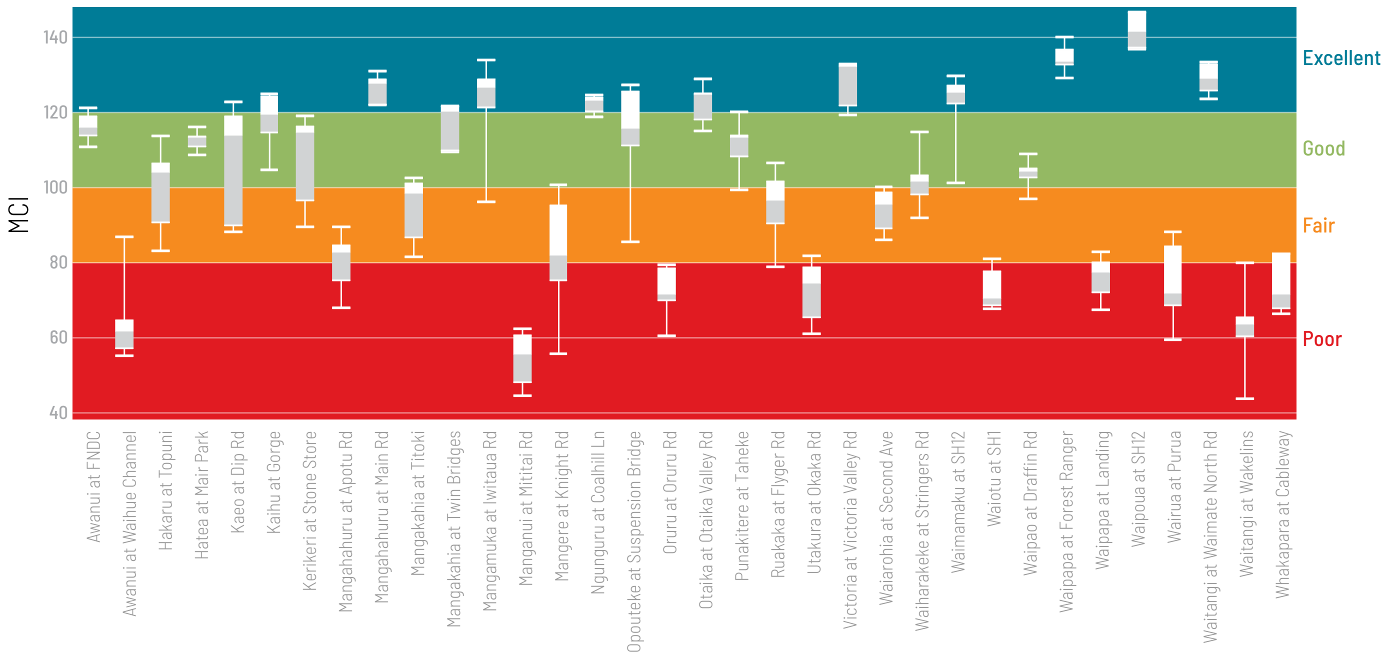





E. Coli (cfu/100mL)
Objective based on reference site 505
Ammoniacal nitrogen (mg/L)
Objective based on reference site 0.01
Nitrate nitrite nitrogen (mg/L)
Objective based on reference site 0.07
Awanui at FNDC
Awanui at Waihue Channel
Hakaru at Topuni
Hatea at Mair Park
Kaeo at Dip Rd
Kaihu at Gorge
Kerikeri at Stone Store
Mangahahuru at Apotu Rd
Mangakahia at Titoki
Mangakahia at Twin Bridges
Mangamuka at Iwitaua Rd
Manganui at Mititai Rd
Mangere at Knight Rd
Ngunguru at Coalhill Ln
Opouteke at Suspension Bridge
Oruru at Oruru Rd
Otaika at Otaika Valley Rd
Punakitere at Taheke
Ruakaka at Flyger Rd
Victoria at Victoria Valley Rd
Waiarohia at Second Ave
Waiharakeke at Stringers Rd
Waimamaku at SH12
Waiotu at SH1
Waipao at Draffin Rd
Waipapa at Forest Ranger
Waipapa at Landing
Waipoua at SH12
Wairua at Purua
Waitangi at Waimate North Rd
Waitangi at Wakelins
Whakapara at Cableway



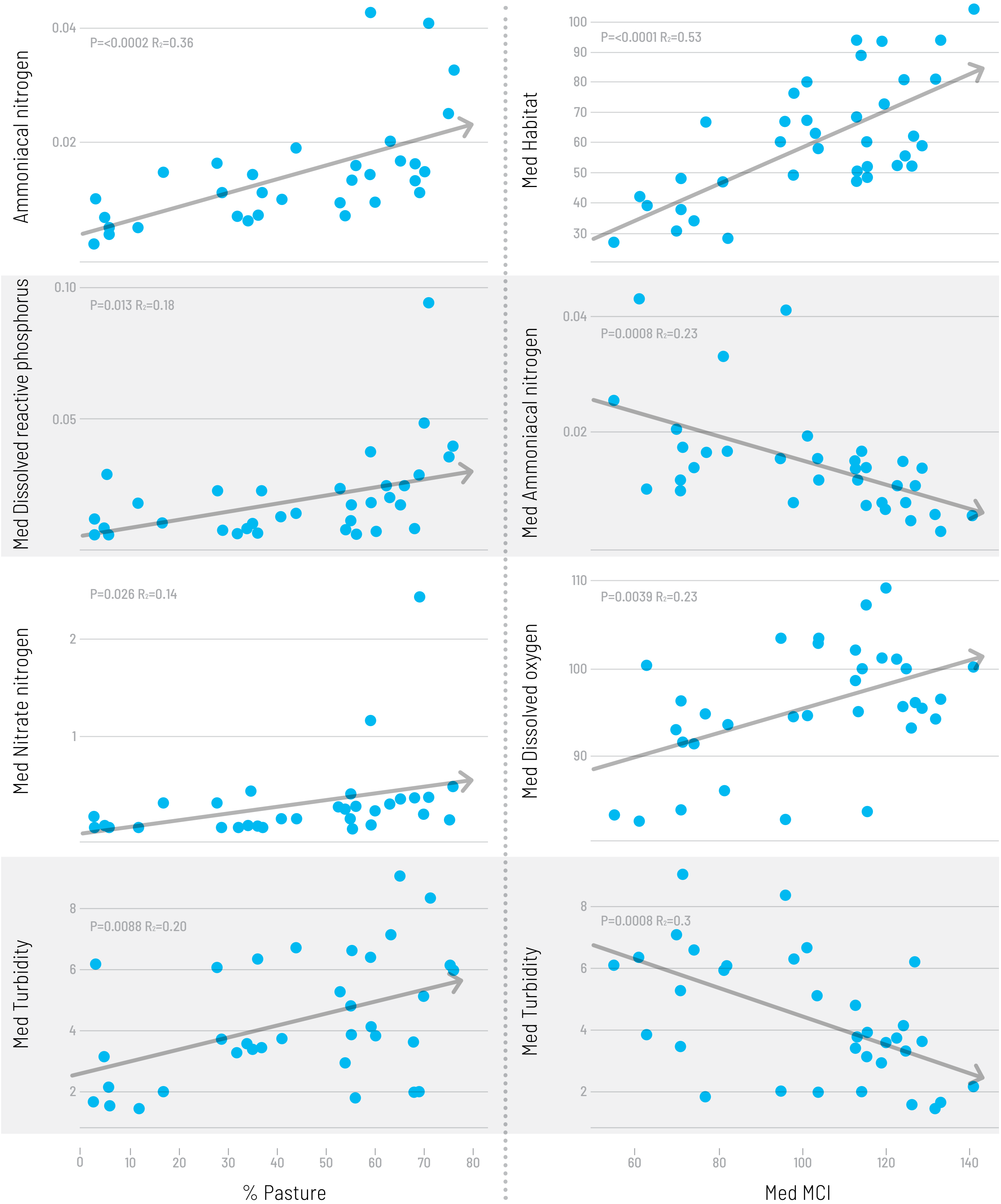
Turbidity (NTU)
500
200
100
50
20
10
5
2
1
0.5
Objective based on reference site 6.2
Chlorophyll a (mg/m²)
1000
100
10
1
0.1
0.01
Objective based on reference site 19.4
Awanui at FNDC
Awanui at Waihue Channel
Hakaru at Topuni
Hatea at Mair Park
Kaeo at Dip Rd
Kaihu at Gorge
Kerikeri at Stone Store
Mangahahuru at Apotu Rd
Mangakahia at Titoki
Mangakahia at Twin Bridges
Mangamuka at Iwitaua Rd
Manganui at Mititai Rd
Mangere at Knight Rd
Ngunguru at Coalhill Ln
Opouteke at Suspension Bridge
Oruru at Oruru Rd
Otaika at Otaika Valley Rd
Punakitere at Taheke
Ruakaka at Flyger Rd
Victoria at Victoria Valley Rd
Waiarohia at Second Ave
Waiharakeke at Stringers Rd
Waimamaku at SH12
Waiotu at SH1
Waipao at Draffin Rd
Waipapa at Forest Ranger
Waipapa at Landing
Waipoua at SH12
Wairua at Purua
Waitangi at Waimate North Rd
Waitangi at Wakelins
Whakapara at Cableway



MCI
140
120
100
80
60
40
Excellent
Good
Fair
Poor
Awanui at FNDC
Awanui at Waihue Channel
Hakaru at Topuni
Hatea at Mair Park
Kaeo at Dip Rd
Kaihu at Gorge
Kerikeri at Stone Store
Mangahahuru at Apotu Rd
Mangahahuru at Main Rd
Mangakahia at Titoki
Mangakahia at Twin Bridges
Mangamuka at Iwitaua Rd
Manganui at Mititai Rd
Mangere at Knight Rd
Ngunguru at Coalhill Ln
Opouteke at Suspension Bridge
Oruru at Oruru Rd
Otaika at Otaika Valley Rd
Punakitere at Taheke
Ruakaka at Flyger Rd
Utakura at Okaka Rd
Victoria at Victoria Valley Rd
Waiarohia at Second Ave
Waiharakeke at Stringers Rd
Waimamaku at SH12
Waiotu at SH1
Waipao at Draffin Rd
Waipapa at Forest Ranger
Waipapa at Landing
Waipoua at SH12
Wairua at Purua
Waitangi at Waimate North Rd
Waitangi at Wakelins
Whakapara at Cableway

Appendix D: Correlations

Graphs below describes meaningful correlations detected between water quality measures and both pastoral land use and ecological health as measured by the Macroinvertebrate Community Index (MCI) using regression analysis.



Appendix E: National standards

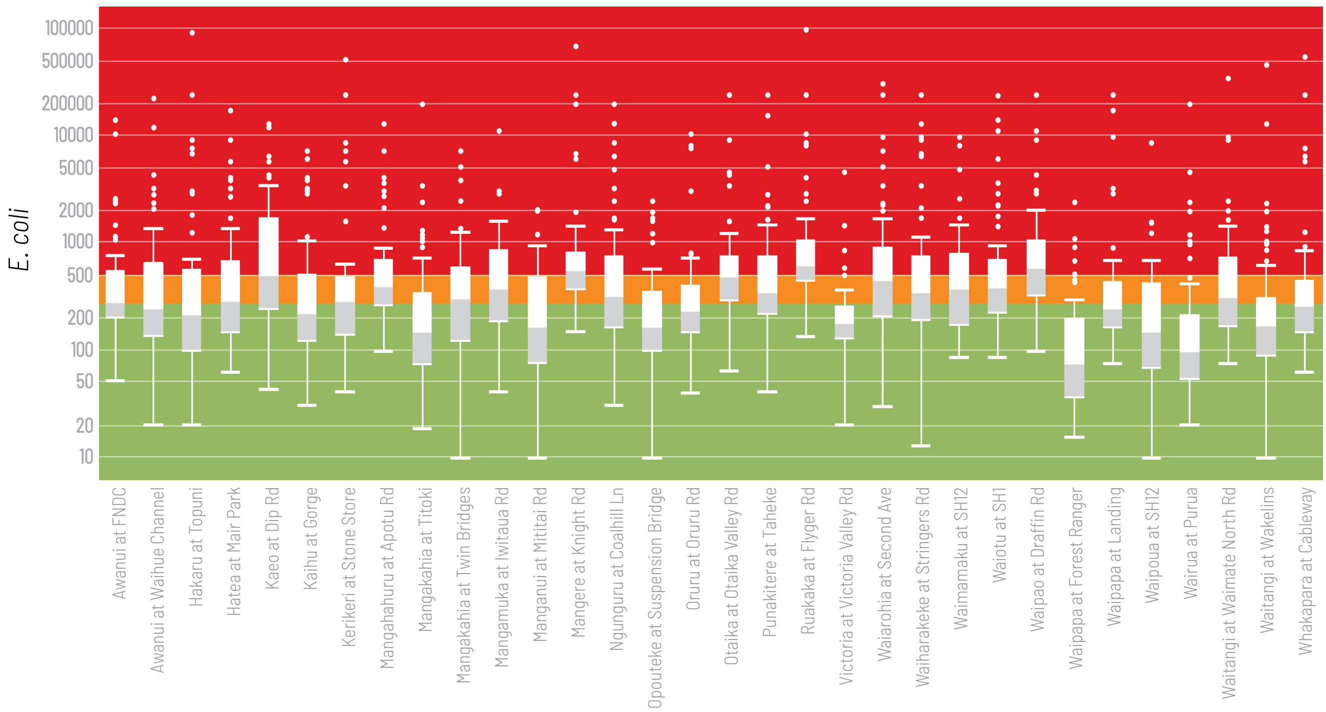
The table below describes water quality in the Northland region against compulsory measures and grades which apply to various uses of water, through the National Policy Statement (NPS 2014, updated 2017) for Fresh Water Management. Grades 'A', 'B' and 'C' indicate quality from best to acceptable; 'D' (or below) is unacceptable and improvement in water quality is required.

Use	Ecosystem Health					Primary contact recreation
Measure & Purpose	Periphyton trophic state	Nitrate-N limit on toxicity		NH_4 limit on toxicity		
Site	Chla	Typical state (median)	Worst state (95th percentile)	Typical state (median)	Worst state (maximum)	*E. coli* Human health
Awanui River at FNDC	C	A	A	A	A	E
Awanui River at Waihue Channel	ND	A	A	A	C	E
Hakaru River at Topuni	D	A	A	A	B	E
Hatea River at Mair Park	A	A	A	A	B	E
Kaeo River at Dip Rd	A	A	A	A	A	E
Kaihu River at Gorge	B	A	A	A	A	E
Kerikeri River at Stone Store	A	A	A	A	B	E
Mangahahuru River at Apotu Rd	ND	A	A	A	A	E
Mangahahuru River at Main Rd	A	A	A	A	B	E
Mangakahia River at Titoki	ND	A	A	A	B	E
Mangakahia River at Twin Bridges	B	A	A	A	B	E
Mangamuka River at Iwitaua Rd	A	A	A	A	A	E
Manganui River at Mititai Rd	ND	A	A	A	C	C
Mangere River at Knight Rd	ND	A	A	A	B	E
Ngunguru River at Coalhill Lane	B	A	A	A	A	E
Opouteke River at Suspension Bridge	C	A	A	A	B	E
Oruru River at Oruru Rd	ND	A	A	A	A	E
Otaika River at Otaika Valley Rd	B	B	B	A	A	E
Punakitere River at Taheke	B	A	A	A	A	E
Ruakaka River at Flyger Rd	A	A	A	A	B	E
Utakura River at Okaka Rd	ND	A	A	A	A	E
Victoria River at Victoria Valley Road	A	A	A	A	A	D
Waiarohia River at Second Avenue	B	A	A	A	B	E
Waiharakeke River at Stringers Rd	C	A	A	A	B	E
Waimamaku River at SH12	A	A	A	A	A	E
Waiotu River at SH1	ND	A	A	A	B	E
Waipao River at Draffin Rd	A	C	B	A	A	E
Waipapa River at Forest Ranger	A	A	A	A	A	B
Waipapa River at Landing	C	A	A	A	A	E
Waipoua River at SH12	A	A	A	A	A	E
Wairua River at Purua	ND	A	A	A	B	E
Waitangi River at Waimate North Rd	A	A	A	A	A	E
Waitangi River at Wakelins	ND	A	A	A	A	E
Whakapara River at Cableway	ND	A	A	A	A	E

ND indicates No Data

Appendix F: Swimming water quality

This describes swimming water quality results in the Northland region according to Ministry for the Environment (MfE) and Ministry of Health (MoH) 2003 guidelines for *E. coli*. The **GREEN** area represents values that meet swimming guidelines, the **AMBER** represents an alert level where *E. coli* levels are slightly elevated, and the **RED** represents values unsuitable for swimming.



MfE and MoH single sample guidelines for freshwater sites, 2003:		
***E. coli* concentration**	**Category**	**Suggested response**
sample ≤260/100 mL	**SUITABLE**	No response necessary – continue weekly sampling.
260< sample ≤550/100 mL	**ALERT**	Undertake catchment assessment and sanitary survey where applicable to isolate source of faecal contamination.
sample >550/100 mL	**ACTION**	- Collect follow-up sample. - Undertake sanitary survey when applicable. - Erect warning signs. - Inform public through the media that a public health risk exists.

Parapara River

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Northland REGIONAL COUNCIL
Te Kaunihera ā rohe o Te Taitokerau