Recommended Coastal Water Quality Standards for Northland

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2016

Putting Northland first

NORTHLAND REGIONAL COUNCIL

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1. Introduction

1.1 Background

Northland Regional Council (Council) is currently developing a new Regional Plan for Northland that will replace its three existing Regional Plans. As part of this process, the Council is reviewing and will potentially revise the coastal water quality classifications and the associated water quality standards in the operative Regional Coastal Plan (RCP) for Northland (Northland Regional Council 2004).

Water quality classifications (or water classes) identify the designated uses or values for which different water bodies are managed. The associated standards are intended to ensure that the water quality supports the designated uses and values.

Coastal water quality classifications and standards are important for several reasons:

- They provide clarity and certainty to resource users and the wider community about what uses and values a water body is being managed for;
- They help Council manage water quality so that it supports the designated uses and values;
- They are a tool for controlling cumulative effects; and
- They assist in the processing of applications for resource consents.

The purpose of this document is to review the existing coastal water quality classifications and make recommendations for revised coastal water quality classifications and associated standards to be included in Northland's new Regional Plan.

1.2 Legal and policy context

The Resource Management Act 1991 (RMA) is the principal statute governing the management of New Zealand's water resources. The RMA tasks regional councils with managing coastal water quality. It does this by providing regional councils with a comprehensive suite of functions, including controlling the use of land for the purpose of maintaining and enhancing the quality of water (and ecosystems) in water bodies and coastal water, and controlling discharges of contaminants into water.

Regional councils control activities that affect coastal water quality by way of policies and rules in regional plans. Section 69 of the RMA directs regional councils on rules relating to water quality. In particular, it provides for the classification of waters for different management purposes (that is, water quality-dependent uses and values) and the setting of associated water quality standards. Schedule 3 of the RMA contains water quality classes and standards that can be used. Where these are not adequate or appropriate, regional councils have the ability to incorporate in their plans additional classes and standards about the quality of water.

Section 69 of the RMA also instructs that *"...a regional council shall not set standards in a plan which result, or may result, in a reduction of the quality of water in any water at the time of the public notification date of the proposed plan unless it is consistent with the Act to do so."*

1.3 Current water quality classifications and standards

The RCP classifies coastal waters in the Whangārei Harbour (Figure 1) and Bay of Islands (Figure 2) into three management zones and prescribes water quality standards for these different zones. The three zones are:

- Natural Quality Standard (CN) – protection of natural state;
- General Quality Standard (CA) – provides for virtually all uses and protection of marine ecosystems; and
- Contact Recreation Standard (CB) – provides for contact recreation.

The purpose of the CN (Natural Quality Standard) class is "*the protection of natural state"* and the associated standards contain narratives for 19 parameters, including temperature, dissolved oxygen, visual clarity, heavy metals, faecal coliforms, nutrients and other toxicants (Table1). There is a narrative standard for all these parameters which states "*Shall not be altered"*.

The purpose of the CA (General Quality standards) class is to provide for "*virtually all uses and protection of* [the] *marine ecosystem"* and the associated standards contain numerical standards for 17 water quality parameters, including temperature, dissolved oxygen, visual clarity, heavy metals, faecal coliforms, nutrients and other toxicants (Table1). There is also a narrative standard for oil/grease film, scum, foam, odour.

The purpose of water classified as CB (Contact Recreation Standard) is to provide for "*contact recreation in coastal waters"*. The CB class contains standards for faecal coliforms, natural visual clarity, natural hue, oil/grease film, scum, foam odour, and toxicants. All other parameters are listed as "*n/a"* (not applicable) or "*not relevant*".

In both the Whangārei Harbour and the Bay of Islands, tidal creek and inner estuarine environments are classified as CB, the main bodies of estuaries are classified as CA, and open coastal areas are classified as CN (see Figures 1 and 2). For all other coastal waters outside the Whangārei Harbour and the Bay of Islands, the plan uses the RMA Schedule 3 classes and standards.

This review has identified the following issues with the current coastal water quality classifications and the associated standards:

- Waters outside the Whangārei Harbour and the Bay of Islands have not been classified by Council. These waters are managed using RMA Schedule 3 standards. Consequently there are two different classification systems.
- Schedule 3 of the RMA contains a number of narrative standards that are open to interpretation.
- The standards for nutrients, heavy metals and other toxicants for CA waters were derived from the ANZECC 1992 guidelines (Australian and New Zealand Environment and Conservation Council, 1992), which have now been superseded by the ANZECC 2000 guidelines (Australian and New Zealand Environment and Conservation Council 2000).
- The areas classified as CB in the Whangārei Harbour and Bay of Islands are generally upper harbour tidal creek environments, and are not typically used for primary contact reaction (i.e. swimming).
- Water classified as CB does not have associated standards for nutrients, metals or toxicants, which may be relevant for contact recreation.
- Faecal coliforms are used as indicators of faecal contamination for waters classified as CA and CB. However, the Ministry for the Environment's Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas (Ministry for the Environment 2003) state that "*For marine water the preferred indicator is enterococci. The New Zealand Marine Bathing Study showed that enterococci are the indicator most closely correlated with health effects in New Zealand marine waters, confirming a pattern seen in a number of overseas studies. Faecal coliforms and E. coli were not as well correlated with health risks".*
- There is no classification specifically for areas used for aquaculture or shellfish consumption although water classified as CA should provide for virtually all uses.
- There are no standards for nutrients or metals in sediments.

It is recommended that the coastal water quality classification in the RCP be revised to address the issues above and to utilise the latest national and international guideline values, and incorporate standards derived from Northland-specific reference data.

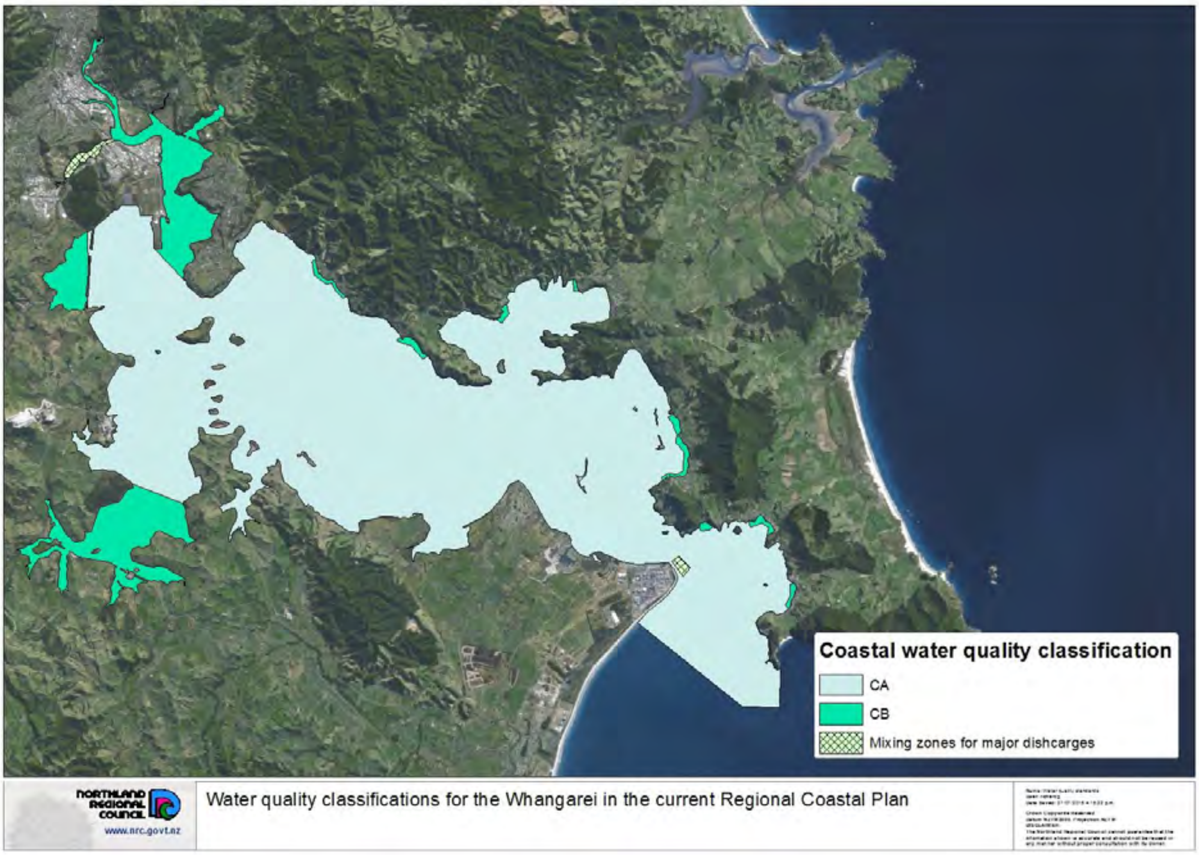

Figure 1: Water quality classification of the Whangārei Harbour in the Regional Coastal Plan for Northland.

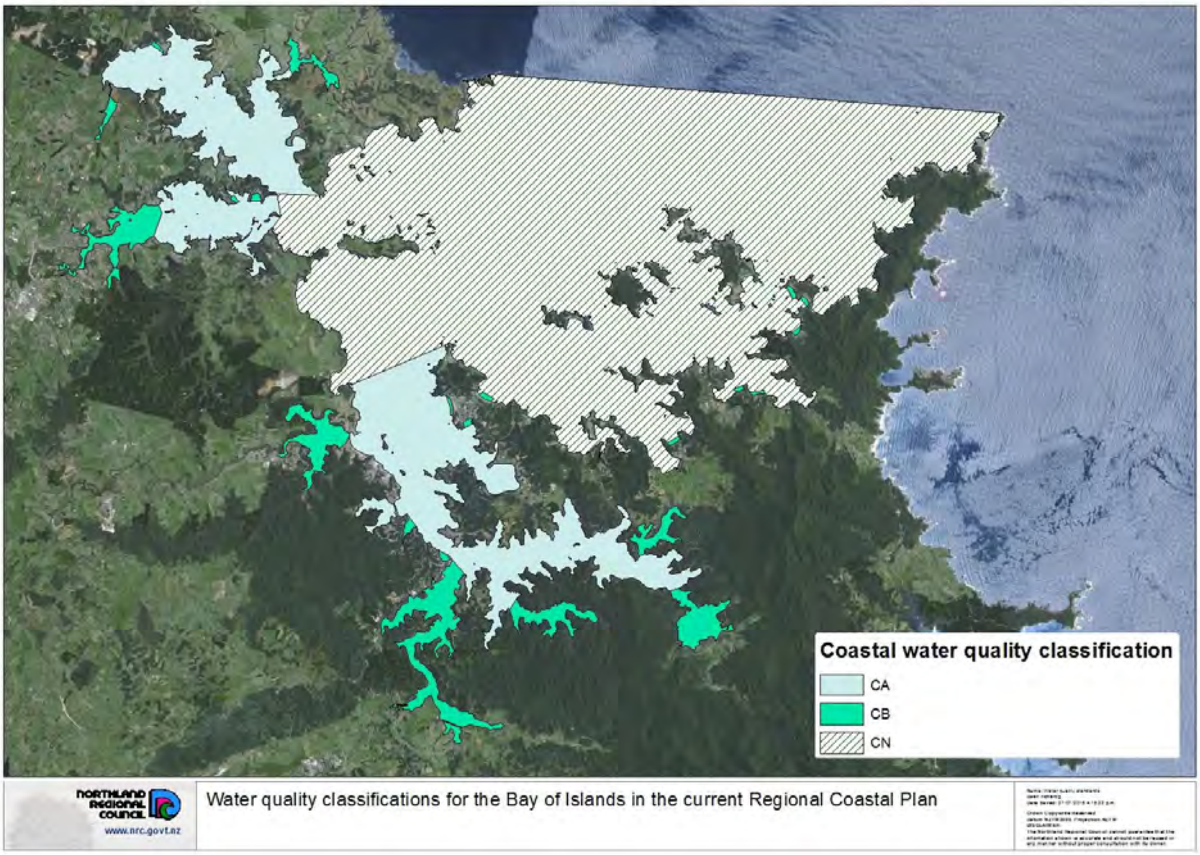

Figure 2: Water quality classification of the Bay of Islands in the Regional Coastal Plan for Northland.

Table 1: Coastal water quality standards in the current Regional Coastal Plan for Northland (reproduced from Appendix 4 of the Plan).

The following standards apply to coastal waters classified under this Plan, and differ from those specified in the Third Schedule of the RMA

	Standards for Coastal Waters		
Standard	**Natural Quality Standard CN**	**General Quality Standard CA**	**Contact Recreation Standard CB**
Purpose	Protection of natural state	Provides for virtually all uses and protection of marine ecosystems	Provides for contact recreation in coastal waters
Natural temperature	Shall not be altered	Not changed by more than 3°C	n/a
Natural pH	"	Not changed by more than 0.2 units	n/a
Concentration of dissolved oxygen	"	Not reduced below 80% saturation	n/a
Natural visual clarity	"	Not reduced more than 20%	
Natural hue	"	Not changed more than 10 Munsell units	
Natural euphotic depth	"	Water deeper than $0.5.z_{eu}$ not changed more than 10% Water shallower than $0.5.z_{eu}$ maximum reduction in light at sediment bed not more than 20%	n/a
Oil/grease film, scum, foam, odour	"	No conspicuous oil or grease film, scums or foams, floatable or suspended materials, or emissions of objectionable odour	
Toxic Metals	"		
Total Arsenic	"	50 mg/L	n/a
Total Cadmium	"	2 mg/L	n/a
Total Chromium	"	50 mg/L	n/a
Hexavalent Chromium	"	-	n/a
Total Copper	"	5 mg/L	n/a
Total Lead	"	5 mg/L	n/a
Total Zinc	"	50 mg/L	n/a
Faecal Coliforms	"	Based on not fewer than 10 samples within any 30 day period median < 14/100 ml 90%ile < 43/100 ml	Based on not fewer than 5 samples within any 30 day period median < 150/100 ml 80%ile < 600/100 ml
Nutrients (Default standards in the absence of specific site investigations)	"	DRP 1-10 mmg/L NO_3-N 10-60 mmg/L NH_4-N <5 mg/L	Nutrient levels are not relevant to waters managed for contact recreation.
Other toxicants and parameters	"	As per Table 2.1 of ANZECC Water Quality Guidelines 1992 as appropriate	As per Drinking Water Standards for New Zealand 1989

2. Development of new standards

2.1 Overview

This section sets out the approach for developing a new coastal water quality classification system and associated standards for Northland's coastal waters.

In summary the approach involves:

1. Determine the important water quality 'resource uses' or 'values' for Northland's waters;
2. Classify Northland's coastal water into ecosystem types or management zones;
3. Classify the ecosystem condition of Northland's coastal waters;
4. Identify which uses or resource values occur in which management zones;
5. Identify the water quality parameters or 'attributes' that are relevant to each 'resource use' or 'value'; and
6. Develop water quality standards for each water quality parameter.

2.2 Resource values

This document proposes that the new standards are set to safeguard the following water quality dependent 'uses' and 'values':

- Aquatic ecosystem health;
- Aquaculture and shellfish consumption; and
- Recreation and aesthetics.

These could be considered analogous to the Class AE Water (being water managed for aquatic ecosystem purposes), Class SG Water (being water managed for the gathering or cultivating of shellfish for human consumption) and Class CR Water (being water managed for contact recreation) in Schedule 3 of the RMA.

The objective of waters managed to support 'aquatic ecosystem health' is to maintain the healthy functioning of coastal ecosystems. The objective of waters managed for 'aquaculture and shellfish consumption' is that the health risk associated with the consumption of shellfish is acceptable and that the water body supports the growth and survival of shellfish. The objective for areas managed for 'recreation and aesthetics' is to ensure that the health risks associated with primary contact recreation (i.e. swimming) is acceptable and that the visual and aesthetic values of the environment are not compromised.

2.3 Ecosystem types

For the purposes of managing coastal water quality and developing appropriate standards, this report classifies Northland's coastal waters into three types of aquatic ecosystem or 'management zone'. This is in acknowledgment of the fact that the water quality varies significantly in these different ecosystem types and that different resource uses and values occur in these different zones.

The three ecosystem types are:

- Open coast waters;
- Estuarine environments (which refer to the main bodies of estuaries and harbours); and
- Tidal creeks (which refer to shallow, narrow, depositional areas in the upper reaches of estuaries.

Tidal creeks have been differentiated from estuarine environments because these areas are the immediate receiving environment for streams and rivers, and water quality in these environments is typically more variable and of lower quality than estuarine and open coastal environments (Griffiths, 2015). The separation of tidal creeks and estuarine waters also aligns closely with the different water quality dependent ‘uses’ or ‘values’ of the respective areas. For example, tidal creeks are infrequently used for primary contact recreation (that is, swimming), shellfish gathering and aquaculture.

Northland’s coastal waters have all been classified into these three ecosystem types. Maps for Whangārei Harbour (Figure 3), Bay of Islands (Figure 4), and the Kaipara Harbour (Figure 5) are shown for illustrative purposes. It is also proposed that the water in the Hātea River, in the Whangārei Harbour, be treated as a distinct zone because it has been classified as a Condition 3 (highly disturbed) ecosystem (see Section 2.4).

The landward extent of the Hātea River unit was defined by the landward boundary of the coastal marine area (CMA). The seaward extent of the unit was determined by professional judgement. Consideration was given to water quality data, aerial images and the width of the channel. The landward extent of the tidal creek unit was defined by the landward boundary of the CMA. The seaward extent of the unit was determined by professional judgement. Consideration was given to water quality data, aerial images and the width of the channel. The extent of the estuary unit was defined by the boundary with the tidal creek unit and the entrance of each estuary with the open coast. The extent of open coast unit was defined by the boundary of the estuary unit and the seaward boundary of the CMA.

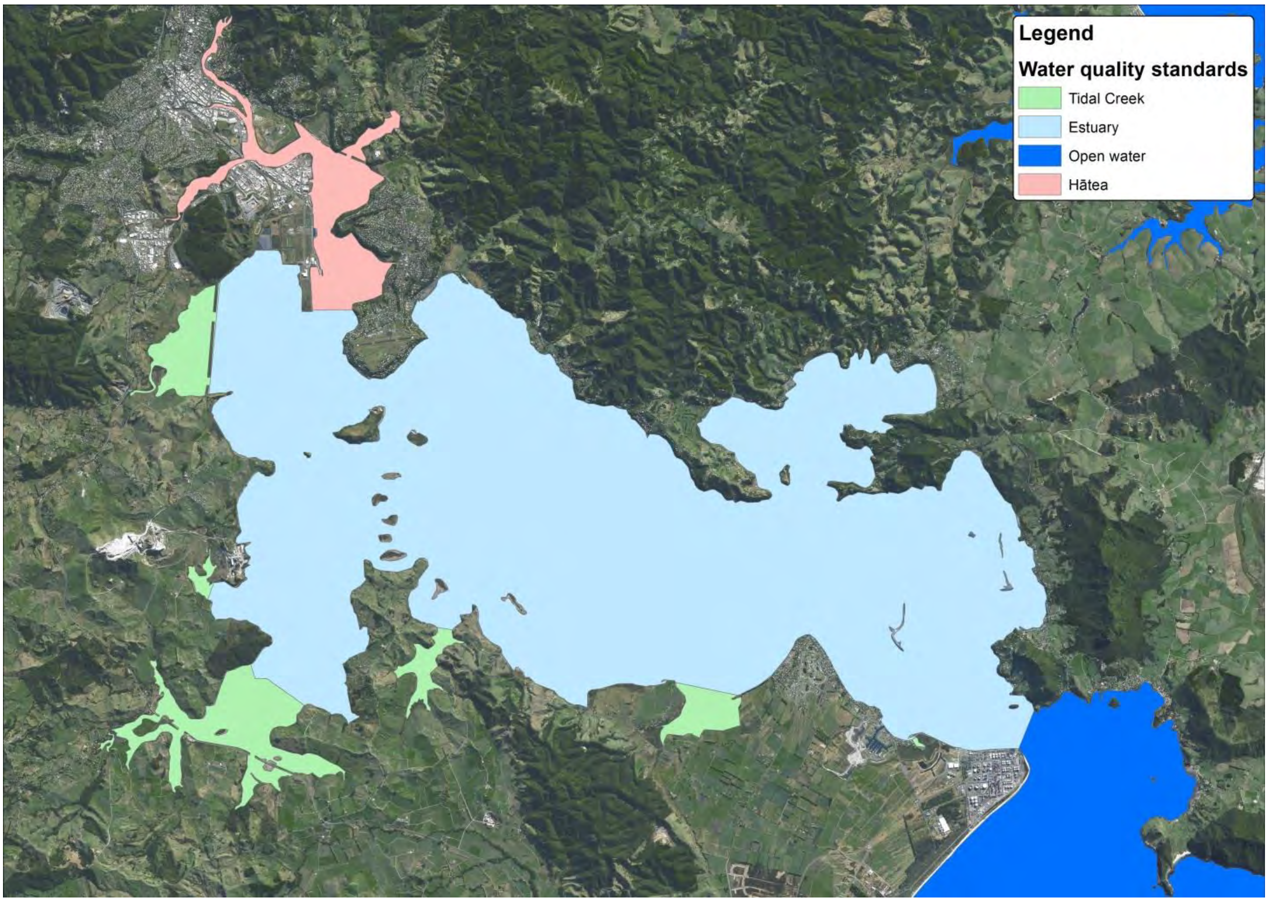

Figure 3: Ecosystem types in the Whangārei Harbour.

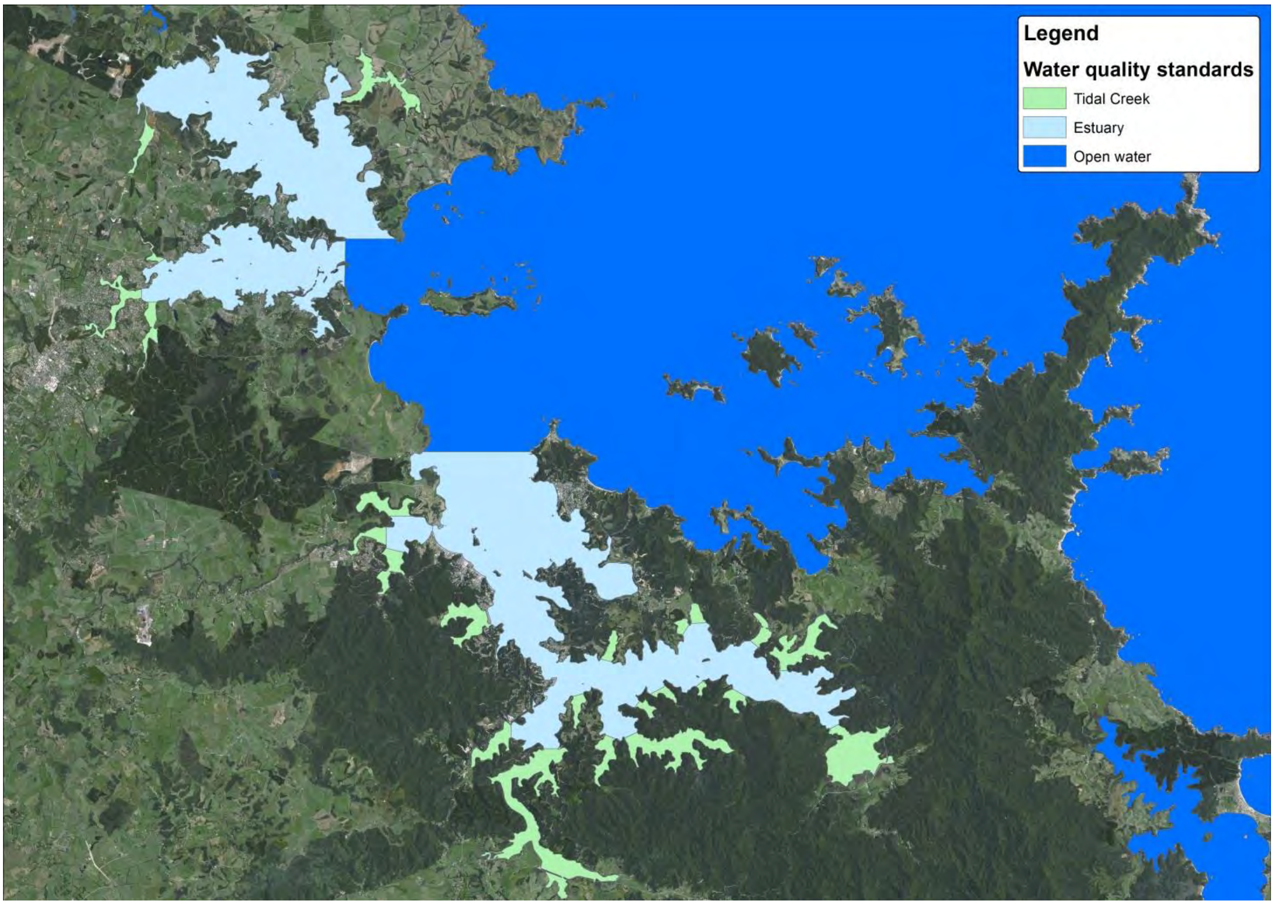

Figure 4: Ecosystem types in the Bay of Islands.

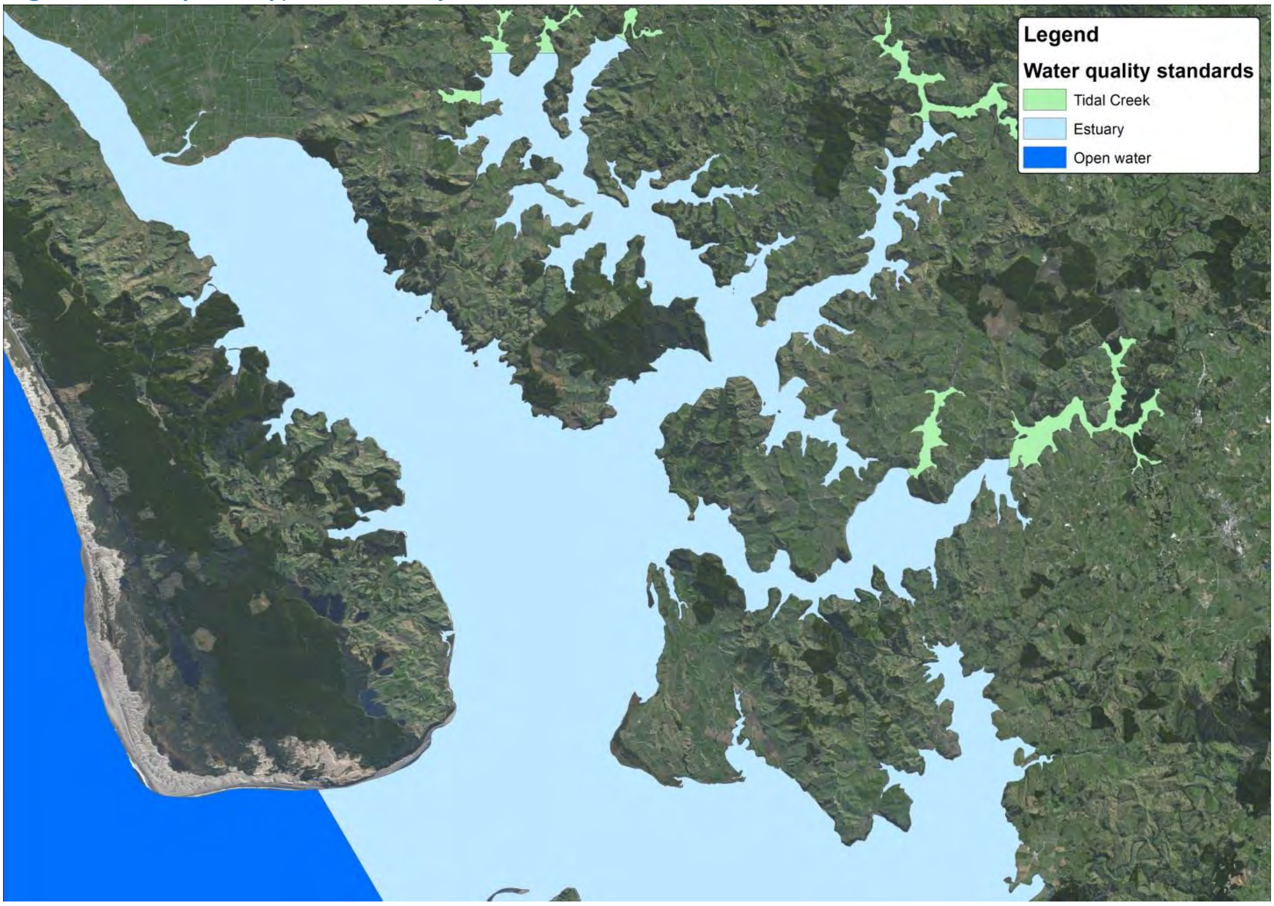

Figure 5: Ecosystem types in the Kaipara Harbour.

2.4 Ecosystem condition

The ecosystem condition of Northland's waters has also been assessed for the purpose of developing appropriate standards. This was in recognition of the fact that heavily modified or disturbed environments may require different standards to pristine environments. Ecosystem condition for Northland's waters was evaluated using the three ecosystem conditions described in the ANZECC 2000 guidelines. This system identifies three ecosystem conditions:

- Condition 1: high conservation/ecological value systems. These are unmodified or other highly-valued ecosystems;
- Condition 2: slightly to moderately disturbed systems. These are ecosystems in which aquatic biological diversity may have been adversely affected to a relatively small but measurable degree by human activity. The biological communities remain in a healthy condition and ecosystem integrity is largely retained; and
- Condition 3: highly disturbed systems. These are measurably degraded ecosystems of lower ecological value. Examples of highly disturbed systems would be some shipping ports and sections of harbours serving coastal cities, urban streams receiving road and stormwater run-off.

Using these definitions, the majority of Northland's 'open coast' waters were classified as Condition 2 ecosystems. The main exceptions to this being open coastal waters adjacent to Cape Brett, Karikari Peninsula, North Cape and several offshore Islands (areas identified as Marine Management 1(Protection) in the Regional Coastal Plan for Northland), which are classified as Condition 1 waters.

It is important to note that the decision was fundamentally a value judgment based on what was perceived to be "unmodified" versus what is "adversely affected to a relatively small but measurable degree by human activity" using the classification system in the ANZECC 2000 guidelines. Furthermore, it is important to note that the ANZECC 2000 guidelines are not entirely clear about what aspects of ecosystem condition should be assessed (for example, modification of physical habitat or water quality). Consequently, another stressor (for example, fishing) may be responsible for some modification of open coastal ecosystems rather than the existing water quality. In Northland on a purely water quality basis there is likely to be very little difference between Condition 1 and Condition 2 'open coast' ecosystems. It is therefore proposed that the same standards apply to Condition 1 and Condition 2 ecosystems for 'open coast' waters.

Based on the ANZECC 2000 guidelines classification system, the majority of Northland's 'tidal creek' and 'estuarine' waters were classified as Condition 2 ecosystems (slightly to moderately disturbed ecosystems), with the exception of Pārengarenga Harbour and Rangaunu Harbour which were classified as Condition 1 systems. Once again the distinctions between Condition 1 and 2 'estuarine' ecosystems is essentially a judgement based on ecosystem health and the level of modification using the ANZECC classification rather than the existing water quality. It is therefore proposed that the same standards apply to Condition 1 and Condition 2 ecosystems for 'tidal creek' and 'estuarine' waters.

One Condition 3 ecosystem (highly disturbed system), the Hātea River in the Whangārei Harbour, has been identified. The Hātea River is a tidal creek which flows through the city of Whangārei, the regional capital of Northland. The Hātea River receives road run-off and stormwater from Whangārei city and is the receiving environment for the Whangārei wastewater treatment plant and a number of industrial discharges. The shoreline and hydrology of the river have also been significantly altered by saltmarsh drainage and reclamation for urban development. Council's water quality monitoring has indicated that five sites in the Hātea River have the lowest water quality of all 42 State of the Environment coastal water quality sites (Griffiths, 2015). Council's sediment and estuary monitoring programmes have also found elevated concentrations of nutrients and metal contaminants in the sediment (Griffiths, 2014a). It is therefore proposed that the Hātea River is treated as a distinct unit (Figure 3), with different standards to Condition 1 and Condition 2 ecosystems.

2.5 What resource values occur in each management zone

In order to be consistent with the purpose of the RMA and the objectives of the New Zealand Coastal Policy Statement 2010 (Department of Conservation 2010) it is recommended that the quality of all of Northland's coastal waters be managed to safeguard 'aquatic ecosystem health'. The standards associated with 'aquatic ecosystem health' therefore apply to all of Northland's coastal waters.

It is recommended that aquaculture management areas (Marine 3 (Marine Farming) Management Areas in the current RCP) and recreational shellfish gathering sites identified by Council (Appendix 1) be managed for 'aquaculture and human consumption of shellfish'.

It is recommended that estuaries and open coastal waters be managed for primary contact recreation. It is proposed that water quality in tidal creek environments be managed for secondary contact recreation, not primary contact recreation. This is because tidal creeks are not typically used for swimming. For example, none of the 43 sites currently monitored in Council's recreational water quality monitoring network are located in tidal creek environments.

2.6 Water quality parameters

In order to identify the water quality parameters that are relevant to each 'resource use' or 'value' consideration was given to the RMA, the ANZECC 2000 guidelines, the Microbiological Water Quality Guidelines for Marine and Freshwater Areas (Ministry for the Environment 2003), and the Canadian Water Quality Guidelines (Canadian Council of Ministers of the Environment, 2007).

2.6.1 Ecosystem Health

In Schedule 3 of the RMA, Class AE Water (aquatic ecosystem purposes) includes numerical limits for temperature and dissolved oxygen, and a standard that any change in pH, any increase in deposition on the bed and any discharge of contaminant shall not be allowed if they have an adverse effect on aquatic life. There is also a clause that there "*shall also be no undesirable biological growths as a result of contaminants*". Section 70 of the RMA, which deals with rules about discharges, includes clauses relating to: conspicuous oil or grease films, scums or foams or floatable or suspended materials; change in colour or clarity; odour; and any significant adverse effects on aquatic life. These clauses are repeated in Section 107 of the RMA, which places restrictions on the granting of certain discharge permits.

In this document it is proposed that standards be set for water clarity, eutrophic state, metals, other toxicants, temperature, pH and that narrative standards be included for 'oil, grease, scums or foams' and 'litter and gross pollutants' (Table 2). The parameters proposed to measure water clarity include turbidity, suspended solids and secchi depth. The parameters proposed to measure eutrophic state include chlorophyll *a*, dissolved oxygen and concentrations of nutrients.

It is proposed that adverse effects on ecosystem health as a result of sediment deposition be dealt with separately in the new Regional Plan. Although there is a wide scientific consensus that sedimentation rates have increased significantly since pre-human times and that this has caused adverse effects on ecosystem health, there is currently little agreement on what rate of sediment accumulation provides for healthy ecosystem functioning.

2.6.2 Aquaculture and shellfish consumption

In schedule 3 of the RMA Class SG Water (water being managed for gathering or cultivating of shellfish for human consumption) includes limits for temperature, dissolved oxygen and a clause that "*aquatic organisms shall not be rendered unsuitable for human consumption by the presence of contaminants*".

In this document it is proposed that standards be set for indicators of faecal contamination (Table 2). It is anticipated that the proposed standards associated with 'aquatic ecosystem health' for pH, temperature, dissolved oxygen, metals and other toxicants will provide adequate protection for waters managed for shellfish consumption.

2.6.3 Recreation and aesthetics

In schedule 3 of the RMA Class CR Water (water being managed for contact recreation purposes) includes clauses relating to visual clarity, undesirable biological growths and contaminants that render the water unsuitable for bathing.

It is proposed that standards be set for indicators of faecal contamination and water clarity (Table 2). It is anticipated that the standards set for 'aquatic ecosystem health' should provide protection against 'contaminants' such as metals and toxicants. In addition, the narrative standards for aquatic ecosystem health for 'oil, grease films, scum and foam' and 'litter and gross pollutants' should provide for aesthetic expectations associated with waters managed for contact recreation.

Setting a standard for biological growth for the purpose of recreational and aesthetic values is problematic because the presence of 'undesirable' biological growth includes an element of subjectivity. What is considered nuisance plant growth to some may be desirable to others. In addition, the presence of 'undesirable biological growths' is often random or unpredictable and may occur as a result of an unusual weather pattern or a particularly high tide. For example, large quantities of algae sometimes get washed ashore at surf beaches during storms or during a period of onshore wind which coincides with the peak of the tidal cycle. Trying to manage for the presence of biological growths in these circumstances would therefore present a very difficult challenge.

The presence of 'undesirable biological growth' in more sheltered settings such as estuaries may, however, be a symptom of nutrient enrichment. It is therefore recommended that the presence of biological growths be managed through the underlying standards for aquatic ecosystem health, which include parameters for eutrophic state.

Table 2: Proposed resource values, objectives and water quality parameters relevant to each value.

Resource value	Objective	Relevant water quality parameters/variables	Method to determine the appropriate standard
Aquatic ecosystem health	The water body supports the healthy functioning of coastal ecosystems	Water clarity: Turbidity Secchi depth Suspended solids Trophic state: Chlorophyll *a* Dissolved oxygen Nutrients Temperature pH Oil/grease film, scum foam, odour Litter and gross pollutants Metals Other toxicants	Use reference data Use reference data Insufficient data Use reference data Use reference data Use reference data RMA 1991 Use ANZECC 2000 guidelines Narrative standard Narrative standard Use ANZECC 2000 guidelines Use ANZECC 2000 guidelines
Aquaculture and shellfish consumption	The health risk associated with the consumption of shellfish is acceptable. The water body supports the growth and survival of shellfish.	Indicator of faecal contamination (faecal coliforms) Temperature pH Dissolved oxygen Metals Other toxicants	Use MfE 2003 guidelines As per aquatic ecosystems As per aquatic ecosystems As per aquatic ecosystems As per aquatic ecosystems As per aquatic ecosystems
Recreation	The health risks associated with primary contact recreation (i.e. swimming) is acceptable and that the visual and aesthetic values of the environment are not compromised.	Indicator of faecal contamination (enterococci) Water clarity	Use MfE 2003 guidelines As per aquatic ecosystems

2.7 Developing standards

2.7.1 Aquatic ecosystem health

The ANZECC 2000 guideline document outlines the preferred approach to deriving trigger values for physical and chemical stressors as follows: use of biological effects data, then local reference data (mainly physical and chemical stressors) and finally (least preferred) the tables of default values provided in the guideline document. The default trigger values were derived using the statistical distribution of reference data collected from five geographical regions across Australia and New Zealand together with the professional judgement of representatives from these regions.

In the case of chlorophyll *a*, dissolved oxygen, nutrients and turbidity specific guidelines were not developed for New Zealand estuarine and marine ecosystems and the ANZECC 2000 guideline document states that consideration should be given to the use of interim trigger values for south-east Australian estuarine and marine ecosystems. Council's state of the environment monitoring data indicates that the default trigger values for nutrients are too conservative for Northland waters (Griffiths 2015). It is also not clear if the turbidity standards are appropriate.

Accordingly, local reference data has been used to derive water quality standards for chlorophyll *a*, dissolved oxygen, nutrients and water clarity. This approach is consistent with the ANZECC 2000 guidelines, which states *"…for biological indicators, and for physical and chemical stressors where no biological effects data are available, the preferred approach to deriving guideline trigger values is from local reference data."*

In the case of toxicants (such as heavy metals), the recommended method for deriving water quality standards in the ANZECC 2000 guidelines is the use of local biological data (e.g. exotoxicity tests). No appropriate biological effects data are available for Northland's coastal waters, and to obtain them would require significant resourcing. Accordingly, it is recommended that the ANZECC 2000 guideline values and other relevant international guidelines be used. The use of reference data is only recommended if background data exceeds the default values.

2.7.2 Use of reference data to develop standards

The preferred approach to developing water quality standards advocated in the ANZECC 2000 guidelines is to derive guideline values from local reference data. A number of sources of information are suggested including:

1) Historical data from the site prior to a disturbance or management action;
2) Spatial data collected from a site relatively uninfluenced by the disturbance being assessed; and
3) Data from other sources such as scientific literature, models, expert opinion and consultation with stakeholders.

It is proposed that reference data from the Council's coastal water quality monitoring sites be used to derive standards for turbidity, secchi depth, chlorophyll *a*, total nitrogen, total ammoniacal nitrogen, nitrate-nitrite nitrogen, total phosphorus and dissolved reactive phosphorus.

Council currently operates three long-term coastal monitoring programmes in Whangārei Harbour (17 sites), the Bay of Islands (16 sites) and the Kaipara Harbour (nine sites). While the majority of the monitoring sites in these three systems do not represent reference conditions in the sense of being 'pristine', they are representative of local conditions generally remote from specific impacts or activities (for example, authorised discharges). Importantly, the current water quality at these reference sites is high enough to support 'healthy coastal ecosystems (for example, healthy shellfish and seagrass beds).

For example, the Whangārei Harbour has extensive intertidal and subtidal seagrass beds and supports dense shellfish beds towards the harbour entrance (Griffiths and Eyre, 2014). The Bay of Islands also supports large seagrass beds, turf algal mats and shellfish beds. The Northern Kaipara supports large dense shellfish beds and is a productive fish nursery (Griffiths, 2014b and Morrison *et al.,* 2014). Seagrass and filter feeding shellfish are susceptible to excess nutrient and sediment loading so the presence of dense seagrass and shellfish beds indicates that the current water quality in these systems is able to support healthy coastal ecosystems. There is also no evidence that nutrient enrichment in these harbours has caused noticeable adverse effects, such as algal blooms, and analysis of Council's coastal water quality data indicates that chlorophyll *a* and dissolved oxygen levels are generally within the default trigger values contained in the ANZECC 2000 guidelines and other international guideline values (Griffiths, 2015).

The ANZECC 2000 guidelines recommend that trigger values for physical and chemical stressors for Condition 2 ecosystems be defined in terms of the 80^{th} and/or 20^{th} percentile. Standards have therefore generally been derived from the 80^{th} and/or 20^{th} percentile for the relevant ecosystem types (tidal creeks, estuarine, open coast). However, the ANZECC 2000 guidelines state that the choice of an 80^{th} percentile is arbitrary and that professional judgment can be used to set an appropriate point on the distribution curve. In situations where the 80^{th} percentile of the reference data did not seem appropriate when compared to the default trigger values contained in the ANZECC 2000 guidelines, other international guideline values and the reference data itself, other points on the distribution curve have been recommended.

The Hātea River in Whangārei Harbour has been identified as an environment that has been significantly modified by human activity and has been classified in this document as a Condition 3 environment. For Condition 3 ecosystems the ANZECC 2000 guidelines state that, depending on management objectives, the trigger values can be defined using a more conservative percentile to improve water quality, or a less conservative percentile to maintain water quality.

Consideration was given to using reference data from the other 'tidal creek' (Condition 2) environments and then defining a standard based on the 80^{th} or 90^{th} percentile of this data set. However, when these values were tested against the existing water quality data for the six Hātea River sites, the median values typically exceeded even the 90^{th} percentiles. It is therefore proposed that the standards for the Hātea River be derived from water quality data collected at the six sites in the Hātea River (Appendix 2). It is anticipated that standards defined in terms of the 80^{th} percentile of reference data from the Hātea River itself are likely to represent a low risk that any further meaningful ecological or biological changes will occur. The Council's state of the environment monitoring data indicates that water and sediment quality improves as you move down the Hātea River towards the 'boundary' with the 'estuarine' zone of the harbour and that water quality at the 'estuarine' site closest to the 'boundary' is not noticeably worse than other estuarine sites (Griffiths, 2015). The risks of flow-on effects to the adjacent 'estuarine' zone are therefore considered to be low.

2.7.3 Analysis of the reference data

The Bay of Islands and Whangārei Harbour sites are sampled every two months (in January, March, May, July, September, and November) while the Kaipara Harbour is sampled monthly. Because of the different sampling frequency for the three programmes, all data from the Kaipara Harbour collected in February, April, June, August, October and December was omitted to reduce any potential bias. Five full years of data (2010-2014) was used for the analysis (30 samples per site).

All 42 sampling sites were categorised according to their ecosystem type (open coast, estuarine or tidal creek (Appendix 2). Six sites were categorised as ‘tidal creek’, 29 sites as ‘estuarine’ and one site as ‘open coast’. Six sites located within the Hātea River in Whangārei Harbour were treated separately as this area has been identified as a ‘Condition 3 - highly disturbed system’.

As there is only one sampling site categorised as ‘open coast’ it is not considered prudent to derive standards for all of Northland’s ‘open coast’ water from this one site. Instead it is recommended that either the existing ANZECC 2000 default trigger values for marine waters be used or a narrative standard.

2.7.4 Compliance metrics

The ANZECC 2000 guidelines recommend that median values should be used to assess water quality against trigger values derived from the 80th percentile of reference data. There is no guidance on the number of samples required for meaningful comparison with the trigger values.

Since most of these water quality variables are naturally variable, the median seems an appropriate metric for compliance. In general, chronically high levels are of more concern than a single exceedance (depending on the magnitude) which may be the result of natural variation, an unusual climatic event or a one-off incident (e.g. sewage overflow). This does not discount the possibility that even a relatively short period of elevated chlorophyll *a* or depressed dissolved oxygen may have quite severe ecological effects, but there is an expectation that an extreme result would prompt further investigation.

For toxicants, the ANZECC 2000 guidelines recommend that a more conservative approach is applied. The guidelines state “*it is recommended that action is triggered if the 95th percentile of the test distribution exceeds the default value*”. The more stringent approach is recommended because “*unlike physical and chemical stressors, toxicant default values are based upon actual biological effects data and so by implication, exceedance of the value indicates the potential for ecological harm*”.

Assuming that samples are collected monthly, this recommendation implies that even a single exceedance in a year would trigger management actions. The document itself states “…*because the proportion of values required to be less than the default trigger value is very high (95%), a single observation greater than the trigger value would be legitimate grounds for action in most cases*”. Therefore, for clarity and ease of use, it is proposed that for toxicants the compliance metric be an absolute value i.e. concentrations must fall below the standard.

2.7.5 Contact recreation and aesthetics

Standards for indicators of faecal contamination guidance have been informed by the Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas (Ministry for the Environment 2003) which is the best available technical directive on managing microbiological water quality for human health.

2.7.6 Shellfish consumption

Standards for indicators of faecal contamination guidance have been informed by the Microbiological Water Quality Guidelines for Marine and Freshwater Areas (Ministry for the Environment 2003).

3. Standards for aquatic ecosystem health

3.1 Water clarity

Water clarity can be important for the healthy functioning of marine ecosystems. Increased suspended solid loads that reduce water clarity can affect the amount of photosynthesis (primary production) of aquatic plants. Reduced water clarity can also affect the feeding efficiency of visual predators like fish and sea birds.

Reduced water clarity can also be an indicator of trophic state as algae can reduce water clarity. However, in this document reduced water clarity has been identified as a stressor in its own right. Water clarity is also an important attribute for waters managed for 'recreation and aesthetics' as poor water clarity makes the water less desirable for swimming and recreational activities.

Secchi depth, turbidity and total suspended solids are different measures of water clarity. Secchi depth is a measure of the vertical transparency of the water body. Turbidity is a measure of the degree to which light is scattered in water by particles, such as sediment and algae. Total suspended solids are a measure of the amount of suspended material in the water column.

Council has monitored turbidity and secchi depth in Whangārei and Bay of Islands for a number of years but has only recently added total suspended solids to these monitoring programmes. Secchi depth, turbidity and total suspended solids have been monitored in the Kaipara Harbour since the inception of the programme in 2008. Council's monitoring data indicates that there are reasonably strong correlations between the three parameters (Griffiths, 2015).

3.1.1 Turbidity

The current coastal water quality standards in the RCP do not include a standard for turbidity but there is a standard for natural visual clarity, which states that water clarity "*Shall not be altered"* for CN waters and "*not reduced more than 20%*" for CA and CB waters. In Schedule 3 of the RMA for Class AE water (aquatic ecosystem) turbidity or water clarity is not expressly mentioned although there is mention of deposited matter on the seabed. Sections 70 and 107 of the RMA, which deal with rules for discharges and restrictions on the ability of consenting authorities to grant certain discharge permits, both restrict the discharge of a contaminant into water if it causes "any conspicuous change in the colour or visual clarity in the receiving waters" after reasonable mixing.

The ANZECC 2000 guidelines include a default trigger value of 0.5-10 NTU for turbidity in estuarine and marine water (Table 3) but note that *"higher values may be found in estuaries or inshore coastal waters due to wind-induced resuspension or to the input of turbid water from the catchment"*. The document also states that "*turbidity is not a very useful indicator in estuarine and marine waters"* and recommends "*a move towards the measurement of light attenuation"*. Other international standards have narratives for changes to background levels of turbidity for different durations of time (Table 3).

Reference data was used to calculate 75th, 80th, and 90th percentiles for turbidity (Table 4). It is recommended that the 80th percentile be used as the standard for estuarine, tidal creek and Hātea River waters (Table 5). The proposed standards for estuarine waters and the Hātea River are therefore more conservative than the default trigger values in the ANZECC 2000 guidelines (10 NTU) but slightly more relaxed for tidal creek waters. The ANCECC default trigger value of 10 NTU is likely to be inappropriate for open coast waters, given that the 80th percentile of data from the one coastal site is 0.9 NTU. It is therefore recommended that a narrative standard apply to open coast waters.

Table 3: Turbidity guidelines from the Regional Coastal Plan for Northland and international sources.

Region	Source	Standard
Northland	Regional Coastal Plan	Visual clarity: CA waters and CB waters "Not be reduced by more than 20%". CN waters "Shall not be altered".
New Zealand	RMA 1991	Class AE water (aquatic ecosystem purposes) no specific standard for turbidity. Class CR (contact recreation purposes) the visual clarity of the water shall not be so low as to be unsuitable for bathing. Sections 70 and 107 seek to restrict the discharge of a contaminant into water if it causes "any conspicuous change in the colour or visual clarity of receiving waters".
Australia/New Zealand	ANZECC 2000 guidelines	Estuarine and marine waters: 0.5-10 NTU.
Government of British Columbia	(Singleton, 2001)	• Change from background of 8 NTU at any one time for a duration of 24 hours in all waters during clear flows or in clear waters. • Change from background of 2 NTU at any one time for a duration of 30 days in all waters during clear flows or in clear waters. • Change from background of 5 NTU at any time when background is 8-50 NTU during high flows or in turbid waters. • Change from background of 10% when background is greater than 50 NTU at any time during high flows or in turbid waters.
Canada	Canadian Council of Ministers of the Environment (2007)	Clear flow • Maximum increase of 8 NTUs from background levels for a short-term exposure (for example, 24-hour period). • Maximum average increase of 2 NTUs from background levels for a longer-term exposure (for example, 30-day period). • High flow or turbid waters: Maximum increase of 8 NTUs from background levels at any one time when background levels are between 8 and 80 NTUs. • Should not increase more than 10% of background levels when background is greater than 80 NTUs.

Table 4: The 75th, 80th, 90th percentiles derived from reference data for turbidity (NTU).

Ecosystem condition	Ecosystem type	Samples	75th	80th	90th
Condition 1 and 2	Open coast	n = 28	0.9	0.9	2.2
	Estuary	n = 810	6.3	6.9	8.9
	Tidal creek	n = 152	10	10.8	14.3
Condition 3	Hātea river	n = 168	-	7.5	9

Table 5: Proposed standards for turbidity in Northland waters. Median shall not exceed the following standards.

Ecosystem condition	Ecosystem type	Turbidity (NTU)
Condition 1 and 2	Open coast	No change from natural state
	Estuary	6.9
	Tidal creek	10.8
Condition 3	Hātea River	7.5

3.1.2 Secchi depth

The current coastal water quality standards in the RCP do not include a standard for secchi depth (Table 6) but there is a standard for natural visual clarity, which states that water clarity shall "*Not be reduced by more than 20%"* in CA and CB waters, and that water clarity "*Shall not be altered"* in CN waters. The ANZECC 2000 guidelines do not contain default trigger values for water clarity (based on secchi depth) for the protection of aquatic ecosystem health. Bricker *et al.* (1999, 2003) provide ranges for 'turbidity' in surface waters of U.S. estuaries which are based on secchi depths (Table 6).

Reference data was used to calculate 10th, 20th and 25th percentiles for secchi depth (Table 7). It is recommended that the 20th percentile is used for estuary, tidal creek and Hātea River waters (Table 8). As there is no ANZECC default trigger value for secchi depth it is recommended that a narrative standard apply to open coast waters.

Table 6: Secchi depth standards from the Regional Coastal Pan for Northland and other sources.

Region	Source	Standard
Northland	Regional Coastal Plan	Visual clarity: CA waters and CB waters "Not be reduced by more than 20%". CN waters "Shall not be altered".
New Zealand	RMA 1991	Class AE water (aquatic ecosystem purposes) no specific standard for secchi depth. Class CR (contact recreation purposes) the visual clarity of the water shall not be so low as to be unsuitable for bathing. Sections 70 and 107 seek to restrict the discharge of a contaminant into water if it causes "any conspicuous change in the colour or visual clarity of receiving waters".
Australia/New Zealand	ANZECC 2000 guidelines	No guideline values.
USA	Bricker *et al.* (1999, 2003)	Secchi depth <1m high turbidity, 1-3m medium turbidity, >3m low turbidity.
Sweden	Swedish EPA (2000)	<2.5m very slight, 2.5-3.4m slight, 3.4-4.0m moderate, 4.0-5.4m deep, >5.4m very deep.

Table 7: The 10th, 20th, 25th percentiles derived from reference data for secchi depth (m).

Ecosystem condition	Ecosystem type	Samples	25th	20th	10th
Condition 1 and 2	Open coast	n = 17	3.00	2.90	2.55
	Estuary	n = 744	1.00	1.00	0.80
	Tidal creek	n = 147	0.75	0.70	0.60
Condition 3	Hātea River	n = 173	-	0.80	0.70

Table 8: Proposed standards for secchi depth in Northland waters. Median value shall not fall below the following standards:

Ecosystem condition	Ecosystem type	Secchi depth (m)
Condition 1 and 2	Open coast	No change from natural state
	Estuary	1.00
	Tidal creek	0.70
Condition 3	Hātea River	0.80

3.1.3 Suspended solids

The coastal water quality standards in the RCP do not include a standard for suspended solids and the ANZECC 2000 guidelines do not include default trigger values for suspended solids (Table 9). There is no specific standard for suspended sediments in schedule 3 of the RMA although for Class AE water (aquatic ecosystem health) it states that "*any increase in the deposition of matter on the bed of the water body or coastal water*" shall not be allowed if it has an adverse effect on aquatic life. Other international standards for suspended solids include limits on changes in relation to existing background concentrations (Table 9).

Table 9: Turbidity standards from the Regional Coastal Pan for Northland and international sources.

Region	Source	Standard
Northland	Regional Coastal Plan	Visual clarity: CA waters and CB waters "Not be reduced by more than 20%". CN waters "Shall not be altered".
New Zealand	RMA 1991	Class AE water (aquatic ecosystem purposes) no specific standard for suspended solids. Class CR (contact recreation purposes) the visual clarity of the water shall not be so low as to be unsuitable for bathing. Sections 70 and 107 seek to restrict the discharge of a contaminant into water if it causes "any conspicuous change in the colour or visual clarity of receiving waters".
Australia/New Zealand	ANZECC 2000 guidelines	No standard.
Government of British Columbia	(Singleton, 2001)	• Change from background of 25 mg/L at any one time for a duration of 24 hours in all waters during clear flows or in clear waters. • Change from background of 5 mg/L at any one time for a duration of 30 days in all waters during clear flows or in clear waters. • Change from background of 10 mg/L at any time when background is 25-100 mg/L during high flows or in turbid waters. • Change from background of 10% when background is greater than 100 mg/L at any time during high flows or in turbid waters.
Canada	Canadian Council of Ministers of the Environment (2007)	Clear flow: • Maximum increase of 25 mg/L from background levels for any short-term exposure (for example, 24-hour period). • Maximum average increase of 5 mg/L from background levels for longer-term exposures (for example, inputs lasting between 24 hours and 30 days). High flow: • Maximum increase of 25 mg/L from background levels at any time when background levels are between 25 and 250 mg/L. • Should not increase more than 10% of background levels when background is greater than or equal to 250 mg/L.

Reference data for suspended solids (mg/L) was only available from the Kaipara Harbour so it was only possible to calculate 75th, 80th and 90th percentiles for 'estuarine' and 'tidal creek' environments (Table 10). As there is only reference data available from the Kaipara Harbour and no ANZECC default trigger value it is recommended that no standard be adopted for total suspended solids at this stage. Instead, it is recommended that the proposed standards for turbidity and secchi be used to maintain suitable water clarity for aquatic ecosystem health. A guideline value could be adopted when there is sufficient data from the Whangārei and Bay of Islands water monitoring programmes.

Table 10: The 75th, 80th, 90th percentiles derived from reference data for suspended solids (mg/L).

Ecosystem condition	Ecosystem type	Samples	75th	80th	90th
Condition 1 and 2	Open coast	No data			
	Estuary	n = 211	19.0	21.0	26.0
	Tidal creek	n = 30	26.8	27.6	38.2
Condition 3	Hātea River	No data			

3.2 Trophic state

While nutrients are essential for all forms of life, nutrients that enter the environment from anthropogenic sources, such as fertiliser, stormwater, treated wastewater, sewage overflows and failing septic systems, may exceed the needs of an ecosystem. Elevated nutrient concentrations in the water can cause excessive plant growth leading to algal blooms and lowered levels of dissolved oxygen. This can reduce the life-supporting capacity of the water, and pose a significant human health risk through contact with toxic algal blooms and eating contaminated shellfish. Excessive plant growth can also look unattractive and can cause an unpleasant odour when it dies and decays.

Chlorophyll *a*, dissolved oxygen and concentrations of nutrients are all indicators of trophic state. Water clarity can also be a response indicator to nutrient enrichment but in this document, water clarity has been treated as a separate stressor because sediment also contributes to reduced water clarity (see Section 3.1).

3.2.1 Chlorophyll a

Chlorophyll *a* is a green pigment found in plants that is used to absorb sunlight during photosynthesis. Chlorophyll *a* concentrations are therefore an indicator of phytoplankton abundance and biomass in coastal waters. This is in turn an indicator of trophic status. Chlorophyll *a* itself can also have negative ecological impacts. For example, elevated chlorophyll *a* concentrations can reduce the light available for sea grass and other submerged aquatic vegetation.

There are no standards for chlorophyll *a* in the coastal water quality standards listed in the RCP. Schedule 3 of the RMA states that for Class AE water (water being managed for aquatic purposes) *"There shall be no undesirable biological growths as a result of any discharge of a contaminant into the water".* The default trigger values for south-east Australia in the ANZECC 2000 guidelines are 0.004 mg/L for estuarine waters and 0.001 mg/L for marine waters and there are a number of other international standards (Table 11).

Reference data was used to calculate 75th, 80th and 90th percentiles for chlorophyll *a* concentrations (Table 12). It is recommended that the 80th percentile of the reference data is used for estuarine waters (0.004 mg/L) and the Hātea River (0.003 mg/L) (Table 13). The 80th percentile for tidal creek waters (0.005 mg/L) is higher than the 80th percentile for the Hātea River and is also higher than the ANZECC 2000 default trigger values for south-east Australian estuarine waters of 0.004 mg/L. As all 42 coastal water quality sites had a median value of less than 0.004 mg/L (see Appendix 3) the 80th percentile for tidal creek waters appears too relaxed and may permit a deterioration in water quality. It is therefore recommended that the 70th percentile (0.004 mg/L) be adopted for tidal creeks. It is recommended that the ANZECC 2000 default trigger value for marine waters (0.001 mg/L) be adopted for open coast waters.

It is recommended that an annual median be used to assess compliance with the standards. However, as a single algal bloom could result in lasting damage to the health of an ecosystem, annual maximums and any elevated concentrations should also be closely monitored. In the period January 2010 to December 2014, chlorophyll *a* concentrations only exceeded 0.02 mg/L on three occasions at the 42 monitoring sites (3 samples from a total of 917 samples). A chlorophyll *a* concentration ≥ 0.02 mg/L therefore appears to be a useful threshold to prompt further monitoring or investigation.

Table 11: Chlorophyll *a* standards from the Regional Coastal Plan for Northland and international sources.

Region	Source	Standard (Chlorophyll a concentration)
Northland	Regional Coastal Plan	No standard.
New Zealand	RMA 1991	Class AE water (aquatic ecosystem purposes). There shall be no undesirable biological growths as a result of any discharge of a contaminant into the water.
Australia/New Zealand	ANZECC 2000 guidelines	South-east Australia estuaries 0.004 mg/L (Queensland estuaries 0.005 mg/L), South-east Australia marine waters 0.001 mg/L (Queensland inshore waters 0.0015 mg/L).
USA	Bricker *et al*. (1999, 2003)	Hypereutrophic (>0.06 mg/L), High (>0.020, ≤0.06 mg/L), Medium (>0.005, ≤0.02 mg/L), Low (>0, ≤0.005 mg/L).
USA	USEPA (2015)	Surface chlorophyll *a* Good < 0.005 mg/L (Tropical: < 0.0005 mg/L), Fair 0.005 – 0.02 (Tropical 0.0005 – 0.001 mg/L), Poor > 0.05 mg/L (Tropical > 0.001 mg/L Poor).
Europe	OSPAR (2005)	Maximum and mean chlorophyll *a* concentrations should remain below elevated levels, defined as >50% above area specific background concentrations.
Sweden	Swedish EPA (2000)	Reference values for different regions and circulation classes, which range from 0.001 to 0.0027 mg/L and a table of deviations from these reference values. Deviations: None/insignificant ≤ 0.001 mg/L, Slight 0.001 – 0.0019 mg/L, Significant 0.001 9 – 0.0027 mg/L, Large 0.0027 – 0.0036 mg/L, Very large > 0.0036 mg/L.
	Vollenweider *et al*. (1998)	Oligotrophic <0.001 mg/L, Mesotrophic ≥ 0.001-0.003 mg/L, Eutrophic ≥ 0.003-0.005 mg/L, Hypereutrophic >0.005 mg/L.

Table 12: The 75th, 80th, 90th percentiles derived from reference data for chlorophyll *a* (mg/L).

Ecosystem condition	Ecosystem type	Samples	75th	80th	90th
Condition 1 and 2	Open coast	n = 12	0.001	0.002	0.002
	Estuarine	n = 483	0.004	0.004	0.005
	Tidal creek	n = 89	0.005	0.005	0.007
Condition 3	Hātea river	n = 72	-	0.003	0.005

Table 13: Proposed standards for chlorophyll *a* in Northland waters. Median shall not exceed the following standards.

Ecosystem condition	Ecosystem type	Chlorophyll *a* (mg/L)
Condition 1 and 2	Open coast	0.001*
	Estuarine	0.004
	Tidal creek	0.004**
Condition 3	Hātea River	0.003

*ANZECC 2000 guidelines default trigger value for south-east Australian marine waters.
**70th percentile

3.2.2 Dissolved oxygen

Dissolved oxygen is a measure of the quantity of oxygen in the water column. Oxygen is required by marine organisms (for example, fish, invertebrates and microorganisms) for efficient functioning (ANZECC, 2000) and reduced oxygen levels have been shown to cause lethal and sub-lethal effects (physiological and behavioural) in a variety of organisms, especially in fish (Canadian Council of Ministers of the Environment, 1999). Significant decreases in dissolved oxygen levels can occur when there is an excess of organic material in the system, for example, sewage effluent or dead plant material.

Dissolved oxygen levels fluctuate diurnally and seasonally. Diurnal changes are caused by the respiration of plants and animals and the photosynthetic activity of aquatic plants during the day. Plants and animals consume oxygen for respiration throughout the day and night but during the daytime oxygen is released by aquatic plants as a bi-product of photosynthesis so typically oxygen levels are higher during the day and decrease at night when photosynthesis ceases. Seasonal variations are related to changes in water temperature, as cold water holds more oxygen than warm water, and to seasonal changes in the abundance of plants and animals.

Schedule 3 of the RMA states that for Class AE water (water being managed for aquatic purposes) *"The concentration of dissolved oxygen shall exceed 80% of saturation concentration."* The current coastal water quality standards in the RCP also state that dissolved oxygen shall "*Not* [be] *reduced below 80% saturation*" for CA waters and "*shall not be altered"* for CN waters. The relevant ANZECC 2000 default trigger values are > 80% and < 110% saturation for estuarine waters and > 90% and < 110% saturation for marine waters. There are also a number of other international standards for dissolved oxygen (Table 14).

The RMA standard that dissolved oxygen should not be reduced below 80% saturation, repeated in the RCP, appears to be inappropriate. Dissolved oxygen levels routinely fall below this level at most of the reference sites (33 of the 42 sites had dissolved oxygen levels fall below 80% in the sampling period January 2010 to December 2014). Data from YSI sondes, deployed by Council and Cawthron Institute, which made continuous measurements of dissolved oxygen throughout a complete tidal cycle, found that dissolved oxygen % saturation was frequently below 80% at the Town Basin in Whangārei Harbour and the Waipapa River in Kerikeri Inlet (Cornelisen *et al.* 2011).

Reference data was used to calculate the 20th, 25th, 75th and 80th percentiles for dissolved oxygen (mg/L) and (% saturation) (Table 15 and 16). It is proposed that the 20th percentile derived from the reference data be used as the lower value for estuarine and tidal creek environments (Table 17). For the Hātea River, the 20th percentile was 77.1%. However, as the lowest median value in the Hatea River is 84.8% (Appendix 3) it is proposed that the ANZECC 2000 guidelines default trigger value of 80% be adopted. This will also align with the proposed standard for tidal creek waters. The proposed standards appear to provide a good level of protection relative to other national and international standards (Table 14 & 17). It is recommended that the ANZECC 2000 default trigger value of 110% be adopted as the upper value. It is recommended that the ANZECC 2000 default trigger values for marine waters (>90% and <110%) be adopted for open coast waters (Table 17). These percentiles and the ANZECC 2000 default trigger values were calculated from daytime measurements when dissolved oxygen is likely to be higher than at night because of photosynthesis of aquatic plants so these standards should only apply to daytime measurements.

It is recommended that an annual median be used to assess compliance with the standards. However, as even short periods of depressed dissolved oxygen levels can result in lethal consequence for certain organisms, low levels of dissolved oxygen need to be closely monitored. Vaquer-Sunyer and Duarte (2008) have examined data from 872 published experiments, covering 206 species that examined oxygen thresholds and lethal times. They comment that "*water with oxygen concentrations below 4.6 mg/L, the 90th percentile of the distribution of mean lethal concentrations, would be expected to maintain the population for most, except 10% of the most sensitive species. The oxygen level could thus be considered as a precautionary limit to avoid catastrophic events, except for the most sensitive crab species, and effectively conserve biodiversity*". A dissolved oxygen concentration of ≤ 4.6 mg/L therefore appears to be a useful threshold to prompt further monitoring or investigation.

Table 14: Dissolved oxygen standards from the Regional Coastal Plan for Northland and international sources.

Region	**Source**	**Standard**
New Zealand	RMA	Class AE Water (aquatic ecosystem purposes): "The concentration of dissolved oxygen shall exceed 80% of saturation concentration."
Northland	Regional Coastal Plan	CN: "Shall not be altered." CA: "Not reduced below 80% saturation."
Australia/New Zealand	ANZECC 2000 guidelines	Estuary lower limit = 80, upper limit = 110, Marine lower limit = 90, upper limit = 110.
USA	Bricker *et al*. (1999, 2003)	0 mg/L Very poor (anoxia), >0 ≤ 2 mg/L Poor (hypoxia), >2 ≤ 5 mg/L Fair (biological stress), >5 mg/L Low.
Europe	OSPAR (2005)	<2 mg/L Acute toxicity, 4-5 mg/L Deficiency causing stress, 5-6 mg/L Deficient, > 6 mg/L Low stress.
UK	UK Technical Advisory Group on the Water Framework Directive (2008)	5th percentile: 5.7 mg/L High (protects all life-stages of salmonid fish), 4.0-5.7 mg/L Good (resident salmonid fish), 2.4-4.0 mg/L Moderate (protects most life-stages of non-salmonid adults) 1.6-2.4 mg/L Poor (resident non-salmonid fish, poor survival of salmonid fish), 1.6 mg/L Bad (no salmonid fish. Marginal survival of resident species).
Canada	Canadian Council of Ministers of the Environment (2007)	The recommended minimum concentration of dissolved oxygen in marine and estuarine waters is 8.0 mg/L. Depression of dissolved oxygen below the recommended value should only occur as a result of natural processes. When the natural dissolved oxygen level is less than the recommended interim guideline, the natural concentration should become the interim guideline at that site. When ambient dissolved oxygen concentrations are >8.0 mg/L, human activities should not cause dissolved oxygen levels to decrease by more than 10% of the natural concentration expected in the receiving environment at that time.
Sweden	Swedish EPA (2000)	Bottom waters (annual minimum dissolved oxygen ml/l), 0 Hydrogen sulphide (widespread extinction of species), 0-2.0 ml/L Very low (long term effects kill most species), 2.0-4.0 ml/L Low (negative effects begin to appear), 4.0-6.0 ml/L Moderate (probably no effects), >6 High (good oxygen supply, no negative effects).

Table 15: The 20th, 25th, 75th, 80th percentiles derived from reference data for dissolved oxygen (% saturation).

Ecosystem condition	Ecosystem type	Samples	25th	20th	75th	80th
Condition 1 and 2	Open coast	n = 28	96.7	96.2	102.5	103.4
	Estuary	n = 838	90.9	89.8	99.0	99.9
	Tidal creek	n = 156	81.8	79.6	92.8	93.5
Condition 3	Hātea River	n = 174	-	77.1	-	94.6

Table 16: The 20th, 25th, 75th, 80th percentiles derived from reference data for dissolved oxygen (mg/L).

Ecosystem condition	Ecosystem type	Samples	25th	20th	75th	80th
Condition 1 and 2	Open coast	n = 29	7.4	7.3	8.2	8.4
	Estuary	n = 846	7.0	6.9	8.1	8.2
	Tidal creek	n = 157	6.5	6.3	8.3	8.5
Condition 3	Hātea River	n = 174	-	6.2	-	8.5

Table 17: Proposed standards for dissolved oxygen in Northland waters. Median shall fall between the lower and upper values (daytime measurements only).

Ecosystem condition	Ecosystem type	Lower value	Upper value
Condition 1 and 2	Open coast	> 90%*	<110*
	Estuary	> 90% or 6.9mg/L whichever is greater	<110*
	Tidal creek	> 80% or 6.3mg/L whichever is greater	<110*
Condition 3	Hātea River	> 80%* or 6.2mg/L whichever is greater	<110*

*ANZECC 2000 guidelines default trigger value.

3.2.3 Total phosphorus

Total phosphorus includes the total of all filterable and particulate forms of phosphorus. Phosphorus occurs naturally in water as a result of the weathering of rocks and soils, and the decomposition of organic material. Human sources of phosphorus include human sewage, cleaning products and detergents, fertilisers and animal effluent. Human activities such as earthworks and forestry that can cause soil erosion will also release phosphorus, which may reach waterways. The drainage of wetlands for development may also expose phosphorus that was buried. Industrial discharges may also contain phosphorus as polyphosphates are sometimes added to water to prevent iron oxides or calcium carbonates.

The current coastal water quality standards in the RCP do not include a standard for total phosphorus but for CN waters it states that nutrients '*Shall not be altered'* (Table 18). In Schedule 3 of the RMA, for Class AE water (water being managed for aquatic purposes) it states that *"There shall be no undesirable biological growths as a result of any discharge of a contaminant into the water".* The ANZECC default trigger values for south-east Australian estuarine waters and marine waters are 0.03 mg/L and 0.025 mg/L respectively.

Table 18: Total phosphorus standards from the Regional Coastal Plan for Northland and international sources.

Region	Source	Standard
New Zealand	RMA	Class AE Water (aquatic ecosystem purposes): *"*There shall be no undesirable biological growths as a result of any discharge of a contaminant into the water."
Northland	Regional Coastal Plan	CN: "Shall not be altered." CA: No standard.
Australia/New Zealand	ANZECC 2000 guidelines	Estuaries: 0.03 mg/L, Marine: 0.025 mg/L.
USA	Bricker *et al*. (1999, 2003)	Maximum dissolved surface concentration: High: ≥ 0.1 mg/L, Medium: ≥ 0.001, ≤ 0.1 mg/L, Low: ≥ 0 and ≤ 0.001 mg/L.

Reference data was used to calculate the 75th, 80th and 90th percentiles for total phosphorus (Table 19). The 80th percentiles of the reference data appear to be appropriate standards for estuarine and tidal creek waters and similar to the default trigger values contained in the ANZECC 2000 guidelines (Table 20). However, the 80th percentile for water in the Hātea River (0.140 mg/L) appears to be too relaxed when compared to the median values for the six sites in the Hātea River (see Appendix 3). The highest median value for sites in the Hātea River was 0.1175 mg/L at Limeburners Creek, which is well below the 80th percentile. Even the 75th percentile appears to be overly relaxed. Instead, it is proposed that the 70th percentile be adopted for water in the Hātea River (see Table 20). The proposed standard for the Hātea River is therefore significantly higher than the relevant ANZECC 2000 default trigger value. However, all six sites in the Hātea River have median values that exceed the trigger value in the ANZECC 2000 guidelines, which suggests that the ANZECC default trigger value is not appropriate for this environment. It is recommended that the ANZECC 2000 default trigger value for marine waters (0.025 mg/L) be adopted for open coast waters (Table 20).

Table 19: The 70th, 75th, 80th, 90th percentiles derived from reference data for total phosphorus (mg/L).

Ecosystem condition	Ecosystem type	Samples	70th	75th	80th	90th
Condition 1 and 2	Open coast	n = 30	0.012	0.014	0.015	0.018
	Estuary	n = 867	0.014	0.027	0.030	0.038
	Tidal creek	n = 162	0.038	0.041	0.044	0.058
Condition 3	Hātea	n = 180	0.119	0.130	0.140	0.190

Table 20: Proposed standards for total phosphorus in Northland waters. Median shall not exceed the following standards.

Ecosystem condition	Ecosystem type	TP (mg/L)
Condition 1 and 2	Open coast	0.025*
	Estuary	0.030
	Tidal creek	0.044
Condition 3	Hātea River	0.119**

*ANZECC 2000 guidelines default trigger value.
**70th percentile

3.2.4 Dissolved reactive phosphorus

Dissolved reactive phosphorus is the fraction of phosphorus that consists largely of the inorganic orthophosphate (PO_4) form of phosphorus. The inorganic orthophosphate fraction is the form of phosphorus that is directly taken up by algae. The amount of dissolved reactive phosphorus therefore indicates the amount of phosphorus that is immediately available for algal growth.

The coastal water quality standards in the RCP have a standard for dissolved reactive phosphorus of 1-10 mg/m^3 (0.001-0.01 mg/L) for CA waters and for CN waters it states that nutrients "*Shall not be altered"*. The ANZECC 2000 default trigger value for south-east Australian estuarine waters is 0.005 mg/L and 0.010 mg/L for marine waters.

Reference data was used to calculate the 75th, 80th and 90th percentiles for dissolved reactive phosphorus (Table 21). The 80th percentiles appear to be appropriate for estuarine and tidal creek waters when compared to medians from the reference sites (see Appendix 3, Table 21). However, the 80th percentile (0.110 mg/L) appears to be too relaxed for the Hātea River. The highest median value at the six Hātea River sites was 0.090 mg/L at Limeburners Creek, followed by 0.0885 mg/L at the Waiarohia Canal. Even the 75th percentile (0.100 mg/L) of the reference data (Table 21) appears to be too relaxed and would allow for deterioration of water quality in the Hātea River. Instead, it is recommended that the 70th percentile (0.092 mg/L) of the reference data be used for Hātea River waters (Table 22). It is recommended that the ANZECC 2000 default trigger value of 0.010 mg/L for marine waters be adopted for open coast waters (Table 22).

The proposed standards will represent a more relaxed standard for estuarine, tidal creek and Hātea River waters compared to the ANZECC default trigger value. The ANZECC 2000 default trigger value appears to be too conservative for Northland's coastal waters given that all 41 estuarine and tidal creek sites had a median value ≥ 0.005 mg/L (Griffiths 2015). Interestingly, the proposed standard for the estuary zone is very similar to the ANZECC 2000 default trigger value for Queensland estuaries of 0.015 mg/L.

Table 21: The 70th, 75th, 80th, 90th percentiles derived from reference data for dissolved reactive phosphorus (mg/L).

Ecosystem condition	Ecosystem type	Samples	70th	75th	80th	90th
Condition 1 and 2	Open coast	n = 30	0.007	0.007	0.008	0.011
	Estuary	n = 866	0.013	0.015	0.017	0.022
	Tidal creek	n = 161	0.015	0.018	0.021	0.035
Condition 3	Hātea	n = 180	0.092	0.100	0.110	0.150

Table 22: Proposed standards for dissolved reactive phosphorus in Northland waters. Median shall not exceed the following standards.

Ecosystem condition	Ecosystem type	DRP (mg/L)
Condition 1 and 2	Open coast	0.010*
	Estuary	0.017
	Tidal creek	0.021
Condition 3	Hātea River	0.092**

*ANZECC 2000 guidelines default trigger value.
**70th percentile

3.2.5 Total nitrogen

Total nitrogen is a measure of all forms of dissolved and particulate nitrogen present in a water sample. The coastal water quality standards in the RCP do not have a standard for total nitrogen but for CN waters it states that nutrients "*Shall not be altered"*. The relevant ANZECC 2000 default trigger values are 0.300 mg/L for estuarine waters and 0.120 mg/L for marine waters. There is only reference data available from the Kaipara Harbour so it was only possible to calculate 75th, 80th and 90th percentiles for 'estuarine' and 'tidal creek' environments (Table 23). As there is limited reference data to derive standards, one option is to include a narrative standard such as "there shall be no change from background levels". Another option is to adopt the relevant ANZECC 2000 default trigger values for south-east Australia for 'open coast' waters and condition 3 (Hātea River) waters. One issue with applying ANZECC default trigger values for the Hātea River is that the proposed standard (0.300 mg/L) would be less than the proposed standard for nitrate-nitrite nitrogen (0.580 mg/L).

Total nitrogen was added to the Whangārei and Bay of Islands water quality programmes in January 2016. It is recommended that when sufficient data is data is available for the Kaipara, Whangārei and Bay of Islands reference data be used to derive new coastal standards for 'open coast' and condition 3 (Hātea River) waters.

In the interim it is recommended that the 80th percentile be used for 'estuarine' and 'tidal creek' waters (Table 24) and that the ANZECC 2000 default trigger values of 0.12 mg/L be adopted for 'open coast' waters and 0.3 mg/L be adopted for Condition 3 (Hātea River) waters (Table 24).

Table 23: The 75th, 80th, 90th percentiles derived from reference data for total nitrogen (mg/L).

Ecosystem condition	Ecosystem type	Samples	75th	80th	90th
Condition 1 and 2	Open coast	No data			
	Estuary	n = 237	0.170	0.190	0.244
	Tidal creek	n = 30	0.280	0.290	0.342
Condition 3	Hātea River	No data			

Table 24: Proposed standards for total nitrogen in Northland waters. Median shall not exceed the following standards.

Ecosystem condition	Ecosystem type	TN (mg/L)
Condition 1 and 2	Open coast	0.120*
	Estuary	0.190
	Tidal creek	0.290
Condition 3	Hātea River	0.300*

*ANZECC 2000 guidelines default trigger value.

3.2.6 Nitrate-nitrite nitrogen

The RCP does not contain a standard for nitrate-nitrite nitrogen, although there is a standard for nitrate nitrogen (NO_3-N) of between 10-60 mg/m^3 (0.01-0.06 mg/L) for CA waters. For CN waters it also states that nutrients "*Shall not be altered".* The ANZECC 2000 default trigger values for south-east Australia are 0.015 mg/L for estuarine waters and 0.005 mg/L for marine waters. Twenty three of the 42 reference sites had median values that exceeded the ANZECC 2000 guidelines default trigger values (Griffiths, 2015), which suggests that the ANZECC 2000 default trigger values are too conservative for Northland coastal water. Reference data was used to calculate the 75th, 80th and 90th percentiles for nitrate-nitrite nitrogen (Table 25).

For estuarine and tidal creek waters the 80th percentiles appear to be appropriate (see Appendix 3 & Table 26). For Hātea River waters, the 80th percentile (0.652 mg/L) appears to be too relaxed. The highest median value at the six sites in the Hātea River was 0.575 mg/L at Waiarohia Canal followed by 0.445 mg/L at the Upper Hātea River, which are both well below the 80th percentile (see Appendix 3). It is recommended that the 75th percentile be used for Hātea River waters (Table 26). It is recommended that the ANZECC 2000 default trigger values for marine waters (0.005 mg/L) be adopted for open coast waters (Table 26).

Table 25: The 75th, 80th, 90th percentiles derived from reference data for nitrate-nitrite nitrogen (mg/L).

Ecosystem condition	Ecosystem type	Samples	75th	80th	90th
Condition 1 and 2	Open coast	n = 30	0.017	0.022	0.041
	Estuary	n = 867	0.036	0.048	0.088
	Tidal creek	n = 162	0.148	0.218	0.340
Condition 3	Hātea River	n = 180	0.580	0.652	0.783

Table 26: Proposed standards for nitrate-nitrite nitrogen in Northland waters. Median shall not exceed the following standards.

Ecosystem condition	Ecosystem type	NNN (mg/L)
Condition 1 and 2	Open coast	0.005*
	Estuary	0.048
	Tidal creek	0.218
Condition 3	Hātea River	0.580**

*ANZECC 2000 guidelines default trigger value for marine waters.
** 75th percentile.

3.2.7 Ammoniacal nitrogen

The current water quality standards for ammoniacal nitrogen (NH_4-N) in the RCP are < 5 mg/m^3 (0.005 mg/L) for CA waters and for CN waters it states that nutrients "*Shall not be altered".* The relevant ANZECC 2000 default trigger value is 0.015 mg/L for both estuarine and marine waters. Eighteen of the 42 reference sites had median values that exceeded the ANZECC 2000 default trigger value (Griffiths, 2015) which suggests that the ANZECC 2000 default trigger value may be too conservative for Northland coastal waters. Reference data was used to calculate the 70th, 75th, 80th and 90th percentiles (Table 27). The 80th percentiles appear to be appropriate for estuarine and tidal creek waters when compared to the median values from the reference data itself (see Appendix 3 and Table 27). The highest median concentration was 0.0445 mg/L for tidal creek sites and 0.0215 mg/L for estuary sites.

However, the 80th percentile (0.125 mg/L) appears to be too relaxed for Hātea River waters when compared to the median values from the reference data (see Appendix 3). The highest median (0.196 mg/L) was recorded at Limeburners Creek in the Hātea River waters but this median value was almost double the next highest median at the Waiarohia Canal (0.098 mg/L). Limeburners Creek is the immediate receiving environment for discharges from the Whangārei wastewater treatment plant and appears to have significantly higher concentrations of NH_4 than the other sites in the Hātea River. If the Limeburners Creek site is ignored, even the 75th percentile of the reference data (Table 27) appears to be too relaxed and would allow for a significant deterioration of water quality at most sites in the Hātea River. Instead, it is proposed that the 70th percentile (0.099 mg/L) of the reference data be used for Hātea River waters (Table 28). It is recommended that the ANZECC 2000 default trigger value for marine waters (0.015 mg/L) be adopted for the open coast (Table 28).

Table 27: The 70th, 75th, 80th, 90th percentiles derived from reference data for NH4 (mg/L).

Ecosystem condition	Ecosystem type	Samples	70th	75th	80th	90th
Condition 1 and 2	Open coast	n = 30	0.004	0.008	0.012	0.019
	Estuary	n = 867	0.016	0.019	0.023	0.035
	Tidal creek	n = 162	0.036	0.039	0.043	0.060
Condition 3	Hātea	n = 180	0.099	0.110	0.125	0.170

Table 28. Proposed standards for NH4 in Northland waters. Median shall not exceed the following standards.

Ecosystem condition	Ecosystem type	NH4 (mg/L)
Condition 1 and 2	Open coast	0.015*
	Estuary	0.023
	Tidal creek	0.043
Condition 3	Hātea River	0.099**

* ANZECC 2000 guidelines default trigger value for marine waters.
**70th percentile.

3.3 Temperature

Temperature affects many chemical and biological processes. Temperature can therefore have adverse effects on marine organisms. The current coastal water quality standards in the RCP state that natural temperature shall "*Not be changed by more than 3°C*" for CA waters and that temperature "*Shall not be altered"* for CN waters. Schedule 3 of the RMA states that, for Class AE water (water being managed for aquatic purposes), "*The natural temperature of the water shall not be changed by more than 3° Celsius*." The ANZECC 1992 guidelines recommended that the maximum permissible increase in the temperature of any inland or marine waters should be 2°C but the ANZECC 2000 guidelines do not provide default trigger values for temperature. The document states that "*Managers need to define their own upper and lower low-risk trigger values, using the 80th and 20th percentiles, respectively, of ecosystem temperature distribution.*" The Canadian water quality guidelines (Canadian Council of Ministers of the Environment 2007) state that "*Human activities should not cause changes in ambient temperature of marine and estuarine waters to exceed ±1°C at any time, location, or depth".*

The council's state of the environment monitoring shows that water temperature varies according to location and proximity to freshwater inputs (Griffiths, 2015). Temperature also displays both seasonal and diurnal variability. Because of this variability, defining a trigger value based on the 80th and 20th percentile of the temperature distribution is not recommended. Instead, it is proposed that the following standard shall apply to all of Northland's coastal waters: "The natural temperature of the water shall not be changed by more than *3°* Celsius".

3.4 pH

The pH of seawater is known to influence the toxicity of other contaminants and can be toxic in its own right. The current coastal water quality standards in the RCP state that pH shall "*Not be changed by more than 0.2 units*" for CA waters and "Shall not be altered" for CN Waters. The ANZECC 2000 default trigger values include a lower limit of 7.0 and an upper limit of 8.5 for estuarine waters and a lower limit of 8.0 and upper limit of 8.4 for marine waters. The standard in the RCP is likely to have come from the ANZECC 1992 guidelines and is included in a number of resource consents. It is proposed that the following standard apply to tidal creek, estuarine and Hātea River waters: "The pH shall be within 7.0 and 8.5 and shall not be changed by 0.2 units." For open coast waters: "The pH shall be within 8.0 and 8.4 and shall not be changed by 0.2 units."

3.5 Oil, grease films, scum and foam

The current RCP has a standard for oil, grease films, scum and foam for CA and CB waters. The standards state there shall be '*No conspicuous oil or grease film, scums or foams, floatable or suspended materials, or emissions of objectionable odour*.' This standard is included in most resource consents. It is recommended that this standard apply to all coastal waters.

3.6 Litter and gross pollutants

The proliferation of litter and gross pollutants reaching the coastal environment is a growing problem internationally. Plastics are now one of the most common pollutants of our oceans and as they biodegrade extremely slowly they have the potential to cause problems indefinitely. Litter can have lethal and sub-lethal effects on animals that ingest litter or get entangled in litter. There are no standards for litter or gross pollutants in the current coastal plan or the ANZECC 2000 guidelines. It is recommended that the following standard apply to all coastal waters: "No litter or gross pollutants."

3.7 Metals and other toxicants

Schedule 3 of the RMA states that for Class AE Water (being water managed for aquatic ecosystem purposes) "*The following shall not be allowed if they have an adverse effect on aquatic life: (c) any discharge of a contaminant into the water*."

The USEPA have both acute and chronic guideline values for metals and toxicants (U.S. Environmental Protection Agency 2004) (Table 29). Toxicity tests were used to estimate the highest one-hour average concentration that should not result in unacceptable effects on aquatic organisms for the acute guideline values. Data from chronic toxicity tests were used to estimate the highest four day average concentration that should not cause unacceptable toxicity during a long term exposure. The Canadian water quality guidelines for metals and toxicants (Canadian Council of Ministers of the Environment 2007) include values for long-term exposure (chronic) and short term exposure (acute) but for the specific parameters listed in Table 29 there are no recommended guidelines for short term exposure.

For metals and toxicants the ANZECC 2000 guidelines set out guideline trigger values for four different levels of protection: 99%, 95%, 90% and 80% (see Table 3.4.1 of the ANZECC 2000 guidelines as reproduced in Appendix 4 of this report & Table 29), which signify the percentage of species expected to be protected at each level. The ANZECC guidelines are based on toxicity test data for a large range of marine species and are based on chronic (long term) toxicity. Most of the trigger values were derived from single-species toxicity tests on a range of test species. Values were calculated from chronic 'no observable effect concentration data' or by applying acute-to-chronic conversion factors to short term acute toxicity tests.

Table 29: ANZECC 2000, USEPA and Canadian guidelines for selected metal contaminants.

	ANZECC 2000 guidelines		**USEPA**		**Canadian guidelines**
	99%	**95%**	**Acute**	**chronic**	**Long-term**
Total cadmium (mg/L)	0.0007	0.0007	0.033	0.0079	0.00012
Total chromium (CrIII) (mg/L)	0.0077	0.0274	-	-	0.056
Total chromium (CrVI) (mg/L)	0.00014	0.0044	1.1	0.05	0.0015
Total copper (mg/L)	0.0003	0.0013	0.0048	0.0031	No data
Total lead (mg/L)	0.0022	0.0044	0.21	0.0081	No data
Total nickel (mg/L)	0.007	0.007	0.074	0.0082	No data
Total zinc (mg/L)	0.007	0.015	0.09	0.081	No data

ANZECC 2000 guidelines assign the decision to apply a certain protection level to the relevant local jurisdiction, in consultation with the community and stakeholders, but suggest the following method for viewing the levels of protection in relation to the ecosystem conditions.

> *"In most cases, the 95% protection level trigger values should apply to ecosystems that could be classified as slightly-moderately disturbed, although a higher protection level could be applied to slightly disturbed ecosystems where the management goal is no change in biodiversity. For a few chemicals, higher levels of protection are recommended as default levels for those ecosystems, and the recommended trigger values for typical slightly-moderately disturbed ecosystems are in the shaded boxes in table 3.4.1. The highest protection level (99%) has been chosen as the default value for ecosystems with high conservation value, pending collection of local chemical and biological monitoring data."*

For chemicals that bioaccumulate, the ANZECC 2000 guidelines recommend that the 99% level of protection can be used if there is no local data on the potential for bioaccumulation: "*The 99%*

protection levels can also be used as default values for slightly-moderately disturbed systems where local data are lacking on bioaccumulation effects or where it is considered that the 95% protection level fails".

For Northland's coastal waters it is recommended that the 99% level of protection be adopted for open coast waters and that the 95% level of protection be adopted for tidal creek, estuarine and Hātea River waters. For chemicals that bioaccumulate, the 99% level of protection should apply (Table 30).

Table 30: Proposed standards for metals and toxicants in Northland coastal waters.

Zone:	Hātea River	Tidal creek	Estuarine	Open coast
Total cadmium (mg/L)	0.0007			0.0007
Total chromium (CrIII) (mg/L)	0.0274			0.0077
Total chromium (CrVI) (mg/L)	0.0044			0.00014
Total copper (mg/L)	0.0013			0.0003
Total lead (mg/L)	0.0044			0.0022
Total nickel (mg/L)	0.007			0.007
Total zinc (mg/L)	0.015			0.007
Other metals and toxicants	Should not exceed the 95% level of protection listed in Table 3.4.1 of ANZECC 2000 guidelines (Appendix 4). For chemicals that have the potential bioaccumulate, the 99% level of protection should apply.			Should not exceed the 99% level of protection listed in Table 3.4.1 of ANZECC 2000 guidelines (Appendix 4).

4. Standards for sediment quality

There are currently no sediment standards in the RCP and there is no reference to sediment standards in Schedule 3 of the RMA. However, the ANZECC 2000 guidelines and other international guidelines include standards for metals in estuarine and marine sediments.

4.1 Metals

Metal contaminants can have lethal and sub-lethal effects on marine organisms. Although plants and animals can usually regulate metal contaminants within a certain range, metals that cannot be excreted remain within the organisms and accumulate over time. As metals accumulate in an organism they can interfere with biological processes. The contaminants can also move progressively up the food chain as organisms are consumed by other animals and humans so this can ultimately pose a risk to human health. In a contaminated environment the species diversity and species richness may decrease as the community becomes dominated by a smaller number of more tolerant species which are able to survive and reproduce in these conditions. Metal contaminants are generally not subject to bacterial attack or other breakdown so are permanent additions to the marine environment.

The National Oceanic and Atmospheric Administration (NOAA) have developed effects range low (ERL) and effects range median (ERM) concentrations for toxicants in marine and estuarine sediments (Long *et al.*, 1995). The concentrations were derived from a database of toxicity tests where effects on test species have been observed. The data was ranked from the lowest concentration to the highest. The ERL corresponds to the 10^{th} percentile of concentrations that generated an effect. The ERL indicates the concentration below which adverse effects are unlikely to be observed. The ERM corresponds to the 50^{th} percentile of concentrations that generated an effect. The ERM indicates concentrations above which adverse effects are expected to occur more frequently.

The ANZECC 2000 guidelines for sediment have been adapted from Long *et al.* (1995) and include trigger values for a range of metals, metalloids, organometallic and organic sediment contaminants. The ANZECC 2000 ISQG-Low trigger values and ISQG-High trigger correspond to the ERL and ERM used in the NOAA listings.

The ANZECC 2000 guideline document emphasises a number of issues and uncertainties with the methodology used to derive the values and states that the trigger values should not be used as pass or fail values but should instead be used as triggers to prompt further action and investigation. ANZECC 2000 guidelines suggest that the guidelines should apply to moderately disturbed (condition 2) and highly disturbed (condition 3) aquatic ecosystems and a precautionary approach is recommended for high conservation/ecological value (condition1) ecosystems.

The Canadian Environmental Quality Guidelines also include standards for sediment toxicants (Canadian Council of Ministers of the Environment 2007) which were derived from a biological effects database. These guidelines include a threshold effects level (TEL) and a probable effects level (PEL). The procedure for deriving these guidelines involved both an effects data set and a no effects data base. The TEL values were derived by calculating the mean of the 15^{th} percentile of the effects data set and the 50^{th} percentile of the no effect data set. The PEL values were derived by calculating the mean of the 50^{th} percentile of the effects data set and the 85^{th} percentile of the no effects data set.

The two values define three ranges: (1) the minimal effect range within which adverse effects rarely occur (that is, fewer than 25% adverse effects occur below TEL); (2) the possible effect range (the range between TEL and PEL); and (3) the probable effect range within which adverse biological effects frequently occur (that is, more than a 50% chance of adverse effects occur above PEL). The Canadian TELs are more conservative than the ANZECC 2000 guidelines ISQG-Low trigger values (Table 31) which reflects the use of both the no effects data set in and the effects data set to calculate the TELs.

Council has collected metal sediment data from 114 sites as part of a number of state of the environment monitoring programmes throughout Northland. These sites are sampled less frequently than water quality sites (typically, annually or biennially although some sites have only been sampled once as part of 'one-off' projects) because sediment metal concentrations are typically more stable and display less temporal variation. The 80th percentiles were calculated from Council's sediment data for tidal creek, estuarine, open coast and Hātea River waters. For sites which have been sampled on more than one occasion, only the most recent data was included. In total, there were three open coast sites, 86 estuarine sites, 16 tidal creek sites and 9 Hātea River sites (Appendix 5). The 80th percentiles of all metal contaminants were well below the ANZECC 2000 ISQG-low trigger values and the Canadian TELs (Table 31 and 32) in tidal creek, estuarine and open coast zones. In the Hātea River, the 80th percentiles for copper, lead and zinc were above the Canadian TELs but below the ANZECC 2000 ISQG-low trigger values. However, sediment concentrations at two sites in the Hātea River did exceed the ANZECC 2000 ISQG-low trigger values (Griffiths, 2014a). The 80th percentiles for chromium, nickel and cadmium were below both the Canadian TELs and the ANZECC 2000 ISQG-low trigger values (Table 31 and 32).

Table 31: ANZECC 2000 guidelines, NOAA and Canadian sediment guidelines for selected metal contaminants.

	ANZECC 2000 guidelines		**NOAA**		**Canadian guidelines**	
	ISQG-Low	**ISQG-High**	**ERL**	**ERM**	**TEL**	**PEL**
Copper (mg/kg)	65	270	34	270	18.7	108
Lead (mg/kg)	50	220	46.7	218	30.2	112
Zinc (mg/kg)	200	410	150	410	124	271
Chromium (mg/kg)	80	370	81	370	52.3	160
Nickel (mg/kg)	21	52	20.9	51.6	15.9	42.8
Cadmium (mg/kg)	1.5	10	1.2	9.6	0.68	4.21

Table 32: 80th percentiles derived from reference data for sediment metal.

Ecosystem condition	**Condition 1 & 2**	**Condition 1 & 2**	**Condition 1 & 2**	**Condition 3**
Zone	**Tidal creek**	**Estuarine**	**Open coast**	**Hātea River**
Total copper (mg/kg)	17.0	10.0	2.2	47.6
Total lead (mg/kg)	9.8	7.1	3.7	27.4
Total zinc (mg/kg)	67.0	48.0	17.6	172
Total chromium (mg/kg)	16.0	16.0	10.0	22.8
Total nickel (mg/kg)	9.5	8.3	4.7	12.8
Total cadmium (mg/kg)	0.09	0.09	0.09	0.16

For Northland coastal waters, it is recommended that the Canadian TEL concentartions be adopted for tidal creek, estuarine and open coast zones (Table 33). Sediment concentartions in Northland are generally well below these values. If the more relaxed ANZECC ISQG-Low concentartions were adopted it may in effect permit a deterioration in the quality of Northland's coastal water resources. Section 69 of the RMA states that Regional Councils shall not set a standard in a plan which results, or may result, in a reduction of the quality of the water in any waters at the time of the public notification of the proposed plan. It is recommended that a qualifying statement be included with the standards for circumstances where metal concentrations naturally exceed the standards, for example, due to local geology.

For the Hātea River, it is recomended that the ANZECC 2000 ISQG-low trigger values be adopted (Table 33). Several sites in the Hātea River have metal concentrations that already exceed the Canadaian TEL and at some sites the ANZECC ISQG-low trigger values (Griffiths, 2014a). Metal contaminants are not subject to bacterial attack or breakdown so are essentially permanent additions to the marine environments. The legacy of historical activities therefore means it will be difficult for levels at these sites to reduce significantly in the short-term.

Table 33: Proposed standards for metals in sediment. Concentrations must not exceed the standards except where background concentrations are naturally elevated.

Ecosystem condition	Condition 1 & 2	Condition 1 & 2	Condition 1 & 2	Condition 3
Zone	**Tidal creek**	**Estuarine**	**Open coast**	**Hātea River**
Total copper (mg/kg)	18.7			65
Total lead (mg/kg)	30.2			50
Total zinc (mg/kg)	124			200
Total chromium (mg/kg)	52.3			80
Total nickel (mg/kg)	15.9			21
Total cadmium (mg/kg)	0.68			1.5

4.2 Nutrients in coastal sediments

The ANZECC 2000 guidelines do not contain default trigger values for nutrients in marine sediments and there are currently no other nationally accepted guideline values although Robertson and Stevens (2007) have developed their own four level classification system (see Table 34 below). However, there is no explanation as to how this classification system was developed and it is not clear whether this classification is appropriate for all types of estuaries and for open coast environments.

Council has collected nutrient sediment data from 114 sites as part of its state of the environment monitoring programme (Appendix 5). These sites are sampled less frequently than water quality sites (typically, annually or biennially although some sites have only been sampled once as part of ‘one off’ projects). This sediment monitoring data was again used to calculate the 80th percentiles for the different ecosystems (or zones). For sites which have been sampled on more than one occasion, only the most recent data was included.

For total nitrogen, the 80th percentiles of reference data for tidal creek, estuarine and open coast waters were within the ‘low to moderately enriched’ classification developed by Robertson and Stevens (Table 34 and 35). The 80th percentile calculated for the Hātea River was within the ‘enriched’ classification developed by Robertson and Stevens (Table 34 and 35). For total phosphorus the 80th percentiles for reference data from tidal creek, estuarine and open coast waters was within the ‘enriched’ classification developed by Robertson and Stevens, while the 80th percentile of reference data for the Hātea River was within the ‘very enriched’ classification (Table 34 and 35).

Table 34: Robertson and Stevens (2007) classification system for nutrients in estuarine sediments.

	Good	Low to moderately enriched	Enriched	Very enriched
Nitrogen	<500	500-2000	2000-4000	>4000
Phosphorus	<200	200-500	500-1000	>1000

Table 35: 80th percentiles derived from reference data for nutrients in sediment.

Ecosystem condition	Condition 1 & 2	Condition 1 & 2	Condition 1 & 2	Condition 3
Zone	**Tidal creek**	**Estuarine**	**Marine**	**Hātea River**
Total nitrogen (mg/kg)	1476	1000	586	2160
Total phosphorus (mg/kg)	702	524	560	1044

There is limited information in the literature to determine whether the 80th percentiles derived from Council's reference data are appropriate for use as sediment standards. Sediment nutrients behave very differently to metal contaminants as they are available for uptake by organisms and so are not permanent additions to the coastal environment.

It is not recommended that numerical standards for nutrient sediment concentrations are included in the new plan at this stage because there is insufficient information to recommend appropriate guideline values. The proposed water quality standards include nutrient concentrations for water and these should provide appropriate safeguards to maintain water quality for aquatic ecosystem health. Instead, it is proposed that a narrative standard be adopted stating that "*nutrient concentrations shall not exceed existing background levels*". It is recommended that data be used from the most appropriate council sediment sampling site or new sampling be undertaken to determine 'existing background levels'.

4.3 Proposed standards for aquatic ecosystem health

Table 36 and 37 are a summary of the proposed standards for aquatic ecosystem health.

Table 36: Water quality standards for aquatic ecosystem health.

Ecosystem condition	**Compliance metric**	**Condition 3**	**Condition 1 & 2**	**Condition 1 & 2**	**Condition 1 & 2**
Zone:		**Hātea River**	**Tidal creek**	**Estuarine**	**Open coast**
Temperature		Temperature shall not be changed by 3°C.			
Dissolved oxygen [a,b]	Median	> 80% or 6.2 mg/L	> 80% or 6.3 mg/L	> 90% or 6.9 mg/L	No change from natural state.
pH	Shall fall within	7.0-8.5	7.0 – 8.5	7.0-8.5	8 – 8.4
Turbidity (NTU)	Median	<7.5	<10.8	<6.9	No change from natural state.
Secchi depth (m)	Median	>0.8	>0.70	>1.00	No change from natural state.
Oil/grease film, scum foam, odour		No conspicuous oil or grease film, unnatural scums or foams, floatable or suspended materials, or emissions of objectionable odour.			
Litter and gross pollutants		No litter or gross pollutants.			
Chlorophyll *a* (mg/L)[b]	Median	0.003	0.004	0.004	0.001
Total phosphorus (mg/L) [b]	Median	0.119	0.044	0.030	0.025
DRP (mg/L) [b]	Median	0.092	0.021	0.017	0.010
TN (mg/L) [b]	Median	0.300	0.290	0.190	0.120
NNN (mg/L) [b]	Median	0.580	0.218	0.048	0.005
NH4 (mg/L) [b]	Median	0.099	0.043	0.023	0.015
Total cadmium (mg/L)	Shall not exceed	0.0007			0.0007
Total chromium (CrIII) (mg/L)	Shall not exceed	0.0274			0.0077
Total chromium (CrVI) (mg/L)	Shall not exceed	0.0044			0.00014
Total copper (mg/L)	Shall not exceed	0.0013			0.0003
Total lead (mg/L)	Shall not exceed	0.0044			0.0022
Total nickel (mg/L)	Shall not exceed	0.007			0.007
Total zinc (mg/L)	Shall not exceed	0.015			0.007
Other metals and toxicants	Shall not exceed	Should not exceed the 95% level of protection listed in Table 3.4.1 of ANZECC 2000 guidelines (Appendix 4). For chemicals that have the potential bioaccumulate, the 99% level of protection should apply.			The 99% level of protection listed in Table 3.4.1 of ANZECC 2000 guidelines (Appendix 4).

[a] Daytime measurements only.
[b] Surface waters only (top 0.5m).

Table 37: Proposed sediment standards for aquatic ecosystem health. Concentrations should not exceed the following values except when metal concentrations naturally exceed these values.

Ecosystem condition	**Condition 1 & 2**	**Condition 1 & 2**	**Condition 1 & 2**	**Condition 3**
Zone	**Tidal creek**	**Estuarine**	**Open coast**	**Hātea River**
Total copper (mg/kg)	18.7			65
Total lead (mg/kg)	30.2			50
Total zinc (mg/kg)	124			200
Total chromium (mg/kg)	52.3			80
Total nickel (mg/kg)	15.9			21
Total cadmium (mg/kg)	0.68			1.5
Nutrients	Nutrient concentrations shall not exceed existing background levels*			

* It is recommended that data be used from the most appropriate Council sediment sampling site or new sampling be undertaken to determine 'existing background levels'.

5. Standards for shellfish consumption

In the RCP there is no specific water classification for aquaculture although the standards for CA waters (General quality standard) should provide for virtually all uses and protection of marine ecosystem). The standard for faecal coliforms in CA waters is that the median is <14/100 ml and the 90th percentile < 43/100ml (based on not fewer than 10 samples within any 30 day period). Schedule 3 of the RMA for Class SG Water (being water managed for the gathering or cultivating of shellfish for human consumption) states that *"Aquatic organisms shall not be rendered unsuitable for human consumption by the presence of contaminants."*

The Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas (Ministry for the Environment 2003) set the following guideline for recreational shellfish-gathering:

> *"Median faecal coliform content of samples taken over a shellfish gathering seasons shall not exceed a most probable number (MPN) of 14 per 100ml and not more than 10% of samples should exceed an MPN of 43 per 100ml."*

The Ministry of Primary Industry operates a Shellfish Quality Assurance programme to ensure that commercially grown shellfish are suitable for human consumption. Under this programme, in order to maintain classification as a growing area for harvest of shellfish directly for consumption, the required water samples over the previous three-year period must have a median faecal coliform value of less than 14 MPN/100ml and no more that 10% of the samples may exceed 43 MPN/100ml. In addition, the median E.coli level of the required shellfish samples over the previous three-year period may not exceed 230 MPN/100g, and no more than 10% of samples may exceed 700 MPN/100g. These results are calculated on a rolling three-year data set. The annual data set runs from the beginning of November in one year until the end of October in the next.

It is recommended that the guidance for faecal contamination in the Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas (Ministry for the Environment 2003) be adopted as the standards for waters managed for 'aquaculture and shellfish consumption' (Table 38).

Table 38: Proposed water quality standards aquaculture and shellfish consumption.

Parameter	Standard
Faecal coliforms	Median faecal coliform content of samples taken over a shellfish gathering season shall not exceed a most probable number (MPN) of 14 per 100ml and not more than 10% of samples should exceed a MPN of 43 per 100ml

6. Standards for recreation and aesthetics

6.1 Indicators of faecal contamination

The RCP sets numerical microbiological standards for CA and CB waters and for CN waters it states that faecal coliforms "*Shall not be altered*". In Schedule 3 of the RMA for Class CR water (being water managed for contact recreation purposes) it states that "*The water shall not be rendered unsuitable for bathing by the presence of contaminants*". The ANZECC 2000 guidelines contain faecal coliforms and enterococci guidelines for recreational waters (see Appendix 6 of this report). For primary contact, the median bacterial content taken over the bathing season should not exceed 150 faecal coliforms or 35 enterococci/100ml and pathogenic free-living protozoans should be absent.

The Ministry for the Environment's Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas (Ministry for the Environment 2003) recommends that enterococci be used as the faecal indicator bacteria in marine waters. The document states "*For marine water the preferred indicator is enterococci. The New Zealand Marine Bathing Study showed that enterococci are the indicator most closely correlated with health effects in New Zealand marine waters, confirming a pattern seen in a number of overseas studies. Faecal coliforms and E. coli were not as well correlated with health risks.*"

The guidelines set concentrations for different levels of action (Table 39). This three-tier system is likened to traffic lights.

- *Highly likely to be uncontaminated (green): 'suitable' for bathing, but requiring water managers to continue surveillance (for example, routine monitoring) ;*
- *Potentially contaminated (amber): 'potentially unsuitable', requiring water managers to undertake further investigation to assess the suitability for recreation ; and*
- *Highly likely to be contaminated (red): 'highly likely to be unsuitable', requiring urgent action from water managers, such as public warnings.*

Table 39: Ministry for the Environment surveillance, alert and action levels for marine waters.

	Level of action
Surveillance/green mode	No single sample greater than 140 enterococci/100ml.
Alert/amber mode	Single sample greater 140 enterococci/100ml.
Action/red mode	Two consecutive samples greater than 280 enterococci/100ml.

The ministry guidelines also detail concentrations of enterococci for different microbiological assessment categories (Table 40), which are used to grade beaches according to their suitability for recreation.

Table 40: Ministry for the Environment microbiological assessment category definitions for marine waters.

Grade	**Standard**
A	Sample 95 percentile ≤ 40 enterococci/100ml.
B	Sample 95 percentile 41-200 enterococci/100ml.
C	Sample 95 percentile 201-500 enterococci/100ml.
D	Sample 95 percentile >500 enterococci/100ml.

For Northland's coastal waters it is recommended that the surveillance/green level of 140 enterococci/100ml be adopted as a maximum concentration of enterococci (Table 41). It is also recommended that the 95th percentile of samples collected shall be ≤ 40 enterococci/100ml for waters managed for recreation and aesthetics (Table 41).

Table 41: Proposed water quality standards for recreation and aesthetic values.

Parameter	Standard
Enterococci	The concentrations of enterococci shall be below <140/100ml at all times and the 95th percentile of samples collected shall be ≤ 40 enterococci/100ml.

6.2 Water clarity

Poor water clarity may make an area undesirable for recreation. In the RCP, for CN waters it states that visual clarity shall not be reduced by 20% and that natural hue shall not be changed by more than 10 Munsell units. In Schedule 3 of the RMA for Class CR Water (being water managed for contact recreation purposes) it states that "*The visual clarity of the water shall not be so low as to be unsuitable for bathing*." In Table 5.2.2 of the ANZECC guidelines (Appendix 6) it states that "*to protect the aesthetic quality of a waterbody: the natural visual clarity should not be reduced by more than 20%; the natural hue of the water should not be changed by more than 10 points on the Munsell Scale; the natural reflectance of the water should not be changed by more than 50% and, to protect the visual clarity of waters used for swimming, the horizontal sighting of a 200 mm diameter black disc should exceed 1.6 m*".

The Ministry for the Environment's guidelines for the management of water colour and clarity (Ministry for the Environment 1994) recommended that for Class A waters (where hue is an important characteristic of the water body) the hue should not be changed by more than 5 points on the Munsell scale. For other waters, the hue should not be changed by more than 10 points on the Munsell scale. Based on a study of user preferences for bathing waters it recommended that 'the horizontal sighting range of a 200mm back disk should exceed 1.6m, which corresponds to a secchi depth of 2.2m. As this was derived from user preferences for a freshwater stream it may not correspond to user's preference in the coastal environment. Recreational users of an area are likely to have different expectations for freshwater streams, estuarine areas and open coast beaches.

The water clarity standards proposed in Section 3.1 of this report for aquatic ecosystem state that turbidity should not exceed 6.9 NTU and secchi depth should be greater than 1.00 m for estuarine environments and that there shall be "*No change from natural state*" for marine environments. These values probably correspond relatively closely to recreational users' expectations for these different environments. In estuarine areas a secchi depth of 1.0 m means that most users would still be able to see the seabed when they are waist deep in water and able to start swimming. On the open coast where expectations for water clarity are likely to be higher than in estuarine areas the narrative standard that there shall be "*No change from natural state*" is likely to appropriate. It is therefore recommended that the underlying standards proposed for aquatic ecosystem health will ensure that waters are suitable for recreation and aesthetics.

7. Acknowledgments

Thanks to Dr. Emma Newcombe and Dr. Paul Gillespie who reviewed the draft report and provided valuable feedback and comments.

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9. Appendices

Appendix 1 – Shellfish gathering sites

The following sites are defined by the Northland Regional Council's Annual Plan. They may be subject to change and as such reference to the Council's latest Annual Plan or report should be made.

- Baylys beach at Sea View Rd
- Intertidal beach at One Tree Point east cliffs
- Mangawhai Heads at motor camp
- Matauri Bay at camp ground
- Ngunguru Estuary at school
- Oakura Bay at beach
- Ocean Beach
- Ohawini Bay at Parutahi Beach
- Paihia at Te Haumi River
- Pataua South at east end of beach
- Ruakaka River at motor camp
- Sandy Bay at beach
- Taipā estuary at motor camp
- Teal Bay at beach – 10
- Tinopai at below shops

Other sites may be identified through other means, such as the Northland Regional Council's priority catchment planning process.

Appendix 2 – Coastal water quality monitoring sites.

Coastal water quality monitoring sites used as reference data for guideline values.

Sampling site	Harbour	Ecosystem condition	Ecosystem type
Ōtamatea Channel	Kaipara	Condition 1	Estuarine
Five Fathom Channel	Kaipara	Condition 1	Estuarine
Burgess Island	Kaipara	Condition 1	Estuarine
Kapua Point	Kaipara	Condition 1	Estuarine
Te Kopua	Kaipara	Condition 1	Estuarine
Te Hoanga Point	Kaipara	Condition 1	Estuarine
Hargreaves Basin	Kaipara	Condition 1	Estuarine
Ōruawharo River	Kaipara	Condition 1	Estuarine
Wahiwaka Creek	Kaipara	Condition 1	Tidal creek
Upper Kawakawa	Bay of Islands	Condition 1	Tidal creek
Kerikeri River	Bay of Islands	Condition 1	Tidal creek
Waipapa River	Bay of Islands	Condition 1	Tidal creek
Paihia NW	Bay of Islands	Condition 1	Estuarine
Te Puna	Bay of Islands	Condition 1	Estuarine
Doves Bay	Bay of Islands	Condition 1	Estuarine
Waikare Inlet	Bay of Islands	Condition 1	Estuarine
Russel	Bay of Islands	Condition 1	Estuarine
Ōpua Basin	Bay of Islands	Condition 1	Estuarine
Tapu Point	Bay of Islands	Condition 1	Estuarine
Mid-north mooring	Bay of Islands	Condition 1	Estuarine
Windsor Landing	Bay of Islands	Condition 1	Estuarine
Wainui Island	Bay of Islands	Condition 1	Estuarine
Waitangi	Bay of Islands	Condition 1	Estuarine
Te Haumi	Bay of Islands	Condition 1	Estuarine
Paihia toilets	Bay of Islands	Condition 1	Estuarine
Mair Bank	Whangārei	Condition 1	Open Coast
Otaika	Whangārei	Condition 1	Tidal Creek
Mangapai	Whangārei	Condition 1	Tidal Creek
Portland	Whangārei	Condition 1	Estuarine
Onerahi	Whangārei	Condition 1	Estuarine
Snake Bank	Whangārei	Condition 1	Estuarine
Tamaterau	Whangārei	Condition 1	Estuarine
Blacksmith Creek	Whangārei	Condition 1	Estuarine
One Tree Point	Whangārei	Condition 1	Estuarine
Kaiwaka Point	Whangārei	Condition 1	Estuarine
Marsden Point	Whangārei	Condition 1	Estuarine
Upper Hātea	Whangārei	Condition 2	Hātea River
Waiarohia	Whangārei	Condition 2	Hātea River
Lower Hātea	Whangārei	Condition 2	Hātea River
Town Basin	Whangārei	Condition 2	Hātea River
Limeburners Creek	Whangārei	Condition 2	Hātea River
Kissing Point	Whangārei	Condition 2	Hātea River

Appendix 3 – Coastal water quality data.

Secchi depth data collected from January 2010 to December 2014.

Site	Count	Minimum	Maximum	Mean	S.E	Median
Marsden Point	25	2.00	8.50	4.58	0.4	4.50
Blacksmith Creek	24	1.90	6.00	3.67	0.2	3.80
Mair Bank	17	2.25	6.75	4.05	0.3	3.60
One Tree Point	29	1.70	6.00	3.75	0.2	3.50
Snake Bank	20	2.00	6.10	3.48	0.3	3.50
Tamaterau	30	0.75	3.80	2.26	0.1	2.15
Russell	29	1.30	4.00	2.10	0.1	2.00
Five Fathom Channel	59	0.90	3.95	2.09	0.1	2.00
Doves Bay	30	1.00	5.40	1.95	0.2	1.90
Paihia North	30	0.40	3.00	1.61	0.1	1.60
Paihia	30	0.50	2.70	1.55	0.1	1.53
Paihia South	30	0.75	2.50	1.52	0.1	1.50
Windsor Landing	30	1.00	3.00	1.59	0.1	1.50
Te Kopua Point	58	0.60	2.90	1.42	0.1	1.40
Wainui Island	30	0.80	2.10	1.27	0.1	1.30
Waitangi	30	0.25	2.05	1.33	0.1	1.28
Onerahi	24	0.55	2.00	1.28	0.1	1.28
Te Puna	30	0.70	2.00	1.27	0.1	1.25
Town Basin	30	0.30	2.25	1.24	0.1	1.25
Te Hoanga Point	58	0.45	2.00	1.21	0.0	1.25
Lower Hātea River	30	0.75	3.50	1.32	0.1	1.23
Kaiwaka Point	30	0.60	2.90	1.30	0.1	1.23
Kerikeri River	29	0.60	1.65	1.19	0.1	1.20
Te Haumi	25	0.45	2.30	1.09	0.1	1.10
Waipapa River	30	0.55	1.60	1.15	0.0	1.10
Upper Hātea River	30	0.25	1.80	1.10	0.1	1.10
Kissing Point	30	0.50	2.10	1.17	0.1	1.10
Ōruawharo River	5	0.95	1.25	1.11	0.1	1.10
Portland	30	0.50	2.25	1.15	0.1	1.08
Ōpua Basin	30	0.65	2.30	1.10	0.1	1.00
Waiarohia Canal	28	0.20	2.20	1.07	0.1	1.00
Tapu Point	30	0.55	2.30	1.02	0.1	0.98
Kapua Point	58	0.45	2.05	1.02	0.0	0.98
Kawakawa River	29	0.25	1.20	0.85	0.0	0.90
Waikare Inlet	30	0.40	1.80	0.90	0.1	0.90
Limeburners Creek	25	0.25	2.20	0.99	0.1	0.90
Wahiwaka Creek	58	0.25	1.75	0.90	0.0	0.90
Burgess Island	59	0.50	2.80	1.07	0.1	0.90
Mangapai River	30	0.20	1.80	0.84	0.1	0.80
Hargreaves Basin	5	0.65	1.00	0.79	0.1	0.75

Turbidity data collected from January 2010 to December 2014. Values ranked lowest to highest median.

Site	Count	Minimum	Maximum	Mean	S.E	Median
Mair Bank	28	0.4	2.7	0.8	0.1	0.6
Marsden Point	28	0.4	3.5	1.0	0.2	0.7
Blacksmith Creek	28	0.4	3.6	1.1	0.2	0.7
One Tree Point	28	0.4	2.7	1.3	0.2	0.9
Snake Bank	28	0.4	3.4	1.3	0.2	0.9
Ōtamatea Channel	53	0.7	15.9	2.9	0.4	1.8
Five Fathom Channel	57	0.5	7.7	2.5	0.2	2.1
Tamaterau	27	0.4	9.7	2.7	0.3	2.7
Russell	28	1.0	6.3	2.7	0.2	2.7
Doves Bay	28	1.0	6.5	3.0	0.2	2.9
Paihia North	27	1.0	18.0	4.3	0.6	3.5
Windsor Landing	28	1.3	7.6	3.6	0.3	3.6
Paihia	27	1.0	11.1	4.3	0.4	3.7
Te Kopua Point	57	1.5	11.7	4.4	0.3	3.8
Ōruawharo River	57	2.2	30.0	5.3	0.5	4.0
Paihia South	28	1.3	10.5	5.0	0.5	4.2
Waiarohia Canal	28	2.1	50.0	7.1	1.7	4.3
Town Basin	28	2.6	32.0	5.3	1.0	4.3
Kerikeri River	28	2.1	10.4	4.7	0.4	4.3
Upper Hātea River	28	2.4	35.0	6.0	1.1	4.5
Te Hoanga Point	57	2.1	24.5	5.5	0.5	4.7
Te Puna	27	2.0	13.7	5.2	0.5	4.7
Wainui Island	28	1.0	14.2	5.3	0.5	4.7
Kaiwaka Point	28	1.5	12.4	5.7	0.5	5.0
Onerahi	27	1.7	8.5	5.1	0.4	5.0
Waipapa River	28	2.5	20.9	5.7	0.6	5.2
Waitangi	28	2.0	16.0	5.5	0.6	5.2
Lower Hātea River	28	1.5	9.2	4.8	0.4	5.2
Te Haumi	28	1.7	16.7	6.7	0.6	5.5
Kissing Point	28	1.0	11.0	5.7	0.5	5.7
Ōpua Basin	28	1.9	9.4	6.0	0.4	6.0
Limeburners Creek	28	1.6	78.2	10.4	3.0	6.2
Portland	28	2.1	16.5	6.9	0.6	6.2
Burgess Island	57	1.7	17.3	6.9	0.5	6.6
Kapua Point	57	2.2	28.8	8.2	0.7	6.6
Hargreaves Basin	58	2.6	19.0	7.1	0.4	6.9
Tapu Point	28	1.9	12.2	6.8	0.4	7.2
Kawakawa River	28	2.3	20.9	8.9	0.9	7.3
Waikare Inlet	28	1.9	21.0	8.6	0.8	8.1
Wahiwaka Creek	57	2.8	22.6	8.8	0.6	8.3
Mangapai River	28	1.7	16.1	8.7	0.8	8.5
Otaika Creek	12	3.1	112.8	18.6	8.7	9.1

Suspended solids data collected from January 2010 to December 2014. Values ranked lowest to highest median.

Site	n	Min	Max	Mean	S.E.	Median
Five Fathom Channel	60	1.6	32	8.5	0.66	7.5
Ōtamatea Channel	53	2.3	35	9.6	0.86	8.2
Te Kopua Point	60	4	37	12.5	0.94	10.0
Ōruawharo River	57	6.8	58	15.4	1.18	13.0
Burgess Island	60	3.2	32	14.2	0.76	13.0
Te Hoanga Point	60	5	40	15.1	1.05	13.0
Hargreaves Basin	58	7.5	47	17.5	0.95	16.0
Kapua Point	60	6.2	58	19.5	1.37	17.0
Wahiwaka Creek	60	5.8	53	21.6	1.55	18.0

Dissolved oxygen (mg/L) data collected from January 2010 to December 2014. Values ranked lowest to highest median.

Site	Count	Minimum	Maximum	Mean	Median	S.E
Ōtamatea Channel	53	6.7	9.2	8.1	8.0	0.1
Otaika Creek	11	6.1	10.5	8.2	7.9	0.4
Burgess Island	57	6.4	9.6	8.0	7.9	0.1
Kerikeri River	29	5.7	10.1	7.9	7.8	0.2
Waipapa River	29	5.7	10.3	7.9	7.8	0.2
Town Basin	30	3.9	10.6	7.7	7.8	0.3
Five Fathom Channel	57	6.3	9.3	7.9	7.8	0.1
Blacksmith Creek	30	6.6	9.3	7.8	7.7	0.1
Marsden Point	29	6.9	8.9	7.8	7.7	0.1
Ōruawharo River	57	6.5	9.8	7.9	7.7	0.1
One Tree Point	30	6.5	9.0	7.7	7.7	0.1
Snake Bank	30	6.7	8.9	7.7	7.6	0.1
Mair Bank	29	7.0	8.9	7.8	7.6	0.1
Hargreaves Basin	57	6.6	9.7	7.8	7.6	0.1
Russell	30	5.0	9.0	7.4	7.5	0.1
Waikare Inlet	30	5.3	9.1	7.4	7.5	0.2
Te Puna	29	5.5	9.1	7.5	7.4	0.2
Waiarohia Canal	29	4.5	10.2	7.4	7.4	0.3
Te Kopua Point	57	6.1	9.4	7.6	7.4	0.1
Paihia North	30	5.1	8.5	7.3	7.4	0.1
Upper Hātea River	30	4.2	10.6	7.4	7.4	0.3
Tamaterau	30	6.4	9.1	7.6	7.4	0.1
Doves Bay	29	5.0	9.1	7.4	7.3	0.1
Ōpua Basin	30	5.2	8.8	7.3	7.3	0.1
Paihia	30	5.2	8.6	7.3	7.3	0.1
Paihia South	29	5.2	9.1	7.3	7.3	0.1
Tapu Point	30	5.3	9.4	7.4	7.3	0.2
Wainui Island	29	5.1	9.0	7.2	7.3	0.2
Waitangi	30	4.9	9.0	7.3	7.3	0.2
Onerahi	30	6.1	9.2	7.5	7.3	0.2
Te Hoanga Point	57	6.1	9.7	7.6	7.3	0.1
Kawakawa River	30	5.5	8.8	7.3	7.3	0.2
Te Haumi	30	5.2	8.8	7.2	7.2	0.1
Windsor Landing	29	5.0	8.8	7.2	7.2	0.1
Kapua Point	58	5.9	9.4	7.4	7.2	0.1
Portland	30	5.9	9.4	7.3	7.2	0.2
Kaiwaka Point	30	5.8	9.0	7.3	7.0	0.2
Kissing Point	30	4.8	9.4	7.1	7.0	0.2
Lower Hātea River	30	5.1	9.3	7.2	7.0	0.2
Limeburners Creek	30	3.9	9.7	6.9	6.8	0.3
Wahiwaka Creek	57	4.8	9.6	7.1	6.7	0.1
Mangapai River	30	4.7	9.4	6.6	6.4	0.2

Dissolved oxygen (percentage saturation) data collected from January 2010 to December 2014. Values ranked lowest to highest median.

Site	Count	Minimum	Maximum	Mean	S.E	Median
Ōtamatea Channel	53	94.3	109.5	102.8	0.4	102.7
Five Fathom Channel	57	75.0	108.0	98.8	0.8	99.8
Marsden Point	28	91.0	106.1	98.9	0.7	99.0
Mair Bank	28	91.8	106.9	99.5	0.8	99.0
Snake Bank	29	91.5	105.5	98.7	0.7	98.9
Blacksmith Creek	29	91.3	112.9	98.8	0.8	98.8
One Tree Point	29	90.6	104.0	98.0	0.7	98.5
Ōruawharo River	57	79.8	106.0	98.0	0.6	98.3
Te Puna	29	62.4	106.8	96.0	1.5	97.7
Hargreaves Basin	57	77.5	109.0	97.3	0.7	97.2
Russell	30	59.3	106.5	95.3	1.6	97.1
Burgess Island	57	70.2	106.0	96.4	0.8	96.9
Onerahi	29	83.4	106.5	95.6	1.0	96.7
Tamaterau	29	83.0	102.9	95.8	0.7	96.5
Te Kopua Point	58	71.7	106.0	94.6	0.8	95.6
Te Hoanga Point	57	70.0	105.0	93.6	0.9	94.9
Doves Bay	29	59.0	102.1	93.1	1.5	94.5
Paihia South	29	60.8	107.6	92.5	1.5	94.3
Ōpua Basin	30	61.7	101.7	92.0	1.4	93.4
Paihia North	30	60.9	100.8	92.0	1.4	93.1
Paihia	30	61.1	100.8	92.0	1.4	92.5
Windsor Landing	29	59.5	103.7	91.6	1.5	92.5
Te Haumi	30	60.8	101.0	90.7	1.5	92.4
Tapu Point	30	62.2	101.2	91.2	1.3	92.2
Waikare Inlet	30	64.0	102.5	91.9	1.3	91.9
Kapua Point	58	68.1	104.0	91.7	0.9	91.8
Waitangi	30	59.2	100.1	90.7	1.4	91.5
Kerikeri River	29	60.8	100.2	89.4	1.6	91.3
Portland	29	70.4	103.0	91.2	1.1	91.2
Waipapa River	29	61.4	100.4	89.7	1.5	91.0
Kaiwaka Point	29	81.5	99.1	90.7	0.9	90.9
Wainui Island	29	59.2	105.0	90.2	1.5	90.0
Town Basin	29	55.6	103.0	86.0	2.3	87.8
Kawakawa River	30	62.3	96.2	86.5	1.2	87.6
Waiarohia Canal	29	63.0	104.3	85.8	2.2	87.6
Kissing Point	29	67.7	100.9	86.6	1.4	87.5
Lower Hātea River	29	73.2	100.1	88.1	1.3	87.4
Wahiwaka Creek	57	65.4	103.9	85.9	1.0	87.0
Otaika Creek	11	61.2	126.9	90.2	5.2	85.9
Limeburners Creek	29	52.4	101.2	82.5	2.2	85.7
Upper Hātea River	29	59.2	114.4	84.6	2.3	84.8
Mangapai River	29	64.9	100.4	81.3	1.6	79.4

Chlorophyll *a* data collected from January 2010 to December 2014. Values ranked lowest to highest median.

Site name	N	Minimum	Maximum	Mean	SE Mean	Median
Blacksmith Creek	12	0.00030	0.00270	0.00094	0.0002	0.00083
Mair Bank	12	0.00030	0.00280	0.00132	0.0002	0.00115
Marsden Point	12	0.00030	0.00470	0.00147	0.0004	0.00115
Snake Bank	12	0.00030	0.00240	0.00130	0.0002	0.00130
One Tree Point	12	0.00030	0.00260	0.00132	0.0002	0.00140
Tamaterau	12	0.00030	0.00650	0.00176	0.0005	0.00140
Paihia North	12	0.00060	0.00310	0.00153	0.0003	0.00150
Waitangi	12	0.00060	0.00220	0.00137	0.0001	0.00150
Paihia South	12	0.00060	0.00250	0.00150	0.0002	0.00155
Russell	12	0.00060	0.00390	0.00196	0.0003	0.00165
Kaiwaka Point	12	0.00030	0.00540	0.00212	0.0004	0.00175
Limeburners Creek	12	0.00030	0.00610	0.00233	0.0006	0.00175
Onerahi	12	0.00030	0.00550	0.00183	0.0004	0.00175
Te Haumi	12	0.00068	0.00260	0.00171	0.0002	0.00185
Mangapai River	12	0.00068	0.00440	0.00196	0.0003	0.00190
Paihia	12	0.00060	0.00340	0.00198	0.0003	0.00190
Kissing Point	12	0.00030	0.00520	0.00210	0.0004	0.00200
Waiarohia Canal	12	0.00030	0.00740	0.00243	0.0006	0.00200
Windsor Landing	12	0.00060	0.00330	0.00192	0.0002	0.00200
Kawakawa River	12	0.00078	0.00630	0.00253	0.0004	0.00220
Otaika Creek	12	0.00030	0.13000	0.01390	0.0106	0.00220
Portland	12	0.00068	0.00460	0.00218	0.0003	0.00225
Opua Basin	12	0.00060	0.02500	0.00413	0.0019	0.00230
Doves Bay	12	0.00060	0.00330	0.00218	0.0003	0.00240
Lower Hātea River	12	0.00030	0.00510	0.00237	0.0004	0.00250
Town Basin	12	0.00030	0.01000	0.00315	0.0009	0.00250
Te Puna	12	0.00060	0.00560	0.00277	0.0005	0.00255
Wainui Island	12	0.00060	0.00460	0.00260	0.0003	0.00260
Tapu Point	12	0.00060	0.01700	0.00388	0.0013	0.00270
Ōtamatea Channel	53	0.00030	0.02000	0.00320	0.0004	0.00280
Upper Hātea River	12	0.00068	0.00890	0.00307	0.0006	0.00280
Five Fathom Channel	58	0.00080	0.01580	0.00352	0.0004	0.00290
Te Hoanga Point	59	0.00030	0.00800	0.00342	0.0002	0.00290
Te Kopua Point	59	0.00030	0.01300	0.00334	0.0003	0.00290
Wahiwaka Creek	59	0.00078	0.01010	0.00384	0.0003	0.00300
Waikare Inlet	12	0.00060	0.00870	0.00379	0.0008	0.00300
Waipapa River	12	0.00078	0.00820	0.00356	0.0006	0.00315
Kapua Point	59	0.00030	0.00970	0.00354	0.0003	0.00320
Ōruawharo River	57	0.00030	0.01800	0.00408	0.0004	0.00340
Kerikeri River	12	0.00069	0.00840	0.00355	0.0007	0.00360
Burgess Island	59	0.00080	0.01300	0.00430	0.0003	0.00370
Hargreaves Basin	58	0.00030	0.01910	0.00466	0.0004	0.00395

Ammonia (NH_4) data collected from January 2010 to December 2014. Values ranked lowest to highest median concentration.

Site name	N	Minimum	Maximum	Mean	SE Mean	Median
Blacksmith Creek	30	0.0025	0.1800	0.0131	0.0059	0.0025
Five Fathom Channel	60	0.0025	0.0900	0.0099	0.0018	0.0025
Mair Bank	30	0.0025	0.0250	0.0065	0.0013	0.0025
Marsden Point	30	0.0025	0.0360	0.0065	0.0015	0.0025
One Tree Point	30	0.0025	0.0270	0.0063	0.0012	0.0025
Ōtamatea Channel	53	0.0025	0.0930	0.0070	0.0018	0.0025
Snake Bank	30	0.0025	0.0200	0.0066	0.0011	0.0025
Doves Bay	30	0.0050	0.3810	0.0251	0.0125	0.0050
Ōpua Basin	30	0.0050	0.3750	0.0215	0.0123	0.0050
Russell	30	0.0050	0.3880	0.0216	0.0128	0.0050
Tapu Point	30	0.0050	0.3750	0.0226	0.0122	0.0050
Te Puna	30	0.0050	0.3800	0.0190	0.0125	0.0050
Waikare Inlet	30	0.0050	0.3870	0.0208	0.0127	0.0050
Windsor Landing	30	0.0050	0.3900	0.0255	0.0128	0.0050
Onerahi	30	0.0025	0.0610	0.0157	0.0031	0.0053
Paihia	30	0.0050	0.3750	0.0232	0.0123	0.0055
Paihia South	30	0.0050	0.4000	0.0241	0.0131	0.0065
Ōruawharo River	57	0.0025	0.1000	0.0137	0.0023	0.0070
Paihia North	30	0.0050	0.4000	0.0253	0.0130	0.0090
Tamaterau	30	0.0025	0.0560	0.0150	0.0028	0.0095
Te Haumi	30	0.0050	0.3940	0.0261	0.0129	0.0095
Te Kopua Point	60	0.0025	0.1020	0.0168	0.0026	0.0110
Wainui Island	30	0.0050	0.4000	0.0311	0.0131	0.0130
Portland	30	0.0025	0.0510	0.0168	0.0029	0.0140
Te Hoanga Point	60	0.0025	0.0900	0.0200	0.0025	0.0155
Mangapai River	30	0.0025	0.1900	0.0232	0.0063	0.0160
Burgess Island	60	0.0025	0.1300	0.0255	0.0038	0.0165
Hargreaves Basin	58	0.0025	0.0890	0.0216	0.0027	0.0165
Waitangi	30	0.0050	0.4400	0.0329	0.0142	0.0170
Kapua Point	60	0.0025	0.0850	0.0202	0.0024	0.0175
Kawakawa River	30	0.0050	0.3830	0.0372	0.0127	0.0175
Kerikeri River	30	0.0050	0.3180	0.0328	0.0104	0.0195
Kaiwaka Point	30	0.0025	0.0840	0.0262	0.0041	0.0215
Waipapa River	30	0.0050	0.3720	0.0424	0.0123	0.0245
Wahiwaka Creek	60	0.0025	0.0930	0.0291	0.0030	0.0280
Lower Hātea River	30	0.0025	0.1400	0.0508	0.0068	0.0340
Otaika Creek	12	0.0120	0.0950	0.0485	0.0069	0.0445
Kissing Point	30	0.0150	0.2600	0.0744	0.0101	0.0650
Town Basin	30	0.0140	0.1590	0.0730	0.0080	0.0660
Upper Hātea River	30	0.0190	0.2700	0.0975	0.0123	0.0745
Waiarohia Canal	30	0.0090	0.3200	0.0981	0.0130	0.0790
Limeburners Creek	30	0.0140	2.1000	0.1962	0.0693	0.0835

Nitrate-nitrite nitrogen (NNN) data collected from January 2010 to December 2014. Values ranked lowest to highest median.

Site name	N	Minimum	Maximum	Mean	SE Mean	Median
Te Puna	30	0.0010	0.0096	0.0026	0.0004	0.0010
Blacksmith Creek	30	0.0010	0.0780	0.0103	0.0030	0.0024
Mair Bank	30	0.0010	0.1010	0.0144	0.0044	0.0028
Marsden Point	30	0.0010	0.0990	0.0120	0.0038	0.0030
One Tree Point	30	0.0010	0.0760	0.0110	0.0030	0.0032
Snake Bank	30	0.0010	0.0890	0.0117	0.0033	0.0035
Waikare Inlet	30	0.0010	0.0660	0.0133	0.0036	0.0045
Russell	30	0.0010	0.0950	0.0156	0.0039	0.0046
Ōtamatea Channel	53	0.0010	0.1630	0.0158	0.0041	0.0051
Five Fathom Channel	60	0.0010	0.2200	0.0428	0.0082	0.0052
Tapu Point	30	0.0010	0.0750	0.0213	0.0046	0.0069
Ōpua Basin	30	0.0010	0.1250	0.0196	0.0050	0.0073
Tamaterau	30	0.0010	0.0680	0.0139	0.0031	0.0075
Mangapai River	30	0.0010	0.0520	0.0109	0.0022	0.0079
Te Haumi	30	0.0010	0.2000	0.0251	0.0073	0.0082
Portland	30	0.0010	0.0730	0.0163	0.0038	0.0091
Onerahi	30	0.0010	0.0670	0.0185	0.0035	0.0100
Ōruawharo River	57	0.0010	0.2400	0.0350	0.0071	0.0100
Te Hoanga Point	60	0.0010	0.2300	0.0451	0.0075	0.0135
Te Kopua Point	60	0.0010	0.2300	0.0445	0.0077	0.0135
Doves Bay	30	0.0010	0.1900	0.0349	0.0081	0.0145
Windsor Landing	30	0.0010	0.1190	0.0304	0.0061	0.0145
Wainui Island	30	0.0010	0.2700	0.0574	0.0140	0.0160
Kapua Point	60	0.0010	0.2200	0.0410	0.0066	0.0165
Paihia	30	0.0010	0.1000	0.0309	0.0060	0.0170
Paihia South	30	0.0010	0.1100	0.0277	0.0054	0.0170
Hargreaves Basin	58	0.0010	0.2300	0.0459	0.0078	0.0175
Kawakawa River	30	0.0010	0.1400	0.0431	0.0083	0.0180
Paihia North	30	0.0010	0.1370	0.0334	0.0072	0.0180
Waitangi	30	0.0010	0.1850	0.0526	0.0112	0.0190
Kaiwaka Point	30	0.0010	0.1700	0.0534	0.0089	0.0430
Wahiwaka Creek	60	0.0010	0.2500	0.0667	0.0083	0.0455
Burgess Island	60	0.0010	0.5040	0.1288	0.0187	0.0525
Waipapa River	30	0.0010	0.4800	0.1557	0.0281	0.0735
Lower Hātea River	30	0.0010	0.8900	0.1684	0.0340	0.1035
Kerikeri River	30	0.0010	0.7500	0.2016	0.0354	0.1450
Kissing Point	30	0.0280	0.9800	0.2867	0.0433	0.2100
Otaika Creek	12	0.0270	0.5300	0.2692	0.0414	0.3000
Town Basin	30	0.0600	0.9800	0.4672	0.0384	0.4100
Limeburners Creek	30	0.0890	4.0000	0.9080	0.2130	0.4400
Upper Hātea River	30	0.0500	0.9100	0.4968	0.0404	0.4450
Waiarohia Canal	30	0.1850	1.4000	0.5714	0.0408	0.5750

Total phosphorus (TP) data collected from January 2010 to December 2014. Values ranked lowest to highest median.

Site name	N	Minimum	Maximum	Mean	SE Mean	Median
Mair Bank	30	0.0025	0.0810	0.0126	0.0025	0.0100
Marsden Point	30	0.0050	0.0230	0.0109	0.0008	0.0100
Blacksmith Creek	30	0.0060	0.0200	0.0116	0.0007	0.0105
Snake Bank	30	0.0025	0.0230	0.0115	0.0010	0.0105
One Tree Point	30	0.0025	0.0240	0.0127	0.0009	0.0120
Russell	30	0.0050	0.1500	0.0181	0.0046	0.0135
Ōtamatea Channel	53	0.0025	0.0630	0.0172	0.0019	0.0140
Paihia North	30	0.0090	0.0470	0.0169	0.0014	0.0150
Paihia	30	0.0080	0.0260	0.0162	0.0008	0.0155
Doves Bay	30	0.0090	0.0300	0.0166	0.0010	0.0160
Five Fathom Channel	60	0.0060	0.0380	0.0182	0.0009	0.0160
Paihia South	30	0.0060	0.0780	0.0185	0.0022	0.0160
Kerikeri River	30	0.0050	0.0380	0.0180	0.0013	0.0180
Te Haumi	30	0.0100	0.0350	0.0191	0.0010	0.0180
Waitangi	30	0.0090	0.0320	0.0183	0.0010	0.0180
Windsor Landing	30	0.0100	0.0280	0.0177	0.0010	0.0185
Te Puna	30	0.0080	0.0470	0.0200	0.0015	0.0195
Ōpua Basin	30	0.0100	0.0350	0.0208	0.0011	0.0200
Tamaterau	30	0.0060	0.0380	0.0192	0.0015	0.0200
Waipapa River	30	0.0050	0.0380	0.0197	0.0014	0.0200
Wainui Island	30	0.0080	0.0390	0.0219	0.0014	0.0205
Tapu Point	30	0.0080	0.3100	0.0332	0.0097	0.0220
Waikare Inlet	30	0.0090	0.0570	0.0262	0.0020	0.0235
Onerahi	30	0.0100	0.0500	0.0263	0.0019	0.0245
Te Kopua Point	60	0.0090	0.0600	0.0272	0.0013	0.0250
Kawakawa River	30	0.0080	0.0650	0.0277	0.0021	0.0255
Ōruawharo River	57	0.0080	0.1900	0.0305	0.0032	0.0260
Otaika Creek	12	0.0060	0.1900	0.0543	0.0175	0.0275
Portland	30	0.0120	0.0530	0.0300	0.0019	0.0290
Burgess Island	60	0.0100	0.0560	0.0314	0.0014	0.0300
Te Hoanga Point	60	0.0130	0.0550	0.0307	0.0013	0.0300
Mangapai River	30	0.0100	0.0500	0.0326	0.0020	0.0345
Kapua Point	60	0.0140	0.0750	0.0363	0.0015	0.0350
Kaiwaka Point	30	0.0200	0.0820	0.0372	0.0026	0.0355
Hargreaves Basin	58	0.0150	0.0850	0.0376	0.0016	0.0370
Lower Hātea River	30	0.0190	0.1100	0.0558	0.0048	0.0480
Wahiwaka Creek	60	0.0330	0.1100	0.0569	0.0021	0.0565
Kissing Point	30	0.0290	0.3600	0.0862	0.0119	0.0665
Town Basin	30	0.0120	0.2100	0.0891	0.0097	0.0820
Upper Hātea River	30	0.0150	0.2200	0.1035	0.0093	0.1020
Waiarohia Canal	30	0.0240	0.4000	0.1221	0.0132	0.1150
Limeburners Creek	30	0.0330	0.9700	0.2199	0.0436	0.1175

Dissolved reactive phosphorus (DRP) data collected from January 2010 to December 2014. Values ranked lowest to highest median.

Site name	N	Minimum	Maximum	Mean	SE Mean	Median
Kerikeri River	29	0.0050	0.0140	0.0066	0.0004	0.0050
Waipapa River	30	0.0050	0.0110	0.0065	0.0003	0.0060
Blacksmith Creek	30	0.0025	0.0120	0.0071	0.0005	0.0070
Mair Bank	30	0.0025	0.0150	0.0067	0.0006	0.0070
Marsden Point	30	0.0025	0.0130	0.0066	0.0005	0.0070
Ōtamatea Channel	53	0.0025	0.0370	0.0083	0.0008	0.0070
Russell	30	0.0050	0.0240	0.0076	0.0007	0.0070
Te Puna	30	0.0050	0.0120	0.0075	0.0003	0.0070
One Tree Point	30	0.0025	0.0120	0.0073	0.0005	0.0075
Doves Bay	30	0.0050	0.0160	0.0088	0.0005	0.0080
Otaika Creek	12	0.0030	0.0590	0.0133	0.0044	0.0080
Paihia North	30	0.0050	0.0130	0.0086	0.0004	0.0080
Paihia South	30	0.0050	0.0140	0.0086	0.0004	0.0080
Snake Bank	30	0.0025	0.0130	0.0072	0.0005	0.0080
Waitangi	30	0.0050	0.0200	0.0088	0.0006	0.0080
Ōpua Basin	30	0.0050	0.0200	0.0094	0.0006	0.0090
Paihia	30	0.0050	0.0130	0.0086	0.0004	0.0090
Tapu Point	30	0.0050	0.0230	0.0097	0.0007	0.0090
Wainui Island	30	0.0050	0.0200	0.0097	0.0007	0.0090
Windsor Landing	30	0.0050	0.0170	0.0091	0.0005	0.0090
Five Fathom Channel	60	0.0025	0.0190	0.0105	0.0004	0.0100
Tamaterau	30	0.0025	0.0340	0.0117	0.0011	0.0100
Te Haumi	30	0.0050	0.0220	0.0101	0.0007	0.0100
Waikare Inlet	30	0.0050	0.0280	0.0105	0.0008	0.0100
Kawakawa River	30	0.0050	0.0180	0.0116	0.0006	0.0115
Onerahi	30	0.0025	0.0320	0.0150	0.0012	0.0135
Portland	30	0.0025	0.0360	0.0166	0.0016	0.0140
Mangapai River	30	0.0060	0.0290	0.0156	0.0011	0.0145
Ōruawharo River	57	0.0025	0.0300	0.0157	0.0008	0.0150
Te Kopua Point	60	0.0050	0.0360	0.0171	0.0007	0.0170
Burgess Island	60	0.0060	0.0340	0.0190	0.0008	0.0180
Te Hoanga Point	59	0.0060	0.0320	0.0196	0.0008	0.0190
Kaiwaka Point	30	0.0080	0.0450	0.0225	0.0017	0.0200
Hargreaves Basin	58	0.0025	0.0460	0.0211	0.0012	0.0215
Kapua Point	60	0.0080	0.0440	0.0227	0.0009	0.0215
Wahiwaka Creek	60	0.0120	0.0580	0.0344	0.0012	0.0345
Lower Hātea River	30	0.0170	0.0860	0.0406	0.0037	0.0380
Kissing Point	30	0.0170	0.1500	0.0621	0.0068	0.0585
Town Basin	30	0.0120	0.2000	0.0687	0.0084	0.0650
Upper Hātea River	30	0.0090	0.2000	0.0789	0.0080	0.0735
Waiarohia Canal	30	0.0200	0.3500	0.0954	0.0120	0.0885
Limeburners Creek	30	0.0220	0.9100	0.1887	0.0433	0.0900

Appendix 4 – ANZECC 2000 guidelines, Table 3.4.1

Table 3.4.1 Trigger values for toxicants at alternative levels of protection. Values in grey shading are the trigger values applying to typical *slightly–moderately disturbed systems*; see table 3.4.2 and Section 3.4.2.4 for guidance on applying these levels to different ecosystem conditions.

Chemical		Trigger values for freshwater (µgL⁻¹)				Trigger values for marine water (µgL⁻¹)			
		Level of protection (% species)				Level of protection (% species)			
		99%	95%	90%	80%	99%	95%	90%	80%
METALS & METALLOIDS									
Aluminium	pH >6.5	27	55	80	150	ID	ID	ID	ID
Aluminium	pH <6.5	ID	ID	ID	ID	ID	ID	ID	ID
Antimony		ID	ID	ID	ID	ID	ID	ID	ID
Arsenic (As III)		1	24	94 [C]	360 [C]	ID	ID	ID	ID
Arsenic (AsV)		0.8	13	42	140 [C]	ID	ID	ID	ID
Beryllium		ID	ID	ID	ID	ID	ID	ID	ID
Bismuth		ID	ID	ID	ID	ID	ID	ID	ID
Boron		90	370 [C]	680 [C]	1300 [C]	ID	ID	ID	ID
Cadmium	H	0.06	0.2	0.4	0.8 [C]	0.7 [B]	5.5 [B, C]	14 [B, C]	36 [B, A]
Chromium (Cr III)	H	ID	ID	ID	ID	7.7	27.4	48.6	90.6
Chromium (CrVI)		0.01	1.0 [C]	6 [A]	40 [A]	0.14	4.4	20 [C]	85 [C]
Cobalt		ID	ID	ID	ID	0.005	1	14	150 [C]
Copper	H	1.0	1.4	1.8 [C]	2.5 [C]	0.3	1.3	3 [C]	8 [A]
Gallium		ID	ID	ID	ID	ID	ID	ID	ID
Iron		ID	ID	ID	ID	ID	ID	ID	ID
Lanthanum		ID	ID	ID	ID	ID	ID	ID	ID
Lead	H	1.0	3.4	5.6	9.4 [C]	2.2	4.4	6.6 [C]	12 [C]
Manganese		1200	1900 [C]	2500 [C]	3600 [C]	ID	ID	ID	ID
Mercury (inorganic)	B	0.06	0.6	1.9 [C]	5.4 [A]	0.1	0.4 [C]	0.7 [C]	1.4 [C]
Mercury (methyl)		ID	ID	ID	ID	ID	ID	ID	ID
Molybdenum		ID	ID	ID	ID	ID	ID	ID	ID
Nickel	H	8	11	13	17 [C]	7	70 [C]	200 [A]	560 [A]
Selenium (Total)	B	5	11	18	34	ID	ID	ID	ID
Selenium (SeIV)	B	ID	ID	ID	ID	ID	ID	ID	ID
Silver		0.02	0.05	0.1	0.2 [C]	0.8	1.4	1.8	2.6 [C]
Thallium		ID	ID	ID	ID	ID	ID	ID	ID
Tin (inorganic, SnIV)		ID	ID	ID	ID	ID	ID	ID	ID
Tributyltin (as µg/L Sn)		ID	ID	ID	ID	0.0004	0.006 [C]	0.02 [C]	0.05 [C]
Uranium		ID	ID	ID	ID	ID	ID	ID	ID
Vanadium		ID	ID	ID	ID	50	100	160	280
Zinc	H	2.4	8.0 [C]	15 [C]	31 [C]	7	15 [C]	23 [C]	43 [C]
NON-METALLIC INORGANICS									
Ammonia	D	320	900 [C]	1430 [C]	2300 [A]	500	910	1200	1700
Chlorine	E	0.4	3	6 [A]	13 [A]	ID	ID	ID	ID
Cyanide	F	4	7	11	18	2	4	7	14
Nitrate	J	17	700	3400 [C]	17000 [A]	ID	ID	ID	ID
Hydrogen sulfide	G	0.5	1.0	1.5	2.6	ID	ID	ID	ID
ORGANIC ALCOHOLS									
Ethanol		400	1400	2400 [C]	4000 [C]	ID	ID	ID	ID
Ethylene glycol		ID	ID	ID	ID	ID	ID	ID	ID
Isopropyl alcohol		ID	ID	ID	ID	ID	ID	ID	ID
CHLORINATED ALKANES									
Chloromethanes									
Dichloromethane		ID	ID	ID	ID	ID	ID	ID	ID
Chloroform		ID	ID	ID	ID	ID	ID	ID	ID
Carbon tetrachloride		ID	ID	ID	ID	ID	ID	ID	ID
Chloroethanes									
1,2-dichloroethane		ID	ID	ID	ID	ID	ID	ID	ID
1,1,1-trichloroethane		ID	ID	ID	ID	ID	ID	ID	ID

Chemical		Trigger values for freshwater (µgL⁻¹)				Trigger values for marine water (µgL⁻¹)			
		Level of protection (% species)				Level of protection (% species)			
		99%	95%	90%	80%	99%	95%	90%	80%
1,1,2-trichloroethane		5400	6500	7300	8400	140	1900	5800 C	18000 C
1,1,2,2-tetrachloroethane		ID	ID	ID	ID	ID	ID	ID	ID
Pentachloroethane		ID	ID	ID	ID	ID	ID	ID	ID
Hexachloroethane	B	290	360	420	500	ID	ID	ID	ID
Chloropropanes									
1,1-dichloropropane		ID	ID	ID	ID	ID	ID	ID	ID
1,2-dichloropropane		ID	ID	ID	ID	ID	ID	ID	ID
1,3-dichloropropane		ID	ID	ID	ID	ID	ID	ID	ID
CHLORINATED ALKENES									
Chloroethylene		ID	ID	ID	ID	ID	ID	ID	ID
1,1-dichloroethylene		ID	ID	ID	ID	ID	ID	ID	ID
1,1,2-trichloroethylene		ID	ID	ID	ID	ID	ID	ID	ID
1,1,2,2-tetrachloroethylene		ID	ID	ID	ID	ID	ID	ID	ID
3-chloropropene		ID	ID	ID	ID	ID	ID	ID	ID
1,3-dichloropropene		ID	ID	ID	ID	ID	ID	ID	ID
ANILINES									
Aniline		8	250 A	1100 A	4800 A	ID	ID	ID	ID
2,4-dichloroaniline		0.6	7	20	60 C	ID	ID	ID	ID
2,5-dichloroaniline		ID	ID	ID	ID	ID	ID	ID	ID
3,4-dichloroaniline		1.3	3	6 C	13 C	85	150	190	260
3,5-dichloroaniline		ID	ID	ID	ID	ID	ID	ID	ID
Benzidine		ID	ID	ID	ID	ID	ID	ID	ID
Dichlorobenzidine		ID	ID	ID	ID	ID	ID	ID	ID
AROMATIC HYDROCARBONS									
Benzene		600	950	1300	2000	500 C	700 C	900 C	1300 C
Toluene		ID	ID	ID	ID	ID	ID	ID	ID
Ethylbenzene		ID	ID	ID	ID	ID	ID	ID	ID
o-xylene		200	350	470	640	ID	ID	ID	ID
m-xylene		ID	ID	ID	ID	ID	ID	ID	ID
p-xylene		140	200	250	340	ID	ID	ID	ID
m+*p*-xylene		ID	ID	ID	ID	ID	ID	ID	ID
Cumene		ID	ID	ID	ID	ID	ID	ID	ID
Polycyclic Aromatic Hydrocarbons									
Naphthalene		2.5	16	37	85	50 C	70 C	90 C	120 C
Anthracene	B	ID	ID	ID	ID	ID	ID	ID	ID
Phenanthrene	B	ID	ID	ID	ID	ID	ID	ID	ID
Fluoranthene	B	ID	ID	ID	ID	ID	ID	ID	ID
Benzo(a)pyrene	B	ID	ID	ID	ID	ID	ID	ID	ID
Nitrobenzenes									
Nitrobenzene		230	550	820	1300	ID	ID	ID	ID
1,2-dinitrobenzene		ID	ID	ID	ID	ID	ID	ID	ID
1,3-dinitrobenzene		ID	ID	ID	ID	ID	ID	ID	ID
1,4-dinitrobenzene		ID	ID	ID	ID	ID	ID	ID	ID
1,3,5-trinitrobenzene		ID	ID	ID	ID	ID	ID	ID	ID
1-methoxy-2-nitrobenzene		ID	ID	ID	ID	ID	ID	ID	ID
1-methoxy-4-nitrobenzene		ID	ID	ID	ID	ID	ID	ID	ID
1-chloro-2-nitrobenzene		ID	ID	ID	ID	ID	ID	ID	ID
1-chloro-3-nitrobenzene		ID	ID	ID	ID	ID	ID	ID	ID
1-chloro-4-nitrobenzene		ID	ID	ID	ID	ID	ID	ID	ID
1-chloro-2,4-dinitrobenzene		ID	ID	ID	ID	ID	ID	ID	ID
1,2-dichloro-3-nitrobenzene		ID	ID	ID	ID	ID	ID	ID	ID
1,3-dichloro-5-nitrobenzene		ID	ID	ID	ID	ID	ID	ID	ID
1,4-dichloro-2-nitrobenzene		ID	ID	ID	ID	ID	ID	ID	ID
2,4-dichloro-2-nitrobenzene		ID	ID	ID	ID	ID	ID	ID	ID

Chemical	Trigger values for freshwater (µgL⁻¹)				Trigger values for marine water (µgL⁻¹)			
	Level of protection (% species)				Level of protection (% species)			
	99%	95%	90%	80%	99%	95%	90%	80%
1,2,4,5-tetrachloro-3-nitrobenzene	ID	ID	ID	ID	ID	ID	ID	ID
1,5-dichloro-2,4-dinitrobenzene	ID	ID	ID	ID	ID	ID	ID	ID
1,3,5-trichloro-2,4-dinitrobenzene	ID	ID	ID	ID	ID	ID	ID	ID
1-fluoro-4-nitrobenzene	ID	ID	ID	ID	ID	ID	ID	ID
Nitrotoluenes								
2-nitrotoluene	ID	ID	ID	ID	ID	ID	ID	ID
3-nitrotoluene	ID	ID	ID	ID	ID	ID	ID	ID
4-nitrotoluene	ID	ID	ID	ID	ID	ID	ID	ID
2,3-dinitrotoluene	ID	ID	ID	ID	ID	ID	ID	ID
2,4-dinitrotoluene	16	65 [c]	130 [c]	250 [c]	ID	ID	ID	ID
2,4,6-trinitrotoluene	100	140	160	210	ID	ID	ID	ID
1,2-dimethyl-3-nitrobenzene	ID	ID	ID	ID	ID	ID	ID	ID
1,2-dimethyl-4-nitrobenzene	ID	ID	ID	ID	ID	ID	ID	ID
4-chloro-3-nitrotoluene	ID	ID	ID	ID	ID	ID	ID	ID
Chlorobenzenes and Chloronaphthalenes								
Monochlorobenzene	ID	ID	ID	ID	ID	ID	ID	ID
1,2-dichlorobenzene	120	160	200	270	ID	ID	ID	ID
1,3-dichlorobenzene	160	260	350	520 [c]	ID	ID	ID	ID
1,4-dichlorobenzene	40	60	75	100	ID	ID	ID	ID
1,2,3-trichlorobenzene B	3	10	16	30 [c]	ID	ID	ID	ID
1,2,4-trichlorobenzene B	85	170[c]	220[c]	300[c]	20	80	140	240
1,3,5-trichlorobenzene B	ID	ID	ID	ID	ID	ID	ID	ID
1,2,3,4-tetrachlorobenzene B	ID	ID	ID	ID	ID	ID	ID	ID
1,2,3,5-tetrachlorobenzene B	ID	ID	ID	ID	ID	ID	ID	ID
1,2,4,5-tetrachlorobenzene B	ID	ID	ID	ID	ID	ID	ID	ID
Pentachlorobenzene B	ID	ID	ID	ID	ID	ID	ID	ID
Hexachlorobenzene B	ID	ID	ID	ID	ID	ID	ID	ID
1-chloronaphthalene	ID	ID	ID	ID	ID	ID	ID	ID
Polychlorinated Biphenyls (PCBs) & Dioxins								
Capacitor 21 B	ID	ID	ID	ID	ID	ID	ID	ID
Aroclor 1016 B	ID	ID	ID	ID	ID	ID	ID	ID
Aroclor 1221 B	ID	ID	ID	ID	ID	ID	ID	ID
Aroclor 1232 B	ID	ID	ID	ID	ID	ID	ID	ID
Aroclor 1242 B	0.3	0.6	1.0	1.7	ID	ID	ID	ID
Aroclor 1248 B	ID	ID	ID	ID	ID	ID	ID	ID
Aroclor 1254 B	0.01	0.03	0.07	0.2	ID	ID	ID	ID
Aroclor 1260 B	ID	ID	ID	ID	ID	ID	ID	ID
Aroclor 1262 B	ID	ID	ID	ID	ID	ID	ID	ID
Aroclor 1268 B	ID	ID	ID	ID	ID	ID	ID	ID
2,3,4'-trichlorobiphenyl B	ID	ID	ID	ID	ID	ID	ID	ID
4,4'-dichlorobiphenyl B	ID	ID	ID	ID	ID	ID	ID	ID
2,2',4,5,5'-pentachloro-1,1'-biphenyl B	ID	ID	ID	ID	ID	ID	ID	ID
2,4,6,2',4',6'-hexachlorobiphenyl B	ID	ID	ID	ID	ID	ID	ID	ID
Total PCBs B	ID	ID	ID	ID	ID	ID	ID	ID
2,3,7,8-TCDD B	ID	ID	ID	ID	ID	ID	ID	ID
PHENOLS and XYLENOLS								
Phenol	85	320	600	1200 [c]	270	400	520	720
2,4-dimethylphenol	ID	ID	ID	ID	ID	ID	ID	ID
Nonylphenol	ID	ID	ID	ID	ID	ID	ID	ID
2-chlorophenol T	340 [c]	490 [c]	630 [c]	870 [c]	ID	ID	ID	ID
3-chlorophenol T	ID	ID	ID	ID	ID	ID	ID	ID
4-chlorophenol T	160	220	280 [c]	360 [c]	ID	ID	ID	ID
2,3-dichlorophenol T	ID	ID	ID	ID	ID	ID	ID	ID
2,4-dichlorophenol T	120	160 [c]	200 [c]	270 [c]	ID	ID	ID	ID

Chemical		Trigger values for freshwater (µgL-1)				Trigger values for marine water (µgL-1)			
		Level of protection (% species)				Level of protection (% species)			
		99%	95%	90%	80%	99%	95%	90%	80%
2,5-dichlorophenol	T	ID	ID	ID	ID	ID	ID	ID	ID
2,6-dichlorophenol	T	ID	ID	ID	ID	ID	ID	ID	ID
3,4-dichlorophenol	T	ID	ID	ID	ID	ID	ID	ID	ID
3,5-dichlorophenol	T	ID	ID	ID	ID	ID	ID	ID	ID
2,3,4-trichlorophenol	T	ID	ID	ID	ID	ID	ID	ID	ID
2,3,5-trichlorophenol	T	ID	ID	ID	ID	ID	ID	ID	ID
2,3,6-trichlorophenol	T	ID	ID	ID	ID	ID	ID	ID	ID
2,4,5-trichlorophenol	T,B	ID	ID	ID	ID	ID	ID	ID	ID
2,4,6-trichlorophenol	T,B	3	20	40	95	ID	ID	ID	ID
2,3,4,5-tetrachlorophenol	T,B	ID	ID	ID	ID	ID	ID	ID	ID
2,3,4,6- tetrachlorophenol	T,B	10	20	25	30	ID	ID	ID	ID
2,3,5,6- tetrachlorophenol	T,B	ID	ID	ID	ID	ID	ID	ID	ID
Pentachlorophenol	T,B	3.6	10	17	27 [A]	11	22	33	55 [A]
Nitrophenols									
2-nitrophenol		ID	ID	ID	ID	ID	ID	ID	ID
3-nitrophenol		ID	ID	ID	ID	ID	ID	ID	ID
4-nitrophenol		ID	ID	ID	ID	ID	ID	ID	ID
2,4-dinitrophenol		13	45	80	140	ID	ID	ID	ID
2,4,6-trinitrophenol		ID	ID	ID	ID	ID	ID	ID	ID
ORGANIC SULFUR COMPOUNDS									
Carbon disulfide		ID	ID	ID	ID	ID	ID	ID	ID
Isopropyl disulfide		ID	ID	ID	ID	ID	ID	ID	ID
n-propyl sulfide		ID	ID	ID	ID	ID	ID	ID	ID
Propyl disulfide		ID	ID	ID	ID	ID	ID	ID	ID
Tert-butyl sulfide		ID	ID	ID	ID	ID	ID	ID	ID
Phenyl disulfide		ID	ID	ID	ID	ID	ID	ID	ID
Bis(dimethylthiocarbamyl)sulfide		ID	ID	ID	ID	ID	ID	ID	ID
Bis(diethylthiocarbamyl)disulfide		ID	ID	ID	ID	ID	ID	ID	ID
2-methoxy-4H-1,3,2-benzodioxaphosphorium-2-sulfide		ID	ID	ID	ID	ID	ID	ID	ID
Xanthates									
Potassium amyl xanthate		ID	ID	ID	ID	ID	ID	ID	ID
Potassium ethyl xanthate		ID	ID	ID	ID	ID	ID	ID	ID
Potassium hexyl xanthate		ID	ID	ID	ID	ID	ID	ID	ID
Potassium isopropyl xanthate		ID	ID	ID	ID	ID	ID	ID	ID
Sodium ethyl xanthate		ID	ID	ID	ID	ID	ID	ID	ID
Sodium isobutyl xanthate		ID	ID	ID	ID	ID	ID	ID	ID
Sodium isopropyl xanthate		ID	ID	ID	ID	ID	ID	ID	ID
Sodium sec-butyl xanthate		ID	ID	ID	ID	ID	ID	ID	ID
PHTHALATES									
Dimethylphthalate		3000	3700	4300	5100	ID	ID	ID	ID
Diethylphthalate		900	1000	1100	1300	ID	ID	ID	ID
Dibutylphthalate	B	9.9	26	40.2	64.6	ID	ID	ID	ID
Di(2-ethylhexyl)phthalate	B	ID	ID	ID	ID	ID	ID	ID	ID
MISCELLANEOUS INDUSTRIAL CHEMICALS									
Acetonitrile		ID	ID	ID	ID	ID	ID	ID	ID
Acrylonitrile		ID	ID	ID	ID	ID	ID	ID	ID
Poly(acrylonitrile-co-butadiene-co-styrene)		200	530	800 [C]	1200 [C]	200	250	280	340
Dimethylformamide		ID	ID	ID	ID	ID	ID	ID	ID
1,2-diphenylhydrazine		ID	ID	ID	ID	ID	ID	ID	ID
Diphenylnitrosamine		ID	ID	ID	ID	ID	ID	ID	ID
Hexachlorobutadiene		ID	ID	ID	ID	ID	ID	ID	ID
Hexachlorocyclopentadiene		ID	ID	ID	ID	ID	ID	ID	ID

Chemical	Trigger values for freshwater (μgL^{-1})				Trigger values for marine water (μgL^{-1})			
	Level of protection (% species)				Level of protection (% species)			
	99%	95%	90%	80%	99%	95%	90%	80%
Isophorone	ID	ID	ID	ID	ID	ID	ID	ID
ORGANOCHLORINE PESTICIDES								
Aldrin B	ID	ID	ID	ID	ID	ID	ID	ID
Chlordane B	0.03	0.08	0.14	0.27 [C]	ID	ID	ID	ID
DDE B	ID	ID	ID	ID	ID	ID	ID	ID
DDT B	0.006	0.01	0.02	0.04	ID	ID	ID	ID
Dicofol B	ID	ID	ID	ID	ID	ID	ID	ID
Dieldrin B	ID	ID	ID	ID	ID	ID	ID	ID
Endosulfan B	0.03	0.2 [A]	0.6 [A]	1.8 [A]	0.005	0.01	0.02	0.05 [A]
Endosulfan alpha B	ID	ID	ID	ID	ID	ID	ID	ID
Endosulfan beta B	ID	ID	ID	ID	ID	ID	ID	ID
Endrin B	0.01	0.02	0.04 [C]	0.06 [A]	0.004	0.008	0.01	0.02
Heptachlor B	0.01	0.09	0.25	0.7 [A]	ID	ID	ID	ID
Lindane	0.07	0.2	0.4	1.0 [A]	ID	ID	ID	ID
Methoxychlor B	ID	ID	ID	ID	ID	ID	ID	ID
Mirex B	ID	ID	ID	ID	ID	ID	ID	ID
Toxaphene B	0.1	0.2	0.3	0.5	ID	ID	ID	ID
ORGANOPHOSPHORUS PESTICIDES								
Azinphos methyl	0.01	0.02	0.05	0.11 [A]	ID	ID	ID	ID
Chlorpyrifos B	0.00004	0.01	0.11 [A]	1.2 [A]	0.0005	0.009	0.04[A]	0.3 [A]
Demeton	ID	ID	ID	ID	ID	ID	ID	ID
Demeton-S-methyl	ID	ID	ID	ID	ID	ID	ID	ID
Diazinon	0.00003	0.01	0.2 [A]	2 [A]	ID	ID	ID	ID
Dimethoate	0.1	0.15	0.2	0.3	ID	ID	ID	ID
Fenitrothion	0.1	0.2	0.3	0.4	ID	ID	ID	ID
Malathion	0.002	0.05	0.2	1.1 [A]	ID	ID	ID	ID
Parathion	0.0007	0.004 [C]	0.01 [C]	0.04 [A]	ID	ID	ID	ID
Profenofos B	ID	ID	ID	ID	ID	ID	ID	ID
Temephos B	ID	ID	ID	ID	0.0004	0.05	0.4	3.6 [A]
CARBAMATE & OTHER PESTICIDES								
Carbofuran	0.06	1.2 [A]	4 [A]	15 [A]	ID	ID	ID	ID
Methomyl	0.5	3.5	9.5	23	ID	ID	ID	ID
S-methoprene	ID	ID	ID	ID	ID	ID	ID	ID
PYRETHROIDS								
Deltamethrin	ID	ID	ID	ID	ID	ID	ID	ID
Esfenvalerate	ID	0.001*	ID	ID	ID	ID	ID	ID
HERBICIDES & FUNGICIDES								
Bypyridilium herbicides								
Diquat	0.01	1.4	10	80 [A]	ID	ID	ID	ID
Paraquat	ID	ID	ID	ID	ID	ID	ID	ID
Phenoxyacetic acid herbicides								
MCPA	ID	ID	ID	ID	ID	ID	ID	ID
2,4-D	140	280	450	830	ID	ID	ID	ID
2,4,5-T	3	36	100	290 [A]	ID	ID	ID	ID
Sulfonylurea herbicides								
Bensulfuron	ID	ID	ID	ID	ID	ID	ID	ID
Metsulfuron	ID	ID	ID	ID	ID	ID	ID	ID
Thiocarbamate herbicides								
Molinate	0.1	3.4	14	57	ID	ID	ID	ID
Thiobencarb	1	2.8	4.6	8 [C]	ID	ID	ID	ID
Thiram	0.01	0.2	0.8 [C]	3 [A]	ID	ID	ID	ID
Triazine herbicides								
Amitrole	ID	ID	ID	ID	ID	ID	ID	ID
Atrazine	0.7	13	45 [C]	150 [C]	ID	ID	ID	ID

Chemical	Trigger values for freshwater (µgL⁻¹)				Trigger values for marine water (µgL⁻¹)			
	Level of protection (% species)				Level of protection (% species)			
	99%	95%	90%	80%	99%	95%	90%	80%
Hexazinone	ID	ID	ID	ID	ID	ID	ID	ID
Simazine	0.2	3.2	11	35	ID	ID	ID	ID
Urea herbicides								
Diuron	ID	ID	ID	ID	ID	ID	ID	ID
Tebuthiuron	0.02	2.2	20	160 [C]	ID	ID	ID	ID
Miscellaneous herbicides								
Acrolein	ID	ID	ID	ID	ID	ID	ID	ID
Bromacil	ID	ID	ID	ID	ID	ID	ID	ID
Glyphosate	370	1200	2000	3600 [A]	ID	ID	ID	ID
Imazethapyr	ID	ID	ID	ID	ID	ID	ID	ID
Ioxynil	ID	ID	ID	ID	ID	ID	ID	ID
Metolachlor	ID	ID	ID	ID	ID	ID	ID	ID
Sethoxydim	ID	ID	ID	ID	ID	ID	ID	ID
Trifluralin B	2.6	4.4	6	9 [A]	ID	ID	ID	ID
GENERIC GROUPS OF CHEMICALS								
Surfactants								
Linear alkylbenzene sulfonates (LAS)	65	280	520 [C]	1000 [C]	ID	ID	ID	ID
Alcohol ethoxylated sulfate (AES)	340	650	850 [C]	1100 [C]	ID	ID	ID	ID
Alcohol ethoxylated surfactants (AE)	50	140	220	360 [C]	ID	ID	ID	ID
Oils & Petroleum Hydrocarbons	ID	ID	ID	ID	ID	ID	ID	ID
Oil Spill Dispersants								
BP 1100X	ID	ID	ID	ID	ID	ID	ID	ID
Corexit 7664	ID	ID	ID	ID	ID	ID	ID	ID
Corexit 8667		ID	ID	ID	ID	ID	ID	ID
Corexit 9527	ID	ID	ID	ID	230	1100	2200	4400 [A]
Corexit 9550	ID	ID	ID	ID	ID	ID	ID	ID

Notes: Where the final water quality guideline to be applied to a site is below current analytical practical quantitation limits, see Section 3.4.3.3 for guidance.

Most trigger values listed here for metals and metalloids are *High reliability* figures, derived from field or chronic NOEC data (see 3.4.2.3 for reference to Volume 2). The exceptions are *Moderate reliability* for freshwater aluminium (pH >6.5), manganese and marine chromium (III).

Most trigger values listed here for non-metallic inorganics and organic chemicals are *Moderate reliability* figures, derived from acute LC_{50} data (see 3.4.2.3 for reference to Volume 2). The exceptions are *High reliability* for freshwater ammonia, 3,4-DCA, endosulfan, chlorpyrifos, esfenvalerate, tebuthiuron, three surfactants and marine for 1,1,2-TCE and chlorpyrifos.

* = *High reliability* figure for esfenvalerate derived from mesocosm NOEC data (no alternative protection levels available).

A = Figure may not protect key test species from acute toxicity (and chronic) — check Section 8.3.7 for spread of data and its significance. 'A' indicates that trigger value > acute toxicity figure; note that trigger value should be <1/3 of acute figure (Section 8.3.4.4).

B = Chemicals for which possible bioaccumulation and secondary poisoning effects should be considered (see Sections 8.3.3.4 and 8.3.5.7).

C = Figure may not protect key test species from chronic toxicity (this refers to experimental chronic figures or geometric mean for species) — check Section 8.3.7 for spread of data and its significance. Where grey shading and 'C' coincide, refer to text in Section 8.3.7.

D = Ammonia as TOTAL ammonia as [NH_3-N] at pH 8. For changes in trigger value with pH refer to Section 8.3.7.2.

E = Chlorine as total chlorine, as [Cl]; see Section 8.3.7.2.

F = Cyanide as un-ionised HCN, measured as [CN]; see Section 8.3.7.2.

G = Sulfide as un-ionised H_2S, measured as [S]; see Section 8.3.7.2.

H = Chemicals for which algorithms have been provided in table 3.4.3 to account for the effects of hardness. The values have been calculated using a hardness of 30 mg/L $CaCO_3$. These should be adjusted to the site-specific hardness (see Section 3.4.3).

J = Figures protect against toxicity and do not relate to eutrophication issues. Refer to Section 3.3 if eutrophication is the issue of concern.

ID = Insufficient data to derive a reliable trigger value. Users advised to check if a low reliability value or an ECL is given in Section 8.3.7.

T = Tainting or flavour impairment of fish flesh may possibly occur at concentrations below the trigger value. See Sections 4.4.5.3/3 and 8.3.7.

Appendix 5 – Coastal sediment quality monitoring sites.

Coastal sediment quality monitoring sampling sites (used as reference data for guideline values).

Sampling site	Harbour	Ecosystem condition	Ecosystem type
Home Point	Whangārei	Condition 2	Open coast
Kaingahoa Bay	Bay of Islands	Condition 2	Open coast
Onewhero Bay	Bay of Islands	Condition 2	Open coast
K6 Pahi River	Kaipara Harbour	Condition 2	Tidal creek
K10 Koareare Creek	Kaipara Harbour	Condition 2	Tidal creek
K19 Tauhara Creek	Kaipara Harbour	Condition 2	Tidal creek
K41 Kaiwaka River	Kaipara Harbour	Condition 2	Tidal creek
K42 Wairau River	Kaipara Harbour	Condition 2	Tidal creek
WAT3	Waitangi Estuary	Condition 2	Tidal creek
WAT6	Waitangi Estuary	Condition 2	Tidal creek
WAT8	Waitangi Estuary	Condition 2	Tidal creek
WAT10	Waitangi Estuary	Condition 2	Tidal creek
Kawakawa River	Bay of Islands	Condition 2	Tidal creek
Upper Waikare	Bay of Islands	Condition 2	Tidal creek
Te Haumi River	Bay of Islands	Condition 2	Tidal creek
Otaika Creek	Whangārei Harbour	Condition 2	Tidal creek
Mangapai River	Whangārei Harbour	Condition 2	Tidal creek
Otaika	Whangārei Harbour	Condition 2	Tidal creek
Kerikeri River	Kerikeri Inlet	Condition 2	Tidal creek
Waipapa River	Kerikeri Inlet	Condition 2	Tidal creek
WHG1	Whangārei Harbour	Condition 3	Hātea River
WHG3	Whangārei Harbour	Condition 3	Hātea River
WHG2	Whangārei Harbour	Condition 3	Hātea River
WHG4	Whangārei Harbour	Condition 3	Hātea River
Upper Hātea	Whangārei Harbour	Condition 3	Hātea River
Waiarohia Canal	Whangārei Harbour	Condition 3	Hātea River
Limeburners Creek	Whangārei Harbour	Condition 3	Hātea River
Awaroa Creek	Whangārei Harbour	Condition 3	Hātea River
Waimahanga Creek	Whangārei Harbour	Condition 3	Hātea River
WHG7	Whangārei Harbour	Condition 2	Estuarine
WHG21	Whangārei Harbour	Condition 2	Estuarine
WHG5	Whangārei Harbour	Condition 2	Estuarine
WHG12	Whangārei Harbour	Condition 2	Estuarine
WHG22	Whangārei Harbour	Condition 2	Estuarine
WHG25	Whangārei Harbour	Condition 2	Estuarine
WHG8	Whangārei Harbour	Condition 2	Estuarine
WHG11	Whangārei Harbour	Condition 2	Estuarine
WHG10	Whangārei Harbour	Condition 2	Estuarine
WHG9	Whangārei Harbour	Condition 2	Estuarine
WHG17	Whangārei Harbour	Condition 2	Estuarine
WHG6	Whangārei Harbour	Condition 2	Estuarine
WHG23	Whangārei Harbour	Condition 2	Estuarine
WHG20	Whangārei Harbour	Condition 2	Estuarine
WHG24	Whangārei Harbour	Condition 2	Estuarine
WHG19	Whangārei Harbour	Condition 2	Estuarine
WHG16	Whangārei Harbour	Condition 2	Estuarine
WHG14	Whangārei Harbour	Condition 2	Estuarine
WHG15	Whangārei Harbour	Condition 2	Estuarine
WHG18	Whangārei Harbour	Condition 2	Estuarine
WHG13	Whangārei Harbour	Condition 2	Estuarine

K1 Hokorako Creek	Kaipara Harbour	Condition 2	Estuarine
K2 Te Kopua Point Bay	Kaipara Harbour	Condition 2	Estuarine
K3 Whakapirau Creek	Kaipara Harbour	Condition 2	Estuarine
K4 Kirikiri Inlet	Kaipara Harbour	Condition 2	Estuarine
K5 Paparoa Creek	Kaipara Harbour	Condition 2	Estuarine
K7 Hargreaves Basin	Kaipara Harbour	Condition 2	Estuarine
K8 Ōruawharo River	Kaipara Harbour	Condition 2	Estuarine
K9 Gittos Point	Kaipara Harbour	Condition 2	Estuarine
K11 Topuni River	Kaipara Harbour	Condition 2	Estuarine
K12 Waitieke Creek	Kaipara Harbour	Condition 2	Estuarine
K13 Te Kiakia Bay	Kaipara Harbour	Condition 2	Estuarine
K14 Waikeri Bank	Kaipara Harbour	Condition 2	Estuarine
K15 Okaro Creek	Kaipara Harbour	Condition 2	Estuarine
K16 Pareotaunga Point	Kaipara Harbour	Condition 2	Estuarine
K17 Waikeri Creek	Kaipara Harbour	Condition 2	Estuarine
K18 Tauhara	Kaipara Harbour	Condition 2	Estuarine
K20 Clarks Bay	Kaipara Harbour	Condition 2	Estuarine
K21 Clarks Banks	Kaipara Harbour	Condition 2	Estuarine
K22 Fifty Acre Bank	Kaipara Harbour	Condition 2	Estuarine
K23 Kotiroreka Bay	Kaipara Harbour	Condition 2	Estuarine
K24 Tangikiki Bay	Kaipara Harbour	Condition 2	Estuarine
K25 Burgess Island Outer	Kaipara Harbour	Condition 2	Estuarine
K26 Frenchmans Bay	Kaipara Harbour	Condition 2	Estuarine
K27 Moturoa Island	Kaipara Harbour	Condition 2	Estuarine
K28 Sandy Beach	Kaipara Harbour	Condition 2	Estuarine
K29 Komiti Bay	Kaipara Harbour	Condition 2	Estuarine
K30 Otairi Creek	Kaipara Harbour	Condition 2	Estuarine
K31 Te Ruruku Bay	Kaipara Harbour	Condition 2	Estuarine
K32 Kumuakiiti Point	Kaipara Harbour	Condition 2	Estuarine
K33 Subritzky Channel	Kaipara Harbour	Condition 2	Estuarine
K34 Burgess Island Inner	Kaipara Harbour	Condition 2	Estuarine
K35 Burgess Island Oysters	Kaipara Harbour	Condition 2	Estuarine
K36 Matanginui	Kaipara Harbour	Condition 2	Estuarine
K37 Ruawai	Kaipara Harbour	Condition 2	Estuarine
K38 Whakapirau	Kaipara Harbour	Condition 2	Estuarine
K39 Hanerau Stream	Kaipara Harbour	Condition 2	Estuarine
K40 Wahiwaka Creek	Kaipara Harbour	Condition 2	Estuarine
K43 Otara	Kaipara Harbour	Condition 2	Estuarine
K44 Stony Creek	Kaipara Harbour	Condition 2	Estuarine
WAT9	Waitangi Estuary	Condition 2	Estuarine
WAT1	Waitangi Estuary	Condition 2	Estuarine
WAT2	Waitangi Estuary	Condition 2	Estuarine
WAT4	Waitangi Estuary	Condition 2	Estuarine
WAT5	Waitangi Estuary	Condition 2	Estuarine
WAT7	Waitangi Estuary	Condition 2	Estuarine
Wainui Island	Bay of Islands	Condition 2	Estuarine
Doves Bay	Bay of Islands	Condition 2	Estuarine
Te Puna entrance	Bay of Islands	Condition 2	Estuarine
Dead Whale Reef	Bay of Islands	Condition 2	Estuarine
Lower Waikare	Bay of Islands	Condition 2	Estuarine
Paihia	Bay of Islands	Condition 2	Estuarine
Waitangi River	Bay of Islands	Condition 2	Estuarine
Mangawhati Point	Whangārei Harbour	Condition 2	Estuarine
Tamaterau	Whangārei Harbour	Condition 2	Estuarine

Takahiwai Creek	Whangārei Harbour	Condition 2	Estuarine
Parua Bay	Whangārei Harbour	Condition 2	Estuarine
Snake Bank	Whangārei Harbour	Condition 2	Estuarine
Marsden Bay	Whangārei Harbour	Condition 2	Estuarine
Marsden Point	Whangārei Harbour	Condition 2	Estuarine
Manganese Point	Whangārei Harbour	Condition 2	Estuarine
Pickmere Channel	Kerikeri Inlet	Condition 2	Estuarine
Ruakaka	Ruakaka Estuary	Condition 2	Estuarine
Tamure	Ruakaka Estuary	Condition 2	Estuarine
Kaeo	Whangaroa Harbour	Condition 2	Estuarine
Kahoe	Whangaroa Harbour	Condition 2	Estuarine

Appendix 6 – ANZECC 2000 Guidelines, Table 5.2.2 Summary of water quality guidelines for recreational waters.

Table 5.2.2 Summary of water quality guidelines for recreational waters

Parameter	Guideline
Microbiological	
Primary contact*	The median bacterial content in fresh and marine waters taken over the bathing season should not exceed 150 faecal coliform organisms/100 mL or 35 enterococci organisms/100 mL. Pathogenic free-living protozoans should be absent from bodies of fresh water.**
Secondary contact*	The median value in fresh and marine waters should not exceed 1000 faecal coliform organisms/100 mL or 230 enterococci organisms/100 mL.**
Nuisance organisms	Macrophytes, phytoplankton scums, filamentous algal mats, sewage fungus, leeches, etc., should not be present in excessive amounts.* Direct contact activities should be discouraged if algal levels of 15 000–20 000 cells/mL are present, depending on the algal species. Large numbers of midges and aquatic worms should also be avoided.
Physical and chemical	
Visual clarity & colour	To protect the aesthetic quality of a waterbody: • the natural visual clarity should not be reduced by more than 20%; • the natural hue of the water should not be changed by more than 10 points on the Munsell Scale; • the natural reflectance of the water should not be changed by more than 50%. To protect the visual clarity of waters used for swimming, the horizontal sighting of a 200 mm diameter black disc should exceed 1.6 m.
pH	The pH of the water should be within the range 5.0–9.0, assuming that the buffering capacity of the water is low near the extremes of the pH limits.
Temperature	For prolonged exposure, temperatures should be in the range 15–35°C.
Toxic chemicals	Waters containing chemicals that are either toxic or irritating to the skin or mucous membranes are unsuitable for recreation. Toxic substances should not exceed values in tables 5.2.3 and 5.2.4.
Surface films	Oil and petrochemicals should not be noticeable as a visible film on the water nor should they be detectable by odour.

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