Warkworth to Wellsford

Existing Water Quality Report

Technical Report

July 2019

QUALITY ASSURANCE

Prepared by

Jacobs GHD Joint Venture in association with Tonkin & Taylor Ltd. Prepared subject to the terms of the Professional Services Contract between the Client and Jacobs GHD Joint Venture for the Route Protection and Consenting of the Warkworth to Wellsford Project.

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GLOSSARY AND DEFINED TERMS

Refer to the Water Assessment Report for a master glossary and defined terms table.

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1 INTRODUCTION

The Warkworth to Wellsford Project (Project) crosses the Mahurangi River, Hōteo River and tributaries of the Oruawharo River to the north of Auckland. These freshwater environments drain into the Mahurangi Harbour and Kaipara Harbour. This report provides a characterisation of the current water quality in the freshwater and estuarine/saline environments throughout the Project area.

1.1 Project description

The Project involves the construction, operation and maintenance of a new four lane state highway. The route is approximately 26 km long. The Project commences at the interface with the Pūhoi to Warkworth project (P-Wk) near Woodcocks Road. It passes to the west of the existing State Highway 1 (SH1) alignment near The Dome, before crossing SH1 just south of the Hōteo River. North of the Hōteo River the Project passes to the east of Wellsford and Te Hana, bypassing these centres. The Project ties into the existing SH1 to the north of Te Hana near Maeneene Road.

1.2 Project Features

The key features of the Project, based on the Indicative Alignment, are as follows:

a) A new four lane dual carriageway state highway, offline from the existing State Highway 1, with the potential for crawler lanes on the steeper grades.

b) Three interchanges as follows:

   i. Warkworth Interchange, to tie-in with the Pūhoi to Warkworth section of state highway and provide a connection to the northern outskirts of Warkworth.

   ii. Wellsford Interchange, located at Wayby Valley Road to provide access to Wellsford and eastern communities including Tomarata and Mangawhai.

   iii. Te Hana Interchange, located at Mangawhai Road to provide access to Te Hana, Wellsford and communities including Port Albert, Tomarata and Mangawhai.

c) Twin bore tunnels under Kraack Road, each serving one direction, which are approximately 850 metres long and approximately 180 metres below ground level at the deepest point.

d) A series of steep cut and fills through the forestry area to the west of the existing SH1 within the Dome Valley and other areas of cut and fill along the remainder of the Project.

e) A viaduct (or twin bridge structures) approximately 485 metres long, to span over the existing SH1 and the Hōteo River.

f) A tie in to existing SH1 in the vicinity of Maeneene Road, including a bridge over Maeneene Stream.

g) Changes to local roads:

   i. Maintaining local road connections through grade separation (where one road is over or under the other). The Indicative Alignment passes over Woodcocks Road, Wayby Valley Road, Whangaripo Valley Road, Mangawhai Road and Maeneene Road. The Indicative Alignment passes under Kaipara Flats Road, Rustybrook Road, Farmers Lime Road and Silver Hill Road.

ii. Realignment of sections of Wyllie Road, Carran Road, Kaipara Flats Road, Phillips Road, Wayby Valley Road, Mangawhai Road, Vipond Road, Maeneene Road and Waimanu Road.

iii. Closing sections of Phillips Road, Robertson Road, Vipond Road and unformed roads affected by the Project.

h) Associated works including bridges, culverts, drainage, stormwater treatment systems, soil disposal sites, signage, lighting at interchanges, landscaping, realignment of access points to local roads, and maintenance facilities.

i) Construction activities, including construction yards, lay down areas for storage of materials and establishment of construction access and haul roads.

A full description of the Project including its current design, construction and operation is provided in Section 4: Description of the Project and Section 5: Construction and Operation of the AEE contained in Volume 1 and shown on the Drawings in Volume 3.

Figure 1 depicts the Project Sections and Indicative Alignment. The Indicative Alignment is a preliminary alignment for a state highway that could be constructed within the proposed designation boundary. The assessment within this Catchment Sediment Modelling report provides inputs into the assessment of the effects of the Indicative Alignment, and also considers the sensitivity to effects if the alignment shifts within the proposed designation boundary when the design is finalised.

The final alignment for the Project (including the detailed design and location of associated works including bridges, culverts, stormwater management systems, soil disposal sites, signage, lighting at interchanges, landscaping, realignment of access points to local roads, and maintenance facilities), will be refined and confirmed at the detailed design stage.

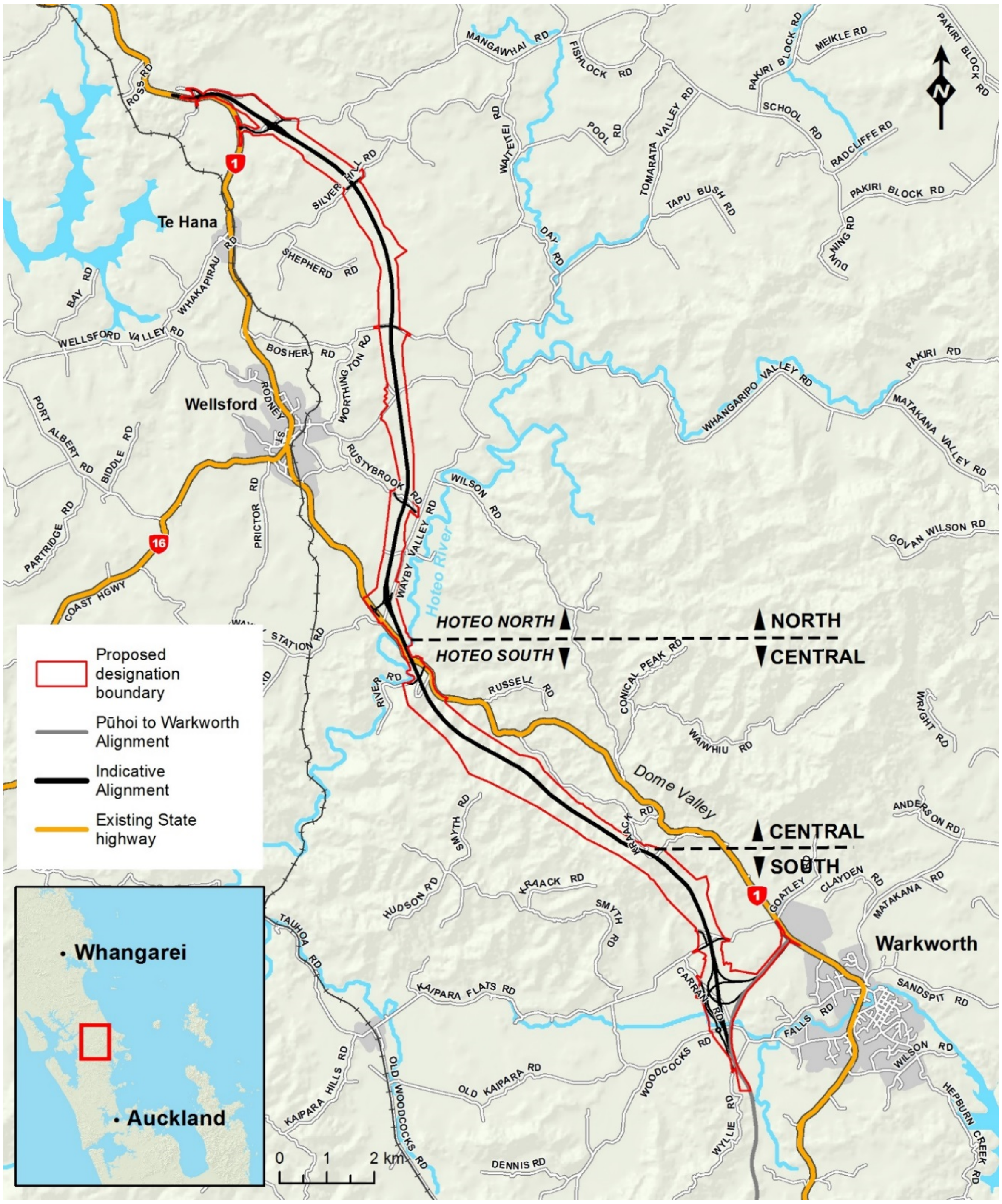

Figure 1 - Project Sections and Indicative Alignment

1.3 Purpose and scope of this report

This Existing Water Quality Technical Report (this report) forms part of a suite of water related design and technical reports prepared for the Ara Tūhono – Pūhoi to Wellsford - Warkworth to Wellsford section (the Project).

These reports are listed below with a short description of each:

- **Water Assessment Report (WAR) –** This report contains a summary of the work carried out and assessment of water related effects associated with construction and operation of the Project.
- **Construction Water Management Design technical report–** This report contains indicative details of the proposed construction methodology, proposed erosion and sediment controls (ESCs), and other construction phase mitigation measures recommended to reduce and erosion and sediment laden stormwater discharges from entering the receiving environment during construction.
- **Operational Water Design technical report** – This report contains details of the operational stormwater management and other operational phase mitigation by design.
- **Existing Water Quality technical report (this report)**– This report summarises water quality monitoring carried out by Auckland Council and for the Project.
- **Catchment Sediment Modelling technical report** – Sediment models have been developed to predict changes in sediment and water quality within receiving watercourses associated with the Project. This report summarises the modelling methodology and results.
- **Operational Water - Road Runoff technical report** – An assessment has been carried out to predict changes to water quality in relation to the Project and pollutants.
- **Flood Modelling technical report** – A model has been developed to predict any changes to flood risk associated with the Project. This report summarises any changes.
- **Hydrological technical report** – Catchment analysis has been developed to predict catchment wide hydrological changes associated with the Project. This report summarises predicted changes to the hydrological environment

This report characterises the current condition and status of the fresh and saline waters throughout the Project area. This report primarily establishes the existing water quality in the fresh and estuarine environments for the Water Assessment Report and supporting technical reports. The relationship between the reports is illustrated in Figure 2. The aquatic ecology of the freshwater and marine environments is reported separately in the Terrestrial and Freshwater Ecology Assessment Report, and Marine Ecology Assessment Report, respectively.

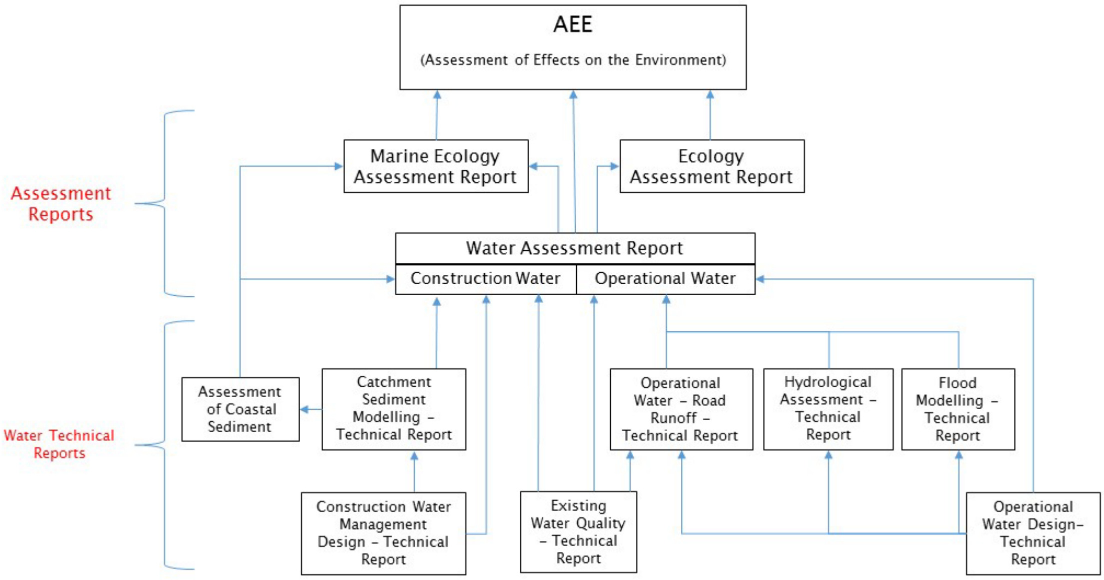

Figure 2 – Existing Water Quality Technical Report – Relationships to other reports.

The scope of this Report is to:

- Identify and assess existing fresh and saline water quality data available in the Project area from Auckland Council (Council) and NIWA;
- Undertake a literature review of existing information and studies on the water quality of the freshwater and estuarine environments;
- Assess existing water quality and sediment quality monitoring data gathered for the Project (freshwater, saline water and sediment samples were collected and analysed for the Project); and
- Characterise the current condition of the watercourses and estuaries by comparison with relevant guidelines and limits.

This Report does not predict or assess changes in water quality associated with the Project. The changes in water quality associated with the Project are discussed in the Water Assessment report and the supporting Operational Water Road Runoff and Catchment Sediment Modelling technical reports. Effects on ecology are specifically assessed in the Ecology Assessment report, and Marine Ecology Report.

2 CATCHMENT OVERVIEW

Catchment overview summary

The proposed designation passes through three main catchments: the Mahurangi, the Hōteo and the Oruawharo river catchments. The proposed designation crosses many tributaries in these areas, as well as the main branch of the Hōteo River.

The land use in all three catchments is mainly a mixture of pasture and forestry. The steepness of these catchments along the proposed designation varies, with steeper catchments in the area of Dome Ranges, and lower gradient catchments associated with the Mahurangi River and Hōteo River floodplains.

The Mahurangi River flows to the Mahurangi Harbour, whereas the Hōteo and Oruawharo Rivers flow to the Kaipara Harbour.

A map of the catchments, proposed designation is provided in Figure 3.

Moving south to the north, the proposed designation begins in the Mahurangi River catchment. The proposed Warkworth interchange northbound and southbound off-ramps cross the left branch of the Mahurangi River. Continuing north, the proposed designation passes into the Hōteo River catchment. The proposed designation crosses many tributaries, with the Indicative Alignment crossing the main channel of the Hōteo River (via the proposed Hōteo Viaduct) near the existing SH1 crossing. Continuing north, the proposed designation passes into the Oruawharo catchment. It crosses two tributaries of the estuarine Oruawharo River, Te Hana Creek and Maeneene Stream.

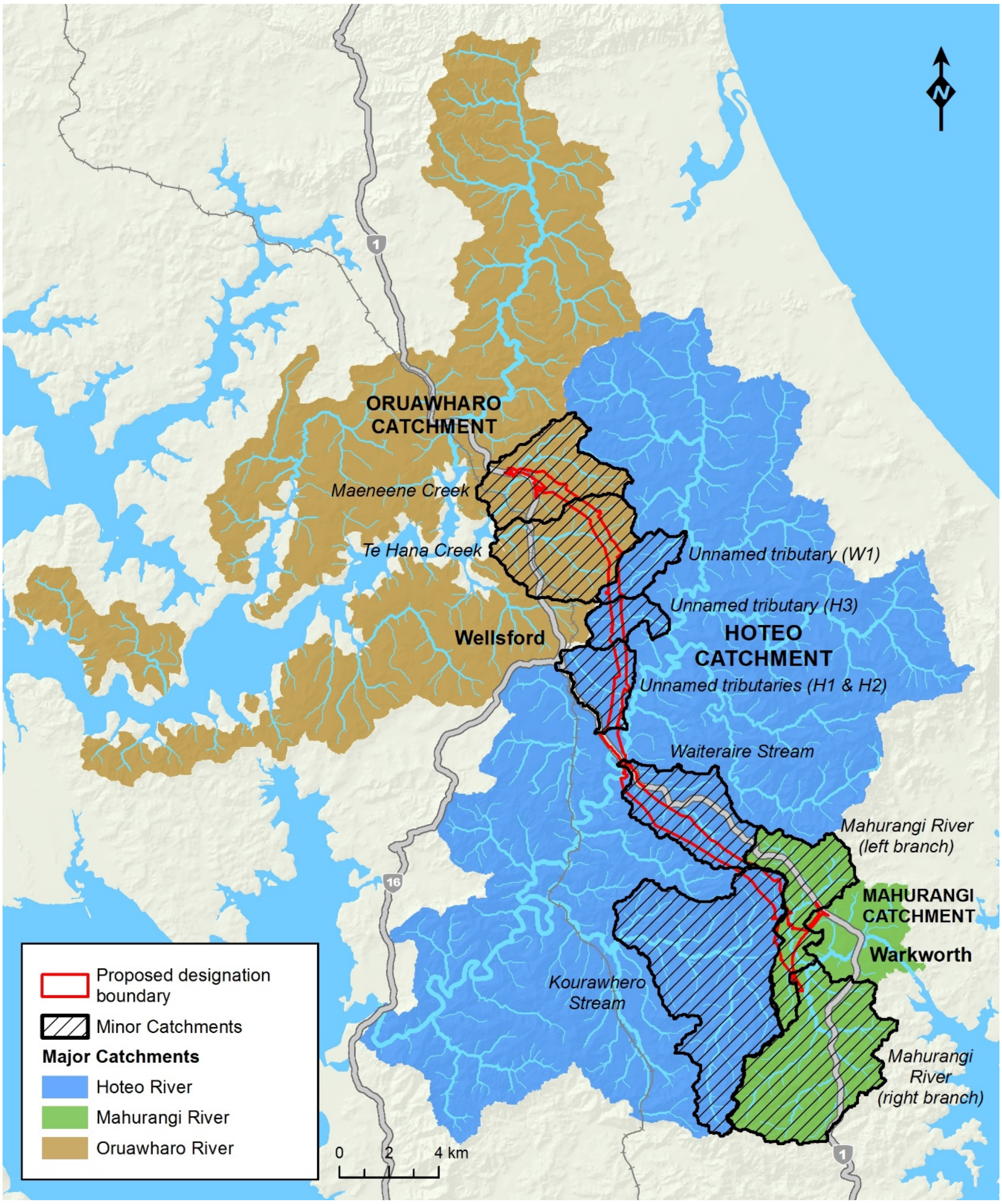

Figure 3 - Watercourses and catchment boundaries within the Project area

The Mahurangi River is the main tributary of the Mahurangi Harbour, a long harbour estuary flowing southwards from Warkworth on the eastern coast. There are many small bays and estuaries along the sides of the harbour with two larger arms to the south. Many of the small bays and upper estuaries are dry during the tidal cycle and are comprised of soft muddy sediment.

The Hōteo River drains to the southern part of the Kaipara Harbour, a large enclosed harbour estuary complex located on the west coast. Te Hana Creek and Maeneene Stream are tributaries of the estuarine Oruawharo River, which flows into the central Kaipara Harbour.

The Kaipara Harbour is a complex drowned-valley enclosed harbour estuary on the west coast of the Northland peninsula (Gibbs et al., 2012). The harbour is composed of intertidal flat and shallow sub-tidal habitats, with deep channels following historic rivers. Sand barriers form north and south heads, as well as tidal deltas, beach and dune systems.

Table 1 provides an overview of each catchment and its watercourses, land forms and land uses.

Table 1 - Overview of catchments along the proposed designation

Catchment	Watercourse	Landform and land use
Mahurangi River	Mahurangi River (Right Branch)	The proposed designation runs to the west of the Mahurangi River (right branch). Within this catchment the land is predominantly flat or undulating pasture leading into the Dome Valley where the slopes become steeper. The proposed designation runs through the predominantly flat pasture area.
	Mahurangi River (Left Branch)	The proposed designation extends along and across the Mahurangi River (left branch). The Indicative Alignment runs to the west of the left branch. The proposed Warkworth interchange northbound and southbound off-ramps cross the Mahurangi River (left branch). The catchment is generally flat or undulating which is predominantly used for pasture and lifestyle land uses.
Hōteo River	Kourawhero Stream	The proposed designation extends up and along the headstreams of the Kourawhero Stream. The Indicative Alignment crosses the headstreams as it heads up an increasingly steep slope towards the Dome Valley tunnel. The land in this area is a generally pasture and exotic forest. The Kourawhero Stream joins the Hōteo River approximately 6.5 km due south-west of the proposed Hōteo River crossing (approximately 14 km downstream).
	Waiteraire Stream	The catchment is steep and predominantly forestry. The proposed designation extends along the western slope of the stream valley. The Indicative Alignment crosses multiple tributaries of Waiteraire Stream, which generally run perpendicular to the Alignment. Waiteraire Stream joins the Hōteo River at the proposed Hōteo River viaduct. The proposed viaduct crosses both the Waiteraire Stream and the main stem of the Hōteo River.
	Hōteo River	The proposed designation crosses the Hōteo River immediately upstream of the existing SH1 road crossing. On the Indicative Alignment, this crossing is via the proposed Hōteo Viaduct. The Hōteo River catchment upstream of the proposed crossing is approximately 200 km^2. The catchment land use is mainly pastoral grasslands with large areas of exotic forestry to the east of the catchment associated with the Waiwhiu stream tributary, such as the Matariki Forest covering 35.2 km^2.
	Unnamed tributaries (H1 & H2) of Hōteo River	The proposed designation extends across the undulating pasture to the east of Wellsford. The Indicative Alignment crosses two unnamed tributaries (H1 & H2) of the Hōteo River. These tributaries join to the east of the Indicative Alignment prior to flowing to the Hōteo River. These catchments are mainly pasture; the town of Wellsford is in the upper catchment. The land in this area is flat or undulating. The streams are small, however, the floodplains are extensive.

Catchment	Watercourse	Landform and land use
	Unnamed tributary of Hōteo River (H3)	The proposed designation extends across the upper reaches of this unnamed tributary (H3) of the Hōteo River. The land in this catchment is generally undulating pasture, with some forest along the Hōteo River stream bank. The stream is within a steep valley at the proposed crossing of the Indicative Alignment.
	Unnamed tributary of Waiteitei Stream (W1)	The proposed designation extends across the upper reaches of an unnamed tributary (W1) of Waiteitei Stream, which is a tributary of the Hōteo River. The stream is in a steep valley at this location and the land use is predominantly undulating to rolling pasture.
Oruawharo River	Te Hana Creek	The proposed designation extends across the undulating to rolling pasture associated with the upper reaches Te Hana Creek, a tributary of the estuarine Oruawharo River. The Indicative Alignment crosses multiple tributaries of this stream.
	Maeneene Creek	The proposed designation crosses through the catchment of the Maeneene Creek. The land in this area is rolling pasture and crops. The Indicative Alignment crosses many tributaries of the stream, as well as the main channel of the stream where the alignment ties back into SH1.

3 WATER QUALITY PARAMETERS AND GUIDELINES

Water quality parameters and guidelines summary

The freshwater catchments that the proposed designation passes through have a range of existing values and uses. The catchments support existing aquatic ecosystems and the watercourses have the potential to be used for recreational activities, stock water supply, irrigation, and fish farming.

Environmental values and uses associated with the saline estuarine and marine areas include supporting the marine and estuarine ecosystems; use for aquaculture as oyster farms; and recreational use.

We have identified relevant guideline water quality concentrations relevant to both freshwater and marine values and uses. These guidelines set the framework against which the existing water quality of the freshwater catchments and marine environments can be compared and determined.

3.1 Introduction

Characterisation of water quality within a catchment requires an understanding of:

- existing environmental values of the catchment; and
- parameters relevant to assessing the health or suitability of the waterbody to support those values.

This section discusses the water quality parameters used in this assessment.

3.1.1 Existing freshwater values and uses

The existing landform, geology and land uses within the freshwater catchments affect the existing water and sediment quality. Within the catchments, the rivers and streams have a range of values and uses, including the following:

- supporting aquatic ecosystems;
- use for stock water supply and irrigation;
- use [to supply] aquaculture (fish farming); and
- recreational use including contact recreation, informal boating and bankside amenity-based recreational activities (such as fishing).

To characterise the existing environments, we have compared these values and uses against established guidelines.

3.1.2 Existing marine values and uses

The estuarine and marine environments have their own range of potential values and uses including the following:

- supporting aquatic ecosystems (Kaipara Harbour is an important natural nursery for finfish and snapper fish, as well as supporting other habitats);
- use for aquaculture (oyster farming); and
- recreation use including contact recreation, boating and fishing.

These estuarine and marine environments have their own established guidelines for comparison.

3.2 Water quality parameters

The water quality parameters assessed in this report are listed in Table 2. The table details the relevance of each parameter to understanding the overall water quality.

Table 2 – Water quality parameters

Parameter	Details
pH	pH is a measure of the hydrogen ion concentration in water (i.e. a measure of acidity or basicity). In natural aquatic systems pH is likely to be influenced by geology and surrounding vegetation and soils. pH in natural systems would be expected to be within 1 or 1.5 pH units of neutral (pH of 7.0). pH is useful for general characterisation of a waterbody.
Temperature	Temperature affects the ability of water to hold oxygen, as temperature increases oxygen levels decrease. Temperature is also a direct stressor on aquatic species. Changes to streamside vegetation and light penetration can affect water temperature in a channel, as can the temperature of discharged water. The range of existing temperatures provides an indication of stresses on the existing environment.
Dissolved oxygen	Dissolved oxygen is a relevant measure for the life supporting capacity of a waterbody for aerobic aquatic species. Oxygen enters streams through aeration/exchange with air and photosynthesis and is utilised by processes including consumption by aquatic species within the waterbody and the decomposition of organic matter. Low levels of oxygen can directly impact upon aquatic species and also release nutrients and metals in sediments to the overlying water column.
Suspended solids, turbidity, clarity and colour	Suspended solids, turbidity and clarity are related parameters. Suspended solids are particles of organic and inorganic matter suspended in, and generally passing down, a waterbody. These can be sourced from in channel (bed and bank erosion) or out of channel (runoff from land after rainfall and discharges). Turbidity is a measure of the amount of cloudiness or haziness of water due to suspended sediments in a water column. Clarity is a measure of the ability to see through water and is primarily influenced by the amount of suspended solids/turbidity of water. High levels of suspended solids/turbidity can directly affect aquatic ecosystems and associated photosynthesis, and low clarity can affect bathing water use. Water colour is influenced by the suspended solids in the water column and the contributing geology/chemistry and land use. The colour of the water can affect its amenity and recreational value.
Biological oxygen demand	Biological oxygen demand (BOD), or biochemical oxygen demand, is a measure of the degree of organic matter present in the water. Sources of organic matter include leaf litter, decaying plants, microbes, sewage and animal waste. Large quantities of organic matter in water are a potential risk to aquatic ecosystems and human health and can indicate organic pollution. BOD measures the amount organic matter by measuring the amount of oxygen required by aerobic biological organisms to breakdown the organic

Parameter	Details
	matter present in a sample of water. BOD is commonly reported as BOD5, the amount of oxygen consumed over a 5-day period of incubation.
Bacteria (*E.coli* and *Enterococci*)	Bacteriological indicators are used to indicate the risk of faecal contamination in waterways. They indicate the possible presence of pathogenic disease causing bacteria such as protozoans and viruses that also live in the digestive systems of warm-blooded animals. *Escherichia coli* (*E.coli*) is the preferred indicator of faecal contamination in freshwaters of New Zealand as this bacterial species is generally only associated with warm blooded animals (NZTA, 2011). *E.coli* contamination can render water unsuitable for recreational activities such as contact recreation. *Enterococci* are the preferred indicator in marine environments as they are the indicator most closely correlated with health effects in New Zealand marine waters.
Nitrogen nutrients - total nitrogen, ammoniacal nitrogen, nitrate, nitrite, total Kjeldahl nitrogen (TKN)	Nitrogen is a nutrient in waterbodies that contributes to plant life and the health of aquatic ecosystems. Nitrogen can be present in various forms, some of which are more bioavailable than others, and which have differing degrees of potential impacts upon aquatic ecosystems. Nitrogen concentrations would typically be related to land use activities, with undisturbed native land use having lower concentrations than pasture (as nutrients can be flushed from animal wastes and fertilisers used on pasture into waterbodies). Excess nitrogen nutrients can promote algal growth in waterbodies, which can in turn reduce oxygen concentrations and affect the wider ecology. For algal growth to occur a combination of both nitrogen and phosphorus is required. Nitrogen species such as ammonia can also be directly toxic to aquatic species.
Phosphorus nutrients - total & dissolved reactive phosphorus	Phosphorus is another nutrient required for aquatic ecosystems that can promote excess algal growth in high concentrations. It is more likely to be associated with particulate matter. As such, sediment transported into streams can be a source of particulate phosphorus.
Metals – copper, zinc	Metals occur naturally in streams at low concentrations, with the types of metals depending on the geology. Various land uses can also input metals to waterbodies. Copper and zinc are considered to be the metals likely to be associated with operational road runoff and therefore of most relevance to the Project. Metals can be in either dissolved or total forms. Dissolved metals are those in the water column that can be directly bioavailable to aquatic species. 'Total metals' include dissolved metals plus those bound in suspended sediment (which are less available to affect aquatic ecosystems).
Hydrocarbons – total petroleum hydrocarbons (TPHs) & polycyclic aromatic hydrocarbons (PAHs)	Hydrocarbons would not be expected to occur naturally in waterbodies. Discharges from roads can contain hydrocarbons from oil and fuel drips/spills. The two measures commonly associated with roads and road runoff are TPHs and PAHs. TPHs are petroleum oil based hydrocarbons, such as natural gas, liquid petroleum gas, petrol, kerosene, jet fuel, diesel, fuel oils, bunker oils, lubricating oil, transformer oil, greases, asphalt, and bitumen and are reported as a total TPH weight. PAHs come principally from diesel, heavy petroleum fractions and from coal sources (Hill Laboratories, 2011). Naphthalene is a PAH compound.

3.3 Freshwater quality guidelines

The freshwater quality guideline values relevant to this Project are presented in Table 3. These guidelines have been used to characterise the nature of the existing freshwater environments. Generally, the guidelines are for the protection of the aquatic ecosystems and are used as the benchmark for assessing freshwater quality given that aquatic ecosystems are present across all streams. Additionally, the aquatic ecosystem guidelines are generally the most stringent of the guidelines presented in Table 3.

Many of the guidelines are from the Australia and New Zealand Environment and Conservation Council Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ, 2000). These guidelines are based on the principles of Ecologically Sustainable Development (ESD) and provide governments and the general community with a sound set of tools for assessing and managing water quality in natural and semi-natural water resources.

The ANZECC/ARMCANZ guidelines have default trigger values rather than absolute limits. Exceedances of the trigger values do not mean that a negative impact is inevitable. Rather, exceedances may indicate the requirement for further investigation into potential impacts. These values can also be used to indicate potential stressors in the environment where data indicates values in excess of a trigger.

Draft revised default trigger values for zinc and copper have been included in the Table 3 as a comparison against the ANZECC/ARMCANZ 2000 values. However, the existing water quality data has not been assessed against the draft revised trigger values as at the time of writing these are in 'draft' and are still subject to peer-review through the ANZECC guidelines committee.

The National Policy Statement for Freshwater (NPS-FW) 2014 (amended 2017), includes the national objectives framework. Numeric attributes relevant to this Project, include for Nitrate, Ammonia and *E. coli*. The NPS-FW classifies attribute states from A to D and identifies the National Bottom Line attribute states.

The purpose of the guideline values in Table 3 is to assist with the general characterisation of current water quality of the freshwater receiving environments. There are no relevant guidelines for some determinands (i.e. TPHs and total PAHs) in relation to the water environment.

It is noted that a significant update of the NPS-FM and a proposed NES for freshwater are currently under consideration by central government. Submissions on the draft documents were provided in October 2019. The updated policy statement is intended to replace NPS-FM 2014 in full.

Table 3 - Guideline concentrations for assessment of fresh water quality data.

Parameter	Aquatic ecosystem	Stock watering	Irrigation	Aquaculture	Contact recreation
pH (pH units)	6.5-9.0^{A}	6-8.5^{E}	6-8.5^{E}	5-9^{K}	6.5-8.5^{M}
Temperature (°C)	-	-	-	2°C change in 1hr^{K,A}	15-35^{M,N}
Dissolved oxygen (mg/L)	>6^{A*}	-	-	>5^{K}	-

Parameter	Aquatic ecosystem	Stock watering	Irrigation	Aquaculture	Contact recreation
Total suspended solids (mg/L)	-	-	-	40[K]	-
Turbidity (NTU)	5.6[B]	-	-	-	-
Clarity (m)	0.6 [B]	-	-	-	1.6[M]
E.coli (cfu/100mL)	-	-	-	-	260[O]
Total nitrogen (mg/L)	0.614[B]	-	5[J]	-	-
Ammoniacal nitrogen (mg/L)	0.021 [B]–1.3 [P]	-	-	-	-
Nitrate (mg/L)	6.9[P]	400[F]	-	50[L]	10 [M]
Nitrite (mg/L)	-	30[G]	-	0.1[L]	1 [M]
Nitrate/Nitrite (mg/L)	0.444[B]	-	-	-	-
Total Phosphorus (mg/L)	0.033[B]	-	0.05[J]	0.1[L]	-
Dissolved reactive phosphorus (mg/L)	0.01[B]	-	-	-	-
Copper (mg/L)	0.0014[C,D] (0.0012)[Q]	0.4[H,I]	0.2[J]	0.005[L,D]	1[M]
Zinc (mg/L)	0.008[C,D] (0.003)[Q]	20[H]	2[J]	0.005[L]	5[M]
Naphthalene (mg/L)	0.016[C]	-	-	-	-

Notes:

A - From ANZECC 1992 guidelines as reported in ANZECC/ARMCANZ 2000

A* Note that the NPS-FW sets a national bottom line for D.O. in rivers for the purpose of ecosystem health. (5.0mg/L).

B - Default trigger values for physical or chemical stressors in unmodified or slightly disturbed ecosystems in lowland rivers in New Zealand (ANZECC/ARMCANZ 2000)

C - Trigger values for toxicants at 95% level of species protection in freshwaters (ANZECC/ARMCANZ 2000)

D - Trigger values are hardness dependant; these are values for a hardness of 30 mg/L CaCO3

E - Guideline to limit corrosion and fouling of watering and irrigation systems (ANZECC/ARMCANZ 2000)

F - Concentration that should not be harmful to animal health (ANZECC/ARMCANZ 2000)

G - Concentrations in excess of this may be harmful to animal health (ANZECC/ARMCANZ 2000)

H - Trigger values of a low risk for heavy metals in livestock drinking water (ANZECC/ARMCANZ 2000)

I - Trigger value (0.4) is for sheep, also cattle (1), pigs or poultry (5)

J - Long term trigger values for irrigation water, long term – up to 100years (ANZECC/ARMCANZ 2000)

K - Physio-chemical stressor guidelines for the protection of freshwater aquaculture species (ANZECC/ARMCANZ 2000)

L - Toxicant guidelines for the protection of aquaculture species – freshwater production (ANZECC/ARMCANZ 2000)

M – Summary of water quality guidelines for recreational waters (ANZECC/ARMCANZ 2000)

N – For prolonged exposure

0 - Freshwater surveillance level for acceptable water quality. Exceedance triggers further monitoring with action level >550 cfu/100mL (MfE, 2003)

P – NPS-FW. National Objectives Framework. Annual Median, National Bottom Line

Q – ANZECC/ARMCANZ ‘draft’ revised default guideline trigger values for 95% species protection in freshwaters.

3.4 Saline water quality guidelines

The guideline values for saline waters in estuarine and marine environments are given in Table 4. These guidelines are relevant to the protection of aquatic ecological values, aquaculture and contact recreation.

As for the freshwater values listed in Table 3, many of the saline water guidelines are from the Australia and New Zealand Environment and Conservation Council Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ, 2000). Therefore, many of the guidelines are trigger values rather than absolute limits. Draft revised default trigger values for zinc and copper have been included in Table 4 as a comparison against the ANZECC/ARMCANZ 2000 values.

As is the case for guideline values in Table 3 above, values in Table 4 below have been used to assist with the general characterisation of current water quality of the estuarine and marine receiving environments, not as triggers for further investigation or as the primary basis for developing construction discharge limits. There are no relevant guidelines for some determinands (i.e. total TPHs and PAHs) in relation to the water environment.

Table 4 - Guideline concentrations for assessment of saline water quality data.

Parameter	Aquatic ecosystem	Aquaculture	Contact recreation
pH (pH units)	-	6-9[D]	6.5-8.5[H]
Temperature (°C)	-	2°C change in 1hr[D]	15-35[H,I]
Dissolved Oxygen (mg/L)	-	>5[D]	-
Total Suspended Solids (mg/L)	-	10 (75 Brackish)[D]	-
Turbidity (NTU)	0.5-10[B]	-	-
Enterococci (cfu/100mL)	-	-	140[G]
Total nitrogen (mg/L)	0.3 estuary/0.12 marine[A]	-	-
Ammoniacal nitrogen (mg/L)	0.015 estuary/0.015 marine[A]	-	-
Nitrate (mg/L)	-	100[E]	-
Nitrite (mg/L)	-	0.1[E]	-
Nitrate/Nitrite (mg/L)	0.015 estuary/0.005 marine[A]	-	-
Total phosphorus (mg/L)	0.03 estuary/0.025 marine[A]	0.05[E]	-
Dissolved reactive phosphorus (mg/L)	0.005 estuary/0.01 marine[A]	-	-
Chlorophyll *a* (mg/L)	0.004 estuary/0.001 marine[A]	-	-
Copper (mg/L)	0.0013[C] / (0.0006)[J]	0.005[E,F]	1[H]
Zinc (mg/L)	0.015[C] / (0.0065)[J]	0.005[E]	5[H]

Notes:

A - Default trigger values for physical or chemical stressors in slightly disturbed ecosystems in south-east Australia. These are the recommended guidelines for New Zealand in ANZECC/ARMCANZ 2000.

B - Default trigger values for turbidity in slightly disturbed ecosystems in south-east Australia. These are the recommended guidelines for New Zealand in ANZECC/ARMCANZ 2000. The guidelines note: Low turbidity values are normally found in offshore waters. Higher values may be found in estuaries or inshore coastal water due to wind-induced resuspension or to the input of turbid water from the catchment. Turbidity is not a very useful indicator in estuarine and marine waters.

C - Trigger values for toxicants at 95% level of protection (ANZECC/ARMCANZ 2000)

Parameter	Aquatic ecosystem	Aquaculture	Contact recreation
D - Physio-chemical stressor guidelines for the protection of aquaculture species - saltwater (ANZECC/ARMCANZ 2000) E - Toxicant guidelines for the protection of aquaculture species – saltwater (ANZECC/ARMCANZ 2000) F - Trigger values are hardness dependant G- Marine water surveillance level for acceptable water quality. Exceedance triggers further monitoring with action level >280 cfu/100mL (MfE, 2003) H – Summary of water quality guidelines for recreational waters (ANZECC 2000) I – For prolonged exposure J - ANZECC/ARMCANZ 'draft' revised default guideline trigger values for 95% species protection in marine waters.			

3.5 Sediment quality guidelines

The sediment quality guidelines include both the recommended Sediment Quality Guidelines - low (ISQG-low) from revised ANZECC/ARMCANZ (2013) and Council values. The ANZECC/ARMCANZ ISQG-low values are trigger levels indicating where a low range of effects would be likely to occur at the noted contaminant concentrations. Council has generated a set of Environmental Response Criteria (ERC) for assessing sediments from operational motorway runoff in the Auckland Region. These are based on the ANZECC triggers and provide colour coded criteria for sediments. Table 5 presents data from Council (2004b) and the ANZECC/ARMCANZ sediment quality guidelines.

Table 5 - Guideline values for assessment of sediment quality data.

Parameter (mg/kg dry wt)	ANZECC/ARMCANZ SQGV	Auckland Council ETC		
		Red	Amber	Green
Copper	65	>34	19-34	<19
Zinc	200	>150	124-150	<124
Total petroleum hydrocarbons	280	-	-	-
High molecular weight PAHs[A]	-	>1.7	0.66-1.7	<0.66
Total PAHs	10[B]	-	-	-

Notes:

A - High molecular weight PAHs are the sum of concentrations of benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene, fluoranthene and pyrene.

B - Normalised to 1% total organic carbon within the limits of 0.2 to 10%.

4 REVIEW OF EXISTING INFORMATION

Review of existing information summary

A literature review was undertaken into existing water quality in the Mahurangi, Hōteo and Oruawharo River catchments. The first part of the literature review covers published reports by Council and NIWA on water quality, environmental conditions and environmental stressors in the catchments. The second part is an analysis of existing monitoring data from sites within the Project area collected by Council and NIWA.

A review of literature reveals that both the Mahurangi Harbour and Kaipara Harbour receive considerable sediment inputs from surrounding land uses. Both harbours have been the subject of studies into sedimentation and water quality, which has resulted in a focus on sediment management in the Mahurangi and Hōteo catchments.

The Mahurangi River catchment has been the subject of long term monitoring at three sites, two of these are within Warkworth township on the main river stem and the other on the Mahurangi River (Right Branch). Within the catchment, water quality is generally within relevant guidelines specified in Section 3, indicating good water quality. However, the catchment has elevated turbidity/suspended solids and phosphorus, especially in the lower catchment.

The Mahurangi Harbour water quality indicates that the harbour has elevated turbidity/suspended sediment in the upper harbour, however this reduces towards the harbour mouth.

The Hōteo River catchment has long-term monitoring at one site on the river (Hōteo at Gubbs), with some recent suspended sediment monitoring at another site on Waiteitei Stream within the catchment. Both sites indicate that turbidity and suspended sediment are elevated within the Hōteo River catchment, with high turbidity lower in the catchment. The Hōteo catchment also has elevated nutrient concentrations. This indicates that the water quality is generally fair within the catchment.

The water quality within the estuarine Oruawharo River is generally good, however, there are slightly elevated turbidity/suspended sediment and elevated dissolved reactive phosphorus concentrations.

The southern Kaipara Harbour, adjacent to the Hōteo River mouth, has high suspended sediments and elevated phosphorus concentrations. Water quality improves towards the entrance of the Kaipara Harbour where the water quality data indicates good water quality, generally below the guidelines for estuarine and marine aquatic ecosystems. However, dissolved reactive phosphorus remains slightly elevated in this area.

4.1 Methodology

This section summarises and discusses the existing water quality water information available for the freshwater and estuarine/marine water bodies that may be impacted by the Project. There is a large amount of information available for the Mahurangi catchment, the Hōteo River catchment and the wider Kaipara Harbour catchment, which provides a characterisation of the existing environment, in relation to water and sediment quality, prior to the construction of the Project.

This review is in two parts; a literature review and an analysis of existing data. The literature review covers published reports by Council and NIWA on water quality, environmental conditions and environmental stressors in the catchments. The data analysis presents existing monitoring data from sites within the Project area collected by Council and NIWA.

4.2 Literature review – water quality issues in the project catchments

4.2.1 Mahurangi River and Harbour

The Mahurangi Harbour has existing issues relating to the rate and amount of sediment entering the harbour, which results in sedimentation in the harbour and impacts on water quality and habitats. Due to these issues, there have been a number of studies into the Mahurangi River and the development of the Mahurangi Action Plan. Investigations by Council in 2004 identified a range of specific activities that contribute to sedimentation within the Mahurangi River and Mahurangi Harbour, (Auckland Council, 2004a) such as earthworks, stock access and instream processes.

Subsequently, NIWA assessed sediments deposited within the harbour with a view to identifying the relative contributions of each land use (plantation forestry, native forestry, pasture, urban) to the sediments in the harbour (Auckland Council, 2006). This study found that pasture and native forest catchments along the harbour sides contributed the most sediment to the harbour. Plantation forestry also contributed a disproportionately large amount of sediment for the size of land area.

Council undertook further work during the five years from 2006 to determine objectives and priorities for 2010-2030. An assessment of water quality in the harbour and contributing issues from catchment land use was undertaken to feed into this Project (Auckland Council, 2009). While the predominant focus was still on sedimentation effects and sources, other water quality effects were noted as having origins in the catchment. The following were identified as key issues of relevance to water quality in the catchment:

- Stock access to waterways;
- Stream bank erosion;
- Point source discharges of contaminants (stormwater, wastewater);
- Harvesting of forestry; and
- Non-point source discharges (e.g. runoff of nutrients and biocides, septic tank leachate).

The Mahurangi Action Plan was adopted by Rodney District Council in 2010 and continued to have a focus on sediment as a priority water quality issue. The Plan also notes that other contaminants (e.g. nutrients, septic tank and agricultural leachates and fertilisers) enter the river and harbour and impact on aquatic habitats and human health (Mahurangi Action Plan, 2010).

The Mahurangi Action Plan is a strategic action plan for the catchment for the years 2010-2030. The plan contains specific objectives and priority actions for 2010-2016 riparian management, and best practice methods of land use to reduce sediment generation (Mahurangi Action Plan, 2010). The plan also contains medium to long term actions for Council relevant to reducing sediment generation, including encouraging the development and implementation of sustainable farm and property plans to reduce sediment generation. These medium to long term actions are relevant to the timeframe of this Project.

The Auckland Unitary Plan Operative in Part (AUP(OP)), defines the majority of the catchment of the Mahurangi River as a High-Use Stream Management Area, which is classified as a stream under pressure from demands to take or use water. The AUP(OP) also classifies a portion of the Mahurangi River (Left Branch) as a Natural Stream Management Area within the AUP(OP), which means that the stream has high natural character, high ecological values and indicates a good water quality. In addition, the AUP(OP) also identifies a number of SEAs along the river and throughout most of the Harbour.

4.2.2 Hōteo River and the Kaipara Harbour

A review of environmental information available for the Kaipara Harbour marine environment was undertaken in 2008 (Haggitt *et al.*, 2008). This report was prepared due to concern regarding the quality of water and sediment in the harbour. The Haggitt Report reviewed the marine environment and confirmed that the Kaipara contains many high value species, communities and habitats, and that these environments and values of the Kaipara Harbour have been and are continuing to degrade. The Report identifies key threats to the harbour, which includes land use activities generating sediment and other contaminants. The impact of these contaminants is already evident in many parts of the harbour.

NIWA investigated the source and dispersion of sediments within Kaipara Harbour; this identified the river sources of sediments within the harbour as well as the dispersion patterns within the harbour (Gibbs et al., 2012). The NIWA report found that the Wairoa River to the north contributes most sediment to the harbour; however, the Hōteo River contributes a significant amount of sediment to the west of the southern Kaipara Harbour.

Further to this Council carried out a review of information relating to the Hōteo River catchment (Hart & Scott, 2014). They identified the Hōteo catchment as a priority catchment, as river sedimentation poses a threat to the snapper breeding ground located near the Hōteo river mouth in the Kaipara harbour. The key issues identified within the Hōteo catchment are the degradation of water quality and soil quality, flood risk and loss of biodiversity. The report recommends increased governance relating to water quality policies and strategies, and the management of erosion and sediment, including targeted intervention along the lower reaches and riparian management. In August 2017 Council was granted $1 million from the Freshwater Improvements Fund towards Hōteo Sediment Reduction Project (Ministry for the Environment (MfE), 2017). The Hōteo Sediment Reduction Project will aim to reduce erosion within the catchment through stock exclusion, riparian planting and tree planting.

The AUP(OP), defines the Hōteo River and the Waiteraire Stream, and the corresponding riparian zones, as Natural Stream Management Areas, which means that the Hōteo River and Waiteraire Stream has high natural character, high ecological values and indicates a good water quality. The Hōteo River downstream of the proposed designation is also classified as an Outstanding Natural Site by the AUP(OP) for its incised meanders. The AUP(OP) also identifies a number of SEAs along the river and throughout most of the Harbour.

4.2.3 Summary

There are existing issues with water quality and sedimentation within both the Mahurangi and Hōteo catchments and harbours relating to sediment generation and leaching of other contaminants. These issues relate primarily due to impacts of sedimentation on the Mahurangi Harbour and Kaipara Harbour respectively, both of which have been the subject of a number of studies into sedimentation and water quality. The existing sedimentation issues are particularly relevant to the Project due to the sediment that may be generated during the construction phase.

4.3 Existing data analysis – freshwater quality

There are four Council and NIWA long term freshwater quality monitoring sample points within the catchments traversed by the Project. That is, sites that have been monitored for a number of determinands regularly for a number of years. Three of these sample points are within the Mahurangi River catchment and one is within the Hōteo River catchment. To assess spatial variability in the Hōteo catchment we have also assessed an additional turbidity/suspended sediment monitoring site in the upper catchment. These freshwater Council/NIWA site names and the location compared to the (Waiteitei Stream of Sandersons) Project area are as listed below, and are shown on Figure 4.

- Mahurangi at Forestry Headquarters (FHQ) (Council) – located on an unnamed tributary of the Mahurangi River (Right Branch) near to Pohuehue upstream of SH1; this tributary is upstream of the proposed designation and has been included to characterise the Mahurangi water quality.
- Mahurangi Town Bridge (Council) – this site is located in Warkworth, downstream of confluence of the Right and Left Branches of the Mahurangi River, and downstream of all Project works in the Mahurangi River catchment. Monitoring of this site ceased in 2008 with the water treatment plant site now being the primary sample point for the Mahurangi River.
- Mahurangi at WTP (Council) – located by the Watercare WTP in Warkworth and downstream of confluence of the Right and Left Branches of the Mahurangi River, and downstream of all Project works in the Mahurangi River catchment.
- Hōteo at Gubbs (NIWA) – this site is located on the Hōteo River at Tauhoa Road, between Tauhoa and Kaipara Flats. The monitoring site is over 10 km downstream of the proposed Hōteo River viaduct and the Project on the Hōteo River. It is upstream of the confluence with Kourawhero Stream.
- Waiteitei Stream at Sandersons (NIWA) – this site is located on Waiteitei Stream, a tributary of the Hōteo River, on Tomarata Valley Road. A tributary of Waiteitei Stream is proposed to be culverted upstream of the monitoring site, therefore the site has the ability to measure any water quality effects from that part of the Project. However, the majority of the Project works will occur downstream of the site on the Hōteo River.

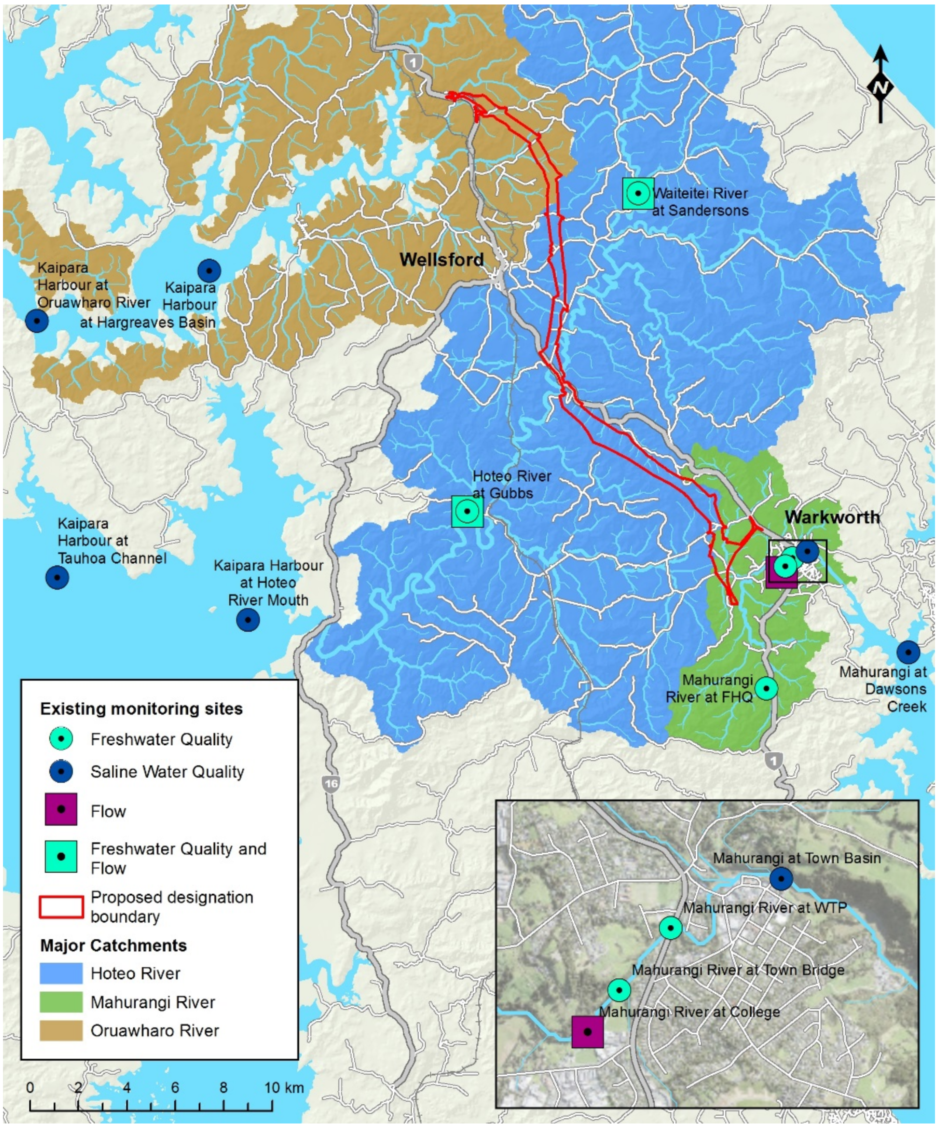

Figure 4 - Existing Council and NIWA Freshwater and Saline Water Quality monitoring locations

4.3.1 Comparison to guidelines and general water quality

Summary data for the long-term freshwater sites are provided in Table 10 to in Appendix A. These summaries provide an indication of the date range of the data, the number of samples and some basic overview statistics of the data. The mean and median data from these long term Council/NIWA monitoring sites have been compared to the relevant guidelines provided in Section 3.2, and findings regarding the Mahurangi River and Hōteo River discussed below.

Unnamed tributary of Mahurangi River (right branch)

The Mahurangi at FHQ monitoring site is located in the south of the Mahurangi River catchment. This site is upstream of the proposed designation so there is no potential that the water quality within the stream will be affected by the Project. However the data has been included to characterise the existing environment of the catchment. Water quality data is available for a range of parameters from 1993 to 2017 which is summarised in Table 10 in Appendix A. The mean and median values have been calculated and compared to the relevant guideline values; additionally, the wider record was reviewed against the relevant guideline values to check for number of exceedances of the trigger values. Generally, the data indicate good water quality, as detailed below.

- Dissolved oxygen and pH are almost always (more than 99% of the time) within the range of the guidelines indicating good water quality.
- The mean and median turbidity is above the guideline value (exceeded for 79% of the record) and average clarity is low and below guidelines (exceeds 54% of record), indicating that the watercourse has elevated suspended solids.
- Biochemical Oxygen Demand is generally low indicating limited organic enrichment.
- The nutrient concentrations indicate that under average conditions the stream does not contain significantly elevated nutrients:
    - nitrogen concentrations are generally below ecological guidelines with the exception of ammoniacal nitrogen which is above the ANZECC/ARMCANZ guideline value in 58% of the records; and
    - total and dissolved reactive phosphorus are on average at or slightly above the guidelines levels, and exceed the guideline value in 30% and 67% of the record respectively.
- The metal concentrations are low in the stream; mean and median total and dissolved copper and zinc are all well below the ecological guideline levels. There are some individual exceedances of the guidelines recorded for total copper and zinc, however this corresponds to less than 1% of samples for dissolved metals.
- Some microbial contamination is indicated by the average faecal coliform counts. Median results are likely to be more representative of general conditions and indicate presence of bacterial contaminants in concentrations around the surveillance level for bathing waters, indicating that the water could be compromised for contact recreation use, especially during storm flows.
- Results indicate that for the monitored parameters the water is suitable for stock watering, irrigation and aquaculture.

Council State of the Environment monitoring generally assessed this site as having either “good” or “excellent” water quality between 2010 and 2015; as shown in Table 6. However, the site was assessed as ‘fair’ in 2015 indicating a decline in water quality at this location (Table 6).

Table 6 - Council State of the Environment Monitoring – Water Quality Class (Auckland Council, 2012b; 2012c; 2013; 2014; 2015; 2016)

Catchment	Monitoring site	Annual water quality class					
		2010	2011	2012	2013	2014	2015
Mahurangi River	Mahurangi at FHQ	Good	Excellent	Good	Excellent	Good	Fair
	Mahurangi at WTP	Excellent	Fair	Fair	Good	Good	Good
Hōteo River	Hōteo at Gubbs	Good	Good	Fair	Good	Poor	Poor

Simply put, water quality classes (i.e. "good" or "excellent") are based on seven parameters (DO, pH, turbidity, temperature, phosphorus, nitrogen) and how often and by how much the water quality at those sites meet or fail water quality criteria in that year (explained in the annual reports referenced in the table above).

Mahurangi River main stem

There are two Council water quality monitoring sites along the Mahurangi River Main stem in Warkworth; that is the Mahurangi at WTP and Mahurangi Town Bridge. Data is available for the Mahurangi Town bridge (1986 to 2008), however the site is no longer operational and has been succeeded by the water treatment plant site (1993 to 2017). These sites are both downstream of the Project. Water quality data is summarised in Table 10 and Table 12 in Appendix A. The mean and median values have been calculated and compared to the relevant guideline values. In addition, the wider record was reviewed against the relevant guideline values to check for number of exceedances of the trigger values. Generally, the data indicate good water quality as detailed below.

- Dissolved oxygen and pH are almost always (more than 99% of the time) within the range of the guidelines indicating good water quality.
- The mean and median turbidity are above guidelines (exceeds 56% of record) and average clarity is low and below guidelines (exceeds 37% of record), indicating that the watercourse has slightly elevated suspended solids. Turbidity and clarity are on average slightly better than at the upstream FHQ site.
- BOD is low at both sites, indicating low organic enrichment.
- Nitrogen concentrations are generally below ecological guidelines with the exception of ammoniacal nitrogen, which is on average above ANZECC/ARMCANZ guidelines as 53% of the records exceeds the trigger values. This is a similar situation to the upstream FHQ site.
- The mean and median concentration of total and dissolved reactive phosphorus are elevated above guidelines, exceeding trigger values for 49% and 88% of the record respectively. Concentrations are higher than at the FHQ site; this is likely due to the inputs of phosphorus from the pasture land use in the lower catchment.
- There are low metal concentrations in the stream; mean and median total and dissolved copper and zinc are all well below the ecological guideline levels. There are some individual exceedances of the trigger levels for dissolved metals, however this equates to <2% of the samples. The metal concentrations are higher than at the upstream FHQ site; this could reflect the changed and more intensified land use in the lower catchment.
- Some microbial contamination is indicated by the mean faecal coliform counts. Median results are likely to be more representative of general conditions and are

below the bathing water surveillance levels. Results can however be well above the surveillance and action levels at times (exceeds trigger values 36% of the record), therefore potentially limiting the bathing water times.

- Results indicate that for the monitored parameters the water is, in general, suitable for stock watering, irrigation and aquaculture. The total phosphorus concentrations indicate slight elevation above the long term irrigation guidelines.

Council State of the Environment monitoring report assessed the water treatment plant site as having fluctuating but generally "good" water quality from 2010-2015, as shown in Table 6.

Waiteitei Stream at Sandersons

Council began suspended sediment and turbidity monitoring in 2011 on the Waiteitei Stream, a tributary of the Hōteo River. This monitoring was carried out at an existing flow monitoring station to inform studies into suspended sediment in the Hōteo River and Kaipara Harbour. Sampling data is available from 2011 to 2014 and consists of event-based suspended sediment sampling. A continuous turbidity monitor was also installed in 2011 with data available up until 2016. The data is summarised in Table 14 in Appendix A.

Data only exists for suspended sediment and turbidity, the mean and median values have been compared to the relevant guideline values, and exceedances across the full record have been reviewed:

- The mean and median suspended sediment concentration is above guidelines, however this is to be expected as the sampling was event based and samples were taken during flood events. As such the data is not representative of the normal conditions of the stream and it is not possible to assess the mean and median at normal stream flows, however, the data indicates that during storm events suspended sediment can be high within the stream, and has been used to inform the Catchment Sediment Model (Water Assessment Technical Report 4).
- The continuous in-situ turbidity data indicates that the median turbidity of the stream (4.1NTU) is below the guideline. The median is likely to be more representative of general conditions. However, the mean (11.1 NTU) is above guideline values, with some high turbidity values (>1000 NTU) recorded.

Hōteo River at Gubbs

There is only one full water quality monitoring site existing within the Hōteo River catchment, this is operated by NIWA and located at Gubbs (downstream of the Project). Data is available from 1989 to 2016, and the data is summarised in Table 13 in Appendix A. The mean and median values have been calculated and compared to the relevant guidelines values. Additionally, the wider record was reviewed against the relevant guideline values to check for number of exceedances of the trigger values. A summary of the data is detailed below.

- Dissolved oxygen and pH are always (100%) within the range of the guidelines indicating good water quality.
- The mean and median turbidity is above guidelines (76% of record above 5.6 NTU), indicating that the watercourse has slightly elevated suspended solids. There is no relevant suspended sediment concentration data available to compare against a median guideline, as suspended sediment data is event based and therefore biased towards high sediment events.

- BOD is very low indicating low organic enrichment.
- The mean total nitrogen and ammoniacal nitrogen concentrations are slightly above the ANZECC/ARMCANZ ecological guidelines, however the medians are below the ANZECC/ARMCANZ guidelines. The trigger values were exceeded 36% and 35% of the record indicating that nitrogen is elevated approximately one third of the time.
- Total and dissolved reactive phosphorus mean and median values are elevated above guidelines, indicating that there is sufficient phosphorus in the water column to promote periphyton (algae) growths. Total phosphorus and dissolved reactive phosphorus are elevated 91% and 92% of the record respectively, indicating that the majority of the time phosphorus concentrations are high.
- The metals copper and zinc have not been assessed at this location.
- Some microbial contamination is indicated by the mean faecal coliform counts. Median results are likely to be more representative of general conditions and are below the bathing water surveillance levels. The trigger values are exceeded for 24% of the record. Results (above 3,000 cfu/100ml) can however be well above the surveillance and action levels (260 cfu/100ml) at times, therefore potentially limiting the use at bathing water at times.
- Results indicate that for the monitored parameters the water is, in general, suitable for stock watering, irrigation and aquaculture. The total phosphorus concentrations indicate slight elevation above the long term irrigation guidelines.

Council State of the Environment monitoring report assessed the Hōteo at Gubbs site as declining in quality from “good” to “poor” in recent years.

4.3.2 Data analysis

The water quality data have been further analysed to identify temporal trends, understand the impact of flow on water quality parameters, and compare conditions between sites.

The analysis for the Mahurangi catchment has focused on the Mahurangi at WTP site, as this site is representative of the lower catchment (the Town Bridge site is no longer active). This site has been compared to the upstream FHQ site. The assessment of data from these two sites has considered total suspended solids, turbidity, metals and nutrients as parameters of particular relevance to the Project. The flow data for the comparison is taken from the Mahurangi at College flow gauging station.

The analysis for the Hōteo catchment has focussed on the Hōteo at Gubbs site. The data analysis has considered total suspended solids, turbidity and nutrients as parameters relevant to the Project, there is no data related to metals for the site. This site has been compared against the upstream Waiteitei site for turbidity and total suspended solids.

Graphs of the data are provided in Appendix A with results discussed below.

Total suspended solids and turbidity

Total suspended solids (TSS) data for the Mahurangi River catchment (Mahurangi FHQ and WTP sites) has been analysed for 1993-2016 (Appendix A). A summary of this data is presented below:

- TSS data has been plotted for the Mahurangi FHQ and WTP over time (1993-2016), and trend lines plotted. These trend lines indicate that concentrations of total suspended solids are relatively stable over time and that there is no change in the general trend in concentrations. The plots of turbidity overtime indicate a similar trend with no major trends across time.

- The relationship of TSS and turbidity has been considered, and a linear relationship has been found for both the FHQ and WTP sites, which is approximately a 1:1 relationship at the WTP and 1:1.5 relationship (TSS: turbidity) at FHQ.
- TSS and turbidity for the Mahurangi at WTP site has been plotted against the daily flow for the Mahurangi at College flow gauge site which is a short distance upstream. The plot shows that, in general, turbidity and suspended sediment increase with flow, however there is not a strong correlation. This indicates that the sediment processes within the catchment are complex and likely are dependent upon more than rain, and likely include seasonal variations, time since previous rainfall event and changes in land use.
- Box plots of TSS and turbidity for both Mahurangi at FHQ and Mahurangi at WTP are shown in Appendix A. These show that generally TSS and turbidity is very similar across both sites.

The TSS and turbidity data for the Hōteo River catchment (Hōteo at Gubbs and Waiteitei at Sandersons sites) has been analysed for 1989-2016 (Appendix A):

- The monthly sampling turbidity data for Hōteo at Gubbs site has been plotted over time and trend lines plotted. These trend lines indicate that turbidity is relatively stable over time. Total suspended solids (TSS) data for the Hōteo catchment is from event based monitoring, as such it is not suitable to use to determine low flow trends. However, this data has been used to inform the Catchment Sediment Modelling Report.
- The continuous in-situ turbidity monitoring at Waiteitei at Sandersons and Hōteo at Gubbs has been plotted (2011-2016) and these similarly show that there is no discernible trend over time. Box plots of the continuous turbidity has been plotted. These box plots show that turbidity at Hōteo at Gubbs is higher than at Sandersons, indicating that turbidity is higher further down in the Hōteo River catchment.
- The relationship of turbidity against suspended solids has been considered. For both Hōteo at Gubbs and Waiteitei at Sandersons, turbidity has been plotted against TSS. NIWA (correspondence 02/10/2017) provided rating curves for both sites based upon their research, which applies a power curve at Hōteo at Gubbs and a linear relationship at Waiteitei. These NIWA rating curves for the Hōteo River catchment have been adopted in this Project. The ratings curves were used to convert the continuous turbidity record to daily TSS load, which in turn was used to calibrate the baseline sediment model; full details of this are provided in the Catchment Sediment Modelling Report.
- Turbidity and TSS at the Hōteo at Gubbs site have been plotted against flow to determine the relationship between flow and suspended sediment. The plot shows that there is a correlation between flow and suspended sediment/turbidity, indicating that storm events correspond to turbidity peaks. However, there are many outliers of the best fit line. This is similar to the Mahurangi River catchment and indicate that the sediment processes within the catchment are complex and likely influenced by factors such as seasonable variations, time since previous rainfall event, and changes in land use.
- The suspended sediment processes in the Hōteo River catchment are discussed in detail in the Catchment Sediment Modelling Report.

The monthly turbidity monitoring at Hōteo at Gubbs has been compared to the turbidity in the Mahurangi river catchment. The results indicate that the turbidity is significantly higher in the Hōteo River than the Mahurangi River. Although this may be influenced by the type of sediment within each catchment, it is likely that the results indicate that the Hōteo River at the Gubbs monitoring station also has higher concentrations of suspended sediment than the Mahurangi River catchment.

Copper and zinc

Appendix A presents the total copper and total zinc concentrations at the Mahurangi FHQ and WTP sites:

- For total copper (mg/L) the average data was below ANZECC/ARMCANZ (2000) guidelines, however there were occasional exceedances of the trigger values on some sample dates. Exceedances occurred more frequently for the downstream Mahurangi at WTP site. At this site the copper was plotted against the daily flow at Mahurangi at College and found that there is a linear correlation (R^2=0.70) between flow and copper concentration.
- For total zinc (mg/L) the average data was below ANZECC/ARMCANZ (2000) guidelines, however there were occasional exceedances of the trigger values on some sampling dates for Mahurangi at FHQ, with frequent exceedances for the downstream Mahurangi at WTP site. At this site the total zinc concentrations were plotted against the daily flow at Mahurangi at College, highlighting a linear correlation (R^2=0.566) between flow and zinc concentration.

There is no metals data available for the Hōteo River catchment.

Nitrogen, Phosphorus and *E. Coli*

Nitrogen, phosphorus and *E. coli* data for the Mahurangi River catchment (Mahurangi at FHQ and Mahurangi at WTP sites) have been analysed for the dates 1993-2016 (Appendix A). This analysis includes an analysis of total nitrogen, ammoniacal nitrogen, nitrate-nitrite nitrogen, total phosphorus and dissolved reactive phosphorus. The results are summarised below:

- Total nitrogen has been plotted over time (1989-2016), the average data was below the guidelines for both monitoring sites, however there are some exceedances for Mahurangi at FHQ and regular exceedances for Mahurangi at WTP further downstream. The general trend was plotted over time and it shows that concentrations of total nitrogen are reducing over time.
- Total nitrogen and flow were compared for Mahurangi at WTP and the Mahurangi at College site, and found that there is a weak correlation between the two (R^2=0.464) indicating that the concentration is likely due to land use as well as flow.
- Ammoniacal nitrogen has been plotted over time (1993-2016). The average data was above the guidelines for both monitoring sites, with large exceedances of the guidelines for both the Mahurangi at FHQ and Mahurangi at WTP sites. The general trend indicates that ammoniacal nitrogen concentrations are reducing over time. Ammoniacal nitrogen was compared with daily flow for Mahurangi at WTP and the Mahurangi at College site, and found that there is no observable correlation between the two.
- Nitrate-nitrite concentrations have been plotted over time (1993-2016), the average data was below the guidelines for both monitoring sites, however there are some

exceedances at both sites. The general trend was plotted over time and it shows that concentrations of nitrate-nitrite are reducing over time; there is only one exceedance of the guideline value since 2002. Nitrate-nitrite concentrations and flow were compared and found that there is a weak correlation between the two (R^2=0.437).

- Total phosphorus has been plotted over time (1993-2016); the average data was approximately at the guideline level for Mahurangi at FHQ and above the guideline value at Mahurangi at WTP. The concentration of total phosphorus regularly exceeds the guideline value at both Mahurangi river sites. The general trend was plotted over time and it showed that concentrations of Total Phosphorus are reducing slightly over time. Total phosphorus and flow were compared, showing a weak correlation between the two (R^2=0.37).
- Dissolved reactive phosphorus has been plotted over time (1993-2016); the average data exceeds the guideline level for both Mahurangi at FHQ a Mahurangi at WTP. The general trend was plotted over time and it shows that concentrations of dissolved reactive phosphorus are reducing slightly over time. A comparison has shown no observable correlation between flow and dissolved reactive phosphorus.
- *E. Coli* has been plotted over time (1993-2016), and the averages are around the guideline values. There are some significant exceedances of the guideline values occurring over time. No relationship with flow was observed.

Nitrogen, phosphorus and *E. coli* data for the Hōteo River catchment (Hōteo at Gubbs site) has been analysed for 1989-2016 (Appendix A), the results of which are summarised below:

- Total Nitrogen has been plotted over time (2008-2016), the average data was approximately at the guideline concentration with some exceedances. The general trend was plotted over time and it shows that concentrations of Total Nitrogen are reducing over time.
- Total Nitrogen and flow were compared for Hōteo at Gubbs site with a power curve, and found that there is a correlation between the two (R^2=0.669) indicating that Total Nitrogen concentration increases following rainfall.
- Ammoniacal Nitrogen has been plotted over time (1989-2016), the average data was just below the guideline concentration however large exceedances of the guidelines observed. The general trend was plotted and shows a slight reduction in Ammoniacal Nitrogen concentration over time.
- Ammoniacal Nitrogen and flow were compared for Hōteo at Gubbs site, and found that there is a power curve relationship between the two (R^2=0.64).
- Nitrate-Nitrite Nitrogen has been plotted over time (1993-2016), the average data was below the guidelines, however there are some exceedances of the guidelines. The general trend was plotted over time and it shows that concentrations of Nitrate-Nitrite Nitrogen are reducing over time. Nitrate-Nitrite Nitrogen and flow were compared but there is no strong correlation between the two (R^2=0.496).
- Total Phosphorus has been plotted over time (1989-2016); the average data is approximately twice the guideline values for Hōteo at Gubbs, with some significant exceedances. The general trend was plotted over time and it shows that concentrations of Total Phosphorus are slightly reducing over time. Total Phosphorus was plotted against flow and found that there is a weak linear correlation between the two (R^2=0.52).
- Dissolved Reactive Phosphorus has been plotted over time (1989-2016); the average data is approximately twice the guideline values for Hōteo at Gubbs, with some

significant exceedances. The general trend was plotted over time and it shows that concentrations of dissolved reactive phosphorus concentrations are slightly reducing over time but generally steady. No relationship with flow is observed.

- *E. Coli* has been plotted over time (2004-2016), and the averages are below the guideline values, however there are some significant exceedances of the guideline values occurring over time. The trend of *E. coli* over time shows no change. *E. Coli* was plotted against flow and found that there is a linear relationship between the two (R^2=0.514).

Box plots of nitrogen, phosphorus and *E. coli* were plotted for the two Mahurangi River sites (Mahurangi at FHQ and Mahurangi at WTP), and the Hōteo River site (Hōteo at Gubbs):

- Total Nitrogen is highest at Hōteo at Gubbs, with the lowest concentration at Mahurangi at FHQ. The speciation of nitrogen varies across the sites, with Hōteo at Gubbs having comparably lower ammoniacal nitrogen and higher nitrate-nitrite speciation.
- Total phosphorus and dissolved reactive phosphorus is highest at Hōteo at Gubbs, indicating that phosphorus enrichment is more of an issue within the Hōteo River catchment.
- *E. coli* concentrations are highest at Mahurangi at FHQ higher in the catchment in the Mahurangi River, and lowest at Hōteo at Gubbs.

4.4 Existing data analysis – Saline water quality

Council carries out long term saline water quality monitoring in the Mahurangi Harbour and the Kaipara Harbour. There are two sites located within the Mahurangi Harbour:

- Mahurangi at Dawsons Creek, located half way up the harbour; and
- Mahurangi at Town Basin.

There are six saline monitoring locations within the Kaipara Harbour:

- Kaipara Harbour at Hōteo River Mouth – this is located in the southern Kaipara Harbour at the mouth of the Hōteo River.
- Kaipara Harbour at Tauhoa Channel – this site is located on the channel which flows from the southern Kaipara Harbour to the harbour entrance.
- Kaipara Harbour at Hargreaves Basin – the Hargreaves Basin is a bay located on the Oruawharo River and receives flows from the Te Hana and Maeneene Creeks.
- Kaipara Harbour at Oruawharo River – this site is located on the estuarine channel of the Oruawharo River downstream of Hargreaves Basin.
- Kaipara Harbour at Otamatea Channel – this is the channel in the Kaipara Harbour that connects the northern Kaipara Harbour with the harbour entrance.
- Kaipara Harbour at Kaipara Heads – Kaipara heads is the outflow point of the Kaipara Harbour.

The locations of the sample sites are shown in Figure 4. A summary of the existing water quality information is given in this section.

4.4.1 Comparison to guidelines and general water quality

Summary data for the eight saline water quality sites are provided in Table 15 to Table 22 in Appendix B. These provide an indication of the date range of the data, the number of samples and some basic overview statistics of the data. The mean and media data from these long term Council monitoring sites have been compared to the relevant guidelines provided in Table 4. The following comments can be made about the Mahurangi Harbour and the Kaipara Harbour.

Mahurangi Harbour

For the two sites in the Mahurangi Harbour, the data indicates that water quality parameters are on average generally below the relevant guideline values. This indicates that water quality is generally good in the harbour, however there are some exceedances of values for nutrients and suspended solids:

- The mean and median concentrations of dissolved reactive phosphorus and total phosphorus were elevated above the ecological guidelines at both sites.
- Mean ammoniacal nitrogen and nitrate-nitrite nitrogen results were above guideline values at Dawsons Creek site and the Town Basin site. This indicates some elevated nitrogen concentrations within the upper harbour.
- The mean and median total suspended solids at the Mahurangi Town Basin, and the mean at Dawsons Creek, are slightly elevated above the guideline values for aquaculture. The mean turbidity at the Town Basin is also above the ecological guideline value for estuarine waters. These sites are upstream and likely reflect the greater input of terrestrial sediments in the headwaters of the harbour. Much of this sediment is likely to settle out before it reaches the harbour head. In addition, the deeper and wider channel at the heads would lead to less sediment remobilisation by tide, wind and water movement.

Council issued marine report cards for the Mahurangi Harbour in 2012 and 2013. These cards reflect the data analysis in the bullet points above. The water quality was rated as "excellent" in 2012 (Auckland Council, 2012a) and "good" in 2013 (Auckland Council, 2013b). This rating was drawn from conclusions of good water quality at Dawsons Creek and excellent water quality further down in the harbour.

Kaipara Harbour

As noted above, there are six Council reporting sites within the Kaipara Harbour. Two of these are located in the southern Kaipara Harbour, three within the estuarine Oruawharo River and the northern Kaipara Harbour, and one at the Harbour heads.

For the two sites located within the southern Kaipara Harbour, the Hōteo River mouth (Table 17) and Tauhoa channel (Table 18), the following general comments can be made:

- The data indicates that water quality parameters are on average generally below the relevant guideline values. This indicates that water quality is generally fair or good in the southern harbour.
- The only parameter where the mean and median concentrations were elevated above the ecological guidelines at both sites was dissolved reactive phosphorus.
- Mean nitrate/nitrite nitrogen water elevated above guideline values at both sites, indicating some elevated nitrogen concentrations. However, median values were

below guidelines. Ammoniacal nitrogen was elevated above guidelines at the Hōteo River mouth.

- The mean and median total suspended solids at the Hōteo River mouth, and the mean the Tauhoa channel are at or slightly elevated above the guideline values for aquaculture.

There are three Council saline sites located within the estuarine Oruawharo River and the lower northern Kaipara Harbour: at Hargreaves Basin (Table 20), on the Oruawharo River (Table 21) and the Otamatea Channel (Table 22). For these sites the following general comments can be made:

- The data indicates that water quality parameters are on average generally below the relevant guideline values. This indicates that water quality is generally fair in the Oruawharo River and the lower northern Kaipara Harbour.
- The only parameter where mean and median concentrations were elevated above the ecological guidelines at all three sites was dissolved reactive phosphorus. Mean and median total phosphorus was elevated at Hargreaves Basin.
- Mean nitrate-nitrite nitrogen water was elevated above guideline values at all three sites indicating some elevated nitrogen concentrations, but median values were generally below guidelines (median value above guideline values at Hargreaves Basin). Ammoniacal nitrogen was elevated above guidelines at the Hargreaves Basin.
- The mean and median total suspended solids at the Hargreaves Basin and the Oruawharo River are elevated above the guideline values for aquaculture. These sites are located within a channel; values were lower in the open central harbour.

The final site is located at the Kaipara Heads (Table 19), which is the channel leading out from the Kaipara Harbour and includes flows from both the northern and southern harbour arms. The following general comments regarding the water quality at this site can be made:

- The data indicates that the water quality is good, with almost all water quality parameters below the relevant guideline values.
- The only parameter elevated above any guideline is dissolved reactive phosphorus, the mean and median concentrations are slightly elevated above the ecological guidelines.
- The suspended solid concentrations at this site are below the guideline values, which indicates that the elevated sediments further up the harbour to the north and south generally settle out before reaching the heads.

Council issued marine report cards for the southern Kaipara Harbour in 2012 and 2013. The report cards cover all Kaipara Harbour sites discussed above as well as saline water quality sites further south in the southern harbour. The water quality was rated as “fair” in 2012 (Auckland Council, 2012a), this is due to water quality within the harbour falling between “poor” to the south and “good” to the north. The water quality in the southern Kaipara Harbour was rated as “fair” in 2013 (Auckland Council, 2013b), with “good” water quality found in the Tauhoa channel. These results indicate that the water quality within the Kaipara Harbour needs to be improved within the harbour; however, the worst water quality is located further south towards the Kaipara River mouth.

4.4.2 Data analysis

The saline water quality data have been further analysed to identify temporal trends, and to compare conditions between the sites and the saline water bodies. This analysis has considered total suspended solids and turbidity, as well as nutrients (Total Nitrogen, Ammoniacal Nitrogen, Total Phosphorus and Dissolved Reactive Phosphorus) at sites within the Mahurangi Harbour and the Kaipara Harbour.

Graphs of the data are provided in Appendix B with results discussed below.

Total suspended solids and turbidity

Total suspended solids (TSS) and turbidity data for the Mahurangi Harbour has been analysed for the Mahurangi at Town Basin and the Mahurangi at Dawsons Creek. The Town Basin site is further up the harbour than Dawsons Creek and therefore has more of a riverine influence. The data has been analysed for 1993-2016 (Appendix B):

- TSS data has been plotted over time for the Mahurangi at Town Basin site (1993-2008). The average concentration is above the guideline value, and there are regular exceedances of the guideline value. No trend is observed over time. Turbidity at Mahurangi at Town Basin also show significant exceedances of the guideline values, however the averages are below the trigger values.
- TSS data has been plotted over time for the Mahurangi at Dawsons Creek site (1993-2016). The average concentrations are also above the guideline value with regular exceedances. No trends are observed over time. Turbidity at Mahurangi at Town Basin also show significant exceedances of the guideline values, however the averages are below the trigger values.
- A comparison of the TSS and turbidity at the Mahurangi sites shows that the concentration is broadly comparable, indicating that increased suspended sediments do not have a chance to settle prior to the Mahurangi at Dawsons Creek site.

The TSS and turbidity data for the southern Kaipara Harbour associated with the Hōteo River has been analysed (2009-2016) for the Kaipara Harbour at Hōteo River mouth and the Kaipara Harbour at Tauhoa channel (Appendix B):

- TSS data has been plotted over time for the Kaipara Harbour at Hōteo River Mouth site (2009-2016). The average concentration is above the guideline value, and there are regular exceedances of the guideline value. Turbidity at this site is on average below the trigger value, yet there are some exceedances over time. No trends are observed over time.
- TSS and turbidity data have been plotted over time for the Kaipara Harbour at Tauhoa Channel site (2009-2016). The average concentrations are below the guideline value, however there are some exceedances of the guideline values. No trends are observed over time.
- TSS concentrations and turbidity are lower at the Tauhoa Channel site, indicating that suspended sediment has settled or become diluted by the time it reaches the site. This indicates that the sediment from the Hōteo River likely settles out in the vicinity of the Hōteo River mouth.

The TSS and turbidity data for the estuarine Oruawharo River and northern Kaipara Harbour has been analysed (2009-2014) for the Kaipara Harbour at Hargreaves Basin, Kaipara Harbour at Oruawharo River and Kaipara Harbour at Otamatea Channel (Appendix B):

- TSS data has been plotted over time for the Kaipara Harbour at Hargreaves Basin (2009-2014). This is the most upstream site on the estuarine Oruawharo River channel. The average concentration is above the guideline value and rarely drops below the guideline value. Turbidity at this site is on average below the trigger value, but with some exceedances over time. No trends are observed over time.
- TSS data has been plotted over time for the Kaipara Harbour at Oruawharo River (2009-2014). The average concentration is above the guideline value, generally the observed values are at the guideline value with regular exceedances. Turbidity at this site is on average below the trigger value, however with some exceedances over time. No trends are observed over time.
- TSS data has been plotted over time for the Kaipara Harbour at Otamatea Channel (2009-2014). This is a channel within the northern Kaipara Harbour, adjacent to the Oruawharo River. The average concentration is below the guideline value, yet there are regular exceedances. Turbidity at this site is on average below the trigger value, with only two exceedances in the sample period. No trends are observed over time.
- TSS concentrations and turbidity reduce along the Oruawharo River from the Hargreaves Basin to the mouth, and then reduce further to the Otamatea Channel site. This trend indicates that suspended sediment has settled or become diluted along the estuarine river.

The TSS and turbidity data for the Kaipara Harbour at Kaipara Heads site has been analysed (2009-2016). This location is at the mouth of the Kaipara Harbour and is considered a marine site (Appendix B).

- TSS data has been plotted over time for the Kaipara Harbour at Kaipara Heads (2009-2016). The average concentration is below the guideline value, but there are occasional exceedances of the guideline value. Turbidity is on average below the trigger value, is not observed to exceed the trigger value. No trends are observed over time.
- TSS concentrations and turbidity are lower at this site that elsewhere in the Kaipara Harbour.

Nitrogen and phosphorus

Nitrogen and phosphorus data (2008-2016) has been analysed for the Mahurangi Harbour, that is the Mahurangi at Town Basin site and the Mahurangi at Dawsons Creek site (Appendix B). The data is discussed below.

- Total nitrogen data only exists for the Mahurangi at Dawsons Creek site (2008-2016). The average data is lower than the estuarine data, and there is only one exceedance of the estuarine guideline value across this time.
- Ammoniacal Nitrogen data was plotted at the Mahurangi at Town Basin site (1992-2008). The average concentration is almost twice the guideline concentration, and there are significant exceedances of the guideline value. The trend line indicates that concentrations were increasing at this location, however monitoring ceased in 2008. Ammoniacal Nitrogen data was plotted at the Mahurangi at Dawsons Creek site (1992-2016). The average concentration is below the guideline concentration,

however there are exceedances of this value. The trend line indicates that concentrations are decreasing slightly at this location.

- Total Phosphorus data was plotted at the Mahurangi at Town Basin site (1992-2008). The average concentration is almost double the guideline concentration, with some significant exceedances of the guideline value. The trend line indicates that concentrations were decreasing at this location. Total Phosphorus data was plotted at the Mahurangi at Dawsons Creek site (1992-2016). The average concentration is above the guideline concentration and there are some significant exceedances of this value. The trend line indicates that concentrations are decreasing slightly over time at this location.
- Dissolved Reactive Phosphorus data was plotted at the Mahurangi at Town Basin site (1992-2008). The average concentration is above the estuarine guideline, with some significant exceedances of the guideline value. The trend line indicates that concentrations were decreasing at this location. Dissolved Reactive Phosphorus data was plotted at the Mahurangi at Dawsons Creek site (1992-2016). The average concentration is above the guideline concentration and there are some significant exceedances of this value. The trend line indicates that concentrations are decreasing slightly at this location.
- A comparison of the nutrient concentrations at the Mahurangi sites shows that the concentration is lower at the Dawsons Creek site, indicating that there is dilution of the water at this site. However, the considerable exceedances of guidelines indicate that terrestrial sources of nutrients are resulting in pollution of the harbour at this location.

Nitrogen and phosphorus data (2009-2016) has been analysed for the southern Kaipara Harbour, that is the Kaipara Harbour at Hōteo River mouth and Kaipara Harbour at Tauhoa channel (Appendix B) and are discussed below.

- Total Nitrogen and Ammoniacal Nitrogen data was plotted for both sites (2009-2016). For both sites the average data for both Nitrogen species is below the trigger values for estuarine and marine environments. However, for the site at the Hōteo River mouth there are regular exceedances of the guideline values. Concentrations are lower at the Tauhoa Channel site, with only occasional exceedances of the guideline values.
- Total Phosphorus data was plotted for both sites (2009-2016), and the average concentration is below the guideline concentration for estuaries at both sites. At Kaipara Harbour at Hōteo River mouth there are some exceedances of the guideline value. Concentrations are lower at the Tauhoa Channel site, with only a few exceedances of the guideline. The trend lines indicate that concentrations may be decreasing slightly at both locations.
- Dissolved Reactive Phosphorus data was plotted at both sites (2009-2016). The average concentration at the Kaipara Harbour at Hōteo River mouth is almost three times the guideline concentration, and all observed data is above the guideline value for estuaries. The average concentration at the Kaipara harbour at Tauhoa Channel is almost twice the estuarine guideline, and the majority of data is above the guideline value. The trend line indicates that concentrations are decreasing over time at both locations.
- Nutrient concentrations are generally lower at the Tauhoa Channel site, indicating that the water has become diluted by the time it reaches the site, however some peaks at this site may indicate other sources of nutrients than the Hōteo River.

Nitrogen and phosphorus data has been analysed for the estuarine Oruawharo River and the northern Kaipara Harbour (2009-2014) for three sites. That is the Kaipara Harbour at Hargreaves Basin, the Kaipara Harbour at Oruawharo River and Kaipara Harbour at Otamatea Channel (Appendix B), the results are discussed below:

- Total Nitrogen data was plotted for all three sites (2009-2014), and all sites were on average below the guideline concentration for estuaries. The concentrations were highest at the Hargreaves Basin and Oruawharo River sites, which are within the estuarine river. Exceedances of the guideline values were observed at these two sites. There are no exceedances of the estuarine guideline for Total Nitrogen at the Otamatea Channel. The trend lines for all three sites indicate that concentrations were decreasing over time.
- Ammoniacal Nitrogen data was plotted for all three sites (2009-2014). Concentrations are highest at the Hargreaves Basin site, where the average exceeds the guideline value. For the Oruawharo River and Otamatea Channel sites the average is below the guideline value, however there are exceedances of the guidelines at both sites. The trend lines for all three sites indicate that concentrations may be decreasing slightly.
- Total Phosphorus data was plotted for all three sites (2009-2014). The average concentrations at the Hargreaves Basin site exceeds the guideline value with regular exceedances. The average concentrations for the Oruawharo River and Otamatea Channel sites is on average below the guideline values, however there are exceedances of the guideline value at both sites. The trend lines for both the Kaipara harbour at Hargreaves Basin and at the Oruawharo Basin do not indicate any changes over time, concentrations appear to be decreasing at the Otamatea Channel site.
- Dissolved Reactive Phosphorus data was plotted for the three sites (2009-2014) and the average concentrations exceed the estuarine guideline at all three sites. At Hargreaves Basin the average concentration is approximately four times the guideline, at the Oruawharo River site is it approximately three times the guideline value and at the Otamatea Channel the average is approximately twice the guideline. All observed dissolved reactive phosphorus data is consistently above the guideline value at all three sites. The trend lines indicate that the concentration is reducing over time.

Nitrogen and phosphorus data (2009-2016) has been analysed the Kaipara Harbour at Kaipara Heads site (Appendix B), and are discussed below:

- Total Nitrogen data (2009-2016) is on average below the guideline values, however there are some exceedances of the marine guideline value (no exceedances of estuarine guideline). The trend line does not indicate any change over time.
- The average of the ammoniacal nitrogen data (2009-2016) was below the guideline values, however there are some exceedances of the marine/estuarine guideline concentration. The trend line does not indicate any change over time.
- Total phosphorus concentrations (2009-2016) were plotted for the site. The average is below both the estuarine and marine guideline values, however there are some exceedances of both guideline concentrations. The trend line indicates that concentrations are reducing over time.
- Dissolved reactive phosphorus data was plotted (2009-2016) and the average concentrations exceed the estuarine guideline, but are below the marine guideline concentration. There are some significant exceedances of the guideline value. The trend line indicates that concentrations may be reducing over time.

5 WATER QUALITY CHARACTERISATION MONITORING

Water quality characterisation monitoring summary
Monitoring of water quality was undertaken between June-September 2017 at ten freshwater locations across the rivers and streams in the Project area. This monitoring is to allow characterisation of existing water quality of watercourses for which no data currently exists, and to add further information at existing monitored locations. The data for the Mahurangi, Hōteo and Oruawharo catchments generally follow the patterns of the long-term monitoring outlined above in Section 4, with elevated turbidity/suspended sediment and nutrients recorded across the Project area. The monitoring also indicates that copper is slightly elevated throughout the Hōteo River catchment.

5.1 Methodology

5.1.1 Freshwater quality monitoring sites

Water quality data has been gathered from 10 sites within the Project area. The intent is to provide information to assist in characterising the water quality in tributaries of the Mahurangi, Hōteo and Oruawharo Rivers to add to the data and understanding available from existing Council data. These sites were selected to assess the current water quality in the area of the Project and as such are generally catchments immediately downstream of the Project. During the sampling programme design, freshwater quality sites were aligned as much as practicable to the freshwater ecology survey sites.

The 10 sites are shown in a map in Figure 5 ,and locations, stream descriptions and surrounding land are listed in Table 7. Table 7 generally follows the proposed designation from south to north, and notes nearby freshwater ecology sites.

All 10 of the sites are freshwater streams. Two sites are existing Council/NIWA monitoring points included in the freshwater sampling regime (Mahurangi at WTP and Hōteo at Gubbs).

The area of catchment upstream of each sample point is provided in Table 8. This table also identifies the area and relative proportions of each land use within each catchment. The catchments related to each sample point are shown on the map in Figure 5.

We note that the data in the table relate to the cumulative area upstream of each sample point rather than the area between the sample point and the next upstream point. Therefore, land use information reflects the overall catchment that contributes flow to that sampling point.

5.1.2 Freshwater sampling methodology

The Project freshwater quality monitoring collected data on water quality, water flow and water clarity. The freshwater sampling occurred monthly between June to September 2017, and additional wet weather sampling was carried out during this period.

Field data observations were collected, including observations of pollution, velocity estimates, and water clarity and colour. In addition, field data was recorded including pH, temperature, dissolved oxygen, electrical conductivity and turbidity. Samples were also collected which were analysed for pH, suspended sediment, metals, PAHs and TPHs.

All water samples were tested for parameters by an International Accreditation New Zealand (IANZ) accredited laboratory (Hill Laboratories in Hamilton).

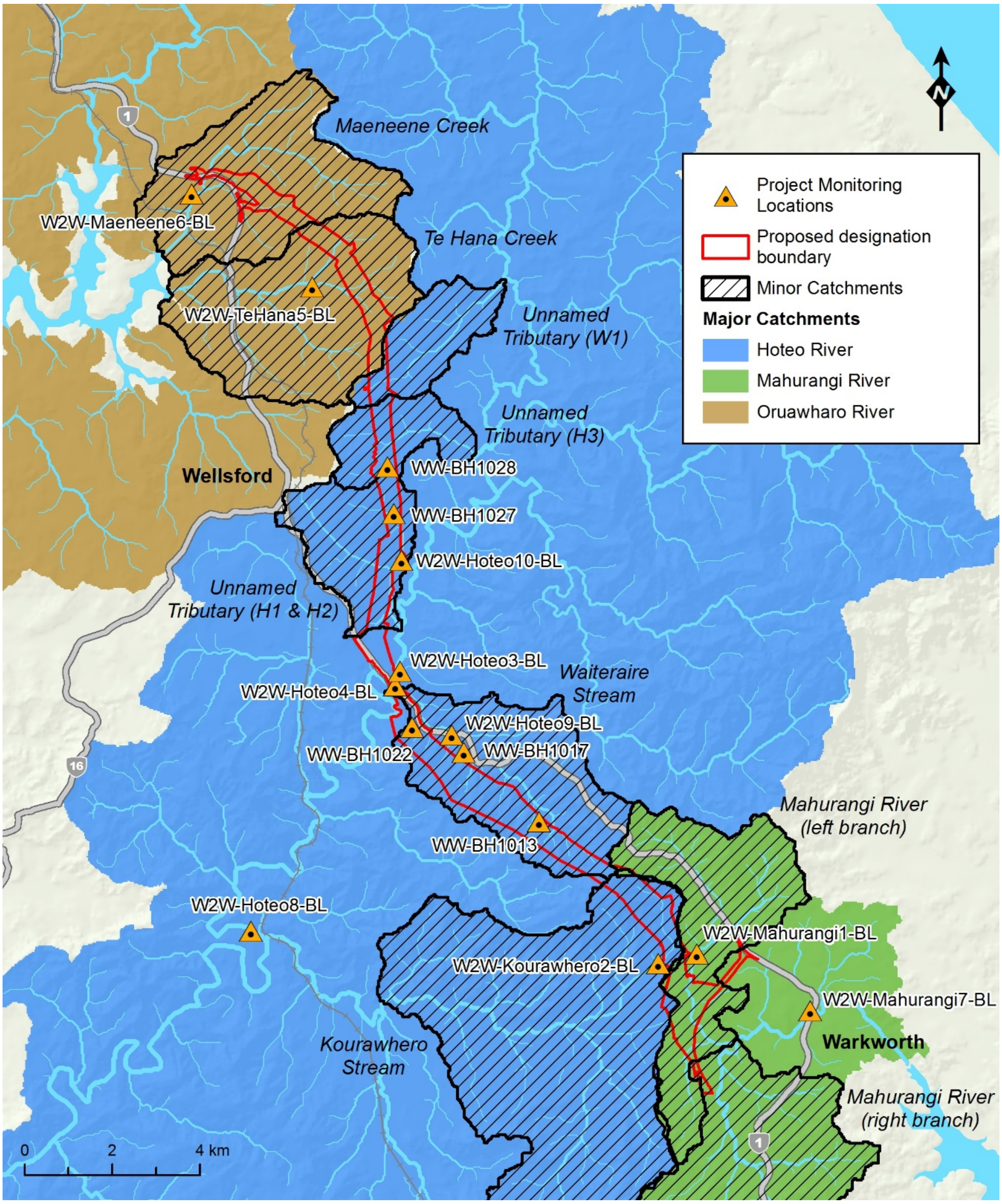

Figure 5 - Project-specific monitoring locations

Table 7 - Water quality sampling points

Catchment	Site name	Site information		Site photographs
Mahurangi catchment	Mahurangi River (left branch) at Kaipara Flats Road	Site number	W2W-Mahurangi1-BL	
		Location	174622X 597171Y	
		Description	This site is located on the left branch of the Mahurangi River, to the east of Kaipara Flats Road. The site is downstream of proposed culverts associated with the Warkworth interchange off-ramps. The river at this location is approximately 2.4 metres wide and is within a small wooded valley. The freshwater ecology survey site WN_F_Mahu_1 on this branch is approximately 300 m upstream of this site.	
	Mahurangi River at State Highway 1	Site number	W2W-Mahurangi7-BL	
		Location	174880X 597244Y	
		Description	This is the downstream monitoring site on the Mahurangi River. The site corresponds to an existing Council water quality station (Mahurangi at WTP). The river is wider and is in a slow flowing pool above a rock step upstream of the existing bridge over State Highway 1. There is no corresponding freshwater ecology survey site on this stretch of river.	
Hōteo catchment	Kourawhero Stream at	Site number	W2W-Kourawhero2-BL	
		Location	174533X 597149Y	

Catchment	Site name	Site information		Site photographs
	Kaipara Flats Road	Description	This site is located in the upper reaches of Kourawhero Stream, downstream of the Dome ranges and downstream of the Project. The stream at this location is small and meandering through pasture adjacent to Kaipara Flats Road. The freshwater ecology survey site WN_F_Koura_1 approximately 1 km upstream of this site.	
	Tributary of Waiteraire Stream at forestry track	Site number	W2W-Hōteo9 -BL	
		Location	174063X 597672Y	
		Description	This site is located on a minor stream draining into Waiteraire Stream, a tributary of the Hōteo River, accessed from a Forestry track. The stream is small and likely ephemeral; the stream enters a culvert beneath the existing SH1 downstream of the monitoring point. There is no corresponding freshwater ecology survey site on this tributary.	
	Waiteraire Stream at	Site number	W2W-Hōteo4 -BL	
		Location	173933X 597784Y	

Catchment	Site name	Site information		Site photographs
	State Highway 1	Description	This is located on Waiteraire Stream, a tributary of Hōteo River, immediately upstream of the confluence. The stream is within an incised channel at this location through pasture. Downstream of the monitoring point is a small road bridge. The freshwater ecology survey site HN_F_Hōteo_2 is located adjacent to this site but on the main Hōteo River stem. The Ecology Assessment Report notes that a full SEV assessment was not undertaken at this site as it was not wadeable.	
Hōteo catchment	Unnamed tributary (H2) of Hōteo River at Rustybrook Road	Site number	W2W-Hōteo10 -BL	
		Location	173948X 598070Y	
		Description	This monitoring point is located on an unnamed tributary of Hōteo River, downstream of Rustybrook Road. The tributary flows through pasture at this location in an incised channel with bank erosion. The upstream catchment is undulating pasture. The freshwater ecology survey site HN_F_Hōteo_3 is located approximately 260 m downstream from this site on the same tributary.	
		Site number	W2W-Hōteo3 -BL	
		Location	173944X 597817Y	

Catchment	Site name	Site information		Site photographs
	Hōteo River at State Highway 1	Description	This is located on the Hōteo River main channel, upstream of the existing SH1 crossing and the proposed Project crossing. The monitoring point is on a large meander, within a wide incised channel through pasture, to the east of an airfield. There is considerable bank slumping at the monitoring point. The freshwater ecology survey site HN_F_Hōteo_1 is located approximately 150 m downstream of this site on the same tributary of the Hōteo River.	
	Hōteo River at Tauhoa Road	Site number	W2W-Hōteo8 -BL	
		Location	173605X 597224Y	
		Description	This monitoring point is located on the Hōteo River a considerable distance downstream of the Project. The site corresponds to the AC water quality site Hōteo at Gubbs. The river is wide at this point and there are signs of bank erosion; monitoring occurs from a small bridge that crosses the river. There is no corresponding freshwater ecology survey site on this stretch of the river.	
Oruawharo catchment	Te Hana Creek at	Site number	W2W-TeHana5-BL	
		Location	173744X 598695Y	

Catchment	Site name	Site information		Site photographs
	Silver Hill Road	Description	The monitoring point is on a branch of Te Hana Creek and is downstream of three tributaries to be culverted for the Project. Monitoring occurs at the Silver Hill road culvert. At this location the stream is within an area of native forest. The freshwater ecology survey site HN_F_TeHana_1 is located on a tributary approximately 1.5 km upstream of this site in the creek’s headwaters, north of the Indicative Alignment.	
	Maeneene Creek at Waimanu Road	Site number	W2W-Maeneene6-BL	
		Location	173469X 598907Y	
		Description	The monitoring point is on Maeneene Creek, adjacent to Waimanu Road and upstream of the North Auckland railway bridge. This site is downstream of the Project. The creek is estuarine at this location, and as such is wide and straight at this point with a tidal influence. Three freshwater ecology survey sites, HN_F_Mae_1, HN_F_Mae_2 and HN_F_Mae_3 are located on a tributary upstream of this site in the creek’s headwaters. This tributary drains into the main stem of the Maeneene Creek where this freshwater quality site is located. HN_F_Mae_3 is the closest site, approximately 1.8 km upstream.	

Table 8 - Catchment land uses and areas upstream of Project sample points.

Catchment	Site	Total area (ha)	Land use											
			Forest		Pasture		Cropland		Scrubs		Urban		Water	
			Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%
Mahurangi River	W2W-Mahurangi1-BL	892	475	53%	412	46%	4	0.4%	0	0%	2	0.2%	0	0%
	W2W-Mahurangi7-BL	4,905	2,318	47%	2,388	49%	27	0.6%	17	0.3%	150	3%	5	0.1%
Hōteo River	W2W-Kourawhero2-BL	184	132	72%	51	28%	0	0%	0	0%	0	0%	0	0%
	W2W-Hōteo 9-BL	76	75	99%	1	1%	0	0%	0	0%	0	0%	0	0%
	W2W-Hōteo 4-BL	1,446	1376	95%	67	5%	0	0%	0	0%	3	0.2%	0	0%
	W2W-Hōteo 10-BL	228	18	8%	209	92%	0	0%	0	0%	0.03	0%	0	0%
	W2W-Hōteo 3-BL	19,645	7,810	40%	11,644	59%	38	0.2%	61	0.3%	45	0.2%	25	0.1%
	W2W-Hōteo 8-BL	26,756	11,711	44%	14,821	55%	38	0.1%	79	0.3%	59	0.2%	25	0.1%
Oruawharo River	W2W-TeHana5-BL	349	36	10%	314	90%	0	0%	0	0%	0	0%	0	0%
	W2W-Maeneene6-BL	1,236	309	25%	916	74%	7	0.6%	1	0.1%	0	0%	1	0.1%

5.1.3 Marine sediment quality monitoring

In addition, sediment samples were taken from the marine environment to inform the ecology assessment. The sampling methodology is described in the Marine Ecology Assessment Report. These four marine sediment sampling sites are shown in Figure 6; two are located by the Maeneene Creek mouth / Oruawharo River and two at the Hōteo River mouth. Sediment samples were collected once at each site in June 2017.

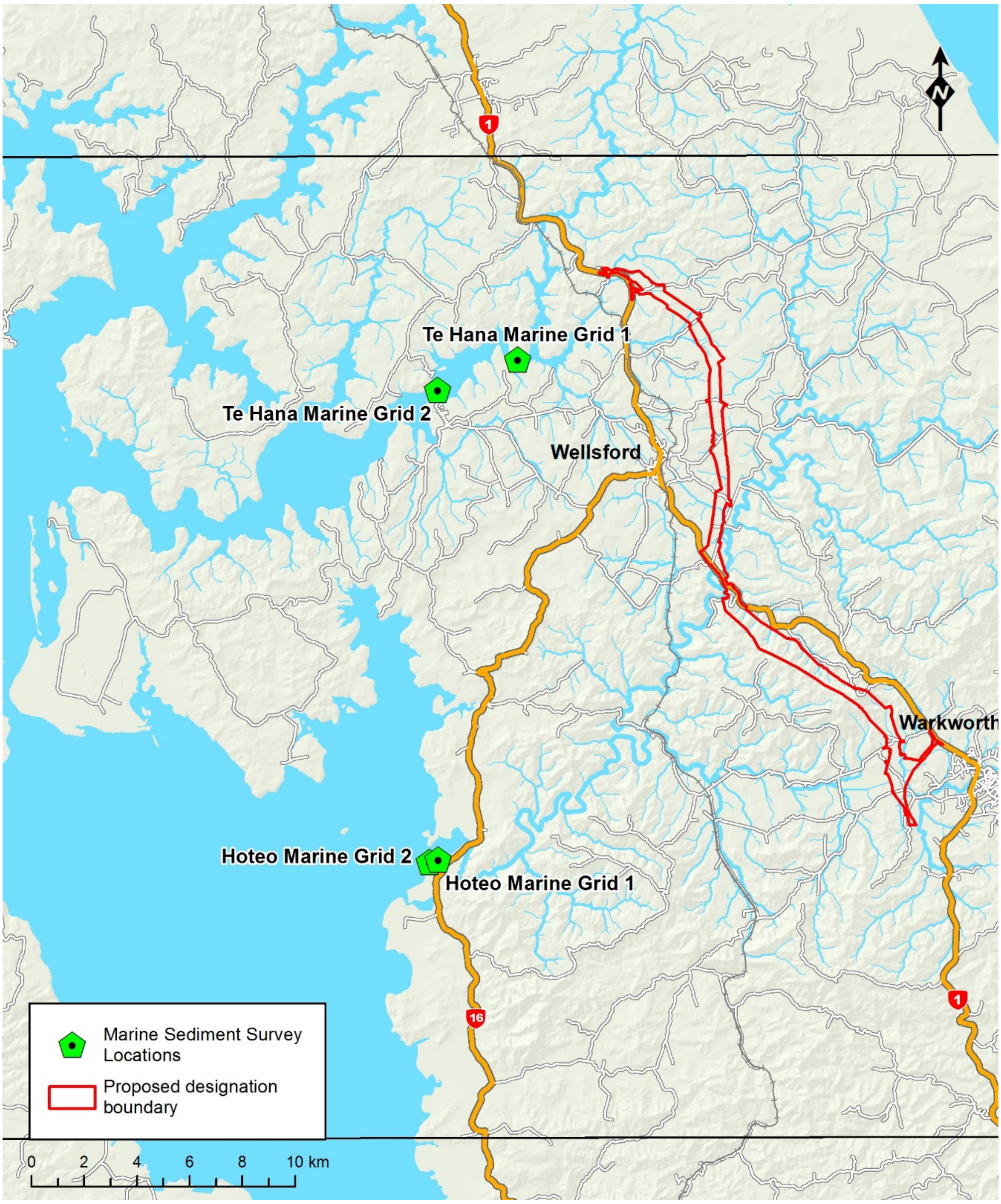

Figure 6 - Marine sediment quality survey locations

Prior to sampling being undertaken, we planned to collect and assess sediment quality for the Project from the freshwater environment. However, we determined during sampling that there was no available loose sediment to sample at all sites. The banks were observed to be a hard clay and no sediment could be obtained using standard methodologies.

5.2 Freshwater sampling results and discussion

The 10 freshwater sites were sampled three times during dry weather conditions, and twice during wet weather conditions, the sampling regime is summarised in Table 9.

Table 9 - Project specific freshwater monitoring dates

Sampling dates	Sampling type
22/6/2017 – 23/6/2017	Wet weather sampling
12/7/2017 – 14/7/2017	Monthly dry weather sampling
9/8/2017-11/8/2017	Wet Weather sampling
23/8/2017-25/8/2017	Monthly dry weather sampling
14/9/2017-15/9/2017	Monthly dry weather sampling

5.2.1 Dry weather samples

The results of the monthly dry weather sampling are presented in Appendix C. Most results were below ANZECC/ARMCANZ (2000) default trigger values for aquatic ecosystems. The results are discussed for each catchment below.

(a) Mahurangi River

The results of the dry weather monitoring for the Mahurangi River catchment are summarised below:

- Exceedances of turbidity at both sites within the Mahurangi catchment (W2W-Mahurangi 1-BL & W2W-Mahurangi7-BL), however this did not correspond with exceedances of suspended sediment which are all below guidelines;
- No exceedances for nutrients, aside from minor exceedances of total phosphorus in July at both sites (W2W-Mahurangi 1-BL & W2W-Mahurangi7-BL) and a minor exceedance in ammoniacal nitrogen in the lower catchment in July (W2W-Mahurangi7-BL);
- Minor exceedances of *E. Coli* in July and September at both sites (W2W-Mahurangi1-BL& W2W-Mahurangi7-BL);
- No exceedances of metals at either site; and
- No exceedances of PAHs or TPHs at either site.
- These results are consistent with the long-term Council monitoring data.

(b) Hōteo River

The results of the dry weather monitoring for the Hōteo River catchment are summarised below:

- Consistent exceedances of turbidity at all sites in the Hōteo River catchment (W2W-Kourawhero2-BL, W2W-Hōteo 3-BL, W2W-Hōteo 8-BL, W2W-Hōteo 9-BL & W2W-Hōteo 10-BL), however this did not correspond with any exceedances of suspended sediment which were below guidelines at all sites during dry weather monitoring;

- Nutrient concentrations were generally recorded at or below the guideline values, however some minor exceedances of nitrogen and phosphorus species were recorded at all sites within the Hōteo River catchment aside from the forestry tributary (W2W-Kourawhero2-BL, W2W-Hōteo 3-BL, W2W-Hōteo 8-BL & W2W-Hōteo 10-BL);
- No exceedances of *E. Coli* aside from one minor exceedance recorded in a tributary of Waiteraire Stream (W2W-Hōteo 9-BL) and one minor exceedance downstream in the Hōteo River (W2W-Hōteo 8-BL);
- No exceedances of dissolved metals compared against the trigger values corrected for hardness. However, there was one minor exceedance of total copper in Waiteraire Stream (W2W-Hōteo 3-BL) and one exceedance of total zinc in the Kourawhero Stream (W2W-Kourawharo2-BL) and;
- No exceedances of PAHs or TPHs at any site.
- These results are consistent with the long-term NIWA monitoring for nutrients and suspended sediments. There is no metals data available from the NIWA site but this data indicates that copper is high throughout the catchment.

(c) Oruawharo River

The results of the dry weather monitoring for the Oruawharo River catchment are summarised below:

- Minor exceedances of turbidity in Te Hana Creek (W2W-TeHana5-BL), but this does not correspond with an exceedance of suspended solids which are below guideline concentrations. Maeneene Creek (W2W-Maeneene6-BL) has consistent exceedances of turbidity and two exceedances of suspended solids;
- Exceedances of nitrogen and phosphorus species on more than one occasion at Te Hana Creek (W2W-TeHana5-BL) and Maeneene Creek (W2W-Maeneene6-BL);
- No exceedances of *E. Coli* in Te Hana Creek, but two exceedances of *E. Coli* in Maeneene Creek (W2W-Maeneene6-BL);
- No exceedances of metals at either site; and
- No exceedances of PAHs or TPHs at any site.
- This data is consistent with the available saline water quality for Oruawharo River, which indicates elevated suspended sediment and nutrients.

5.2.2 Wet weather samples

The results of the wet weather sampling are presented in Appendix C. The results are discussed for each catchment below.

(a) Mahurangi River

The results of the wet weather monitoring for the Mahurangi River catchment are summarised below:

- Consistent exceedances of turbidity at both sites within the Mahurangi catchment (W2W-Mahurangi 1-BL & W2W-Mahurangi7-BL), however suspended solid concentrations were only exceeded on one monitoring round;

- Generally nutrient concentrations were below guideline values, however there were exceedances of some species of nitrogen and phosphorus recorded at both sites (W2W-Mahurangi 1-BL & W2W-Mahurangi7-BL);
- Exceedances of *E. Coli* during both monitoring rounds at both sites, including some very high recorded values (W2W-Mahurangi 1-BL & W2W-Mahurangi7-BL);
- Generally, there were no exceedances of dissolved metals compared against the trigger values corrected for hardness, however there was one recorded exceedance of the copper (dissolved) trigger value at W2W-Mahurangi1-BL in June 2017. Additionally, total copper and total zinc concentrations exceed the trigger values at both sites in wet weather (W2W-Mahurangi 1-BL & W2W-Mahurangi7-BL); and
- No exceedances of PAHs or TPHs at either site;
- These results are consistent with the long-term Council monitoring data.

(b) Hōteo River

The results of the wet weather monitoring for the Hōteo River catchment are summarised below:

- Turbidity was consistently above the guideline value throughout the Hōteo River catchment (W2W-Kourawhero2-BL, W2W-Hōteo 3-BL, W2W-Hōteo 4-BL, W2W-Hōteo 8-BL, W2W-Hōteo 9-BL & W2W-Hōteo 10-BL). Suspended sediment concentrations were also generally above the guideline values;
- Nutrient concentrations varied throughout the Hōteo catchment. In the forested tributaries of Kourawhero Stream and Waiteraire Stream (W2W-Kourawhero2-BL, W2W-Hōteo 4-BL, W2W-Hōteo 9-BL) the nutrients were generally below guideline values, with some minor exceedances of nutrients. For sites in the Hōteo River channel and an unnamed tributary (H2) through pasture (W2W-Hōteo 3-BL, W2W-Hōteo 8-BL & W2W-Hōteo 10-BL) the nutrients are generally above the guideline values;
- *E. Coli* is generally significantly above the guideline value for all sites throughout the Hōteo River (W2W-Kourawhero2-BL, W2W-Hōteo 3-BL, W2W-Hōteo 4-BL, W2W-Hōteo 8-BL & W2W-Hōteo 10-BL), aside from the forestry tributary of the Waiteraire Stream (W2W-Hōteo 9-BL) which recorded only one minor exceedance of *E. Coli.;*
- No exceedances of dissolved metals compared against the trigger values corrected for hardness. However, total copper and total zinc concentrations generally exceed guideline values at most sites on one or more occasion (W2W-Kourawhero2-BL, W2W-Hōteo 3-BL, W2W-Hōteo 4-BL, W2W-Hōteo 8-BL & W2W-Hōteo 10-BL);
- No exceedances of PAHs or TPHs at any site;
- These results are consistent with the long-term NIWA monitoring for elevated nutrients and suspended sediments. In addition, these results are consistent with the upstream land use. The data indicates that copper is prevalent throughout the catchment, which may indicate that it is naturally occurring in this region.

(c) Oruawharo River

The results of the wet weather monitoring for the Oruawharo River catchment are summarised below:

- Minor exceedances of turbidity in Te Hana Creek (W2W-TeHana5-BL), this does not correspond to an exceedance of suspended solids which are below guideline concentrations. Maeneene Creek (W2W-Maeneene6-BL) has consistent exceedances of turbidity and two exceedances of suspended solids recorded;

- For both sites the nutrients are generally above the guidance values (W2W-TeHana5-BL & W2W-Maeneene6-BL;
- *E. Coli* exceeds guidance values for Te Hana Creek and Maeneene Creek (W2W-TeHana5-BL & W2W-Maeneene6-BL), very high concentrations occur at both sites;
- No exceedances of dissolved metals at either site. However, exceedances of total copper and total zinc are recorded in Maeneene Creek (W2W-Maeneene6-BL);
- No exceedances of PAHs or TPHs at any site;
- This data is consistent with the available saline water quality for Oruawharo River which indicates elevated suspended sediment and nutrients. Elevated metals in Maeneene Creek indicate a potential source of pollution upstream.

5.2.3 Quality control

Duplicate samples were taken from one site during three of the sampling rounds (two wet and one dry). In general, no notable differences exist between the results for the duplicate samples.

The only exception to this was during the first wet weather sampling round (23rd June 2017) when the results presented very different turbidity, TSS, phosphorus and bacteriological results. This sampling occurred during a storm event on a small tributary, as such the water quality can change temporally.

The other monitoring rounds presented no differences between the duplicates, indicating that sampling and analysis methods were of suitable accuracy to create replicable results.

5.3 Marine sediment sampling results

The results of the marine (intertidal) sediment sampling undertaken at the Hōteo River mouth and the Maeneene/Te Hana Creek mouth are presented in Appendix D.

The measured concentrations of monitored contaminants in the marine intertidal sediment were below the trigger thresholds with the exception of one exceedance of copper at one Maeneene/Te Hana Creek mouth site (Te Hana 1). Copper concentrations at Te Hana 1 (20 mg/kg) were just above ARC ERC amber guideline value (19 mg/kg), but below the red guideline value (34 mg/kg) (as indicated in Appendix D).

6 SUMMARY

Summary of report

This report has assessed the baseline water quality of the receiving freshwater and saline environments of the Project:

- The Mahurangi Harbour catchment, including the Mahurangi harbour and the Mahurangi River; and
- The Kaipara Harbour catchment, including the Hōteo River and tributaries, and the estuarine Oruawharo River and tributaries, and the Kaipara Harbour.

Existing water quality data, and data collected for this Project, indicates that nutrients and *E. Coli* are elevated in various freshwater sites across both catchments. The data indicates that metals are generally below guideline values, however copper is elevated at some freshwater sites in both the Kaipara and Mahurangi catchments.

Elevated sediment is an issue for both catchments, with elevated turbidity and suspended sediments in freshwater, and elevated sedimentation in the upper reaches of both harbours.

The lower Mahurangi Harbour has excellent saline water quality. The Kaipara Harbour has fair water quality in the southern Harbour and good saline water quality at the entrance of the Kaipara Harbour.

The AUP(OP) identifies both the Kaipara Harbour and Mahurangi Harbour as degraded from a water quality perspective due to human activities.

During construction the Project will input sediments to the streams and rivers that will ultimately be discharged to the harbours. As sediment is already elevated in these catchments, the potential for sediment discharged during construction to alter concentrations and sediment deposition in the receiving environments will need to be considered.

When the road is operational the primary contaminants in road runoff will be metals and hydrocarbons. Concentrations of hydrocarbons are low in the environment at present and therefore are of less concern as environmental stressors at present. Zinc concentrations are generally low, but copper is elevated at some sites.

6.1 Mahurangi Harbour Catchment

The Mahurangi catchment has water quality and ecological issues relating to the rate and amount of sedimentation occurring within the estuary harbour. There have been a number of studies into the Mahurangi River and the development of the Mahurangi Action Plan, which was adopted by Rodney District Council in 2010. The Action Plan has a focus on sediment as a priority water quality issue within the harbour, and also notes other contaminants such as nutrients can impact on aquatic habitats and human health. Therefore, there is currently an environment that is sensitive to sedimentation impacts and also a level of public interest in sediment generation in the catchment.

The Council State of the Environment (2010-2015) reports that water in the Mahurangi River ranges from fair to excellent. The existing water quality data for the Mahurangi River indicates that water quality is generally good, however there are slightly elevated concentration of phosphorus and turbidity/suspended sediments and *E. Coli*. On average the water quality is suitable to provide for the protection of aquatic ecosystems and also for uses such as stock watering, irrigation and aquaculture. Water quality data gathered for the Project presented a similar pattern of water quality to the longer term Council sites. This included generally good water quality with some nutrients (primarily phosphorus), and turbidity/suspended sediments being elevated.

Within the Mahurangi Harbour the water quality is also good, with most parameters being below guidelines. Average suspended sediment, phosphorus and nitrogen concentrations are slightly elevated indicating some impacts in the upper harbour. These sites are both in the upper harbour. Council reports that the lower harbour has excellent water quality.

6.2 Kaipara Harbour Catchment

The Kaipara Harbour also has issues relating to the amount of sediment entering the marine environment, such as sedimentation, water quality and ecological effects. Existing reports into the Kaipara Harbour have found that the environmental values of the Harbour have been and are continuing to degrade. The key threats to the Harbour include land use activities that generate sediment and other contaminants.

The Hōteo River is found to be a key contributor of sediment to the southern Kaipara Harbour; the Hōteo River is also classified by Council as a priority catchment as river sedimentation poses a threat to the snapper breeding ground located near the Hōteo River mouth. As such the Kaipara Harbour and Hōteo River are sensitive to sediment impacts.

The Council State of the Environment reports that in the Hōteo River water quality is declining from ‘good’ to ‘poor’. The existing water quality data for the Hōteo River indicates that for the majority of parameters the water quality is good. However, turbidity/suspended sediments are elevated above the guideline values for the majority of the time and phosphorus concentrations are slightly elevated. On average the water is suitable for stock water supply, irrigation and aquaculture, yet the total phosphorus exceed irrigation guidelines.

Water quality data gathered for the Hōteo River catchment presented a similar pattern of water quality to the longer term NIWA data, with elevated turbidity/suspended sediments recorded and elevated nutrients in the Hōteo River and in an unnamed (H2) pasture tributary. In addition to this, the data shows multiple exceedances of copper throughout the catchment, which may indicate that copper is found naturally within the catchment

Within the estuarine Oruawharo River the existing Council water quality data indicates that suspended solids are elevated above the guideline values of aquaculture, as well as high concentrations of dissolved reactive phosphorus which exceeds the ecological guidelines. The saline water quality improves within the northern Kaipara Harbour, however dissolved reactive phosphorus remains high.

Water quality data gathered for the Oruawharo River was consistent with the estuarine Oruawharo River data, with elevated turbidity/suspended sediments and elevated nutrients recorded. *E. Coli* concentrations were found to be elevated in the Maeneene Creek likely due to the upstream land use. In addition, exceedances of copper and zinc concentrations occurred within Maeneene Creek during wet weather

Within the southern Kaipara Harbour, the data indicates that the Hōteo River results in high suspended sediments at the river mouth above the guideline values for aquaculture as well as elevated phosphorus concentrations. The saline water quality at the Kaipara Harbour mouth indicates that the water quality is good, with almost all water quality parameters below the relevant guideline values, except for dissolved reactive phosphorus which is slightly elevated above the ecological guidelines. The suspended sediment concentration at the Harbour mouth is below guideline values indicating that the elevated sediments from the river mouths settle out prior to reaching the Harbour heads. Council rate the water quality in the southern Kaipara harbour as “fair” which indicate that the water quality within the Kaipara Harbour needs to be improved within the harbour.

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APPENDIX A: AUCKLAND COUNCIL AND NIWA FRESHWATER QUALITY DATA

This appendix includes a summary of the existing Auckland Council (Council) and NIWA freshwater quality data. This data was provided by Council and NIWA in April 2017, any monitoring that has occurred since has not been included. This Appendix is split into the following sub-sections:

A.1 – Summary tables of Council water quality data for the Mahurangi River catchment (Mahurangi at FHQ, Mahurangi and Town Bridge and Mahurangi at WTP). The water quality values have been compared with the guideline values in Table 3, the lower of the guideline values is contained in the table. Exceedances of the values are highlighted in grey and an assessment of the percentage exceedance of the trigger values is also listed.

A.2 - Summary tables of the NIWA water quality data for the Hōteo River catchment (Hōteo at Gubbs and Waiteitei at Sandersons). The water quality values have been compared with the guideline values in Table 3, the lower of the guideline values is contained in the table. Exceedances of the values are highlighted in grey and an assessment of the percentage exceedance of the trigger values is also listed.

A.3 - Data analysis graphs for suspended sediment and turbidity data for the Mahurangi River catchment, this includes a review of suspended sediment and turbidity over time and the relationships between suspended sediment and turbidity and flow.

A.4 - Data analysis graphs for suspended sediment and turbidity data for the Hōteo River catchment, as detailed above.

A.5 - Data analysis graphs for metals (Copper and Zinc) for the Mahurangi River catchment, including analysis of trends over time and comparisons to flow. There are no metals data for the Hōteo River.

A.6 - Data analysis graphs of nutrients (Total Nitrogen, Ammoniacal Nitrogen, Nitrate-Nitrite Nitrogen, Total Phosphorus and Dissolved Phosphorus) for the Mahurangi River catchment. This includes graphs showing the trends over time and comparisons to flow.

A.7 - Data analysis graphs of nutrients (Total Nitrogen, Ammoniacal Nitrogen, Nitrate-Nitrite Nitrogen, Total Phosphorus and Dissolved Phosphorus) for the Hōteo River catchment. This includes graphs showing the trends over time and comparisons to flow.

A.1 Mahurangi River water quality summary tables

Table 10 – Summary of existing Council water quality data for the Mahurangi at FHQ

Parameter (mg/L) unless stated	Trigger value[A]	Date range	#	Data summary				Exceeds[B]	
				Mean	Median	Min	Max	#	%
Dissolved Oxygen	<5	1993-2017	277	9.49	9.60	4.30	16.58	1	0.4%
Dissolved Oxygen (% Saturation)	-	1993-2017	278	91.51	92.65	43.80	153.00	-	-
Conductivity (mS/cm)	-	2004-2017	153	0.178	0.178	0.100	0.459	-	-
Temp (°C)	-	1993-2017	280	14.1	13.9	6.0	21.9	-	-
pH (pH units)	6.5-8.5	1993-2017	280	7.38	7.40	6.02	8.39	3	1%
Biochemical oxygen demand	-	1993-2005	138	1.992	2.000	0.400	2.300	-	-
E. coli (cfu/100mL)	260	2001-2017	134	717	265	9	12,900	70	52%
Total suspended solids	40	1993-2017	281	8.3	4.0	0.8	260.0	6	2%
Turbidity (NTU)	5.6	1993-2017	281	13.7	8.1	1.3	228.0	221	79%
Black Disc Clarity (m)	>0.6	1993-2009	123	0.53	0.50	0.09	1.41	66	54%
Total Phosphorus	0.033	1993-2017	279	0.033	0.030	0.005	0.260	85	30%
Soluble reactive phosphorus	0.01	1993-2017	280	0.012	0.010	<0.005	0.060	188	67%
Total nitrogen	0.614	2009-2017	97	0.272	0.230	0.090	0.730	4	4%
Ammoniacal nitrogen	0.021	1993-2017	278	0.029	0.025	<0.005	0.400	160	58%
Nitrate nitrogen	50	1988-2001	8	0.319	0.228	0.087	0.993	0	0%
Nitrite nitrogen	0.1	1993-2000	89	0.003	0.003	<0.001	0.009	0	0%
Nitrate-Nitrite (TON) nitrogen	0.444	1993-2017	279	0.178	0.146	0.003	1.332	12	4%
Kjeldahl Nitrogen	-	2001-2017	187	0.270	0.200	0.020	2.800	-	-
Total Copper	0.0014[C]	2009-2017	79	0.00075	0.00050	<0.0001	0.0076	8	10%
Dissolved Copper	0.0014[C]	2009-2017	79	0.00037	0.00034	<0.0001	0.00093	0	0
Total Zinc	0.008[C]	2009-2017	79	0.00172	0.00066	0.00030	0.0240	3	4%
Dissolved Zinc	0.008[C]	2009-2017	79	0.00075	0.00036	0.00030	0.0130	1	1%

Notes:

A - Trigger value is the lower guideline trigger value in Table 3, grey shading indicates value exceeds this trigger

B – This details the number of times and % of time monitored that the observed value exceeds the lower guideline trigger value

C - Trigger values are hardness dependant; these are values for a hardness of 30 mg/L $CaCO_3$

Table 11 - Summary of Council water quality data for the Mahurangi at Town Bridge

Parameter (mg/L) unless stated	Trigger value[A]	Date range	#	Data summary			
				Mean	Median	Min	Max
Dissolved Oxygen	<5	1993-2008	144	9.04	9.1	3.7	12.1
Dissolved Oxygen (% Saturation)	-	1993-2008	173	90.36	92	38	115
Conductivity (mS/cm)	-	2004-2008	55	0.210	0.190	0.100	0.460
Temp (°C)	-	1986-2008	170	16.22	16.40	7.70	24.60
pH (pH units)	6.5-8.5	1986-2008	232	7.44	7.5	5.9	8.2
Biochemical oxygen demand	-	1986-2005	201	2.14	2	0.4	9.6
E. coli (cfu/100mL)	260	2005-2008	32	483	229	2	3100
Total suspended solids	40	1986-2008	242	12.93	5.35	0.4	741.5
Turbidity (NTU)	5.6	1986-2008	232	12.06	6.60	0.60	116.0
Black Disc Clarity (m)	<0.6	1993-2008	153	0.70	0.70	0.08	1.70
Total Phosphorus	0.033	1986-2008	232	0.071	0.06	0.01	0.45
Soluble reactive phosphorus	0.01	1986-2008	232	0.021	0.020	<0.005	0.100
Ammoniacal nitrogen	0.021	1986-2008	228	0.056	0.040	<0.001	0.980
Nitrate nitrogen	50	1986-2005	203	0.320	0.280	0.001	2.550
Nitrite nitrogen	0.1	1986-2000	149	0.007	0.007	<0.001	0.021
Nitrate-Nitrite (TON) nitrogen	0.444	1993-2008	171	0.230	0.230	0.003	1.280
Total Kjeldahl Nitrogen	-	2005-2008	32	0.51	0.40	<0.20	1.70

Note:

A - Trigger value is the lower guideline trigger value in Table 3, grey shading indicates value exceeds this trigger

B – This details the number of times and % of time monitored that the observed value exceeds the lower guideline trigger value

Data was not available to analyse number or percentage of exceedances of guideline values.

Table 12 - Summary of existing Council water quality data for the Mahurangi at WTP

Parameter (mg/L) unless stated	Trigger value[A]	Date range	#	Data summary				Exceeds[B]	
				Mean	Median	Min	Max	#	%
Dissolved Oxygen	<5	1993-2017	277	9.49	9.50	5.40	13.73	0	0%
Dissolved Oxygen (% Saturation)	-	1993-2017	270	94.44	95.15	55.00	130.7	-	-
Conductivity (mS/cm)	-	1993-2017	274	0.185	0.181	0.019	0.433	-	-
Temp (°C)	-	1998-2017	213	15.9	15.5	7.6	24.1	-	-
pH (pH units)	6.5-8.5	1993-2017	273	7.62	7.60	6.42	8.45	2	1%
Biochemical oxygen demand	-	1993-2005	136	2.03	2.00	0.40	5.50	-	-
E. coli (cfu/100mL)	260	1993-2017	231	552	150	2	24,000	83	36%
Total suspended solids	40	1993-2017	274	9.1	4.1	0.3	280.0	13	5%
Turbidity (NTU)	5.6	1993-2017	275	11.7	6.3	0.8	230.0	153	56%
Black Disc Clarity (m)	<0.6	1995-2009	156	0.73	0.70	0.05	4.00	57	37%
Total Phosphorus	0.033	1993-2017	275	0.054	0.044	0.010	0.460	134	49%
Soluble reactive phosphorus	0.01	1993-2017	274	0.018	0.018	<0.005	0.070	242	88%
Total nitrogen	0.614	2009-2017	97	0.465	0.330	0.140	1.700	12	12%
Ammoniacal nitrogen	0.021	1993-2017	270	0.031	0.023	<0.005	0.104	144	53%
Nitrate nitrogen	50	1993-2005	137	0.247	0.239	0.004	1.257	0	0%
Nitrite nitrogen	0.1	1993-2000	84	0.008	0.008	<0.002	0.027	0	0%
Nitrate-Nitrite (TON) nitrogen	0.444	1993-2017	274	0.189	0.170	<0.002	1.270	17	6%
Total Kjeldahl Nitrogen	-	2005-2017	138	0.377	0.250	0.120	2.600	-	-
Total Copper	0.0014[C]	2009-2017	79	0.00103	0.00074	0.00023	0.0086	12	15%
Dissolved Copper	0.0014[C]	2009-2017	79	0.00059	0.00048	0.00011	0.0020	2	3%
Dissolved Zinc	0.008[C]	2009-2017	79	0.0039	0.0025	0.0003	0.0370	4	5%
Total Copper	0.008[C]	2009-2017	79	0.0019	0.0015	0.0003	0.0100	1	1%

Notes:

A - Trigger value is the lower guideline trigger value in Table 3, grey shading indicates value exceeds this trigger

B – This details the number of times and % of time monitored that the observed value exceeds the lower guideline trigger value

C - Trigger values are hardness dependant; these are values for a hardness of 30 mg/L $CaCO_3$

A.2 Hōteo River water quality summary tables

Table 13 - Summary of existing NIWA water quality data for the Hōteo at Gubbs

Parameter (mg/L) unless stated	Trigger value[A]	Date range	#	Data summary				Exceeds[B]	
				Mean	Median	Min	Max	#	%
Dissolved Oxygen	<5	1989-2016	334	9.08	9.05	6.5	12.0	0	0%
Dissolved Oxygen (% Saturation)	-	1989-2016	335	90.0	90.8	71.2	106.6	-	-
Conductivity (mS/cm)	-	1989-2016	335	0.187	0.186	0.122	0.258	-	-
Temp (°C)	-	1989-2016	335	15.5	15.2	6.8	23.9	-	-
pH (pH units)	6.5-8.5	1989-2016	334	7.41	7.41	6.57	8.03	0	0%
Biochemical oxygen demand	-	1989-2002	165	0.734	0.600	<0.100	4.25	-	-
E. coli (cfu/100mL)	260	2005-2016	140	298	123	9	3448	33	24%
Total suspended solids[C]	40	2010-2015	148	127.4	102.3	0.9	570.0	125	84%
Suspended sediment conc[C]	40	2010-2016	245	125.5	100.8	2.0	601.0	215	88%
Turbidity[C] (laboratory) (NTU)	5.6	2012-2014	66	96.3	80.2	3.8	398.0	62	94%
Turbidity (monthly) (NTU)	5.6	1989-2016	336	14.6	8.0	1.2	380.0	257	76%
Turbidity (continuous) (NTU)	5.6	2011-2016	-	15.3	5.3	0.0	3277	-	63%
Visual Clarity (m)	<0.6	1989-2016	335	0.93	0.81	0.03	4.00	107	32%
Total Phosphorus	0.033	1989-2016	335	0.063	0.054	0.018	0.465	305	91%
Soluble reactive phosphorus	0.01	1989-2016	336	0.020	0.019	0.005	0.069	308	92%
Total nitrogen	0.614	1989-2016	322	0.686	0.633	0.205	2.235	166	36%
Ammoniacal nitrogen	0.021	1989-2016	323	0.021	0.014	0.001	0.118	114	35%
Nitrate-Nitrite (TON) nitrogen	0.444	1989-2016	336	0.351	0.337	0.001	1.799	123	37%

Notes:

A - Trigger value is the lower guideline trigger value in Table 3, grey shading indicates value exceeds this trigger

B – This details the number of times and % of time monitored that the observed value exceeds the lower guideline trigger value

C – Sampling is event trigger based and only reflects high flow situations, as such the mean and median do not reflect general flow conditions

Table 14 - Summary of Council water quality data for Waiteitei at Sandersons

Parameter (mg/L) unless stated	Trigger value[B]	Date range	#	Mean	Median	St Dev	Min	Max
Turbidity[A] (laboratory) (NTU)	5.6	2011-2014	226	129.1	94.9	105.8	1.6	488.0
Total suspended solids[A]	5.6	2011-2014	169	131.2	85.0	130.1	2.0	608.0
Suspended sediment concentration	40	2012-2014	36	225.7	169.5	178.3	2.0	678.0
Inorganic suspended sediment conc[A]	40	2012-2014	89	154.8	125.0	124.3	1.3	528.0
Turbidity (in-situ continuous) (NTU)	5.6	2011-2016	-	11.1	4.1	31.0	0.0	3988

Notes:

A – Sampling is event trigger based and only reflects high flow situations, as such the mean and median do not reflect general flow conditions.

B - Trigger value is the lower guideline trigger value in Table 3, grey shading indicates value exceeds this trigger

A.3 Mahurangi River suspended sediment and turbidity graphs

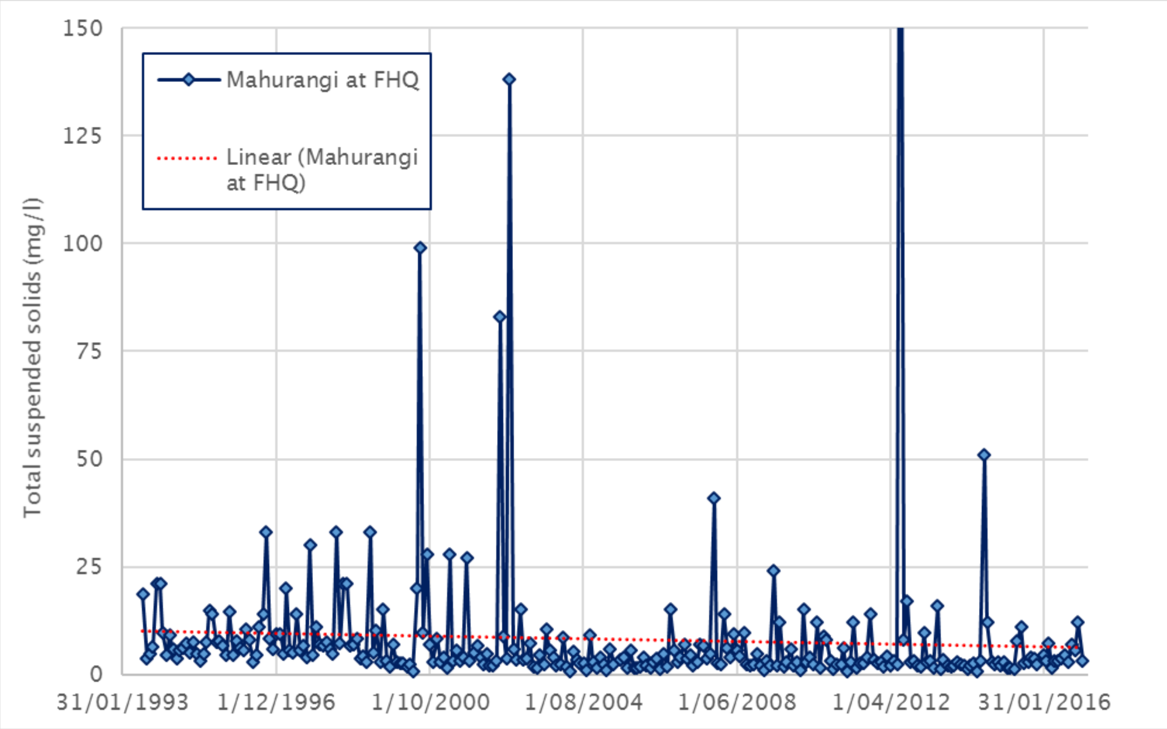

Figure 7 - Total suspended solids at Mahurangi at FHQ from 1993 – 2016 (Note: outlier of 260 mg/L recorded on the 03/07/2012 outside of the window, this is to aid data viewing)

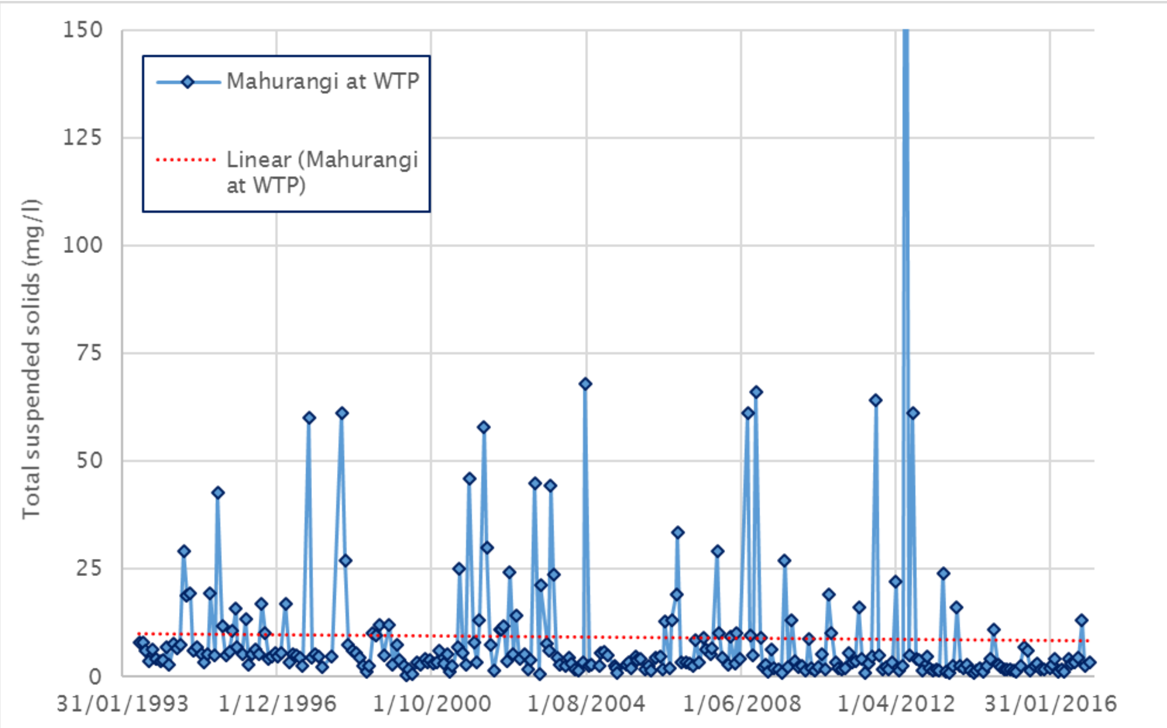

Figure 8 - Total suspended solids (mg/L) at Mahurangi at WTP from 1993 – 2016 (Note: outlier of 280 mg/L recorded on the 03/07/2012 outside of the window, this is to aid data viewing)

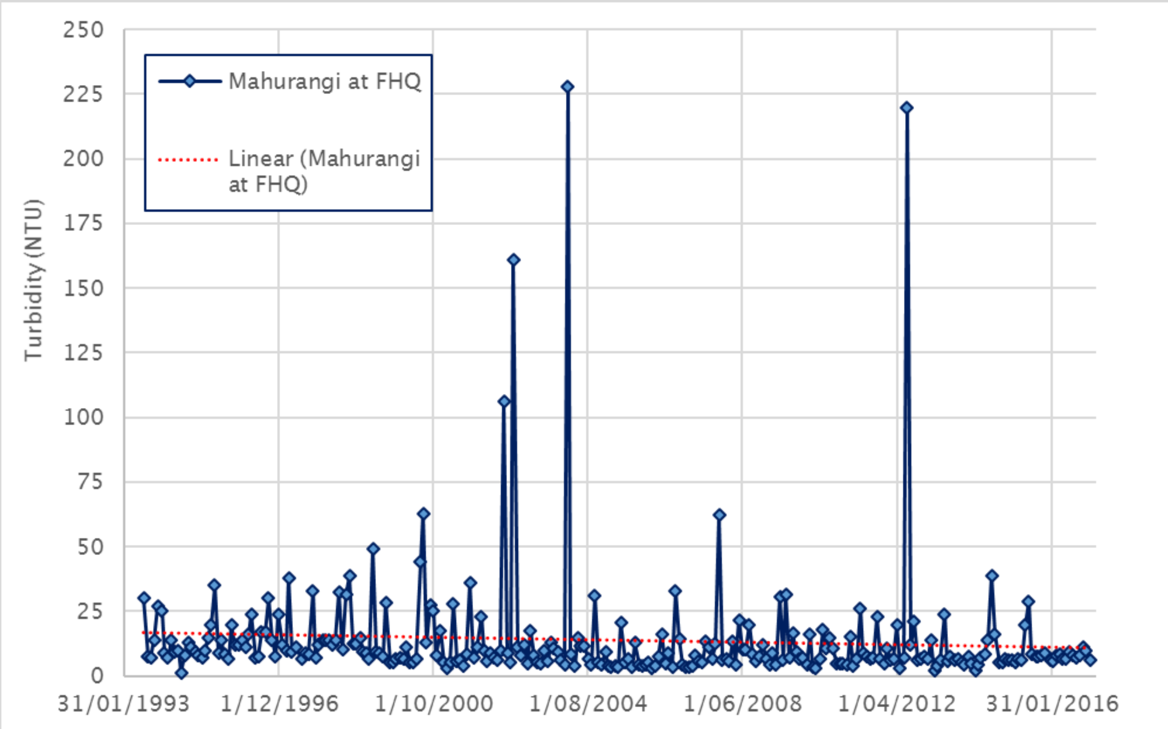

Figure 9 - Turbidity (NTU) at Mahurangi at FHQ from 1993 – 2016

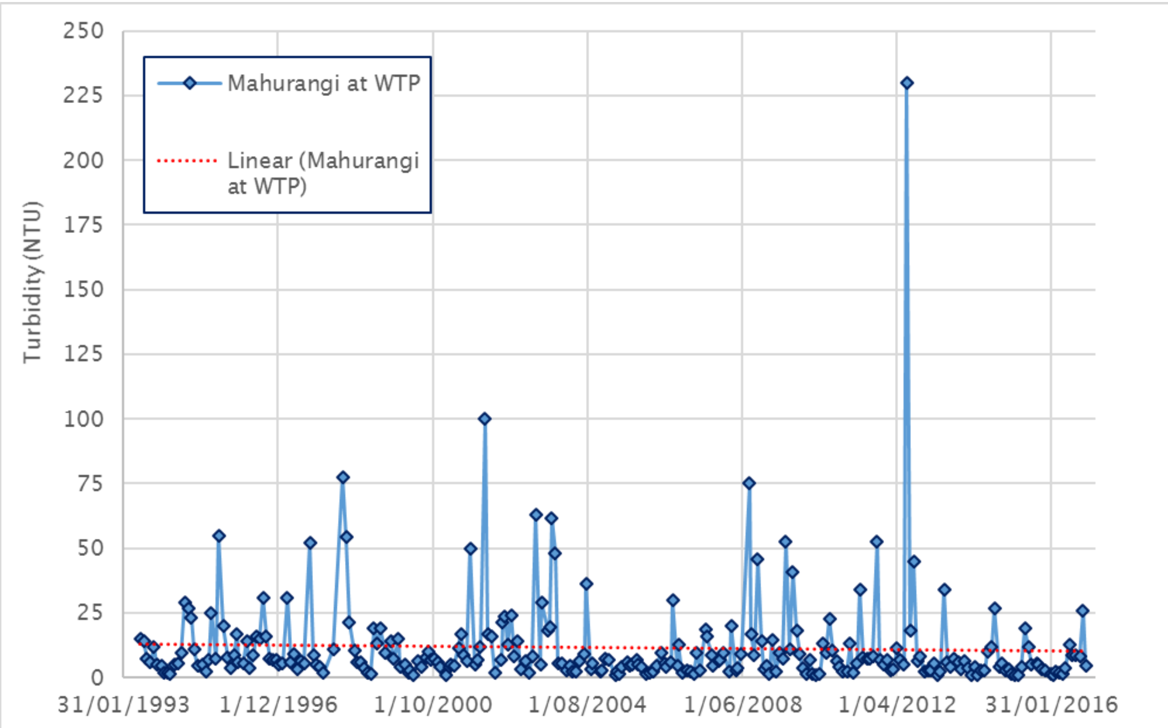

Figure 10 - Turbidity (NTU) at Mahurangi at WTP from 1993 – 2016

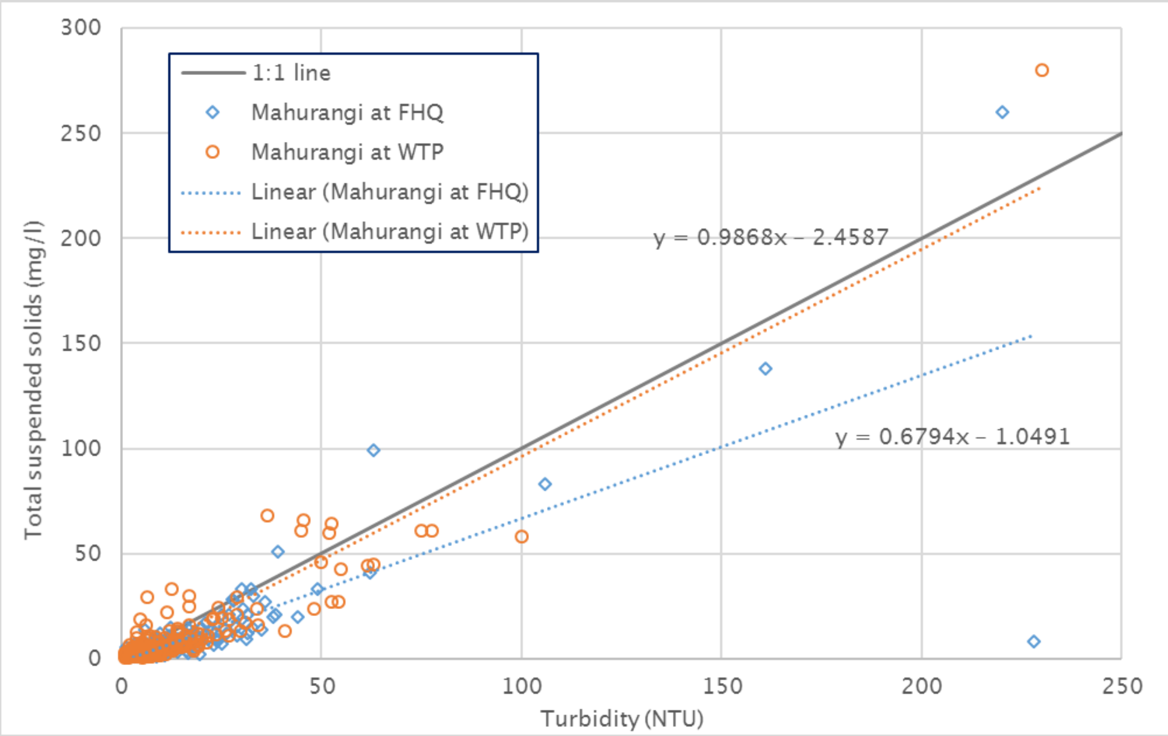

Figure 11 - Turbidity (NTU) vs total suspended solids (mg/L) for at Mahurangi at FHQ and Mahurangi at WTP

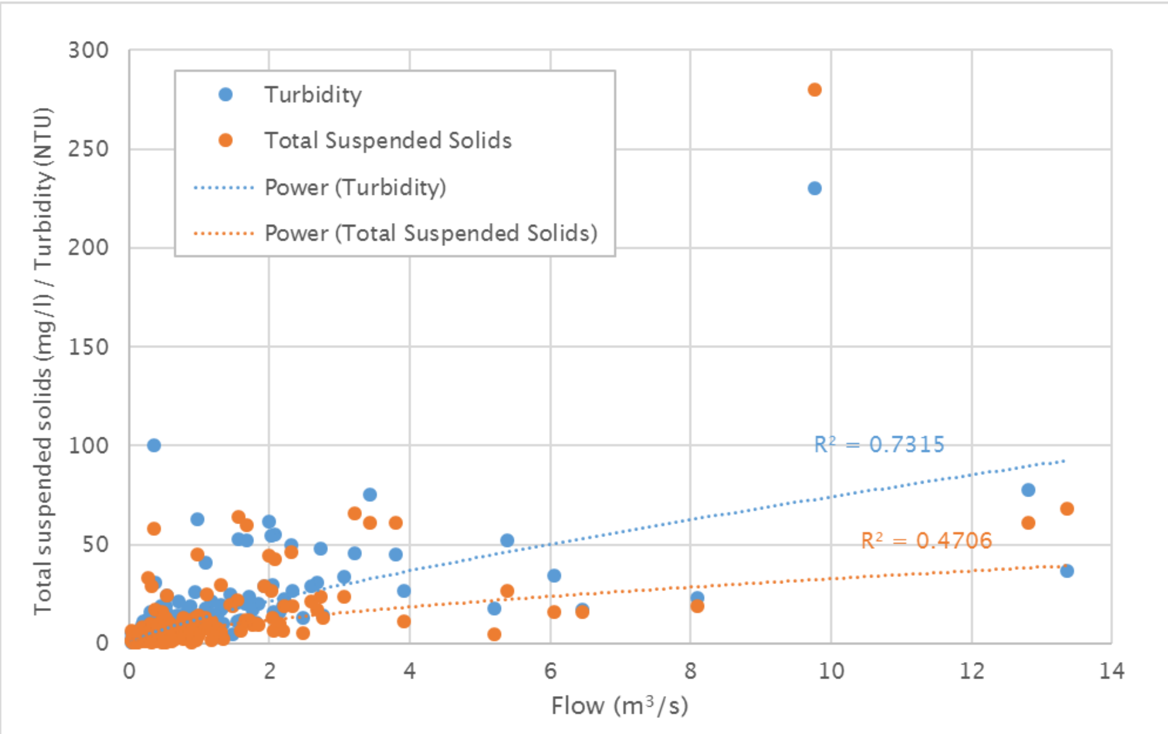

Figure 12 - Turbidity (NTU) and total suspended solids (mg/L) for at Mahurangi at WTP plotted against flow at Mahurangi at College

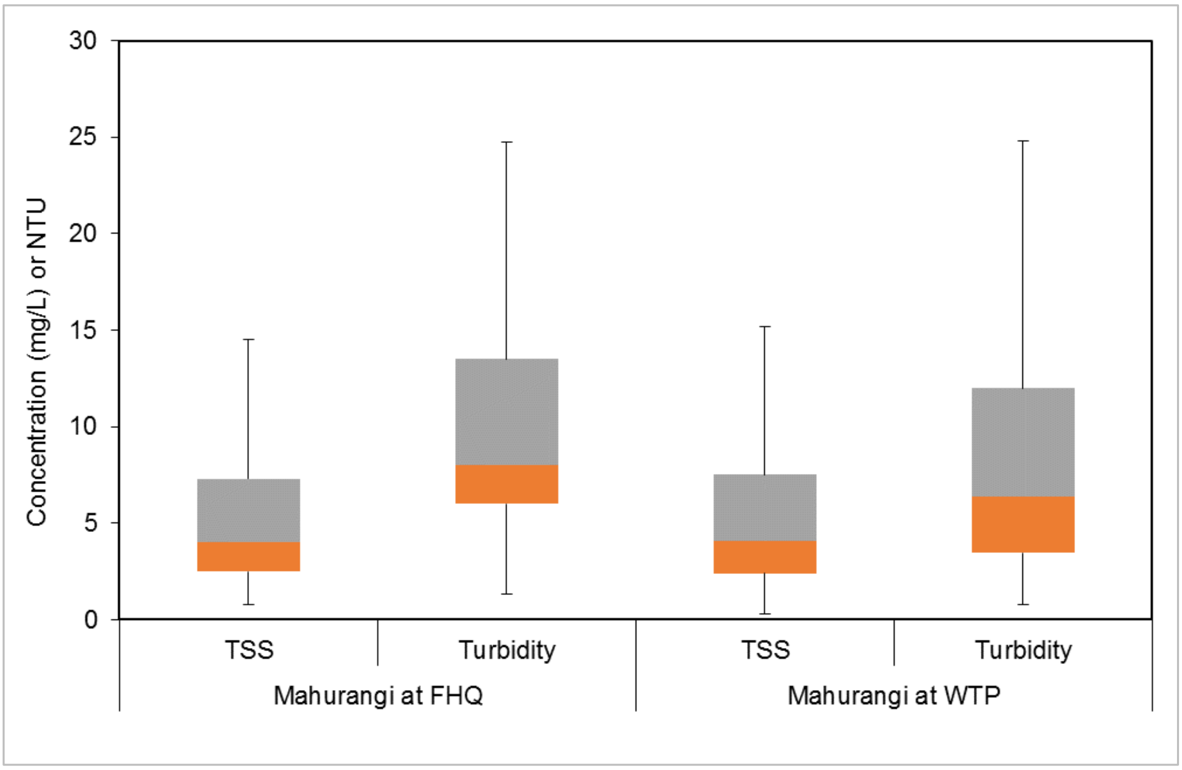

Figure 13 – Comparison of turbidity (NTU) and total suspended solids (mg/L) at Mahurangi FHQ and Mahurangi WTP

A.4 Hōteo River suspended sediment and turbidity graphs

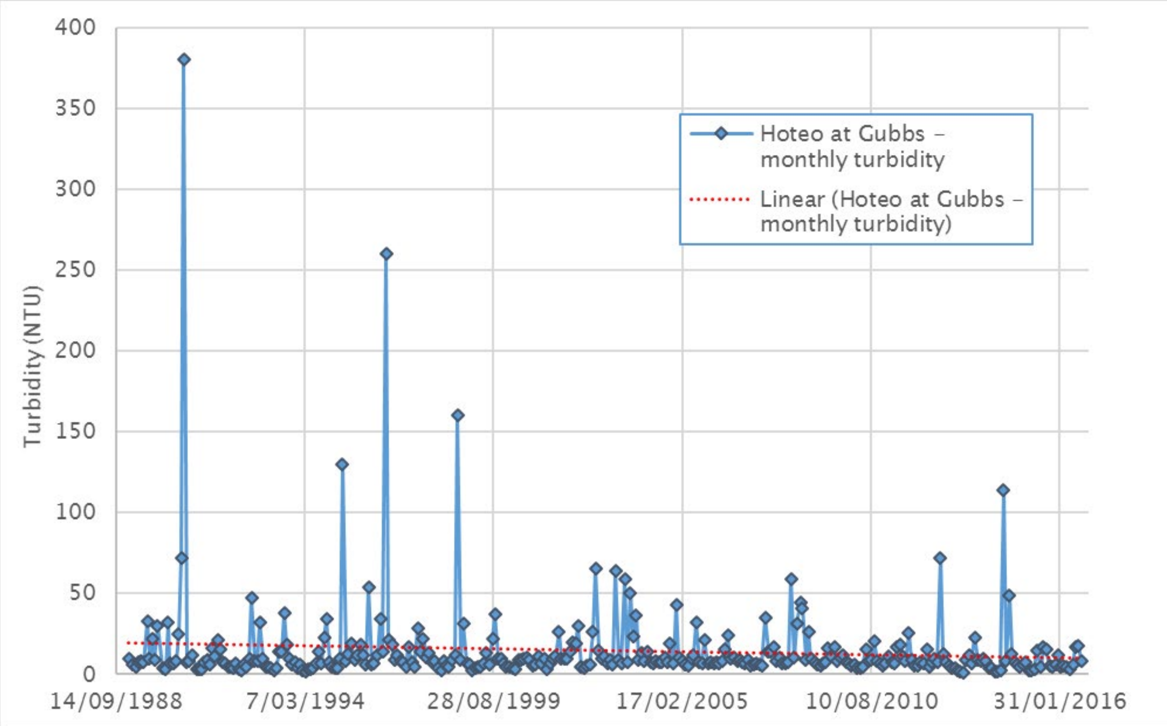

Figure 14 – Monthly turbidity (NTU) at Hōteo at Gubbs from 1989 - 2016

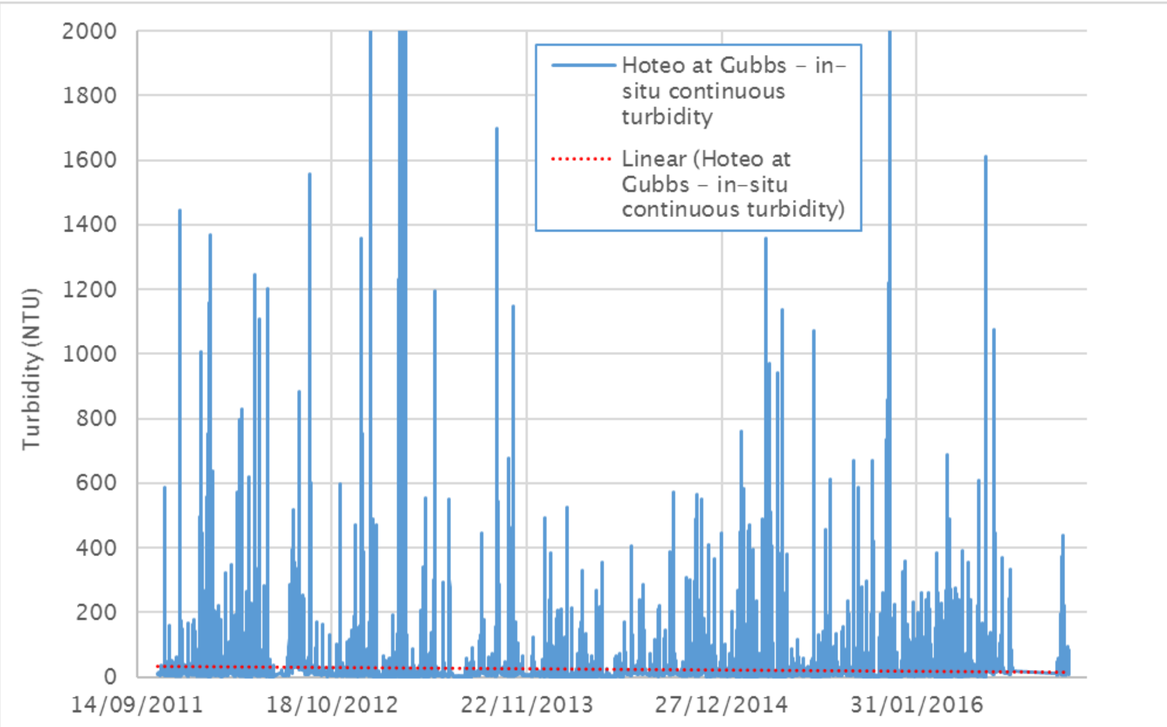

Figure 15 – Continuous in-situ turbidity (NTU) at Hōteo at Gubbs from 2011-2016 (Note: outliers above 1500NTU outside of the window, this is to aid data viewing)

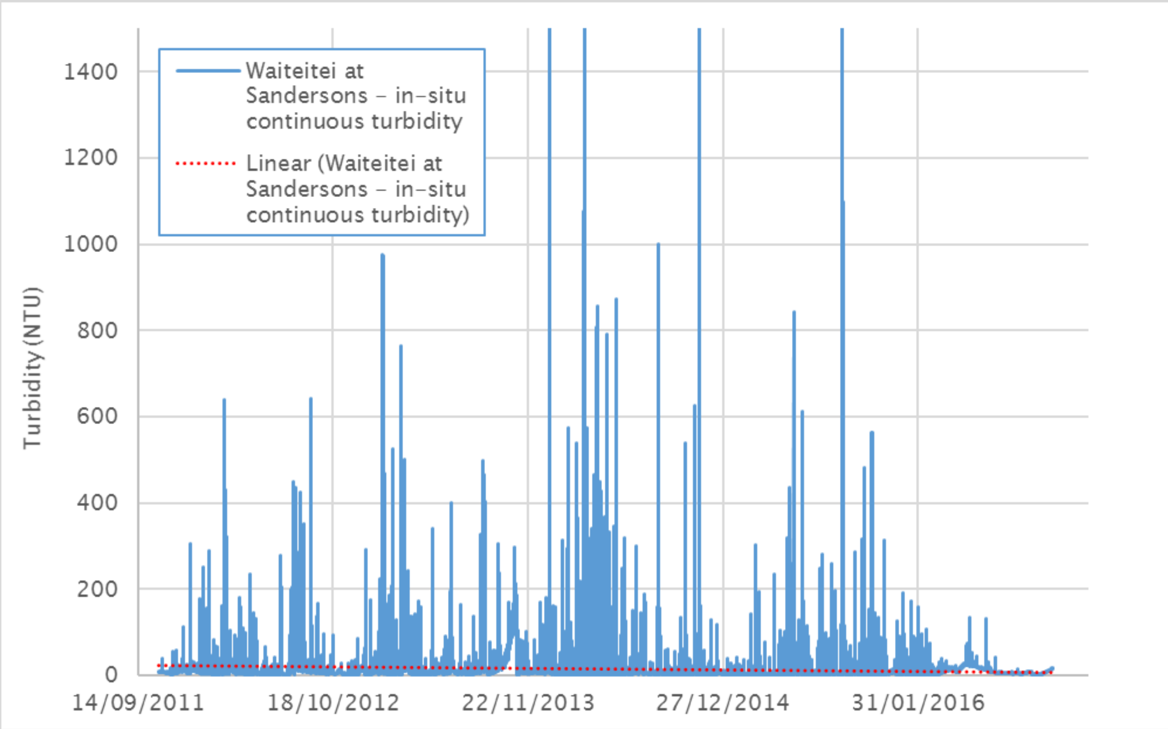

Figure 16 – Continuous in-situ turbidity (NTU) at Waiteitei at Sandersons from 2011-2016 ((Note: outliers above 1500NTU outside of the window, this is to aid data viewing)

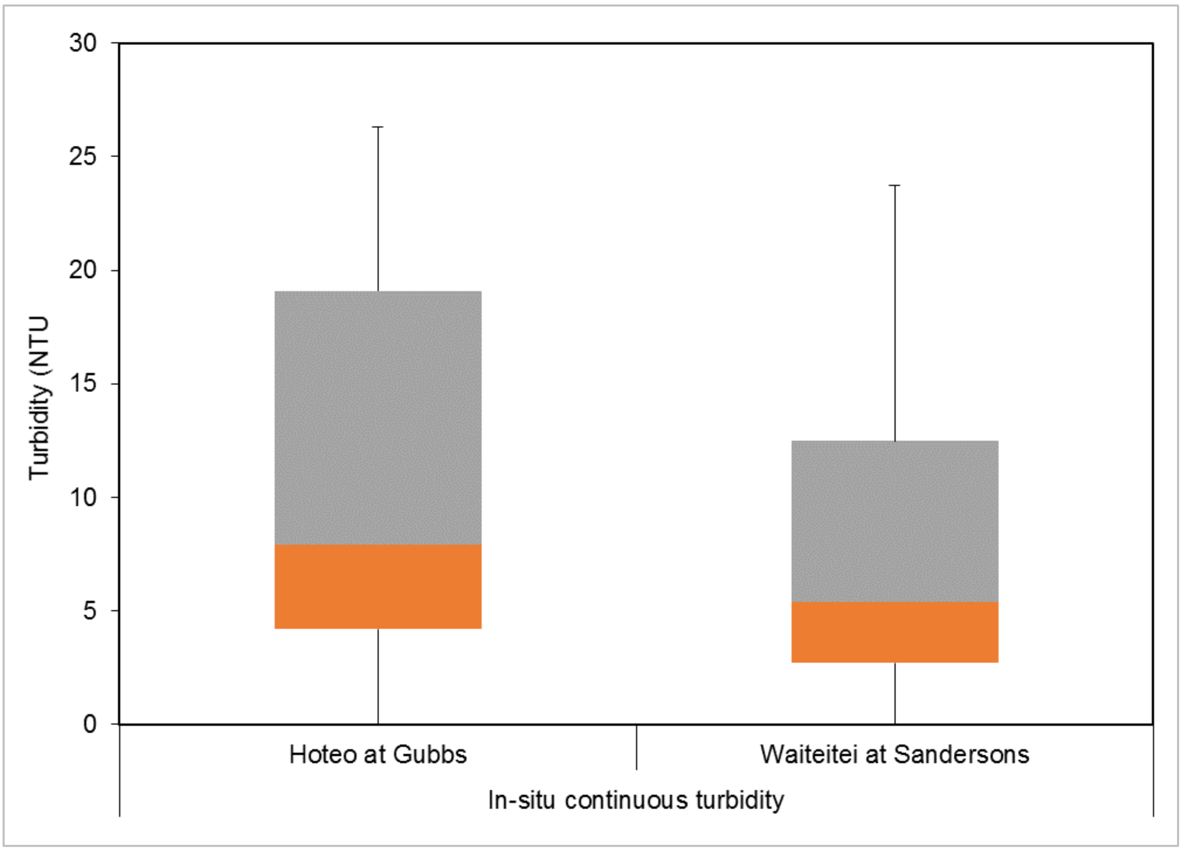

Figure 17 – Comparison of continuous in-situ turbidity (NTU) at Hōteo at Gubbs and Waiteitei at Sandersons

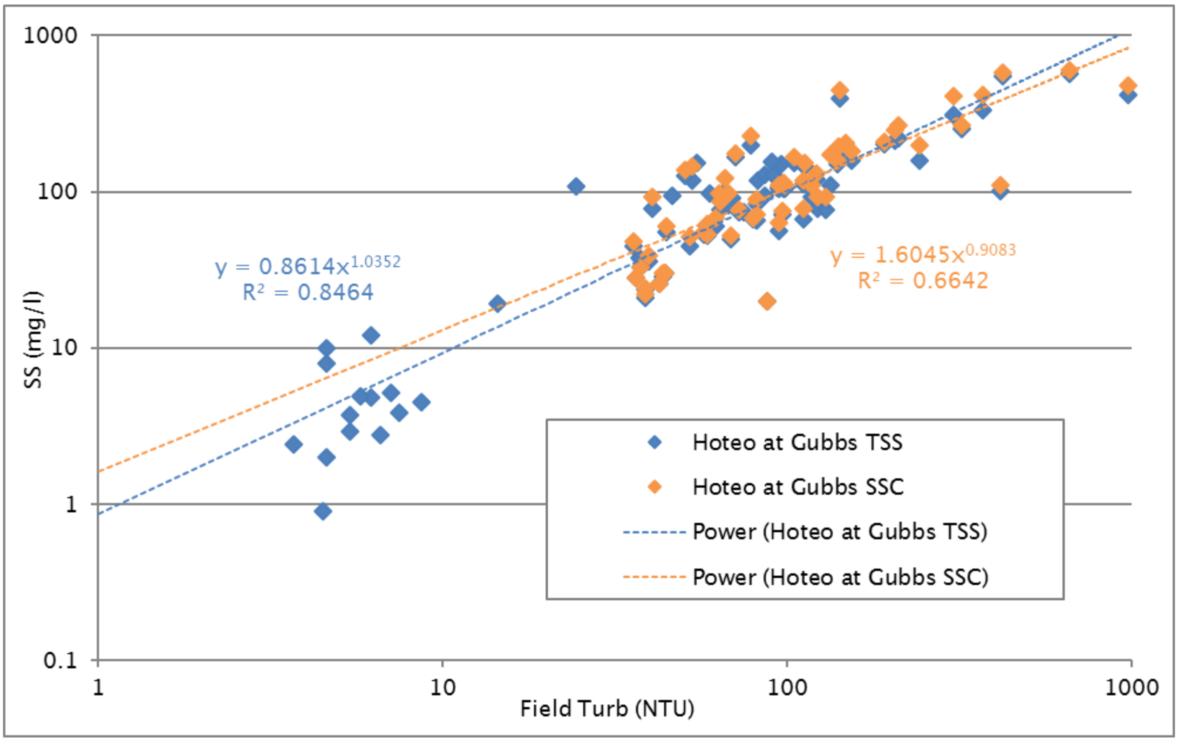

Figure 18 – Turbidity (NTU) vs total suspended solids (mg/L) and suspended sediment concentration (mg/L) for Hōteo at Gubbs (provided by NIWA 4 October 2017)

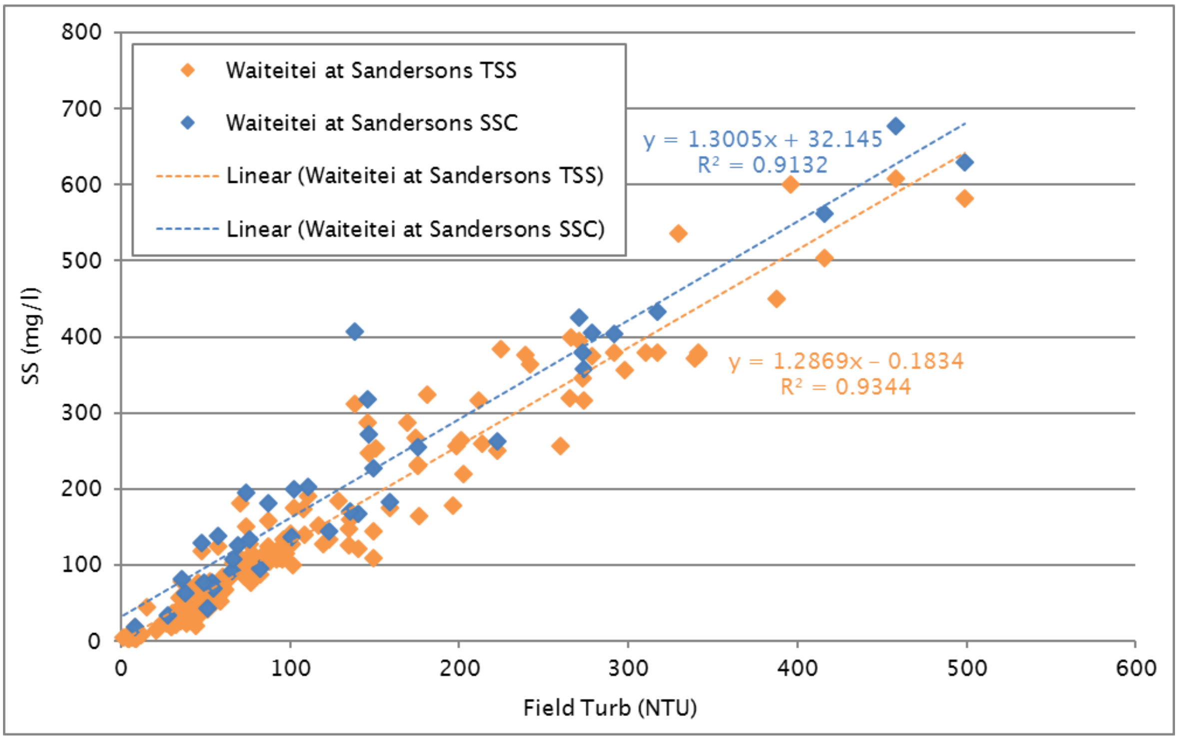

Figure 19 – Turbidity (NTU) vs total suspended solids (mg/L) and suspended sediment concentration (mg/L) for Waiteitei at Sandersons (provided by NIWA 4 October 2017)

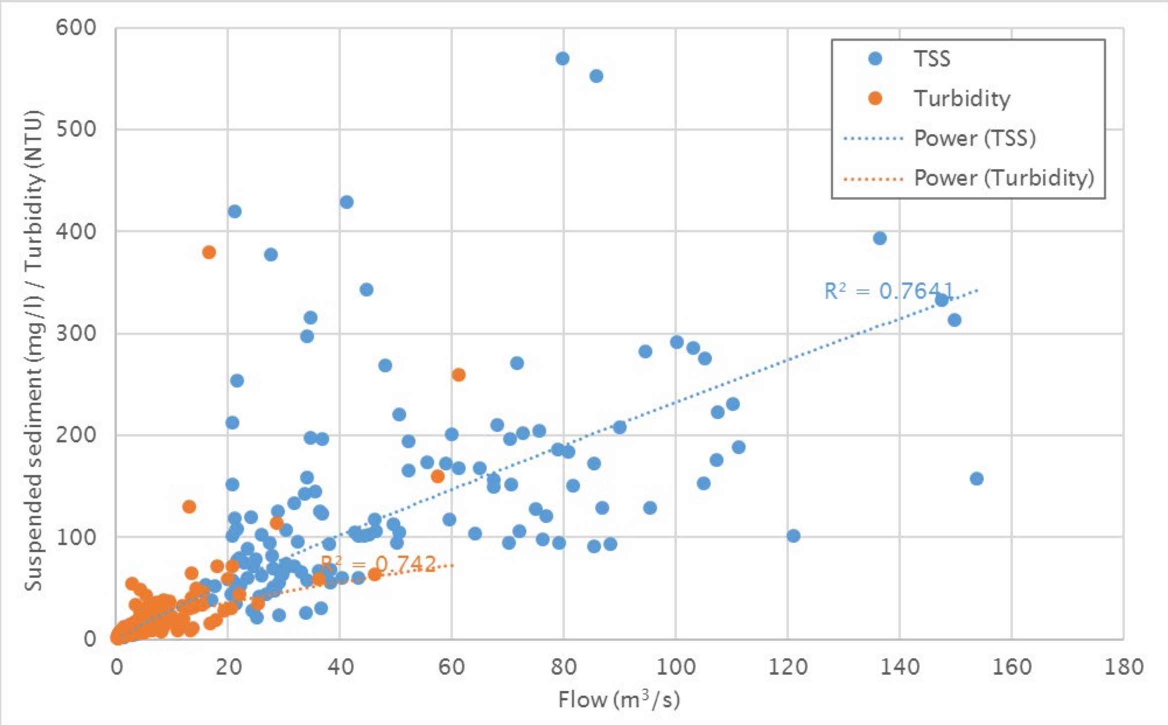

Figure 20 – Turbidity (NTU) and total suspended solids (mg/L) for at Hōteo at Gubbs plotted against flow

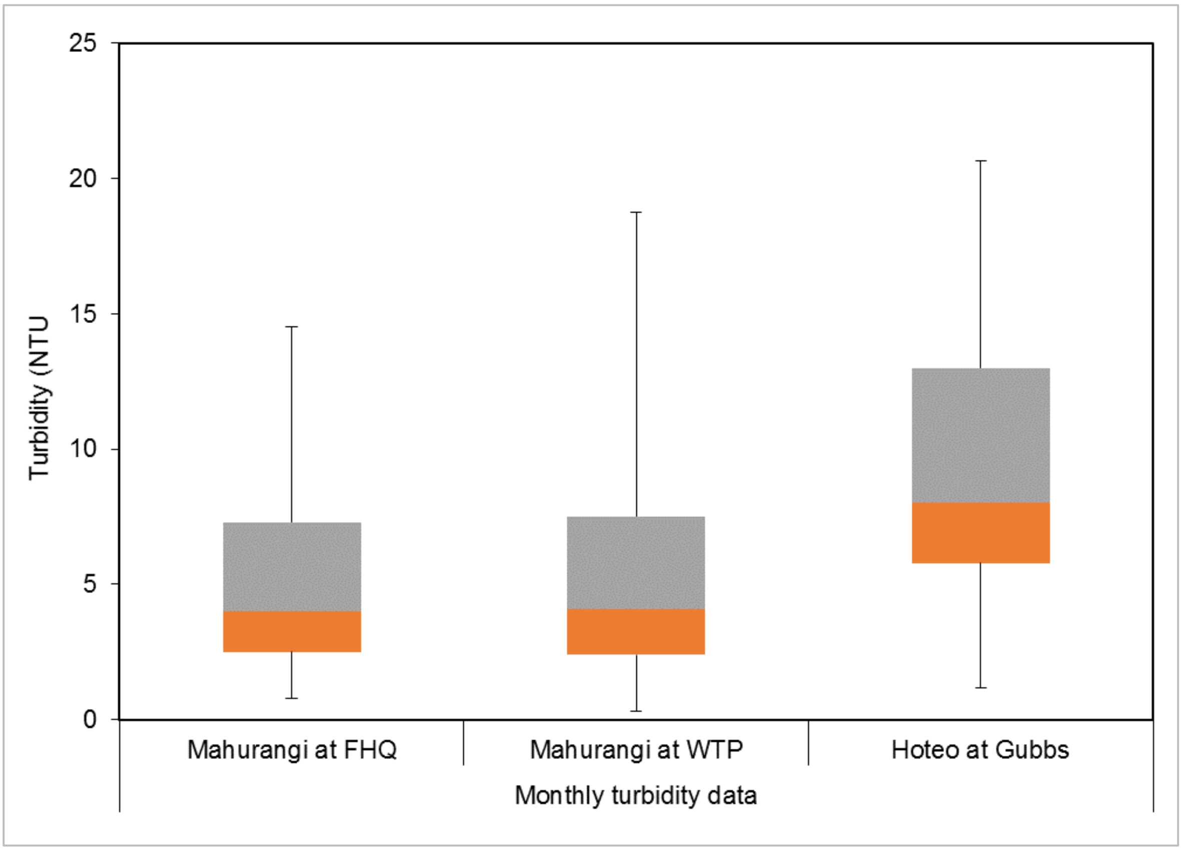

Figure 21 - Comparison of monthly turbidity monitoring (NTU) at Hōteo River at Gubbs and Mahurangi River locations

A.5 Mahurangi River metals graphs

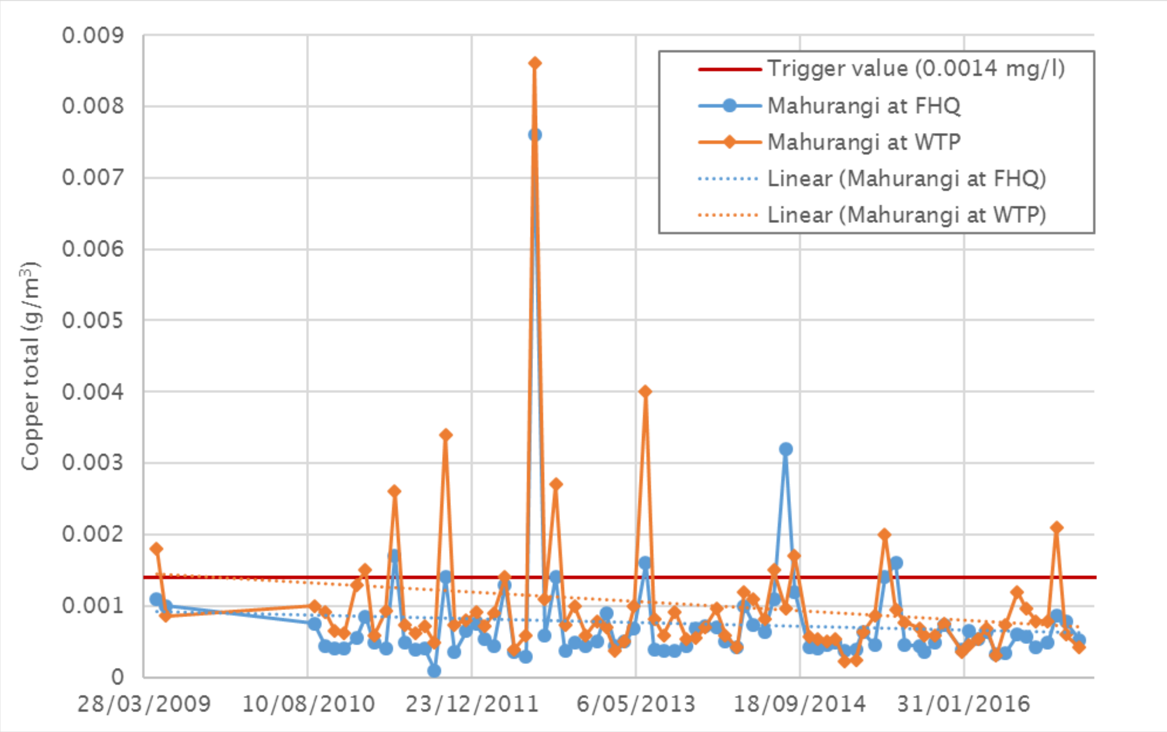

Figure 22 – Total Copper concentration (mg/L) at Mahurangi at FHQ and Mahurangi WTP over time, including a comparison to ANZECC trigger value

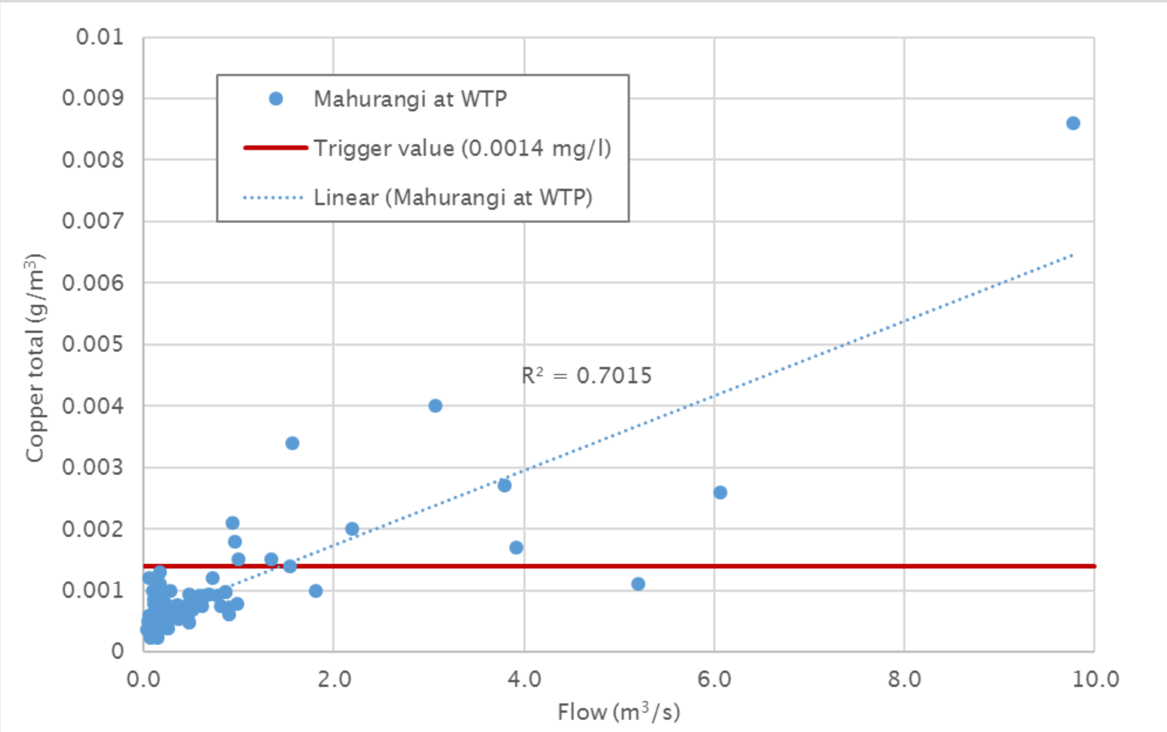

Figure 23 – Comparison of Total Copper concentration (mg/L) and daily flow (m^3/s) at Mahurangi at WTP

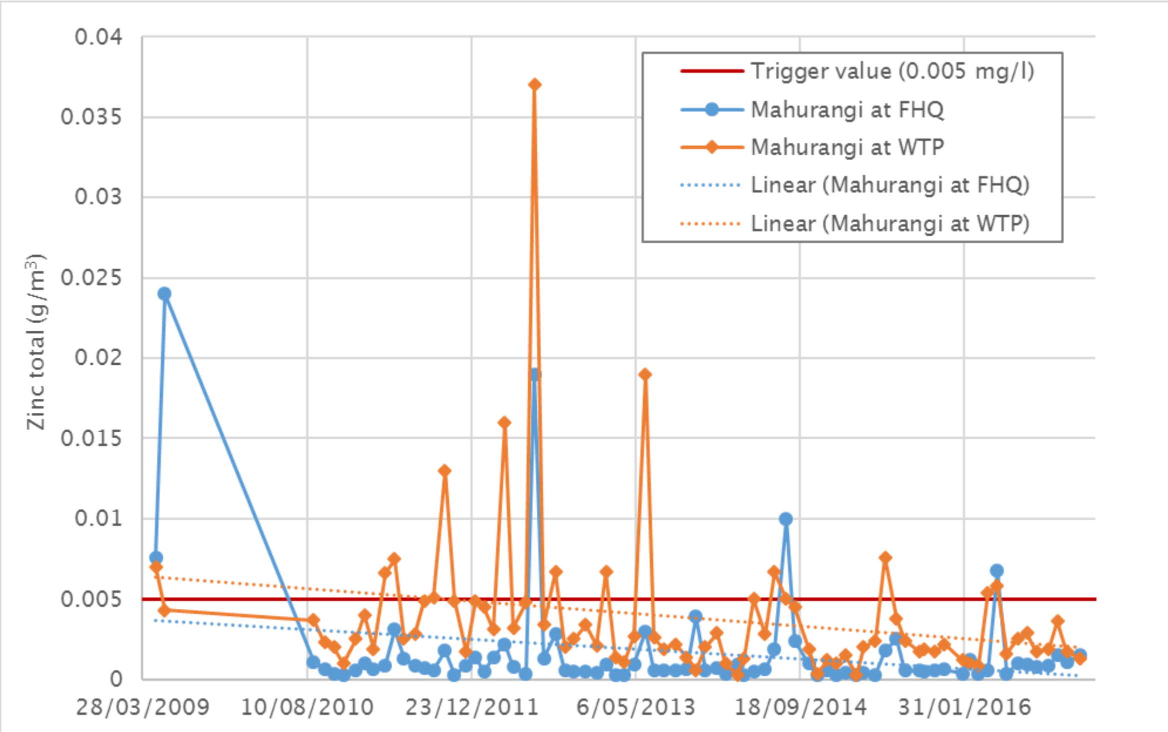

Figure 24 – Total Zinc concentration (mg/L) at Mahurangi at FHQ and Mahurangi WTP over time, including a comparison to ANZECC trigger value

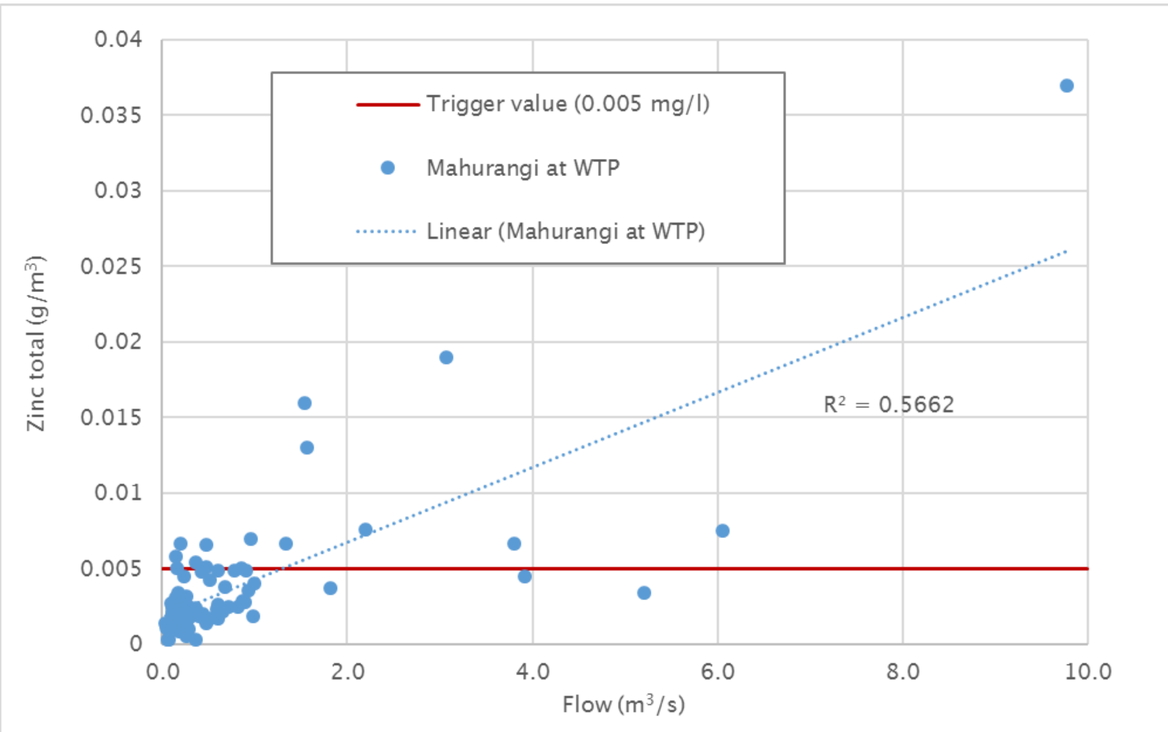

Figure 25 – Comparison of Total Zinc concentration (mg/L) and daily flow (m^3/s) at Mahurangi at WTP

A.6 Mahurangi River nutrients graphs

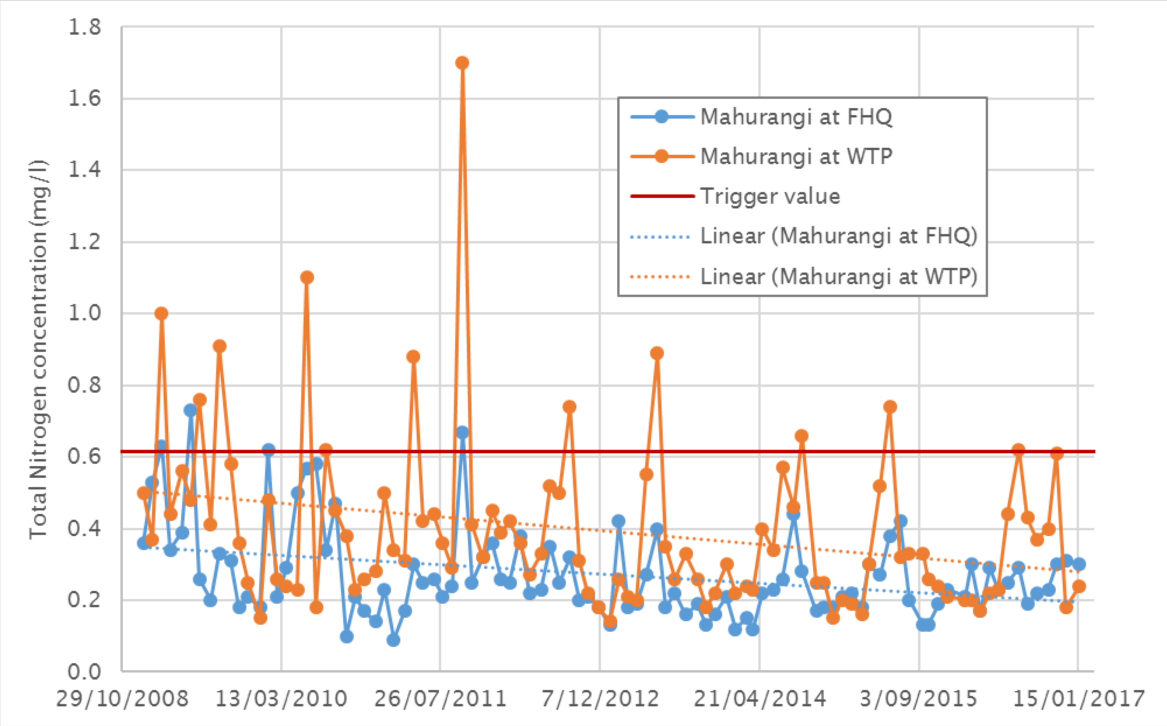

Figure 26 – Total Nitrogen concentration (mg/L) at Mahurangi at FHQ and Mahurangi WTP over time, including a comparison to ANZECC trigger value

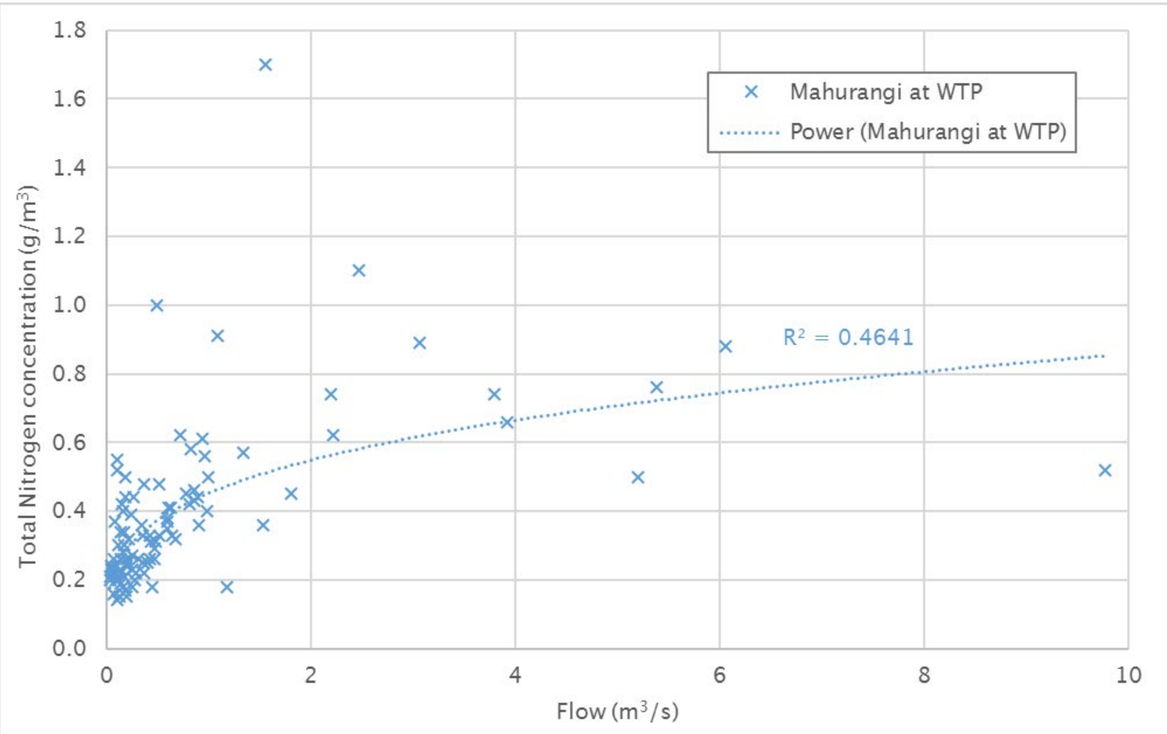

Figure 27 – Comparison of Total Nitrogen concentration (mg/L) and daily flow (m³/s) at Mahurangi at WTP

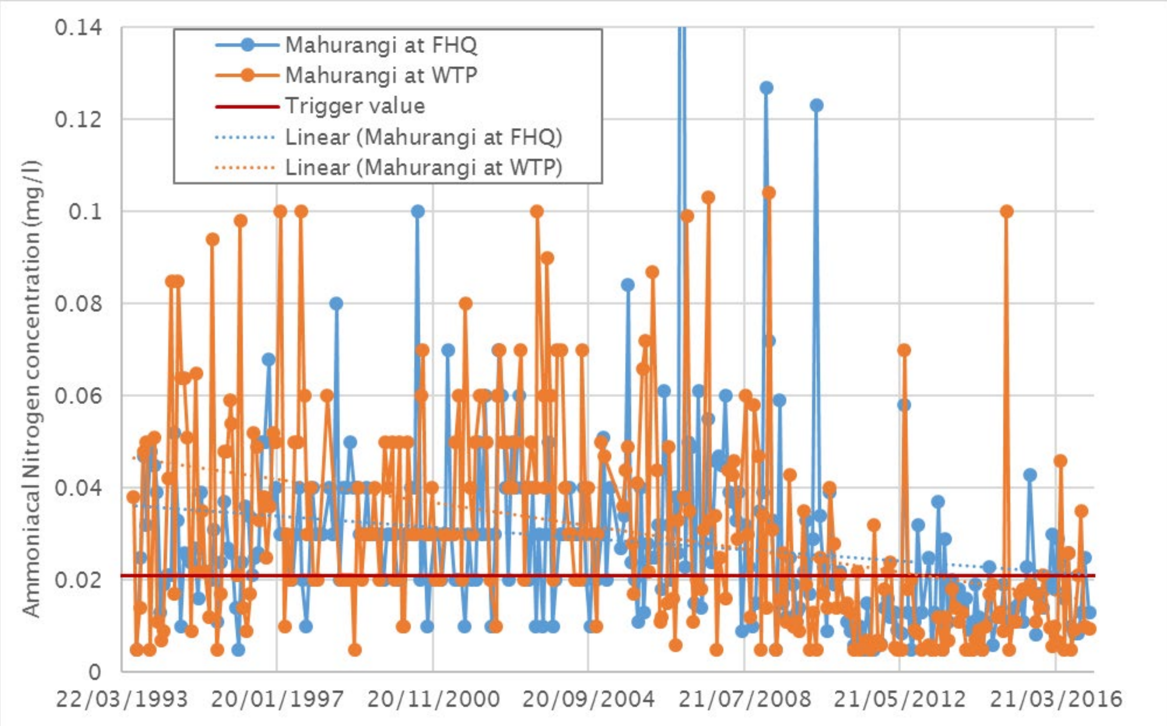

Figure 28 - Ammoniacal Nitrogen concentration (mg/L) at Mahurangi at FHQ and Mahurangi WTP over time, including a comparison to ANZECC trigger value (Note: Figure omits outlier of 0.4 on 4/1/2007 to assist reading of figure)

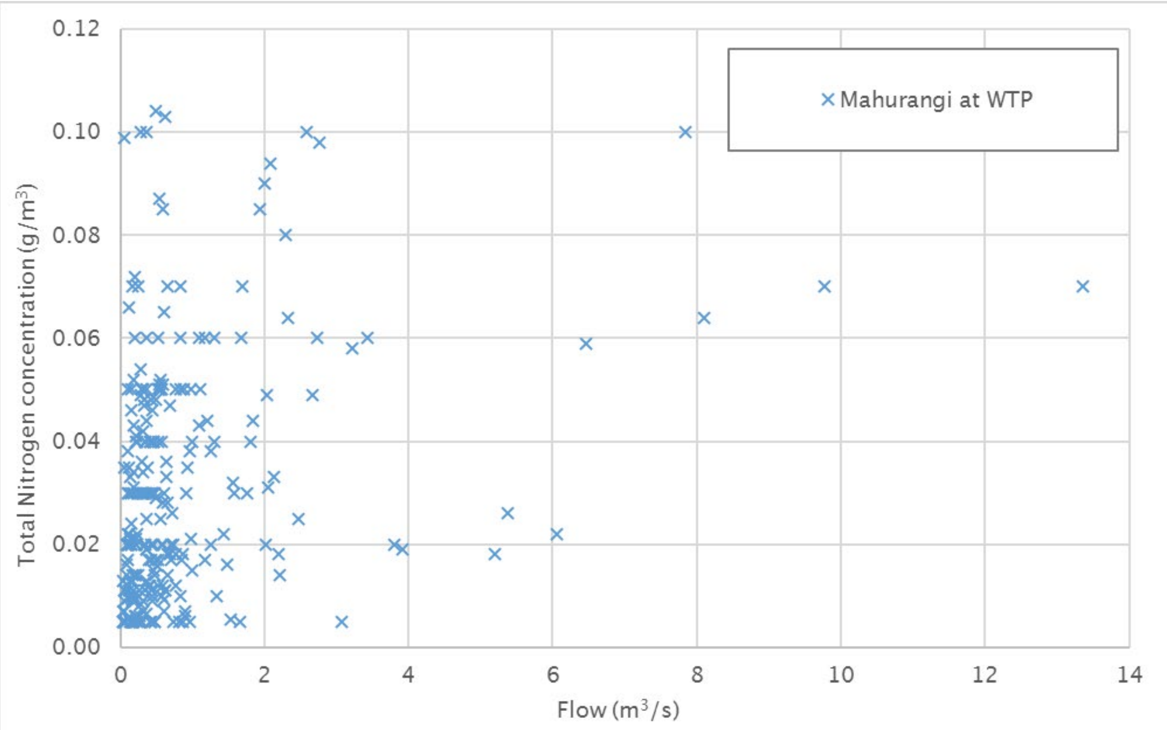

Figure 29 - Comparison of Ammoniacal Nitrogen concentration (mg/L) and daily flow (m^3/s) at Mahurangi at WTP

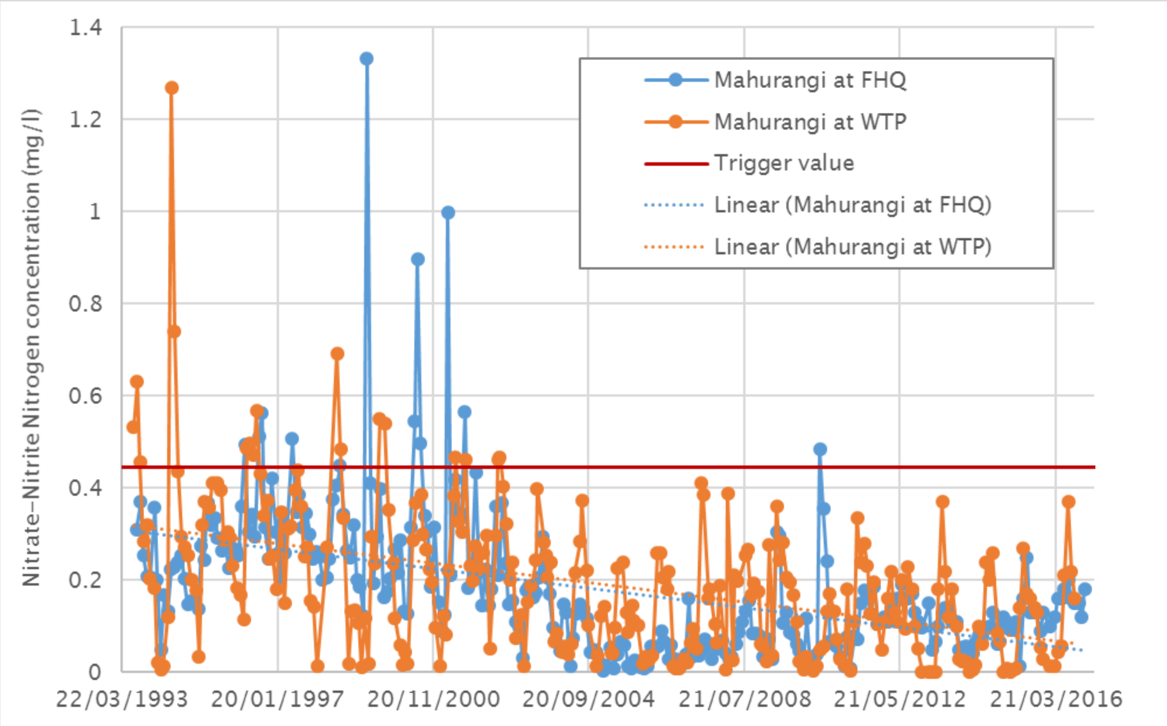

Figure 30 – Nitrate-Nitrite Nitrogen concentration (mg/L) at Mahurangi at FHQ and Mahurangi WTP over time, including a comparison to ANZECC trigger value

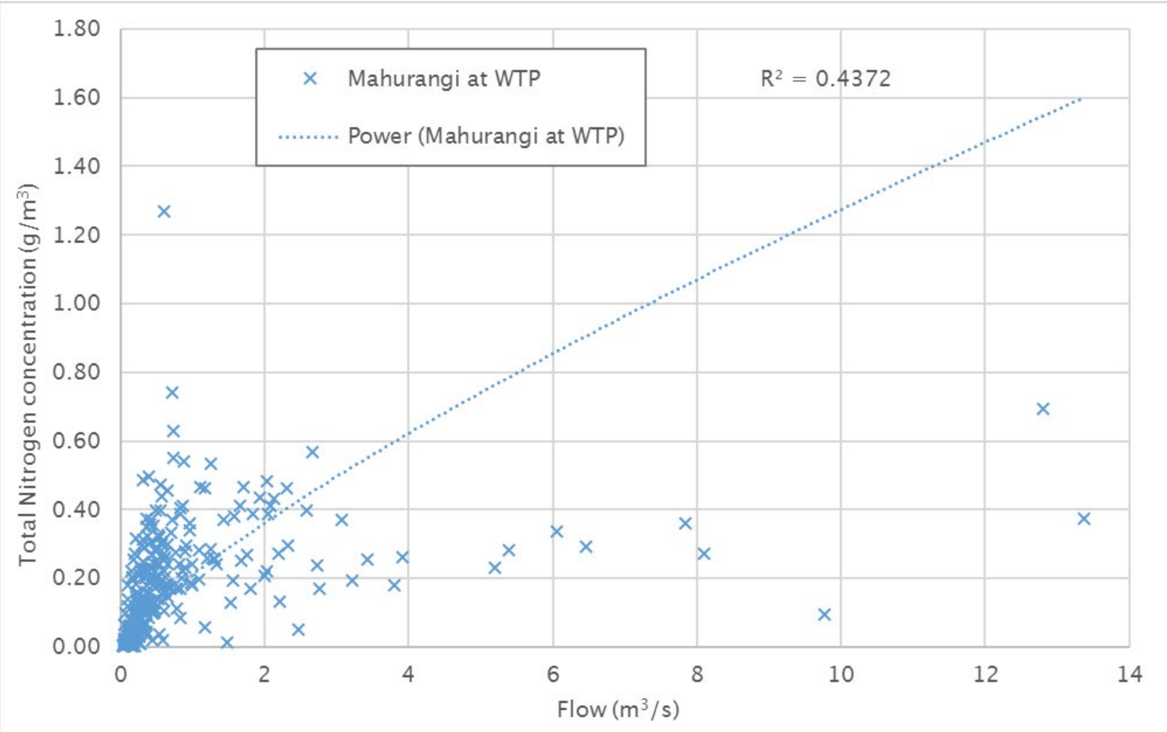

Figure 31 – Comparison of Nitrate-Nitrite Nitrogen concentration (mg/L) and daily flow (m³/s) at Mahurangi at WTP

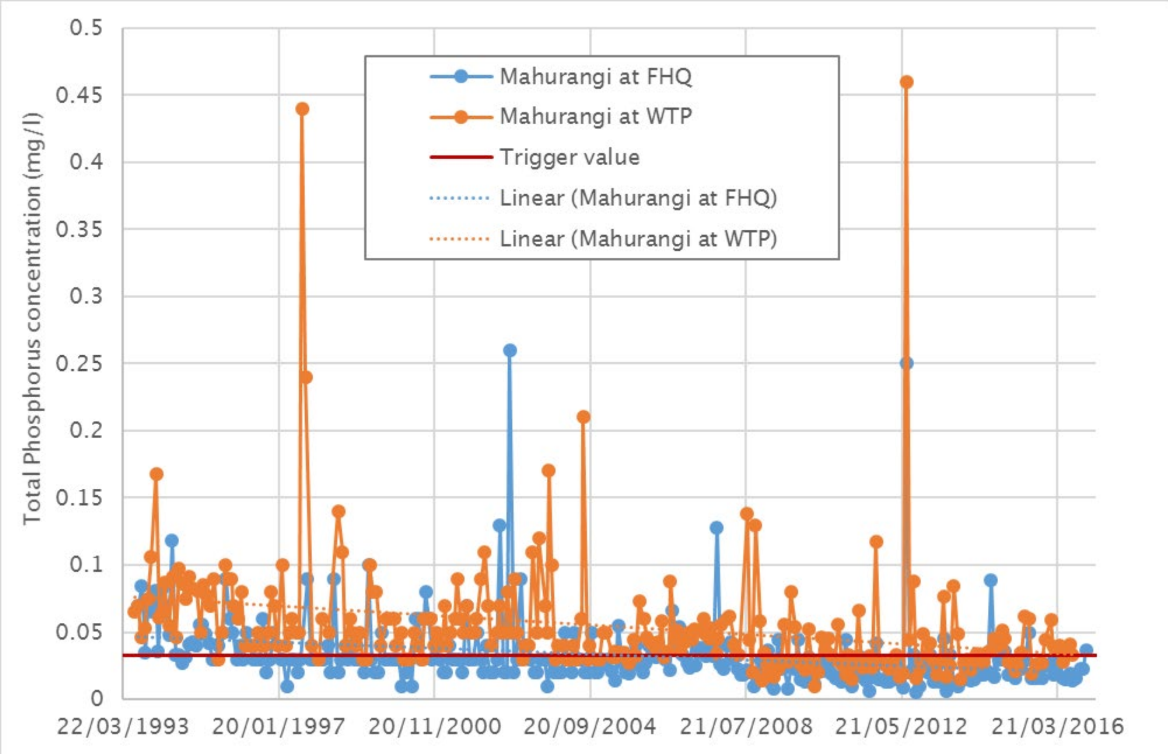

Figure 32 – Total Phosphorus concentration (mg/L) at Mahurangi at FHQ and Mahurangi WTP over time, including a comparison to ANZECC trigger value

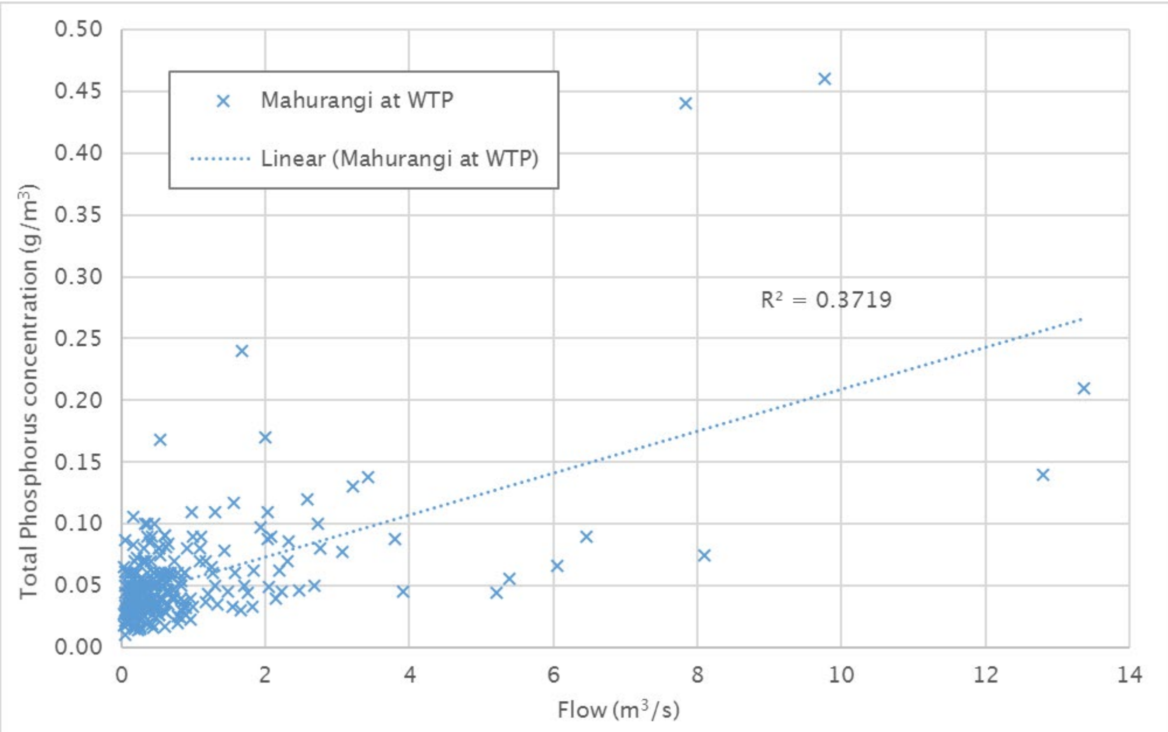

Figure 33 - Comparison of Total Phosphorus concentration (mg/L) and daily flow (m³/s) at Mahurangi at WTP

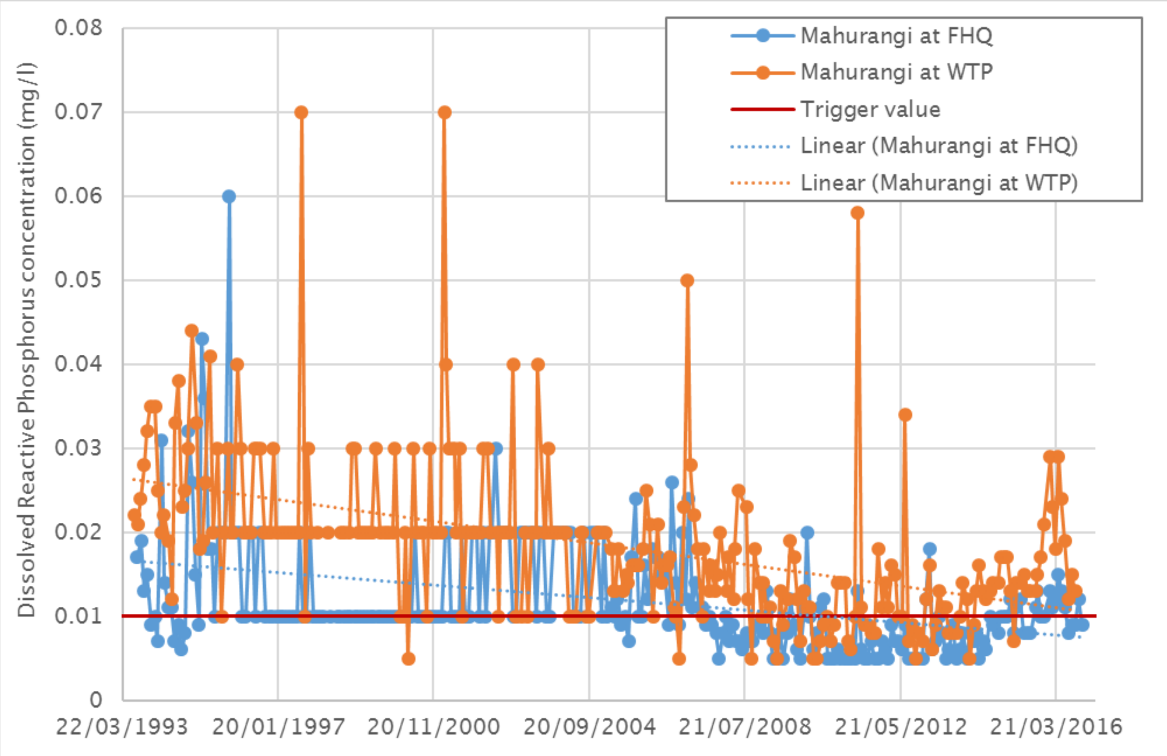

Figure 34 - Dissolved Reactive Phosphorus concentration (mg/L) at Mahurangi at FHQ and Mahurangi WTP over time, including a comparison to ANZECC trigger value

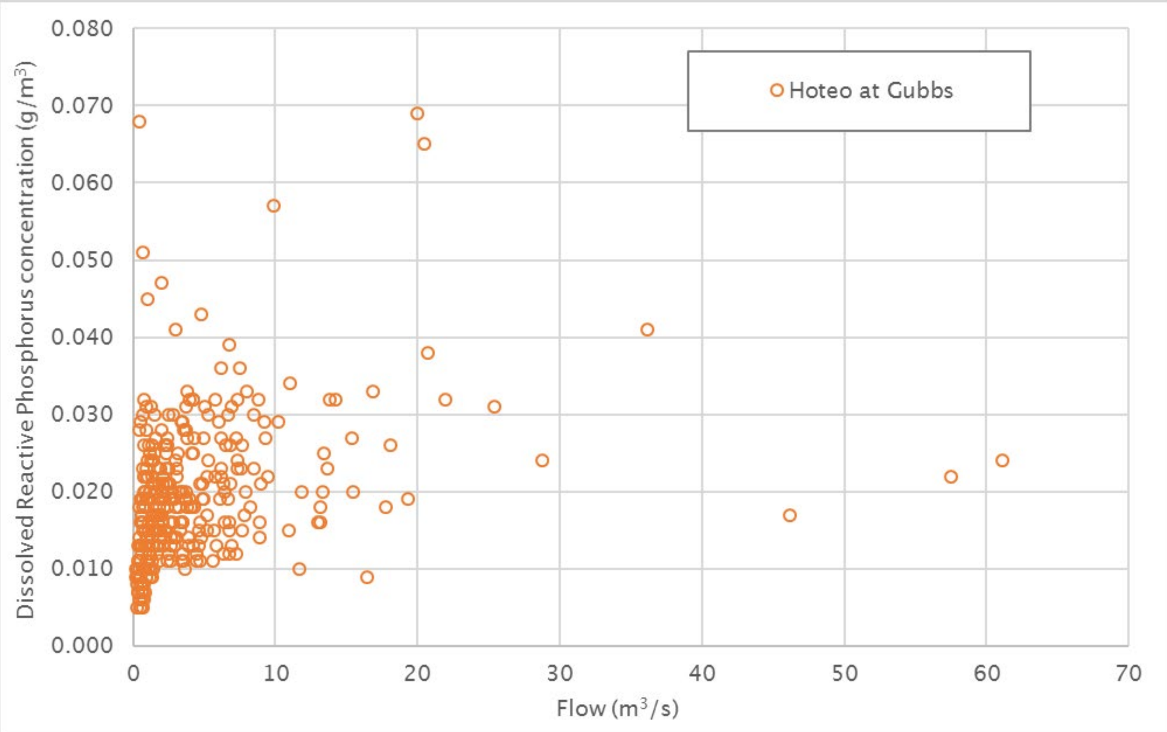

Figure 35 - Comparison of Dissolved Reactive Phosphorus concentration (mg/L) and daily flow (m³/s) at Mahurangi at WTP

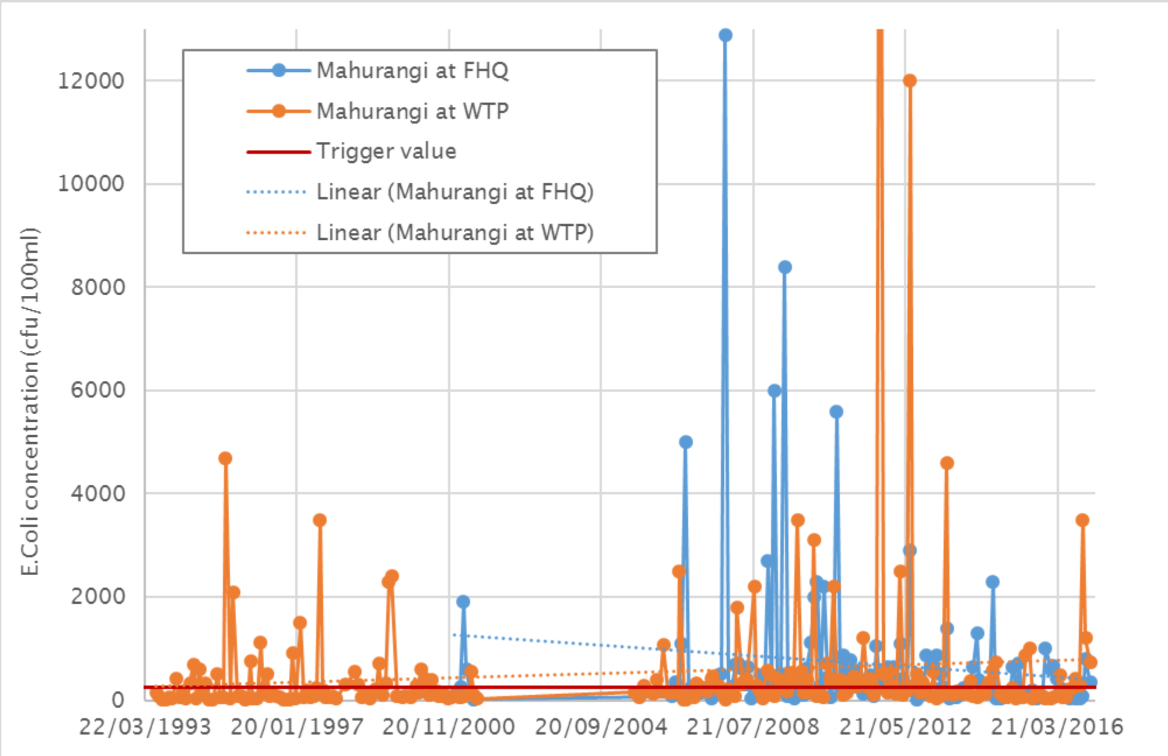

Figure 36 - E. Coli concentration (cfu/100ml) at Mahurangi at FHQ and Mahurangi WTP over time, including a comparison to ANZECC trigger value (Note: Value of 24,000cfu/100ml on 4/10/2011 cut off from graph to aid reading)

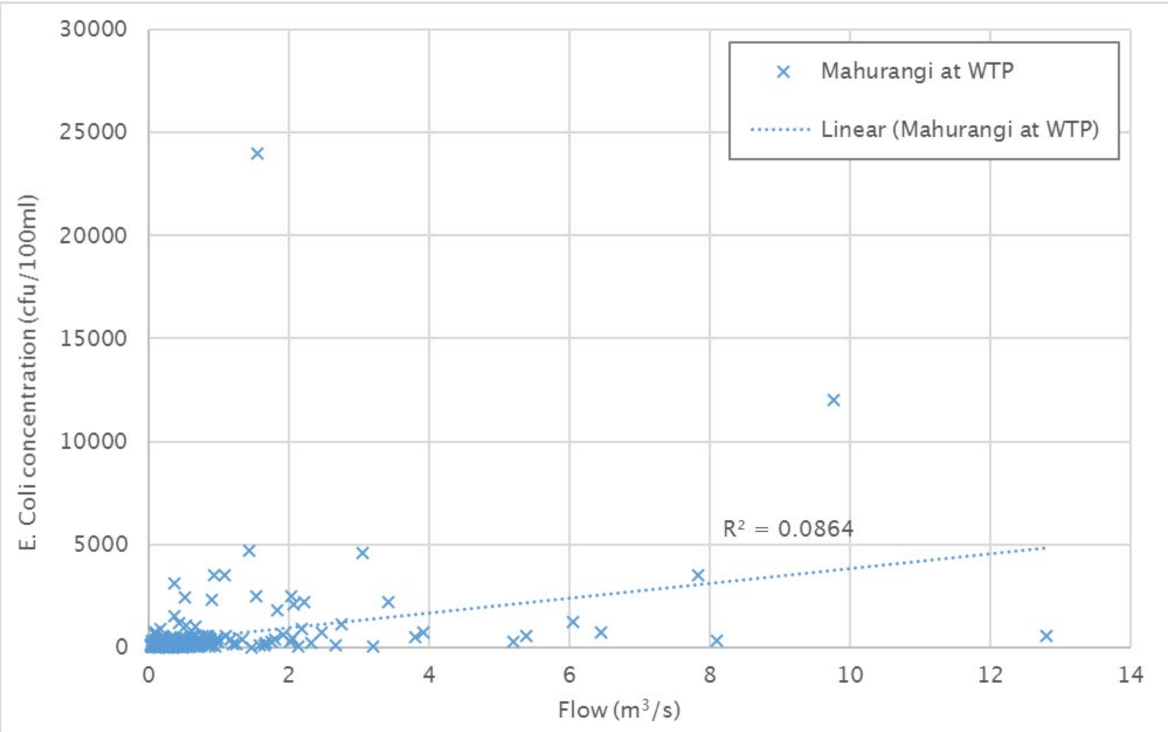

Figure 37 - Comparison of E. Coli concentration (cfu/100ml) and daily flow (m^3/s) at Mahurangi at WTP

A.7 Hōteo River nutrients graphs

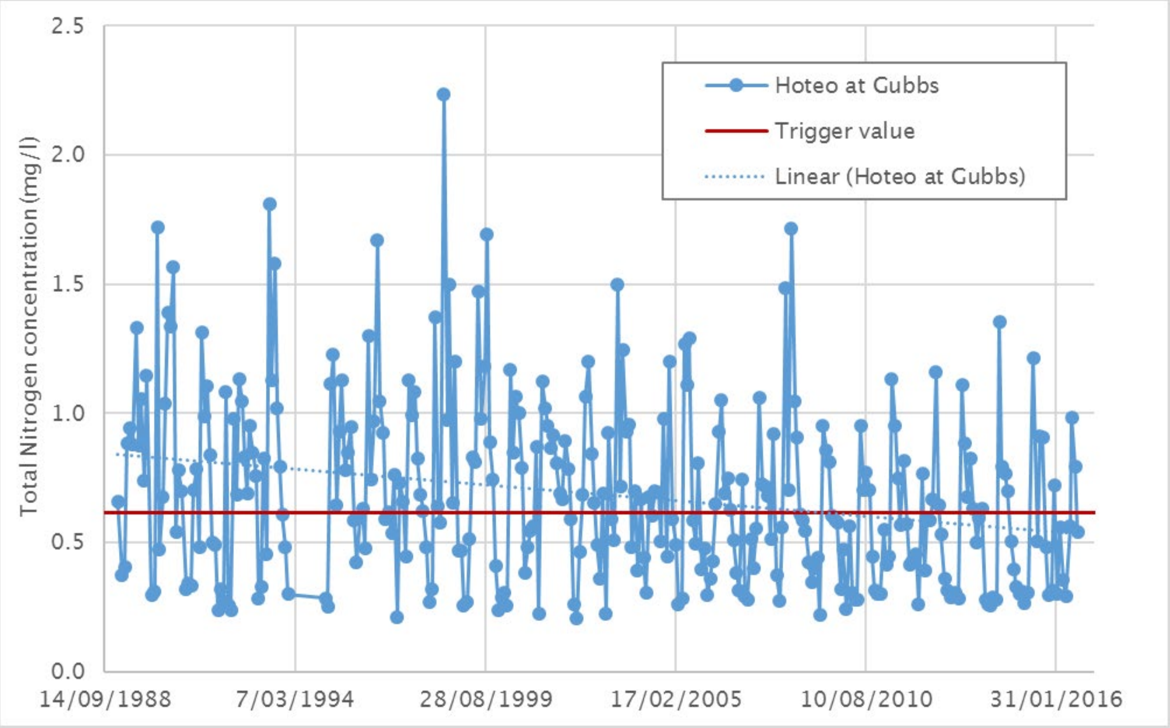

Figure 38 - Total Nitrogen concentration (mg/L) at Hōteo at Gubbs over time, including a comparison to ANZECC trigger value

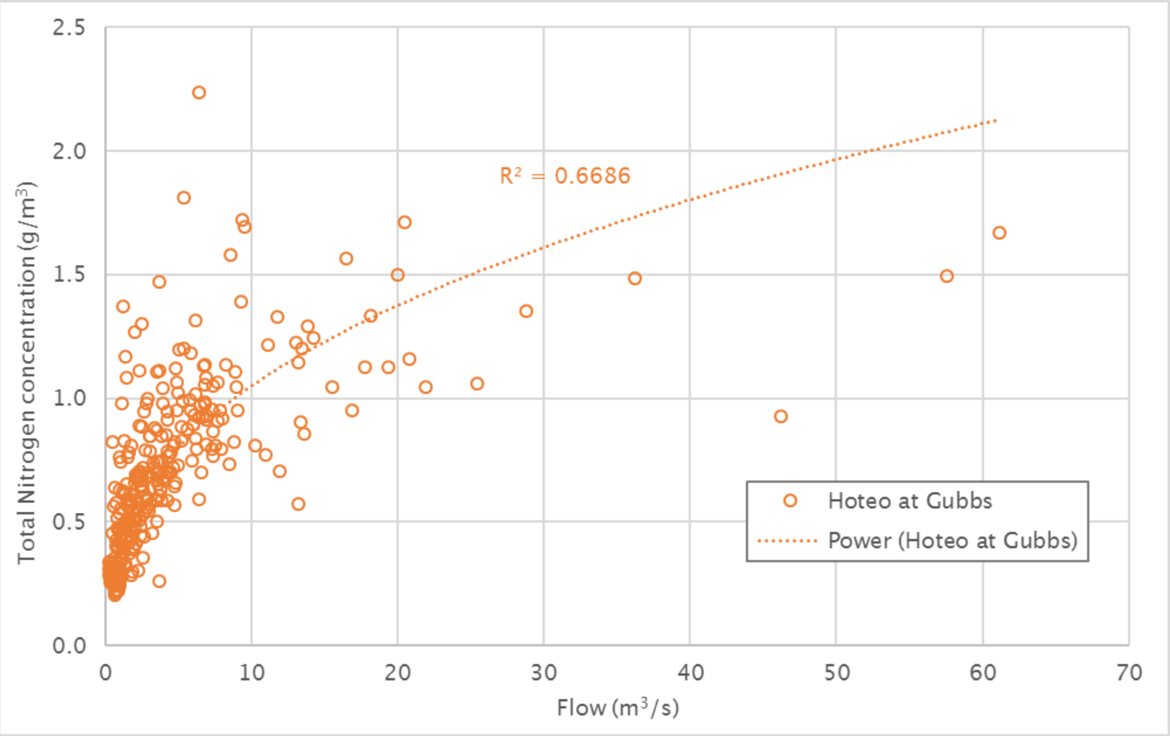

Figure 39 - Comparison of Total Nitrogen concentration (mg/L) and daily flow (m³/s) at Hōteo at Gubbs

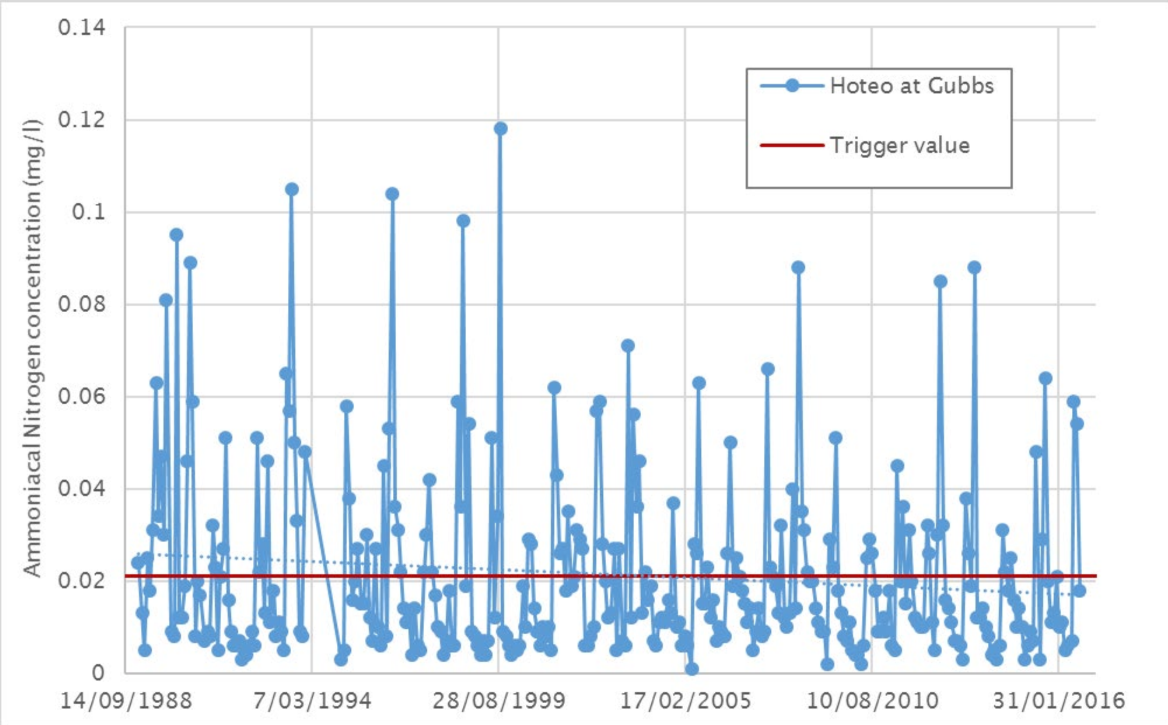

Figure 40 - Ammoniacal Nitrogen concentration (mg/L) at Hōteo at Gubbs over time, including a comparison to ANZECC trigger value

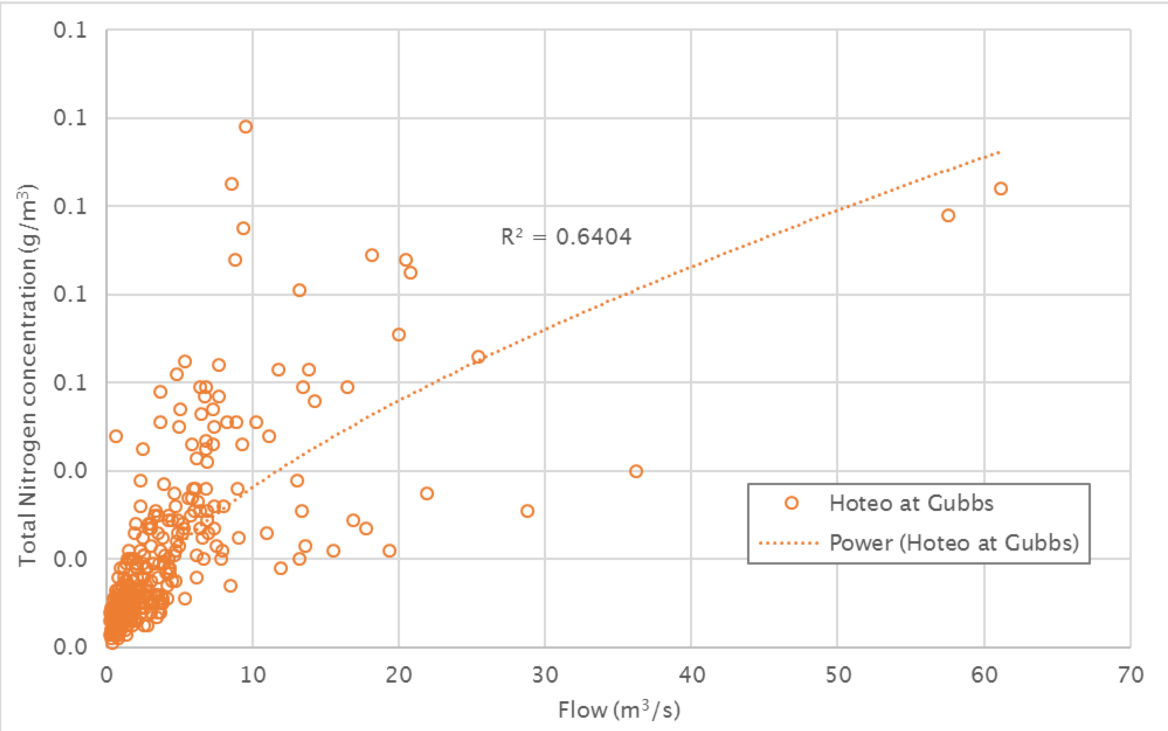

Figure 41 - Comparison of Ammoniacal Nitrogen concentration (mg/L) and daily flow (m³/s) at Hōteo at Gubbs

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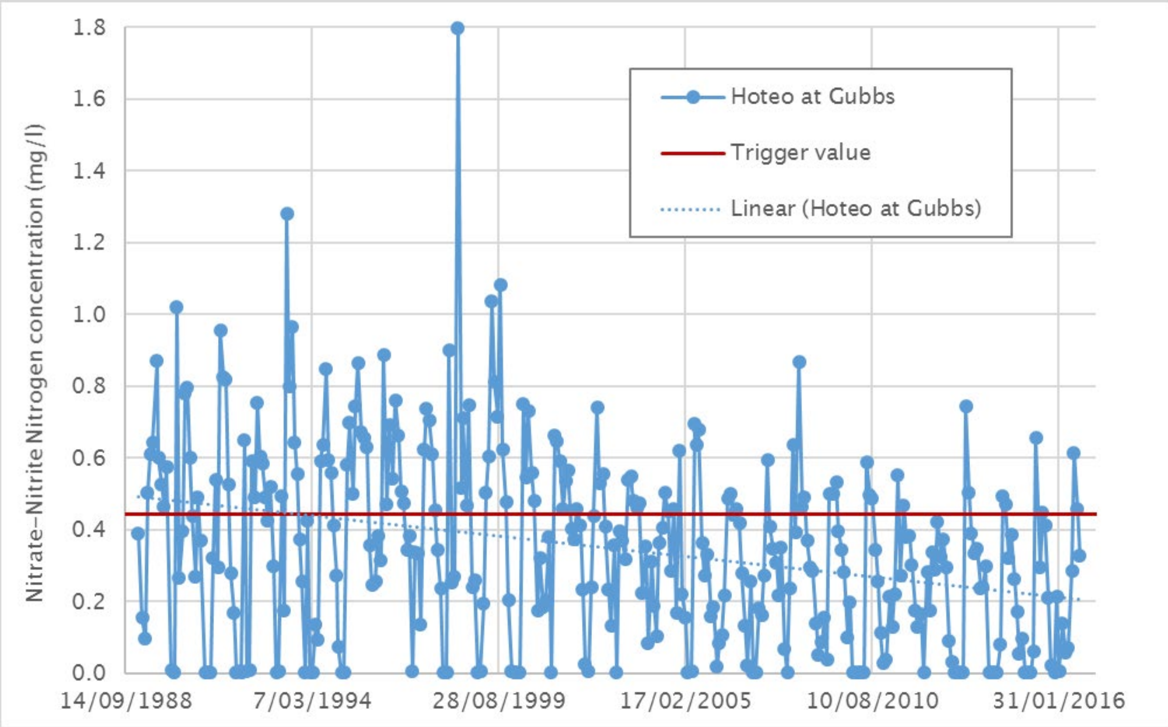

Figure 42 - Nitrate-Nitrite Nitrogen concentration (mg/L) at Hōteo at Gubbs over time, including a comparison to ANZECC trigger value

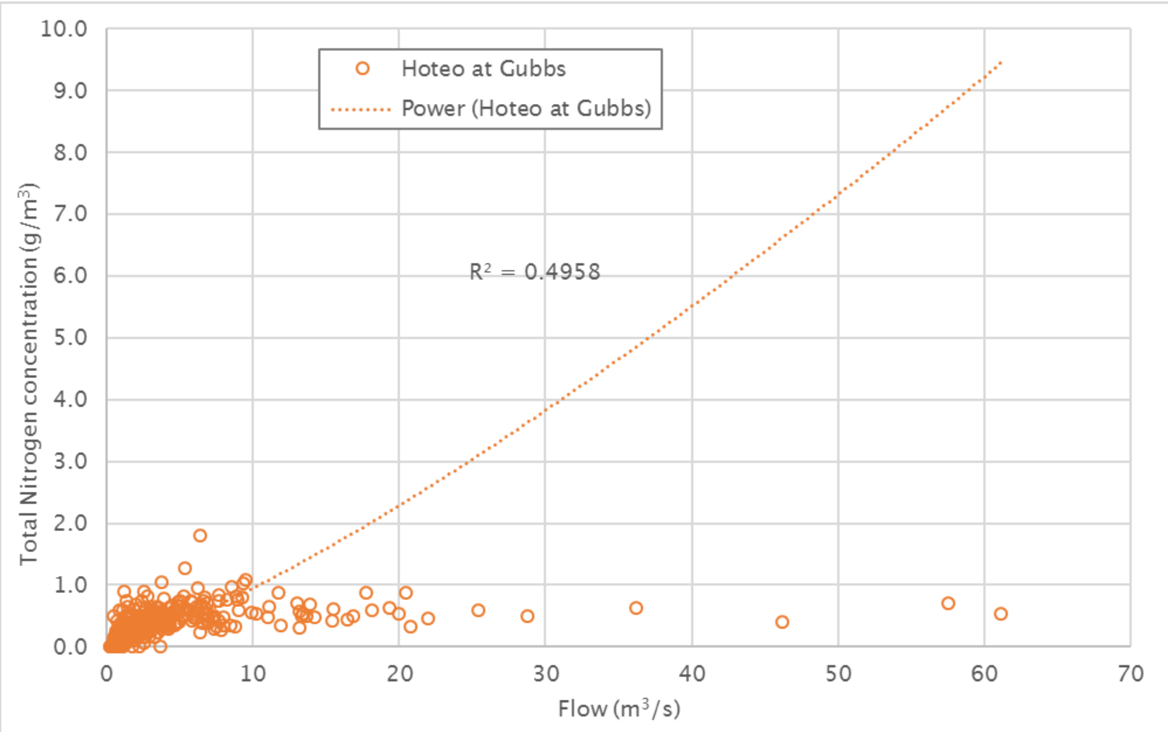

Figure 43 - Comparison of Nitrate-Nitrite Nitrogen concentration (mg/L) and daily flow (m^3/s) at Hōteo at Gubbs

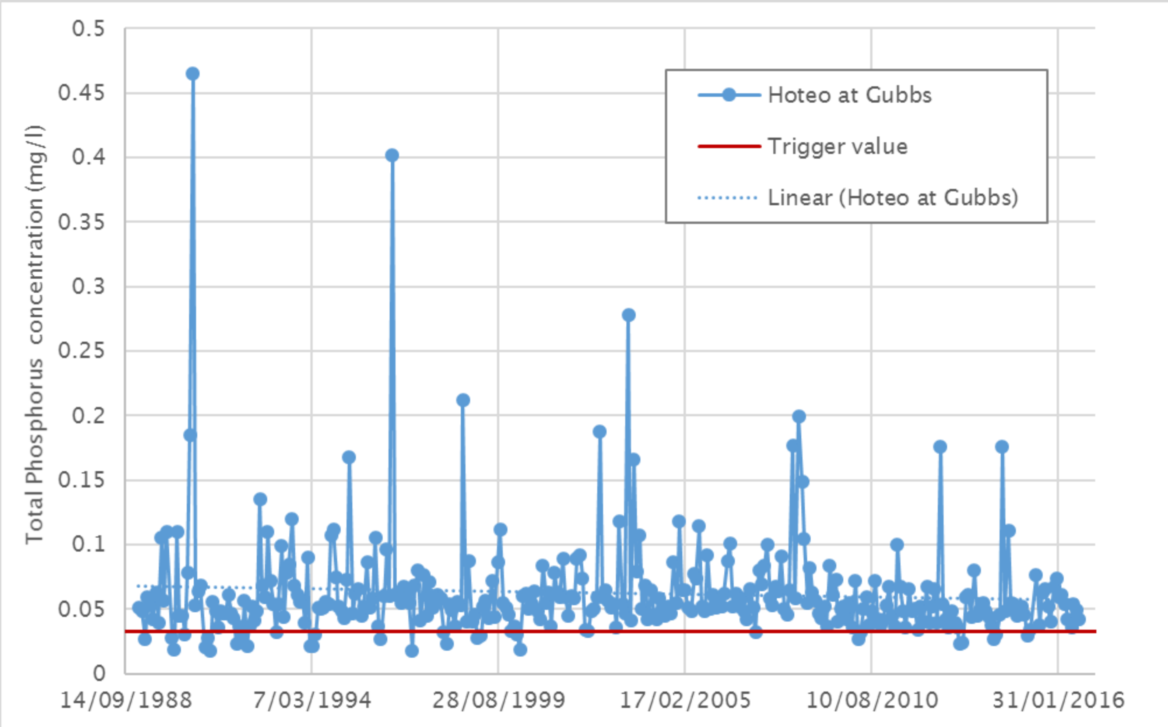

Figure 44 - Total Phosphorus concentration (mg/L) at Hōteo at Gubbs over time, including a comparison to ANZECC trigger value

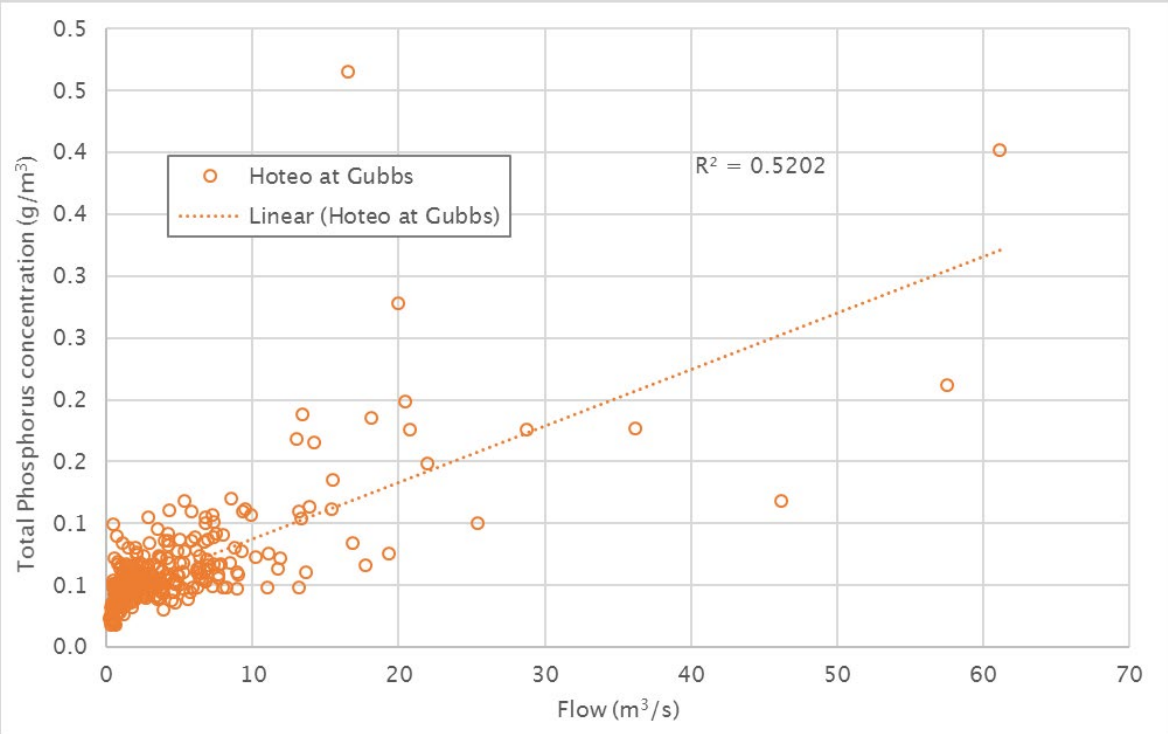

Figure 45 - Comparison of Total Phosphorus concentration (mg/L) and daily flow (m^3/s) at Hōteo at Gubbs

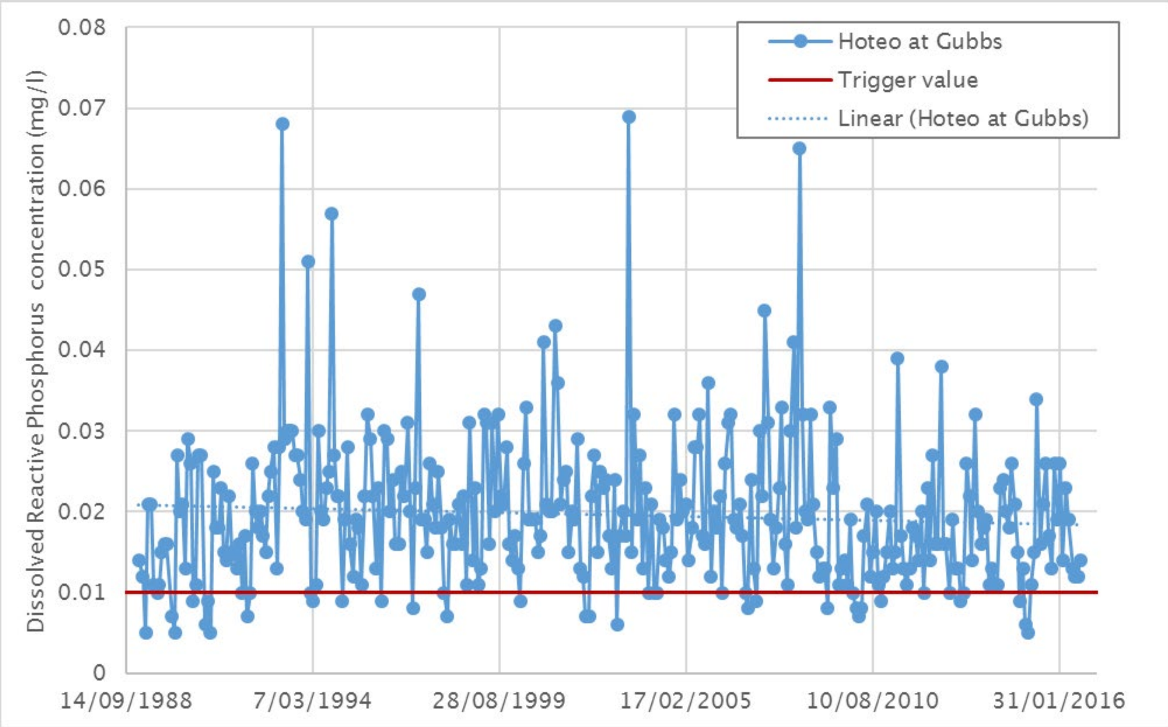

Figure 46 - Dissolved Reactive Phosphorus concentration (mg/L) at Hōteo at Gubbs over time, including a comparison to ANZECC trigger value

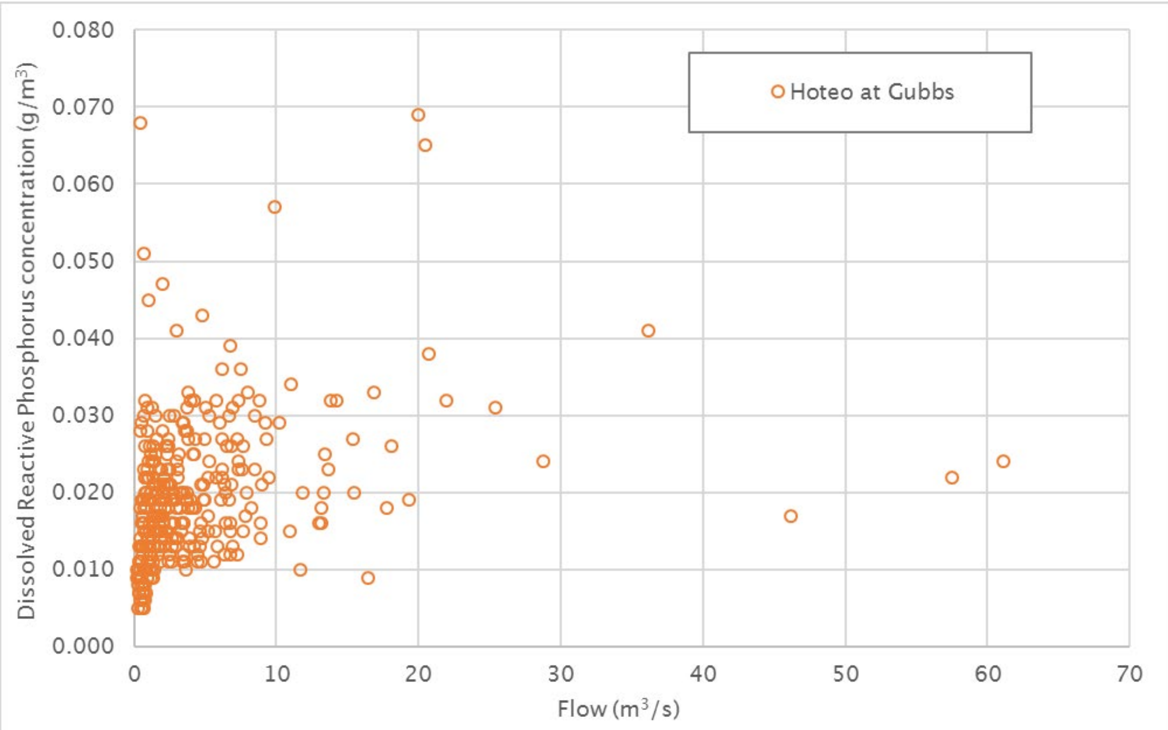

Figure 47 -Comparison of Dissolved Reactive Phosphorus concentration (mg/L) and daily flow (m^3/s) at Hōteo at Gubbs

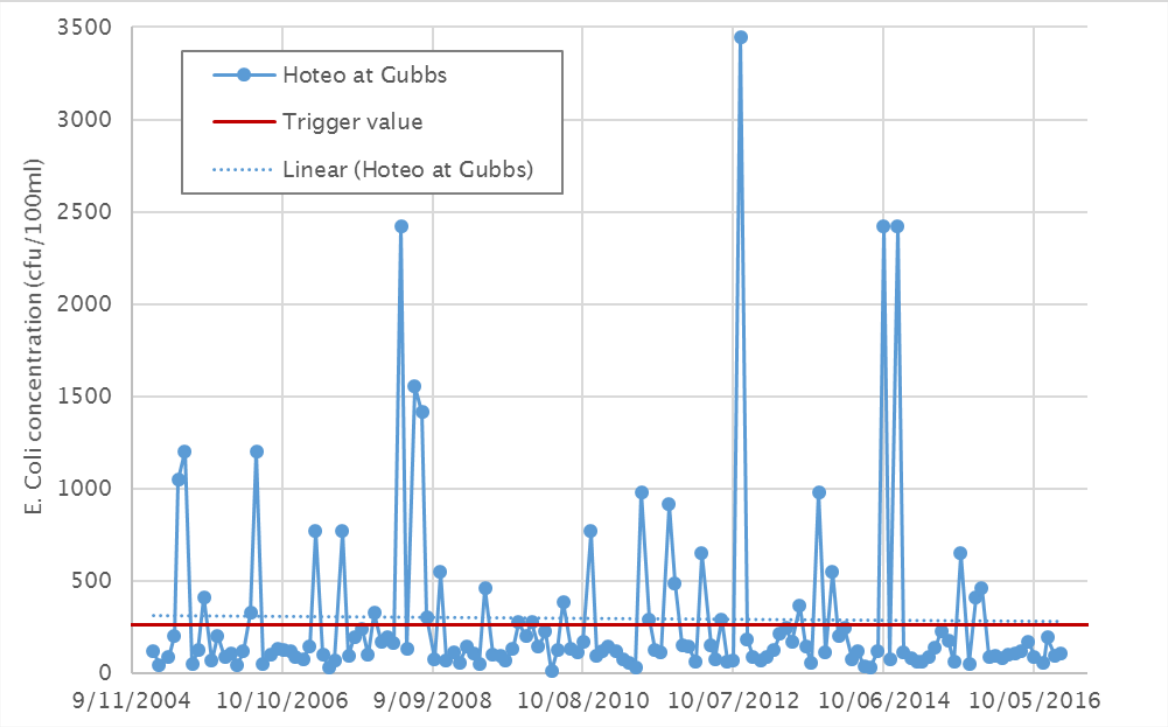

Figure 48 -E. Coli concentration (cfu/100ml) at Hōteo at Gubbs over time, including a comparison to ANZECC trigger value

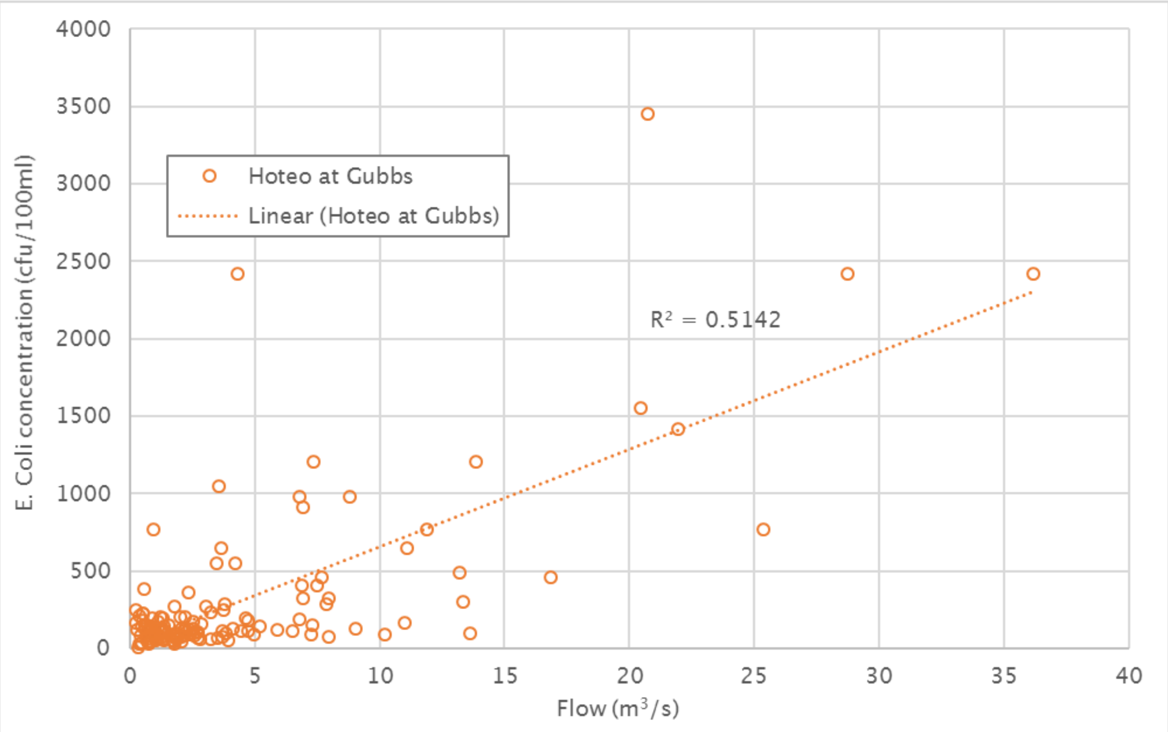

Figure 49 - Comparison of E. Coli concentration (cfu/100ml) and daily flow (m^3/s) at Hōteo at Gubbs

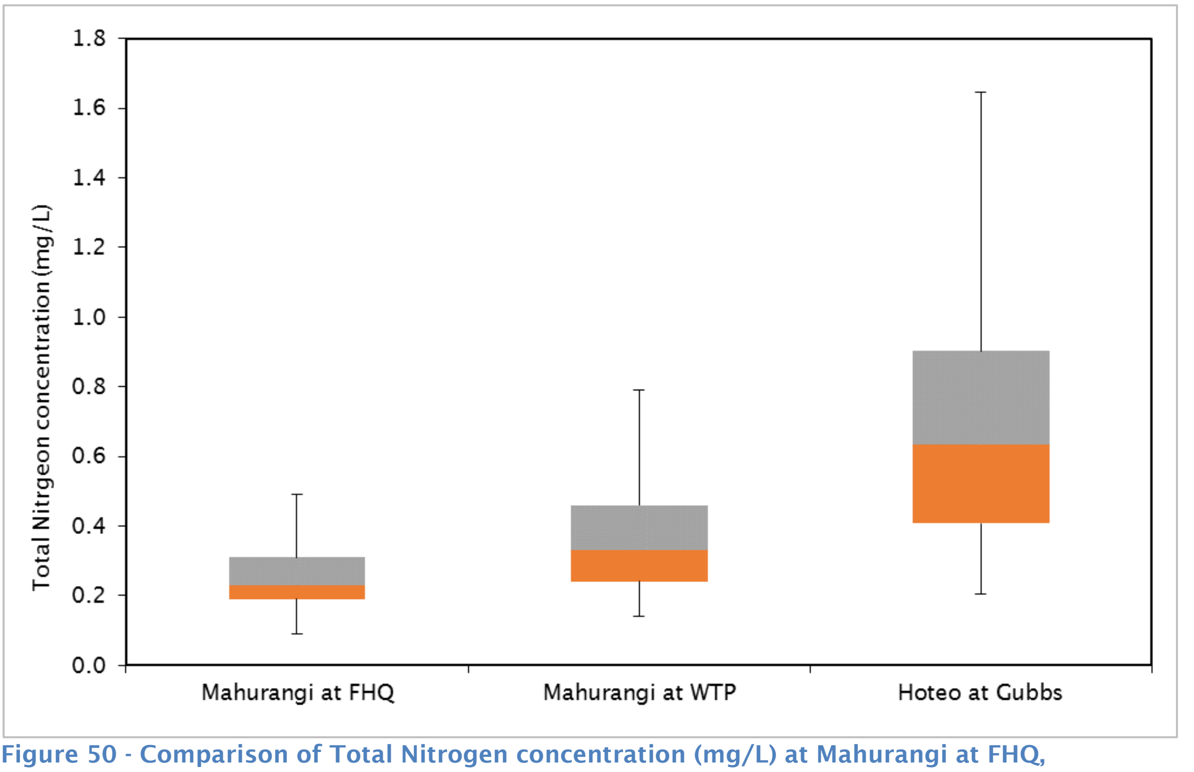

Figure 50 - Comparison of Total Nitrogen concentration (mg/L) at Mahurangi at FHQ, Mahurangi WTP and Hōteo at Gubbs

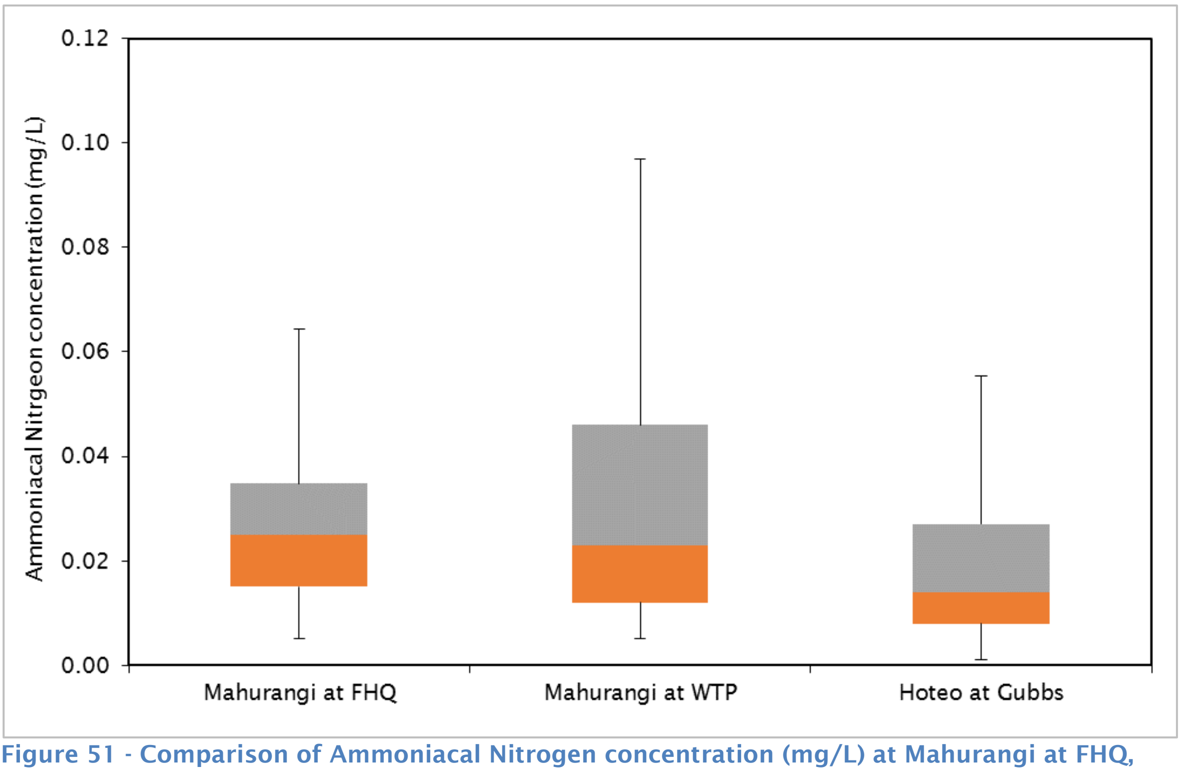

Figure 51 - Comparison of Ammoniacal Nitrogen concentration (mg/L) at Mahurangi at FHQ, Mahurangi WTP and Hōteo at Gubbs

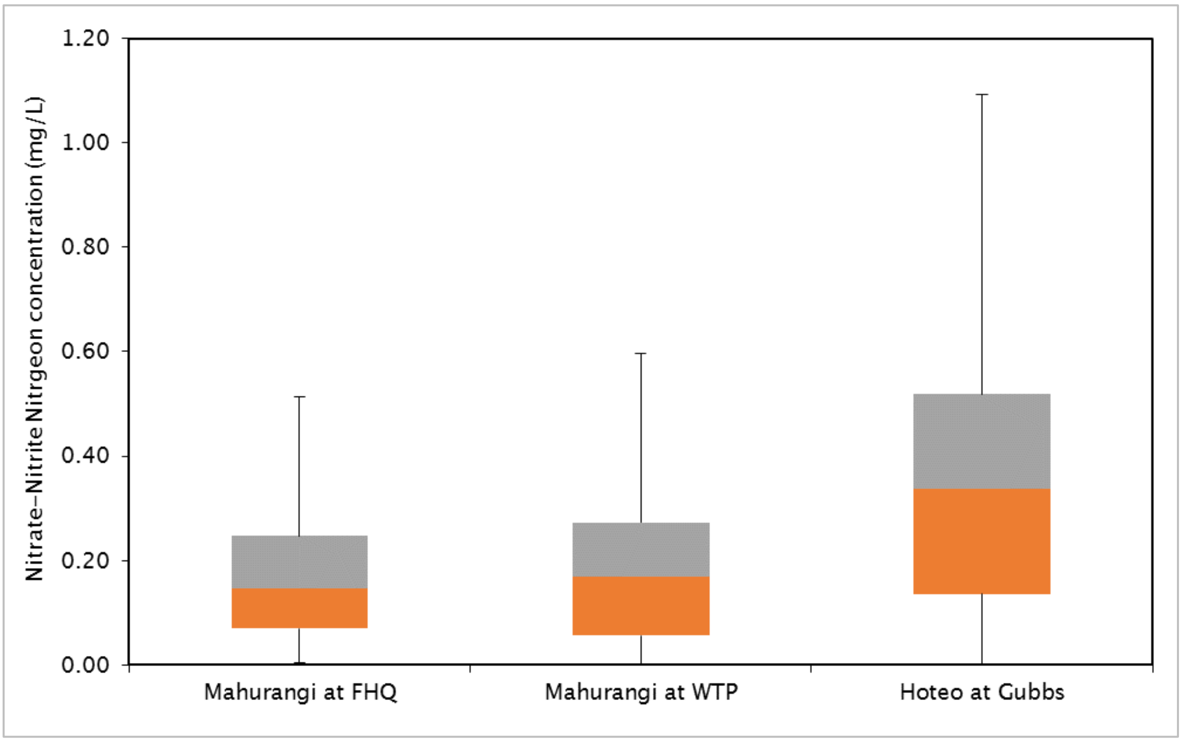

Figure 52 - Comparison of Nitrate-Nitrite Nitrogen concentration (mg/L) at Mahurangi at FHQ, Mahurangi WTP and Hōteo at Gubbs

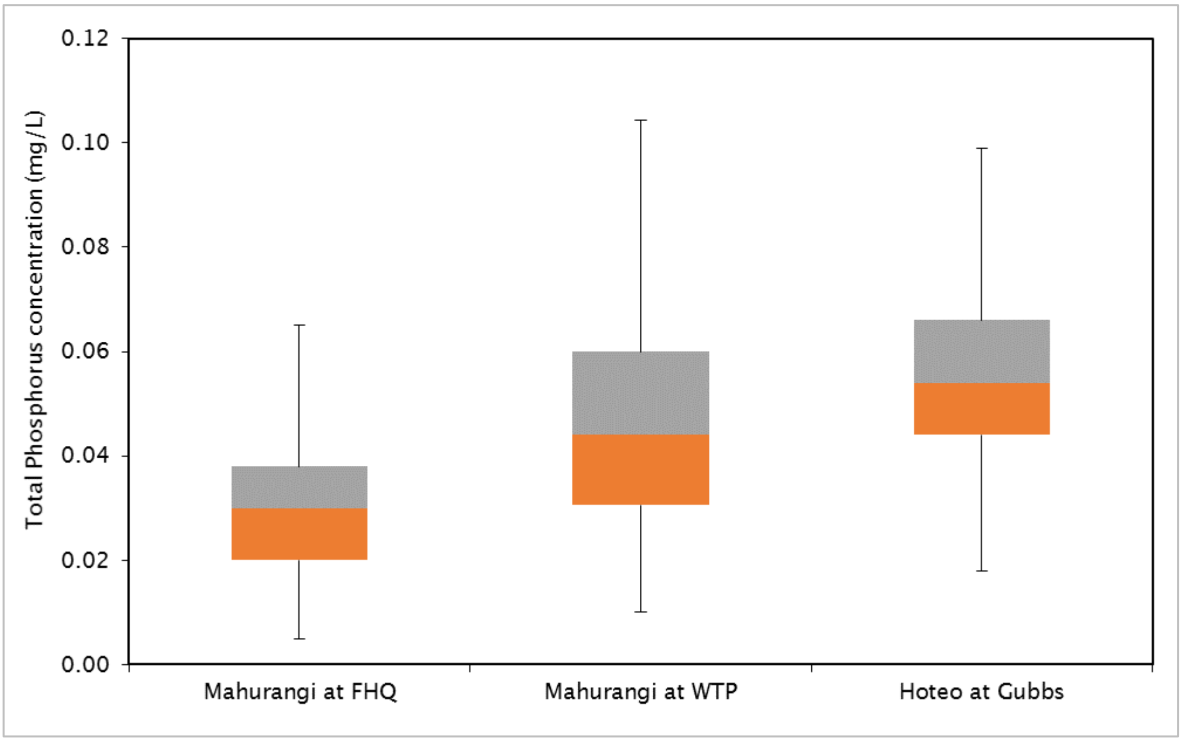

Figure 53 - Comparison of Total Phosphorus concentration (mg/L) at Mahurangi at FHQ, Mahurangi WTP and Hōteo at Gubbs

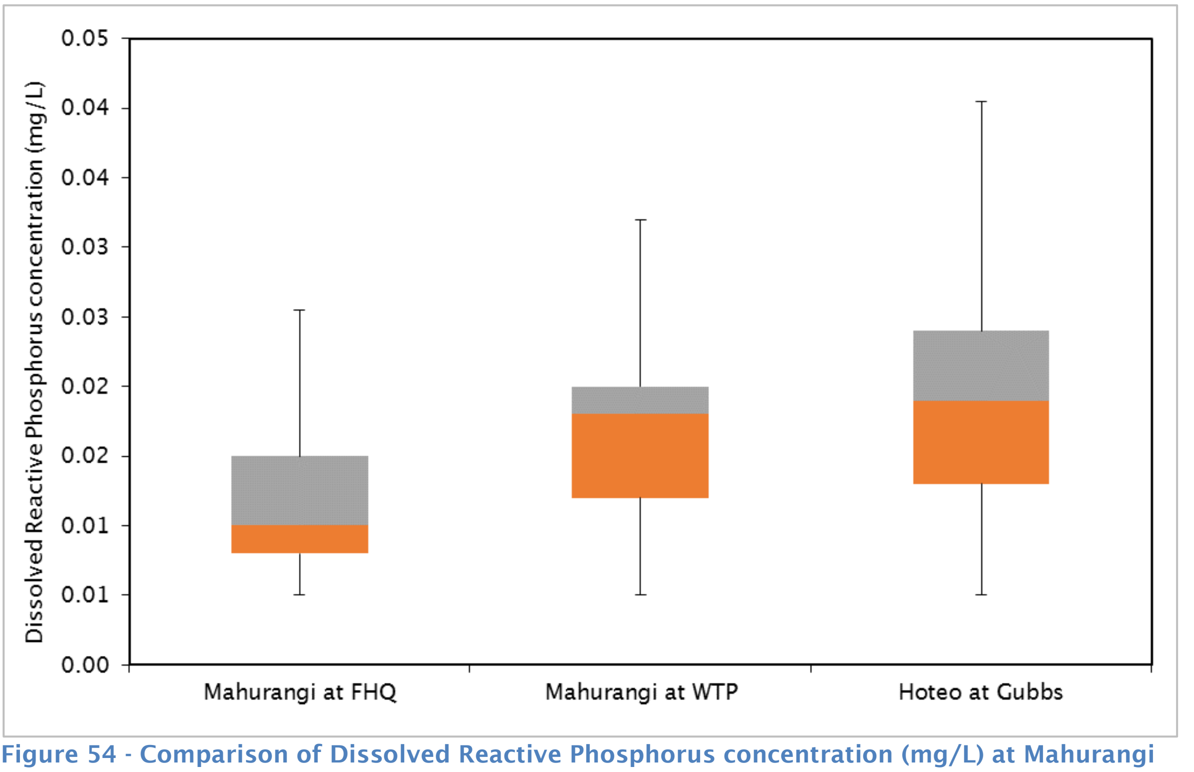

Figure 54 - Comparison of Dissolved Reactive Phosphorus concentration (mg/L) at Mahurangi at FHQ, Mahurangi WTP and Hōteo at Gubbs

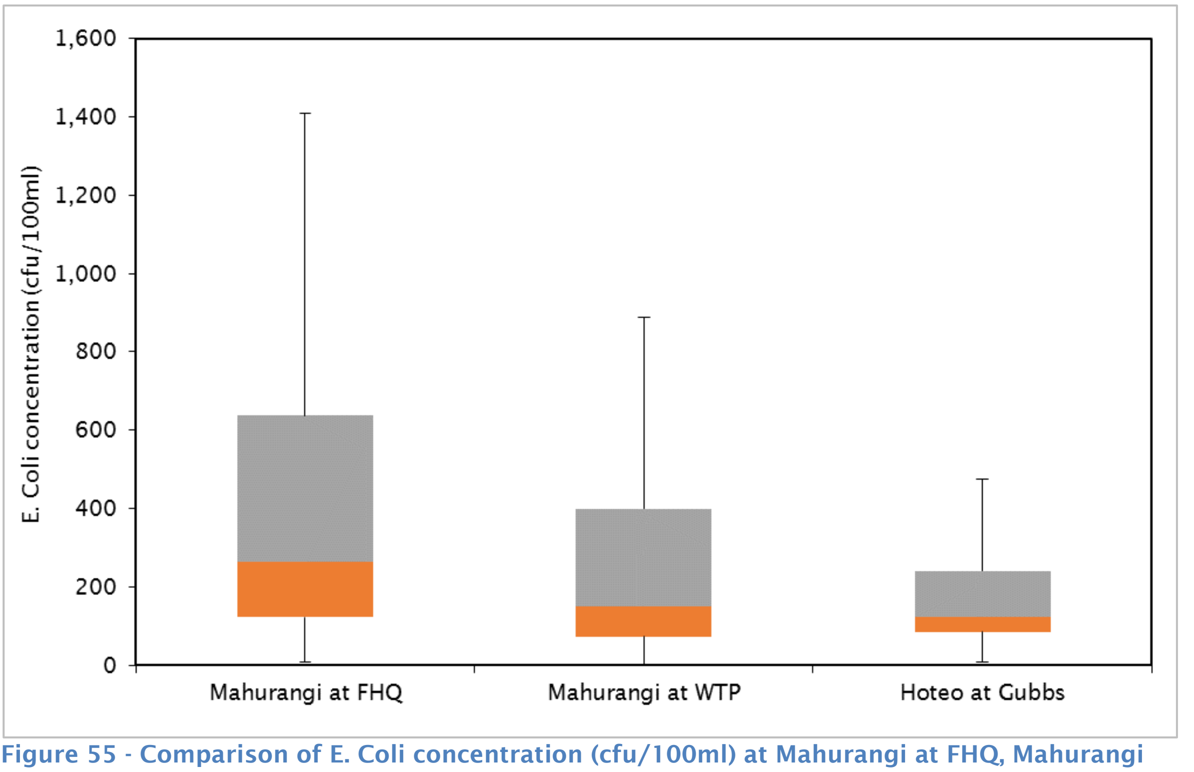

Figure 55 - Comparison of E. Coli concentration (cfu/100ml) at Mahurangi at FHQ, Mahurangi WTP and Hōteo at Gubbs

APPENDIX B: AUCKLAND COUNCIL SALINE WATER QUALITY DATA

This appendix includes a summary of the existing Auckland Council (Council) saline water quality data. This data was provided by Council in April 2017, any monitoring that has occurred since has not been summarised. This appendix is split into the following sub-sections:

B.1 – Summary tables of Council saline water quality data for the Mahurangi Harbour (Mahurangi Harbour at Town Basin and Mahurangi Harbour at Dawsons Creek). The mean and median water quality values have been compared with the guideline values for estuarine and marine water quality in Table 4 (exceedances highlighted in grey).

B.2 – Summary tables of Council saline water quality data for the southern Kaipara Harbour (Kaipara Harbour at Hōteo River Mouth, Kaipara harbour and Tauhoa Channel, Kaipara Harbour at Kaipara Heads). The mean and median water quality values have been compared with the guideline values for estuarine and marine water quality in Table 4 (exceedances highlighted in grey).

B.3 – Summary tables of Council saline water quality data for the estuarine Oruawharo River and northern Kaipara Harbour (Kaipara Harbour at Oruawharo River, Kaipara Harbour at Hargreaves Basin, Kaipara harbour at Otamatea Channel). The mean and median water quality values have been compared with the guideline values for estuarine and marine water quality in Table 4 (exceedances highlighted in grey).

B.4 - Data analysis graphs for suspended sediment and turbidity data for the Mahurangi Harbour, the southern Kaipara Harbour, the Oruawharo River and the northern Kaipara Harbour.

B.4 - Data analysis graphs of nutrients (Total Nitrogen, Ammoniacal Nitrogen, Nitrate-Nitrite Nitrogen, Total Phosphorus and Dissolved Phosphorus) and *E. coli* for the Mahurangi Harbour, the southern Kaipara Harbour, the Oruawharo River and the northern Kaipara Harbour.

B.1 Mahurangi Harbour water quality summary tables

Table 15 - Summary of existing Council saline water quality data for the Mahurangi harbour at Town Basin

Parameter (mg/L) unless stated	Trigger value[A]	Date range	#	Data summary				Exceeds[B]	
				Mean	Median	Min	Max	#	%
Dissolved Oxygen	<5	1993-2008	221	7.1	7.0	2.2	11.2	43	19%
Dissolved Oxygen (%sat)	-	1993-2008	261	75.5	77.5	30.0	107.8	-	-
Conductivity (mS/cm)	-	1993-2008	234	15.68	12.40	0.02	47.00	-	-
Salinity (ppt)	-	1993-2008	259	14.19	15.00	0.03	30.20	-	-
Temperature (°C)	-	1993-2008	145	17.64	17.60	8.90	25.50	-	-
pH (pH units)	6.5-8.5	1993-2008	261	7.62	7.60	6.60	8.40	0	0%
Biochemical oxygen demand	-	1993-2005	220	2.31	2.00	0.40	10.00	-	-
E. coli (cfu/100mL)	140	1993-2008	260	358	94	5	8100	94	67%
Total suspended solids	10	1993-2008	259	14.7	11.0	2.5	144.0	142	55%
Turbidity (FNU)	10	1993-2008	260	10.34	6.17	0.60	106.0	59	23%
Black Disc Clarity (m)	-	1993-2007	94	0.61	0.60	0.10	1.20	-	-
Secchi depth (m)	-	1995-2005	84	0.78	0.80	0.10	1.70	-	-
Total Phosphorus	0.03	1993-2008	259	0.074	0.060	<0.010	0.370	255	98%
Soluble reactive phosphorus	0.005	1993-2008	258	0.029	0.029	<0.005	0.107	256	99%
Ammoniacal nitrogen	0.015	1993-2008	257	0.073	0.061	0.004	0.377	240	93%
Nitrate nitrogen	100	1993-2008	261	0.179	0.130	<0.001	1.644	-	-
Nitrite nitrogen	0.1	1993-2008	206	0.007	0.007	<0.002	0.036	-	-
Nitrate-Nitrite (TON) nitrogen	0.015	1993-2008	261	0.185	0.139	<0.002	1.680	250	96%
Kjeldahl Nitrogen	-	2007-2008	14	0.513	0.470	0.240	0.890	-	-
Chlorophyll *a*	0.004	1999-2008	120	0.0063	0.0035	0.0006	0.048	53	44%

Notes:

A - Trigger value is the lower guideline trigger value in Table 4, grey shading indicates value exceeds this trigger

B – This details the number of times and % of time monitored that the observed value exceeds the lower guideline trigger value

Table 16 - Summary of existing Council saline water quality data for the Mahurangi Harbour at Dawsons Creek

Parameter (mg/L) unless stated	Trigger value[A]	Date range	#	Data summary				Exceeds[B]	
				Mean	Median	Min	Max	#	%
Dissolved Oxygen	<5	1993-2016	364	7.19	7.20	3.40	10.10	2	1%
Dissolved Oxygen (%sat)	-	1993-2016	407	88.1	88.8	46.0	111.0	-	-
Conductivity (mS/cm)	-	1993-2016	358	25.79	38.58	12.00	55.26	-	-
Salinity (ppt)	-	1993-2016	412	31.73	32.18	4.70	38.00	-	-
Temperature (°C)	-	1998-2016	294	17.58	17.45	9.70	25.40	-	-
pH (pH units)	6.5-8.5	1993-2016	413	8.03	8.06	6.96	8.23	0	0%
Biochemical oxygen demand	-	1993-2005	277	2.00	2.00	0.40	3.00	-	-
E. coli (cfu/100mL)	140	1993-2014	383	56	3	2	8700	11	3%
Total suspended solids	10	1993-2016	410	14.5	12.0	1.1	123	250	61%
Turbidity (FNU)	10	1993-2016	412	6.35	5.26	0.30	116	31	8%
Black Disc Clarity (m)	-	1993-2007	93	0.65	0.60	0.10	1.40	-	-
Secchi depth (m)	-	1995-2005	85	0.86	0.90	0.10	2.40	-	-
Total Phosphorus	0.03	1993-2016	413	0.042	0.037	0.006	0.493	292	71%
Soluble reactive phosphorus	0.005	1993-2016	413	0.017	0.017	0.004	0.040	407	99%
Total nitrogen	0.3	2009-2016	94	0.065	0.050	<0.010	0.360	1	1%
Ammoniacal nitrogen	0.015	1993-2016	407	0.016	0.010	0.003	0.210	148	36%
Nitrate (NO_3)	100	2009-2016	94	0.009	0.002	0.001	0.079	-	-
Nitrate nitrogen	100	1993-2009	310	0.020	0.009	0.000	0.331	-	-
Nitrite nitrogen	0.1	1993-2016	308	0.003	0.002	0.001	0.014	-	-
Nitrate-Nitrite (TON) nitrogen	0.015	1993-2016	416	0.020	0.010	<0.002	0.338	153	37%
Kjeldahl Nitrogen	-	2007-2016	111	0.098	0.052	0.001	0.630	-	-
Chlorophyll *a*	0.004	1999-2016	274	0.0029	0.0026	0.0006	0.009	59	22%

Notes:

A - Trigger value is the lower guideline trigger value in Table 4, grey shading indicates value exceeds this trigger

B – This details the number of times and % of time monitored that the observed value exceeds the lower guideline trigger value

B.2 Southern Kaipara Harbour water quality summary tables

Table 17 - Summary of existing Council saline water quality data for the Kaipara Harbour at Hōteo River mouth

Parameter (mg/L) unless stated	Trigger value[A]	Date range	#	Data summary				Exceeds[B]	
				Mean	Median	Min	Max	#	%
Dissolved Oxygen	<5	2009-2016	91	7.94	7.81	6.38	9.62	0	0%
Dissolved Oxygen (%sat)	-	2009-2016	91	98.1	98.2	90.6	105.3	-	-
Conductivity (mS/cm)	-	2009-2016	91	46.44	46.92	33.15	54.81	-	-
Salinity (ppt)	-	2009-2016	91	30.22	30.56	20.74	36.37	-	-
Temperature (°C)	-	2009-2016	91	17.16	17.01	10.98	24.82	-	-
pH (pH units)	6.5-8.5	2009-2016	89	7.96	8.01	3.57	8.29	1	1%
E. coli (cfu/100mL)	140	2009-2014	59	9.0	2.0	1.6	140	0	0%
Total suspended solids	10	2009-2016	90	17.0	14.0	3.6	58.0	68	76%
Turbidity (FNU)	10	2009-2016	90	6.36	5.70	0.76	23.40	12	13%
Total Phosphorus	0.03	2009-2016	90	0.027	0.025	<0.005	0.067	30	33%
Soluble reactive phosphorus	0.005	2009-2016	90	0.014	0.013	<0.005	0.025	89	99%
Total nitrogen	0.3	2009-2016	90	0.142	0.110	<0.010	0.940	4	4%
Ammoniacal nitrogen	0.015	2009-2016	90	0.018	0.012	<0.005	0.105	38	42%
Nitrate (NO_3)	100	2009-2016	88	0.028	0.011	<0.002	0.142	0	0%
Nitrite nitrogen	0.1	2009-2016	90	0.003	0.002	<0.002	0.013	0	0%
Nitrate-Nitrite (TON) nitrogen	0.015	2009-2016	90	0.029	0.013	<0.002	0.148	42	47%
Kjeldahl Nitrogen	-	2009-2016	90	0.115	0.088	0.006	0.885	-	-
Chlorophyll *a*	0.004	2009-2016	90	0.0041	0.0033	0.0006	0.0236	28	31%

Notes:

A - Trigger value is the lower guideline trigger value in Table 4, grey shading indicates value exceeds this trigger

B – This details the number of times and % of time monitored that the observed value exceeds the lower guideline trigger value

Table 18 - Summary of existing Council saline water quality data for the Kaipara Harbour at Tauhoa Channel

Parameter (mg/L) unless stated	Trigger value[A]	Date range	#	Data summary				Exceeds[B]	
				Mean	Median	Min	Max	#	%
Dissolved Oxygen	<5	2009-2016	91	8.08	8.00	6.91	9.27	0	0%
Dissolved Oxygen (%sat)	-	2009-2016	91	95.1	99.6	95.1	108.3	-	-
Conductivity (mS/cm)	-	2009-2016	91	33.77	49.80	33.77	54.27	-	-
Salinity (ppt)	-	2009-2016	91	32.20	32.61	22.19	35.95	-	-
Temperature (°C)	-	2009-2016	91	17.22	17.12	12.51	23.25	-	-
pH (pH units)	6.5-8.5	2009-2016	90	8.04	8.07	6.86	8.62	0	0%
E. coli (cfu/100mL)	140	2009-2014	59	3.9	2.0	1.6	50.0	0	0%
Total suspended solids	10	2009-2016	91	10.0	8.4	2.1	32.0	33	4%
Turbidity (FNU)	10	2009-2016	91	2.77	2.40	0.80	8.87	0	0%
Total Phosphorus	0.025	2009-2016	91	0.017	0.016	<0.005	0.068	9	10%
Soluble reactive phosphorus	0.005	2009-2016	91	0.009	0.009	<0.005	0.020	88	97%
Total nitrogen	0.12	2009-2016	91	0.064	0.049	<0.010	0.250	13	14%
Ammoniacal nitrogen	0.015	2009-2016	91	0.008	0.005	<0.005	0.083	7	8%
Nitrate (NO_3)	100	2009-2016	89	0.016	0.005	0.001	0.119	0	0%
Nitrite nitrogen	0.1	2009-2016	91	0.003	0.002	<0.002	0.009	0	0%
Nitrate-Nitrite (TON) nitrogen	0.005	2009-2016	91	0.017	0.005	<0.002	0.127	42	46%
Kjeldahl Nitrogen	-	2009-2016	91	0.049	0.028	0.002	0.248	-	-
Chlorophyll *a*	0.001	2009-2016	91	0.0033	0.0028	0.0006	0.017	28	31%

Notes:

A - Trigger value is the lower guideline trigger value in Table 4, grey shading indicates value exceeds this trigger

B – This details the number of times and % of time monitored that the observed value exceeds the lower guideline trigger value

Table 19 - Summary of existing Council saline water quality data for the Kaipara Harbour at Kaipara Heads

Parameter (mg/L) unless stated	Trigger value[A]	Date range	#	Data summary				Exceeds[B]	
				Mean	Median	Min	Max	#	%
Dissolved Oxygen	<5	2009-2016	91	8.21	8.19	7.29	9.09	0	0%
Dissolved Oxygen (%sat)	-	2009-2016	91	103.8	103.8	97.5	109.8	-	-
Conductivity (mS/cm)	-	2009-2016	91	51.88	52.43	42.86	55.13	-	-
Salinity (ppt)	-	2009-2016	91	34.17	34.57	28.26	36.60	-	-
Temperature (˚C)	-	2009-2016	91	16.83	16.89	11.41	21.89	-	-
pH (pH units)	6.5-8.5	2009-2016	90	8.07	8.10	7.20	8.36	0	0%
E. coli (cfu/100mL)	140	2009-2014	59	3.1	2.0	1.6	48.0	0	0%
Total suspended solids	10	2009-2016	90	8.2	7.3	2.0	25.0	22	24%
Turbidity (FNU)	10	2009-2016	90	2.15	1.74	0.45	8.62	0	0%
Total Phosphorus	0.025	2009-2016	90	0.013	0.012	<0.004	0.052	5	6%
Soluble reactive phosphorus	0.005	2009-2016	90	0.007	0.007	0.004	0.016	67	74%
Total nitrogen	0.12	2009-2016	90	0.046	0.020	<0.010	0.260	5	6%
Ammoniacal nitrogen	0.015	2009-2016	90	0.007	0.005	<0.005	0.048	5	6%
Nitrate (NO_3)	100	2009-2016	90	0.011	0.004	0.001	0.116	0	0%
Nitrite nitrogen	0.1	2009-2016	90	0.003	0.002	<0.002	0.007	0	0%
Nitrate-Nitrite (TON) nitrogen	0.005	2009-2016	90	0.013	0.005	<0.002	0.122	40	44%
Kjeldahl Nitrogen	-	2009-2016	90	0.038	0.020	<0.005	0.140	-	-
Chlorophyll *a*	0.001	2009-2016	90	0.002	0.002	0.0006	0.009	82	91%

Notes:

A - Trigger value is the lower guideline trigger value in Table 4, grey shading indicates value exceeds this trigger

B – This details the number of times and % of time monitored that the observed value exceeds the lower guideline trigger value

B.3 Oruawharo River and Northern Kaipara Harbour water quality summary tables

Table 20 - Summary of existing Council saline water quality data for the Kaipara Harbour at Hargreaves Basin

Parameter (mg/L) unless stated	Trigger value[A]	Date range	#	Data summary				Exceeds[B]	
				Mean	Median	Min	Max	#	%
Dissolved Oxygen	<5	2009-2014	61	7.91	7.80	6.47	9.74	0	0%
Dissolved Oxygen (%sat)	-	2009-2014	61	97.9	97.5	89.9	109.0	-	-
Conductivity (mS/cm)	-	2009-2014	61	45.74	46.88	30.92	53.89	-	-
Salinity (ppt)	-	2009-2014	61	29.72	30.42	19.27	35.69	-	-
Temperature (°C)	-	2009-2014	61	17.33	17.12	11.94	24.14	-	-
pH (pH units)	6.5-8.5	2009-2014	60	7.98	8.00	5.46	8.77	3	5%
E. coli (cfu/100mL)	140	2009-2014	59	5.6	2.0	1.6	130.0	0	0%
Total suspended solids	10	2009-2014	61	17.4	16.0	7.5	58.0	55	90%
Turbidity (FNU)	10	2009-2014	61	7.06	6.43	2.38	30.0	6	10%
Total Phosphorus	0.03	2009-2014	61	0.038	0.037	0.011	0.085	42	69%
Soluble reactive phosphorus	0.005	2009-2014	61	0.023	0.023	0.008	0.046	61	100%
Total nitrogen	0.3	2009-2014	61	0.171	0.130	<0.020	0.620	5	8%
Ammoniacal nitrogen	0.015	2009-2014	61	0.022	0.017	<0.005	0.106	33	54%
Nitrate (NO_3)	100	2009-2014	60	0.040	0.016	0.001	0.205	0	0%
Nitrite nitrogen	0.1	2009-2014	61	0.004	0.003	<0.002	0.018	0	0%
Nitrate-Nitrite (TON) nitrogen	0.015	2009-2014	61	0.043	0.019	<0.002	0.212	34	56%
Kjeldahl Nitrogen	-	2009-2014	61	0.128	0.110	0.018	0.616	-	-
Chlorophyll *a*	0.004	2009-2014	61	0.005	0.004	0.0006	0.019	27	44%

Notes:

A - Trigger value is the lower guideline trigger value in Table 4, grey shading indicates value exceeds this trigger

B – This details the number of times and % of time monitored that the observed value exceeds the lower guideline trigger value

Table 21 - Summary of existing Council saline water quality data for the Kaipara Harbour at Oruawharo River.

Parameter (mg/L) unless stated	Trigger value[A]	Date range	#	Data summary				Exceeds[B]	
				Mean	Median	Min	Max	#	%
Dissolved Oxygen	<5	2009-2014	61	7.97	7.87	6.66	9.75	0	0%
Dissolved Oxygen (%sat)	-	2009-2014	61	99.0	98.7	88.7	106.0	-	-
Conductivity (mS/cm)	-	2009-2014	61	46.75	46.96	34.44	53.81	-	-
Salinity (ppt)	-	2009-2014	61	30.43	30.58	21.66	35.62	-	-
Temperature (°C)	-	2009-2014	61	17.34	16.99	12.40	23.51	-	-
pH (pH units)	6.5-8.5	2009-2014	60	8.04	8.03	7.43	8.30	0	0%
E. coli (cfu/100mL)	140	2009-2014	59	2.8	2.0	1.6	14.0	0	0%
Total suspended solids	10	2009-2014	60	14.8	12.5	5.2	38.0	41	68%
Turbidity (FNU)	10	2009-2014	60	5.18	4.19	1.99	16.2	5	8%
Total Phosphorus	0.03	2009-2014	60	0.029	0.026	0.008	0.190	17	28%
Soluble reactive phosphorus	0.005	2009-2014	60	0.016	0.016	0.007	0.028	60	100%
Total nitrogen	0.3	2009-2014	60	0.137	0.091	<0.020	1.50	2	3%
Ammoniacal nitrogen	0.015	2009-2014	60	0.014	0.006	<0.005	0.092	17	28%
Nitrate (NO_3)	100	2009-2014	58	0.033	0.009	<0.002	0.174	0	0%
Nitrite nitrogen	0.1	2009-2014	60	0.003	0.002	<0.002	0.013	0	0%
Nitrate-Nitrite (TON) nitrogen	0.015	2009-2014	60	0.035	0.011	<0.002	0.181	25	42%
Kjeldahl Nitrogen	-	2009-2014	60	0.104	0.059	0.007	1.493	-	-
Chlorophyll *a*	0.004	2009-2014	60	0.0042	0.0031	0.0006	0.018	21	35%

Notes:

A - Trigger value is the lower guideline trigger value in Table 4, grey shading indicates value exceeds this trigger

B – This details the number of times and % of time monitored that the observed value exceeds the lower guideline trigger value

Table 22 - Summary of existing Council saline water quality data for the Kaipara Harbour at Otamatea Channel

Parameter (mg/L) unless stated	Trigger value[A]	Date range	#	Data summary				Exceeds[B]	
				Mean	Median	Min	Max	#	%
Dissolved Oxygen	<5	2009-2014	61	8.16	8.10	6.72	9.20	0	0%
Dissolved Oxygen (%sat)	-	2009-2014	61	99.0	97.3	88.7	106.0	-	-
Conductivity (mS/cm)	-	2009-2014	61	50.79	51.09	44.03	54.27	-	-
Salinity (ppt)	-	2009-2014	61	33.36	33.50	28.45	35.97	-	-
Temperature (°C)	-	2009-2014	61	16.92	16.69	13.10	22.44	-	-
pH (pH units)	6.5-8.5	2009-2014	60	8.07	8.09	7.44	8.37	0	0%
E. coli (cfu/100mL)	140	2009-2014	59	2.8	2.0	1.6	14.0	0	0%
Total suspended solids	10	2009-2014	61	9.6	8.2	2.3	35.0	21	34%
Turbidity (FNU)	10	2009-2014	61	2.99	1.85	0.66	16.5	3	5%
Total Phosphorus	0.025	2009-2014	61	0.017	0.014	<0.005	0.063	6	10%
Soluble reactive phosphorus	0.005	2009-2014	61	0.009	0.008	<0.005	0.037	55	90%
Total nitrogen	0.12	2009-2014	61	0.061	0.027	<0.020	0.330	7	11%
Ammoniacal nitrogen	0.015	2009-2014	61	0.009	0.005	<0.005	0.093	6	10%
Nitrate (NO_3)	100	2009-2014	61	0.016	0.005	0.001	0.157	0	0%
Nitrite nitrogen	0.1	2009-2014	61	0.003	0.002	<0.002	0.008	0	0%
Nitrate-Nitrite (TON) nitrogen	0.005	2009-2014	61	0.018	0.007	<0.002	0.163	34	56%
Kjeldahl Nitrogen	-	2009-2014	61	0.045	0.020	0.009	0.228	-	-
Chlorophyll *a*	0.001	2009-2014	61	0.0032	0.0028	0.0006	0.020	13	21%

Notes:

A - Trigger value is the lower guideline trigger value in Table 4, grey shading indicates value exceeds this trigger

B – This details the number of times and % of time monitored that the observed value exceeds the lower guideline trigger value

B.4 Estuarine and marine suspended sediment and turbidity graphs

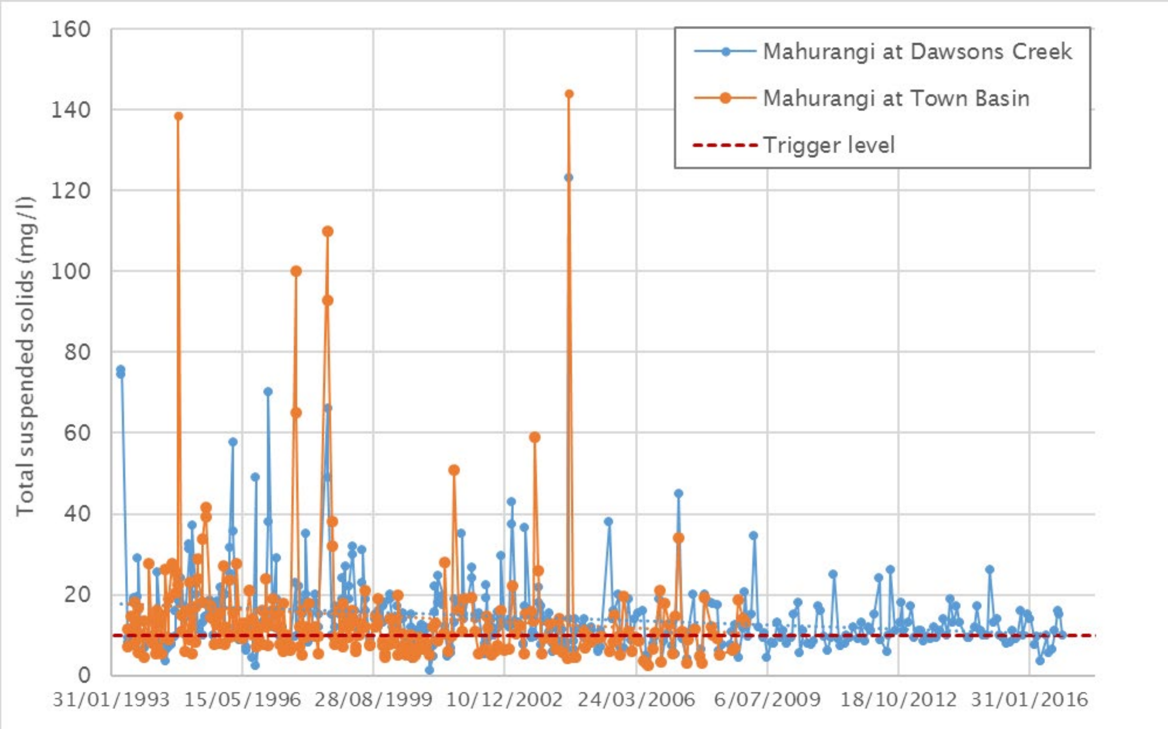

Figure 56 - Total Suspended Solids concentration (mg/L) at Mahurangi Harbour sites over time

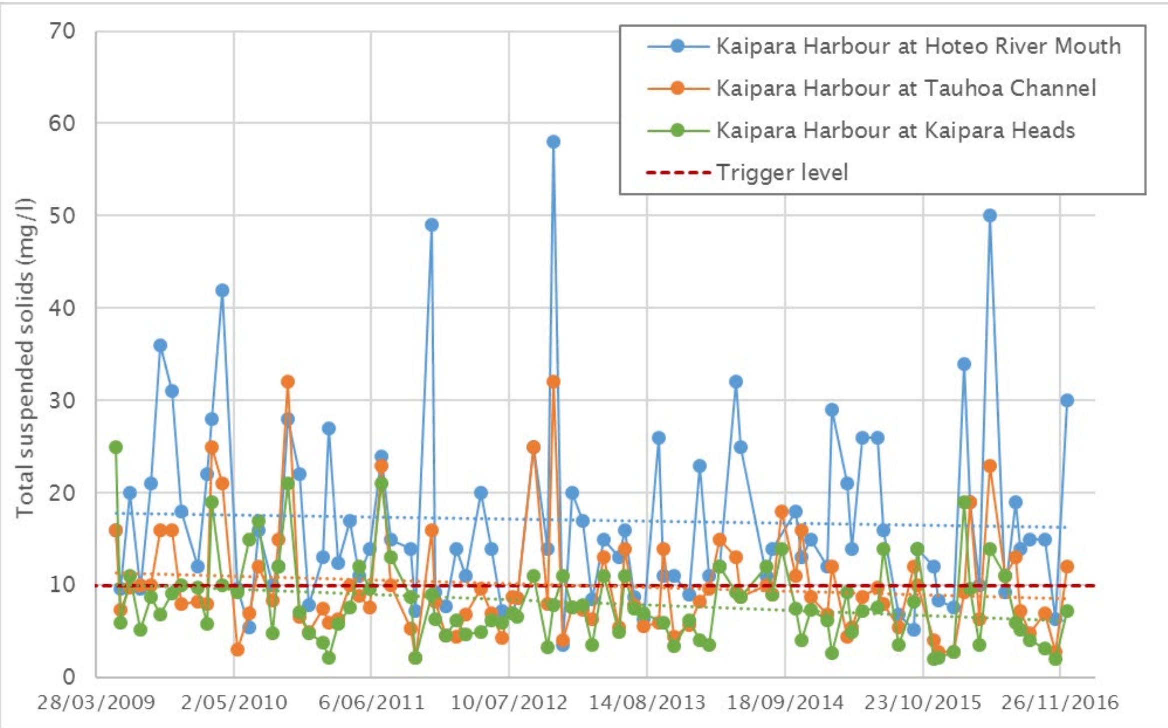

Figure 57 - Total Suspended Solids concentration (mg/L) at southern Kaipara Harbour sites over time

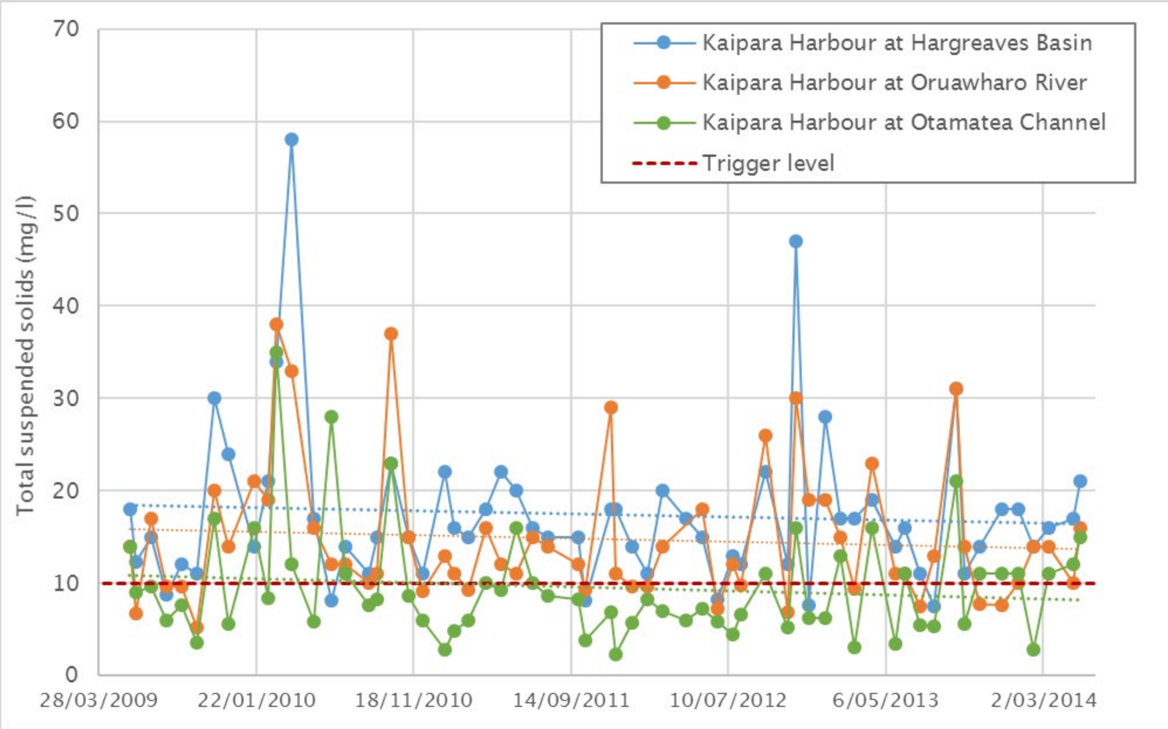

Figure 58 - Total Suspended Solids concentration (mg/L) at Oruawharo River and northern Kaipara Harbour sites over time

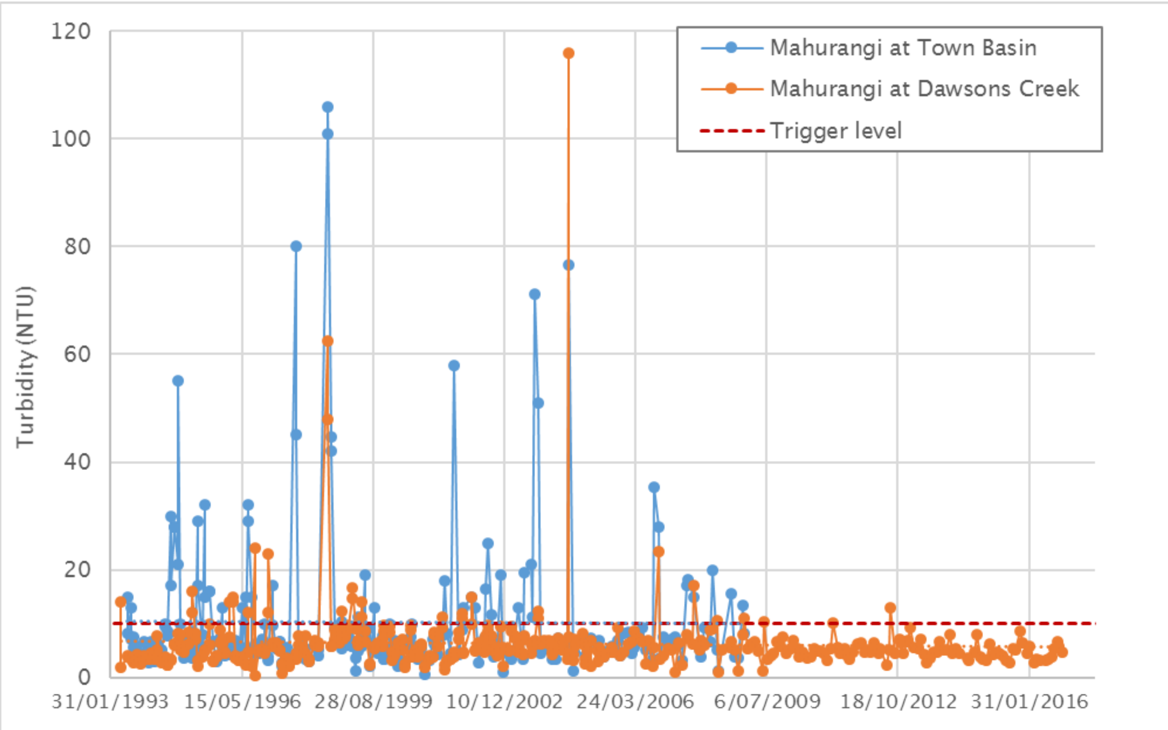

Figure 59 - Turbidity (NTU) at Mahurangi Harbour sites over time

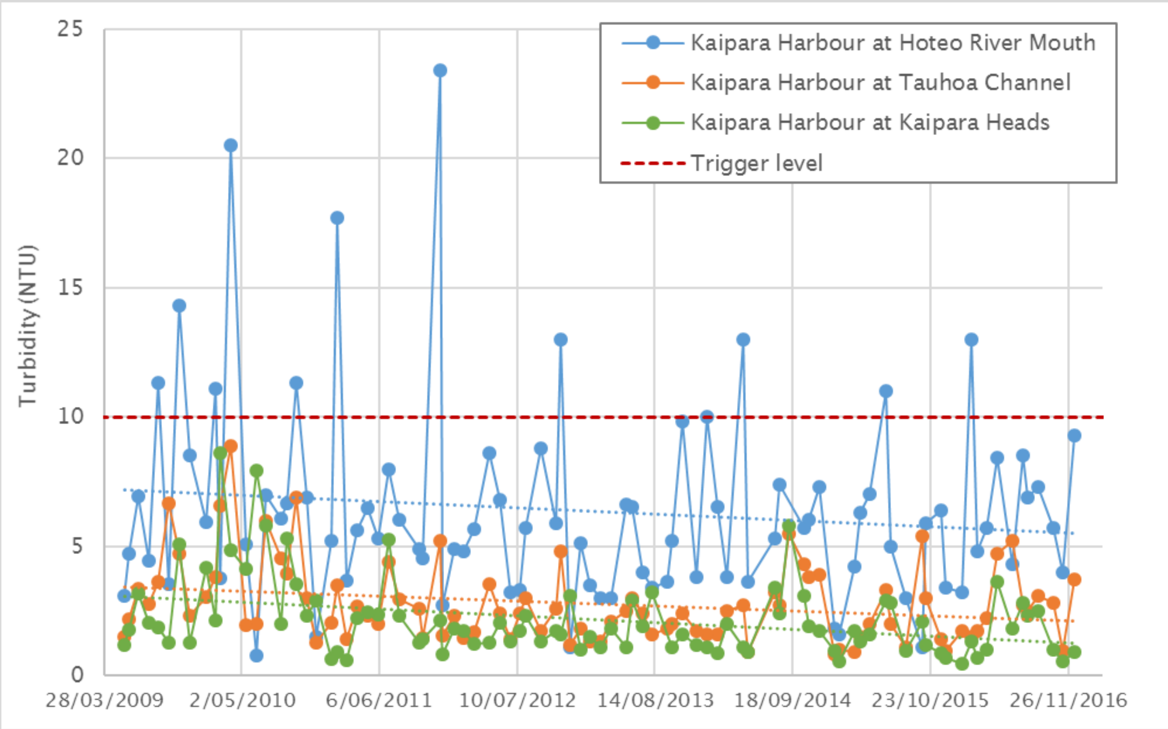

Figure 60 -Turbidity (NTU) at southern Kaipara Harbour sites over time

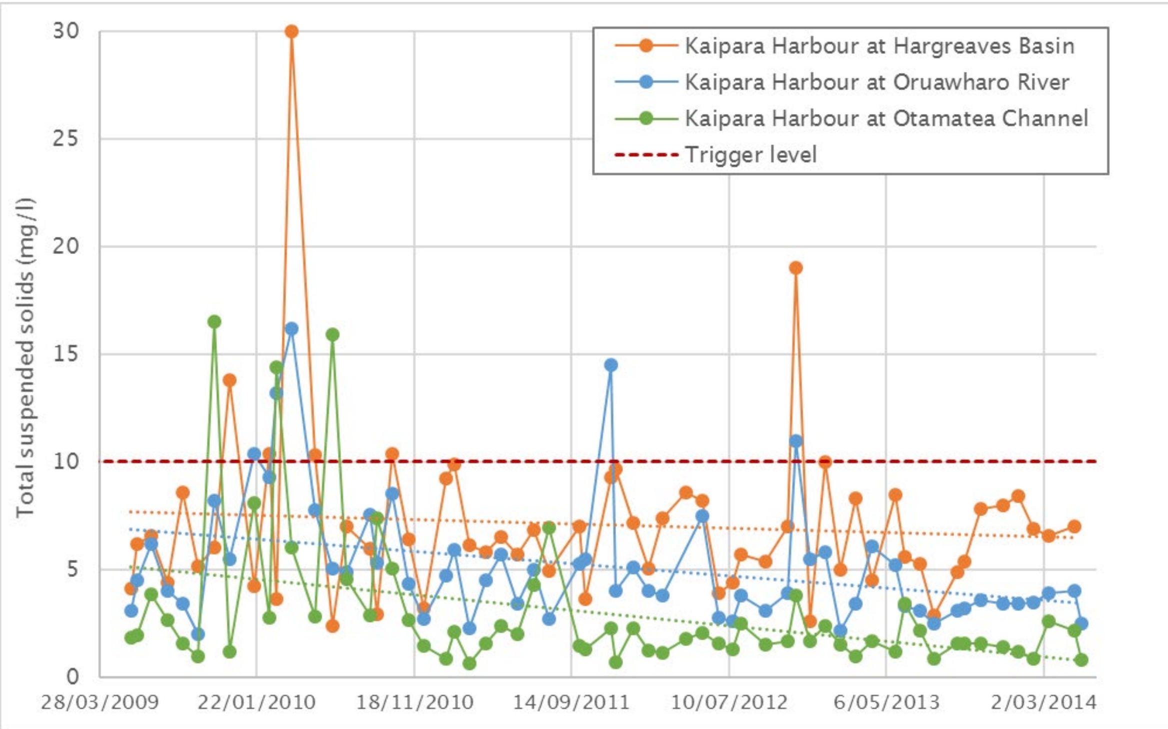

Figure 61 -Turbidity (NTU) at Oruawharo River and northern Kaipara Harbour sites over time

B.5 Estuarine and marine nutrient graphs

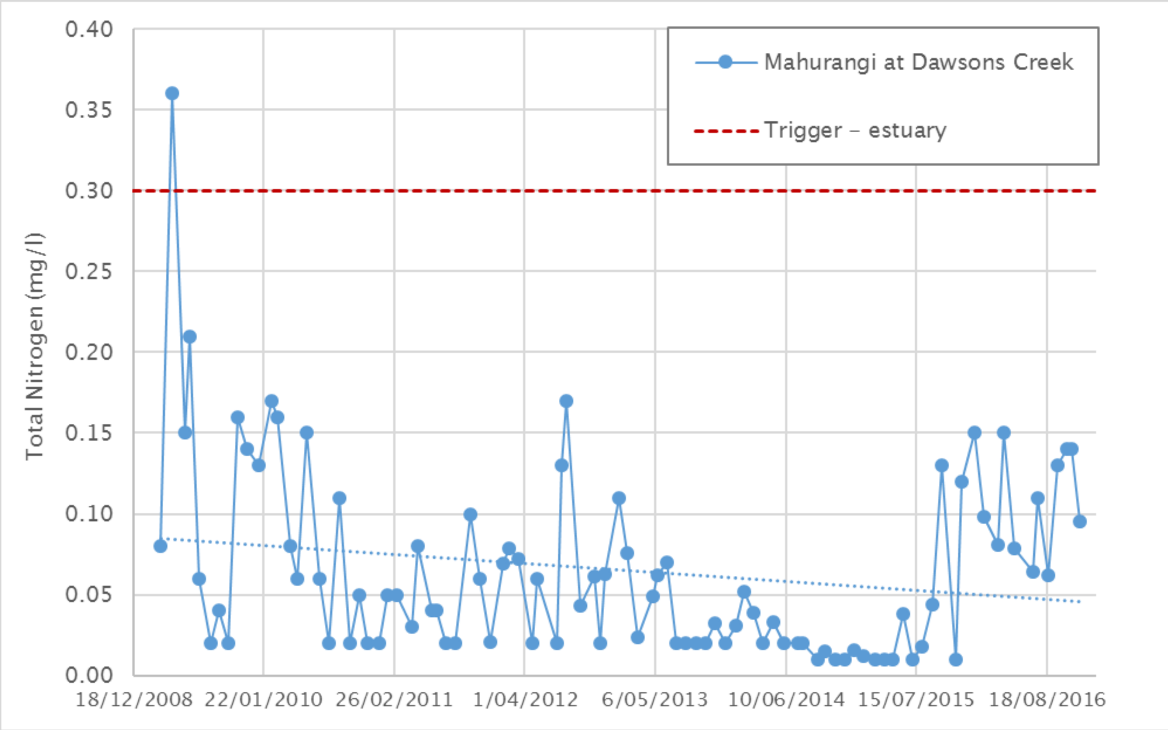

Figure 62 -Total Nitrogen concentration (mg/L) at Mahurangi Harbour sites over time

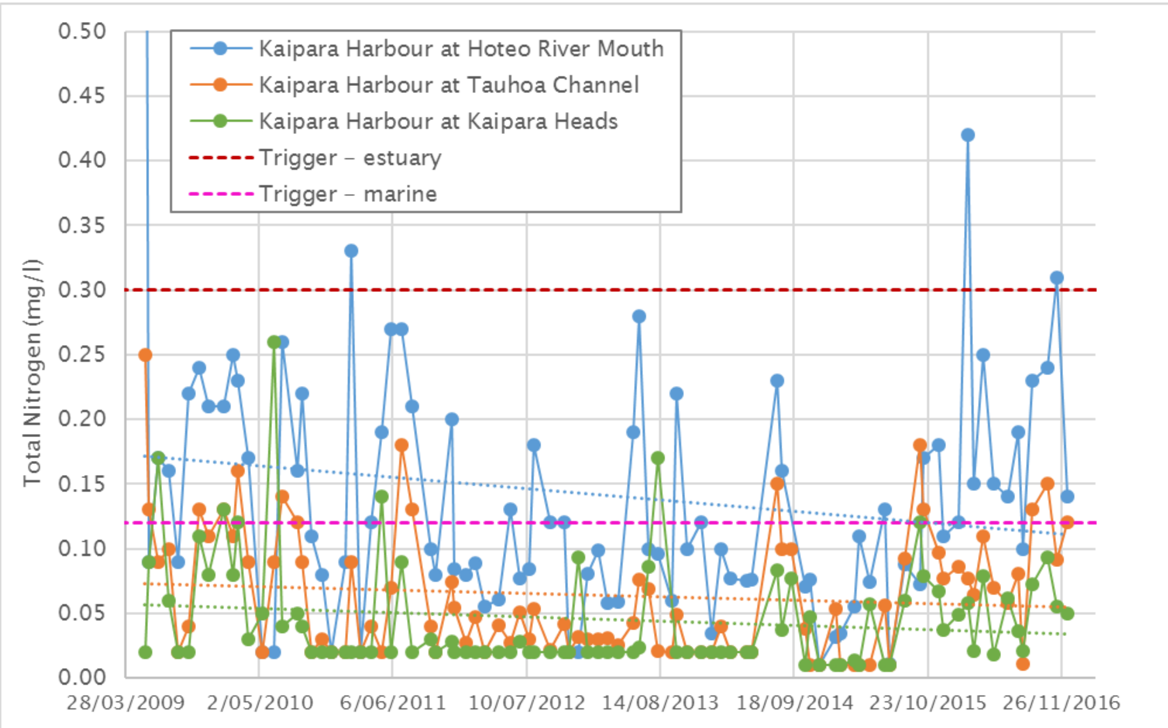

Figure 63 - Total Nitrogen concentration (mg/L) at southern Kaipara Harbour sites over time

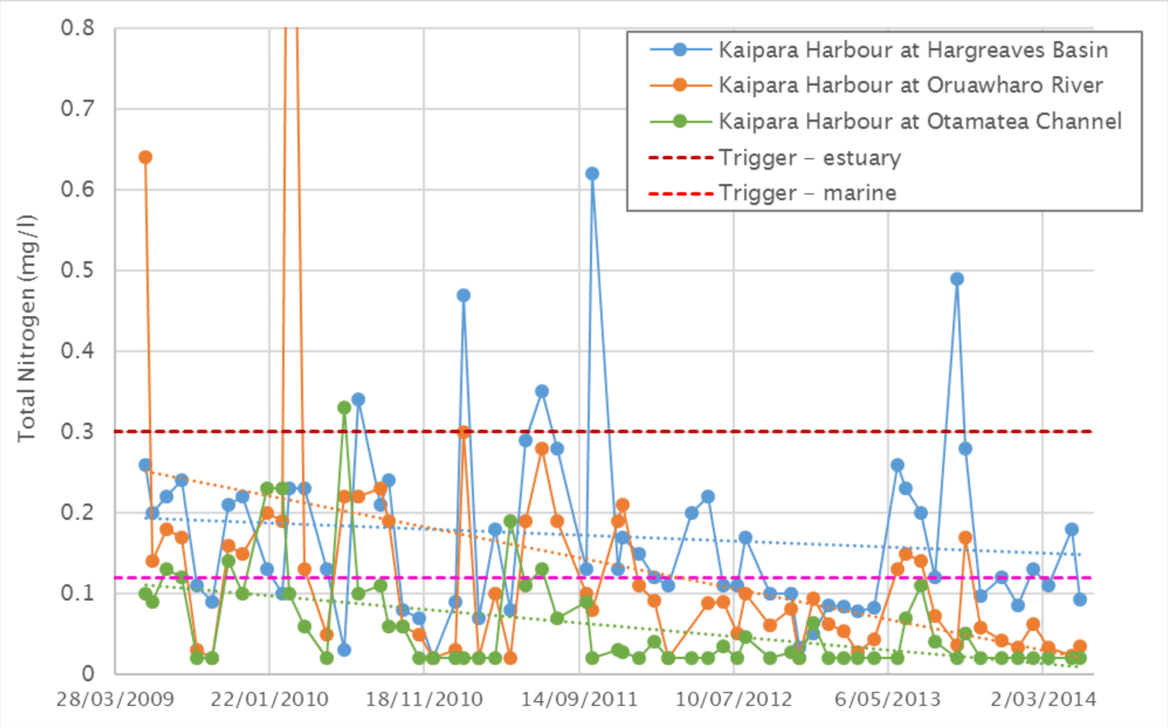

Figure 64 - Total Nitrogen concentration (mg/L) at Oruawharo River and northern Kaipara Harbour sites over time

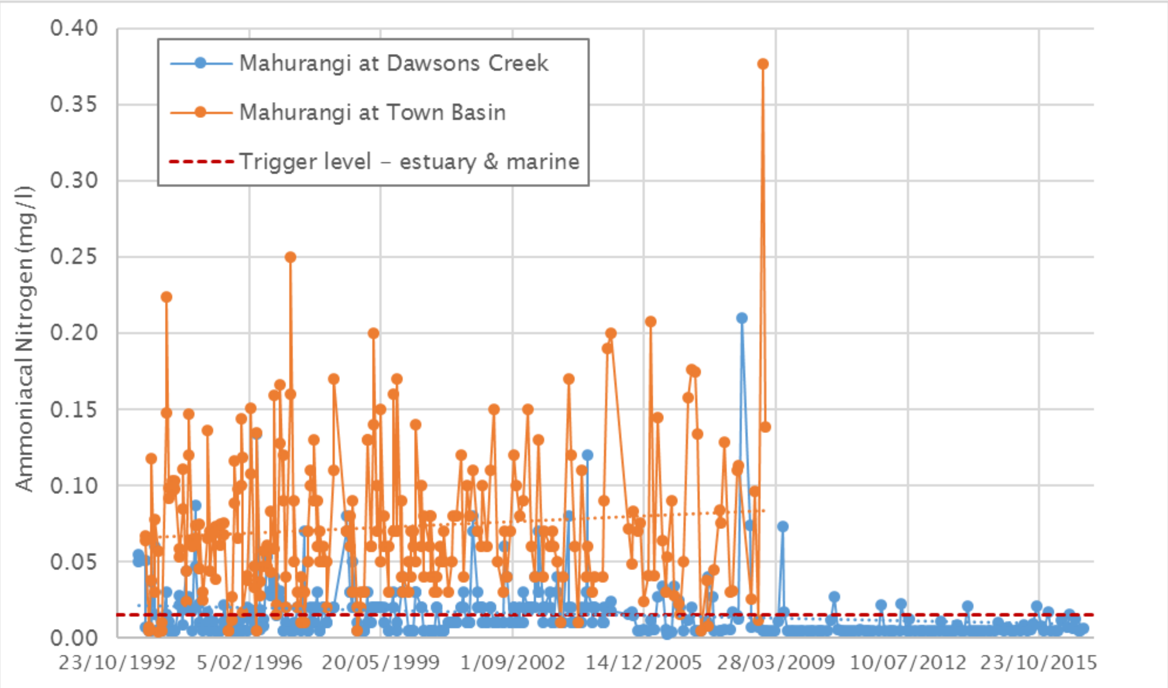

Figure 65 - Ammoniacal Nitrogen concentration (mg/L) at Mahurangi Harbour sites over time

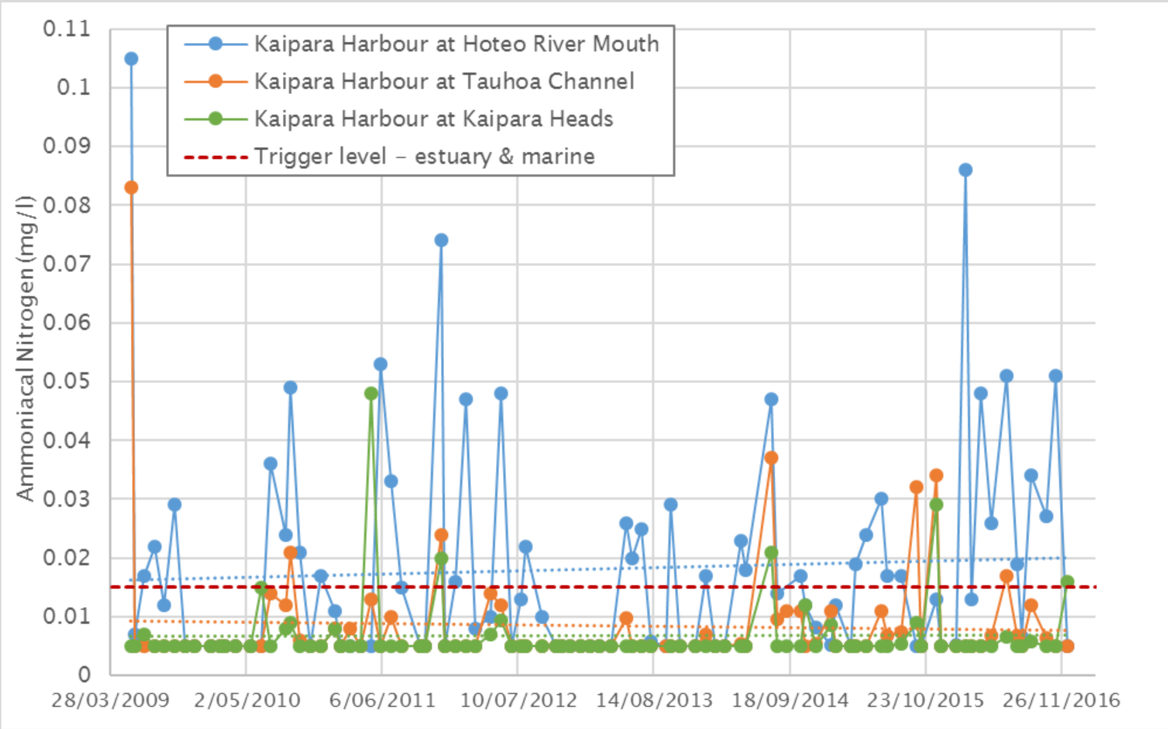

Figure 66 - Ammoniacal Nitrogen concentration (mg/L) at southern Kaipara Harbour sites over time

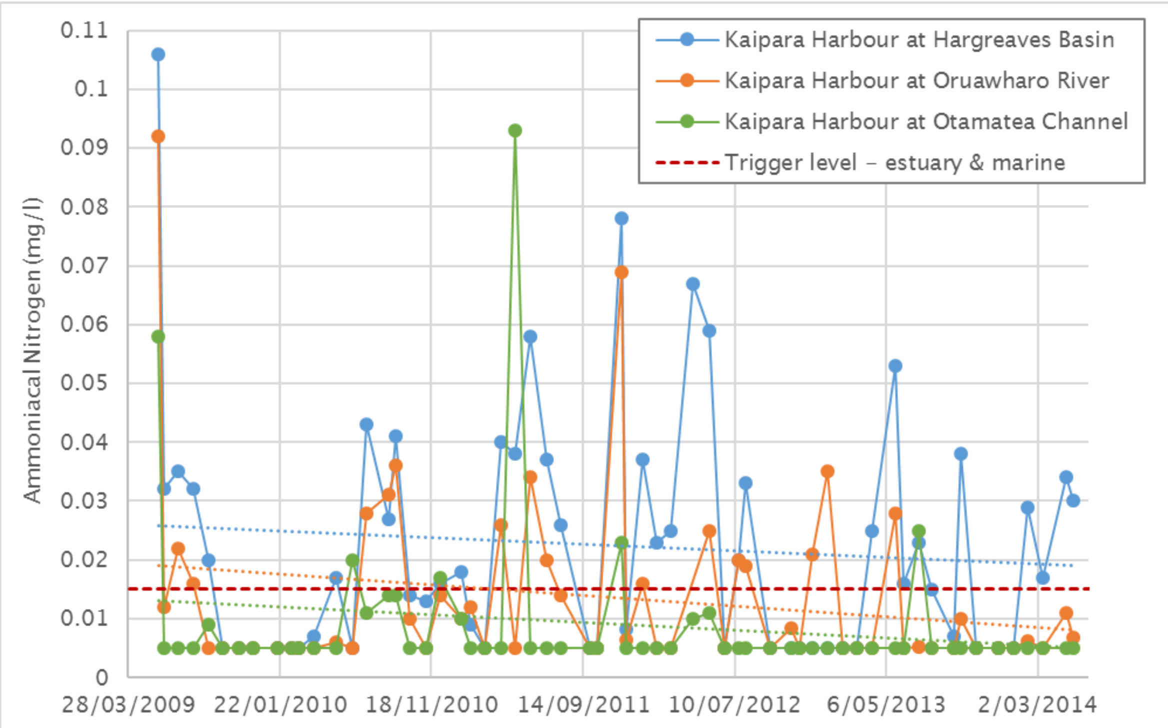

Figure 67 - Ammoniacal Nitrogen concentration (mg/L) at Oruawharo River and northern Kaipara Harbour sites over time

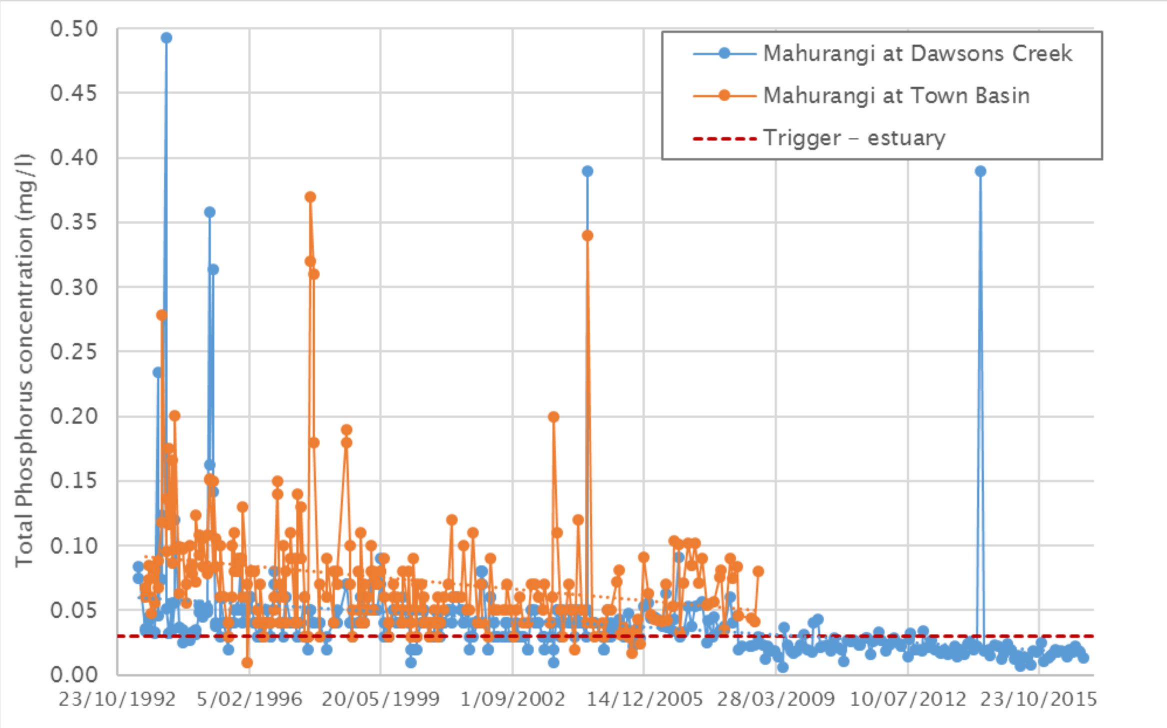

Figure 68 - Total Phosphorus concentration (mg/L) at Mahurangi Harbour sites over time

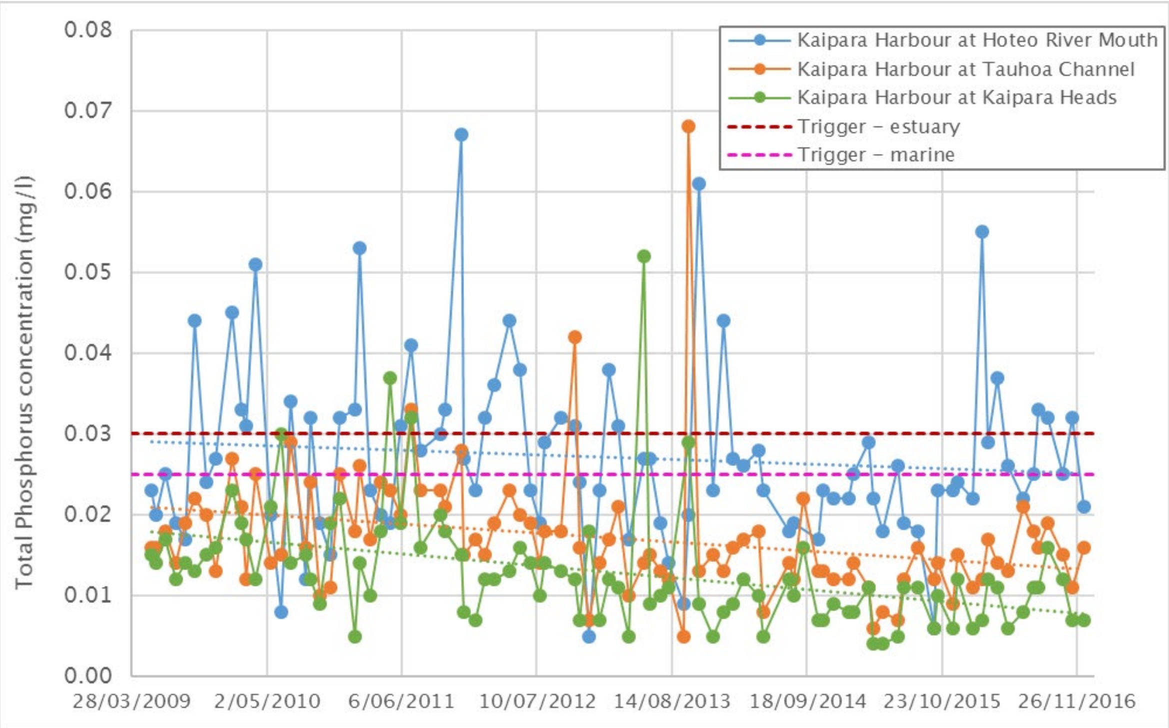

Figure 69 - Total Phosphorus concentration (mg/L) at southern Kaipara Harbour sites over time

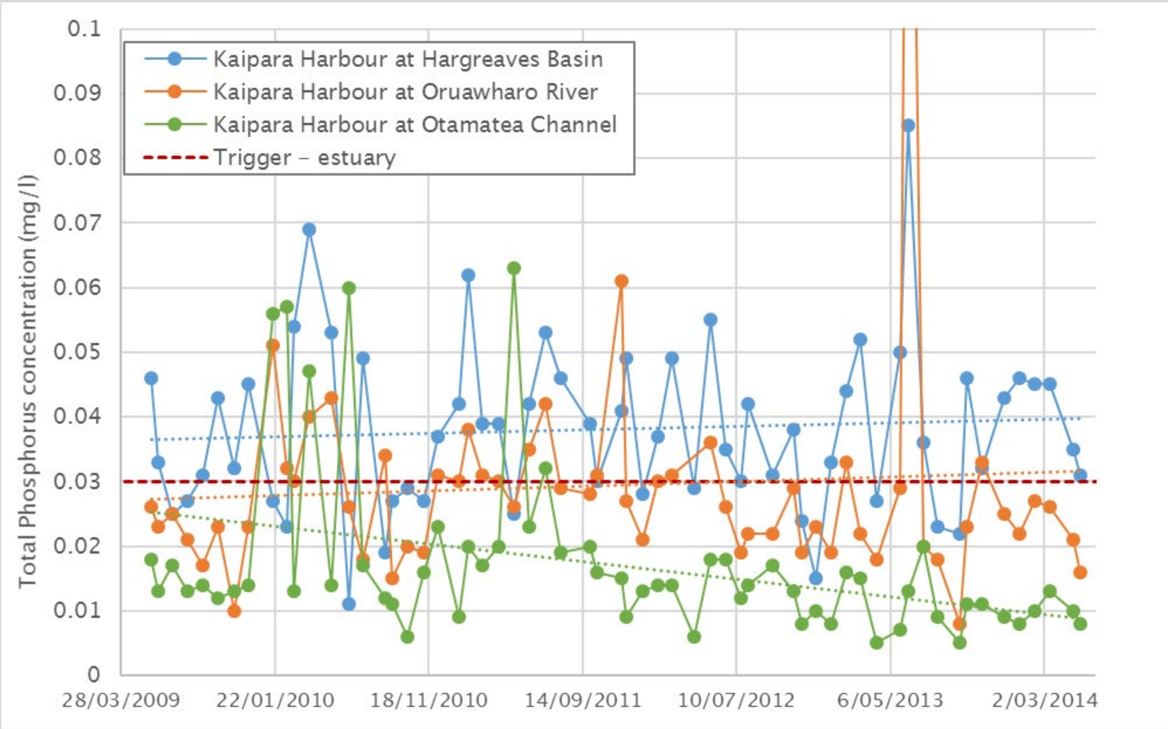

Figure 70 - Total Phosphorus concentration (mg/L) at Oruawharo River and northern Kaipara Harbour sites over time

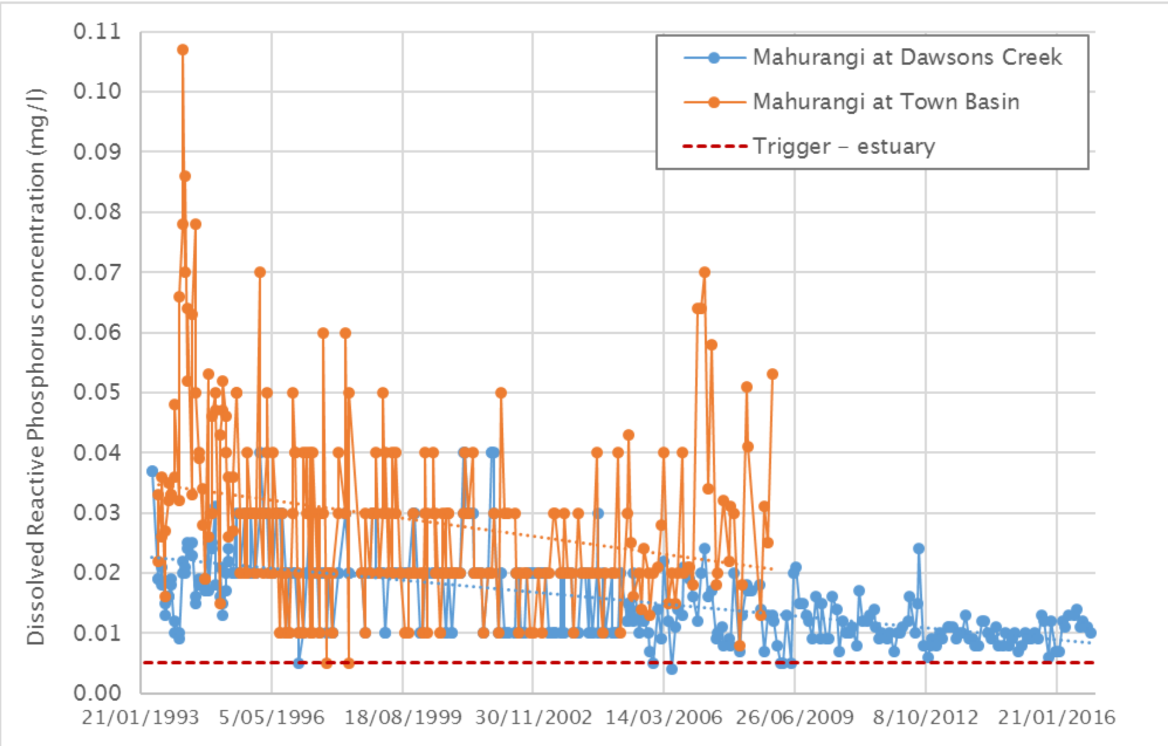

Figure 71 - Dissolved Reactive Phosphorus concentration (mg/L) at Mahurangi Harbour sites over time

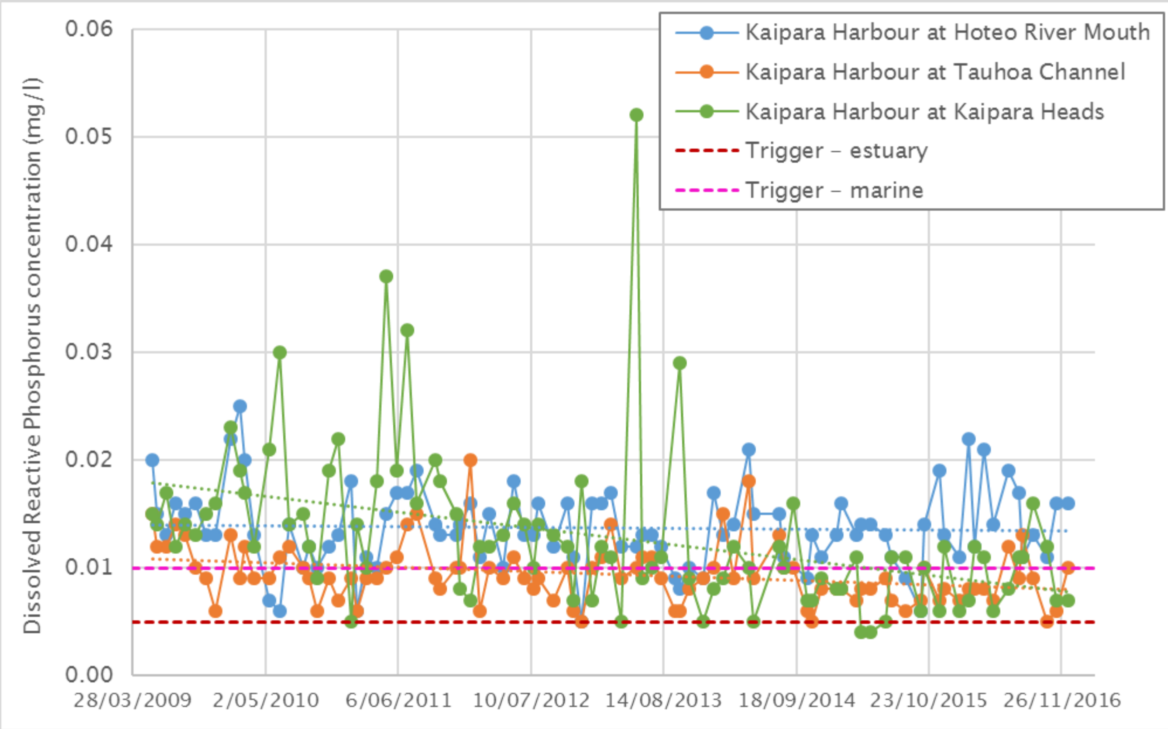

Figure 72 -Dissolved Reactive Phosphorus concentration (mg/L) at southern Kaipara Harbour sites over time

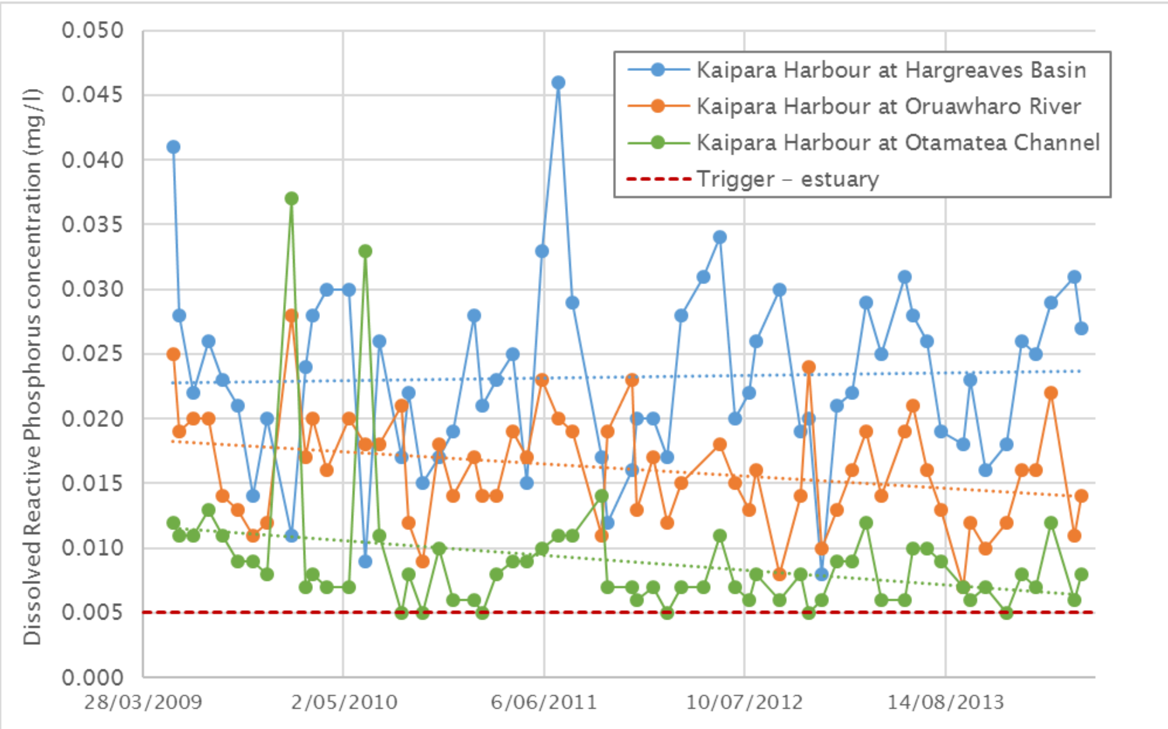

Figure 73 - Dissolved Reactive Phosphorus concentration (mg/L) at Oruawharo River and northern Kaipara Harbour sites over time

APPENDIX C: PROJECT SPECIFIC FRESHWATER MONITORING DATA

C.1 Mahurangi River water quality summary tables

Table 23 -Table C-1 Summary of project specific water quality data for the Mahurangi River (left branch) at Kaipara Flats Road (W2W-Mahurangi1-BL) (dry weather and wet weather monitoring June-September 2017)

Parameter (mg/L) unless stated	Trigger value[A]	#	Dry weather			Wet weather	
			Jul 17	Aug 17	Sep 17	Jun 17	Aug 17
In-situ data							
Dissolved Oxygen	<5	4	10.78	-	10.34	9.16	9.94
Dissolved Oxygen (%sat)	-	4	94.8	-	99.4	89.3	94
Specific conductivity (mS/cm)	-	4	160.3	-	156.9	125.8	151.7
Temp (°C)	-	4	9.5	-	13.4	14.1	12.8
pH (pH units)	6.5-8.5	4	8.07	-	6.78	7.09	7.35
Turbidity (NTU)	5.6	4	10	-	9	56	21.4
Clarity (m)	<0.6	4	0.57	-	1.01	0.11	0.43
Colour Munsell		3	5GY (35) 7/6	-	7.5Y (27.5) 8/2	-	10Y 30 7/6
SEV velocity (m/s)	-	0	Water too deep to measure				
Laboratory data							
pH (pH units)	6.5-8.5	5	7.3	7.3	7.2	7.1	7.1
Turbidity (NTU)	5.6	5	14.2	5	6.9	62	23
Total suspended solids	40	5	7	<3	3	55	6
Suspended Sediment Concentration	40	5	12	<10	<10	58	<10
Total Hardness as $CaCO_3$	-	5	45	46	44	33	38
Total nitrogen	0.614	5	0.49	0.27	0.27	1.56	0.44
Ammoniacal nitrogen	0.021	5	0.015	<0.010	0.013	0.033	0.017
Nitrate nitrogen	50	5	0.126	0.095	0.093	0.240	0.116
Nitrite nitrogen	0.1	5	0.003	<0.002	0.002	0.006	0.002
Nitrate-Nitrite (TON) nitrogen	0.444	5	0.128	0.096	0.095	0.250	0.118
Total Kjeldahl Nitrogen	-	5	0.37	0.17	0.17	1.32	0.32
Total Phosphorus	0.033	5	0.040	0.026	0.022	0.129	0.038
Dissolved reactive phosphorus	0.01	5	0.006	0.010	0.005	0.019	0.007
Biochemical oxygen demand (cBOD5)	-	2	<2	-	-	2	-

Parameter (mg/L) unless stated	Trigger value[A]	#	Dry weather			Wet weather	
			Jul 17	Aug 17	Sep 17	Jun 17	Aug 17
E. coli (cfu/100mL)	260	5	300	230	410	20,000	530
Enterococci (cfu/100mL)	-	5	90	<1	31	9,700	340
Aluminium (dissolved)	-	5	0.175	0.042	0.109	0.430	0.410
Aluminium (total)	-	5	0.370	0.093	0.151	0.820	0.920
Calcium (dissolved)	-	5	11.7	11.2	10.7	8.6	9.7
Magnesium (dissolved)	-	5	3.9	4.3	4.1	2.8	3.3
Manganese (dissolved)	-	2	0.03	-	-	0.052	-
Manganese (total)	-	2	0.039	-	-	0.096	-
Mercury (dissolved)	-	2	<0.00008	-	-	<0.00008	-
Mercury (total)	-	2	<0.00008	-	-	<0.00008	-
Arsenic (dissolved)	-	5	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Arsenic (total)	-	5	<0.0011	<0.0011	<0.0011	<0.0011	<0.0011
Cadmium (dissolved)	-	5	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Cadmium (total)	-	5	<0.000053	<0.000053	<0.000053	<0.000053	<0.000053
Chromium (dissolved)	-	5	0.0005	<0.0005	< 0.0005	0.0008	0.0009
Chromium (total)	-	5	0.00099	0.00062	0.00086	0.00137	0.002
Copper (dissolved)	0.0014[B]	5	0.0007	<0.0005	0.0005	0.0017	0.0008
Copper (total)	0.0014[B]	5	0.00102	<0.00053	0.00065	0.0024	0.00142
Lead (dissolved)	0.0034[B]	5	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Lead (total)	0.0034[B]	5	0.00016	<0.00011	<0.00011	0.00046	0.00029
Nickel (dissolved)	-	5	0.0007	0.0006	0.0007	0.0010	0.0008
Nickel (total)	-	5	0.00086	<0.00053	0.00065	0.00154	0.00115
Zinc (dissolved)	0.005[B]	5	0.0016	0.0011	<0.0010	0.002	0.0013
Zinc (total)	0.005[B]	5	0.0025	0.0015	0.0019	0.0076	0.0037
PAHs[C]	-	2	All results below detection limits				
TPHs[D]	-	2	All results below detection limits				

Notes:

A - Trigger value is the lower guideline trigger value in Table 3, grey shading indicates mean or median value exceeds this value

B - Trigger values are hardness dependant; these are values for a hardness of 30 mg/L $CaCO_3$

C - PAHs analysed were as follows: Acenaphthene, Acenaphthylene, Anthracene, Benzo[a]anthracene, Benzo[a]pyrene (BAP), Benzo[b]fluoranthene + Benzo[j]fluoranthene, Benzo[g,h,i]perylene, Benzo[k]fluoranthene, Chrysene, Dibenzo[a,h]anthracene, Fluoranthene, Fluorene, Indeno(1,2,3-c,d)pyrene, Naphthalene, Phenanthrene, Pyrene, all results were below detection limits.

D - TPHs analysed were as follows: C7 - C9, C10 - C14, C15 - C36, Total hydrocarbons (C7 – C36), all results were below detection limits.

Table 24 - able D-2 Summary of project specific water quality data for the Mahurangi River at SH1 (W2W-Mahurangi7-BL) (dry weather and wet weather monitoring June-September 2017)

Parameter (mg/L) unless stated	Trigger value[A]	#	Dry weather			Wet weather	
			Jul 17	Aug 17	Sep 17	Jun 17	Aug 17
In-situ data							
Dissolved Oxygen	<5	5	11.78	11.49	11.73	10.49	10.64
Dissolved Oxygen (%sat)	-	5	103.3	106.2	112.7	101.3	102.3
Specific conductivity (mS/cm)	-	5	169	177.3	161.9	163.8	143.4
Temp (°C)	-	5	9.6	11.9	13.5	13.8	13.6
pH (pH units)	6.5-8.5	5	7.8	7.93	7.61	7.21	8.14
Turbidity (NTU)	5.6	5	21	10.7	15.7	84	54.2
Clarity (m)	<0.6	5	0.3	0.78	0.54	0.07	0.13
Colour (Munsell)		4	7.5Y (27.5) 7/6	5Y (25) 5/6	5Y (25) 7/6	-	7.5Y (27.5) 7/6
SEV velocity (m/s)	-	0	Water too deep to measure				
Laboratory data							
pH (pH units)	6.5-8.5	5	7.6	7.6	7.5	7.3	7.4
Turbidity (NTU)	5.6	5	26	11	17.8	94	64
Total suspended solids	40	5	15	5	9	99	36
Suspended Sediment Concentration	40	5	20	<10	<10	98	36
Total Hardness as $CaCO_3$	-	5	46	45	43	43	37
Total nitrogen	0.614	5	0.6	0.43	0.49	1.7	0.87
Ammoniacal nitrogen	0.021	5	0.023	0.013	0.018	0.053	0.01
Nitrate nitrogen	50	5	0.22	0.195	0.21	0.30	0.20
Nitrite nitrogen	0.1	5	0.003	0.002	0.002	0.007	0.003
Nitrate-Nitrite (TON) nitrogen	0.444	5	0.22	0.197	0.21	0.31	0.21
Total Kjeldahl Nitrogen	-	5	0.38	0.23	0.28	1.39	0.66
Total Phosphorus	0.033	5	0.048	0.032	0.03	0.22	0.072
Dissolved reactive phosphorus	0.01	5	0.008	0.006	0.005	0.033	0.008
Biochemical oxygen demand (cBOD5)	-	2	<2	-	-	3	-
E. coli (cfu/100mL)	260	5	900	250	270	17,000	2,700
Enterococci (cfu/100mL)	-	5	300	33	29	8,000	1,500
Aluminium (dissolved)	-	5	0.22	0.134	0.24	0.29	0.53
Aluminium (total)	-	5	0.53	0.26	0.66	0.96	1.42

Parameter (mg/L) unless stated	Trigger value[A]	#	Dry weather			Wet weather	
			Jul 17	Aug 17	Sep 17	Jun 17	Aug 17
Calcium (dissolved)	-	5	12.1	11.0	10.7	11.4	10.0
Magnesium (dissolved)	-	5	3.8	4.2	3.9	3.5	3.0
Manganese (dissolved)	-	2	0.0138	-	-	0.0177	-
Manganese (total)	-	2	0.026	-	-	0.143	-
Mercury (dissolved)	-	2	<0.00008	-	-	<0.00008	-
Mercury (total)	-	2	<0.00008	-	-	<0.00008	-
Arsenic (dissolved)	-	5	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Arsenic (total)	-	5	<0.0011	<0.0011	< 0.0011	<0.0011	<0.0011
Cadmium (dissolved)	-	5	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Cadmium (total)	-	5	<0.000053	<0.000053	<0.000053	<0.000053	<0.000053
Chromium (dissolved)	-	5	0.0006	0.0006	0.0006	0.0007	0.0009
Chromium (total)	-	5	0.00138	0.00096	0.00144	0.00181	0.0025
Copper (dissolved)	0.0014[B]	5	0.0008	<0.0005	0.0006	0.0017	0.0014
Copper (total)	0.0014[B]	5	0.00129	0.00071	0.00116	0.0032	0.0027
Lead (dissolved)	0.0034[B]	5	<0.00010	<0.00010	<0.00010	<0.00010	0.00010
Lead (total)	0.0034[B]	5	0.00031	0.00015	0.0002	0.00094	0.00064
Nickel (dissolved)	-	5	0.0007	0.0007	0.0008	0.0009	0.0010
Nickel (total)	-	5	0.00105	0.00078	0.00097	0.0019	0.0017
Zinc (dissolved)	0.005[B]	5	0.0020	0.0011	0.0010	0.0020	0.0015
Zinc (total)	0.005[B]	5	0.0045	0.0017	0.0027	0.0130	0.0069
PAHs[C]	-	2	All results below detection limits				
TPHs[D]	-	2	All results below detection limits				

Notes:

A - Trigger value is the lower guideline trigger value in Table 3, grey shading indicates mean or median value exceeds this value

B - Trigger values are hardness dependant; these are values for a hardness of 30 mg/L $CaCO_3$

C - PAHs analysed were as follows: Acenaphthene, Acenaphthylene, Anthracene, Benzo[a]anthracene, Benzo[a]pyrene (BAP), Benzo[b]fluoranthene + Benzo[j]fluoranthene, Benzo[g,h,i]perylene, Benzo[k]fluoranthene, Chrysene, Dibenzo[a,h]anthracene, Fluoranthene, Fluorene, Indeno(1,2,3-c,d)pyrene, Naphthalene, Phenanthrene, Pyrene, all results were below detection limits.

D - TPHs analysed were as follows: C7 - C9, C10 - C14, C15 - C36, Total hydrocarbons (C7 – C36), all results were below detection limits.

C.2 Hōteo Catchment water quality

Table 25 - Table C-3 Summary of project specific water quality data for the Kourawhero River at Kaipara Flats Road (W2W-Kourawhero2-BL) (dry weather and wet weather monitoring June-September 2017)

Parameter (mg/L) unless stated	Trigger value[A]	#	Dry weather			Wet weather	
			Jul 17	Aug 17	Sep 17	Jun 17	Aug 17
In-situ data							
Dissolved Oxygen	<5	5	11.15	11.5	11	9.2	10.47
Dissolved Oxygen (%sat)	-	5	98.4	105.7	111.5	90.7	100.4
Specific conductivity (mS/cm)	-	5	178.9	194.1	179.8	140.1	174.8
Temp (˚C)	-	5	9.7	11.6	16	14.4	13.5
pH (pH units)	6.5-8.5	5	7.5	6.7	7.03	6.9	7.35
Turbidity (NTU)	5.6	5	14	8	9	50.5	20.3
Clarity (m)	<0.6	5	0.55	0.82	0.88	0.16	0.37
Colour (Munsell)		4	7.5Y (27.5) 8/2	7.5Y (27.5) 8/2	7.5 Y (27.5) 8/2	-	7.5GY 37.5 8/2
SEV velocity (m/s)	-	2	Too deep to measure		0.54	Too deep	0.78
Laboratory data							
pH (pH units)	6.5-8.5	5	7.3	7.4	7.3	7.0	7.2
Turbidity (NTU)	5.6	5	15.2	8.1	8.5	52.0	24.0
Total suspended solids	40	5	11	5	4	41	11
Suspended Sediment Concentration	40	5	16	<10	<10	33	14
Total Hardness as $CaCO_3$	-	5	46	53	51	36	44
Total nitrogen	0.614	5	0.5	0.25	0.28	1.52	0.55
Ammoniacal nitrogen	0.021	5	0.030	0.019	0.025	0.020	0.021
Nitrate nitrogen	50	5	0.132	0.051	0.067	0.380	0.136
Nitrite nitrogen	0.1	5	0.003	0.002	0.002	0.005	0.002
Nitrate-Nitrite (TON) nitrogen	0.444	5	0.135	0.053	0.069	0.390	0.139
Total Kjeldahl Nitrogen	-	5	0.37	0.19	0.21	1.13	0.41
Total Phosphorus	0.033	5	0.034	0.026	0.023	0.091	0.036
Dissolved reactive phosphorus	0.01	5	0.006	0.005	0.005	0.009	0.004
Biochemical oxygen demand (cBOD5)	-	2	<2	-	-	<2	-
E. coli (cfu/100mL)	260	5	90	100	170	2,900	70
Enterococci (cfu/100mL)	-	5	41	14	33	3,000	70

Parameter (mg/L) unless stated	Trigger value[A]	#	Dry weather			Wet weather	
			Jul 17	Aug 17	Sep 17	Jun 17	Aug 17
Aluminium (dissolved)	-	5	0.16	0.05	0.10	0.34	0.26
Aluminium (total)	-	5	0.52	0.179	0.22	0.90	0.97
Calcium (dissolved)	-	5	10.7	11.7	11.2	7.9	10.1
Magnesium (dissolved)	-	5	4.7	5.7	5.5	3.9	4.6
Manganese (dissolved)	-	2	0.152	-	-	0.115	-
Manganese (total)	-	2	0.168	-	-	0.152	-
Mercury (dissolved)	-	2	<0.00008	-	-	<0.00008	-
Mercury (total)	-	2	<0.00008	-	-	<0.00008	-
Arsenic (dissolved)	-	5	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Arsenic (total)	-	5	<0.0011	<0.0011	<0.0011	<0.0011	<0.0011
Cadmium (dissolved)	-	5	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Cadmium (total)	-	5	<0.000053	<0.000053	<0.000053	<0.000053	<0.000053
Chromium (dissolved)	-	5	<0.0005	<0.0005	<0.0005	0.0008	0.0007
Chromium (total)	-	5	0.0014	0.00069	0.00114	0.00163	0.0024
Copper (dissolved)	0.0014[B]	5	0.0006	<0.0005	0.0005	0.0016	0.0007
Copper (total)	0.0014[B]	5	0.00110	0.00145	0.00074	0.0023	0.00164
Lead (dissolved)	0.0034[B]	5	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Lead (total)	0.0034[B]	5	0.00017	0.00012	<0.00011	0.00037	0.00026
Nickel (dissolved)	-	5	0.0010	0.0010	0.0008	0.0011	0.0009
Nickel (total)	-	5	0.00113	0.00118	0.00105	0.00155	0.00154
Zinc (dissolved)	0.005[B]	5	0.0014	< 0.0010	< 0.0010	0.0018	0.0011
Zinc (total)	0.005[B]	5	0.0033	0.0900	0.0013	0.0108	0.0049
PAHs[C]	-	2	All results below detection limits				
TPHs[D]	-	2	All results below detection limits				

Notes:

A - Trigger value is the lower guideline trigger value in Table 3, grey shading indicates mean or median value exceeds this value

B - Trigger values are hardness dependant; these are values for a hardness of 30 mg/L $CaCO_3$

C - PAHs analysed were as follows: Acenaphthene, Acenaphthylene, Anthracene, Benzo[a]anthracene, Benzo[a]pyrene (BAP), Benzo[b]fluoranthene + Benzo[j]fluoranthene, Benzo[g,h,i]perylene, Benzo[k]fluoranthene, Chrysene, Dibenzo[a,h]anthracene, Fluoranthene, Fluorene, Indeno(1,2,3-c,d)pyrene, Naphthalene, Phenanthrene, Pyrene, all results were below detection limits.

D - TPHs analysed were as follows: C7 - C9, C10 - C14, C15 - C36, Total hydrocarbons (C7 – C36), all results were below detection limits.

Table 26 - Summary of project specific water quality data for the Hōteo River at SH1 (W2W-Hōteo 3-BL) (monthly dry weather and wet weather monitoring June-September 2017)

Parameter (mg/L) unless stated	Trigger value^A	#	Dry weather			Wet weather	
			Jul 17	Aug 17	Sep 17	Jun 17	Aug 17
In-situ data							
Dissolved Oxygen	<5	5	11.02	11.42	10.7	9.65	9.69
Dissolved Oxygen (%sat)	-	5	99.5	103.2	103.7	93.4	93.1
Specific conductivity (mS/cm)	-	5	174.8	171.9	161.6	180.4	170.3
Temp (°C)	-	5	11.0	10.8	13.8	13.8	13.5
pH (pH units)	6.5-8.5	5	7.36	7.55	7.62	7.37	7.15
Turbidity (NTU)	5.6	5	15.6	8.5	10	28	37.5
Clarity (m)	<0.6	5	0.40	0.91	0.73	0.21	0.14
Colour (Munsell)	-	5	7.5Y (27.5) 7/6	7.5y (27.5) 7/6	7.5Y (27.5) 7/6	7.5Y (27.5) 7/6	5Y (25) 7/6
SEV velocity (m/s)	-	0	Water too deep to measure				
Laboratory data							
pH (pH units)	6.5-8.5	5	7.2	7.4	7.3	7.3	7.4
Turbidity (NTU)	5.6	5	21	8.3	11.4	30	48
Total suspended solids	40	5	11	4	9	47	59
Suspended Sediment Concentration	40	5	<10	<10	14	38	70
Total Hardness as CaCO3	-	5	43	43	42	47	41
Total nitrogen	0.614	5	0.24	0.63	0.80	0.80	0.97
Ammoniacal nitrogen	0.021	5	<0.010	0.013	0.047	0.026	0.042
Nitrate nitrogen	50	5	0.104	0.35	0.43	0.36	0.35
Nitrite nitrogen	0.1	5	<0.002	0.003	0.016	0.006	0.005
Nitrate-Nitrite (TON) nitrogen	0.444	5	0.105	0.350	0.450	0.360	0.360
Total Kjeldahl Nitrogen	-	5	0.13	0.28	0.36	0.44	0.62
Total Phosphorus	0.033	5	0.019	0.042	0.080	0.089	0.111
Dissolved reactive phosphorus	0.01	5	<0.004	0.015	0.027	0.017	0.025
Biochemical oxygen demand (cBOD5)	-	2	<2	-	-	<2	-
E. coli (cfu/100mL)	260	5	170	150	240	4,400	3,900
Enterococci (cfu/100mL)	-	5	31	70	30	3,900	750
Aluminium (dissolved)	-	5	0.179	0.059	0.159	0.075	0.094
Aluminium (total)	-	5	0.640	0.182	0.173	0.620	0.890

Parameter (mg/L) unless stated	Trigger value[A]	#	Dry weather			Wet weather	
			Jul 17	Aug 17	Sep 17	Jun 17	Aug 17
Calcium (dissolved)	-	5	9.3	10.1	10.9	11.9	10.8
Magnesium (dissolved)	-	5	4.8	4.3	3.7	4.2	3.3
Manganese (dissolved)	-	2	0.027	-	-	0.023	-
Manganese (total)	-	2	0.039	-	-	0.067	-
Mercury (dissolved)	-	2	<0.00008	-	-	<0.00008	-
Mercury (total)	-	2	<0.00008	-	-	<0.00008	-
Arsenic (dissolved)	-	5	<0.0010	< 0.0010	< 0.0010	<0.0010	<0.0010
Arsenic (total)	-	5	<0.0011	< 0.0011	< 0.0011	<0.0011	<0.0011
Cadmium (dissolved)	-	5	<0.00005	< 0.00005	<0.00005	<0.00005	<0.00005
Cadmium (total)	-	5	<0.000053	<0.000053	<0.000053	<0.000053	<0.000053
Chromium (dissolved)	-	5	0.0006	<0.0005	0.0005	<0.0005	<0.0005
Chromium (total)	-	5	0.00198	0.0008	0.00072	0.00129	0.00186
Copper (dissolved)	0.0014[B]	5	0.0006	0.0005	0.0010	0.0009	0.0010
Copper (total)	0.0014[B]	5	0.00240	0.00085	0.00107	0.00185	0.00194
Lead (dissolved)	0.0034[B]	5	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Lead (total)	0.0034[B]	5	0.00022	0.00012	0.00012	0.00034	0.00059
Nickel (dissolved)	-	5	0.0006	0.0006	0.0008	0.0010	0.0009
Nickel (total)	-	5	0.00096	0.00085	0.00098	0.00155	0.00152
Zinc (dissolved)	0.005[B]	5	<0.0010	<0.0010	0.0011	<0.0010	<0.0010
Zinc (total)	0.005[B]	5	0.0025	<0.0011	0.0014	0.0033	0.0048
PAHs[C]	-	2	All results below detection limits				
TPHs[D]	-	2	All results below detection limits				

Notes:

A - Trigger value is the lower guideline trigger value in Table 3, grey shading indicates mean or median value exceeds this value

B - Trigger values are hardness dependant; these are values for a hardness of 30 mg/L $CaCO_3$

C - PAHs analysed were as follows: Acenaphthene, Acenaphthylene, Anthracene, Benzo[a]anthracene, Benzo[a]pyrene (BAP), Benzo[b]fluoranthene + Benzo[j]fluoranthene, Benzo[g,h,i]perylene, Benzo[k]fluoranthene, Chrysene, Dibenzo[a,h]anthracene, Fluoranthene, Fluorene, Indeno(1,2,3-c,d)pyrene, Naphthalene, Phenanthrene, Pyrene, all results were below detection limits.

D - TPHs analysed were as follows: C7 - C9, C10 - C14, C15 - C36, Total hydrocarbons (C7 – C36), all results were below detection limits.

Table 27 - Summary of project specific water quality data for the Waiteraire Stream at SH1 (W2W-Hōteo 4-BL) (monthly dry weather and wet weather monitoring June-September 2017)

Parameter (mg/L) unless stated	Trigger value[A]	#	Dry weather			Wet weather	
			Jul 17	Aug 17	Sep 17	Jun 17	Aug 17
In-situ data							
Dissolved Oxygen	<5	5	10.9	11.95	11.37	9.88	10.21
Dissolved Oxygen (%sat)	-	5	98.8	104.8	107.5	95.7	97.7
Specific conductivity (mS/cm)	-	5	165.2	194.4	179.5	146.4	158.7
Temp (°C)	-	5	11.3	9.5	12.8	14	13.4
pH (pH units)	6.5-8.5	5	7.26	7.66	7.54	7.40	7.45
Turbidity (NTU)	5.6	5	14.1	6.7	7.5	59	115
Clarity (m)	<0.6	5	0.70	1.01	0.71	0.11	0.07
Colour (Munsell)			7.5Y (27.5) 7/6	7.5Y (27.5) 8/2	2.5Y (22.5) 8/2	7.5Y (27.5) 7/6	2.5Y (22.5) 7/6
SEV velocity (m/s)	-	0	Water too deep to measure				
Laboratory data							
pH (pH units)	6.5-8.5	5	7.1	7.5	7.5	7.2	7.4
Turbidity (NTU)	5.6	5	19.6	5.9	7.8	64	155
Total suspended solids	40	5	17	7	6	53	171
Suspended Sediment Concentration	40	4	14	<10	<10	-	134
Total Hardness as $CaCO_3$	-	5	41	50	46	39	38
Total nitrogen	0.614	5	0.89	0.18	0.24	0.74	0.71
Ammoniacal nitrogen	0.021	5	0.065	<0.010	<0.010	<0.010	<0.010
Nitrate nitrogen	50	5	0.44	0.09	0.094	0.126	0.084
Nitrite nitrogen	0.1	5	0.006	<0.002	<0.002	0.004	<0.002
Nitrate-Nitrite (TON) nitrogen	0.444	5	0.450	0.091	0.095	0.130	0.085
Total Kjeldahl Nitrogen	-	5	0.44	<0.10	0.14	0.61	0.63
Total Phosphorus	0.033	5	0.079	0.012	0.014	0.072	0.083
Dissolved reactive phosphorus	0.01	5	0.027	<0.004	<0.004	0.006	<0.004
Biochemical oxygen demand (cBOD5)	-	2	<2	-	-	<2	-
E. coli (cfu/100mL)	260	5	220	70	62	-	1,500
Enterococci (cfu/100mL)	-	5	38	50	14	-	400
Aluminium (dissolved)	-	5	0.173	0.043	0.102	0.350	0.290
Aluminium (total)	-	5	0.510	0.138	0.220	2.500	3.500
Calcium (dissolved)	-	5	10.4	10.6	10.1	8.8	8.9
Magnesium (dissolved)	-	5	3.8	5.7	5	4.2	3.8

Parameter (mg/L) unless stated	Trigger value[A]	#	Dry weather			Wet weather	
			Jul 17	Aug 17	Sep 17	Jun 17	Aug 17
Manganese (dissolved)	-	2	0.019	-	-	0.048	-
Manganese (total)	-	2	0.035	-	-	0.113	-
Mercury (dissolved)	-	2	<0.00008	-	-	<0.00008	-
Mercury (total)	-	2	<0.00008	-	-	<0.00008	-
Arsenic (dissolved)	-	5	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Arsenic (total)	-	5	<0.0011	<0.0011	<0.0011	<0.0011	<0.0011
Cadmium (dissolved)	-	5	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Cadmium (total)	-	5	<0.000053	<0.000053	<0.000053	<0.000053	<0.000053
Chromium (dissolved)	-	5	0.0006	0.0006	0.0007	0.0008	0.0007
Chromium (total)	-	5	0.00131	0.00118	0.0013	0.0045	0.0063
Copper (dissolved)	0.0014[B]	5	0.0009	<0.0005	<0.0005	0.0015	0.0008
Copper (total)	0.0014[B]	5	0.00141	<0.00053	0.00053	0.0032	0.0035
Lead (dissolved)	0.0034[B]	5	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Lead (total)	0.0034[B]	5	0.0002	<0.00011	<0.00011	0.00077	0.00126
Nickel (dissolved)	-	5	0.0008	<0.0005	0.0005	0.0008	0.0007
Nickel (total)	-	5	0.00115	<0.00053	0.00062	0.0024	0.0024
Zinc (dissolved)	0.005[B]	5	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Zinc (total)	0.005[B]	5	0.0033	<0.0011	<0.0011	0.0070	0.0092
PAHs[C]	-	2	All results below detection limits				
TPHs[D]	-	2	All results below detection limits				

Notes:

A - Trigger value is the lower guideline trigger value in Table 3, grey shading indicates mean or median value exceeds this value

B - Trigger values are hardness dependant; these are values for a hardness of 30 mg/L $CaCO_3$

C - PAHs analysed were as follows: Acenaphthene, Acenaphthylene, Anthracene, Benzo[a]anthracene, Benzo[a]pyrene (BAP), Benzo[b]fluoranthene + Benzo[j]fluoranthene, Benzo[g,h,i]perylene, Benzo[k]fluoranthene, Chrysene, Dibenzo[a,h]anthracene, Fluoranthene, Fluorene, Indeno(1,2,3-c,d)pyrene, Naphthalene, Phenanthrene, Pyrene, all results were below detection limits.

D - TPHs analysed were as follows: C7 - C9, C10 - C14, C15 - C36, Total hydrocarbons (C7 – C36), all results were below detection limits.

Table 28 - Summary of project specific water quality data for the Waiteraire Stream at SH1 (Hōteo 8-BL) (dry weather and wet weather monitoring June-September 2017)

Parameter (mg/L) unless stated	Trigger value[A]	#	Dry weather			Wet weather	
			Jul 17	Aug 17	Sep 17	Jun 17	Aug 17
In-situ data							
Dissolved Oxygen	<5	5	10.57	11.51	10.92	9.2	9.96
Dissolved Oxygen (%sat)	-	5	97.2	104.7	105.8	90	95.6
Specific conductivity (mS/cm)	-	5	170.5	183	168.4	178.4	171.2
Temp (°C)	-	5	11.5	11.1	13.9	14.3	13.5
pH (pH units)	6.5-8.5	5	7.34	7.5	7.35	7.11	7.3
Turbidity (NTU)	5.6	5	20.9	7.9	12.8	50	69
Clarity (m)	<0.6	5	0.34	0.75	0.73	0.14	0.07
Colour (Munsell)			7.5Y (27.5) 7/6	7.5Y (27.5) 7/6	7.5y (27.5) 7/6	7.5y (27.5) 5/6	5Y (25) 5/6
SEV velocity (m/s)	-	0	Water too deep to measure				
Laboratory data							
pH (pH units)	6.5-8.5	5	7.2	7.7	7.4	7.4	7.4
Turbidity (NTU)	5.6	5	26.0	8.8	12.7	57.0	91.0
Total suspended solids	40	5	25	5	11	65	116
Suspended Sediment Concentration	40	5	21	<10	17	74	102
Total Hardness as $CaCO_3$	-	5	44	46	45	47	42
Total nitrogen	0.614	5	0.80	0.59	0.71	1.32	1.08
Ammoniacal nitrogen	0.021	5	0.014	<0.010	0.018	0.070	0.017
Nitrate nitrogen	50	5	0.38	0.34	0.36	0.46	0.32
Nitrite nitrogen	0.1	5	0.005	0.003	0.007	0.011	0.004
Nitrate-Nitrite (TON) nitrogen	0.444	5	0.39	0.34	0.36	0.47	0.32
Total Kjeldahl Nitrogen	-	5	0.41	0.25	0.35	0.85	0.76
Total Phosphorus	0.033	5	0.074	0.038	0.060	0.135	0.110
Dissolved reactive phosphorus	0.01	5	0.014	0.011	0.015	0.030	0.013
Biochemical oxygen demand (cBOD5)	-	2	<2			<2	
E. coli (cfu/100mL)	260	5	460	40	210	11,000	3,100
Enterococci (cfu/100mL)	-	5	72	30	18	8,500	450
Aluminium (dissolved)	-	5	0.195	0.054	0.167	0.220	0.198
Aluminium (total)	-	5	0.7	0.194	0.36	0.50	2.00
Calcium (dissolved)	-	5	11.5	11.1	11.5	12	10.7
Magnesium (dissolved)	-	5	3.6	4.4	4.0	4.1	3.7
Manganese (dissolved)	-	2	0.0148	-	-	0.0081	-

Parameter (mg/L) unless stated	Trigger value[A]	#	Dry weather			Wet weather	
			Jul 17	Aug 17	Sep 17	Jun 17	Aug 17
Manganese (total)	-	2	0.043	-	-	0.079	-
Mercury (dissolved)	-	2	<0.00008	-	-	<0.00008	-
Mercury (total)	-	2	<0.00008	-	-	<0.00008	-
Arsenic (dissolved)	-	5	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Arsenic (total)	-	5	<0.0011	<0.0011	<0.0011	<0.0011	<0.0011
Cadmium (dissolved)	-	5	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Cadmium (total)	-	5	<0.000053	<0.000053	<0.000053	<0.000053	<0.000053
Chromium (dissolved)	-	5	0.0006	<0.0005	<0.0005	0.0006	<0.0005
Chromium (total)	-	5	0.00167	0.00137	0.00115	0.00101	0.0038
Copper (dissolved)	0.0014[B]	5	0.0009	0.0006	0.0009	0.0015	0.0010
Copper (total)	0.0014[B]	5	0.00172	0.00084	0.00122	0.0026	0.0031
Lead (dissolved)	0.0034[B]	5	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Lead (total)	0.0034[B]	5	0.00029	<0.00011	0.00017	0.00046	0.00103
Nickel (dissolved)	-	5	0.0008	0.0006	0.0009	0.0011	0.0008
Nickel (total)	-	5	0.00127	0.00078	0.00094	0.00143	0.0023
Zinc (dissolved)	0.005[B]	5	<0.0010	< 0.0010	<0.0010	<0.0010	<0.0010
Zinc (total)	0.005[B]	5	0.0042	< 0.0011	0.0015	0.0042	0.0068
PAHs[C]	-	2	All results below detection limits				
TPHs[D]	-	2	All results below detection limits				

Notes:

A - Trigger value is the lower guideline trigger value in Table 3, grey shading indicates mean or median value exceeds this value

B - Trigger values are hardness dependant; these are values for a hardness of 30 mg/L $CaCO_3$

C - PAHs analysed were as follows: Acenaphthene, Acenaphthylene, Anthracene, Benzo[a]anthracene, Benzo[a]pyrene (BAP), Benzo[b]fluoranthene + Benzo[j]fluoranthene, Benzo[g,h,i]perylene, Benzo[k]fluoranthene, Chrysene, Dibenzo[a,h]anthracene, Fluoranthene, Fluorene, Indeno(1,2,3-c,d)pyrene, Naphthalene, Phenanthrene, Pyrene, all results were below detection limits.

D - TPHs analysed were as follows: C7 - C9, C10 - C14, C15 - C36, Total hydrocarbons (C7 – C36), all results were below detection limits.

Table 29 - Summary of project specific water quality data for a tributary of Waiteraire Stream at forestry track (W2W-Hōteo 9-BL) (dry weather and wet weather monitoring June-September 2017)

Parameter (mg/L) unless stated	Trigger value[A]	#	Dry weather			Wet weather	
			Jul 17	Aug 17	Sep 17	Jun 17	Aug 17
In-situ data							
Dissolved Oxygen	<5	5	10.56	11.09	10.74	9.27	9.68
Dissolved Oxygen (%sat)	-	5	95.4	97.2	100.7	89.6	92.3
Specific conductivity (mS/cm)	-	5	201	227	211.5	192	193.3
Temp (°C)	-	5	10.8	9.5	12.4	13.8	13.2
pH (pH units)	6.5-8.5	5	7.42	7.68	7.5	6.88	7.21
Turbidity (NTU)	5.6	5	13.5	6.2	8.0	31.0	33.5
Clarity (m)	<0.6	5	0.55	1.01	1.01	0.02	0.16
Colour (Munsell)	-	5	7.5Y (27.5) 4/2	5Y (25) 8/2	7.5Y (27.5) 8/2	5Y (25) 8/2	2.5Y (22.5) 8/2
SEV velocity (m/s)	-	4	0.75	0.42	0.67	-	0.64
Laboratory data							
pH (pH units)	6.5-8.5	5	7.5	7.4	7.4	7.3	7.3
Turbidity (NTU)	5.6	5	16.1	6.2	7.8	35.0	42.0
Total suspended solids	40	5	5	6	4	20	43
Suspended Sediment Concentration	40	5	<10	<10	<10	16	52
Total Hardness as $CaCO_3$	-	5	50	58	54	50	46
Total nitrogen	0.614	5	0.18	0.21	0.21	0.46	0.44
Ammoniacal nitrogen	0.021	5	<0.010	0.011	<0.010	0.016	<0.010
Nitrate nitrogen	50	5	0.059	0.070	0.059	0.064	0.047
Nitrite nitrogen	0.1	5	<0.002	<0.002	<0.002	0.003	<0.002
Nitrate-Nitrite (TON) nitrogen	0.444	5	0.060	0.071	0.060	0.068	0.048
Total Kjeldahl Nitrogen	-	5	0.12	0.14	0.15	0.39	0.39
Total Phosphorus	0.033	5	0.021	0.010	0.010	0.044	0.053
Dissolved reactive phosphorus	0.01	5	<0.004	<0.004	<0.004	<0.004	<0.004
Biochemical oxygen demand (cBOD5)	-	2	<2	-	-	<2	-
E. coli (cfu/100mL)	260	5	320	15	52	220	530
Enterococci (cfu/100mL)	-	5	41	12	5	580	390
Aluminium (dissolved)	-	5	0.26	0.041	0.096	0.36	0.24
Aluminium (total)	-	5	0.53	0.139	0.177	0.79	1.26
Calcium (dissolved)	-	5	10.2	11.6	11.1	10	9.6
Magnesium (dissolved)	-	5	6.0	7.1	6.4	6.0	5.3
Manganese (dissolved)	-	2	0.054	-	-	0.066	-

Parameter (mg/L) unless stated	Trigger value[A]	#	Dry weather			Wet weather	
			Jul 17	Aug 17	Sep 17	Jun 17	Aug 17
Manganese (total)	-	2	0.070	-	-	0.105	-
Mercury (dissolved)	-	2	<0.00008	-	-	<0.00008	-
Mercury (total)	-	2	<0.00008	-	-	<0.00008	-
Arsenic (dissolved)	-	5	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Arsenic (total)	-	5	<0.0011	<0.0011	<0.0011	<0.0011	<0.0011
Cadmium (dissolved)	-	5	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Cadmium (total)	-	5	<0.000053	<0.000053	<0.000053	<0.000053	<0.000053
Chromium (dissolved)	-	5	0.0008	<0.0005	<0.0005	0.0009	0.0007
Chromium (total)	-	5	0.00172	0.00093	0.00104	0.00186	0.0032
Copper (dissolved)	0.0014[B]	5	0.0005	<0.0005	<0.0005	0.0009	0.0006
Copper (total)	0.0014[B]	5	0.00091	<0.00053	<0.00053	0.00144	0.00151
Lead (dissolved)	0.0034[B]	5	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Lead (total)	0.0034[B]	5	<0.00011	<0.00011	<0.00011	0.00023	0.0003
Nickel (dissolved)	-	5	<0.0005	<0.0005	<0.0005	0.0006	0.0009
Nickel (total)	-	5	0.00081	<0.00053	<0.00053	0.00108	0.00136
Zinc (dissolved)	0.005[B]	5	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Zinc (total)	0.005[B]	5	0.0014	<0.0011	<0.0011	0.0018	0.0039
PAHs[C]	-	2	All results below detection limits				
TPHs[D]	-	2	All results below detection limits				

Notes:

A - Trigger value is the lower guideline trigger value in Table 3, grey shading indicates mean or median value exceeds this value

B - Trigger values are hardness dependant; these are values for a hardness of 30 mg/L $CaCO_3$

C - PAHs analysed were as follows: Acenaphthene, Acenaphthylene, Anthracene, Benzo[a]anthracene, Benzo[a]pyrene (BAP), Benzo[b]fluoranthene + Benzo[j]fluoranthene, Benzo[g,h,i]perylene, Benzo[k]fluoranthene, Chrysene, Dibenzo[a,h]anthracene, Fluoranthene, Fluorene, Indeno(1,2,3-c,d)pyrene, Naphthalene, Phenanthrene, Pyrene, all results were below detection limits.

D - TPHs analysed were as follows: C7 - C9, C10 - C14, C15 - C36, Total hydrocarbons (C7 – C36), all results were below detection limits.

Table 30 -Summary of project specific water quality data for a tributary of the Hōteo River at Rustybrook Road (W2W-Hōteo 10-BL) (dry weather and wet weather monitoring June-September 2017)

Parameter (mg/L) unless stated	Trigger value[A]	#	Dry weather			Wet weather	
			Jul 17	Aug 17	Sep 17	Jun 17	Aug 17
In-situ data							
Dissolved Oxygen	<5	5	10.42	8.85	8.4	7.37	7.72
Dissolved Oxygen (%sat)	-	5	95.3	81.1	84.6	72.8	75.4
Specific conductivity (mS/cm)	-	5	249.8	266.6	242.5	228.4	288.4
Temp (°C)	-	5	10.9	11.3	15.0	14.8	14.2
pH (pH units)	6.5-8.5	5	7.20	7.34	7.29	6.60	7.14
Turbidity (NTU)	5.6	5	18.0	5.8	8.8	31.1	117.0
Clarity (m)	<0.6	5	0.70	1.01	0.77	0.17	0.04
Colour (Munsell)			7.5Y (27.5) 7/6	5Y (25) 8/2	7.5y (27.5) 8/2	7.5Y (27.5) 8/2	2.5Y (22.5) 8/2
SEV velocity (m/s)	-	3	0.48	0.52	0.49	Too deep to measure	
Laboratory data							
pH (pH units)	6.5-8.5	5	7.0	7.2	7.2	7.0	7.2
Turbidity (NTU)	5.6	5	24.0	5.6	9.7	142.0	176.0
Total suspended solids	40	5	16	<3	6	210	149
Suspended Sediment Concentration	40	5	<11	<10	<10	44	149
Total Hardness as $CaCO_3$	-	5	88	94	89	74	62
Total nitrogen	0.614	5	0.90	0.60	0.63	1.35	2.30
Ammoniacal nitrogen	0.021	5	0.017	<0.010	<0.010	0.052	0.129
Nitrate nitrogen	50	5	0.290	0.158	0.129	0.370	0.148
Nitrite nitrogen	0.1	5	0.005	<0.002	0.002	0.016	0.013
Nitrate-Nitrite (TON) nitrogen	0.444	5	0.300	0.159	0.131	0.390	0.161
Total Kjeldahl Nitrogen	-	5	0.61	0.44	0.50	0.96	2.10
Total Phosphorus	0.033	5	0.072	0.026	0.042	0.185	0.300
Dissolved reactive phosphorus	0.01	5	0.016	0.010	0.012	0.014	0.036
Biochemical oxygen demand (cBOD5)	-	2	<2	-	-	<2	-
E. coli (cfu/100mL)	260	5	220	50	180	1,800	16,000
Enterococci (cfu/100mL)	-	5	35	40	16	600	4,900
Aluminium (dissolved)	-	5	0.086	0.031	0.056	0.106	0.127
Aluminium (total)	-	5	0.240	0.076	0.114	0.300	0.970
Calcium (dissolved)	-	5	28	30	28	23	20

Parameter (mg/L) unless stated	Trigger value[A]	#	Dry weather			Wet weather	
			Jul 17	Aug 17	Sep 17	Jun 17	Aug 17
Magnesium (dissolved)	-	5	4.1	4.8	4.4	3.8	2.7
Manganese (dissolved)	-	2	0.024	-	-	0.0113	-
Manganese (total)	-	2	0.026	-	-	0.024	-
Mercury (dissolved)	-	2	<0.00008	-	-	<0.00008	-
Mercury (total)	-	2	<0.00008	-	-	<0.00008	-
Arsenic (dissolved)	-	5	<0.0010	<0.0010	< 0.0010	< 0.0010	< 0.0010
Arsenic (total)	-	5	<0.0011	<0.0011	< 0.0011	< 0.0011	< 0.0011
Cadmium (dissolved)	-	5	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Cadmium (total)	-	5	<0.000053	<0.000053	<0.000053	<0.000053	0.000086
Chromium (dissolved)	-	5	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Chromium (total)	-	5	0.00059	<0.00053	<0.00053	0.00055	0.00104
Copper (dissolved)	0.0014[B]	5	0.002	0.0014	0.0019	0.0025	0.0022
Copper (total)	0.0014[B]	5	0.0022	0.00168	0.0021	0.0026	0.0039
Lead (dissolved)	0.0034[B]	5	<0.00010	<0.00010	<0.00010	<0.00010	0.00015
Lead (total)	0.0034[B]	5	0.00014	<0.00011	<0.00011	0.00028	0.00106
Nickel (dissolved)	-	5	0.002	0.0018	0.0024	0.0018	0.0021
Nickel (total)	-	5	0.0022	0.0024	0.0026	0.002	0.0025
Zinc (dissolved)	0.005[B]	5	0.0037	0.0021	0.0036	0.0037	0.0022
Zinc (total)	0.005[B]	5	0.0041	0.0024	0.0025	0.004	0.0112
PAHs[C]	-	2	All results below detection limits				
TPHs[D]	-	2	All results below detection limits				

Notes:

A - Trigger value is the lower guideline trigger value in Table 3, grey shading indicates mean or median value exceeds this value

B - Trigger values are hardness dependant; these are values for a hardness of 30 mg/L $CaCO_3$

C - PAHs analysed were as follows: Acenaphthene, Acenaphthylene, Anthracene, Benzo[a]anthracene, Benzo[a]pyrene (BAP), Benzo[b]fluoranthene + Benzo[j]fluoranthene, Benzo[g,h,i]perylene, Benzo[k]fluoranthene, Chrysene, Dibenzo[a,h]anthracene, Fluoranthene, Fluorene, Indeno(1,2,3-c,d)pyrene, Naphthalene, Phenanthrene, Pyrene, all results were below detection limits.

D - TPHs analysed were as follows: C7 - C9, C10 - C14, C15 - C36, Total hydrocarbons (C7 – C36), all results were below detection limits.

C.3 Oruawharo Catchment water quality

Table 31 - Summary of project specific water quality data for the Te Hana Creek at Silver Hill Road (W2W-TeHana5-BL) (dry weather and wet weather monitoring June-September 2017)

Parameter (mg/L) unless stated	Trigger value[A]	#	Dry weather			Wet weather	
			Jul 17	Aug 17	Sep 17	Jun 17	Aug 17
In-situ data							
Dissolved Oxygen	<5	5	11.11	11.77	11.02	8.75	11.17
Dissolved Oxygen (%sat)	-	5	98.4	110	109.5	88.1	107.9
Specific conductivity (mS/cm)	-	5	292.5	338.8	290.8	294.4	294.1
Temp (°C)	-	5	9.9	12.4	15.1	15.2	13.8
pH (pH units)	6.5-8.5	5	7.5	6.99	7.26	7.26	7.39
Turbidity (NTU)	5.6	5	4.3	3.4	4.6	12.5	5.3
Clarity (m)	<0.6	5	0.74	1.01	1.01	0.46	0.84
Colour (Munsell)	-	5	5GY (35) 8/2	10y (30) 8/2	10Y (30) 8/2	7.5 (27.5) 8/2-7/6	10Y (30) 7/6
SEV velocity (m/s)	-	0	Water too deep to measure				
Laboratory data							
pH (pH units)	6.5-8.5	5	7.6	7.5	7.7	7.7	7.7
Turbidity (NTU)	5.6	5	7.6	3.8	5.8	15.1	8.3
Total suspended solids	40	5	4	<3	<3	9	4
Suspended Sediment Concentration	40	5	<10	<10	<10	13	<10
Total Hardness as $CaCO_3$	-	5	110	133	116	105	109
Total nitrogen	0.614	5	1.06	0.38	0.67	1.27	0.94
Ammoniacal nitrogen	0.021	5	0.038	<0.010	<0.010	0.067	0.010
Nitrate nitrogen	50	5	0.61	0.05	0.24	0.47	0.49
Nitrite nitrogen	0.1	5	0.010	<0.002	0.003	0.016	0.007
Nitrate-Nitrite (TON) nitrogen	0.444	5	0.620	0.051	0.240	0.480	0.500
Total Kjeldahl Nitrogen	-	5	0.44	0.33	0.43	0.79	0.45
Total Phosphorus	0.033	5	0.054	0.034	0.039	0.086	0.059
Dissolved reactive phosphorus	0.01	5	0.015	0.012	0.013	0.027	0.018
Biochemical oxygen demand (cBOD5)	-	2	<2	-	-	<2	-
E. coli (cfu/100mL)	260	5	180	200	150	4,200	350
Enterococci (cfu/100mL)	-	5	28	12	13	1,900	170
Aluminium (dissolved)	-	5	0.027	0.005	0.017	0.039	0.027
Aluminium (total)	-	5	0.107	0.027	0.059	0.122	0.130
Calcium (dissolved)	-	5	38	46	40	36	37
Magnesium (dissolved)	-	5	3.7	4.4	4.1	3.9	3.7
Manganese (dissolved)	-	2	0.061	-	-	0.039	-

Parameter (mg/L) unless stated	Trigger value[A]	#	Dry weather			Wet weather	
			Jul 17	Aug 17	Sep 17	Jun 17	Aug 17
Manganese (total)	-	2	0.067	-	-	0.055	-
Mercury (dissolved)	-	2	<0.00008	-	-	<0.00008	-
Mercury (total)	-	2	<0.00008	-	-	<0.00008	-
Arsenic (dissolved)	-	5	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Arsenic (total)	-	5	<0.0011	<0.0011	<0.0011	<0.0011	<0.0011
Cadmium (dissolved)	-	5	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Cadmium (total)	-	5	<0.000053	<0.000053	<0.000053	<0.000053	<0.000053
Chromium (dissolved)	-	5	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Chromium (total)	-	5	<0.00053	<0.00053	<0.00053	<0.00053	<0.00053
Copper (dissolved)	0.0014[B]	5	0.0006	<0.0005	0.0005	0.0011	0.0006
Copper (total)	0.0014[B]	5	0.00081	<0.00053	0.00066	0.00131	0.00117
Lead (dissolved)	0.0034[B]	5	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Lead (total)	0.0034[B]	5	<0.00011	<0.00011	<0.00011	0.00013	0.00012
Nickel (dissolved)	-	5	0.0009	0.0011	0.001	0.0012	0.001
Nickel (total)	-	5	0.00114	0.00115	0.0011	0.00131	0.00132
Zinc (dissolved)	0.005[B]	5	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Zinc (total)	0.005[B]	5	0.0011	<0.0011	<0.0011	0.0016	0.0031
PAHs[C]	-	2	All results below detection limits				
TPHs[D]	-	2	All results below detection limits				

Notes:

A - Trigger value is the lower guideline trigger value in Table 3, grey shading indicates mean or median value exceeds this value

B - Trigger values are hardness dependant; these are values for a hardness of 30 mg/L $CaCO_3$

C - PAHs analysed were as follows: Acenaphthene, Acenaphthylene, Anthracene, Benzo[a]anthracene, Benzo[a]pyrene (BAP), Benzo[b]fluoranthene + Benzo[j]fluoranthene, Benzo[g,h,i]perylene, Benzo[k]fluoranthene, Chrysene, Dibenzo[a,h]anthracene, Fluoranthene, Fluorene, Indeno(1,2,3-c,d)pyrene, Naphthalene, Phenanthrene, Pyrene, all results were below detection limits.

D - TPHs analysed were as follows: C7 - C9, C10 - C14, C15 - C36, Total hydrocarbons (C7 – C36), all results were below detection limits.

Table 32 - Summary of project specific water quality data for the Maeneene Creek at Waimanu Road (W2W-Maeneene6-BL) (monthly dry weather and wet weather monitoring June-September 2017)

Parameter (mg/L) unless stated	Trigger value[A]	#	Dry weather			Wet weather	
			Jul 17	Aug 17	Sep 17	Jun 17	Aug 17
In-situ data							
Dissolved Oxygen	<5	5	11.4	9.91	11.09	9.73	10.87
Dissolved Oxygen (%sat)	-	5	101.1	93	107.6	95.8	101.6
Specific conductivity (mS/cm)	-	5	242	2500	231	245.8	227.3
Temp (°C)	-	5	9.8	11.8	14	14.6	12.3
pH (pH units)	6.5-8.5	5	7.75	7.08	7.55	7.3	8.04
Turbidity (NTU)	5.6	5	53.0	33.8	12.2	30.0	70.4
Clarity (m)	<0.6	5	0.09	0.16	0.53	0.20	0.10
Colour (Munsell)			10Y (30) 7/6	7.5Y (27.5) 7/6	7.5Y (27.5) 7/6	7.5y (27.5) 7/6	5Y (25) 7/6
SEV velocity (m/s)	-	0	Water too deep to measure				
Laboratory data							
pH (pH units)	6.5-8.5	5	7.4	7.6	7.6	7.4	7.4
Turbidity (NTU)	5.6	5	66.0	37.0	12.6	35.0	89.0
Total suspended solids	40	5	63	46	9	18	87
Suspended Sediment Concentration	40	5	54	43	13	27	108
Total Hardness as $CaCO_3$	-	5	67	370	78	57	66
Total nitrogen	0.614	5	1.54	0.76	0.60	1.25	1.41
Ammoniacal nitrogen	0.021	5	0.055	0.049	0.018	0.050	0.065
Nitrate nitrogen	50	5	0.37	0.23	0.21	0.31	0.24
Nitrite nitrogen	0.1	5	0.008	0.006	0.005	0.005	0.007
Nitrate-Nitrite (TON) nitrogen	0.444	5	0.37	0.24	0.22	0.31	0.24
Total Kjeldahl Nitrogen	-	5	1.16	0.52	0.39	0.94	1.16
Total Phosphorus	0.033	5	0.198	0.139	0.058	0.075	0.230
Dissolved reactive phosphorus	0.01	5	0.042	0.054	0.018	0.012	0.042
Biochemical oxygen demand (cBOD5)	-	2	2	-	-	<2	-
E. coli (cfu/100mL)	260	5	1,500	290	140	3,000	13,000
Enterococci (cfu/100mL)	-	5	350	53	23	4,000	14,000
Aluminium (dissolved)	-	5	0.135	0.013	0.080	0.230	0.145
Aluminium (total)	-	5	0.80	0.47	0.25	0.35	1.36
Calcium (dissolved)	-	5	19.2	44.0	20.0	13.5	19.5
Magnesium (dissolved)	-	5	4.6	64.0	6.6	5.7	4.3

Parameter (mg/L) unless stated	Trigger value[A]	#	Dry weather			Wet weather	
			Jul 17	Aug 17	Sep 17	Jun 17	Aug 17
Manganese (dissolved)	-	2	0.031	-	-	0.048	-
Manganese (total)	-	2	0.064	-	-	0.056	-
Mercury (dissolved)	-	2	<0.00008	-	-	<0.00008	-
Mercury (total)	-	2	<0.00008	-	-	<0.00008	-
Arsenic (dissolved)	-	5	<0.0010	<0.002	<0.0010	<0.0010	<0.0010
Arsenic (total)	-	5	<0.0011	<0.0021	<0.0011	<0.0011	0.0012
Cadmium (dissolved)	-	5	<0.00005	<0.00010	<0.00005	<0.00005	<0.00005
Cadmium (total)	-	5	<0.000053	<0.00011	<0.000053	<0.000053	<0.000053
Chromium (dissolved)	-	5	<0.0005	<0.0010	<0.0005	<0.0005	<0.0005
Chromium (total)	-	5	0.00117	<0.0011	0.00054	<0.00053	0.00157
Copper (dissolved)	0.0014[B]	5	0.0009	<0.0010	0.0009	0.0017	0.0013
Copper (total)	0.0014[B]	5	0.00194	0.0038	0.00137	0.0021	0.0033
Lead (dissolved)	0.0034[B]	5	<0.00010	<0.0002	<0.00010	0.00015	0.00013
Lead (total)	0.0034[B]	5	0.00075	0.00043	0.0002	0.00048	0.00168
Nickel (dissolved)	-	5	0.0023	0.0015	0.0024	0.0033	0.0016
Nickel (total)	-	5	0.0031	0.0019	0.0017	0.0029	0.0029
Zinc (dissolved)	0.005[B]	5	0.0020	<0.002	0.0035	0.0075	0.0019
Zinc (total)	0.005[B]	5	0.0077	0.0042	0.0069	0.0088	0.0113
PAHs[C]	-	2	All results below detection limits				
TPHs[D]	-	2	All results below detection limits				

Notes:

A - Trigger value is the lower guideline trigger value in Table 3, grey shading indicates mean or median value exceeds this value

B - Trigger values are hardness dependant; these are values for a hardness of 30 mg/L $CaCO_3$

C - PAHs analysed were as follows: Acenaphthene, Acenaphthylene, Anthracene, Benzo[a]anthracene, Benzo[a]pyrene (BAP), Benzo[b]fluoranthene + Benzo[j]fluoranthene, Benzo[g,h,i]perylene, Benzo[k]fluoranthene, Chrysene, Dibenzo[a,h]anthracene, Fluoranthene, Fluorene, Indeno(1,2,3-c,d)pyrene, Naphthalene, Phenanthrene, Pyrene, all results were below detection limits.

D - TPHs analysed were as follows: C7 - C9, C10 - C14, C15 - C36, Total hydrocarbons (C7 – C36), all results were below detection limits.

APPENDIX D: PROJECT SPECIFIC MARINE SEDIMENT DATA

Table 33 - Intertidal contaminant concentrations in marine sediment in Kaipara Harbour (28 June 2017).

Contaminant mg/kg (unless stated)	Maeneene/Te Hana Creek mouth		Hōteo River mouth	
	Te Hana 1	Te Hana 2	Hōteo 1	Hōteo 2
Dry matter (g/100g as rcvd)	24	35	42	44
Total Organic Carbon (g/100g)	4.0	2.1	2.2	1.9
Arsenic (total recoverable)	8	10	11	11
Cadmium (total recoverable)	<0.1	<0.1	<0.1	<0.1
Chromium (total recoverable)	20	24	29	25
Copper (total recoverable)	20	16	14	12
Lead (total recoverable)	9.1	9.4	7.4	6.7
Mercury (total recoverable)	0.056	0.044	0.05	0.032
Nickel (total recoverable)	12	14	12	11
Zinc (total recoverable)	64	71	64	58
PAHs (excluding Pyrene)[A]	Below level of detection			
Pyrene	0.011	<0.005	<0.004	<0.004
Total PAHs	<0.9[D]	<1.8[D]	<1.5[D]	<1.8[D]
LMW PAHs[B]	<0.5[D]	<0.9[D]	<0.7[D]	<0.8[D]
HMW PAHs[C]	<0.5[D]	<0.9[D]	<0.7[D]	<0.8[D]
C7 - C9	<30	<18	<15	<13
C10 - C14	<50	<40	<30	<30
C15 - C36	250	166	80	112
Total hydrocarbons (C7 - C36)	250	166	<100	112

Notes:

Green shading indicates value is below the council trigger values in Table 5. Amber shading indicates value exceeds the Council trigger values in Table 5.

A - PAHs analysed were as follows: Acenaphthene, Acenaphthylene, Anthracene, Benzo[a]anthracene, Benzo[a]pyrene (BAP), Benzo[b]fluoranthene + Benzo[j]fluoranthene, Benzo[g,h,i]perylene, Benzo[k]fluoranthene, Chrysene, Dibenzo[a,h]anthracene, Fluoranthene, Fluorene, Indeno(1,2,3-c,d)pyrene, Naphthalene, Phenanthrene, Pyrene.

B - Low molecular weight PAHs are the sum of concentrations of acenaphthene, acenaphthalene, anthracene, fluorene, 2-methylnaphthalene, naphthalene and phenanthrene.

C - High molecular weight PAHs are the sum of concentrations of benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene, fluoranthene and pyrene.

D – Normalised to 1% TOC