NZ TRANSPORT AGENCY
WAKA KOTAHI

Roads of national significance

Ara Tūhono – Pūhoi to Wellsford

This document records technical and factual information used to support the NZTA's Assessment of Environmental Effects for the Pūhoi to Warkworth Project. It has been supplied to the Environmental Protection Authority by the NZTA in response to a section 149(2) Resource Management Act 1991 request. This document did not form part of the NZTA's application for the Project, which was lodged on 30 August 2013.

FURTHER NORTH

Pūhoi to Warkworth

Water Assessment Factual Report 4
Water Quality Monitoring Report
August 2013

Pūhoi to Warkworth

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Glossary of abbreviations

Abbreviation	Definition
AC	Auckland Council
ANZECC	Australian and New Zealand Environment Conservation Council
BOD	Biochemical Oxygen Demand
CFU	Colony Forming Units
Cu	Copper
DRP	Dissolved Reactive Phosphorous
DO	Dissolved Oxygen
dw	Dry Weight
ERC	Environmental Response Criteria
HMW	High Molecular Weight
NH_4-N	Ammoniacal Nitrogen
NO_2-N	Nitrite Nitrogen
NO_3-N	Nitrate Nitrogen
NTU	Nephelometric Turbidity Unit
PAHs	Polycyclic Aromatic Hydrocarbons
Pb	Lead
P-Wk	Pūhoi to Warkworth section of the Pūhoi to Wellsford Road of National Significance Project
TKN	Total Kjeldahl Nitrogen
TN	Total Nitrogen
TP	Total Phosphorous
TPH	Total Petroleum Hydrocarbons
TSS	Total Suspended Solids
Zn	Zinc

Glossary of defined terms

Term	Definition
Auckland Council	The unitary authority that replaced eight councils in the Auckland Region as of 1 November 2010.
Contaminant	Defined in section 2 of the RMA as including any substance (including gases, odorous compounds, liquids, solids, and micro-organisms) or energy (excluding noise) or heat, that either by itself or in combination with the same, similar, or other substances, energy, or heat— (a) when discharged into water, changes or is likely to change the physical, chemical, or biological condition of water; or (b) when discharged onto or into land or into air, changes or is likely to change the physical, chemical, or biological condition of the land or air onto or into which it is discharged.
Discharge	Defined in section 2 of the RMA as including to emit, deposit and allow to escape.
Earthworks	The disturbance of land surfaces by blading, contouring, ripping, moving, removing, placing or replacing soil or earth, or by excavation, or by cutting or filling operations.
Project Area	From Johnstone's Hill portals in south to Kaipara Flats Road in the north.
Turbidity	Turbidity is a measure of water clarity or murkiness of a waterbody.

Contents

1. Introduction

The Pūhoi to Warkworth Project (Project) crosses the Pūhoi and Mahurangi River catchments to the north of Auckland. These freshwater environments drain into the Pūhoi and Mahurangi estuaries. The Project could impact upon these freshwater and estuarine environments during both construction and operation. This report provides a characterisation of the water and sediment quality in the freshwater environments and water quality in the estuarine/saline environments throughout the Project area.

1.1 Purpose and scope of this report

This report characterises the current condition and status of the fresh and saline waters throughout the Project area. In addition, the sediment quality of streams is characterised. This report will primarily be used to establish the existing water quality in the fresh and estuarine environments for the construction and operational water assessment reports. Of note, the aquatic ecology within the freshwater environments will be reported separately in the Freshwater Ecology Assessment Report and marine ecology in the Marine Ecology Assessment Report.

The scope of the report is to:

- Identify existing fresh water and saline water quality data available in the Project area.
- Undertake a literature review of existing information on the water quality of the freshwater and estuarine environments.
- Assess water and sediment quality monitoring data gathered for the Project.
- Characterise the current condition of the watercourses and estuaries by comparison with relevant guidelines and limits.

1.2 Report outline

The structure of the report is as follows:

- An overview of the freshwater catchments in the Project area is provided in Section 2.
- Section 3 identifies the parameters and guidelines that have been used to characterise the freshwater and estuarine environments.
- Existing information from the catchments is assessed in Section 4.
- Water quality monitoring undertaken for the Project is assessed in Section 5 and sediment quality monitoring in Section 6.
- Section 7 provides an overall summary of the fresh and saline water quality and sensitivity to potential Project impacts.

2. Existing environment

2.1 Catchment overview

A map of the catchments and Project alignment is provided in Figure 1. Moving from the south to the north the alignment passes through the Pūhoi catchment. Initially the Project passes through tidally influenced areas of the Pūhoi River. The alignment then passes across the Hikauae Creek and crosses into the right branch of the Mahurangi River before crossing the left branch of the Mahurangi River. The Mahurangi River is the main tributary of the Mahurangi Estuary, a long estuary flowing southwards from Warkworth. There are many small bays and estuaries along the sides of the estuary with two larger arms (Pukapuke Inlet and Te Kapa River) to the south. Many of the small bays and upper estuaries dry during the tidal cycle and are comprised of soft muddy sediment. The remainder of the estuary has large areas of permanent water and less soft sediment. The Pūhoi estuary, a thin narrow tidal estuary, is to the south of the Mahurangi Estuary and is much smaller than the Mahurangi.

Table 1 Overview of catchments along the Project route

Catchment	Landform and landuse
Hikauae Creek	The Project route passes through relatively steep slopes of plantation forestry to the west of the existing state highway. There are a number of small unnamed tributaries through this area. The route then crosses undulating farmed pasture before crossing the main creek and heading back into areas of steeper slopes and deep incised gullies in forestry in the headwaters of the creek. Some areas of native vegetation exist alongside watercourses in the forestry areas.
M15 tributary of Mahurangi River (Right Branch)	This unnamed tributary of the Mahurangi River contains steep slopes and many small channels throughout the forestry area. It is almost entirely under plantation forestry. The tributaries flow together and meet the main right branch channel near the existing State highway.
M16 and M19 tributaries of the Mahurangi River (Right Branch)	The Project route passes initially through relatively steep slopes over a number of small tributaries in plantation forestry. The upstream catchment is predominantly in plantation forestry land use. The route then passes into undulating pasture/lifestyle properties with slopes generally becoming less steep as the route heads north.
Mahurangi River (Left Branch)	The Project route passes through generally flatter land near to the main stem of the left branch of the river which is predominantly used for pasture and lifestyle land uses. The left branch combines with the right branch of the Mahurangi River near the junction of Woodcocks and Falls Roads.

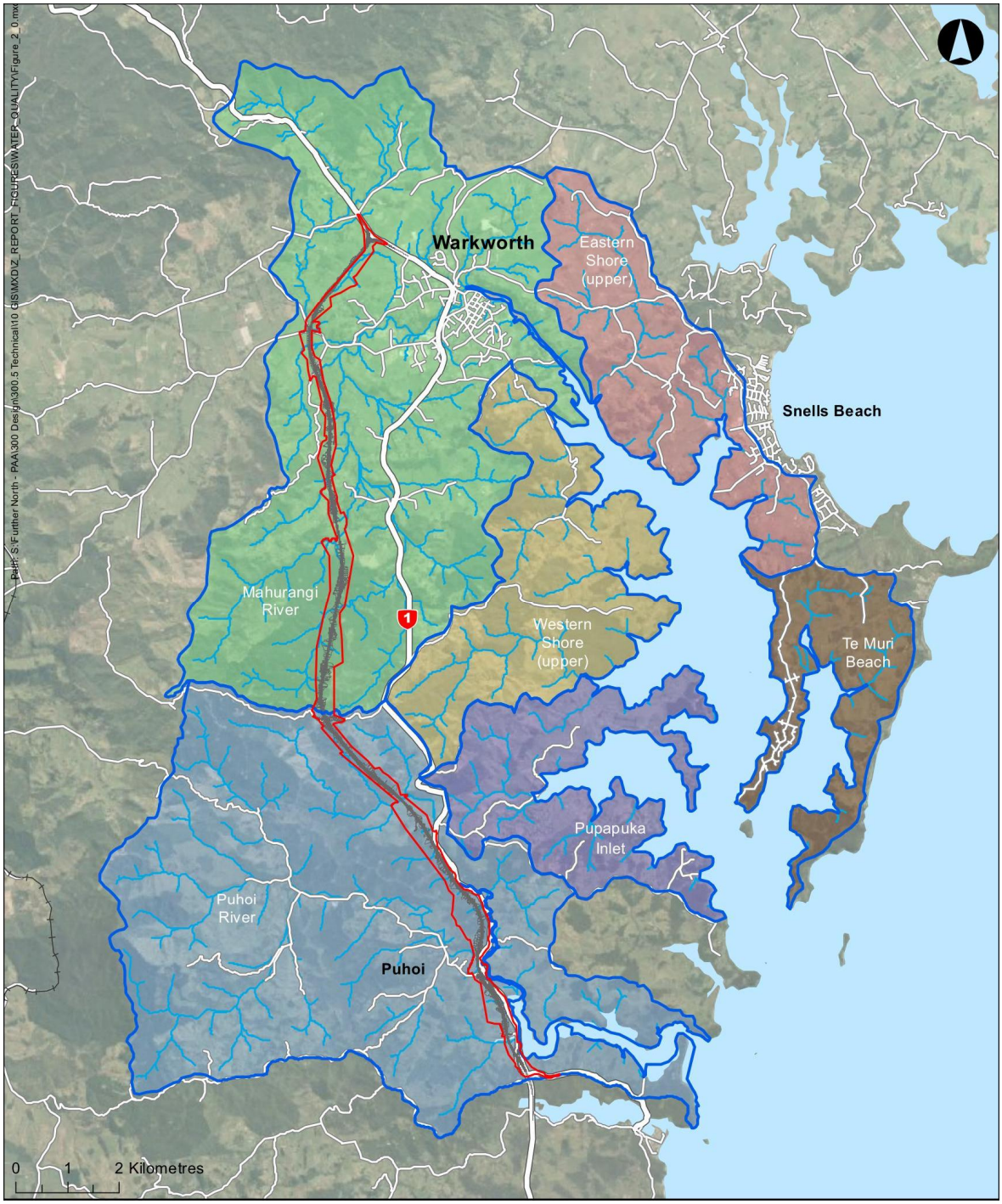


Figure 1 Major watercourses and catchment boundaries within the Project area

Legend [Green shading] = Mahurangi Catchment, [Blue shading] = Pūhoi catchment, [Red] = Project designation boundary

3. Monitoring assessment

The existing landform, geology and land use 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 watering and irrigation
- Use for aquaculture (fish farming)
- Recreation use including contact recreation, informal boating and bankside amenity based recreational activities and fishing

Comparison to guidelines relating to these values and uses is required to characterise the existing environments.

The estuarine environments have their own range of values and uses for which guidelines exist. This includes the following potential values and uses:

- Supporting aquatic ecosystems
- Use for aquaculture (oyster farming)
- Recreation use including contact recreation, boating and fishing

Section 3.1 describes the relevance of the parameters discussed in this report. Sections 3.2, 3.3 and 3.4 outline relevant guidelines against which data has been compared to characterise the current environments. Section 3.2 covers freshwater environments, section 3.3 saline water in estuarine environments and section 3.4 sediments. This characterisation considers the suitability of the existing environment for these values and uses.

3.1 Water quality parameters and guidelines

Table 2 documents the water quality parameters assessed in this report. 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. 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 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 can also provide direct stresses on aquatic species. Changes to streamside vegetation and light penetration can affect water temperature in 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. 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 make nutrients in sediments more available for algal growth.
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 landuse. The colour of the water can affect its amenity and recreational value.
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 aquatic ecosystem. 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 into waterbodies. Excess 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 phosphorous would be required. Nitrogen species such as ammonia can also be directly toxic to aquatic species.
Phosphorous nutrients - total and dissolved reactive phosphorous (DRP)	Phosphorous 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 and as such sediment transported into streams can be a source of particulate phosphorous.
Metals – copper, zinc and lead	Metals will 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, zinc and lead are considered to be the three metals likely to be associated with 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 whereas total metals include those bound in suspended sediment that are less available to affect aquatic ecosystems.
Hydrocarbons – total petroleum hydrocarbons (TPH's) and Polycyclic Aromatic Hydrocarbons (PAH's)	Hydrocarbons would not be expected to occur naturally in waterbodies. Discharges from roads can contain hydrocarbons from oil and fuel drips/spills. The two roading-related measures commonly considered are TPH's and PAH's. TPH's 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 general analysis of compounds of a similar molecular weight. PAH's come principally from diesel, heavy petroleum fractions and from coal sources and are reported for individual compounds (Hill Laboratories, 2011).

3.2 Freshwater quality guidelines

Table 3 presents guideline values for the water quality parameters that have been used in this report to characterise the nature of the existing freshwater environments. The most relevant guidelines are for the protection of aquatic ecosystems as ecological values are present across all streams in the Project area. In addition, the guideline concentrations for non-ecological values are less stringent for any given parameter than the ecological ones. Hence if water quality complies with the ecological guidelines it should also be suitable for the other purposes. 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, 2000). These guidelines are generally trigger levels rather than absolute limits. The guidelines are intended to be triggers providing for further investigation of potential impacts. However they can be informative when used to indicate potential stressors in the environment where data indicates values in excess of a trigger.

Table 3 Guideline concentrations for assessment of fresh water quality data

Parameter (mg/L unless stated)	Aquatic ecosystem	Stock watering	Irrigation	Aquaculture	Contact Recreation
pH (pH units)	6.5-9.0[A]	6-9[E]	6-9[E]	5-9[K]	-
Temperature (°C)	-	-	-	<2°C change over 1hr[K]	-
Dissolved Oxygen	>6[A]	-	-	>5[K]	-
Total Suspended Solids	-	-	-	40[K]	-
Turbidity (NTU)	5.6[B]	-	-	-	-
Clarity (m)	0.8 [B]	-	-	-	-
E.Coli (cfu/100mL)	-	-	-	-	260[N]
Total Nitrogen	0.614[B]	-	5[J]	1[L, M]	-
Ammoniacal Nitrogen	0.021[B]	-	-	-	-
Nitrate	-	400[F]	-	50[L]	-
Nitrite	-	30[G]	-	0.1[L]	-
Nitrate/Nitrite	0.444[B]	-	-	-	-
Total Phosphorous	0.033[B]	-	0.05[J]	0.1[L]	-
Dissolved Reactive Phosphorous	0.01[B]	-	-	-	-
Copper	0.0014[C, D]	0.4[H, I]	0.2[J]	0.005[D, L]	-
Zinc	0.008[C, D]	20 [H]	2[J]	0.005[L]	--
Lead	0.0034[C, D]	0.1 [H]	2[J]	0.001-0.007[D, L]	-
Napthalene (a PAH)	0.016[C]	-	-	-	-

Note:

[A] From ANZECC 1992 guidelines as reported in ANZECC 2000

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

[C] Trigger values for toxicants at 95% level of protection (ANZECC 2000)

[D] Trigger values are hardness dependant; these are values for a hardness of 30 mg/L $CaCO_3$

[E] Guideline to limit corrosion and fouling of watering and irrigation systems (ANZECC 2000)

[F] Concentration that should not be harmful to animal health (ANZECC 2000)

[G] Concentrations in excess of this may be harmful to animal health (ANZECC 2000)

[H] Trigger values of a low risk for heavy metals in livestock drinking water (ANZECC 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 2000)

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

[L] Toxicant guidelines for the protection of aquaculture species

[M] Indication only as trigger is for total available nitrogen – not total nitrogen

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

3.3 Saline water quality guidelines

Table 4 presents guideline values for the saline waters in the estuarine environments. These guidelines are relevant to the protection of aquatic ecological values, aquaculture and contact recreation. As for the freshwater guidelines these are generally trigger levels from the ANZECC (2000) guidelines and are being utilised in a similar manner.

Table 4 Guideline concentrations for assessment of saline water quality data

Parameter (mg/L unless stated)	Aquatic ecosystem	Aquaculture	Contact Recreation
pH (pH units)	-	6-9[C]	
Temperature (°C)	-	<2°C change over 1 hour [C]	
Dissolved Oxygen	-	>5[C]	
Total Suspended Solids	-	<10 (<75 Brackish)[C]	
Turbidity (NTU)	0.5-10[H]	-	
Enterococci (cfu/100mL)	-	-	140[G]
Total Nitrogen	0.3 estuaries, 0.12 marine [A]	1[D, F]	
Ammoniacal Nitrogen	0.015 estuaries, 0.015 marine [A]	-	
Nitrate	-	100[D]	
Nitrite	-	0.1[D]	
Nitrate/Nitrite	0.015 estuaries, 0.005 marine [A]	-	
Total Phosphorous	0.03 estuaries, 0.025 marine [A]	0.05[D]	
Dissolved Reactive Phosphorous	0.005 estuaries, 0.01 marine [A]	-	
Chlorophyll a	0.004 estuaries, 0.001 marine [A]		
Copper	0.0013[B]	0.005[D, E]	
Zinc	0.015[B]	0.005[D]	
Lead	0.0044[B]	0.001-0.007[D, E]	

Note:

[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 2000.

[B] Trigger values for toxicants at 95% level of protection (ANZECC 2000)

[C] Physio-chemical stressor guidelines for the protection of aquaculture species - saltwater production (ANZECC 2000)

[D] Toxicant guidelines for the protection of aquaculture species – saltwater production (ANZECC 2000)

[E] Trigger values are hardness dependant

[F] Indication only as trigger is for total available nitrogen – not total nitrogen

[G] Marine water surveillance level for acceptable water quality. Exceedance triggers further monitoring with action level >280 cfu/100mL (MfE, 2003)

[H] Default trigger values for turbidity in slightly disturbed ecosystems in south-east Australia. These are the recommended guidelines for New Zealand in ANZECC 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.

3.4 Sediment quality guidelines

Table 5 presents the Interim Sediment Quality Guidelines - low (ISQG-low) from ANZECC (2000). These are trigger levels indicating where a low range of effects would be likely to occur at the noted contaminant concentrations. Auckland Council has generated a set of Environmental Response Criteria (ERC) for assessing sediments in the Auckland Region. These are based on the ANZECC triggers and provide colour coded criteria for sediments. Table 5 presents these data from Auckland Regional Council (2004).

Table 5 Guideline concentrations for assessment of sediment quality data (ANZECC, 2000)

Parameter (mg/kg dry wt)	ISQG – Low (trigger value - ANZECC, 2000)	Auckland Council Environmental Response Criteria for sediment contaminants		
		Red	Amber	Green
Copper	65	>34	19-34	<19
Zinc	200	>150	124-150	<124
Lead	50	>50	30-50	<30
Total Petroleum Hydrocarbons	-	-	-	-
Low molecular weight PAH's[A]	0.552[C]	-	-	-
High molecular weight PAH's[B]	1.7 [C]	>1.7	0.66-1.7	<0.66
Total PAH's	4 [C]	-	-	-
Napthalene	0.160 [C]	-	-	-

Notes:
[A] Low molecular weight PAHs are the sum of concentrations of acenaphthene, acenaphthalene, anthracene, fluorene, 2-methylnaphthalene, naphthalene and phenanthrene.
[B] High molecular weight PAHs are the sum of concentrations of benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene, fluoranthene and pyrene.
[C] Normalised to 1%organic carbon

4. Review of existing information

4.1 Methodology

Existing information that characterises the water quality of rivers, streams and the estuary in the Project area has been reviewed. This review is in two parts; a literature review and analysis of existing data. The literature review covers published reports discussing water quality, environmental conditions and stressors in the catchments. The review includes various Auckland Council documents with many reports being produced as part of the development of the Mahurangi Action Plan. The majority of the information comes from the Mahurangi catchment with very little being available from the Pūhoi Catchment.

The data analysis presents existing Auckland Council monitoring data from sites within the Mahurangi River and estuary catchment. There are no existing Auckland Council monitoring points in the Pūhoi River or estuary.

4.2 Literature review – water quality issues in the Project catchments

The Mahurangi catchment has been the focus of a number of research initiatives over at least the last 10 years due to issues identified in the estuary. These predominantly relate to the rate and amount of sedimentation occurring within the estuary. This led to the Mahurangi Action Plan being developed with a five year pilot objective from 2004 being: "To halt, slow or reverse the adverse effects of sedimentation on the health of the Mahurangi Harbour" (Auckland Regional Council, undated).

Further investigations were undertaken into the sediment source processes in creeks (Hicks and Hawcridge, 2004) identifying a range of specific activities such as earthworks, stock access and instream processes that contribute sediment to the catchment. NIWA assessed sediments deposited within the estuary with a view of identifying the relative contributions of each land use (plantation forestry, native forestry, pasture, urban) on the sediments in the estuary (Gibbs, 2006). The pasture and native forest catchments along the estuary sides contributed most sediment to the estuary; however, within the Mahurangi River catchment the plantation forestry contributed a disproportionately large amount of sediment for the size of land area.

Following the five year pilot project further work was undertaken with a view to determining objectives and priorities for 2010-2030. An assessment of water quality in the estuary and contributing issues from catchment land use was undertaken to feed into this project (Boffa Miskell, 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
- 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 existing sedimentation issues are particularly relevant to the Project due to the amount of sediment that may be generated during the construction phase.

4.3 Auckland Council data analysis – freshwater quality

Three Auckland Council long term water quality monitoring sample points exist within the Project catchments. The Auckland Council site names and description of their location within the Project area are as follows:

- Mahurangi at FHQ – Located at the lower end of the M15 section of the Right Branch of the Mahurangi River
- Mahurangi Town Bridge – Located in Warkworth downstream of the confluence of the Right and Left Branches of the Mahurangi River and downstream of all 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.
- Mahurangi at Water Treatment plant (WTP) – by the Watercare water treatment plant in Warkworth located downstream of the confluence of the Right and Left Branches of the Mahurangi River and downstream of all works in the Mahurangi River catchment.

Three sample sites were monitored by Auckland Regional Council through 1994 and 1995 and reported by NIWA in Stroud and Cooper (1997). The sample sites were as follows:

- Wylies Road – located in the headwaters of creek M22.
- Redwood Forest – located high up the M15 tributary of the Mahurangi River.
- Mahurangi College – located lower on the Mahurangi River below the confluence of the right and left branches.

The location of the sample sites are shown in Appendix A.

4.3.1 Comparison of existing data to guidelines and discussion on general water quality

Summary data from the three long term sites are provided in Table 10 to Table 12 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 median data from these long term Auckland Council monitoring sites have been compared to the relevant ecological and water use guidelines provided in Section 3.2 and the following general comments can be made about the M15 Tributary and the main stem of the Mahurangi River. Data from the short term sites are provided in Table 13 in Appendix B and comparison to these has also been provided.

M15 Tributary of Mahurangi River

The Mahurangi at FHQ monitoring site is located at the bottom of this tributaries catchment. Data is available for a range of parameters covering a date range of 1993 to 2012. By comparing the mean and median data in Table 10 in Appendix B to the relevant ecological and water use guideline values the follow following can be concluded regarding the past general quality of the water:

- Oxygen and pH results indicate good water quality.
- Biochemical Oxygen Demand is generally low indicating limited organic enrichment.

- The watercourse appears to have slightly elevated suspended solids as indicated by the average turbidity being above guidelines and average clarity being low and below the acceptable clarity outlined in guidelines.
- Nitrogen concentrations are generally below ecological guidelines with the exception of ammoniacal nitrogen.
- Total and dissolved reactive phosphorous are both on average similar to the guideline levels.
- The nutrient statuses therefore indicate that under average conditions the stream does not contain significantly elevated nutrients.
- The short term nutrient data set gathered at the Redwood site in 1994/5 showed a much greater range of concentrations and higher averages. This may reflect the greater range of flows sampled by using auto samplers and thus impact of greater amounts of particulate-associated nutrients.
- Mean and median total and dissolved copper, zinc and lead are all well below the ecological guideline levels indicating low metal concentrations in the stream.
- 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 above the surveillance level for bathing waters. This indicates that the water could be compromised for contact recreation use.
- Results indicate that for the monitored parameters the water is suitable for stock watering, irrigation and aquaculture uses.

Auckland Council State of the Environment monitoring assessed this site as having "good" water quality in 2008, 2009 and 2010 (Neale, 2010 and Neale, 2012) and "excellent" water quality in 2011 (Lockie and Neale, 2012). In 2011 the site was rated as having the best water quality of monitored sites in the Auckland Region.

Mahurangi River Main Stem

Two Auckland Council water quality monitoring sites exist at the lower end of this catchment in Warkworth. The sites are the Mahurangi at WTP and Mahurangi Town Bridge. Data is available for some parameters from 1986 to 2008 for the Town Bridge site and 1993 to 2012 for the water treatment plant site. By comparing the mean and median data in Table 11 and Table 12 in Appendix B to the relevant ecological and water use guideline values the follow following can be concluded:

- Dissolved oxygen and pH results indicate good water quality.
- BOD is low at both sites indicating low organic enrichment.
- The watercourse appears to have slightly elevated suspended solids as indicated by the average turbidity being above guidelines and average clarity being low and below guidelines. Turbidity and clarity are on average slightly better than at the upstream FHQ site.
- Nitrogen concentrations are generally below ecological guidelines with the exception of ammoniacal nitrogen. This is a similar situation to the upstream FHQ site.
- Total and dissolved reactive phosphorous are elevated above guidelines thus indicating that there is sufficient phosphorous in the water column to promote periphyton (algae) growths. Concentrations are higher than at the FHQ site possibly indicating the extra inputs from the greater prevalence of pasture landuse in the lower catchment.
- The short term nutrient data set gathered at the College site in 1994/5 showed a much greater range of concentrations and higher averages. This may reflect the greater range of flows

sampled by using auto samplers and thus impact of greater amounts of particulate associated nutrients.

- Mean and median total and dissolved copper, zinc and lead are all below the ecological guideline levels. While this indicates low metal concentrations in the stream, results indicate higher concentrations than at the upstream FHQ site. This could again reflect the changed and more intensified landuse in the lower catchment including surrounding urban areas.
- Microbial results (as indicated by median concentrations) identify that there are E.coli indicator species in the stream but these are below the bathing water surveillance level on average. Results can however be well above the surveillance and action levels at times.
- Results indicate that for the monitored parameters the water is, in general, suitable for stock watering, irrigation and aquaculture uses. The total phosphorous concentrations indicate slight elevation above the long term irrigation guidelines.

Auckland Council State of the Environment monitoring report assessed the water treatment plant site as having "good" water quality in 2008, "fair" in 2009, "excellent" in 2010 (Neale, 2010 and Neale, 2012) and "fair" water quality in 2011 (Lockie and Neale, 2012).

4.3.2 Trends and relationships in water quality data

The Auckland Council data covers an approximate 20 year time span and therefore provides information of trends in the catchments over time. Analysis of this data also allows relationships between parameters to be identified. For the Mahurangi main stem this assessment has considered the WTP site rather than the Town Bridge site as being representative of the lower catchment as it is the current Auckland Council sample site. This site has been compared to the upstream FHQ site to understand how the quality can vary throughout the Project area. 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. Graphs of the data are provided in Appendix B with results discussed below.

Total suspended solids and turbidity

Figure 4 and Figure 5 in Appendix B present the total suspended solids data from the FHQ and WTP sites over time. Linear trend lines have been plotted on both of these graphs. These trend lines indicate that concentrations are relatively stable over time at FHQ but appear to have increased slightly at the WTP site in the lower catchment. Turbidity data in Figure 6 and Figure 7 present a similar general trend over time.

The relationship of TSS, turbidity and clarity to stream flow has been considered. Data from the Mahurangi at the WTP site in Warkworth has been compared to flow data from the college flow recorder that is a short distance upstream of Warkworth. Water quality data has been compared to flow variables including maximum daily flow and proceeding day maximum daily flow. Log plots of the relationships between the variables are presented in Figure 8 and Figure 9 in Appendix B. From these it can be seen that in general as flow increases so does TSS and turbidity and consequentially clarity decreases.

Flow data for the Mahurangi College recorder site has been analysed to identify any trends in flow over this time span. This could be relevant as changes in flow regimes over time could affect observed changes in the concentrations of TSS and turbidity and therefore changes in clarity. Figure 10 presents the mean, median and range of data each year. There are no obvious trends in the data to indicate for instance a period of predominantly wet or dry years. Therefore it appears unlikely that the linear trends in water quality that are noted in Figure 4 and Figure 5 result from underlying changes in flow. Therefore the slight increases in concentrations observed in the lower

catchment are more likely to relate to other factors such as changes in land use or discharges in the catchment.

For use in the modelling work and technical assessments of the Project the relationship between total suspended solids and turbidity has been calculated for following the three monitoring sites.

- Mahurangi at FHQ – data from 1993 to 2012 covering 230 samples
- Mahurangi at WTP – data from 1993 to 2012 covering 225 samples
- Mahurangi at Town Bridge – data from 1986 to 2008 covering 230 samples

This data has been plotted to determine the relationship between the variables so that modelled TSS data can be converted to turbidity. Figure 11 to Figure 13 present scatter plots of the TSS/turbidity data from these three sites. A linear trend line is plotted on each with a formula outlining the relationship between the two valuables. The coefficient of determination (R2) is included on each plot to indicate how well the trend line matches the observed data. Values are between 0 and 1 with 1 being a 100% match of the trend line to observed data. These graphs indicate:

- Figure 11 presents the data for the FHQ site, it can be seen that the trend line indicates close to a 1:1 relationship between the two variables.
- Figure 12 presents the data from the WTP site and the relationship is again approximately 1:1.
- Figure 13 has data from the Town Bridge and the graph indicates a less than 1:1 relationship (i.e. that turbidity values are less than TSS for any given TSS result).
- A graph of all paired turbidity and TSS data for all sites is presented in Figure 14. This indicates a relationship slightly less than 1:1 for the combined dataset.

For use in the modelling and assessment work in other Project reports TSS results were modelled for the Project by NIWA at various locations in the catchment. Some of the sites modelled h are not Auckland Council monitoring sites. Therefore it is not possible to use a site specific TSS/Turbidity relationship formula for each modelled TSS result. To convert the modelled TSS results to turbidity values of use in the freshwater ecology assessment a 1:1 relationship is recommended. This is a conservative approach when converting TSS to turbidity as it represents a worst case scenario based on available data. Turbidity is likely to be at most the same as TSS but may be less. Of note Davies-Colley and Nagels (1995) noted when assessing TSS and turbidity data in the Mahurangi that the two variables were often numerically similar in rivers which further supports this approach.

Copper, lead and zinc

Figure 15 and Figure 16 in Appendix B present the total copper concentrations at the FHQ and WTP sites. These demonstrate that the concentrations were higher at the lowland site. While the average data was below ANZECC ecological guidelines there were occasional exceedances of the trigger values on some sample dates, more frequently at the lowland site. Figure 17 and Figure 18 present data for lead and zinc and a similar pattern of increased concentrations lower in the catchment can also be identified. Total lead concentrations were almost all below the guideline trigger levels whereas there were occasional exceedances of the zinc trigger levels. This indicates that on average metal concentrations are within guidelines designed to protect aquatic ecology and that the metal concentrations are higher in the lower catchment.

Nitrogen and phosphorous

Figure 19 and Figure 20 in Appendix B present data on ammoniacal nitrogen at the two monitored sites. This parameter is plotted rather than total nitrogen as it has a much longer time span of

data. From the two sites it can be seen that there is very little trend in concentrations evident. The trend line indicates a slight decrease in nitrogen concentrations at the WTP site in the lower catchment over time.

Analysis was undertaken to determine whether there was a relationship between flow and nutrient concentrations as was completed for the TSS and related parameters (Figure 21 to Figure 25). There was some correlation between total phosphorous and total nitrogen and flow with both nutrients increasing as flow increased. This most likely reflects the increase in sediment with flow as nutrients will be bound in sediment particles. There was almost no relationship between dissolved reactive phosphorous and flow indicating that the dissolved component was not changing as either flow increased or sediment load increased. Nitrate/nitrite nitrogen had a similar relationship to total nitrogen whereas ammoniacal nitrogen did not. This indicates that some constituent of total nitrogen may also increase with flow increases. As there are no apparent trends in the flow data over time then it is not considered that flow characteristics are likely to be driving any trends observed in the nutrient data.

Figure 26 and Figure 27 in Appendix B present similar data for total phosphorous at the two sites. Both sites appear to have a slight downward trend in concentrations over time. The WTP site in the lower catchment does generally have slightly elevated phosphorous concentrations compared to the upper site.

The ratio of total nitrogen to total phosphorous (TN:TP) has been calculated at the FHQ and WTP sites to provide an understanding of the potential importance of each nutrient in the overall management of the Project. The ratio of TN:TP has commonly been used to evaluate the nutrient status of a water body. For example, when the N:P atomic ratio is greater than 16 then the waterbody is said to be P deficient, and when it is less than 16, N deficient. If one nutrient is deficient it can indicate sensitivity to the risk of growths of nuisance periphyton if sufficient concentrations of that nutrient were added. Table 6 presents the median ratio calculated from all the available paired data. This indicates nitrogen limitation; however, results are very close to the value of 16. This result reflects the fact that phosphorous concentrations are elevated as reported above and that some nitrogen compounds are at times. It should be noted that the overall pool of dissolved nutrients is important as if concentrations of both nutrients are elevated above guidelines then algal growth can occur irrespective of the ratio between the two nutrients.

Table 6 Nitrogen: Phosphorous relationship

Site	Measure	Result	Implication
Mahurangi at FHQ	Median TN:TP ratio	14.5	Indicates N limitation
Mahurangi at WTP	Median TN:TP ratio	13.5	Indicates N limitation

Elevated nutrients have the potential to give rise to nuisance algae (periphyton) growths. Algal growths have been observed in the river near to the WTP in late summer 2013. Algal growths do require other factors such as substrate, temperature, light and flow to be suitable to develop to nuisance levels. Consideration has been made of the flow factor by assessing the hydraulic characteristics of the Mahurangi River with respect to the average return frequency of floods that can flush periphyton growth from the river system. Higher flows remove build-up of algae that will then take time to re-grow. Recurrent high flows can keep the stream clear of algae. The flushing flows are considered to be flows that are greater than three times median flow using the methods outlined in Biggs (2000). Using the flow records from the college flow recorder between 1983 and 2012 the average number of days between periphyton flushing events and therefore average number of days for periphyton accrual is 12 days. This indicates that based on the historic flow

record the Mahurangi River has reasonably frequent flows that can flush periphyton and thus limit the growths of nuisance algae.

4.4 Auckland Council data analysis – saline water quality

Auckland Council monitor saline water at two locations within the Mahurangi estuary: the Mahurangi heads and higher up the estuary at Dawson's Creek. Locations of the sample sites are shown in Appendix A.

Summary data from the two long term sites are provided in Table 14 and Table 15 in Appendix C. 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 median data from these long term Auckland Council monitoring sites have been compared to the relevant environmental limits for the protection of ecology and use of the water which are outlined in Section 3.3. The following general comments can be made about the two sites:

- 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 estuary.
- The only parameter whose mean and median concentrations were elevated above the ecological guidelines at both sites was dissolved reactive phosphorous.
- Mean and median total phosphorous was elevated at Dawson's Creek higher in the estuary.
- Mean ammoniacal nitrogen results were above guideline values at both sites indicating some elevated nitrogen concentrations, but median values were generally below guidelines. Nitrate/nitrite nitrogen was elevated above guidelines at Dawson's Creek.
- Total suspended solids concentrations were on average slightly elevated above the guideline for aquaculture at Dawson's Creek. This is the site located higher up the estuary, and values were lower and within guidelines at the heads. This probably reflects the greater input of terrestrial sediments further within the estuary and the fact that much will settle out before it reaches the heads. This sediment load is also likely to contribute to the greater phosphorous concentrations higher up the estuary as phosphorous is often mobilised in a sediment bound form.

The analysis of this data is also reflected in the Auckland Council's marine report card for the Mahurangi Estuary in 2012 that rates water quality within the estuary as being excellent (Auckland Council, 2012). This rating was comprised from conclusions of good water quality at Dawson's Creek and excellent at Mahurangi Heads.

4.4.1 Trends and relationships in water quality data

Temporal trends in the data have been identified to allow an understanding of changes of time to be developed for parameters of relevance to the Project. This has considered total suspended solids and phosphorous at both sites as an indication of the sediment and nutrient trends in the upper estuary. The Dawson's Creek sample site is closer to the mouth of the Mahurangi River and thus to any potential discharges from the Project. Graphs of the data are provided in Appendix C with results discussed below.

Total Suspended Solids

Figure 28 and Figure 29 in Appendix C present the total suspended solids concentrations at both estuary monitoring sites over time. These demonstrate the generally higher concentration of suspended sediments at Dawson's Creek further up the estuary. At Dawson's Creek there appears

to be very slight downward trend in concentrations over time whereas concentrations appear to be more stable at the heads.

Nitrogen and Phosphorous

Figure 30 and Figure 31 in Appendix C present the total phosphorous data as an indication of the nutrient concentrations in the estuary. A slight downward trend is evident. Phosphorous concentrations are often above the ANZECC guideline for aquatic ecology at both sites. Total phosphorous is associated with particulate matter that can deposit on the estuary bed. From here it can become dissolved and more bioavailable under suitable conditions. This is more likely in anaerobic conditions such as could occur if the estuaries were to stratify. However, monitoring work undertaken for the Project and reported in the Marine Ecology Report indicated only small differences in temperature between the surface and depth, which suggests that no stratification was occurring. It is expected that any stratification would be very rare and only very short-lived, if ever, in some parts of the Mahurangi estuary and never in the Pūhoi estuary. Both have extensive intertidal areas with tidal ranges of up to 2.9 m. Hence anaerobic conditions are considered to be unlikely and sediment bound total phosphorous is unlikely to be mobilised.

Total phosphorous and total nitrogen concentrations have been compared to rainfall in the catchment to identify whether there is any trend in nutrient concentrations in the estuary and rainfall/runoff. Figure 32 and Figure 33 present plots of TP and TN respectively with that day's rain. No obvious trends can be identified in nutrient concentration changing with rainfall. A similar pattern existed when the data was compared to the rain in the previous 24, 48 and 72 hours.

The TN:TP ratio has been calculated for the two Auckland Council monitoring sites in the Mahurangi Estuary to understand the control of specific nutrients on potential biological growths in the estuary. Results are presented in Table 7 which indicates that the system is nitrogen limited. That is that even while there is sufficient phosphorous to allow for algal growths the amount of available nitrogen is what is most likely to control whether any algae can actually grow if other factors such as temperature are suitable.

Table 7 Nitrogen: Phosphorous relationship

Site	Measure	Result	Implication
Mahurangi at FHQ	Median TN:TP ratio	2.6	Indicates N limitation
Mahurangi at WTP	Median TN:TP ratio	1.5	Indicates N limitation

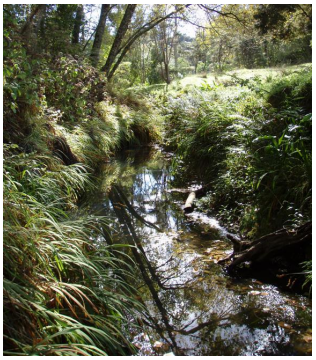
5. Water quality characterisation monitoring

5.1 Methodology

Water quality data was gathered from thirteen sites within the Project area. The intent is to provide information to assist in characterising the water quality in tributaries of the Mahurangi River and the Pūhoi to add to the data and understanding available from existing Auckland Council data. The thirteen sites are shown in a map in Appendix A and locations, stream descriptions and surrounding land uses as observed during low flow conditions are listed in Table 8. Eleven of the sites are in freshwater streams and two are in tidal areas. The two existing Auckland Council monitoring sites are among the freshwater sites sampled.

The area of catchment upstream of each sample point is provided in Table 9. Table 9 also identifies the amounts and proportions of each land use within each catchment. The catchments related to each sample point are shown on the map in Appendix A. 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. From this it can be seen that forestry, pasture and indigenous forestry are the main land uses throughout all the project catchments.

Table 8 Water quality sample points

Watercourse	Sample point	Description and surrounding land use	Site photo
Hikauae Creek	PL	The site is located on the lower main stem of the Hikauae Creek immediately above the tidal limit. Surrounding land use is pasture on the true right bank and plantation forestry and the state highway on the true left bank. The stream is incised into the valley bottom with a reasonably open soft bottomed channel.	
	P9	The site is located on a tributary on the true right of the creek. The creek is small and drains plantation forestry. The site was located immediately upstream of the culvert beneath SH1. The site has dense shading shrub vegetation. The substrate is entirely clay and soft sediments, that are easily disturbed, typically overlaid with small woody debris.	

Watercourse	Sample point	Description and surrounding land use	Site photo
	P10	The sample point is located on the main stem of the Hikauae Creek. It is upstream of the State highway where the stream meanders through pasture. Stream banks are incised and overhanging with some stream bank vegetation. Bed sediments appear soft with slower flowing deeper water. Dense macrophyte beds were observed in the channel.	
	P11	P11 is the uppermost sample point in the catchment. Land use is pasture on the true right bank and plantation forestry on the true left. Upstream land use is a similar mix. Native forest exists along the stream banks. The site contains a series of rock steps and deeper pools. During low flows water was turbid. Macrophytes were observed growing in the pools as were small amounts of periphyton in the shallower water.	
Pūhoi River	Pūhoi Mouth	The site was located underneath the bridge of the main road. Samples were taken about 5 m downstream from the bridge pile on the northern bank of the river. The site is within the coastal marine area of the river and is tidal. Water is brackish with the freshwater influence depending on the state of tide and river flow.	See Figure 2 in Appendix A.
M15 Tributary of Mahurangi River right branch	Mahurangi at FHQ (AC-FHQ)	This is an existing Auckland Council site located in forestry plantations. It is located in open pasture with the upstream catchment in plantation forestry. The channel is relatively straight, incised, u-shaped channel with a fine gravel substrate. Rough pasture with fern growth on stream banks.	

Watercourse	Sample point	Description and surrounding land use	Site photo
M16 Tributary of Mahurangi River right branch	M16	The site is located immediately upstream of Perry Road. Surrounding land use is predominantly lifestyle pasture land with forestry in the higher catchment. The stream is incised with banks well vegetated with native forest. The bed channel is a mix of boulders and cobbles.	
M19 Tributary of Mahurangi River right branch	M19	The site is located in pasture land upstream of the fish farm. The stream is small and narrow and runs within a fenced buffer strip that contains some areas of overhanging vegetation. The sampling site is deep, soft bottomed with a fair amount of woody debris throughout stream.	
Mahurangi River Right Branch	MW	The site is located upstream of Woodcocks Road and is soft bottomed, with macrophytes common throughout. Riparian vegetation is typically rank grass and occasional willows. Site is fenced from stock and contains grazed pasture beyond fences.	
Mahurangi River Left Branch	M22	The site is on a small tributary of the left branch, the stream is shallow with a small baseflow. Some periphyton growth was observed on the soft clay and silt bed material. The banks are vegetated and fenced at the sample site. Upstream land use is entirely pasture.	

Watercourse	Sample point	Description and surrounding land use	Site photo
	M24	M24 is on the main stem of the left branch. The stream is well incised with a reasonable cover of overhanging trees and vegetation. The bed was generally clay based and relatively firm.	
Mahurangi River	Mahurangi at WTP (AC-WTP)	This Auckland Council site is the lowest monitored in the catchment. The river is wider and is in a slow flowing pool above a rock step upstream of the state highway bridge. During low flows the pool had a dense growth of green algae and dense aquatic plant growth in the pooled areas.	
	Mahurangi Mouth	The Warkworth site was located at the boat ramp in town, downstream from the weir. The site is within the coastal marine area of the creek and is tidal. Water is brackish with the freshwater influence depending on the state of tide and river flow.	See Figure 2 in Appendix A.

Table 9 Catchment land uses and areas upstream of Project sample points

Site	Total area (Ha)	Land use											
		Forestry		Pasture		Indigenous Forest		Orchard / Vineyard		Scrubland/ Manuka		Urban	
		Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%
PL	1174	529	45.0	413	35.2	154	13.1	1	0.1	78	6.6	0	0
P9	90	75	83.2	2	2.0	13	14.8	0	0	0	0	0	0
P10	744	398	53.5	259	34.8	58	7.8	0	0	29	3.9	0	0
P11	526	369	70.2	112	21.4	35	6.7	0	0	9	1.7	0	0
M16	575	276	48.1	105	18.2	123	21.4	0	0	71	12.3	0	0
M19	166	6	3.9	101	60.7	52	31.5	0	0	6	3.8	0	0
M22	206	24	11.6	163	79.2	15	7.0	0	0.1	4	2.1	0	0
M24	1073	137	12.8	610	56.8	278	25.9	3	0.3	43	4.0	2	0.2
MW	2892	1005	34.7	1254	43.4	517	17.9	21	0.7	94	3.2	1	0
AC-WTP	4852	1180	24.3	2581	53.2	839	17.3	26	0.5	146	3.0	81	1.7
AC-FHQ	488	478	98.0	1	0.3	8	1.7	0	0	0	0	0	0

Sampling of the eleven freshwater sites has been undertaken by Bioresearches Ltd on behalf of the Project team. Bioresearches have also undertaken the ecological assessment work on the Project. Sampling sites were chosen during a walkover of the catchment by Project staff. Grab samples and field measurements (including flow) have been taken at each site on each sampling occasion. The two sites at the mouth were sampled by eCoast Ltd on behalf of the Project team. eCoast operated turbidity loggers and flow gauges at these locations. Parameters and field measurements taken are as follows:

- Field Tests - pH (ph units), temperature (◦C), dissolved oxygen (mg/L and %), clarity (by clarity tube in m), Flow (m3/s), scums, foams and grease (presence / absence observations).
- Physical and chemical characteristic parameters - total suspended solids (mg/L), turbidity (NTU), colour (Munsell units), Hardness (mg/L CaCO3)
- Microbiological parameters - E.Coli (cfu/100mL) at site PL only and Enterococci (cfu/100mL) at sites Mahurangi and Pūhoi at mouth only.
- Nutrients - total nitrogen, ammoniacal nitrogen, nitrate, nitrite and nitrate/nitrite, total phosphorous and dissolved reactive phosphorous (all as mg/L)
- Metals – total and dissolved copper, zinc and lead (all as mg/L)
- Hydrocarbons - Total Petroleum Hydrocarbons (TPH's) and Polycyclic Aromatic Hydrocarbons (PAH's) (all as mg/L)

All samples were provided to Hill Laboratories for analysis. The laboratory detection limits (minimum value that can be analysed) varies in the sampling undertaken for this project when compared to Auckland Council data and also in the analysis undertaken in freshwater and saline environments. Reported laboratory detection limits are however always lower than the guidelines against which results are being compared. Therefore variations in detection limits do not affect analysis of the data.

For the freshwater sites four sample rounds were undertaken with two of these being in low flow conditions and two in higher flows. Two types of quality control were undertaken during the monitoring as follows:

- A duplicate set of samples was taken at one site each sample round. These duplicate samples can be used to detect both natural variations in the environment and variations caused by field sampling and laboratory methods.
- Two sets of field blanks were taken; these are clean samples of distilled deionised water with bottles filled in the field and treated as normal samples. This provides assurance that no contaminants enter from the field process, in transport or in laboratory analysis.

Data gathered at each site has been compared to relevant guidelines as outlined in Section 3, existing Auckland Council data and the data from other sites studies for the Project. This is presented and discussed in the next section.

The two sites at the mouths were sampled once in wet weather only. These have been compared to the saline water quality guidelines as the water was brackish and are discussed with the wet weather sampling data.

5.2 Results and discussion

5.2.1 Dry weather samples

The eleven freshwater sites were sampled during the autumn of 2013. Stream velocities were very low on the first sampling occasion with no measurable flow existing at some sites. Data are presented in Table 16 and Table 17 in Appendix D. Most results were below ANZECC default trigger values for aquatic ecosystems. Hydrocarbon concentrations were all below detection limits. Metal concentrations and *E. coli* counts were all below guideline values. Occasional exceedances of guidelines occurred for turbidity, ammoniacal nitrogen and dissolved and total reactive phosphorous. Results were however not greatly elevated above guideline values. The exceedances occurred at sites P9 and P10 in the middle of the Hikauae Creek and M24, WTP and FHQ at various locations on the Mahurangi. The parameters that were in exceedance of guidelines are comparable to the available long term Auckland Council data which showed a similar pattern of exceedance in average results. Clarity was the only parameter that frequently exceeded guideline values with 13 of 22 samples having low clarity. This reflects the general exceedance of clarity guidelines in available Auckland Council data and the observations from the walk over by water quality members of the Project team that identified generally low clarity waters in low flow conditions.

Based on the available data the results are broadly similar to the picture presented by the Auckland Council water quality data. There are no obvious differences between the data from the two catchments or specific sites in different land uses/stream network elevations.

5.2.2 Wet weather samples

Two sets of wet weather data were gathered at the eleven freshwater sites during the monitoring period. Data are presented in Table 18 and Table 19 in Appendix D. Turbidity was elevated at all sites except the small stream M22 in the Mahurangi and clarity almost always exceeded guidelines. Hydrocarbon concentrations were, with the exception of one result, below detection limits. Metal concentrations were all below guideline values. Therefore from this data it would appear that metal concentrations are low in both catchments in both wet and dry weather conditions. Some exceedances of total, ammoniacal or nitrite/nitrate nitrogen occurred during one round of the wet weather samples. Phosphorous concentrations were elevated on occasion in the same sample round. These exceedances occurred at various sites in both catchments. The first (8th May) wet weather sampling round had a greater number of exceedances of guidelines than any other sampling occasion. During the second wet weather event nitrogen and phosphorus guidelines were generally not exceeded. *E. coli* counts were elevated above guidelines on one occasion.

Overall a similar pattern of parameters in which exceedances of guidelines occurred existed in wet weather as in dry weather conditions with no hydrocarbons, low concentrations of metals and occasionally elevated nutrient concentrations (both nitrogen and phosphorous). Total nitrogen was notably only exceeded during wet weather conditions. Clarity was almost always low in both flow conditions and turbidity was higher in wet weather conditions as would be expected.

Additional data was gathered from the mouths of the Pūhoi and Mahurangi Rivers in wet weather conditions in March 2013. Four samples were taken at each site over a four hour period. Data are presented in Table 20 and Table 21 in Appendix D. Sample sites are within estuarine areas and are brackish so have been compared to ANZECC saline water ecology guideline values. Exceedances of guideline values were observed for a number of parameters as follows:

- Total and dissolved copper from all samples at the Mahurangi Mouth
- Dissolved and total zinc from one sample at the Mahurangi Mouth
- Total nitrogen, total ammoniacal nitrogen and nitrate/nitrite nitrogen in all samples
- Total and dissolved phosphorous in all samples from the Mahurangi mouth and most from the Pūhoi
- Enterococci in all but one sample

This data therefore indicates that at the stream mouths in wet weather nutrients are generally elevated. Bacteria concentrations would indicate the water may be unsuitable for contact recreation. The metal results indicate a difference between the two catchments with the Mahurangi River having higher results of Copper and Zinc especially. This may be a reflection of the inputs from the urban areas of Warkworth that are not identified in the monitoring at the other locations. Metal results are generally low in the Pūhoi River.

5.2.3 Quality control

Duplicate samples were taken from one site during each sample run. Data are presented in the tables for each sampling round in Appendix D. In general no notable differences existed between the results for the duplicate samples indicating that sampling and analysis methods were of suitable accuracy to create replicable results. The only exception was the phosphorus results in the duplicates from the 14th May. The duplicate and the primary sample were different with the primary sample being above guideline values.

Blank samples were undertaken during each sample round.

6. Sediment quality characterisation monitoring

6.1 Methodology

One set of sediment samples were taken from 8 of the 11 sample points identified in Table 8. Three sites were not sampled as either no fine sediments were present or water depth meant that samples could not be obtained. Samples were analysed by Hill Laboratories for the following parameters:

- Copper (total recoverable)
- Zinc (total recoverable)
- Lead (total recoverable)
- Total Petroleum Hydrocarbons
- Polycyclic Aromatic Hydrocarbons
- Total Organic Carbon
- Total nitrogen and phosphorous

6.2 Results and discussion

Results are presented in Table 21 in Appendix D. These have been compared to the sediment quality guidelines in Table 5 in Section 3.4. All gathered data was within the guidelines identified indicating that sediments do not contain elevated concentrations of metals or hydrocarbons. Results for the eight sites were broadly similar with the exception of site PL, the lowest site on the Pūhoi River. This location had PAH's regularly identified as being present whereas they were below detection limits at most other sites.

Sediment quality data has been gathered for the Project in the Pūhoi Estuary and Mahurangi Estuary. This has been reported in the Marine Ecology Assessment Report which notes that the concentration of metals and high molecular weight PAH's detected in intertidal surface sediment was low at all sites, both in the total sediment and <63µm fraction apart from copper at one site at Vialls landing and on site within Jamieson Bay. This therefore presents a similar picture of low contaminant concentrations in the estuary sediments as occurs in the freshwater environments.

The nutrient data for the instream sediment indicated that the sediments contain much higher concentrations of phosphorous than nitrogen as would be expected due to phosphorous binding with sediment and organic particles.

7. Summary

Existing water quality data from the Mahurangi indicates that while water quality is generally good, there are slightly elevated concentrations of phosphorous and turbidity/suspended sediments. 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.

Within the Mahurangi Estuary the water quality is also good with most parameters being below guidelines. Average suspended sediment and phosphorus concentrations were slightly elevated. Average water quality within the Mahurangi estuary is considered suitable for the existing values and uses. There was no existing information available for the Pūhoi River or Estuary.

Water quality data gathered for the project presented a similar pattern of water quality to the longer term Auckland Council sites. This included generally good water quality with some nutrients (primarily phosphorous) and turbidity/suspended sediments being elevated. Based on the data gathered for the Project there did not appear to be notable differences between the water quality of the Pūhoi and Mahurangi Rivers. However this is based on a small number of samples over a short period of time. It does indicate that the catchment water quality in the two rivers is broadly similar.

Sediment quality data gathered for the Project indicates that contaminant concentrations are low and all below guidelines. Therefore stream sediments appear to be uncontaminated. Data from estuarine and estuary sediments presented a similar picture.

As water quality inputs and sediment quality are good across both the Pūhoi and Mahurangi catchments it is considered that the Pūhoi Estuary is also likely to be of generally good water quality.

In summary, based on the above the environment is generally of good quality with some existing suspended sediment and nutrient issues/stressors impacting upon the area. This leads to the area being suitable for a range of uses and values. The catchments are however sensitive to further additions of sediment and nutrients primarily as these are already elevated and/or causing concern.

During construction the project can input further suspended sediments to the streams that can then enter the estuary. This suspended sediment will contain nutrients including phosphorous and contribute this to the streams/estuary.

When the road is operational the primary contaminants in road runoff will be metals, hydrocarbons and suspended sediments. The catchment will continue to be particularly sensitive to sediment inputs as it is an existing environmental stressor. Concentrations of metals and hydrocarbons are low in the environment at present and therefore are of less concern as environmental stressors at present. Road runoff discharges can alter concentrations in the environment and potential changes in exceedances of guidelines will need to be considered.

8. References

Auckland Regional Council (undated). Mahurangi Action Plan – Weaving science and community into action. PDF slides of Auckland Regional Council presentation by Kim Morrisey.

Auckland Regional Council (2004) Blueprint for monitoring urban receiving environments. Auckland Regional Council Technical Publication 168.

Auckland Council (2012a) State of Auckland Marine Report card – Mahurangi Harbour reporting Area – July 2012.

ANZECC (2000). Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Volume 1, The Guidelines. Australia and New Zealand Environment and Conservation Council

Biggs, B.J.F. (2000).New Zealand Periphyton Guideline: Detecting, Monitoring and Managing Enrichment of Streams. Prepared for the Ministry of the Environment.

Boffa Miskell (2009). Mahurangi Action Plan Draft Working Paper: Water quality and ecological values. Produced for Auckland Regional Council by Boffa Miskell Limited.

Davies-Colley, R. J. and Nagels, J. W. (1995). Optical Water Quality of the Mahurangi Estuarine System. Prepared by NIWA for Auckland Regional Council. Auckland Regional Council Technical Report 2009/057.

Gibbs, M. (2006) Sediment Source Mapping in Mahurangi Harbour. Auckland Regional Council Technical Publication 321. Prepared by NIWA for Auckland Regional Council.

Hicks, D. and Hawcridge, E. (2004) A Survey of Sediment Sources on Streams in the Mahurangi catchment. Auckland Regional Council Technical Publication 270.

Hill Laboratories (2011). Environmental Division Catalogue – R J Hill Laboratories Ltd.

Lockie, S. and Neale, M.W. (2012). State of the Environment Monitoring River Water Quality Annual Report 2011. Auckland Council Technical Report 2012/013.

MfE (2003) Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas. Ministry for the Environment.

Neale, M. W. (2010). State of the Environment Monitoring River Water Quality Annual Report 2009. Auckland Regional Council Technical Report 2010/030.

Neale, M.W. (2012). State of the Environment Monitoring River Water Quality Annual Report 2010. Auckland Council Technical Report 2012/006.

NZTA (2011). Mackays to Peka Peka Expressway: Technical Report 24 – Baseline Water and Sediment Quality Investigation Report. Beca Infrastructure Ltd on behalf of the New Zealand Transport Agency Ltd

Stroud, M. J. and Cooper, A. B. (1997). Modelling sediment loads to the Mahurangi Estuary. Prepared by NIWA for Auckland Regional Council. Auckland Council Technical Report 2009/060.

Appendix A. Sampling site locations

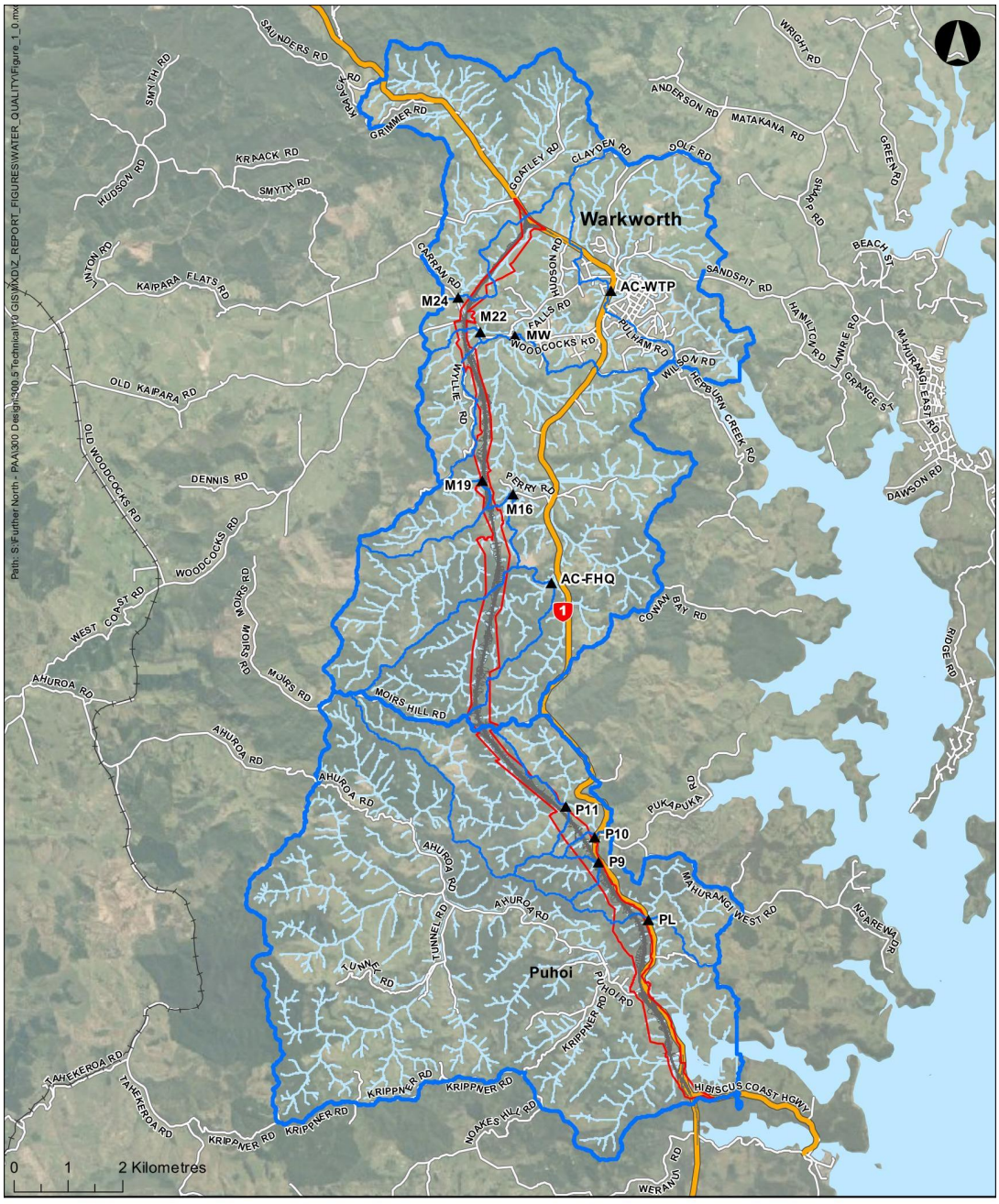


Figure 2 Sample point locations in the Project area

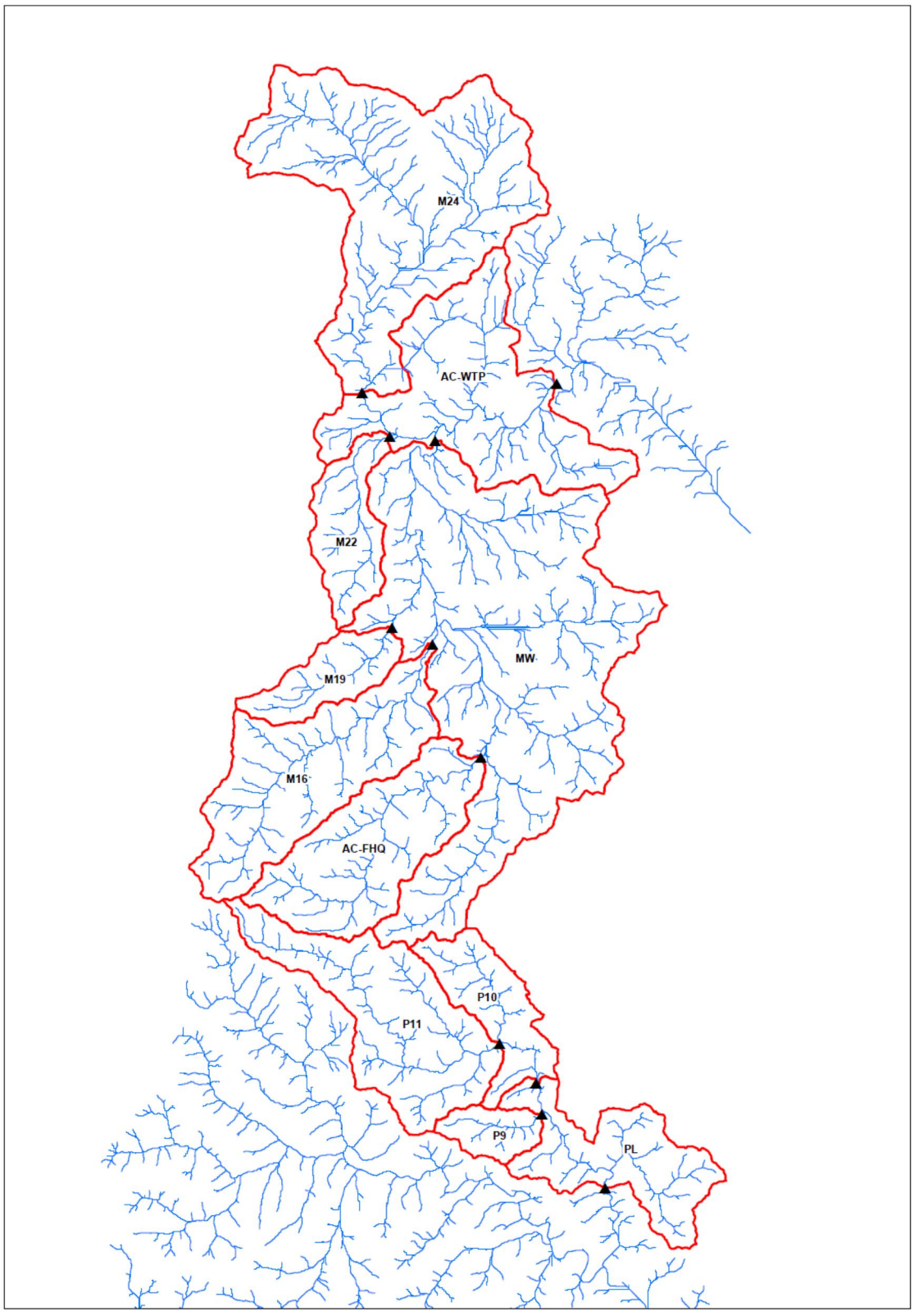


Figure 3 Catchment areas upstream of each sample point

Appendix B. Auckland Council fresh water quality data

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

Parameter (mg/L unless stated)	Date Range	Count	Mean	Median	St Dev	Min	Max
Dissolved Oxygen	1993-2012	228	9.41	9.54	1.35	4.3	16.58
Dissolved Oxygen (%sat)	1993-2012	229	90.65	92	10.62	43.8	153
Conductivity (mS/cm)	2004-2012	104	0.18	0.18	0.04	0.1	0.46
Temp (°C)	1993-2012	231	14.11	13.91	3.21	6	21.9
pH (pH units)	1993-2012	20	7.45	7.4	0.23	6.9	8.39
Biochemical oxygen demand	1993-2005	138	1.99	2	0.17	0.4	2.3
E. coli (cfu/100mL)	2006-2012	78	962	325	1,978	9	12,900
Total suspended solids	1993-2012	232	8.97	4.5	21.25	0.8	260
Turbidity (NTU)	1993-2012	231	14.77	8.9	24.69	1.3	228
Black Disc Clarity (m)	1993-2009	123	0.53	0.5	0.23	0.09	1.41
Total Phosphorous	1993-2012	230	0.035	0.030	0.029	0.005	0.26
Soluble reactive phosphorous	1993-2012	230	0.013	0.01	0.0069	<0.005	0.06
Total nitrogen	2009-2012	48	0.317	0.26	0.154	0.09	0.73
Ammoniacal nitrogen	1993-2012	229	0.032	0.03	0.03	<0.005	0.4
Nitrate nitrogen	2001	8	0.319	0.23	0.29	0.087	0.99
Nitrite nitrogen	1993-2000	89	0.003	0.003	0.0017	<0.001	0.009
Total oxidised inorganic nitrogen	1993-2012	232	0.19	0.16	0.17	0.003	1.33
Total Kjeldahl Nitrogen	1993-2012	138	0.32	0.2	0.33	0.038	2.8
Copper (total)	2010-2012	30	0.00088	0.00049	0.0013	<0.0001	0.0076
Copper (dissolved)	2010-2012	30	0.00037	0.0003	0.00019	<0.0001	0.00091
Lead (total)	2010-2012	30	0.00016	0.00006	0.00034	<0.00005	0.0019
Lead (dissolved)	2010-2012	28	0.00005	0.00005	0.000005	<0.00005	0.00007
Zinc (total)	2010-2012	30	0.0026	0.00084	0.0054	0.0003	0.024
Zinc (dissolved)	2010-2012	30	0.001	0.0003	0.002	0.0003	0.013

Note: Grey shading indicates mean or median value is greater than the lower of the guideline values in Table 3.

Table 11 Summary of existing Auckland Council water quality data for the Mahurangi Town Bridge

Parameter (mg/L unless stated)	Date Range	Count	Mean	Median	St Dev	Min	Max
Dissolved Oxygen	1993-2008	144	9.04	9.1	1.31	3.7	12.1
Dissolved Oxygen (%sat)	1993-2008	173	90.36	92	9.87	38	115
Conductivity (mS/cm)	2004-2008	55	0.21	0.19	0.069	0.1	0.46
Temp (°C)	1986-2008	170	16.22	16.4	3.64	7.7	24.6
pH (pH units)	1986-2008	232	7.44	7.5	0.41	5.9	8.2
Biochemical oxygen demand	1986-2005	201	2.14	2	0.9	0.4	9.6
E.coli (cfu/100mL)	2005-2008	32	483	229	776	2	3100
Total suspended solids	1986-2008	242	12.93	5.35	50.17	0.4	741.5
Turbidity (NTU)	1986-2008	232	12.06	6.6	16.14	0.6	116
Black Disc Clarity (m)	1993-2008	153	0.70	0.7	0.36	0.08	1.7
Total Phosphorous	1986-2008	232	0.071	0.06	0.05	0.01	0.45
Soluble reactive phosphorous	1986-2008	232	0.021	0.02	0.012	<0.005	0.10
Ammoniacal nitrogen	1986-2008	228	0.056	0.04	0.081	<0.001	0.98
Nitrate nitrogen	1986-2005	203	0.32	0.28	0.28	0.001	2.55
Nitrite nitrogen	1986-2000	149	0.0071	0.007	0.0034	<0.001	0.021
Total oxidised inorganic nitrogen	1993-2008	171	0.23	0.23	0.18	0.003	1.28
Total Kjeldahl Nitrogen	2005-2008	32	0.51	0.40	0.37	<0.2	1.7

Note: Grey shading indicates mean or median value is greater than the lower of the guideline values in Table 3.

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

Parameter (mg/L unless stated)	Date Range	Count	Mean	Median	St Dev	Min	Max
Dissolved Oxygen	1993-2012	201	9.53	9.51	1.23	5.4	13.7
Dissolved Oxygen (%sat)	1993-2012	221	95.28	95.9	8.86	55	130.7
Conductivity (mS/cm)	2004-2012	102	0.19	0.18	0.053	0.019	0.43
Temp (°C)	1993-2012	164	15.93	15.6	3.47	7.6	24.1
pH (pH units)	1993-2012	193	7.71	7.7	0.29	6.6	8.4
Biochemical oxygen demand	1993-2005	136	2.03	2	0.36	0.4	5.5
E coli (cfu/100mL)	2005-2012	89	850	250	2845	2	24,000
Total suspended solids	1993-2012	225	10.29	4.7	22.20	0.3	280
Turbidity (NTU)	1993-2012	225	12.87	6.8	20.65	0.89	230
Black Disc Clarity (m)	1994-2009	156	0.73	0.7	0.444	0.05	4
Total Phosphorous	1993-2012	226	0.058	0.05	0.049	0.01	0.46
Soluble reactive phosphorous	1993-2012	225	0.019	0.02	0.01	<0.005	0.07
Total nitrogen	2009-2012	48	0.46	0.39	0.28	0.15	1.7
Ammoniacal nitrogen	1993-2012	222	0.035	0.03	0.023	<0.005	0.10
Nitrate nitrogen	1993-2005	137	0.25	0.24	0.18	0.004	1.26
Nitrite nitrogen	1993-2000	84	0.0079	0.008	0.0041	<0.002	0.027
Total oxidised inorganic nitrogen	1993-2012	227	0.21	0.19	0.16	<0.002	1.27
Total Kjeldahl Nitrogen	2005-2012	89	0.46	0.34	0.38	0.12	2.6
Copper (total)	2010-2012	30	0.0013	0.00088	0.0015	0.00039	0.0086
Copper (dissolved)	2010-2012	30	0.00061	0.00051	0.00035	0.00024	0.0016
Lead (total)	2010-2012	30	0.00046	0.00019	0.00075	<0.00005	0.0039
Lead (dissolved)	2010-2012	28	0.000073	0.000055	0.000037	<0.00005	0.00019
Zinc (total)	2010-2012	30	0.0056	0.0039	0.007	0.00098	0.037
Zinc (dissolved)	2010-2012	30	0.0022	0.002	0.0017	0.00049	0.001

Note: Grey shading indicates mean or median value is greater than the lower of the guideline values in Table 3.

Table 13 Summary of nutrient data as reported in Stroud and Cooper (1997)

Site	Parameter (mg/L)	Date Range	Count	Mean	Median	Range
Redwood	Total Phosphorous	1994-1995	184	0.4	0.15	0.015-10.79
	Dissolved reactive phosphorous	1994-1995	250	0.013	0.01	0.002-0.32
	Total Kjeldahl Nitrogen	1994-1995	198	2.3	0.92	0.11-64.7
	Ammoniacal nitrogen	1994-1995	252	0.066	0.032	0.001-0.71
	Nitrate nitrogen	1994-1995	252	0.24	0.23	0.003-0.61
Wylies	Total Phosphorous	1994-1995	129	0.33	0.13	0.016-1.94
	Dissolved reactive phosphorous	1994-1995	242	0.009	0.006	0.001-0.24
	Total Kjeldahl Nitrogen	1994-1995	120	2.086	1.2	0.22-14.3
	Ammoniacal nitrogen	1994-1995	242	0.037	0.026	0-0.73
	Nitrate nitrogen	1994-1995	242	0.12	0.96	0.031-0.42
College	Total Phosphorous	1994-1995	256	0.48	0.13	0.008-3.22
	Dissolved reactive phosphorous	1994-1995	494	0.028	0.026	0.005-0.13
	Total Kjeldahl Nitrogen	1994-1995	287	2.53	1.39	0.32-15.7
	Ammoniacal nitrogen	1994-1995	494	0.69	0.057	0-0.37
	Nitrate nitrogen	1994-1995	494	0.41	0.35	0.049-1.35

Note: Grey shading indicates mean or median value is greater than the lower of the guideline values in Table 3.

B.1 Auckland Council fresh water quality data analysis

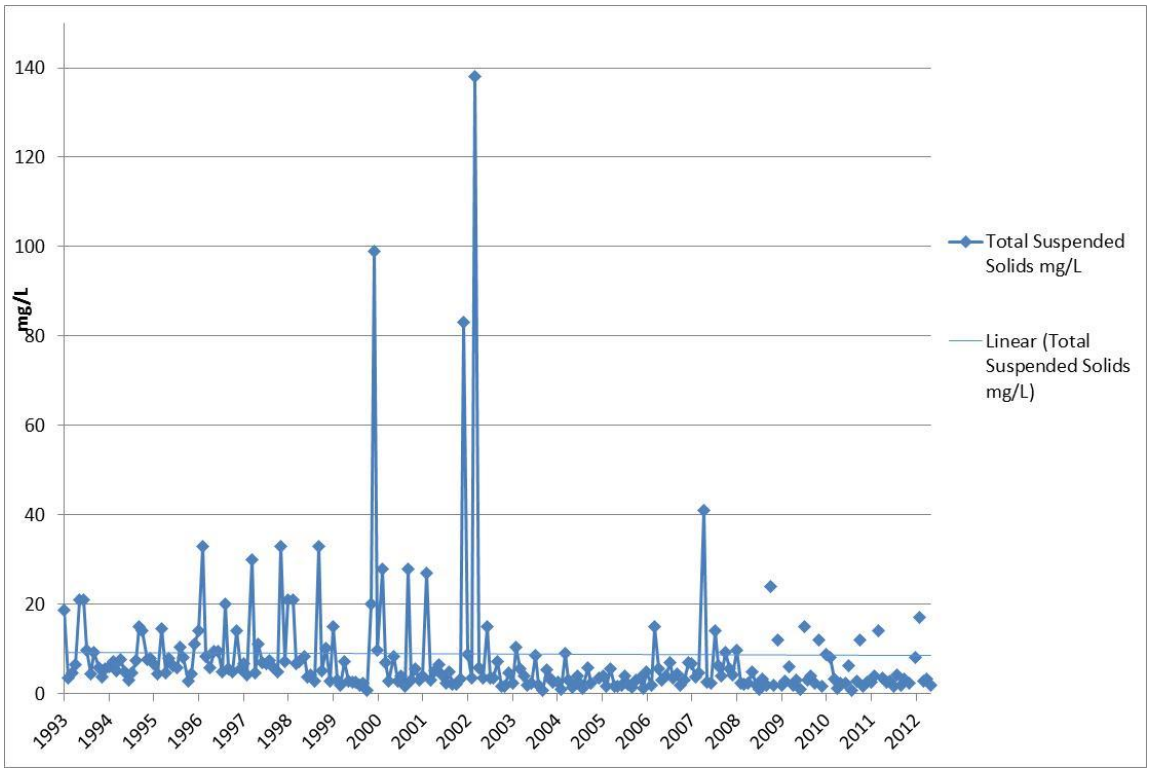


Figure 4 Total suspended solids in the Mahurangi River at the FHQ site

Note: an outlier of 260 mg/L recorded on the 03/07/2012 is not plotted to aid viewing of the data

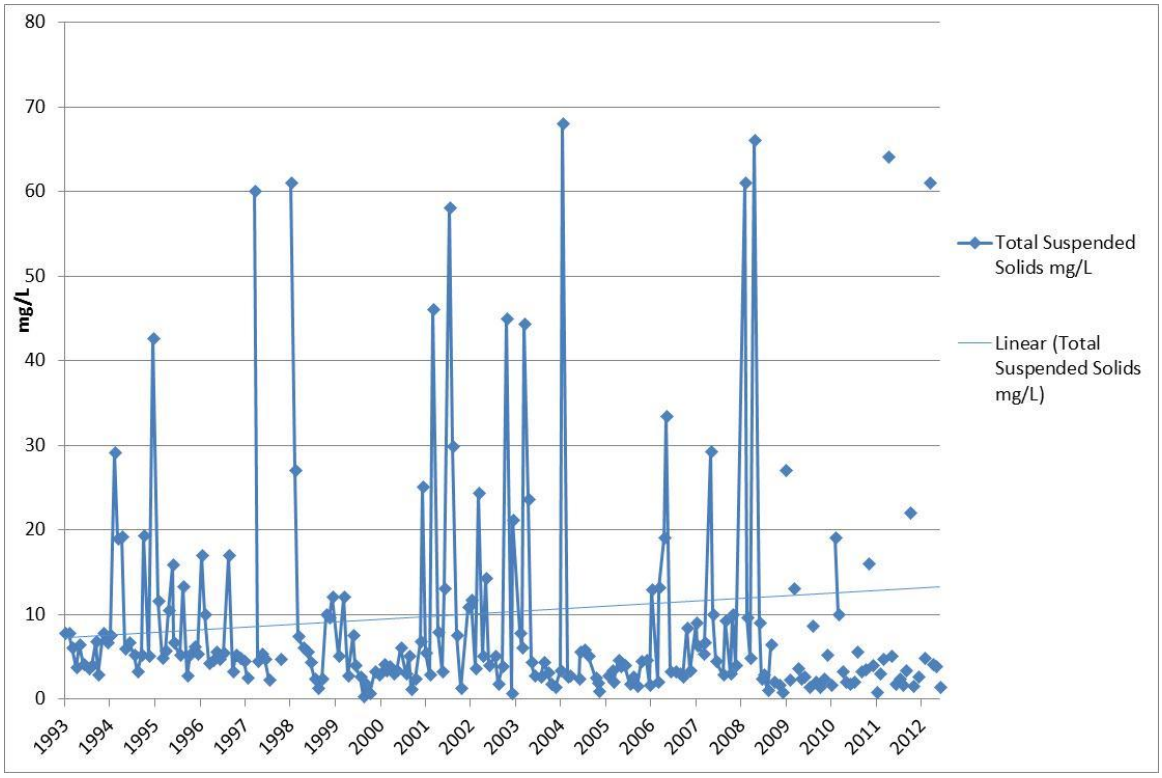


Figure 5 Total suspended solids in the Mahurangi River at the WTP site

Note: an outlier of 280 mg/L recorded on the 03/07/2012 is not plotted to aid viewing of the data

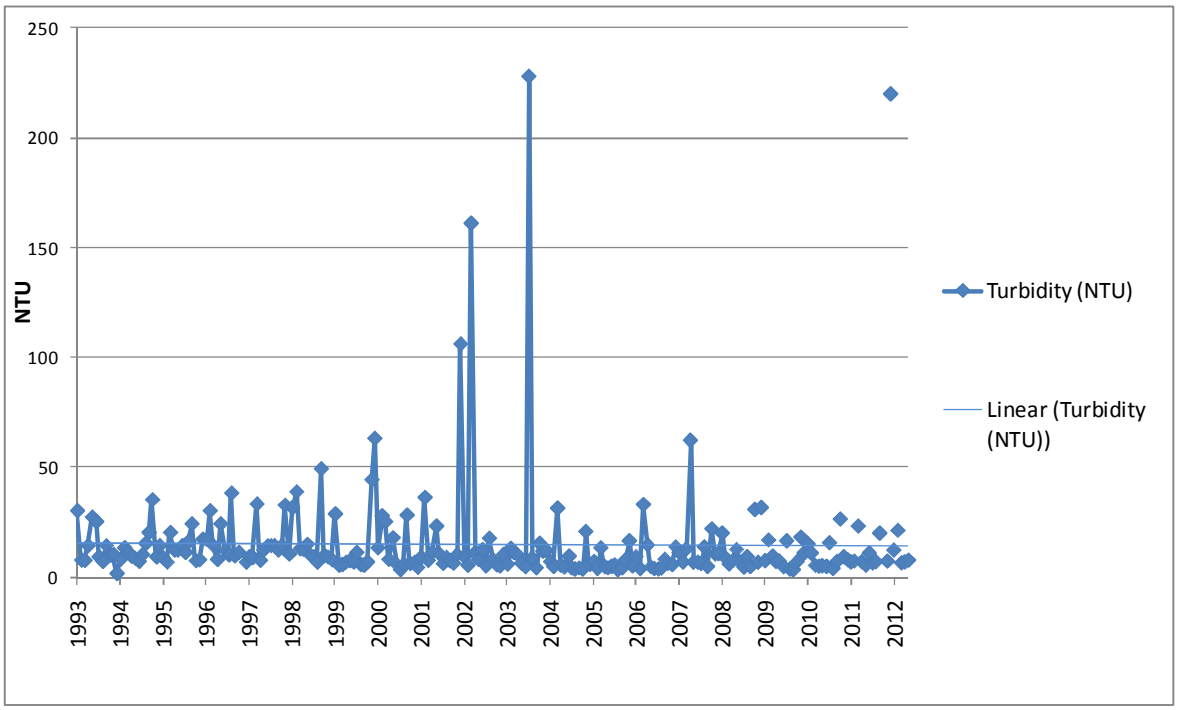


Figure 6 Turbidity in the Mahurangi River at the FHQ site

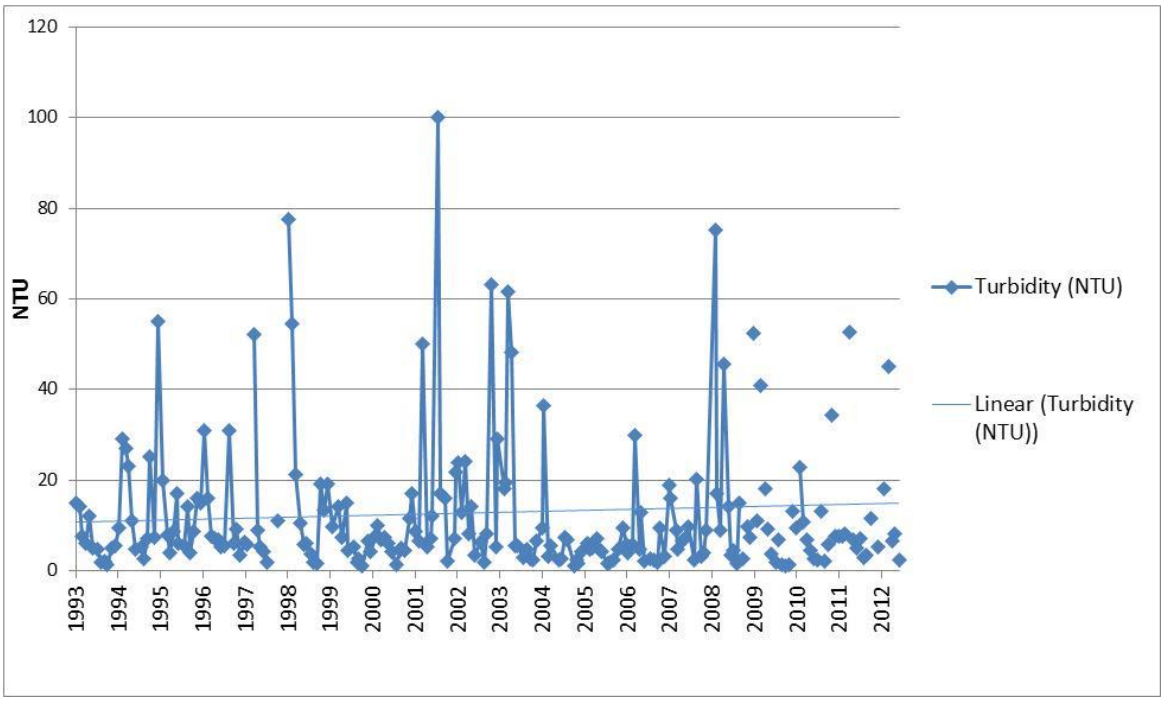


Figure 7 Turbidity in the Mahurangi River at the WTP site

Note: an outlier of 230 NTU recorded on the 03/07/2012 is not plotted to aid viewing of the data

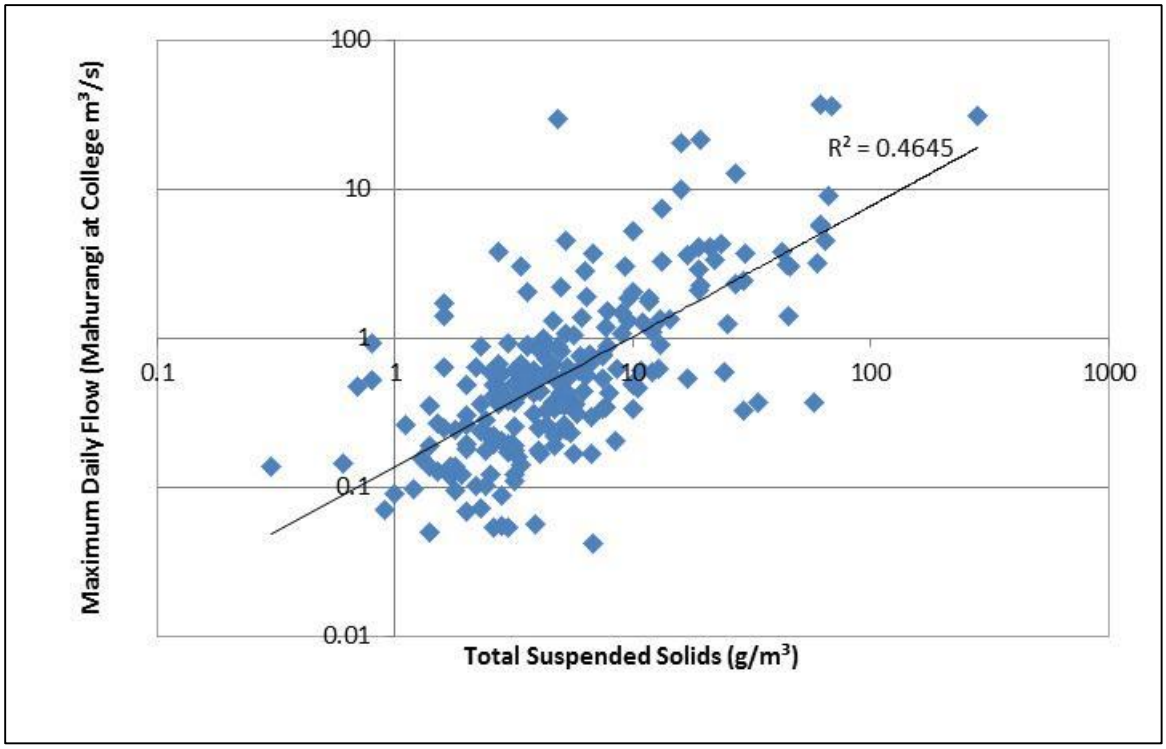


Figure 8 Log plot of total suspended solids at the Mahurangi at WTP site and maximum daily flow (at college site)

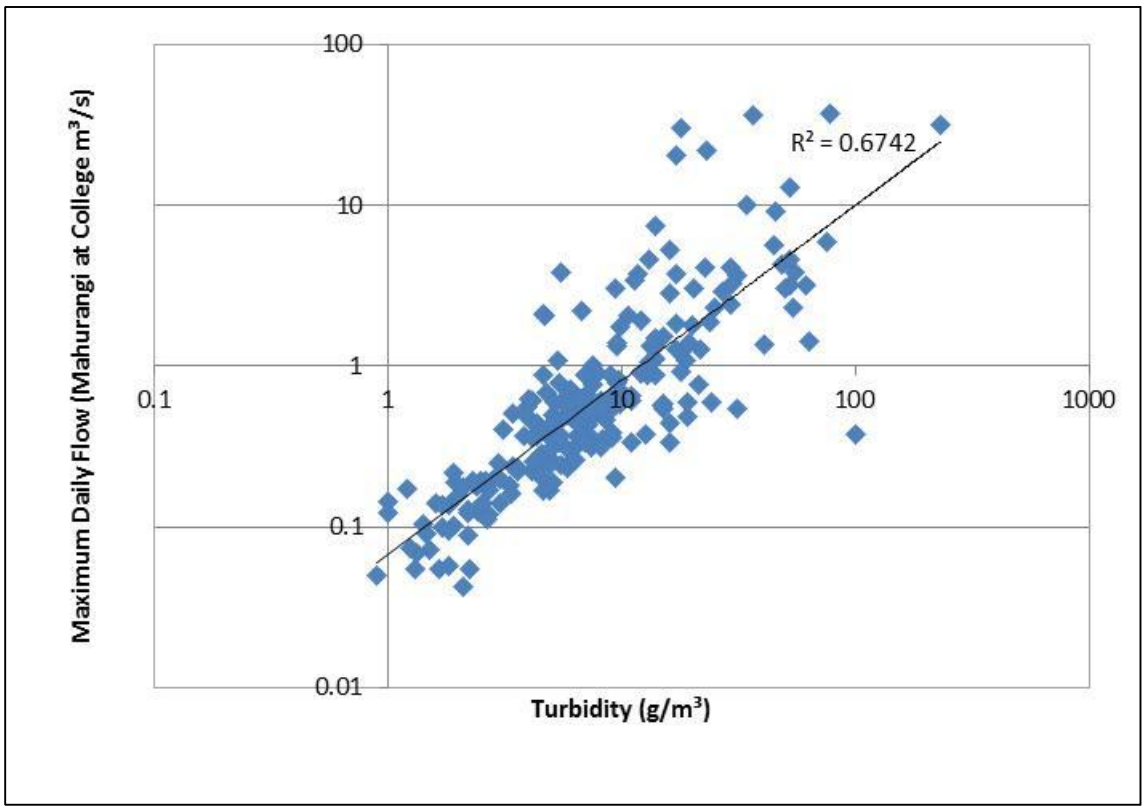


Figure 9 Log plot of turbidity at the Mahurangi at WTP site and maximum daily flow (at college site)

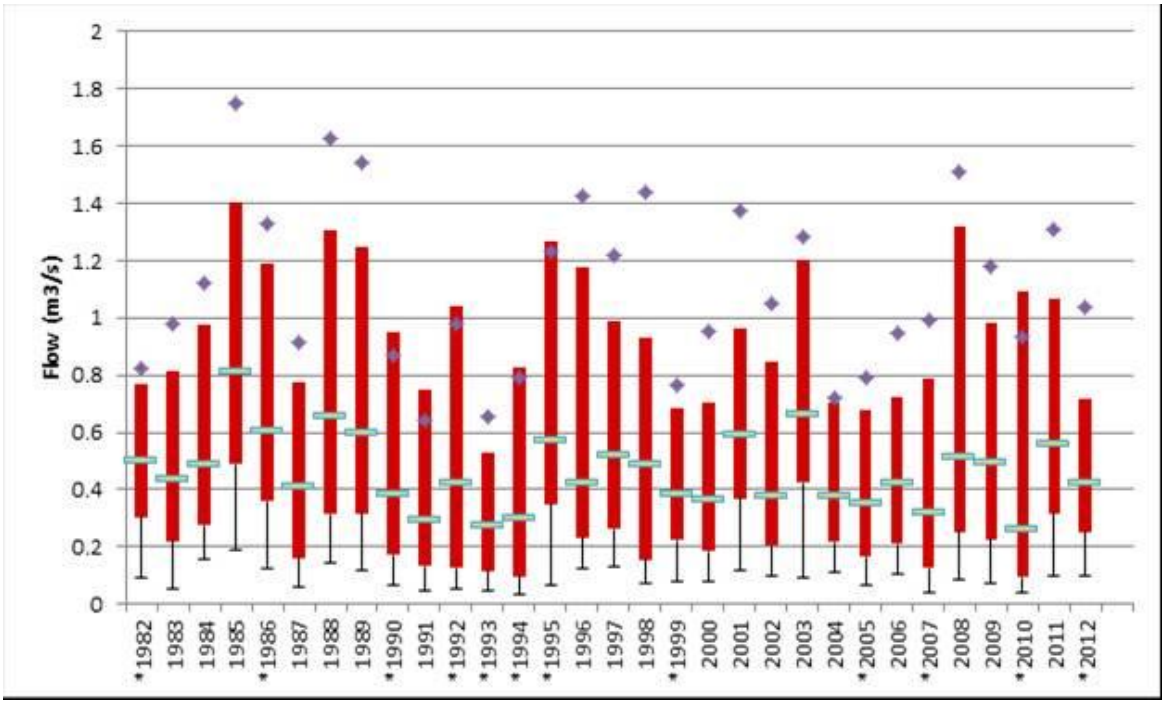


Figure 10 Analysis of flow in the Mahurangi River at the College Recorder site

Note for Figure 10: Graph of annual flow distribution. Purple diamonds are the mean for that year, green bars the median, upper quartile to lower quartile range in red. The minimum value is the lower whisker, upper values are not plotted for scale as these would be well above 2m3/s. Years with gaps in records are denoted (*).

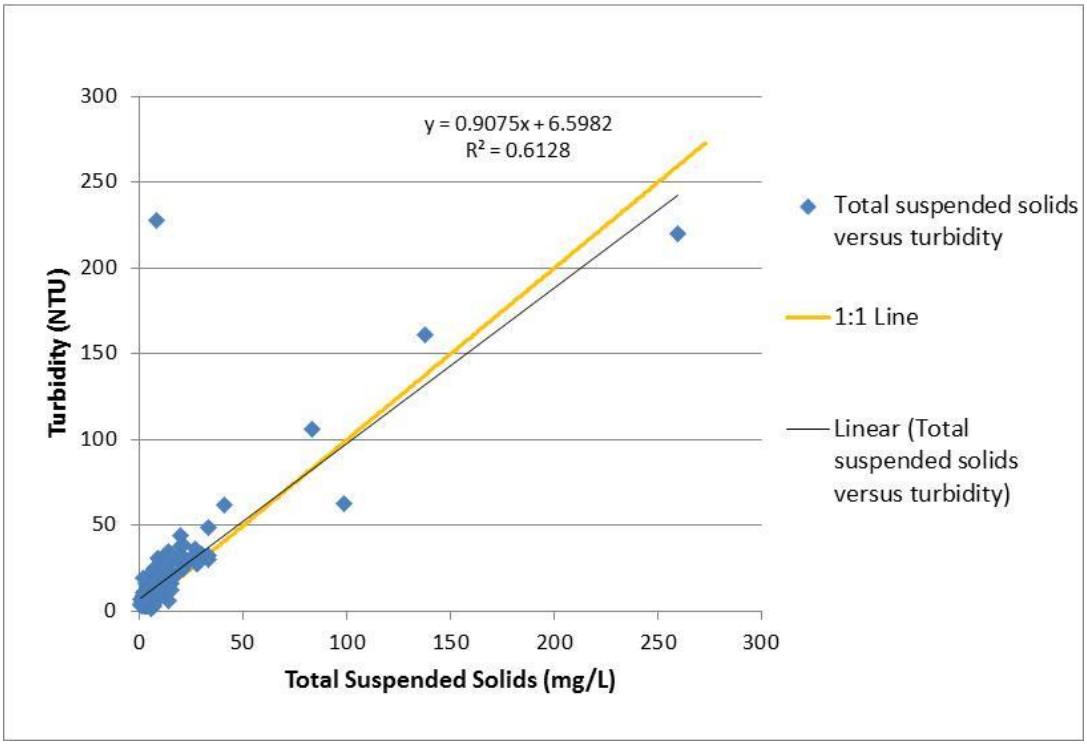


Figure 11 Total suspended solids versus turbidity at Mahurangi at FHQ

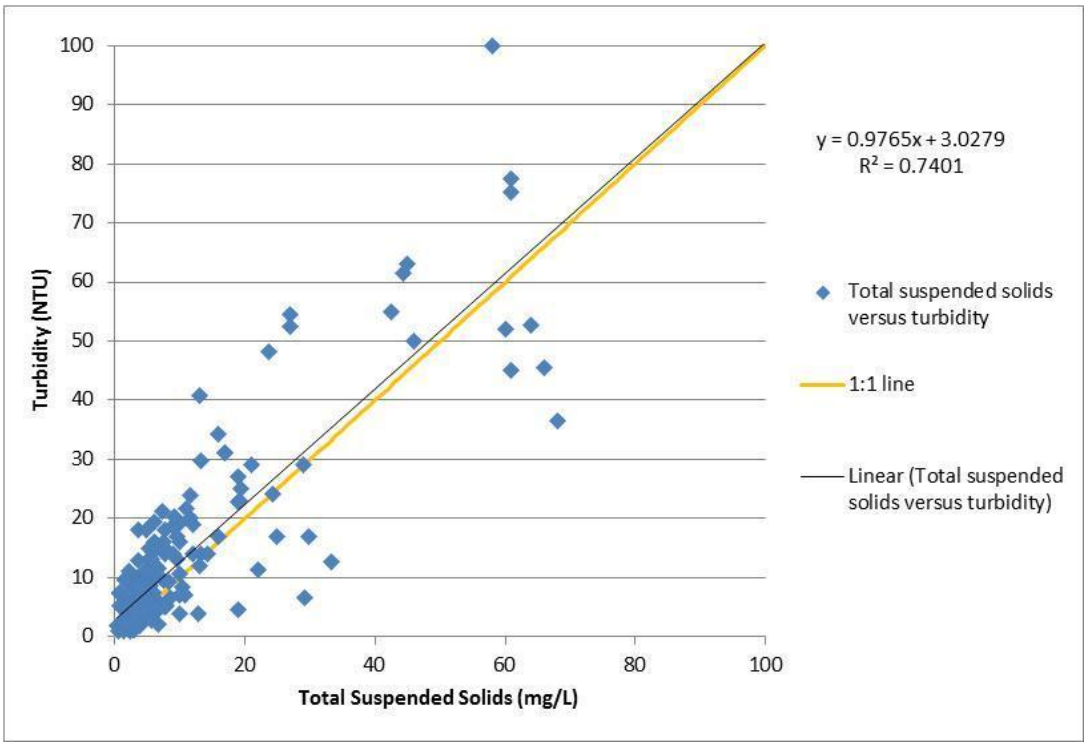


Figure 12 Total suspended solids versus turbidity at Mahurangi at WTP

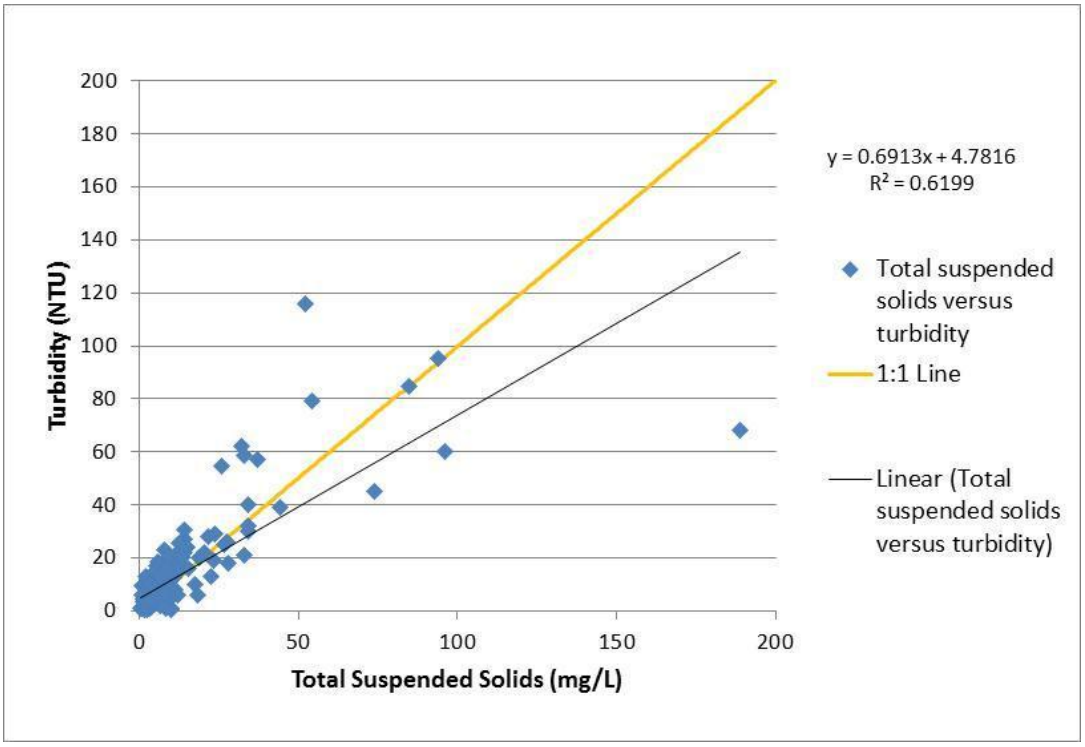


Figure 13 Total suspended solids versus turbidity at Mahurangi at Town Bridge

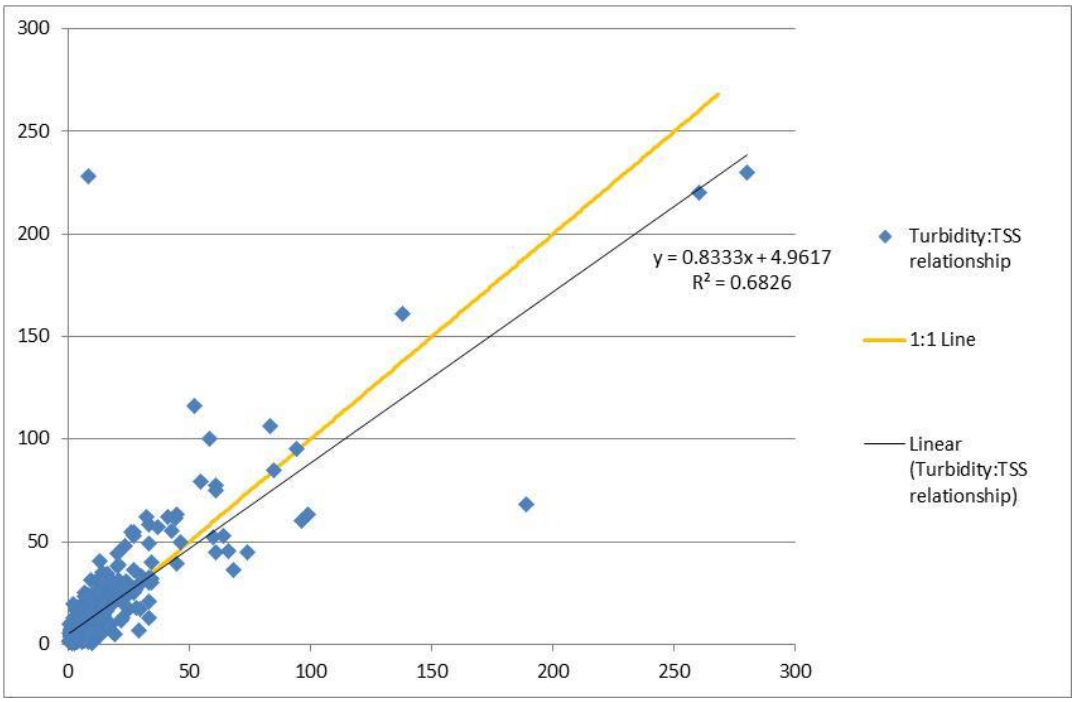


Figure 14 Total suspended solids versus turbidity in all available paired Mahurangi River Data

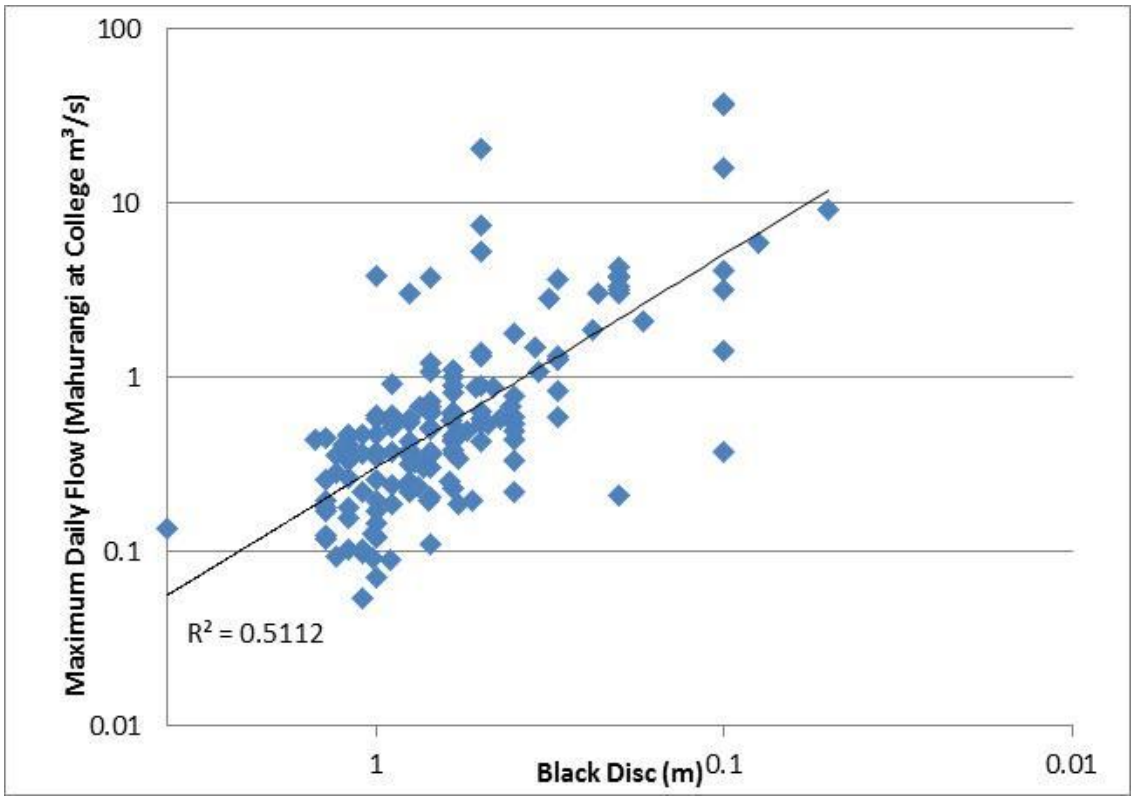


Figure 15 Log plot of black disc clarity at the Mahurangi at WTP site and maximum daily flow (at college site)

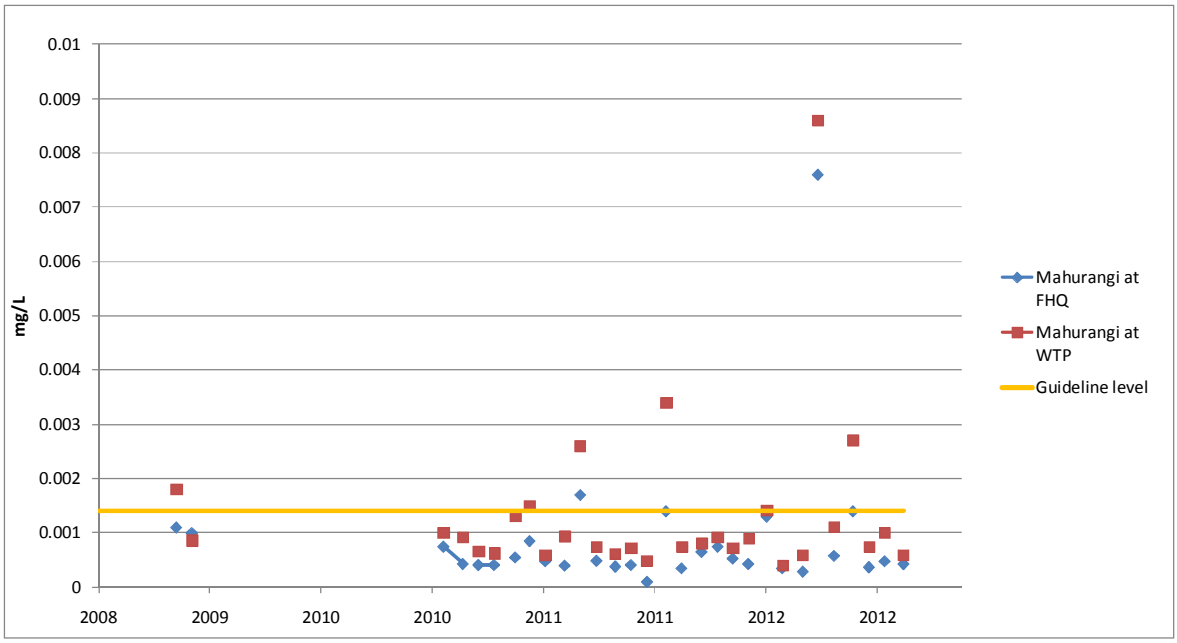


Figure 16 Total copper at the Auckland Council FHQ and WTP sites on the Mahurangi River

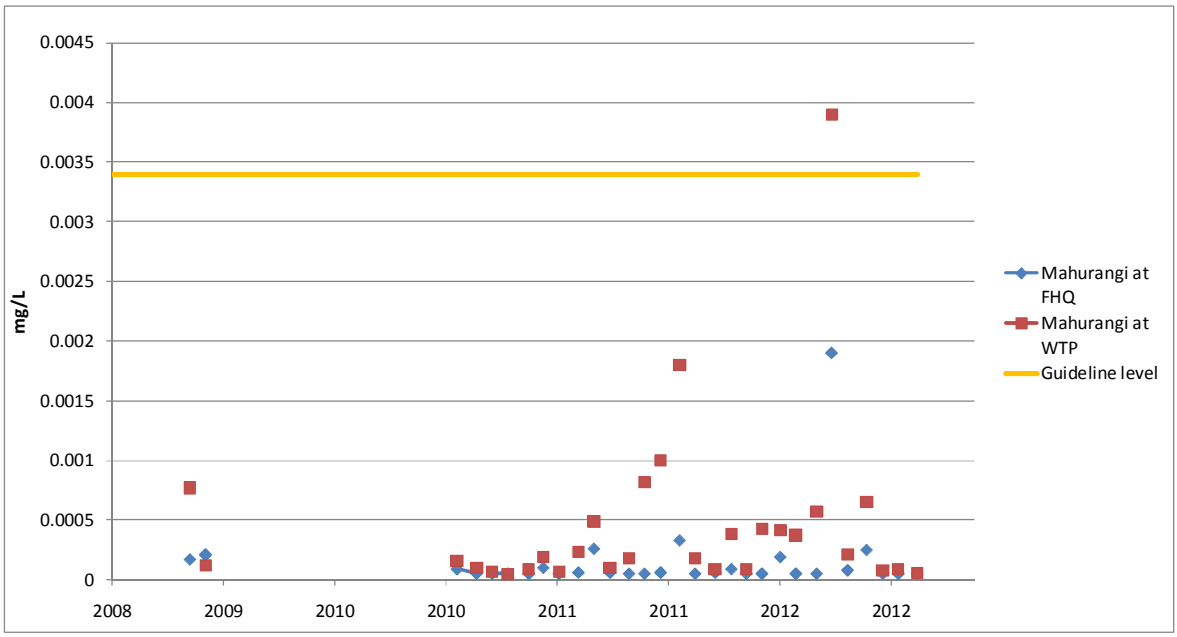


Figure 17 Total Lead at the Auckland Council FHQ and WTP sites on the Mahurangi River

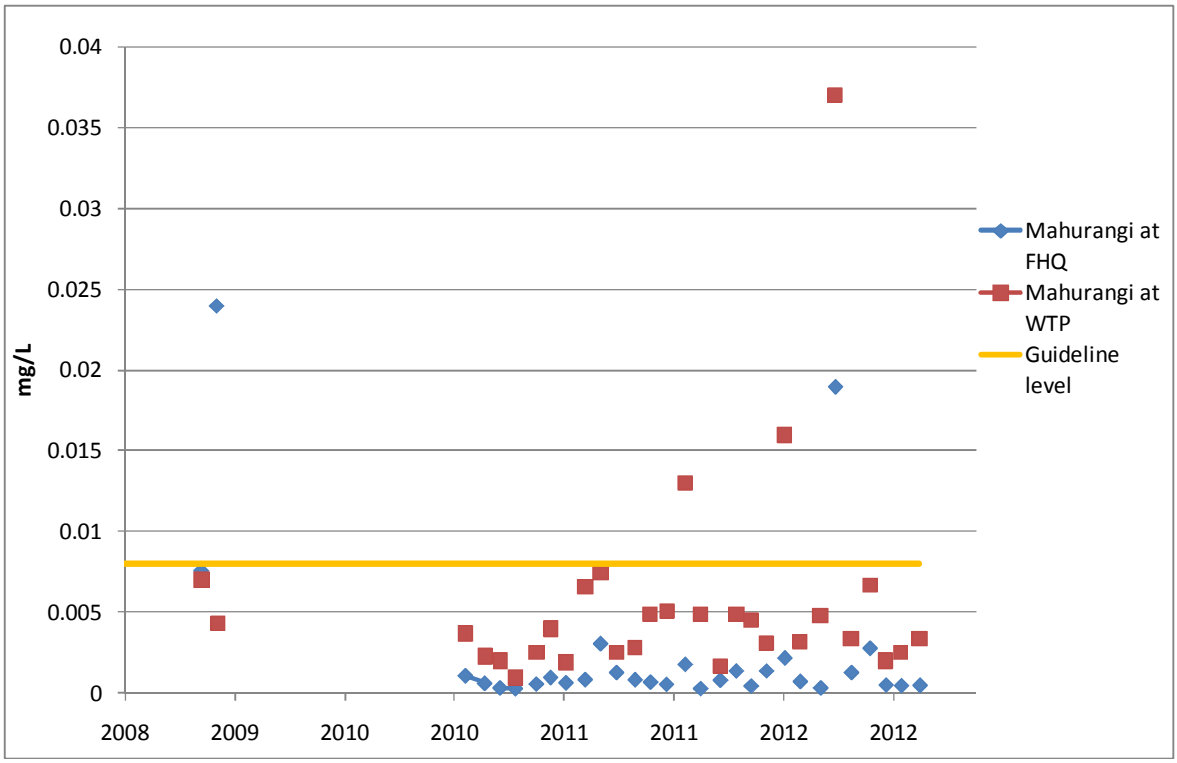


Figure 18 Total Zinc at the Auckland Council FHQ and WTP sites on the Mahurangi River

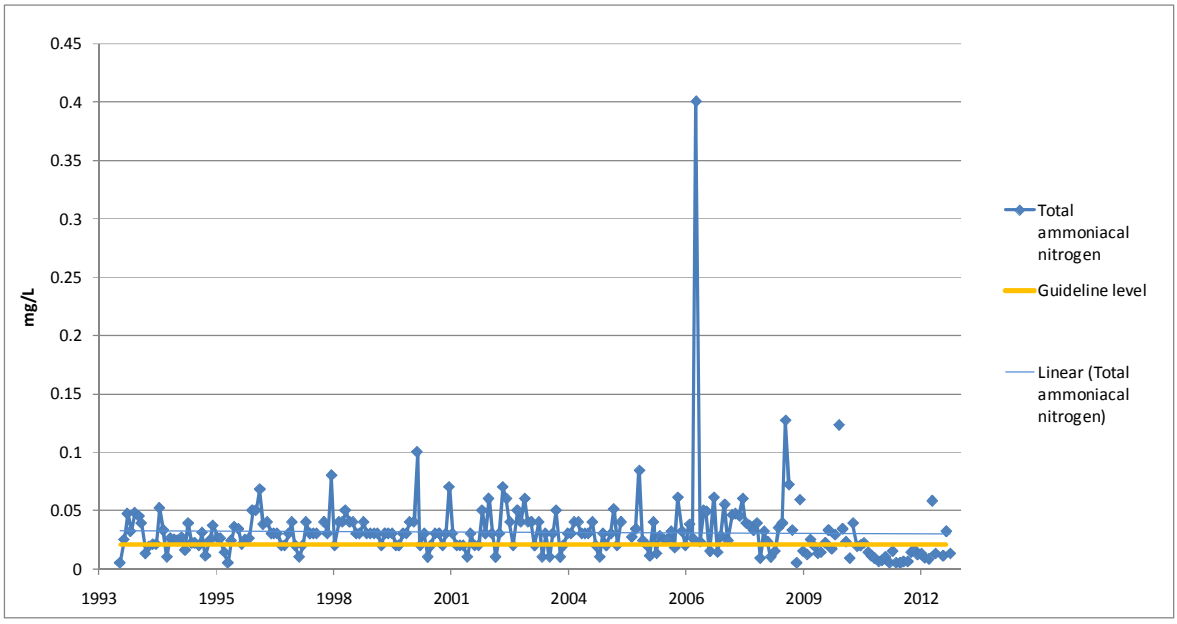


Figure 19 Total ammoniacal nitrogen in the Mahurangi River at the FHQ site

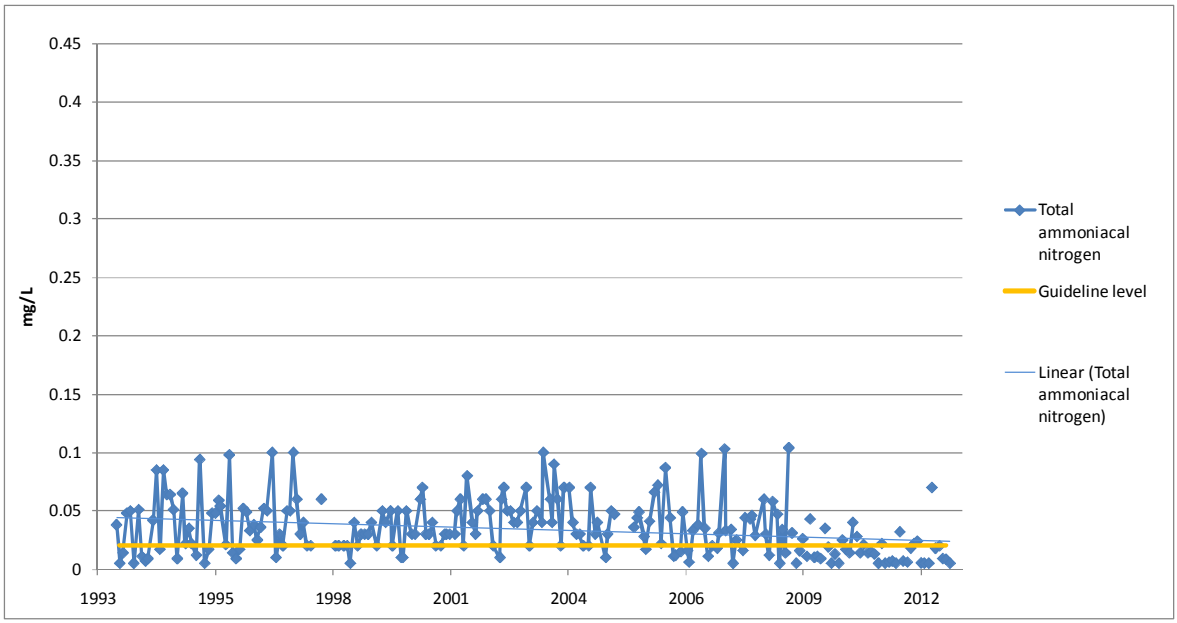


Figure 20 Total ammoniacal nitrogen in the Mahurangi River at the WTP site

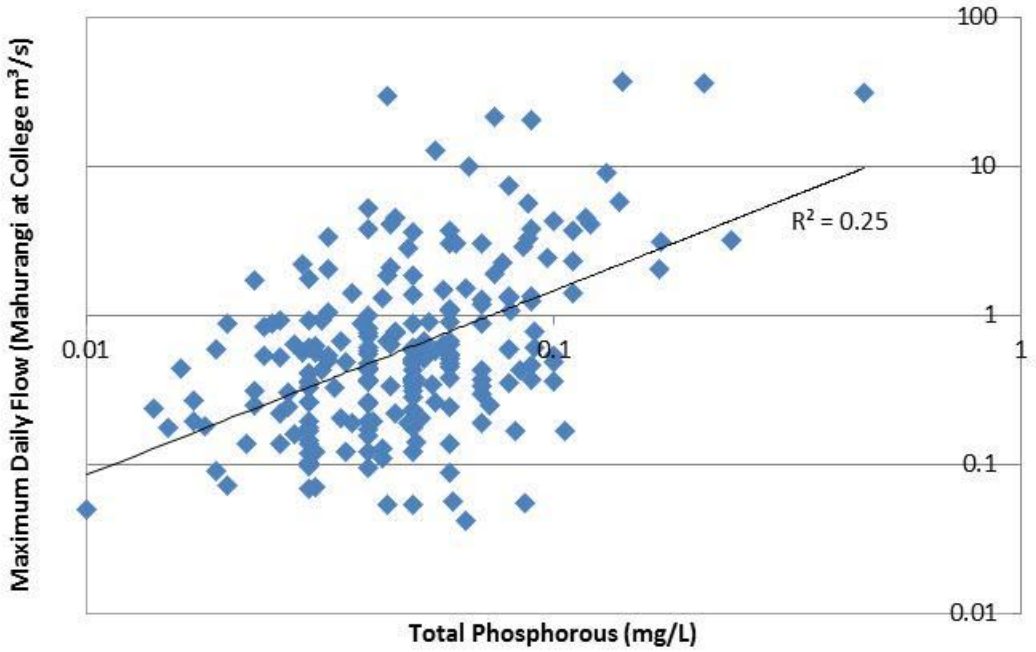


Figure 21 Total phosphorous relationship to flow in the Mahurangi River at the WTP site

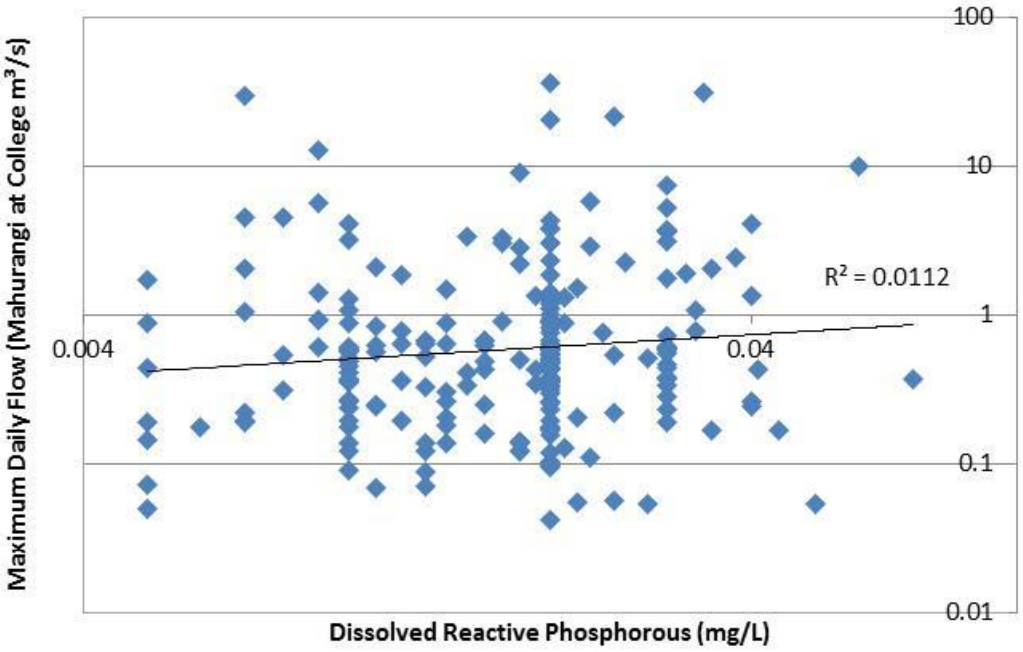


Figure 22 Dissolved reactive phosphorous relationship to flow in the Mahurangi River at the WTP site

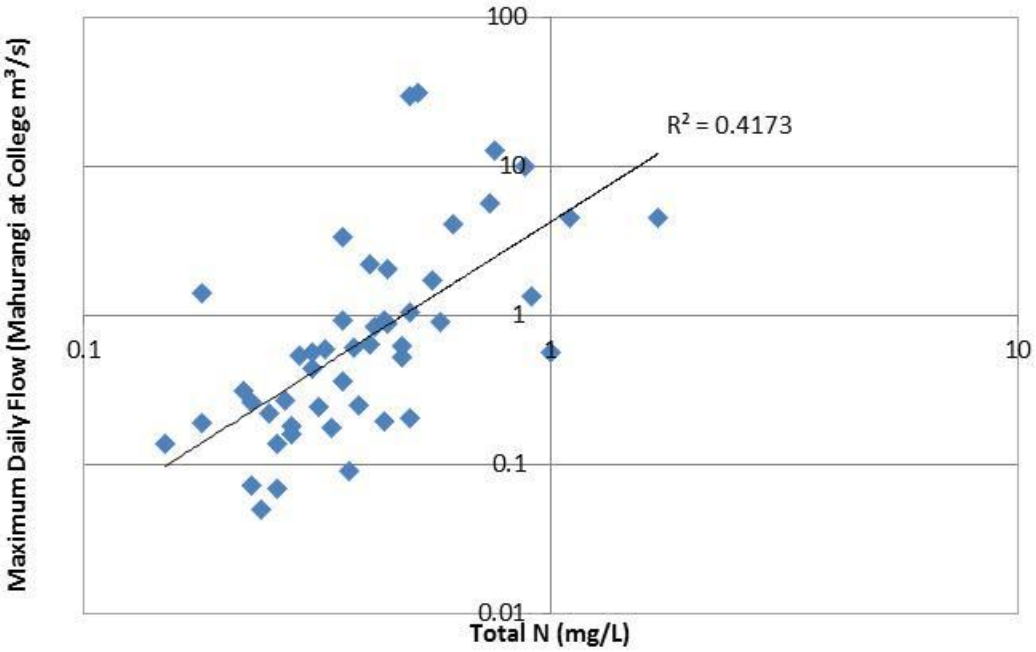


Figure 23 Total nitrogen relationship to flow in the Mahurangi River at the WTP site

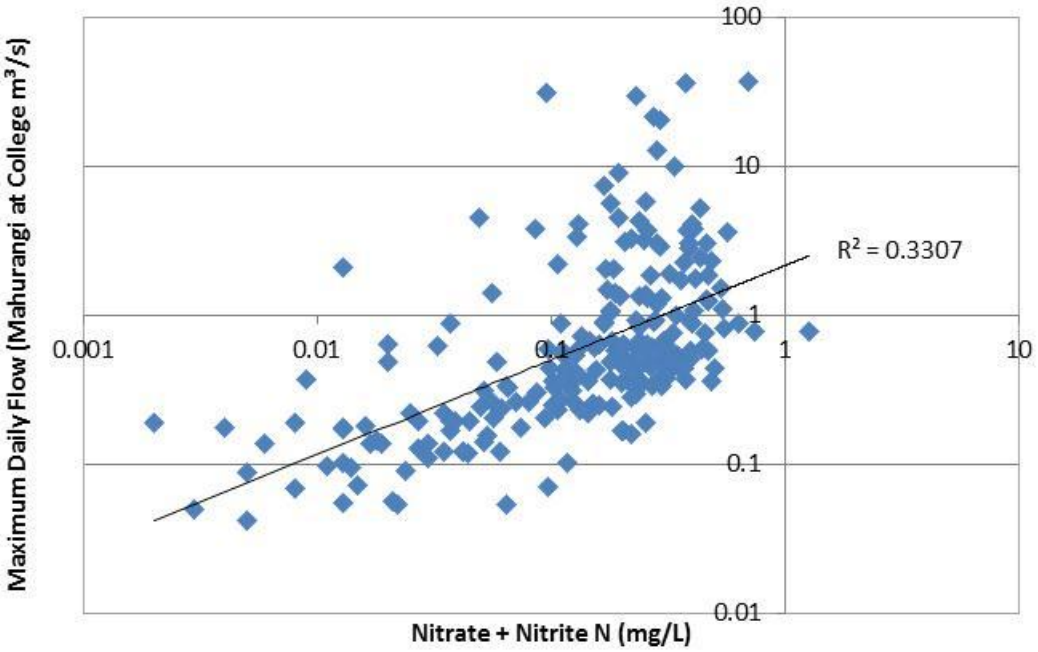


Figure 24 Nitrate/nitrite – N relationship to flow in the Mahurangi River at the WTP site

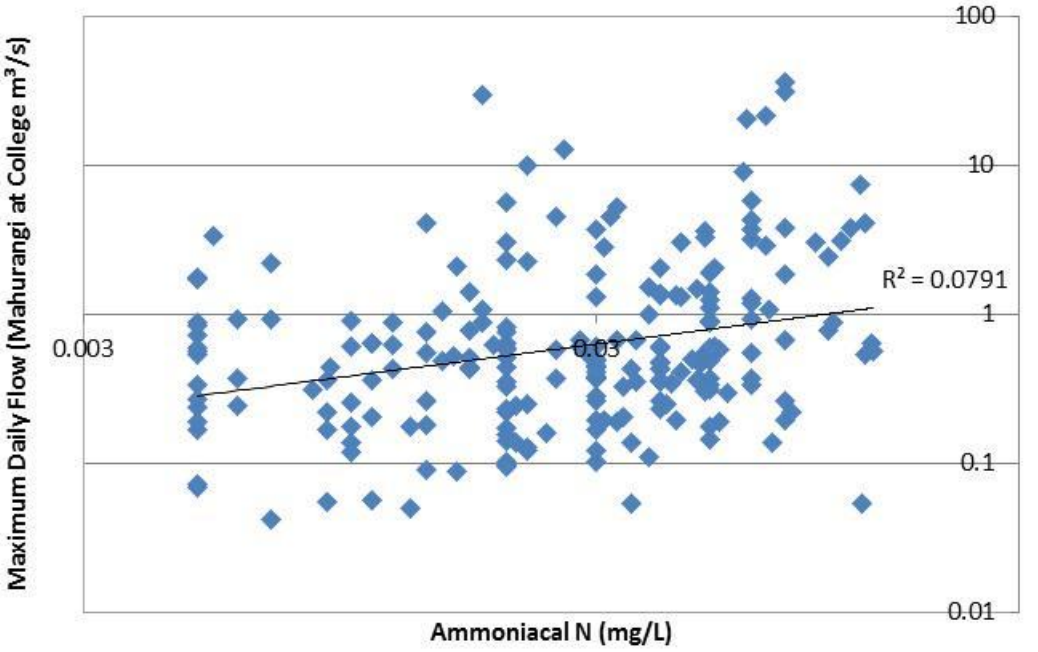


Figure 25 Total ammoniacal nitrogen relationship to flow in the Mahurangi River at the WTP site

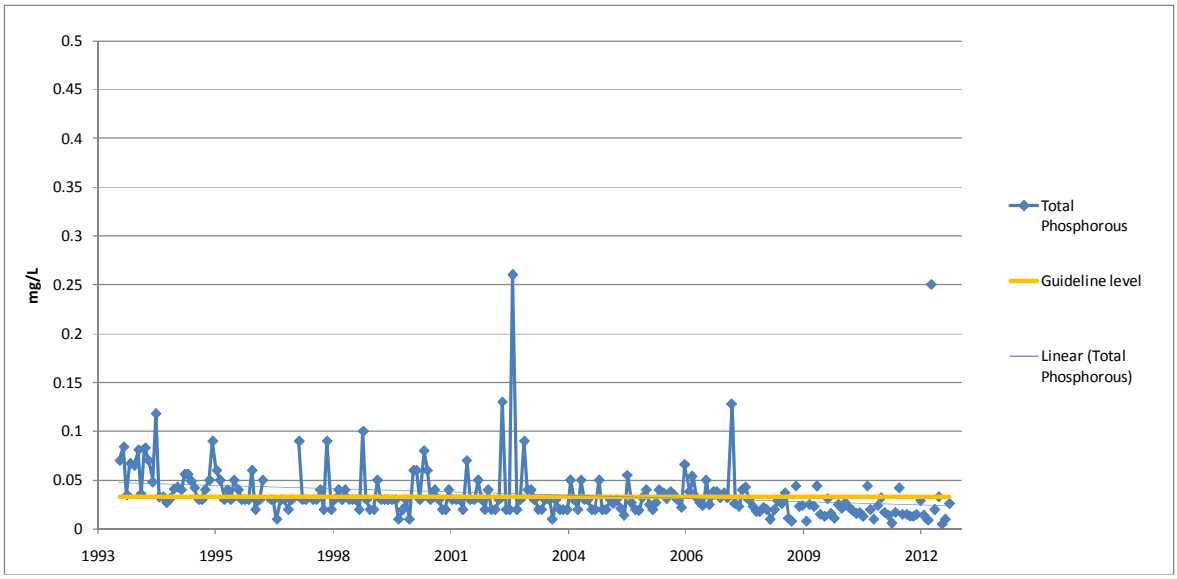


Figure 26 Total phosphorous in the Mahurangi River at the FHQ site

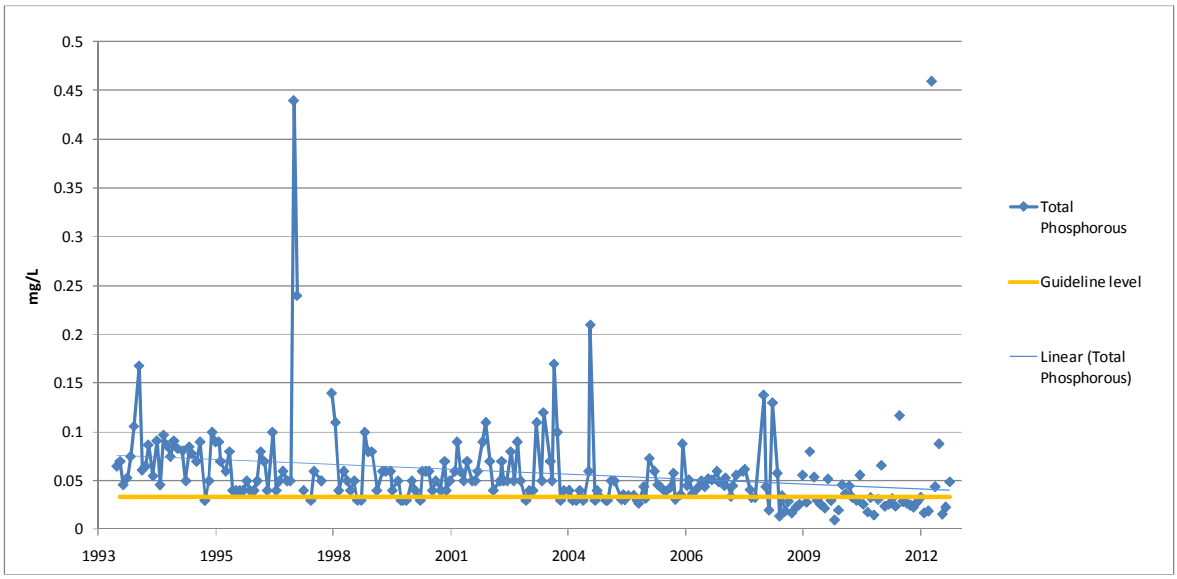


Figure 27 Total phosphorous in the Mahurangi River at the WTP site

Appendix C. Auckland Council saline water quality data

Table 14 Summary of existing Auckland Council saline water quality data for the Mahurangi Estuary at Dawson's Creek

Parameter (mg/L unless stated)	Date Range	Count	Mean	Median	St Dev	Min	Max
Dissolved Oxygen (%)	1993-2013	362	87.16	87	8.14	46	111
Dissolved Oxygen	1993-2013	319	7.15	7.1	0.99	3.4	10.1
Salinity	1993-2013	365	31.45	32	3.61	4.7	38
Conductivity (mS/cm)	2004-2013	121	49.37	49.94	5.02	12	57.78
Temp (°C)	1998-2013	249	17.56	17.5	3.78	9.7	25.4
pH (pH units)	1993-2013	336	8.04	8.1	0.13	7.1	8.2
Biochemical oxygen demand	1993-2005	277	2	2	0.16	0.4	3
Enterococci (cfu/100mL)	1993-2013	366	58.2	2	504.65	2	8700
Total suspended solids	1993-2013	365	14.92	12	11.42	1.1	123
Turbidity (NTU)	1993-2013	367	6.54	5.34	7.51	0.3	116
Black Disc Clarity (m)	1993-2003	93	0.65	0.6	0.25	0.1	1.4
Transparency -secchi disc (m)	1995-2005	85	0.88	0.9	0.31	0.1	2.4
Total Phosphorous	1993-2013	367	0.044	0.04	0.042	0.006	0.49
Soluble reactive phosphorous	1993-2013	367	0.018	0.02	0.0071	0.004	0.04
Total nitrogen	2009-2013	48	0.079	0.06	0.066	0.02	0.36
Ammonia as N (NH_3 + NH_4)	1993-2013	361	0.017	0.01	0.02	0.003	0.21
Nitrate nitrogen	1993-2013	358	0.019	0.0085	0.034	0	0.331
Nitrite nitrogen	1993-2013	262	0.0028	0.002	0.0018	0.001	0.014
Nitrate and nitrite nitrogen	1993-2013	370	0.021	0.011	0.035	0.34	0.002
Total Kjeldahl Nitrogen	2007-2012	65	0.13	0.074	0.14	0.001	0.63
Chlorophyll	1999-2013	228	0.0031	0.0028	0.0016	0.0006	0.0091

Note: Grey shading indicates mean or median value is greater than the lower of the guideline values in Table 4. The estuarine aquatic ecosystem guidelines have been used at this site.

Table 15 Summary of existing Auckland Council saline water quality data for the Mahurangi Estuary at Mahurangi Heads

Parameter (mg/L unless stated)	Date Range	Count	Mean	Median	St Dev	Min	Max
Dissolved Oxygen (%)	1991-2013	298	93.7	94	8.56	57	126
Dissolved Oxygen	1991-2013	208	7.4	7.36	0.78	4.2	9.2
Salinity	1991-2013	317	33.58	34	2.69	14.7	39
Conductivity (mS/cm)	2004-2013	120	51.71	52.26	2.73	34.8	55
Temp (°C)	1991-2013	323	17.32	17.1	3.15	12	24
pH (pH units)	1991-2013	288	8.14	8.2	0.14	7.4	8.4
Biochemical oxygen demand	1991-2005	228	1.93	2	0.34	0.1	3.1
Enterococci (cfu/100mL)	1998-2013	246	57.27	2	562.41	0	6500
Total suspended solids	1991-2013	374	5.4	3.95	6.42	0.4	82
Turbidity (NTU)	1991-2013	376	1.65	1.2	3.24	0.2	52.4
Black Disc Clarity (m)	Not sampled						
Transparency -secchi disc (m)	1991-2005	136	2.96	2.95	1.03	0.8	6
Total Phosphorous	1991-2013	321	0.028	0.03	0.01	0.005	0.138
Soluble reactive phosphorous	1991-2013	321	0.016	0.014	0.0072	0.002	0.05
Total nitrogen	2009-2013	48	0.035	0.02	0.04	0.02	0.27
Ammonia as N (NH_3 + NH_4)	1991-2013	313	0.015	0.01	0.025	0.001	0.26
Nitrate nitrogen	1991-2013	302	0.012	0.006	0.020	0	0.201
Nitrite nitrogen	2005-2013	141	0.0025	0.002	0.0013	0.002	0.01
Nitrate and nitrite nitrogen	1998-2013	247	0.014	0.008	0.022	0.002	0.211
Total Kjeldahl Nitrogen	209-2013	65	0.093	0.02	0.12	0.004	0.38
Chlorophyll	1998-2013	244	0.0019	0.0016	0.0019	0.0004	0.024

Note: Grey shading indicates mean or median value is greater than the lower of the guideline values in Table 4. The estuarine aquatic ecosystem guidelines have been used at this site.

C.1 Auckland Council saline water quality data analysis

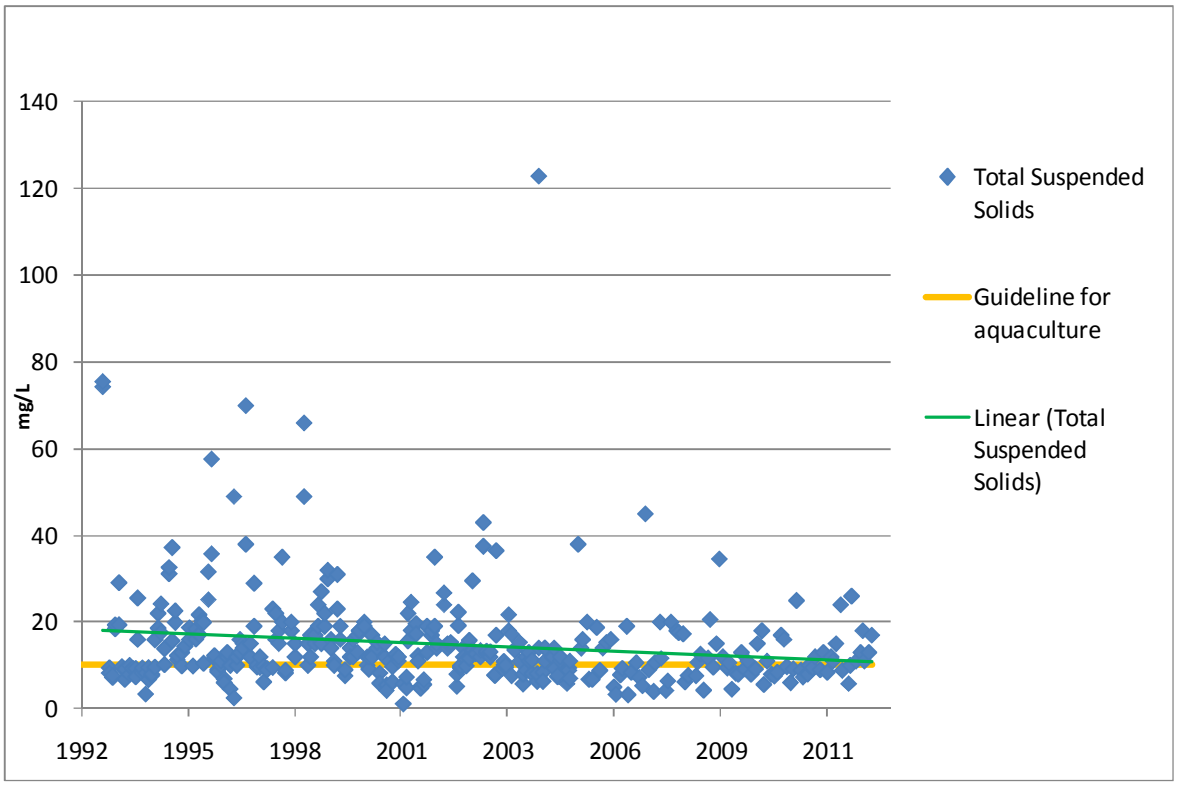


Figure 28 Total suspended solids at Dawson's Creek

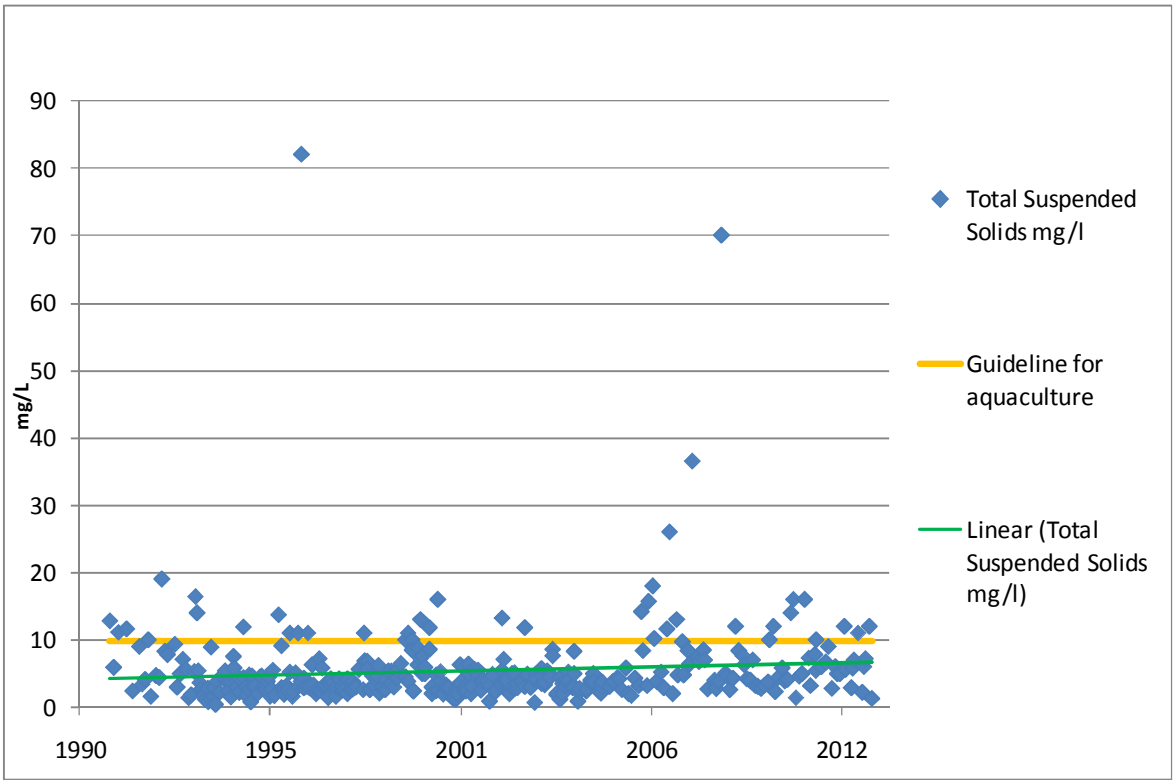


Figure 29 Total suspended solids and Mahurangi Heads

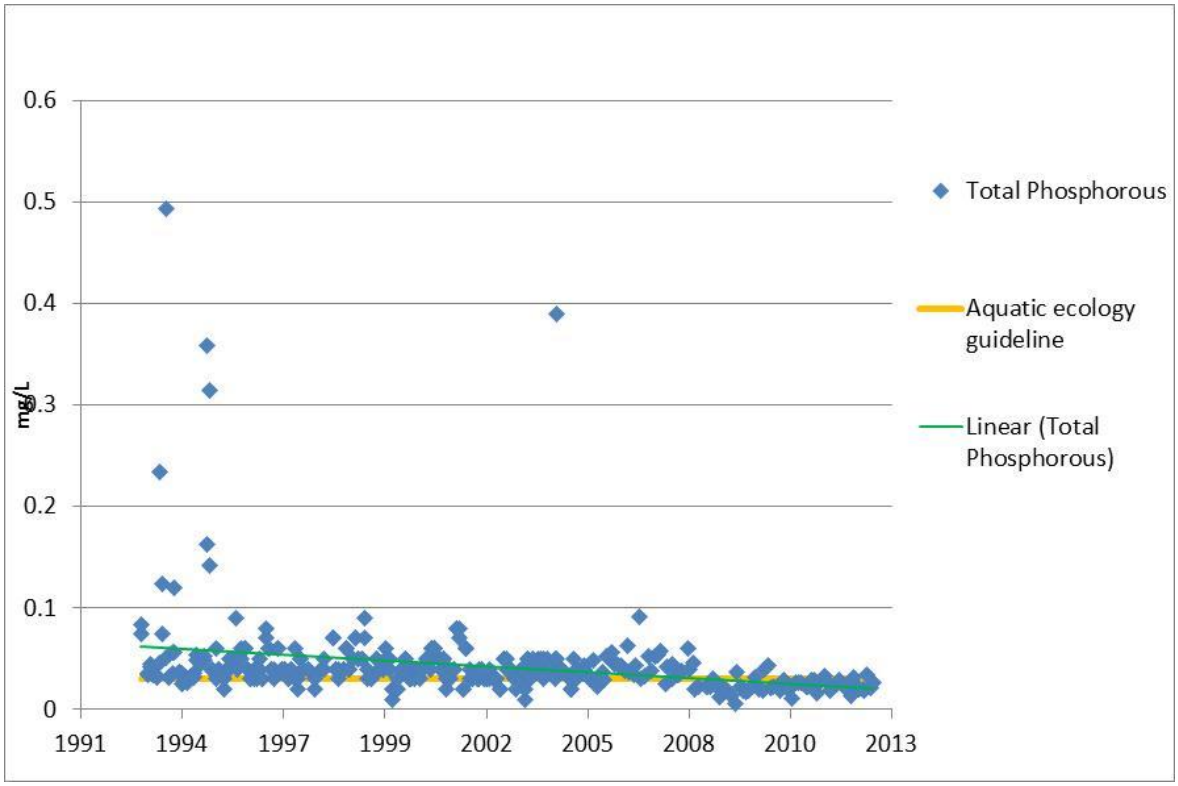


Figure 30 Total phosphorous at Dawson's Creek

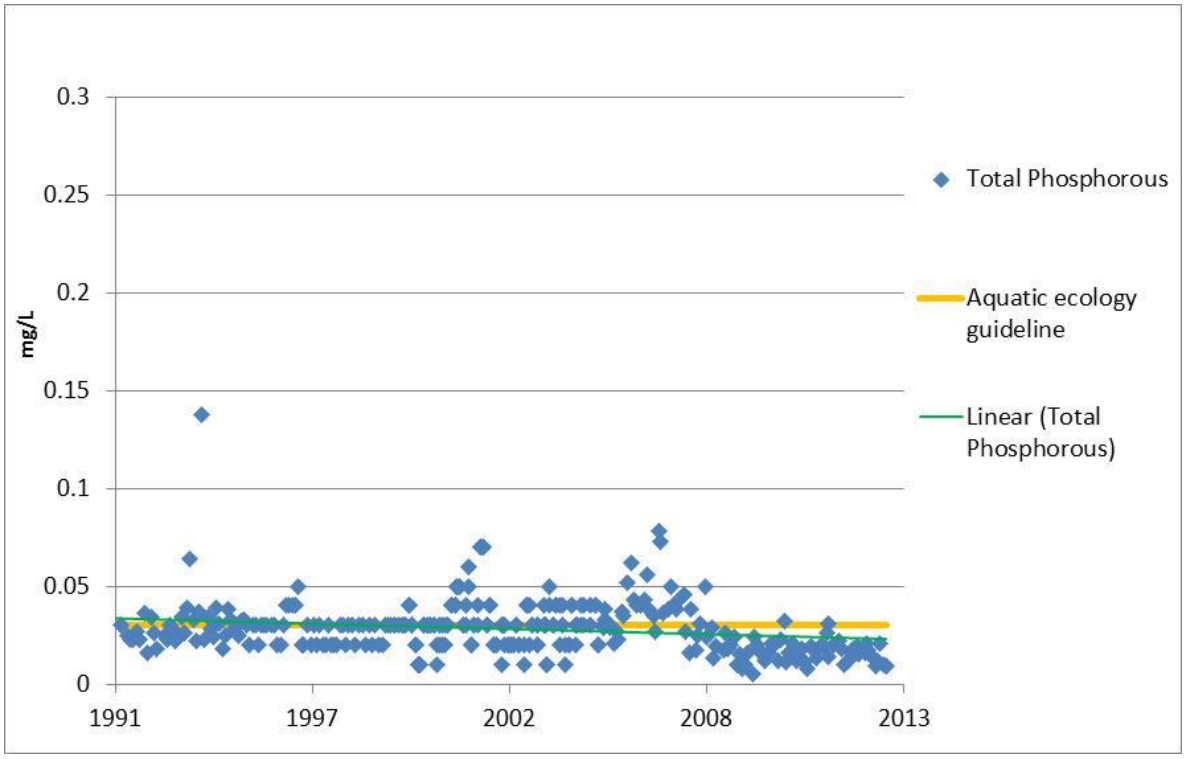


Figure 31 Total phosphorous at Mahurangi Heads

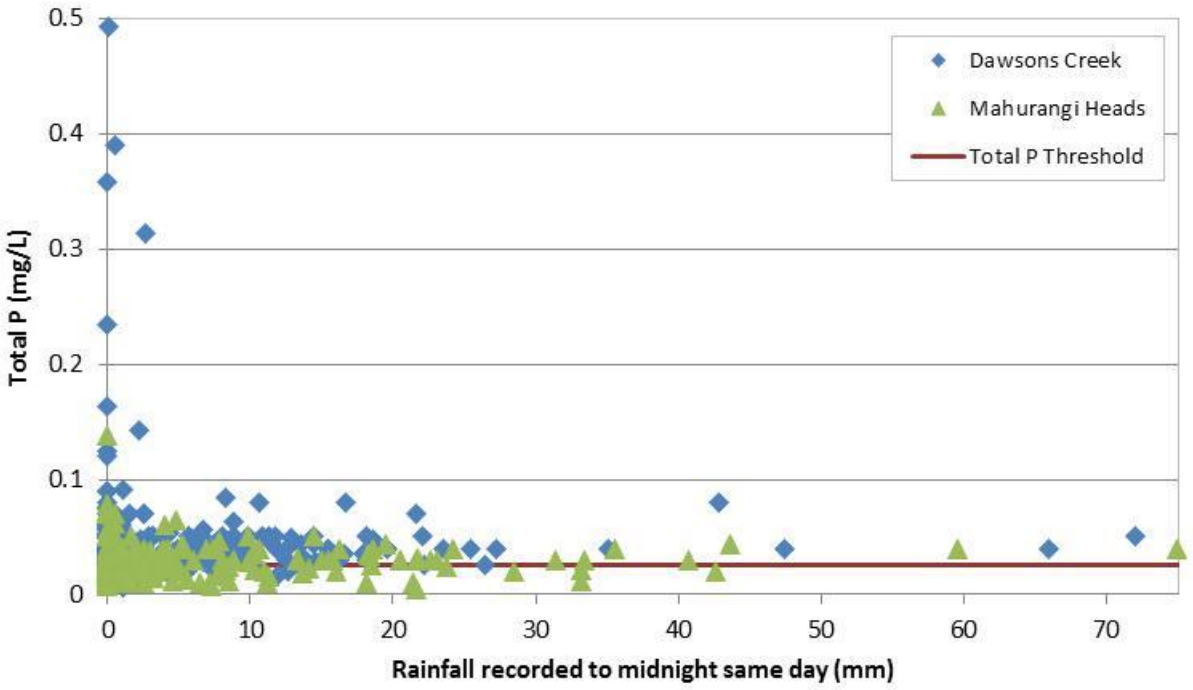


Figure 32 Relationship of total phosphorous concentrations in the Mahurangi Estuary with rainfall

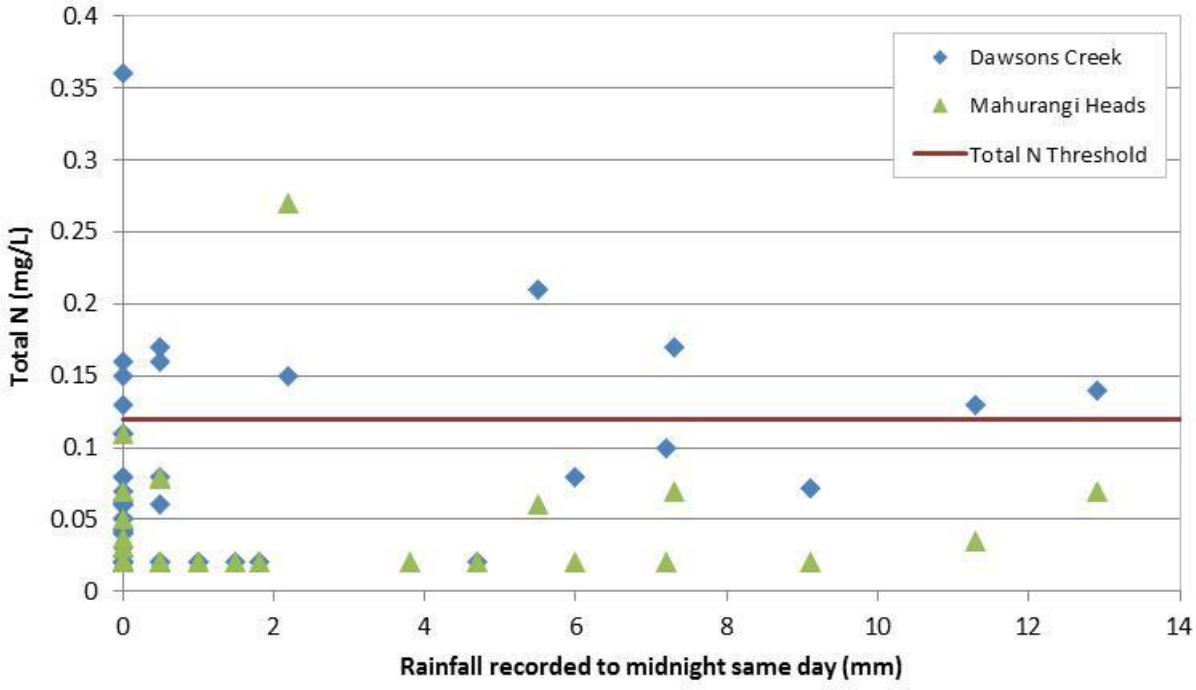


Figure 33 Relationship of total nitrogen concentrations in the Mahurangi Estuary with rainfall

Appendix D. Project specific monitoring data

Table 16 Dry weather monitoring sampling data 09/04/2013 till 11/04/2013

Parameter (mg/L unless stated)	PL	P9	P10	P11	M16	M19	M19 (duplicate)	M22	M24	MW	AC-FHQ	AC-WTP	QC-B
Date	9/04/13	9/04/13	9/04/13	9/04/13	11/04/13	10/04/13	10/04/13	10/04/13	10/04/13	10/04/13	11/04/13	11/04/13	10/04/13
Time	9:55	11:45	12:50	14:05	9:55	13:45	13:50	11:00	10:00	1:10	12:15	11:15	
Colour (Hazen units)	20	125	15	20	20	30	30	5	15	15	40	10	<5
Turbidity (NTU)	2.1	18.7	2.8	2.6	2.1	3.2	3.4	1.8	2.7	1.71	4.6	1.55	0.18
pH (pH units)	7.5	7.3	7.5	7.4	7.6	6.7	7.2	6.8	7.4	7.3	7.5	7.4	6.3
Hardness	66	81	64	54	56	58	55	40	74	65	56	76	<1
Conductivity (mS/m)	27.4	27.1	27.5	21.7	20.4	20.2	20.7	16.8	24.7	25.1	20.2	25.8	0.2
TSS	< 3	4	< 3	< 3	<3	<3	< 3	< 3	< 3	< 3	<3	<3	<3
Calcium (dissolved)	15.4	17.3	15.4	11.8	11.1	12.9	12.1	10.4	17.9	15.3	11.1	18	<0.05
Copper (dissolved)	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.0012
Copper (total)	< 0.00053	< 0.00053	< 0.00053	< 0.00053	< 0.00053	< 0.00053	< 0.00053	< 0.00053	< 0.00053	< 0.00053	< 0.00053	< 0.00053	0.00126
Lead (dissolved)	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	<0.00010
Lead (total)	< 0.00011	< 0.00011	< 0.00011	< 0.00011	< 0.00011	< 0.00011	< 0.00011	< 0.00011	< 0.00011	< 0.00011	< 0.00011	< 0.00011	0.00024

Parameter (mg/L unless stated)	PL	P9	P10	P11	M16	M19	M19 (duplicate)	M22	M24	MW	AC-FHQ	AC-WTP	QC-B
Magnesium (dissolved)	6.6	9.3	6.2	5.9	6.8	6.2	6	3.4	7.1	6.6	6.8	7.5	<0.02
Zinc (dissolved)	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0011	< 0.0010	< 0.0010	0.013
Zinc (total)	< 0.0011	< 0.0011	< 0.0011	< 0.0011	< 0.0011	< 0.0011	0.0013	< 0.0011	< 0.0011	< 0.0011	< 0.0011	< 0.0011	0.0139
Total Nitrogen	0.17	0.43	0.15	0.11	<0.11	0.22	0.16	0.18	0.25	0.18	0.25	0.11	<0.11
Total Ammoniacal-N	< 0.010	0.043	< 0.010	< 0.010	0.013	< 0.010	< 0.010	< 0.010	< 0.010	0.014	0.08	< 0.010	<0.010
Nitrite-N	< 0.002	0.005	< 0.002	< 0.002	< 0.002	< 0.002	0.002	< 0.002	< 0.002	< 0.002	0.01	< 0.002	<0.002
Nitrate-N	0.007	0.138	< 0.002	0.009	0.009	0.042	0.044	0.005	0.025	0.002	0.093	0.002	<0.002
Nitrate-N + Nitrite-N	0.009	0.143	0.003	0.01	0.01	0.044	0.046	0.005	0.027	0.003	0.102	0.003	<0.002
TKN	0.16	0.29	0.14	< 0.10	<0.1	0.18	0.11	0.17	0.22	0.18	0.15	0.11	<0.10
DRP	0.004	0.006	0.005	< 0.004	0.004	0.006	0.008	<0.004	0.013	0.008	0.008	< 0.004	0.014
Total Phosphorus	0.014	0.032	0.014	0.01	0.011	0.011	0.01	0.004	0.021	0.027	0.013	0.007	0.013
PAH's[A]	All results below detection limits												
TPH[B]	All results below detection limits												
Ecoli - (fcu/100mL)	99	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s

Parameter (mg/L unless stated)	PL	P9	P10	P11	M16	M19	M19 (duplicate)	M22	M24	MW	AC-FHQ	AC-WTP	QC-B
Average velocity (m/s)	0.09	0	0.05	0	0.016	0	0	0	0	0.05	0.2	0.05	n/a
Rainfall conditions	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
Flow (m3/s)	0.01	No measurable flow	0.02	No measurable flow	Very slow observable flow	No measurable flow		No measurable flow	No measurable flow	Too deep for flow measurements	0.01	No measurable flow	
Temp (°C)	11.9	11.6	13.4	13.4	11.8	12.2		12.7	12.2	14.3	13.4	16.0	
DO (%)	88	67	74	96	98	54		73	67	93	102	68	
DO	9.5	7.4	7.7	10.0	10.6	5.8		7.8	7.1	9.5	10.7	6.7	
Clarity (m)	0.85	0.49	0.75	0.78	0.80	0.73		0.83	0.75	0.67	0.78	0.81	

Note: Grey shading indicates mean or median value is greater than the lower of the guideline values in Table 3.

[A]PAH's 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.

[B]TPH's analysed were as follows; C7 - C9, C10 - C11, C12 - C14, C15 - C20, C21 - C25, C26 - C29,C30 - C44,Total hydrocarbons (C7 - C44), all results were below detection limits.

Table 17 Dry weather monitoring sampling data 14/05/2013 to 15/05/2013

Parameter (mg/L unless stated)	PL	P9	P10	P11	M16	M19	M22	M24	MW	AC-FHQ	AC-WTP	P10 (Duplicate)	QC-B
Date	14-May-13	14-May-13	14-May-13	14-May-13	15-May-13	15-May-13	15-May-13	15-May-13	14-May-13	14-May-13	14-May-13	14-May-13	15-May-13
Time	9:30	10:45	11:30	12:30	10:45	9:40	12:30	11:45	14:40	13:30	14:10	11:35	-
Colour (Hazen units)	30	30	20	20	30	15	15	20	30	20	30	20	< 5
Turbidity (NTU)	4.8	10.1	4.4	3.7	5.6	4.2	3	5.2	7.7	6.7	8.2	4.4	0.18
pH (pH units)	7	6.9	6.9	6.9	6.7	6.8	6.6	6.8	7	7	7	7	5.9
Conductivity (mS/m)	17.4	21	16.9	15.6	15.9	14.8	14.5	19.1	16.2	16.9	17.6	17	0.2
TSS	< 3	4	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	3	< 3	< 3
Copper (dissolved)	0.0006	0.0007	0.0006	< 0.0005	< 0.0005	0.0005	< 0.0005	0.0014	0.001	< 0.0005	0.0011	0.0006	< 0.0005
Copper (total)	0.00071	0.001	0.00074	0.00053	< 0.00053	< 0.00053	< 0.00053	0.00123	0.00109	0.00059	0.00135	0.00073	0.0028
Lead (dissolved)	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Lead (total)	< 0.00011	< 0.00011	< 0.00011	< 0.00011	< 0.00011	< 0.00011	< 0.00011	< 0.00011	< 0.00011	< 0.00011	0.00013	< 0.00011	0.00023
Zinc (dissolved)	0.001	< 0.0010	0.0032	0.001	0.001	0.0013	0.0033	0.0056	0.0016	< 0.0010	0.0022	0.0034	< 0.0010
Zinc (total)	0.0019	0.0016	0.0075	0.0018	< 0.0011	0.0027	0.0028	0.0062	0.0028	< 0.0011	0.0049	0.0044	0.0126

Parameter (mg/L unless stated)	PL	P9	P10	P11	M16	M19	M22	M24	MW	AC-FHQ	AC-WTP	P10 (Duplicate)	QC-B
Total Nitrogen	0.27	0.27	0.29	0.18	0.32	0.3	0.45	0.38	0.46	0.28	0.58	0.27	< 0.11
Total Ammoniacal-N	0.014	0.041	0.021	0.016	< 0.010	0.014	< 0.010	0.016	0.013	0.041	0.023	0.022	< 0.010
Nitrite-N	< 0.002	0.003	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	0.003	0.003	0.003	< 0.002	< 0.002
Nitrate-N	0.104	0.07	0.113	0.154	0.115	0.115	0.171	0.146	0.24	0.135	0.31	0.117	< 0.002
Nitrate-N + Nitrite-N	0.105	0.073	0.114	0.155	0.117	0.116	0.172	0.148	0.24	0.137	0.31	0.118	< 0.002
TKN	0.17	0.2	0.18	< 0.10	0.21	0.19	0.28	0.23	0.22	0.15	0.27	0.15	< 0.10
DRP	0.005	0.005	0.01	< 0.004	< 0.004	< 0.004	< 0.004	0.012	0.005	0.022	0.01	0.004	0.027
Total Phosphorus	0.016	0.03	0.036	0.006	0.008	0.008	0.006	0.022	0.023	0.014	0.052	0.017	0.034
PAH's[A]	All results below detection limits												
TPH[B]	All results except C15-C20 at QC-B below detection limits. Result 0.1												
Ecoli - (fcu/100mL)	210	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s
Average velocity (m/s)	0.36	0.02	0.07	0.10	0.11	0.03	Very slow flow	0.08	Too deep for survey	0.22	Too deep for survey		
Rainfall conditions	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
Flow (m3/s)	0.20	0.01	0.06	0.19	0.04	0.04	0.00	0.08	Too deep	0.03	Too deep		

Parameter (mg/L unless stated)	PL	P9	P10	P11	M16	M19	M22	M24	MW	AC-FHQ	AC-WTP	P10 (Duplicate)	QC-B
									for survey		for survey		
Temp (°C)	11.1	9.7	11.5	10.4	11.1	11.0	11.7	12.8	11.9	12.2	12.3	11.1	9.7
DO (%)	101	95	100	102	105	101	84	81	89	108	109	101	95
DO	11.1	10.8	10.8	11.4	11.6	11.3	9.1	8.6	9.6	11.5	11.7	11.1	10.8
Clarity (m)	0.80	0.68	0.79	0.86	0.81	0.82	0.79	0.84	0.75	0.77	0.71	0.80	0.68

Note: Grey shading indicates mean or median value is greater than the lower of the guideline values in Table 3.

[A]PAH's 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.

[B]TPH's analysed were as follows; C7 - C9, C10 - C11, C12 - C14, C15 - C20, C21 - C25, C26 - C29,C30 - C44,Total hydrocarbons (C7 - C44), all results were below detection limits.

Table 18 Wet weather monitoring sampling data 08/05/2013

Parameter (mg/L unless stated)	PL	P9	P10	P11	M16	M19	M22	M24	MW	AC-FHQ	AC-WTP	AC-WTP (Duplicate)
Date	8/05/2013	8/05/2013	8/05/2013	8/05/2013	8/05/2013	8/05/2013	8/05/2013	8/05/2013	8/05/2013	8/05/2013	8/05/2013	8/05/2013
Time	9:40	10:45	11:20	13:45	11:15	10:30	13:00	12:15	13:45	9:45	14:20	14:25
Colour (Hazen units)	40	100	50	50	60	15	20	40	40	40	60	60
Turbidity (NTU)	25	23	17.4	13.7	13.2	7.3	5	7.7	18.8	13.1	23	22
pH (pH units)	7.2	7	7	7	7	7	7.1	7.1	7.2	6.8	7.2	7.3
Conductivity (mS/m)	16.6	20.1	16.7	15.7	15.4	15.2	16.1	20.9	16.3	16.8	19.5	19.5
TSS	11	12	6	7	6	4	4	5	13	7	11	10
Copper (dissolved)	0.0015	0.0019	0.002	0.0014	0.0014	0.0008	0.001	0.0013	0.0015	0.0013	0.0016	0.0017
Copper (total)	0.00196	0.0023	0.00153	0.00136	0.00121	0.00084	0.0009	0.00171	0.00159	0.0012	0.0021	0.0021
Lead (dissolved)	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	0.00011	< 0.00010	< 0.00010	< 0.00010
Lead (total)	0.00021	0.00024	0.00015	0.0013	< 0.00011	< 0.00011	< 0.00011	0.00012	0.00042	< 0.00011	0.00027	0.00029
Zinc (dissolved)	0.004	0.0035	0.006	0.0027	0.0027	0.0034	0.0055	0.0069	0.004	0.0022	0.0033	0.0041
Zinc (total)	0.0049	0.003	0.0066	0.0025	0.0017	0.0017	0.005	0.0081	0.0041	< 0.0011	0.0054	0.0052

Parameter (mg/L unless stated)	PL	P9	P10	P11	M16	M19	M22	M24	MW	AC-FHQ	AC-WTP	AC-WTP (Duplicate)
Total Nitrogen	0.79	0.52	0.72	0.68	0.43	0.41	0.6	0.64	0.84	0.43	1.01	0.97
Total Ammoniacal-N	<0.01	0.015	0.013	<0.010	< 0.010	0.021	< 0.010	0.014	0.014	0.038	<0.01	<0.01
Nitrite-N	0.004	0.004	0.004	0.003	0.002	< 0.002	< 0.002	0.003	0.005	0.004	0.005	0.005
Nitrate-N	0.4	0.087	0.43	0.34	0.132	0.17	0.29	0.28	0.38	0.153	0.54	0.55
Nitrate-N + Nitrite-N	0.41	0.091	0.44	0.34	0.134	0.172	0.29	0.29	0.39	0.157	0.54	0.55
TKN	0.38	0.43	0.28	0.34	0.3	0.24	0.3	0.36	0.46	0.28	0.47	0.42
DRP	0.004	0.004	<0.004	<0.004	< 0.004	< 0.004	< 0.004	0.012	0.006	< 0.004	0.007	0.009
Total Phosphorus	0.038	0.034	0.028	0.021	0.032	0.052	0.014	0.032	0.034	0.022	0.04	0.046
PAH's[A]	All results below detection limits											
TPH[B]	All results except C15-C20 at M-FHQ below detection limits. Result 0.17.											
Ecoli - (fcu/100mL)	1200	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s
Average velocity (m/s)	0.47	0.06	0.16	0.08	0.12	0.04	0.08	0.10	Too deep for survey	0.13	Too deep for survey	
Rainfall conditions	wet	wet	wet	wet	wet	wet	wet	wet	wet	wet	wet	wet
Flow (m3/s)	0.30	0.03	0.19	0.20	0.05	0.06	0.09	0.11	Too deep	0.02	Too deep	

Parameter (mg/L unless stated)	PL	P9	P10	P11	M16	M19	M22	M24	MW	AC-FHQ	AC-WTP	AC-WTP (Duplicate)
									for survey		for survey	
Temp (°C)	13.6	13.0	13.9	13.9	12.3	13.0	13.1	14.7	14.0	13.9	14.5	13.6
DO (%)	99	92	94	97	97	102	86	79	89	94	103	99
DO	10.3	9.7	9.7	10.0	10.3	10.7	9.0	8.0	9.2	9.7	10.5	10.3
Clarity (m)	0.34	0.38	0.51	0.62	0.63	0.55	0.70	0.76	0.66	0.44	0.35	0.34

Note: Grey shading indicates mean or median value is greater than the lower of the guideline values in Table 3.

[A]PAH's 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.

[B]TPH's analysed were as follows; C7 - C9, C10 - C11, C12 - C14, C15 - C20, C21 - C25, C26 - C29,C30 - C44,Total hydrocarbons (C7 - C44), all results were below detection limits.

Table 19 Wet weather monitoring sampling data 20/05/2013 to 21/05/2013

Parameter (mg/L unless stated)	PL	P9	P10	P11	M16	M19	M22	M24	MW	AC-FHQ	AC-WTP	M24 (Duplicate)
Date	20/05/2013	20/05/2013	20/05/2013	20/05/2013	21/05/2013	21/05/2013	20/05/2013	20/05/2013	21/05/2013	20/05/2013	21/05/2013	20/05/2013
Time	9:45	10:45	11:30	12:20	10:15	9:20	15:00	14:15	11:30	13:20	12:15	14:20
Colour (Hazen units)	40	50	30	30	35	18	20	40	45	40	45	40
Turbidity (NTU)	9.4	13	7.3	6.5	9.4	5.8	4.9	8.7	11.8	11.2	11.8	9.2
pH (pH units)	7.1	7	7.1	7.1	7	7.2	6.9	6.7	7.6	7.1	7	6.8
Conductivity (mS/m)	16.7	20.2	16.3	15.5	15.5	14.4	14	17.5	16	16.3	17.2	17.5
TSS	3	5	< 3	< 3	< 3	3	< 3	5	< 3	< 3	3	5
Copper (dissolved)	0.0018	0.0013	0.0008	0.0006	0.0009	0.0007	0.0006	0.0015	0.0014	0.0008	0.0017	0.0016
Copper (total)	0.00113	0.00158	0.00092	0.00069	0.00118	0.00084	0.00068	0.00189	0.00144	0.00092	0.0018	0.00178
Lead (dissolved)	0.0002	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Lead (total)	< 0.00011	0.00016	< 0.00011	< 0.00011	0.00011	< 0.00011	< 0.00011	0.00015	0.00015	< 0.00011	0.00016	0.00015
Zinc (dissolved)	0.0025	0.002	0.0032	0.0018	0.0015	0.0021	0.003	0.0057	0.0025	0.0016	0.0038	0.0053
Zinc (total)	0.0022	0.0023	0.0032	0.0016	0.0023	0.0022	0.0027	0.0073	0.0036	0.0014	0.006	0.0066

Parameter (mg/L unless stated)	PL	P9	P10	P11	M16	M19	M22	M24	MW	AC-FHQ	AC-WTP	M24 (Duplicate)
Total Nitrogen	0.33	0.28	0.35	0.38	0.27	0.21	0.46	0.57	0.53	0.33	0.6	0.55
Total Ammoniacal-N	0.012	0.02	0.017	0.014	<0.01	0.011	0.011	0.016	0.012	0.022	<0.01	0.012
Nitrite-N	0.002	0.002	< 0.002	< 0.002	<0.002	<0.002	< 0.002	0.003	0.003	0.003	0.003	0.002
Nitrate-N	0.12	0.047	0.142	0.162	0.102	0.102	0.25	0.193	0.23	0.117	0.27	0.193
Nitrate-N + Nitrite-N	0.122	0.049	0.144	0.164	0.104	0.103	0.25	0.195	0.23	0.12	0.27	0.196
TKN	0.21	0.24	0.21	0.22	0.16	0.11	0.21	0.37	0.29	0.21	0.33	0.35
DRP	0.006	< 0.004	0.004	< 0.004	<0.004	<0.004	< 0.004	0.012	0.004	< 0.004	0.008	0.012
Total Phosphorus	0.031	0.026	0.021	0.015	0.016	0.011	0.012	0.035	0.027	0.018	0.032	0.035
PAH's[A]	All results below detection limits											
TPH[B]	All results below detection limits											
Ecoli - (fcu/100mL)	180	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s
Average velocity (m/s)	0.34	0.02	0.08	0.06	0.19	0.01	0.05	0.18	Too deep for survey	0.26	Too deep for survey	
Rainfall	wet	wet	wet	wet	wet	wet	wet	wet	wet	wet	wet	wet

Parameter (mg/L unless stated)	PL	P9	P10	P11	M16	M19	M22	M24	MW	AC-FHQ	AC-WTP	M24 (Duplicate)
conditions												
Flow (m3/s)	0.09	0.01	0.08	0.14	0.09	0.02	0.05	0.29	Too deep for survey	0.04	Too deep for survey	
Temp (°C)	13.5	11.9	13.6	12.8	13.3	13.0	13.2	15.0	14.5	14.0	14.3	13.5
DO (%)	98	91	90	95	93	97	81	80	87	92	96	98
DO	10.2	9.8	9.4	10.1	9.8	10.3	8.5	8.2	8.9	9.6	9.8	10.2
Clarity (m)	0.77	0.53	0.71	0.73	0.68	0.79	0.84	0.81	0.66	0.65	0.60	0.77

Note: Grey shading indicates mean or median value is greater than the lower of the guideline values in Table 3.

[A]PAH's 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.

[B]TPH's analysed were as follows; C7 - C9, C10 - C11, C12 - C14, C15 - C20, C21 - C25, C26 - C29,C30 - C44,Total hydrocarbons (C7 - C44), all results were below detection limits.

Table 20 Wet weather monitoring sampling data – saline data from river mouths

Parameter (mg/L unless stated)	Pūhoi Mouth				Mahurangi Mouth			
Date	17/03/13	17/03/13	17/03/13	17/03/13	17/03/13	17/03/13	17/03/13	17/03/13
Time	14:30	15:30	16:30	17:30	14:00	15:00	16:00	17:00
Turbidity (NTU)	5.31	6.66	6.97	6.96	6.44	5.60	4.87	6.6
pH (pH units)	7.4	7.34	7.41	7.49	7.4	7.4	7.53	7.6
Conductivity (mS/m)	42.39	39.41	36.9	34.6	42.65	46.72	41.49	52.25
TSS	12	24	30	16	8	9	10	19
Copper (dissolved)	< 0.0010	< 0.0010	< 0.0010	< 0.0010	0.0019	0.0018	0.0029	0.0022
Copper (total)	< 0.0011	< 0.0011	< 0.0011	< 0.0011	0.0021	0.0019	0.0027	0.0019
Lead (dissolved)	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Lead (total)	0.0034	0.0037	0.0032	0.0033	0.0034	0.0038	0.0034	0.0039
Zinc (dissolved)	< 0.004	< 0.004	< 0.004	< 0.004	0.011	0.009	0.015	0.011
Zinc (total)	< 0.0042	< 0.0042	< 0.0042	< 0.0042	0.0125	0.0122	0.0192	0.0107
Total Nitrogen	0.3	0.3	0.3	0.3	0.5	0.4	0.5	0.5
Total Ammoniacal-N	0.05	0.077	0.102	0.12	0.064	0.049	0.055	0.063
Nitrite-N	0.004	0.004	0.005	0.006	0.006	0.006	0.006	0.007
Nitrate-N	0.023	0.031	0.04	0.042	0.105	0.123	0.122	0.114
Nitrate-N + Nitrite-N	0.027	0.035	0.044	0.048	0.111	0.129	0.129	0.12
TKN	0.2	0.3	0.3	0.3	0.4	0.3	0.3	0.4
DRP	0.006	0.005	0.004	0.004	0.027	0.028	0.029	0.029
Total Phosphorus	0.035	0.045	0.045	0.027	0.057	0.08	0.065	0.07
PAH's[A]	All results below detection limits							
TPH[B]	All results below detection limits							
Enterococci - (fcu/100mL)	190	500	380	400	4,500	3,400	3,900	1,200
Average velocity (m/s)								
Flow conditions	wet	wet	wet	wet	wet	wet	wet	wet

Parameter (mg/L unless stated)	Pūhoi Mouth				Mahurangi Mouth			
Temp (°C)	21.5	21.6	22.2	22.5	22.6	23.7	27.4	23.6
DO (%)	74.2	72.8	70.5	69	68.7	72.2	89.7	79.7
Observations	Sticks and debris, no scum				No scum, little debris		No scum	

Note: Grey shading indicates result is greater than the lower of the guideline values in Table 4. The estuarine aquatic ecosystem guidelines have been used at this site.

[A]PAH's 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.

[B]TPH's analysed were as follows; C7 - C9, C10 - C14, C15 - C36, Total hydrocarbons (C7 – C36), all results were below detection limits.

Table 21 Sediment sampling data 08/04/2013 till 11/04/2013

Parameter (mg/kg dry wt unless stated)	PL	P9	P10	P11	M16	M22	M24	AC-FHQ
Date	08/04/2013	08/04/2013	08/04/2013	08/04/2013	11/04/2013	10/04/2013	10/04/2013	11/04/2013
Dry Matter (g/100g)	64	59	49	59	66	56	65	70
Total Recoverable Copper	9.9	14.5	13.6	12.1	13.3	11.8	10.7	12.4
Total Recoverable Lead	4.6	5.7	6.5	4.4	4.3	12.3	3.9	4.6
Total Recoverable Phosphorus	173	230	340	340	210	300	132	280
Total Recoverable Zinc	34	32	40	42	37	38	37	39
Total Nitrogen (g/100g dry wt)	< 0.05	0.08	0.14	0.07	0.07	0.14	0.06	<0.05
Total Organic Carbon (g/100g dry wt)	0.89	1.22	1.88	1.11	1.13	20	1.01	0.38
Polycyclic Aromatic Hydrocarbons								
Acenaphthene	< 0.003	< 0.003	< 0.004	< 0.003	< 0.003	< 0.003	< 0.003	< 0.002
Acenaphthylene	< 0.003	< 0.003	< 0.004	< 0.003	< 0.003	< 0.003	< 0.003	< 0.002
Anthracene	< 0.003	< 0.003	< 0.004	< 0.003	< 0.003	< 0.003	< 0.003	< 0.002
Benzo[a]anthracene	0.029	< 0.003	< 0.004	< 0.003	< 0.003	< 0.003	< 0.003	< 0.002
Benzo[a]pyrene (BAP)	0.049	< 0.003	0.004	< 0.003	< 0.003	< 0.003	< 0.003	< 0.002
Benzo[b]fluoranthene + Benzo[j]fluoranthene	0.048	< 0.003	0.004	< 0.003	< 0.003	< 0.003	< 0.003	< 0.002
Benzo[g,h,i]perylene	0.034	< 0.003	< 0.004	< 0.003	< 0.003	< 0.003	< 0.003	< 0.002
Benzo[k]fluoranthene	0.02	< 0.003	< 0.004	< 0.003	< 0.003	< 0.003	< 0.003	< 0.002
Chrysene	0.025	< 0.003	< 0.004	< 0.003	< 0.003	< 0.003	< 0.003	< 0.002
Dibenzo[a,h]anthracene	0.008	< 0.003	< 0.004	< 0.003	< 0.003	< 0.003	< 0.003	< 0.002

Parameter (mg/kg dry wt unless stated)	PL	P9	P10	P11	M16	M22	M24	AC-FHQ
Fluoranthene	0.035	< 0.003	0.004	< 0.003	< 0.003	< 0.003	< 0.003	< 0.002
Fluorene	< 0.003	< 0.003	< 0.004	< 0.003	< 0.003	< 0.003	< 0.003	< 0.002
Indeno(1,2,3-c,d)pyrene	0.027	< 0.003	< 0.004	< 0.003	< 0.003	< 0.003	< 0.003	< 0.002
Naphthalene	< 0.012	< 0.013	< 0.016	< 0.013	< 0.011	< 0.012	< 0.011	< 0.010
Phenanthrene	0.008	< 0.003	< 0.004	< 0.003	< 0.003	< 0.003	< 0.003	< 0.002
Pyrene	0.039	< 0.003	0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.002
Total Petroleum Hydrocarbons								
C7 - C9	< 10	< 12	< 14	< 12	< 10	< 12	< 11	< 10
C10 - C11	< 10	< 12	< 14	< 12	26	< 12	< 11	< 10
C12 - C14	< 10	< 12	< 14	< 12	< 10	< 12	< 11	< 10
C15 - C20	< 10	< 12	< 14	< 12	< 10	< 12	< 11	< 10
C21 - C25	< 10	< 12	< 14	< 12	< 10	< 12	< 11	< 10
C26 - C29	< 10	< 12	< 14	< 12	< 10	< 12	< 11	< 10
C30 - C44	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
Total hydrocarbons (C7 - C44)	< 70	< 70	< 70	< 70	< 70	< 70	< 70	< 70

Note: Grey shading indicates value is greater than the ERC green value in Table 5