NERMN Estuary water quality report 2020

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Prepared by: Malea Zygadlo

5 Quay Street
P O Box 364
Whakatāne
NEW ZEALAND

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Reviewed by:

Name: Josie Crawshaw
Position: Environmental Scientist
Date: 04/10/2021

Name: Paul Scholes
Position: Senior Environmental Scientist
Date: 05/10/2021

Name: James Dare
Position: Environmental Scientist
Date: 01/11/2021

Executive summary

The purpose of this report is to document the water quality state and trends in the estuaries of the Bay of Plenty. Estuarine water quality is monitored in nine of the larger estuaries under the Natural Environment Regional Monitoring Network (NERMN). Over ten water quality parameters measuring biological, aesthetic and chemical properties are monitored at 17 sites every month, with data extending as far back as 1990. The sample time changed in mid-2015 from sampling at high tide, to now sampling at mid-ebb tide, which impacts trend analysis.

The policies and objectives driving the monitoring programme are found in the Regional Natural Resources Plan (RNRP) and the Regional Coastal Environment Plan (RCEP). Several key objectives of the RCEP are related to water quality issues and the effects catchment landuse have on estuarine environments;

- Determine the quality of estuarine waters in the Bay of Plenty and water quality trends.
- Compare water quality against relevant water quality classifications (standards) for riverine and coastal estuaries.
- Identify potential adverse effects on water quality in the receiving environment.

River estuaries

The Tarawera, Rangitāiki, Whakatāne and Ōpōtiki are the smaller riverine estuaries (river mouths) dominated by freshwater flow. Nutrients are highest in the Rangitāiki and Tarawera river estuaries, likely reflective of the landuse and point source discharges in these catchments. Ammoniacal-N is highest in the Waiōtahe Estuary followed by Tarawera, suggesting a potential dairy signature given the low gradient pumped drainage scheme in both of these catchments. Chlorophyll-*a* is used as an indicator of primary productivity and is highest in the Rangitāiki River estuary. The faecal contamination indicator, *E.coli,* exceeded the Water Quality Microbiological Guidelines red alert mode (550 cfu/100 ml) on at least two occasions at all river estuaries. Median values of *E.coli* for all river estuaries are well below the 260 cfu/100 ml orange alert mode indicating that the estuaries are generally safe for contact recreation, although there are shellfish contamination issues at Waiōtahe.

Central and eastern estuaries

These three estuaries (Maketū, Waihī and Ōhiwa) are moderately sized tidal lagoons, with moderate freshwater inflows and over 70% of their intertidal area exposed at low tide. Nutrient results more closely reflect ecological condition of the estuaries since the sample time change. The high nutrients are clearly observed for Waihī and Maketū. Although, these results are also largely before the Kaituna re-diversion. The median of enterococci is well below the orange alert level of 280 cfu/100 ml, indicating that it is generally safe for contact recreation. It is worth noting however, that the shellfish guidelines are often exceeded in Ōhiwa and Maketū estuaries (Dare, 2020).

Tauranga Harbour

Tauranga Harbour is largely composed of tidal flats (66% of area) with large intertidal flats in the centre of the harbour separating the north from the south. Although nutrient parameters are relatively consistent across the harbour, Tilby Point does display consistently higher nitrogen, phosphorus and chlorophyll-*a* concentrations. The Wairoa River is the largest inflow into the harbour and is located close to the Tilby Point sample site. The ecological monitoring programmes show that fine sediments and mud are accumulating faster than background rates within the Harbour. The water quality results here do not appear to capture this with TSS and turbidity generally being low across the Harbour. Bacterial contamination is generally low across the Harbour.

Conclusion and recommendations

The analysis and conclusions from this report are limited due to the sample time change in 2015. Even without the added complexity of the sample time change, it is often difficult to assess estuary state and few appropriate guidelines are available because of their complexity and sensitivity to stressors. Trend analysis on five years' worth of data generally provides unreliable results as the time period does not adequately account for climatic variation or the inherent variation observed in water quality data.

The key recommendations from this report are to:

- Create better links with fluvial (river and stream) and estuarine ecological monitoring.
- Investigate what reporting framework would be of most use for interpreting the data, whether that is aligning with the NERMN Rivers or the NERMN coastal ecology reporting framework.
- Based on information to-date (not including input from tangata whenua or community), monitoring should focus on data collection for trend information. Consideration could be given to creating sites that assist in more longitudinal monitoring of inputs into estuaries. However, changing site locations should be considered carefully given the benefits of long-term datasets.
- Develop automatic site report generation for all NERMN Estuary water quality sites to show state and trends on an annual basis.
- Establish Waiōtahe River officially as a NERMN site to include chlorophyll-*a* analysis.
- Investigate best site for monitoring in the Kaituna and Maketū area since the re-diversion has occurred.

Contents

1 Introduction

1.1 Overview

Estuaries form a transitional environment between the land and the sea mixing together fresh and saline waters. In these unique coastal environments different mixtures of oceanic and freshwaters create many different habitat types, supporting an abundance of animal and plant wildlife. Estuaries are traversed by over half of our 54 native freshwater fish species and contain resident marine species, and species that migrate with the tide (Ministry for the Environment & Stats NZ, 2017). They form an important cultural and economic resource.

Estuaries are impacted by catchment development through land use change, hydrological alterations and the direct use of the estuary waterways. The greatest influence in many estuaries is that of oceanic waters constantly draining in and out of an estuary with the changing tides.

Worldwide estuarine health is reported to be in decline, exhibiting eutrophication symptoms such as elevated algal biomass (Bricker et al., 2008). The causes of eutrophication is attributed to agricultural activities, urban runoff, wastewater treatment plants and atmospheric N deposition (Bricker et al., 2008). Nutrients, sediments and toxins that originate within a catchment as a result of urbanisation, agricultural activities, vegetation clearing, and industry, can end up in estuaries potentially affecting the water quality and estuarine ecosystem. As such, estuaries are often a sink for sediments and associated contaminants from discharges related to these activities. Our larger coastal estuaries are influenced by discharges that stem from multiple river, streams and storm water discharges. Estuarine health largely reflects activities in the catchment.

The National Policy Statement for Freshwater Management (NPS-FM) (Ministry for the Environment, 2020) requires the Bay of Plenty Regional Council to implement freshwater objectives, limits and methods for achieving agreed sustainable freshwater quality and quantity in the region, taking consideration of the receiving environment.

1.2 Purpose

The purpose of this report is to document the water quality state and trends in the estuaries of the Bay of Plenty. Estuarine water quality is monitored under the Natural Environment Regional Monitoring Network (NERMN) and this covers a range of physico-chemical and microbiological properties. The data extends as far back as 1990.

The policies and objectives driving the monitoring programme are found in the Regional Natural Resources Plan (RNRP) and the Regional Coastal Environment Plan (RCEP). Several key objectives of the RCEP are related to water quality issues and the effects catchment landuse have on estuarine environments.

The policies and objectives found in these two plans form the objectives of the monitoring programme, which are to:

- Determine the quality of estuarine waters in the Bay of Plenty and water quality trends.
- Compare water quality against relevant water quality classifications (standards) for riverine and coastal estuaries.
- Identify potential adverse effects on water quality in the receiving environment.

The anticipated environmental results from implementation of the RCEP most relevant to the objectives of this report are:

- Safeguarding the life-supporting capacity of coastal water and coastal ecosystems.
- Water quality in harbours and estuaries is maintained and enhanced.
- Reduction in human induced sedimentation within harbours and estuaries.

2 Background

The Estuary water quality monitoring programme has been established since 1991 in a number of different forms. Some sites have had data collected since 1991, while others have been established later on in the development of the programme, with one site only having three years' worth of data.

Scholes (2015) made recommendations for the Estuary water quality programme which are summarised in Table 2-1 with action to-date. These recommendations were largely based on providing data that was more reflective of the actions on land. As a result, there were a number of sites that were discontinued or established in mid-2015. The major change that is key in the analyses in this report, is the sample time change from high tide to mid-ebb tide at all locations.

Table 2.1 Scholes (2015) recommendations and actions to-date.

Scholes (2015) Recommendation	Action to-date
Development of water quality guidelines and/or criteria for Bay of Plenty estuaries related to a predetermined reference state.	This is being implemented through the Essential Freshwater Policy Programme (EFPP) for implementing the NPS-FM (2020)
Monitoring of water column using grab samples should occur monthly to improve trend detection.	Implemented mid-2015
Monitoring of river estuaries on outgoing low tides, and ideally monitoring should occur when other sites on the respective river are monitored.	Implemented mid-2015
Removal of the Ōpōtiki Wharf site – there is good correlation between sites indicating that one site in the Ōpōtiki River Estuary will be adequate for the programme.	Implemented mid-2015
Determine whether nutrient, sediment and bacterial loads to the Eastern estuaries are changing and relate to changes in primary productivity. This will require better quantification of loads of these contaminants to the estuaries.	Development of Sednet model for Ōhiwa Harbour (and region wide) has begun. This will also be addressed in the EFPP
Tauranga Harbour – retain channel monitoring sites: Pilot Bay; Whareroa; Maungatapu; Ōmokoroa; and north harbour sites. Move Te Puna at Pitua Road to the end of Waipa Road. Add a site in the main channel opposite Motutangaroa Island. Sites should be monitored on the mid-low (outgoing) tide.	Implemented mid-2015.
Establish high frequency measures of temperature, salinity, turbidity, dissolved oxygen and chlorophyll-*a* at a number of sites (upper and lower estuary). The locations need to be chosen so that it is possible to detect impacts of significant rainfall events on the estuary, salinity gradients and seasonal changes.	Continuous monitored site at Tauranga Harbour Toll Bridge Marina installed June 2020 (See section 6.3.4)
Build better synergies with other programmes that may be collecting data in relevant locations. For example the bathing surveillance programme collects data on faecal indicators but could collect salinity, conductivity, turbidity, dissolved oxygen, temperature, and chlorophyll-*a* using hand held sensors which would provide a wealth of data over a range of tidal conditions.	Bathing programme does not collect any extra data. There could still be work to investigate this, although it may be more worthwhile investing in continuous monitoring sites.

Scholes (2015) Recommendation	Action to-date
Consider surveys of sediment structure and distribution across estuaries, along with high frequency monitoring to establish exposure times for suspended solids. This will add valuable insight into the potential degrading effects suspended silts and clays can have on estuarine food-webs	Storm event monitoring has been undertaken in Ohiwa, Maketū and Waihī catchments. High frequency sampling has also occurred on some rivers entering Tauranga Harbour (autosampler and turbidity sensor). The Tauranga monitoring was reported on in Hicks (2019). The focus for this was around determining relationships with TSS and turbidity to calculate sediment loading to the harbour, rather than potential degrading effects from suspended silts and clays. Projects are underway in the Waihī catchment which will include high frequency monitoring. The region-wide Sednet model will also focus on sediment loadings.
Investigation into the minimum flows (including groundwater) required to sustain salinity gradients in Waihī, Maketū (underway) and Tauranga Harbour. This potentially would require the development of catchment runoff models to estuaries (accounting for water extraction); and a model of flow and salinity within the estuaries.	No progress to date.
Ensure that the setting of water quality limits for freshwater (as part of implementation of the National Policy Statement for Freshwater) takes account of the effects on estuaries. This could be enabled by moving to a more holistic reporting framework which takes a 'mountains to the sea' approach, rather than the current separate reporting of state and trends for freshwater and estuarine sites. Such an approach would include a process that account for the 'mauri' of the waters.	This will be addressed through the EFPP for implementing the NPS-FM (2020)

3 Methods

3.1 Data

3.1.1 Sites and sample frequency

Nine estuaries are currently monitored under the NERMN programme (Figures 3.1 to 3.4). Seventeen sites are sampled every month at a mid-ebb tide. Dissolved oxygen (near the surface), temperature and salinity are measured in the field and samples are collected for analysis of turbidity, suspended solids, conductivity, salinity (laboratory), pH, chlorophyll-*a*, nitrate-nitrite-nitrogen, ammonium-nitrogen, dissolved reactive phosphorus, total phosphorus, and indicator bacteria. Laboratory methods for analysis are listed below in Table 3.2.

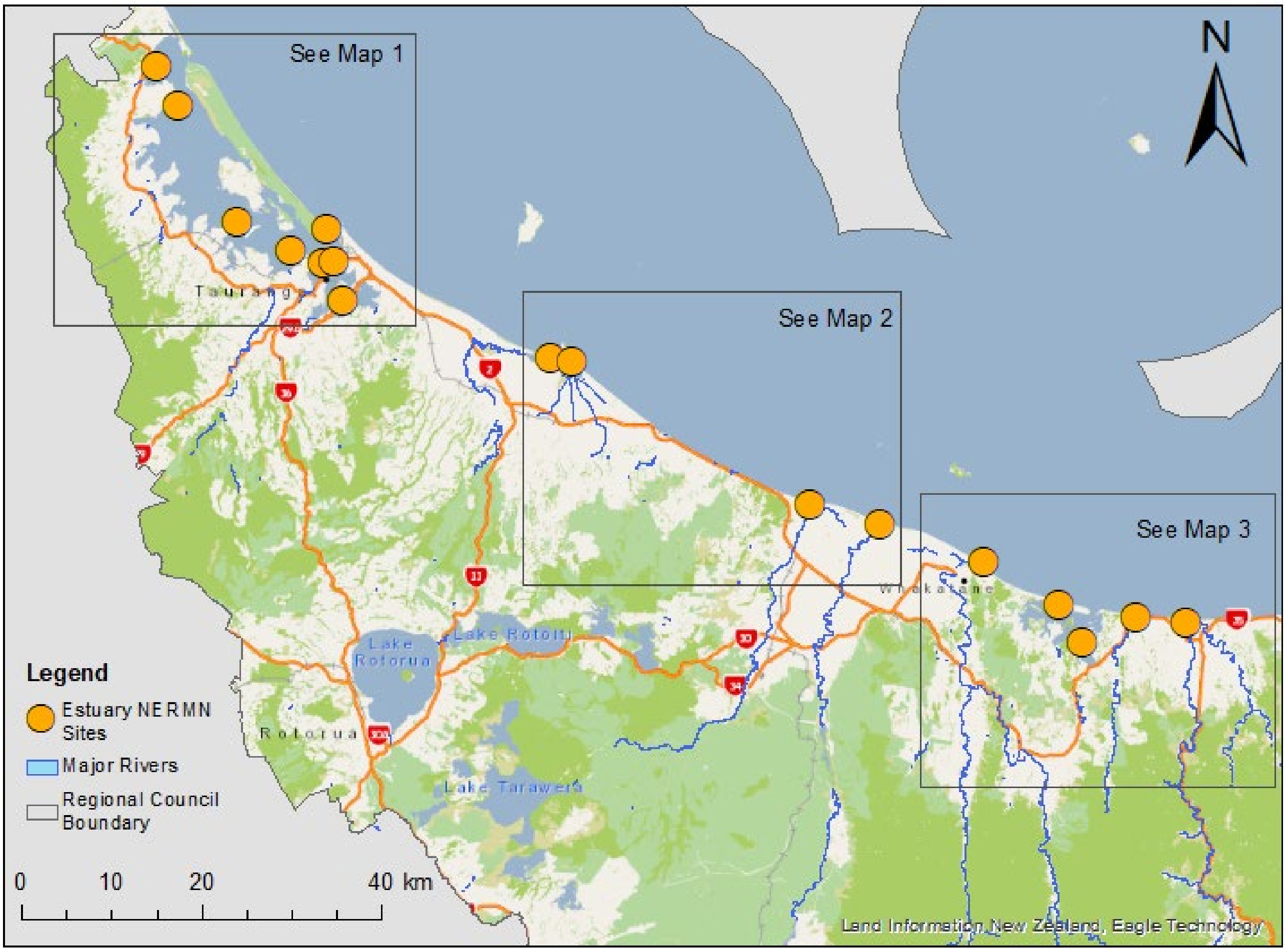

Figure 3.1 NERMN Estuary sampling locations in the Bay of Plenty region.

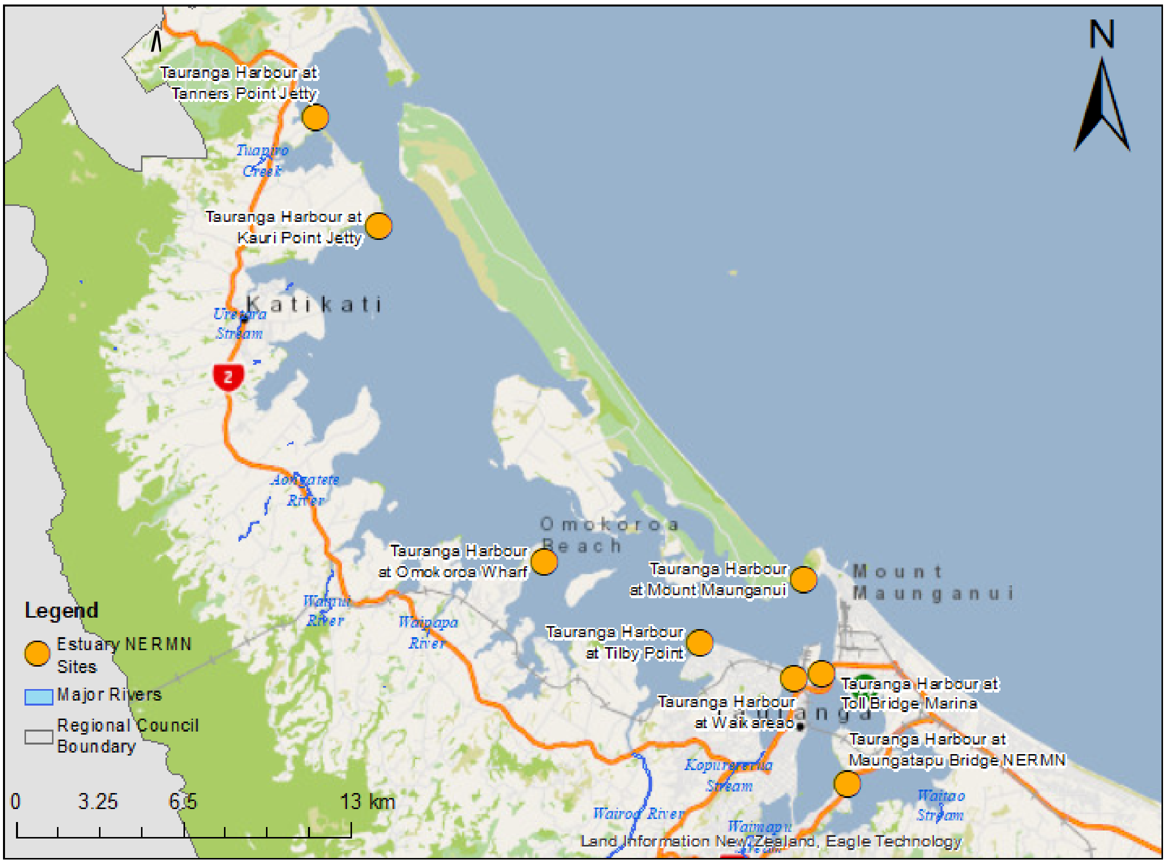

Figure 3.2 Tauranga Harbour NERMN Estuary sampling locations.

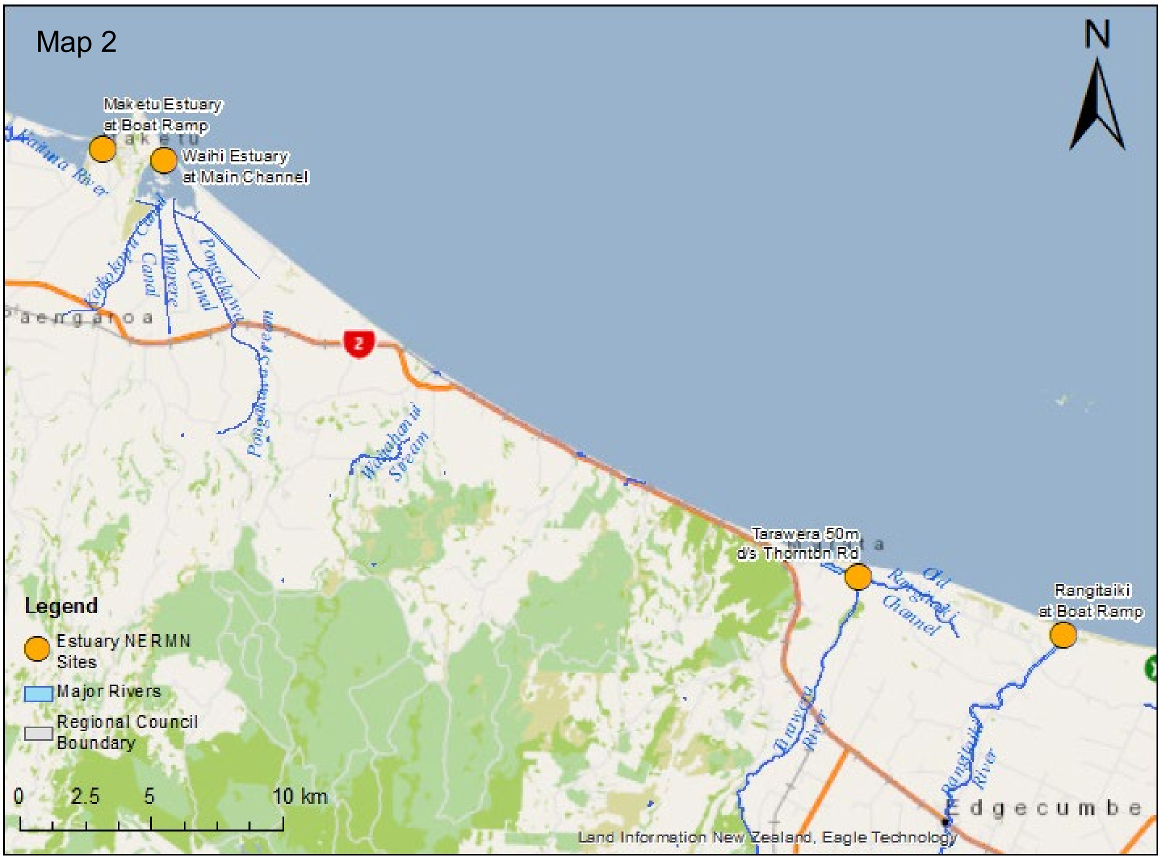

Figure 3.3 NERMN Estuary sampling locations for central area of the region.

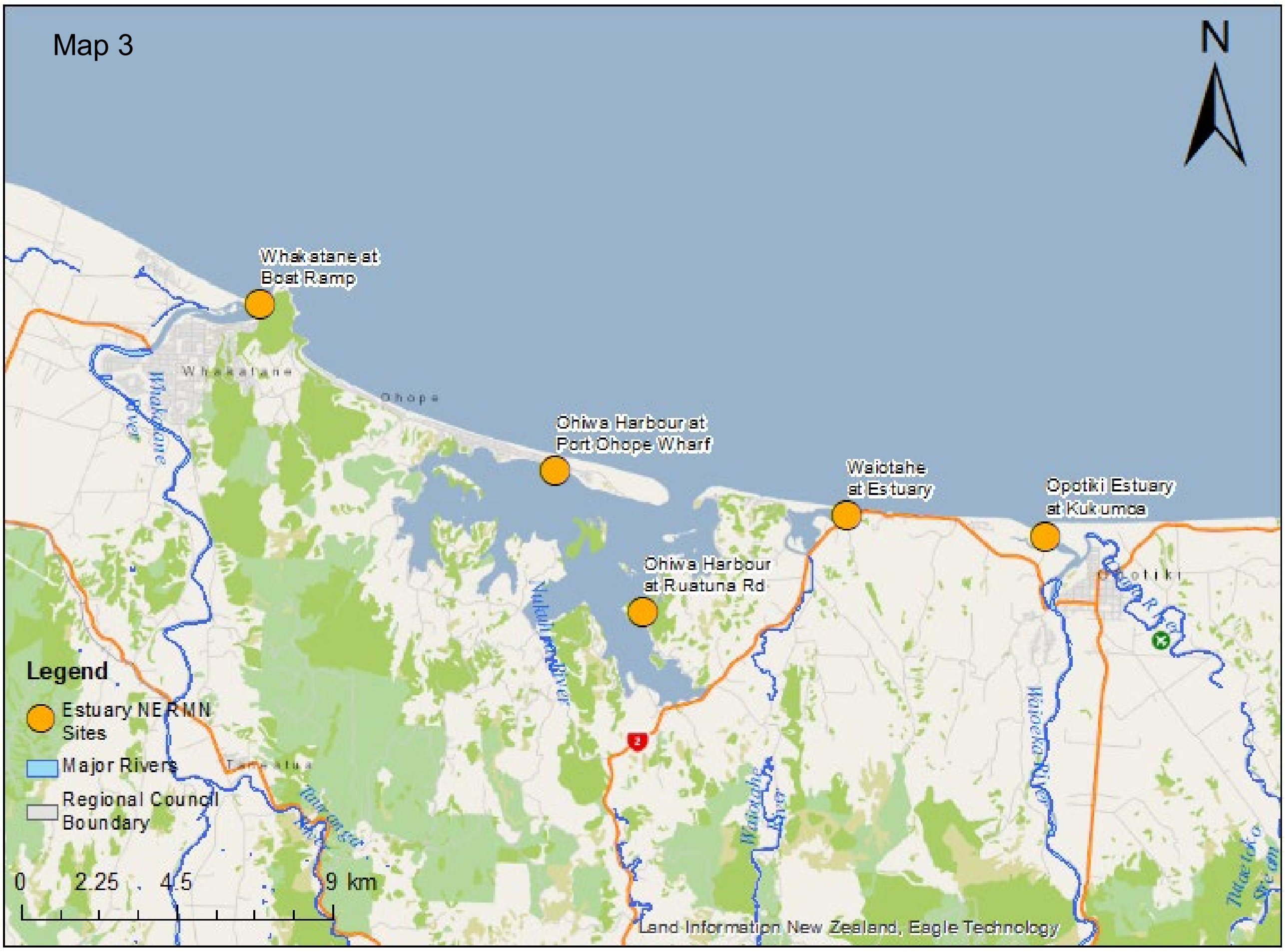

Figure 3.4 NERMN Estuary sampling locations for the eastern region.

Table 3.1 Location details for estuarine monitoring sites

Site ID	Site name	NZTM coordinates	
LM227254	Whakatāne at Boat Ramp	1952299	5792786
KM083686	Rangitāiki at Boat Ramp	1940875	5796975
JM306916	Tarawera 50 m d/s Thornton Road	1933061	5799164
NL493611	Ōpōtiki Estuary at Kukumoa	1974933	5786113
ML081799	Ōhiwa Harbour at Port Ōhope Wharf	1960816	5787994
ML335393	Ōhiwa Harbour at Ruatuna Road	1963350	5783936
ML922670	Waiōtahe at Estuary	1969229	5786705
GO661503	Waihī Estuary at Main Channel	1906617	5815039
GO429546	Maketū Estuary at Boat Ramp	1904290	5815461
CQ947053	Tauranga Harbour at Ōmokoroa Wharf	1869468	5830535
CR059778	Tauranga Harbour at Tanners Point Jetty	1860593	5847783
CR301357	Tauranga Harbour at Kauri Point Jetty	1863019	5843575
DP547739	Tauranga Harbour at Tilby Point	1875472	5827396
DP912601	Tauranga Harbour at Waikareao	1879122	5826016
DP952985	Tauranga Harbour at Mount Maunganui	1879529	5829853

Site ID	Site name	NZTM coordinates	
EP027600	Tauranga Harbour at Toll Bridge Marina	1880275	5826004
EP118190	Tauranga Harbour at Maungatapu Bridge NERMN	1881186	5821902

3.1.2 Sampling and analysis

Sampling was undertaken as per Bay of Plenty Regional Council internal protocols which follow standard best practice guidelines. Most analyses were performed by the Bay of Plenty Regional Council Laboratory, but for some periods analyses were undertaken by Hills Laboratory (Hamilton) and NIWA Laboratory (Hamilton). All chlorophyll-*a* analyses were performed by NIWA Laboratory (Hamilton). Laboratory methodologies are shown in Table 3.2.

Table 3.2 Laboratory methods for analysis.

Parameter (abbreviation)	Method	Detection Limit / Unit
Chlorophyll *a* (Chl-*a*)	APHA 10200 H and Fluorimetry	1.0 mg/m³
Conductivity	APHA 2510 B	1 µS/cm at 25°C
E. coli by MF (surface waters & natural bathing waters)	APHA 9213D by membrane filtration (mTEC agar)	1 cfu/100 ml
Enterococci – MF (surface waters)	9230 C by membrane filtration (mE agar)	1 cfu/100 ml
Faecal coliforms – MF	APHA 9222D (modified) by membrane filtration (mFC agar)	1 cfu/100 ml
Nitrogen, Total Oxidised (NNN/TON)	APHA 4500-NO_3^- I (modified) by Flow Injection Analyser	0.001 g/m³
Nitrogen, Total (Direct TN-A)	APHA 4500-P J (modified) by Flow Injection Analyser	0.01 g/m³
Nitrogen, Total Ammoniacal (NH4-N)	APHA 4500-NH3 H (modified) by Flow Injection Analyser	0.002 g/m³
Oxygen, Dissolved (DO)	APHA 4500-O G	0.1 mg/L
pH	APHA 4500-H+ B at 25°C	
Phosphorus, Dissolved Reactive (DRP)	APHA 4500-P G by Flow Injection Analyser	0.001 mg/L
Phosphorus, Total (TP)	APHA 4500-P J by Flow Injection Analyser	0.001 mg/L
Solids, Total Suspended (TSS)	APHA 2540 D dried at 103-105°C	1 mg/L
Temperature	APHA 2550B	0.1 °C
Turbidity	APHA 2130 B (modified) by white light turbidity meter	NTU

3.1.3 Dataset

Water quality datasets were obtained from the BOPRC Aquarius database. Occasional anomalous results were excluded with the details recorded in the R script[1]. These include: DO >90 mg/L, occasional records of EC < 10 µS/cm, and water clarity >150 m.

3.1.4 Detection limits and censoring

Changes in analytical procedures during the course of the monitoring programme resulted in changes in detection limits at different times. Historical laboratory methods and detection limits for the variables of TP and TN are provided in Scholes & Hamill (2016).

Measurements that are less than the laboratory detection limit are currently recorded as uncensored values. Using uncensored data allows for more accurate trend analysis even though the individual measurements may have low accuracy when they are below the detection limit. There have been periods in the past when water quality data has been censored. For the variables TN and TP the majority of censored values were recorded over the period September 2008 to October 2009 (inclusive). Since November 2009 the detection limit for TN and TP was 1 ppb, and prior to August 2008 the laboratory method was not as sensitive but actual results were usually recorded which reduced bias from censoring data.

Data used in this report was not adjusted for any censored values. Changes in the detection limit can result in anomalous trends in waters where measurements are close to detection, however this risk was minimised by setting rules on the number/percentage of non-detects in the datasets used for trend analysis.

3.2 Trend analysis

Estuary water quality data sets have been assessed for trends using the methods described below.

The sample time for estuary water quality changed mid-2015. Where samples had historically been taken at high tide (and some sites low tide), all samples were changed to be taken at mid-ebb tide to capture a greater freshwater influence and therefore more representative of terrestrial inputs that have greater anthropogenic influence.

Due to this sample time change, trends are analysed for data up to mid-2015 (June 2015) and for the 5-years post mid-2015. It was determined that the data would need to be treated as separate datasets due to this sample time change. Investigations showed that sites where you might not expect a step change to occur were showing a significant difference in conductivity or other water quality measure pre and post- the sample time change. While the analysis adjusts for conductivity (to account for the inevitable slightly different sample times), this would not capture all potential influence from the sample time change. The methodology below therefore describes the analysis undertaken for both datasets.

Trend analysis has been undertaken on estuary sites with five or more years of data where the data offers reasonable continuity. Analysis is undertaken taking into account temporal and tidal changes where appropriate. The trend test procedures were performed using the R software packages described in Snelder & Fraser (2019). These are consistent with the procedures in the statistical software TimeTrends v6.3 (Jowett, 2018)

[1] Avaiable on request.

and allows for directional confidence testing as recommended by McBride et al. (2014). The tests were performed using the median value for each season.

3.2.1 Tidal adjustment

Tidal flow adjustment may be necessary as many water quality parameters will change with tidal influences. Monitoring of sites is timed to occur on the same tide, but this does not always happen. A change in tide and the mixture of fresh to saline waters can obscure underlying trends. To adjust for tidal influence, conductivity as a measure of the change in the saline to freshwater environment has been used to help decrease variability and increase the power of trend detection.

Tidal/conductivity adjustment was performed only for site variables that shows strong flow relationships. Tidal adjustment was performed by fitting a curve relationship between the variable and conductivity, each variable is then adjusted according to the value of the flow and the selected relationship. The trend analysis is performed on the residual after adjusting for conductivity.

For each variable a curve relationship with conductivity was fitted using LOESS or GAM models. The curve that had the strongest relationship (lowest p-value) was used for conductivity adjustment. Conductivity adjustment was only used for variables where the curve p-value was <0.05.

3.2.2 Seasonality

The seasonality of each site variable combination was tested using a Kruskal Wallis test (non-parametric ANOVA). The data was assessed as seasonal if the p-value was < 0.05. If the data was seasonal, the trend analysis applied to the data was seasonal, i.e. the seasonal Kendall test and the seasonal Sen slope. If the data was not seasonal a Mann Kendall test was performed followed by the Sen slope estimator. Seasonal adjustment for each site variable is shown in Appendix A.

The Mann-Kendall test and its variant, the Seasonal Kendall test, are the most commonly used non-parametric methods of detecting trends statistically (Helsel & Hirsch, 1992).

3.2.3 Time period

As discussed above, trend analysis was undertaken for two different time periods: 5-years (mid-2015 to mid-2020 inclusive) and the full available dataset up to mid-2015. Actual start dates for each site are shown in Appendix A.

Trends for the five-year dataset should be interpreted with care as conductivity relationships formed from short term datasets are less reliable and are sensitive to occasional extreme values.

3.2.4 Trend interpretation

The output of trend analysis was classified into four categories: ‘Increasing’, ‘Decreasing’, ‘Indeterminate’ or ‘Not analysed’. A trend was categorised with confidence as increasing or decreasing when the probability from the Kendall test (p-value) was ≥95% or ≤5%. An “indeterminate” (or “uncertain”) trend was generally due to insufficient data relative to the variability in the dataset. An “insufficient data” trend category was assigned when the probability was ≤95% and ≥5% (Larned et al., 2016; McBride, 2019).

For final reporting the terms ‘Increasing’, ‘Decreasing’ were expressed as either ‘improving’, ‘worsening or ‘uncertain’ depending on whether an increasing or decreasing trend represents an improvement or a degradation e.g. an increasing trend in TN is a degradation but an increasing trend in clarity is an improvement.

Rather than just accept a *p*-value to define statistical significance (e.g. *p*-value <0.05), the likelihood that the trend has a given direction was expressed in a more nuanced way using probability. Trends are declared to be "confidently" detected when direction is established with 95% certainty. However, the direction can be determined with lower levels of confidence and a categorisation is used to convey that information. We have used the categorical levels of confidence to express the likelihood that water quality was improving for each site and variable as described in Table 3.3 (consistent with Snelder & Fraser (2018)). The categories are "fuzzy" boundaries; a statement that an outcome is "likely" means that the probability of this outcome can range from =66% (fuzzy boundaries implied) to 100% probability (McBride, 2019).

The slope analysis based on confidence limits (Sen Probability) and the Kendall test (*p*-value) are usually very similar, however they can give different results when censored values are present in the data. Even though a "very likely" trend or higher may be detected, the trend may not be environmentally important. Where the Kendall Statistic and slope analysis provided different results, the trend was assessed as 'indeterminate. This avoids the need of using an arbitrary threshold for PAC (e.g. of >1%) to assess "*practically important*" trends as used in past approaches (e.g. Ballantine et al., 2010; Scarsbrook, 2006).

*Table 3.3 Confidence categories used to express the probability that water quality was improving using the 'confidence categories' approach for aggregating trends (categories consistent with **Snelder & Fraser, 2018)***

Categorical level of confidence used by LAWA	**Categorical level of confidence of improvement**	**Probability (%)**
Very Likely Improving	Virtually certain	99-100
	Extremely likely	95-99
Likely Improving	Very likely	90-95
	Likely	67-90
Indeterminate/Uncertain	About as likely as not	33-67
Likely Worsening	Unlikely	10-33
	Very unlikely	5-10
Very Likely Worsening	Extremely unlikely	1-5
	Exceptionally unlikely	0-1

3.2.5 Exclusion of series

The trend method is robust to the occasional missing data and to censored data (Hirsch and Slack 1984), but it is good practice in trend analysis to exclude time-series that offer insufficient temporal span or frequency of detection (e.g., Helsel & Hirsch, 1992). Prior to trend analysis the dataset was filtered to restrict site-variable combinations to those for which there were measurements for at least 90% of the years and at least 90% of seasons within the time-period of analysis (consistent with Larned et al., (2015) and Snelder & Fraser (2018).

Similarly, trends are most robust when there are few censored values in the time-period of analysis. Variable site combinations were excluded that had >15% of the samples as censored (or tied) data. Helsel & Hirsch (1992) estimated that the impact of censored values on the Sen slope is negligible when fewer than 15% of the values are censored.

Trends were not analysed in situations where there were a large proportion of censored values or when there was no, or very little, variation in the data (e.g. a long run of identical values).

3.2.6 Uncertainty in trend analysis

Evaluations of water quality trends at individual sites always contain some uncertainty. The level of uncertainty depends on the number of observations and the magnitude of the water quality change through the time-period being analysed. Trend analysis is sensitive to the time period chosen for analysis and, in particular, changes in water quality between years is non-linear.

Establishing a trend in the data is not necessarily predictive of future trends. When trying to link trends to pressures or interpolating possible future trends in water quality, more confidence should be placed on trends observed over long periods of time than short periods. While we have calculated trends over a five year period, these should be interpreted with caution because they are sensitive to inter-annual variability in climatic conditions.

3.3 Estuary state graphs

Data has been presented using “box and whisker plots” to provide a visual summary of the state and relationships between water quality parameters at each site. These show the spread of the data with key statistics shown by the “boxes” (which span the 25 percentile and 75 percentile – i.e. the interquartile range or IQR, with the median concentration shown by a horizontal line within each box) and the “whiskers” (which span the range from the 25 percentile minus 1.5 x IQR and the 75 percentile plus 1.5 x IQR). Values lying beyond the whiskers are considered “outliers” and are shown as “o”s.

3.4 Guidelines

Developing a picture of potential threats to estuarine water quality can be established by comparison of water quality parameters with water quality guideline values and between similar estuaries. This in part helps to meet the objectives of the RCEP and RWLP. Threats such as increasing sedimentation from urban development, erosion, and rural runoff, increased nutrients loads from intensive livestock farming, fertiliser runoff, and urban stormwater all have the potential to negatively impact on water quality. Algal blooms may occur as a direct result of increases in nitrogen and phosphorus. Reduced oxygen may result from excess ammonia and increased organic loading.

To help give a clearer picture as to the relevance of concentrations of a given parameter in the estuarine environment, previous reports have made use of the methods and trigger values developed for south-east Australian[2] estuaries (ANZECC, 2000) as well as trigger values for New Zealand lowland rivers (ANZG, 2018). However, these trigger values may not represent a reliable or realistic measure of protection for Bay of Plenty waters as these values have been developed in different catchments with differing ecosystems. It is suggested that water quality managers develop their own physico-chemical indicators better suited to their respective regions. The ANZECC trigger values for south-east Australia (Table 3.4) will occasionally be referenced to provide some comparison where more relevant tools cannot provide insight.

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[2] These are the most appropriate standards for New Zealand waters, although they should still be used with caution, as New Zealand waters are more productive than Australian waters.

Table 3.4 ANZECC (2000) trigger values for South-Eastern Australia

	Chl *a* (g/m^3)	TP (g/m^3)	NO_xN (g/m^3)	NH_4N (g/m^3)	Turbidity (NTU)
Trigger value estuaries	0.004	0.030	0.015	0.015	10*

**Adopted from Murphy & Crawford (2002)*

3.4.1 ETI Tool and estuary classification

Until recently, relevant guidance on how to assess the extent of eutrophication in an estuary was limited. To fill this gap, the New Zealand Estuary Trophic Index (ETI) toolbox was developed through an Envirolink Tools Grant. The purpose of this toolbox was to provide a nationally consistent approach to the assessment of estuarine eutrophication, including nutrient load thresholds. Specifically, the toolbox was developed to assist Regional Councils to determine the susceptibility of an estuary to eutrophication, assess its current trophic state and assess how changes to nutrient load limits may alter its current state.

An understanding of the eutrophication state of estuaries is particularly important as the National Policy Statement for Freshwater Management (NPS-FM) is implemented. The NPS-FM directs Regional Councils to manage fresh water in an integrated and sustainable way and includes requirements to set limits in freshwater systems to protect ecosystem health. Sensitive receiving environments, such as estuaries, must be taken into consideration as part of this limit setting process. The ETI toolkit has provided a useful approach to explore the potential effects of freshwater nutrient load limits on the eutrophication status of estuaries in the Bay of Plenty.

To assess an estuaries susceptibility to eutrophication an estuary must be classified into types to account for different levels of susceptibility. The ETI has adopted a simple four category typology (simplifying the New Zealand Coastal Hydrosystem (NZCHS)) specifically suited to the assessment of estuarine eutrophication susceptibility as follows

1. Intermittently closed/open lakes and lagoons estuaries (ICOLLs),
2. Shallow intertidal dominated estuaries (SIDEs),
3. Shallow, short residence time tidal river and tidal river with adjoining lagoon estuaries (SSRTREs), and
4. Deeper subtidal dominated, longer residence time estuaries (DSDEs).

For further descriptions of these broad estuary types, refer to (B. M. Robertson, Stevens, Robertson, et al., 2016). Classifications for the monitored estuaries in Bay of Plenty are shown in Table 3.5.

Table 3.5 ETI estuary classifications for estuaries in the NERMN estuary water quality programme

Name	NZCHS code	NZCHS class	ETI class
Maketū Estuary	7A	Tidal lagoon (permanently open)	SIDE
Ōhiwa Harbour	9	Deep drowned valley	SIDE
Tauranga Harbour System	8	Shallow drowned valley	SIDE
Waihī Estuary	7A	Tidal lagoon (permanently open)	SSRTRE
Waiōtahe River	7A	Tidal lagoon (permanently open)	SIDE
Whakatāne River	6B	Tidal river mouth (spit enclosed)	SSRTRE

Name	NZCHS code	NZCHS class	ETI class
Rangitāiki River	6B	Tidal river mouth (spit enclosed)	SSRTRE
Tarawera River	6B	Tidal river mouth (spit enclosed)	SSRTRE

This report does not go into detail of the ETI tool and its application. This is covered in Lawton (2017) for Waihī, Maketū, Tauranga and Ōhiwa Harbours. However, this report does make use of the interim NZ chlorophyll-*a* threshold ratings for NZ estuaries (Table 3.6) provided in Robertson et al. (2016), although it is not a particularly strong indicator of elevated nutrients for the estuary types observed in the Bay of Plenty region. Chlorophyll-*a* is recommended to be used as a primary symptom indicator for subtidal dominated estuaries (residence time weeks rather than days) and ICOLLs during their closed phase. In the Bay of Plenty region, the estuaries are characterised as SIDEs or SSRTREs. These systems have short residence times and therefore indicators such as macroalgae are much better suited as primary symptom indicators (B. M. Robertson, Stevens, Zeldis, et al., 2016). It is also noted that these thresholds are based on overseas estuary data as data in New Zealand is limited.

Table 3.6 Recommended interim rating thresholds for phytoplankton chlorophyll-a concentrations in NZ estuaries (as 90th percentile based on monthly measurements) ***(B. M. Robertson, Stevens, Zeldis, et al., 2016)****.*

Band	A	B	C	D
Ecological Quality	Ecological communities are healthy and resilient.	Ecological communities are slightly impacted by additional phytoplankton growth arising from nutrients levels that are elevated	Ecological communities are moderately impacted by phytoplankton biomass elevated well above natural conditions. Reduced water clarity likely to affect habitat available for native macrophytes	Excessive algal growth making ecological communities at high risk of undergoing a regime shift to a persistent, degraded state without macrophyte/seagrass cover.
Euhaline Estuaries[1]	<3 mg/m^3	3 – 8 mg/m^3	>8 – 12 mg/m^3	>12 mg/m^3
Oligo/Meso/PolyHaline Estuaries[1]	<5 mg/m^3	5 – 10 mg/m^3	>10 – 16 mg/m^3	>16 mg/m^3

[1] **90th percentile based on monthly measures.** Oligohaline 0.5 ppt-5 ppt salinity, Mesohaline >5 ppt-18 ppt, Polyhaline >18 ppt-30 ppt, Euhaline>30 ppt. River Estuaries classed as Oligohaline, Tauranga harbour as Euhaline and Central and Eastern Estuaries as Euhaline.

3.4.2 Bacteria

For indicator bacteria, the Microbiological Water Quality Guidelines (2003) are used for comparative purposes and to see if the qualitative standard for the classification has been met. The guidelines use enterococci for comparison in marine waters and *Escherichia coli* (*E. coli*) for freshwaters. Table 3.7 displays the guideline values as recommended by the Microbiological Water Quality Guidelines, 2003.

Table 3.7 Microbiological Assessment Category (MAC) definitions ***(MfE and MoH, 2003)***

	Marine waters	Freshwater
Safe/Green	No single sample > 140 Enterococci per 100 mL	Mode No single sample > 260 Escherichia coli per 100 mL
Alert/Amber	Single sample > 140 Enterococci per 100 mL	Single sample > 260 Escherichia coli per 100 mL
Action/Red	Two consecutive samples > 280 Enterococci per 100 mL	Single sample > 550 Escherichia coli per 100 mL

4 Estuary descriptions

4.1 River estuaries

4.1.1 Tarawera River

The Tarawera River Estuary is a small estuary of approximately 0.72 km^2 with a catchment of approximately 984 km^2. The river originates at the outlet of Lake Tarawera and flows 65 km to the ocean at Matatā. The upper catchment is a mixture of indigenous forest, pasture and exotic forestry and scrub. The lower catchment contains the township of Kawerau and the Tasman industrial complex, which processes wood based products and is a large user of Tarawera River water. Stormwater and treated sewage from the Edgecumbe Township also flow into the river by way of the Omeheu/Awaiti canal system. The plains of the lower catchment are dominated by intensive dairying with some horticulture and cropping. Monitoring is undertaken 50 m downstream of the Thornton Road Bridge. Water Quality statistics are in Appendix B.

4.1.2 Rangitāiki River

The small Rangitāiki Estuary is influenced by a large continuous fresh water input and is a popular recreational area for fishing and boating. The Rangitāiki River is the longest river in the Bay of Plenty (155 km long), with a catchment of approximately 3,005 km^2 ranging from the native forest dominated Te Urewera National Park to the Rangitāiki coastal plains. Three power schemes form dams in the river system, Aniwaniwa Dam, Matahina Dam and the Whaeo and Flaxy Scheme. The Galatea and Rangitāiki plains are dominated by dairy farming with other pastoral farming supporting sheep, drystock and deer. Cropping and horticulture are also scattered over the plains with exotic forestry the primary land use on surrounding hill country as far back as Te Urewera National Park. The townships of Te Teko and Edgecumbe are located on the lower reaches of the Rangitāiki and at Edgecumbe the Fonterra Dairy Factory is a significant user of river water and discharges process waste water to the river. Water Quality statistics are in Appendix B.

4.1.3 Whakatāne River

The highly modified Whakatāne Estuary is approximately 1.3 km^2 in size and is largely influenced by the freshwater flow from the Whakatāne River. The catchment (1,768 km^2) is predominantly in native and exotic forest with intensive livestock agriculture dominating the lowlands. The estuary has several drainage canals entering it which are likely to be influencing its ecological health. Water quality statistics are given in Appendix B.

4.1.4 Waiōtahe River

The Waiōtahe Estuary is approximately 1.1 km^2 of high conservation and recreational value. The catchment (148 km^2) is made up of alluvial plains (14%), and hill country (86%). Land use is similar to Whakatāne River catchment in that it is dominated by indigenous forest in the upper catchment, moving in to forestry and intensive livestock farming on the plains. A permanent health warning has been in place for the collection of shellfish since January 2017, due to elevated faecal coliform results observed as part of the recreational waters monitoring programme. Water quality statistics are given in Appendix B.

4.1.5 Ōpōtiki

The Ōpōtiki Estuary is a relatively small riverine estuary (0.5 km^2) joining with the confluence of the Waioeka and Otara Rivers to provide a common mouth for these rivers. The lower catchment for this estuary is dominated by intensive livestock farming, while the upper catchment is dominated by native forest. Water Quality statistics are in Appendix B.

4.2 Central and eastern estuaries

4.2.1 Ōhiwa Harbour

Ōhiwa Harbour covers an area of approximately 26.4 km^2 and is shallow with 83% of its area exposed at low tide. The estuary is enclosed by Ōhope and Ōhiwa spits and is rapidly changing with coastal and catchment sediment contributing to infilling of the estuary. Fresh water inflows to the estuary are dominated by the Nukuhou River which drains part of the 171 km^2 Ōhiwa Catchment. Pastoral farming dominates the land use in the catchment followed by indigenous and production forest. Urban areas are restricted to the northern end of the estuary predominantly on the Ōhope side. Monitoring takes place at two sites in the estuary, one at Port Ōhope Wharf and the other at Ruatuna Road (Figure 3.4). Sites are geographically distinct from one another, with the Port site representative of the harbours western side. The Ruatuna Road site represents the eastern side of the harbour which has the Kutarere and Te Kahaha streams flowing into its southern extent. There is limited freshwater influence at the two monitoring sites, which is demonstrated by the conductivity levels (Appendix B).

4.2.2 Waihī

The Waihī estuary is fed by the Pongakawa, Kaikokopu, Pukehina, and Wharere canals which drain approximately 32,819 ha. Waihī estuary is sensitive to nutrient enrichment with the large conversion of wetland to pasture changing landuse as well as creating direct inflows, health warnings have been in place for shellfish gathering. Modelling has indicated that significant reductions in nutrients and faecal contamination are necessary to achieve a ‘moderately healthy ecological state’ (Park, 2018b). Water quality statistics are provided in Appendix B.

4.2.3 Maketū

The 2.3 km^2 Maketū Estuary has been affected by flood protection schemes and wetland reclamation over the years resulting in a significant impact on the health of the estuary (KRTA, 1986). In February 2020, the re-diversion of the Kaituna River was completed, which reintroduced 400,000 m^3 of flow per tidal cycle. Ecological health following restoration efforts as part of the final re-diversion has significantly improved (Park, 2020). The water quality data used here does not include data since completion of the re-diversion.

The catchment is dominated by intensive livestock agriculture and horticulture as well as discharges associated with the township of Te Puke and industrial discharges from AFFCO freezing works. The upper Kaituna Catchment encompasses the Rotorua and Rotoiti Lakes catchments as Lake Rotorua discharges through Lake Rotoiti and down the Kaituna River. Water quality statistics for the estuary are listed in Appendix B.

4.2.4 Tauranga Harbour

Tauranga Harbour covers an area of 210 km^2 and is largely composed of tidal flats (66% of area) with large intertidal flats in the centre of the harbour separating the north from the south. It is also impounded by a large barrier island (Matakana Island) and two barrier tombolos, Mauao (Mount Maunganui) in the south entrance, and Bowentown to the north.

Deep channels are maintained by tidal ebb and flood flows and water quality is influenced by a mix of oceanic and fresh water.

Research has identified that nutrients, heavy metals and sediment are key factors affecting the ecology of the harbour (Ellis et al., 2013; Park, 2003, 2011). There has previously been some indication that nitrogen is increasing in the harbour, but phosphorus decreasing (Scholes, 2015). These trends could not be reliably re-assessed here due to the change in sample time and only 5-years' worth of data at this stage. The implications of potential increase in nitrogen are not yet well understood, particularly with respect to the factors causing nuisance growths of sea lettuce.

5 Trend results

Trend analysis is presented here for years up to mid-2015 (starting years ranging from 1989–1998) and 5-year trends (i.e. mid-2015 to mid-2020). This provides information on trends up to the sample time change and an indication of trends detected post this sample time change. There may be some contrasting trends due to the sample time change, however it is difficult to pull these apart given the potential for land use change and/or management that could equally be influencing these changes. It is also important to understand that short term trends can give very different information from longer term trends (Ballantine, 2012), both in the sense that trends may indicate improving or worsening waters when they may only be moving back to values characteristic of earlier monitoring, but also in that they may be representative of climatic variation such as rainfall and water temperatures. Therefore, these 5-year trends should be interpreted with care and re-visited once more data is available post mid-2015.

Note that Waiōtahe at estuary only has three years of data and is therefore not included in the trend analysis. The following sites were added to the programme in 2015 as recommended by Scholes (2015) and therefore only have 5-year trend analysis results;

- Tauranga Harbour at Mount Maunganui,
- Tauranga Harbour at Waikareao, and
- Tauranga Harbour at Tilby Point.

5.1 River estuaries

Full time series plots for river estuary sites are in Appendix C. Note that Waiōtahe River Estuary only has three years' worth of data and is therefore not included in trend analysis.

5.1.1 Tarawera River

The Tarawera River Estuary shows a number of significant trends with an overall improving trend for water quality parameters across both pre-2015 and 5-year trend analysis (Table 5.1). This may be a result of improvements in point source discharges into the Tarawera River such as the Tasman Mill and Kawerau wastewater discharges.

5.1.2 Rangitāiki River

Five significant trends were detected in the data from 1995 to mid-2015 (Table 5.1). A worsening trend in phosphorus, total and dissolved were observed. TSS displayed a significant improving trend however turbidity did not.

TP displays the opposite trend in the 5-year data with indications of improvement. Whereas both TSS and turbidity show significant improving trends as TSS does pre-2015. TN and NNN show worsening trends, which is inconsistent with the pre-2015 data.

The most downstream river NERMN site is Rangitāiki at Te Teko, which is approximately 22 km upstream of the estuary site. Land use between these two sites is predominantly dairy. The Te Teko site shows some contrasting trends up to 2018, with TP and DRP improving over the >15 year trend analysis (Hamill et al., 2020). The Rangitāiki river has multiple aspects that affect the water quality outcomes along the river, including the lakes/dams and the mobile pumice substrate. The Te Teko site may be more impacted by the effects in the lakes/dams, whereas the downstream estuary site may reflect changes in the surrounding land use more closely.

5.1.3 Whakatāne River

Trend analysis up to mid-2015 show that DRP and bacterial contamination was very likely worsening, with Enterococci showing a worsening trend at a percent annual change of 0.56%.

Results for the 5-year trends show DRP to be improving, which is in contrast to the pre-2015 data. DO and chlorophyll-*a* display a worsening trend (Table 5.1). As discussed above, there are issues with undertaking trend analysis over the 5-year period, so these trends should be interpreted with caution.

The bathing site at Whakatāne Heads (this site is very close to the estuary monitoring site) is shown to occasionally exceed the amber (alert) threshold over the last five years, with the Suitability for Recreation Grade rated as 'Good' (Dare, 2020). Approximately 3.5 km upstream, the rivers bathing site Whakatāne at Landing Road had degraded from 'suitable' over the 2014-2019 seasons to 'unsuitable' over the 2015-2020 seasons. This was due to the median value exceeding 130 cfu/100 ml enterococci (Dare, 2020), which could indicate evidence of faecal contamination worsening. The potential for increasing bacterial contamination in the lower Whakatāne River should be investigated, focus could initially be on the drainage canal and Waioho stream as likely sources.

Hamill et al. (2020) found that the Whakatāne River had worsening trends for many parameters over a 10-year period, but only for TP and DRP over the 15-year period. This is based on sample locations further upstream. More data at the mid-ebb tide sample time may allow for better comparison between the estuary results and trends observed higher up in the freshwater environment.

5.1.4 Ōpōtiki

A significant improving trend in ammoniacal-N is detected pre-2015, possibly due to improvements in agricultural waste discharges in the early 1990s. This is in part backed up by the pre-2015 significant improving trends for bacteria indicators *E. coli* and faecal coliforms, another potential indicator of improvements in agricultural discharges. Suspended solids and chlorophyll-*a* show worsening trends at a percent annual change (PAC) of 0.9% and 3.0% respectively pre-2015 (Appendix D).

The only significant trend identified for the 5-year analysis is an improving trend for DRP.

5.2 Central and eastern estuaries

Full time series plots for central and eastern estuary sites are in Appendix C.

5.2.1 Ōhiwa Harbour

Ōhiwa at Ruatuna Road

Table 5.1 show pre-2015 trends are improving for turbidity and water clarity. TP also shows an improving trend which could be related to improved suspended sediment at this location, although TSS shows only a 'likely improving' result. Faecal contamination is indicating that it is worsening in pre-2015 trends. There is significant work in the catchment to reduce sedimentation which would also assist in reducing faecal contamination.

Ōhiwa Harbour at Port Ōhope Wharf

The Port Ōhope Wharf site is located on the harbour side of the Ōhope spit, representing the western inputs into the harbour (compared to the southern and eastern input that Ruatuna Rd represents). Microbiological results for recreation and shellfish collection are generally good for Ōhiwa sites (Dare, 2020). Shellfish occasionally exceed the ‘no more than 10% of samples should exceed a MPN of 43/100 ml’ test (Dare, 2020)

The pre-2015 trends show only one significant trend of TP improving (Table 5.1). Which is consistent with the Ruatuna Road trends. Five year data shows chlorophyll-*a*, TP, DRP, DO, turbidity and TSS to be improving at quite significant percent annual changes (2.1% – 20%). The 5-year time period is often not long enough to account for the short-term variability at a site (such as climatic variability, seasonal patterns) as detailed in Ballantine (2012). The decline in rainfall over this 5-year period is one example of climatic variability observed over shorter time periods. As a result, short-term trends can give very different information from the longer trends (Ballantine, 2012). These ‘significant trends’ from the 5-year dataset should therefore be interpreted with care and re-visited when more data is available.

5.2.2 Waihī

The pre-2015 trends show worsening trends for faecal contamination and TSS. Five year trends show several ‘very likely improving’ trends (Table 5.1). A significant amount of work has been undertaken in the catchment to improve the state of the estuary. However, it would be surprising if we were already seeing the impacts of this in trend analysis. It is more likely that the short-term trend analysis is misleading in its results due to climatic variation and estuarine nutrient recycling.

5.2.3 Maketū

Pre-2015 trends show faecal contamination to be worsening, along with DO and TSS (Table 5.1). The location of the sampling point is at the estuary mouth, and therefore less influenced by river inputs and more reflective of estuary water being flushed out to the coast. These worsening trends are likely reflective of processes within the estuary and climatic drivers, especially as the pre-2015 data was collected at high tide. DO, DRP and TP show improving trends in the 5-year trend analysis.

5.3 Tauranga Harbour

Tauranga Harbour at Maungatapu Bridge NERMN

Total phosphorus and turbidity show an improving trend pre-2015 which is consistent with what Scholes (2015) reported. The 5-year trends at this site generally show improving trends and at quite high PACs. As discussed above, this should be interpreted with care and re-assessed once more data is available.

Tauranga Harbour at Ōmokoroa Wharf

Turbidity, TP and chlorophyll-*a* all show improving trends pre-2015 (Table 5.1). The Waipapa River discharges to the Tauranga Harbour in vicinity of this estuary site. The NERMN river site ‘Waipapa at Old Highway’ generally show indeterminate or worsening trends over 10 years (up to 2018) and some improving trends over >15 years (up to 2018) (Hamill et al., 2020). All significant trends over the 5-year period are improving.

Tauranga Harbour at Toll Bridge Marina

The pre-2015 trends show only one significant trend of turbidity improving (Table 5.1). Significant trends for the 5-year period show improving trends for faecal contamination and DRP (Table 5.1).

Tauranga Harbour at Kauri Point Jetty

Trend analysis for pre-2015 and 5-year time period are tabulated in Table 5.1. Improving trends for DRP and TP are apparent pre-2015. The freshwater inputs at this site are not considered to have a natural phosphorus source (Hamill et al., 2020). The Uretara and Tuapiro rivers that discharge to this area of the harbour do not show accompanying improving trends in DRP or TP. This might suggest that internal estuary processes may be responsible for these trends. Five year trends show a range of improving trends for nutrient parameters.

Tauranga Harbour at Mount Maunganui

This site began monitoring post the recommendations in Scholes (2015), therefore only 5-year trend results are available. These results indicate that some parameters are improving, however more long-term data would be required to reliably interpret trends (Table 5.1).

Tauranga Harbour at Tanners Point Jetty

Scholes (2015) identified an increasing trend in chlorophyll-*a* suggesting an increase in productivity. However, trend analysis up to mid-2015 here show no significant trends for chlorophyll-*a* and improving trends for DRP, TP, turbidity and faecal indicators. 5-year trends also show improving trends for some nutrient parameters (Table 5.1).

Tauranga Harbour at Tilby Point

This site began monitoring post the recommendations in Scholes (2015), therefore only 5-year trend results are available. These results indicate that some parameters are improving (Table 5.1), however, more long-term data would be required to reliably interpret trends.

Tauranga Harbour at Waikareao

This site began monitoring post the recommendations in Scholes (2015), therefore only 5-year trend results are available. These results indicate that some parameters are improving (Table 5.1), however more long-term data would be required to reliably interpret trends.

Table 5.1 Trend direction for all Estuary sample sites. Note Waiōtahe at Estuary is not included as there is only three years' worth of data. VLI = Very Likely Improving; LI = Likely Improving; Ind = Indeterminate; LW = Likely Worsening; VLW = Very Likely Worsening

	Ammoniacal-N		Chlorophyll-*a*		DIN		DO		DRP		*E. Coli*		Enterococci		Faecal coliforms		NNN		TN		TP		TSS		Turbidity		Water Clarity	
	pre-2015	5-year	pre-2015	5-year	pre-2015	5-year	pre-2015	5-year	pre-2015	5-year	pre-2015	5-year	pre-2015	5-year	pre-2015	5-year	pre-2015	5-year	pre-2015	5-year	pre-2015	5-year	pre-2015	5-year	pre-2015	5-year	pre-2015	5-year
Tarawera 50 m d/s Thornton Road	VLI	VLI	LI	Ind	VLI	LI	Ind	LI	LW	LW	VLI	LI	VLI	LW	VLI	Ind	LI	LI	NA	VLI	LI	VLI	VLI	VLI	VLI	VLI	NA	VLI
Rangitāiki at Boat Ramp	LI	Ind	LI	LI	LI	VLW	VLW	LI	VLW	LI	LI	LI	LI	Ind	VLI	Ind	LI	VLW	NA	VLW	VLW	VLI	VLI	VLI	LI	VLI	NA	LI
Whakatāne at Boat Ramp	Ind	LI	LI	VLW	LW	LI	Ind	VLW	VLW	VLI	Ind	LW	VLW	LW	LW	LW	LW	LI	NA	LI	LW	LI	LW	LI	LI	Ind	NA	LW
Ōpōtiki Estuary at Kukumoa	VLI	LI	VLW	LI	Ind	LI	LI	LW	LW	VLI	VLI	LI	LI	Ind	VLI	LW	Ind	LI	NA	LI	Ind	LI	VLW	LI	LI	LI	Ind	Ind
Ōhiwa Harbour at Ruatuna Road	LW	Ind	Ind	LI	LI	LI	LI	LI	Ind	VLI	VLW	LW	VLW	Ind	VLW	VLW	Ind	LI	NA	LI	VLI	Ind	LI	LI	VLI	LW	VLI	LI
Ōhiwa Harbour at Port Ōhopef	LW	Ind	LI	VLI	LI	LI	LI	VLI	LI	VLI	LW	LI	LW	Ind	LW	VLW	NA	Ind	NA	LI	VLI	VLI	LW	VLI	Ind	VLI	NA	LI
Waihī Estuary at Main Channel	LW	VLI	Ind	VLI	Ind	Ind	LW	Ind	LW	VLI	VLW	Ind	VLW	Ind	Ind	Ind	LW	LW	NA	Ind	LI	VLI	VLW	VLI	Ind	VLI	LW	LI
Maketū Estuary at Boat Ramp	LW	LI	LI	Ind	LI	LI	VLW	VLI	VLI	VLI	VLW	Ind	VLW	Ind	LI	LW	LI	LW	NA	LI	LI	VLI	VLW	LI	LI	LW	Ind	LI
Tauranga Harbour at Maungatapu Bridge	LW	VLI	LI	Ind	LW	VLI	LI	LW	Ind	VLI	Ind	VLI	LI	LI	Ind	VLI	LW	VLI	LW	VLI	VLI	VLI	Ind	VLI	VLI	LI	NA	Ind
Tauranga Harbour at Ōmokoroa Wharf	LW	LI	VLI	Ind	NA	VLI	LI	LI	Ind	VLI	NA	VLI	VLW	LI	LW	VLI	NA	VLI	NA	LI	VLI	VLI	Ind	VLI	VLI	LI	Ind	Ind
Tauranga Harbour at Toll Bridge Marina	LW	LI	Ind	LI	Ind	LI	Ind	LI	LI	VLI	Ind	VLI	Ind	LI	Ind	VLI	LW	LI	LI	VLW	LI	LI	LW	LI	VLI	Ind	LI	Ind
Tauranga Harbour at Kauri Point Jetty	LI	VLI	LW	LW	NA	VLI	Ind	LI	VLI	NA	NA	VLI	Ind	Ind	LI	VLI	NA	LI	LW	Ind	VLI	VLI	Ind	LI	LI	Ind	LI	Ind
Tauranga Harbour at Mount Maunganui	-	LI	-	LI	-	VLI	-	VLI	-	VLI	-	LI	-	LI	-	LI	-	LI	-	Ind	-	VLI	-	VLI	-	Ind	-	LW
Tauranga Harbour at Tanners Point Jetty	LI	Ind	LI	Ind	NA	VLI	LW	LW	VLI	VLI	VLI	LI	Ind	Ind	LI	Ind	NA	VLI	LW	Ind	VLI	VLI	LI	LI	VLI	Ind	LI	LW
Tauranga Harbour at Tilby Point	-	Ind	-	LI	-	Ind	-	LW	-	VLI	-	LI	-	LI	-	LI	-	Ind	-	Ind	-	Ind	-	VLI	-	LI	-	LW
Tauranga Harbour at Waikareao	-	LI	-	Ind	-	VLI	-	Ind	-	VLI	-	VLI	-	LW	-	VLI	-	LI	-	Ind	-	VLI	-	VLI	-	LI	-	Ind

6 Estuary state

6.1 River estuaries

River estuaries are very dynamic environments with daily tidal fluxes and frequent changes in freshwater inputs, from flood flows to drought conditions. The water quality of river estuaries are usually dominated by freshwater creating longitudinal and vertical salinity gradients. Flood flows and the delivery of sediment and nutrients can result in these estuaries being light-limited compared to more saline waters. In the Bay of Plenty the river estuaries are characterised by little, if any, aquatic vegetation or macro-algae and there is little evidence of eutrophication.

6.1.1 Nutrients

The distribution of nutrient and chlorophyll-*a* concentrations are shown in Figure 6.1–6.4. The Rangitāiki and Tarawera Rivers are highest in nitrogen and phosphorus, likely due to diffuse discharges from land activities and point source industrial discharges. The Whakatāne, Waiōtahe and Ōpōtiki Estuaries have no major point source discharges and in comparison to the Tarawera and Rangitāiki rivers, have less land use activity that could result in diffuse contamination (Figure 6.2). The Waiōtahe and Tarawera have the largest percentage of nitrogen in its organic form i.e. not nitrate or ammoniacal-N. Ammoniacal-N is highest in the Waiōtahe Estuary followed by Tarawera, suggesting a potential dairy signature given the low gradient pumped drainage scheme in both of these catchments. The median of all the river estuary sites exceed the ANZECC guidelines for ammoniacal-N, however as discussed above, these guidelines are likely to be too low for New Zealand waters.

The ETI provides a banding system for chlorophyll-*a* as discussed in section 3.4. The Rangitāiki is the only river estuary that does not fall in the 'A' attribute, with the 90th percentile exceeding the 5 mg/m^3 threshold at 5.18 mg/m^3 (Figure 6.3).

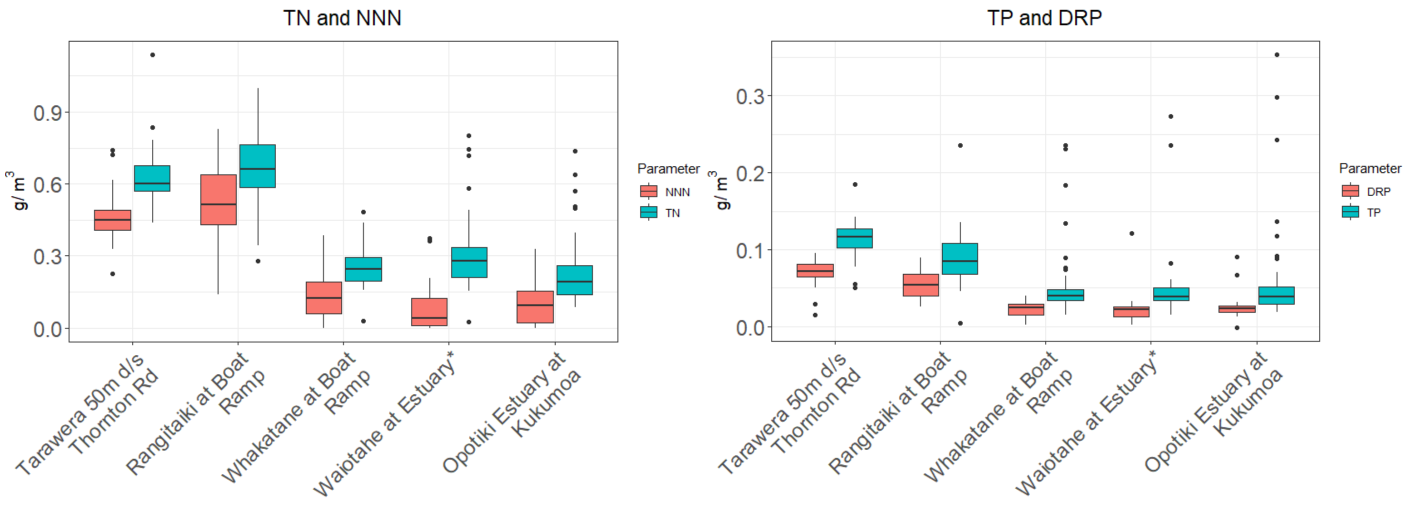

Figure 6.1 Box and whisker plots for river estuary total nitrogen and nitrate-nitrite-nitrogen; and total phosphorus and dissolved reactive phosphorus. Data from mid-2015 to mid-2020.

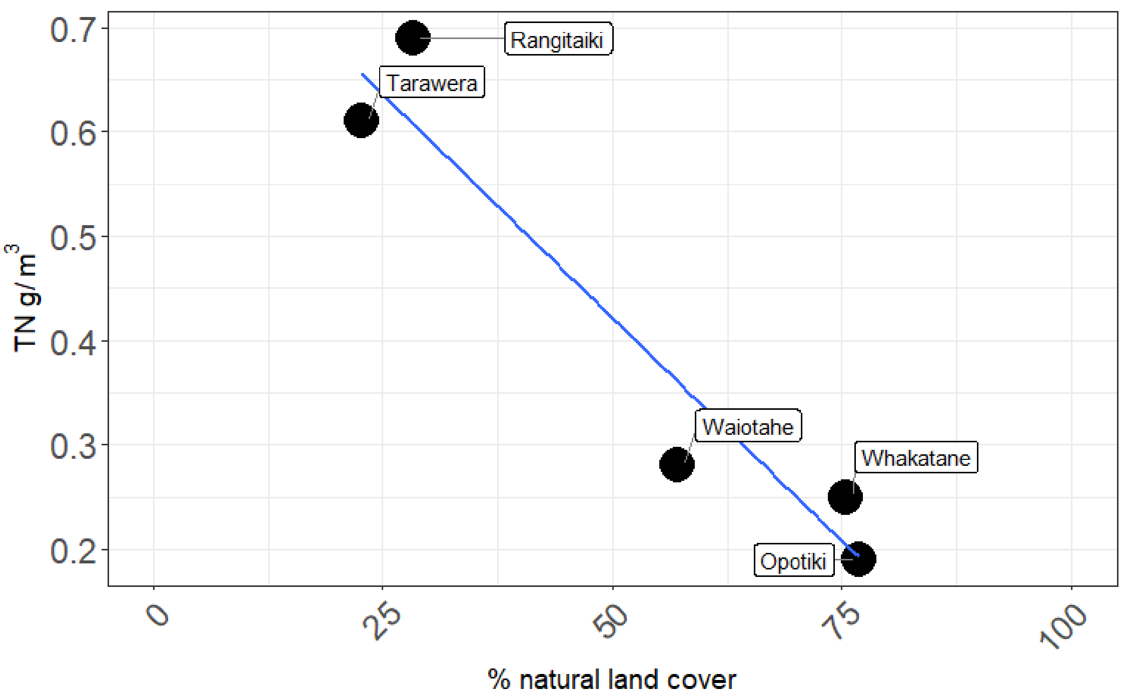

Figure 6.2 River Estuary total nitrogen concentrations against percentage natural land cover (land cover data sourced from RECv1)

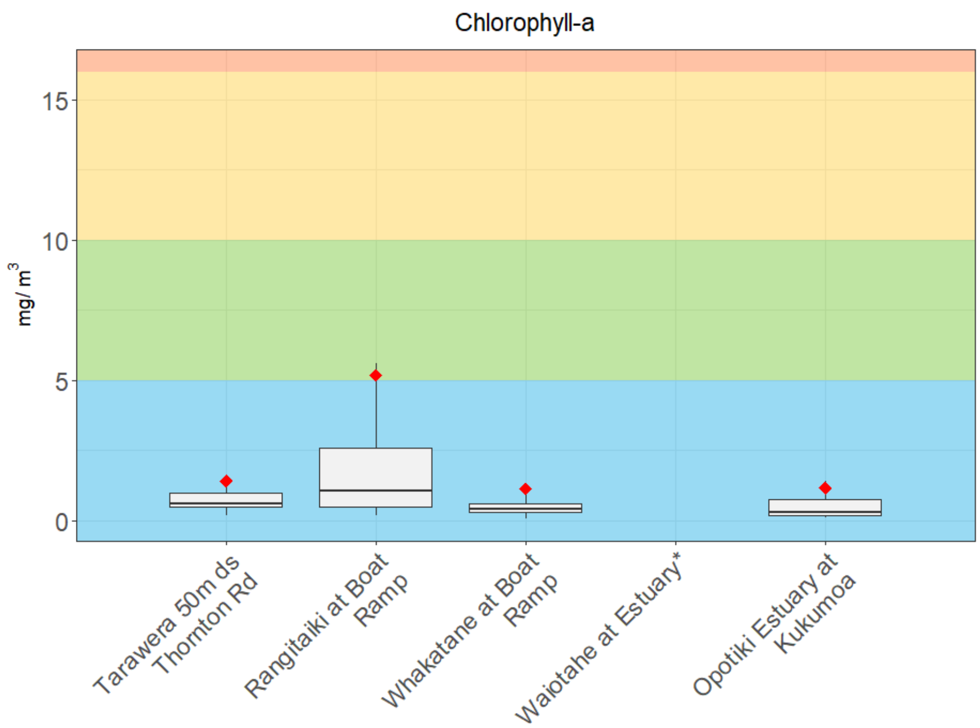

*Figure 6.3 Box and whisker plots for river estuary chlorophyll-a concentrations between mid-2015 to mid-2020. Blue = A band, Green = B band, Orange = C band, Red = D band. Red points are the 90th percentiles. *Waiōtahe has not had chlorophyll-a analysed as it was not initially established as a NERMN site.*

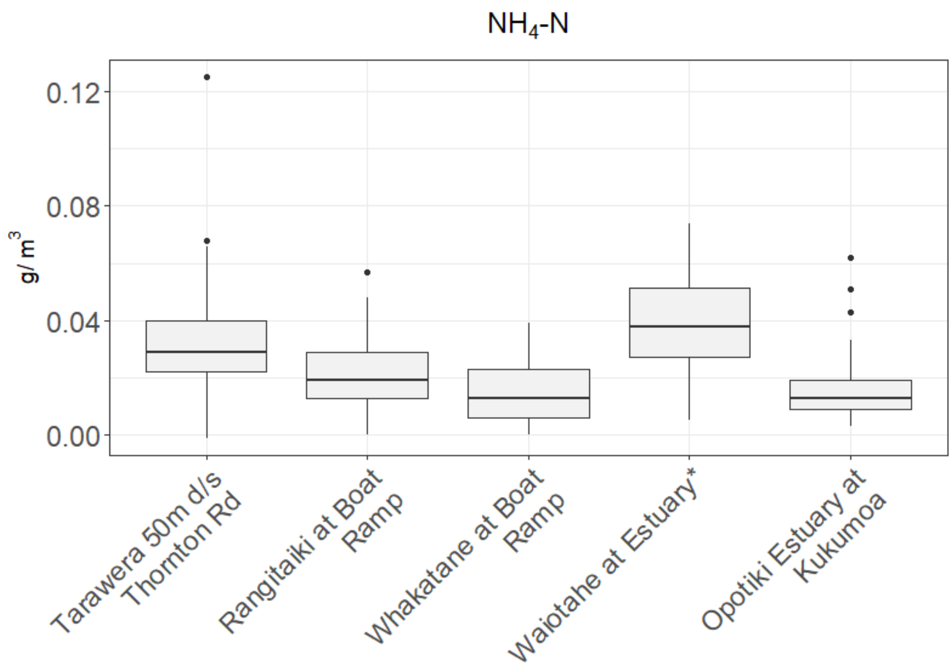

Figure 6.4 *Box and whisker plots for river estuary ammoniacal-N concentrations between mid-2015 to mid-2020.*

An understanding of the nutrient limiting plant growth is important when attempting to manage eutrophication. The relationships between chlorophyll-*a*, dissolved inorganic nitrogen (DIN) and dissolved reactive phosphorus (DRP) are shown in Figure 6.5 for the riverine estuaries. These show the following:

- Results are similar to that from Scholes (2015) indicating that nutrient limitation patterns have not changed within the last five years.
- In the Rangitāiki River, Ōpōtiki, Waiōtahe, and Whakatāne River estuaries phytoplankton appear to be more co-limited in terms of nutrients.
- In the Tarawera River Estuary the DIN:DRP ratio suggests nitrogen limitation (based on Redfield weight ratio where <7:1 for DIN:DRP suggests nitrogen limitation). Figure 6.5 show little response in chlorophyll-*a* to either DRP or DIN. As Scholes (2015) identifies, this would suggest that other factors such as light limitation may be limiting phytoplankton growth. While water clarity has been improving, there has been no statistical change detected in chlorophyll-*a*.

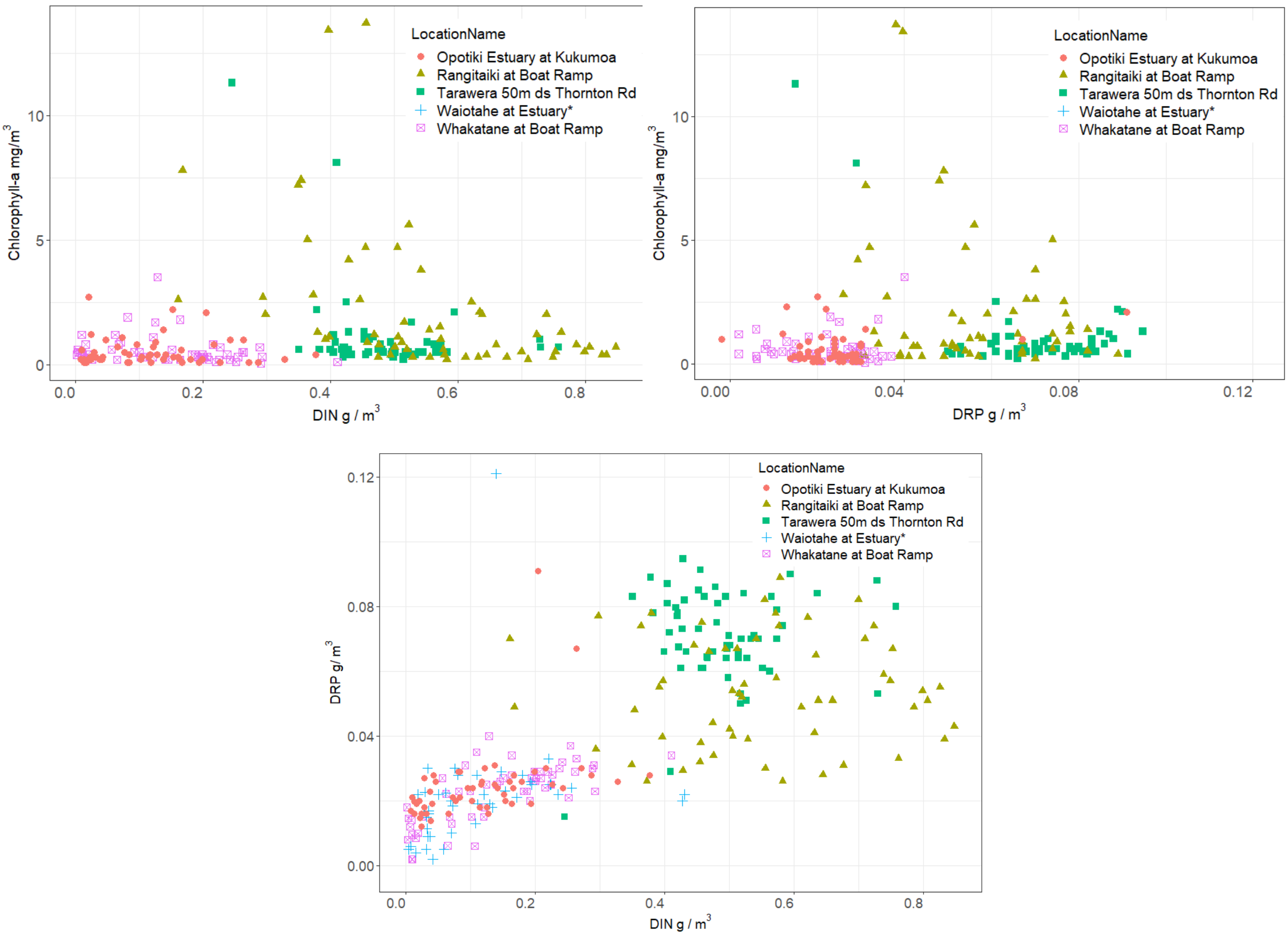

Figure 6.5 *Relationships between chlorophyll-a and DIN (top left), chlorophyll-a and DRP (top right), and DRP and DIN (bottom) for river estuaries. Data from mid-2015 to mid-2020.*

6.1.2 Sediment

Sedimentation may not be such an issue in river estuaries as flushing is more prominent than in tidal lagoons. All medians are below the ANZECC guideline of 10 NTU. Turbidity does reach over 100 NTU at both Whakatāne and Ōpōtiki river estuaries on more than one occasion (Figure 6.6).

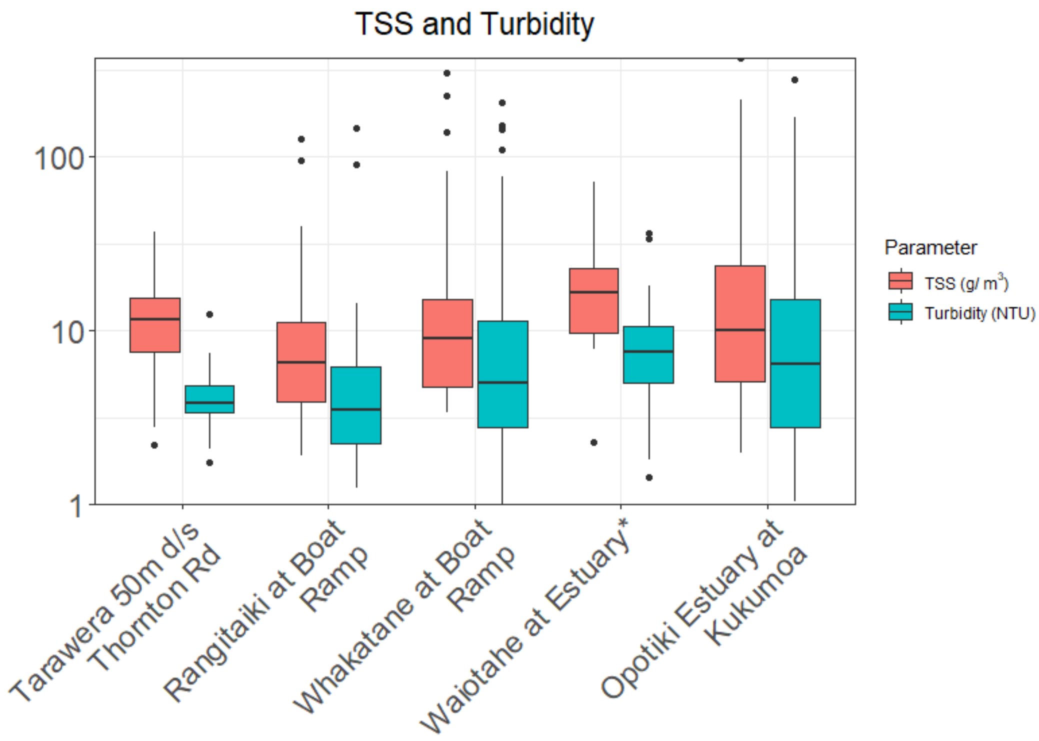

Figure 6.6 *Box and whisker plots of river estuary TSS concentrations and turbidity between 2015 and 2020.*

6.1.3 Bacteria

Because riverine estuaries are at the bottom of river catchments they are vulnerable to faecal contamination events which occur due to rainfall events. *E.coli* are the preferred indicator of faecal contamination risk to human health in many of the riverine estuaries due to the low salinity (generally oligohaline with salinity at 0 ppt-5 ppt). For saline waters enterococci are the preferred indicator of faecal contamination and which may be relevant to the Whakatāne and Ōpōtiki estuaries[3], however, the resulting microbiological grading of *E.coli* and Enterococci are not significantly different (Figure 6.7). Over the period 2015 to 2020 all of the river estuaries exceeded the Microbiological Guideline red alert mode (*E.coli* greater than 550 cfu/100 ml) on at least two occasions. The median *E.coli* levels for all estuaries were well below the orange alert level (260 cfu/100 ml) indicating that the estuaries are generally safe for contact recreation.

[3] Whakatāne and Ōpōtiki salinity is often over 5 ppt, median = 3.83 and 1.99, upper quartile = 8.07 and 5.11 respectively.

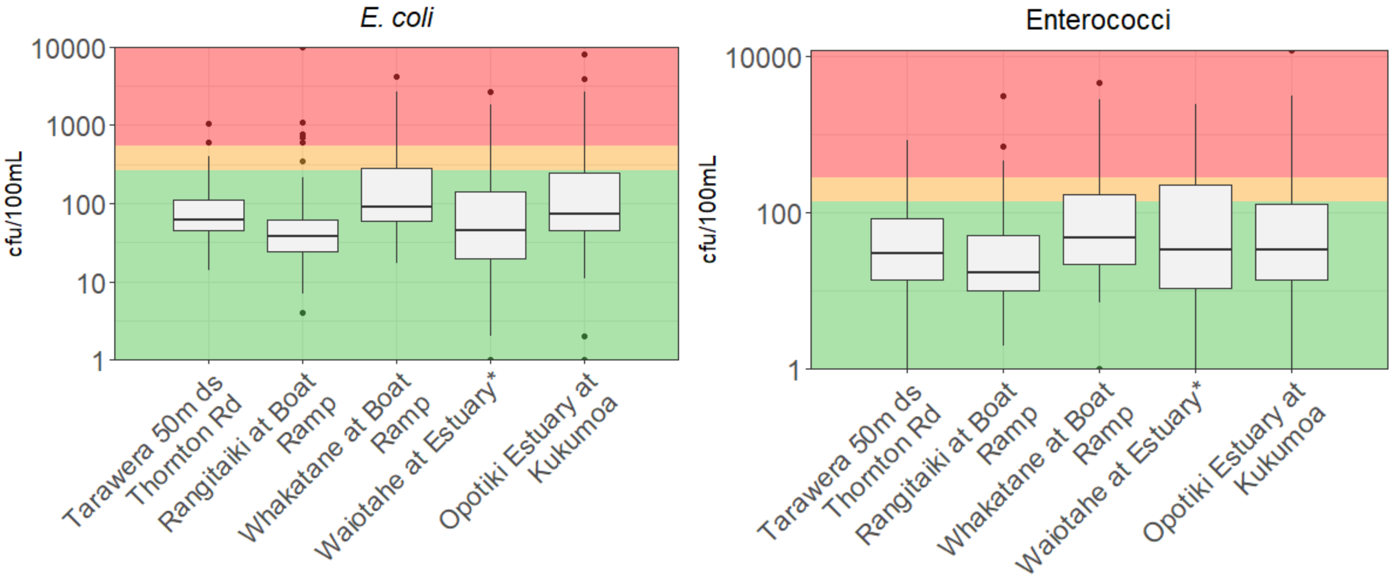

Figure 6.7 Box and whisker plots of E. coli and enterococci river estuary concentrations between mid-2015 and mid-2020.

6.2 Eastern and central estuaries

The eastern and central estuaries are comprehensively monitored as part of the NERMN estuary ecological monitoring programmes which includes monitoring of seagrass, macro algae and macro benthic communities (e.g. Bevan, 2018; Park, 2012). The three estuaries described in this section are tidal lagoons of moderate size and have lower levels of fresh water influence. All of these estuaries have one dominant freshwater input and over 70% of their intertidal area is exposed sand and mudflats at low tide. The ETI classes them as SIDEs (Ōhiwa and Maketū) or SSRTRE (Waihī), indicating short residence times.

6.2.1 Nutrients

Previously these estuaries have shown similar levels of nutrients, however, with the change of sample time, the Waihī Estuary shows a clear elevation of nutrients (Figure 6.8). This will be reflective of the mid-ebb tide capturing higher freshwater input compared to the previous high tide sampling. Trend analysis in the Pongakawa River (which discharges to Waihī Estuary) showed worsening trends in many of the nutrient parameters (Hamill et al., 2020). This could suggest that the elevation in nutrients could also in part be a result of worsening trends in the catchment. Maketū Estuary is elevated compared to Ōhiwa, but not to the same extent as Waihī.

Waihī has a higher proportion of nitrate contributing to TN, indicating a higher freshwater influence and/or higher contamination of freshwaters. TP and DRP are also higher in the Waihī Estuary. Ammoniacal-N concentrations are similar at Maketū and Waihī but both are elevated in comparison to Ōhiwa (Figure 6.9). All sites are above the ANZECC trigger for ammoniacal-N of 0.015 g/m^3.

It should be noted that these results are mostly from before the Kaituna re-diversion, which has since resulted in significant ecological improvements in the Maketū Estuary (Park, 2020). It is predicted that some water quality parameters may degrade post the diversion as there is now a larger freshwater influence (Park, 2018a; Scholes, 2018). Therefore these results may be underestimating the now current water quality condition in the Maketū Estuary.

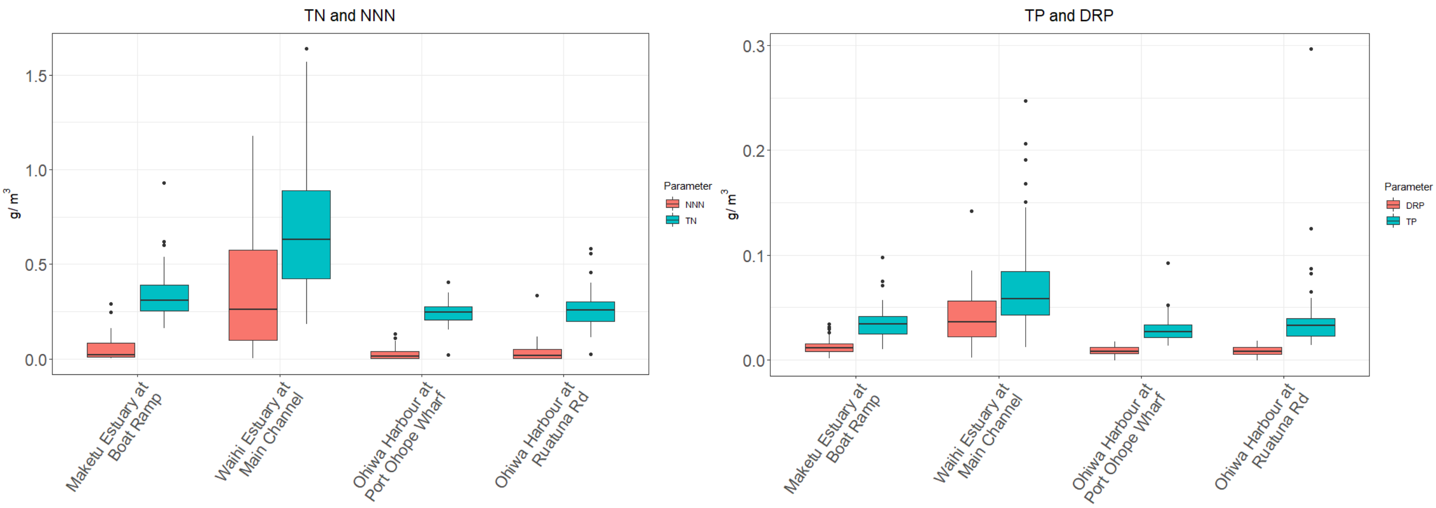

Figure 6.8 *Box and whisker plots for eastern and central estuary total nitrogen and nitrate-nitrite-nitrogen; and total phosphorus and dissolved reactive phosphorus. Data from mid-2015 to mid-2020.*

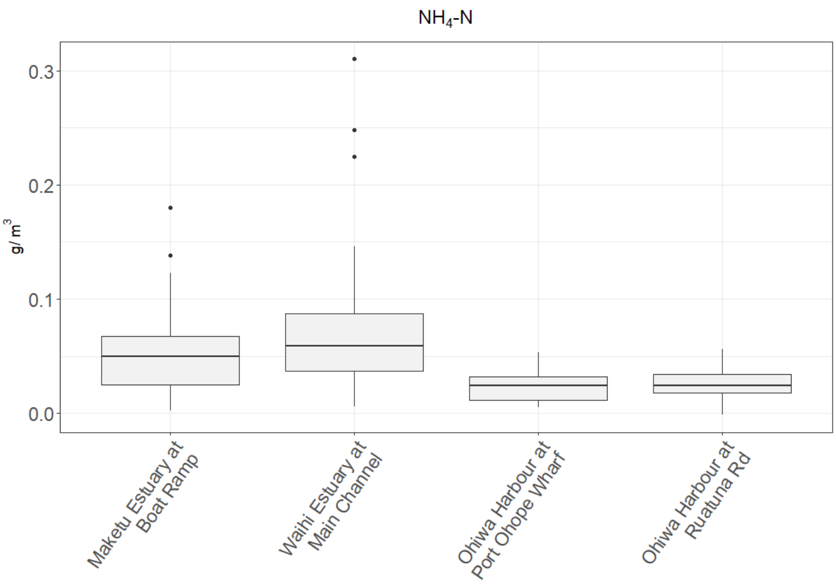

Figure 6.9 *Box and whisker plots for central and eastern estuary ammoniacal-N concentrations between mid-2015 to mid-2020.*

Figure 6.10 shows the distribution of chlorophyll-*a* concentrations at the three estuaries. All fall within the ‘A’ band developed for the ETI. Ōhiwa Harbour appears to have slightly higher chlorophyll-*a* concentrations than Maketū and Waihī. As discussed in Section 3.4, chlorophyll-*a* isn’t necessarily a good indicator in these estuaries due to the low residence time of waters. Primary indicators for eutrophication effects should be macroalgae growth.

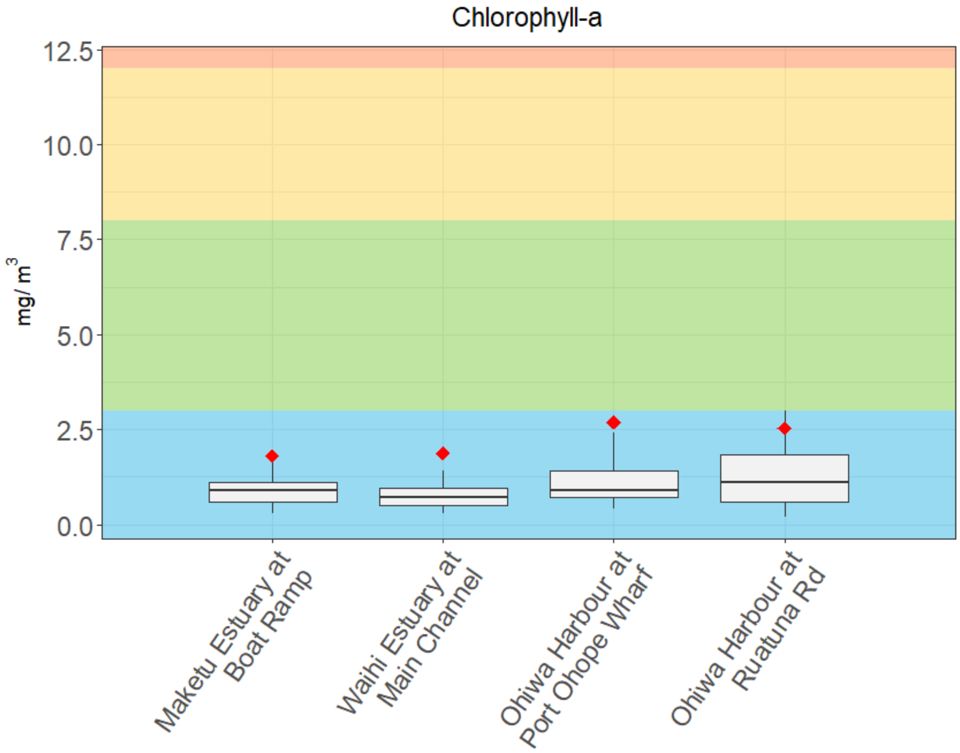

Figure 6.10 Box and whisker plots for central and eastern estuary chlorophyll-a concentrations between mid-2015 to mid-2020. Blue = A band, Green = B band, Orange = C band, Red = D band.

The relationships between chlorophyll-*a*, dissolved inorganic nitrogen (DIN) and dissolved reactive phosphorus (DRP) are shown in Figure 6.11 for the central and eastern estuaries, these show the following:

- The DIN:DRP ratio suggests all three estuaries appear to be nitrogen limited.
- Figure 6.11 shows little response in chlorophyll-*a* to either DRP or DIN. As identified above, this would suggest that other factors such hydraulic stability may be limiting phytoplankton growth.

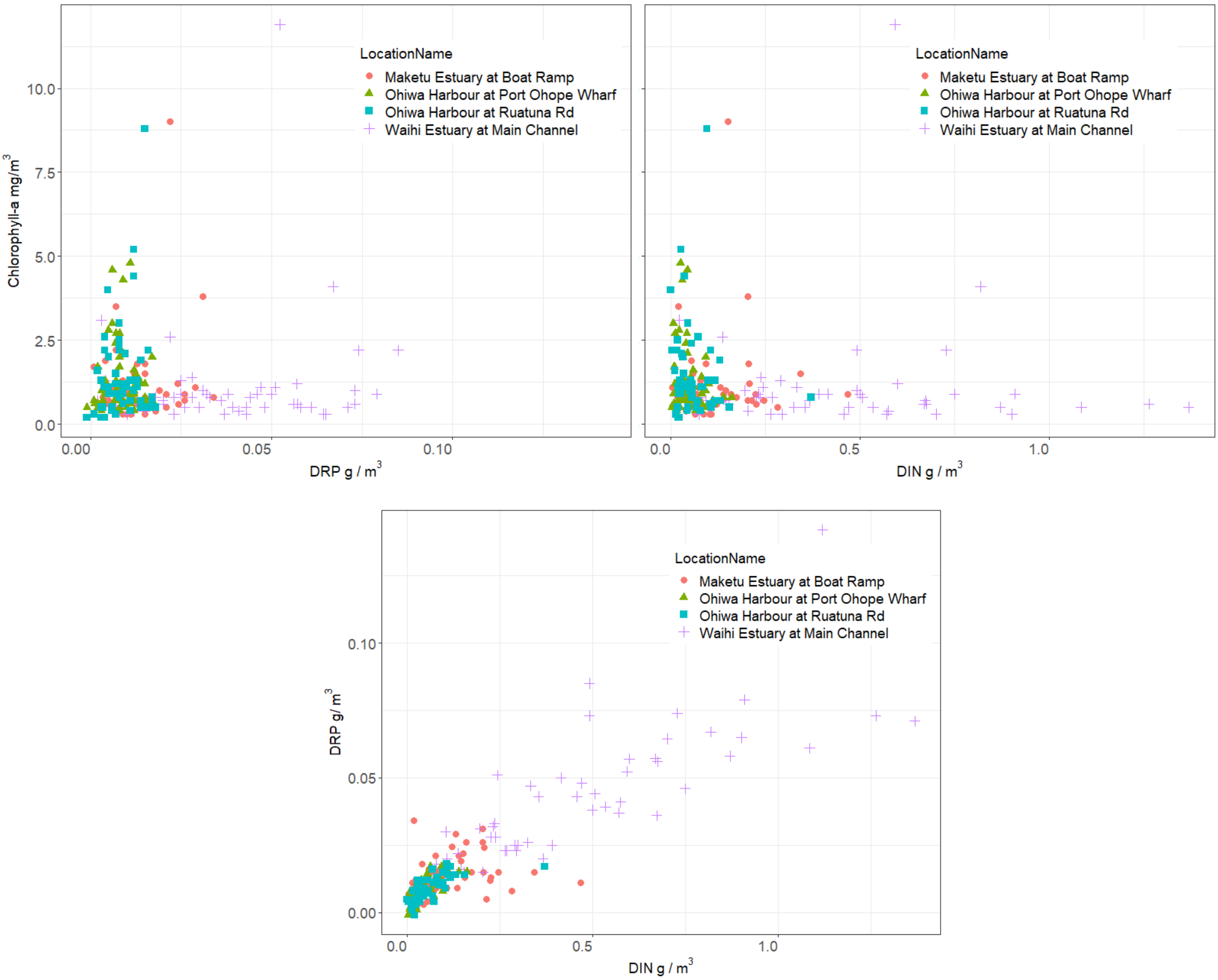

Figure 6.11 Relationships between chlorophyll-a and DIN (top left), chlorophyll-a and DRP (top right), and DRP and DIN (bottom) for central and eastern estuaries. Data from mid-2015 to mid-2020.

6.2.2 Sediment

Turbidity is below the ANZECC guidelines for south-east Australia at all sites but Ōhiwa Harbour at Ruatuna Road, which is just over (10.28 vs. 10.0) (Figure 6.12). Scholes (2015) reported that these estuaries have relatively higher suspended sediment concentrations compared to river estuaries. This is consistent with results in this report, even with the change in sample time to the mid-ebb tide (median values 16.1–24.8 and 7.0–16.7 for eastern and central estuaries and river estuaries respectively). This is to be expected given the shallower depth and being more susceptible to sediment re-suspension than in deeper well-flushed estuaries such as the river estuaries.

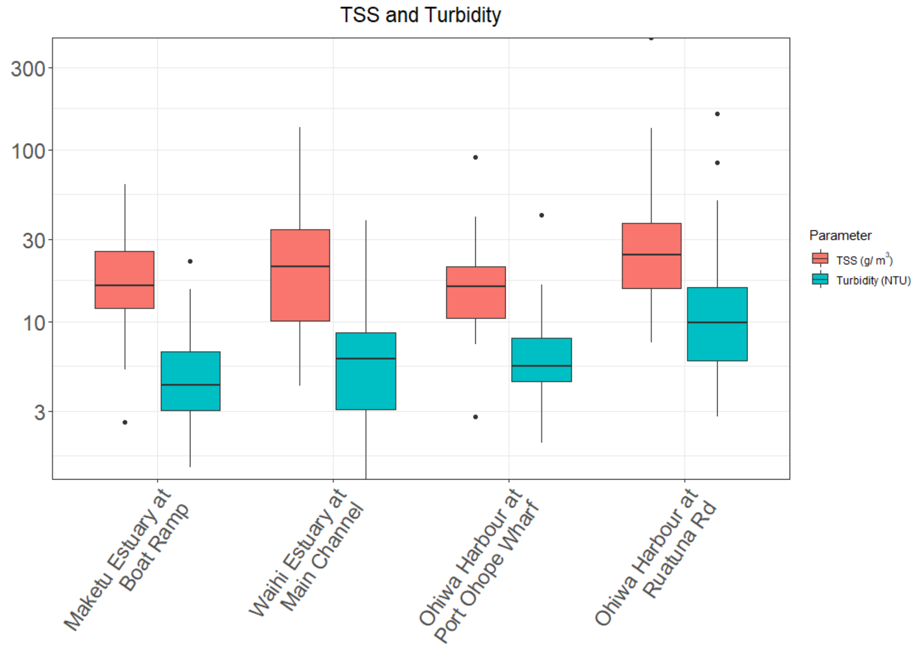

Figure 6.12 Box and whisker plots of central and eastern estuary TSS concentrations and turbidity between 2015 and 2020.

6.2.3 Bacteria

For saline waters enterococci are the preferred indicator of faecal contamination although levels of *E.coli* and enterococci are not significantly different at the eastern and central estuaries (Figure 6.13). Over the period 2015 to 2020 all of the estuaries exceeded the Microbiological Guideline red alert mode (enterococci greater than 280 cfu/100 ml) on at least one occasion. The median enterococci levels for all estuaries were well below the orange alert level (140 cfu/100 ml) indicating that the estuaries are generally safe for contact recreation.

It was predicted that bacterial contamination of Maketū Estuary may increase post the Kaituna re-diversion, due to the increased freshwater input to the estuary. The full increase in flow was added in February 2021, which is outside the analysis period here.

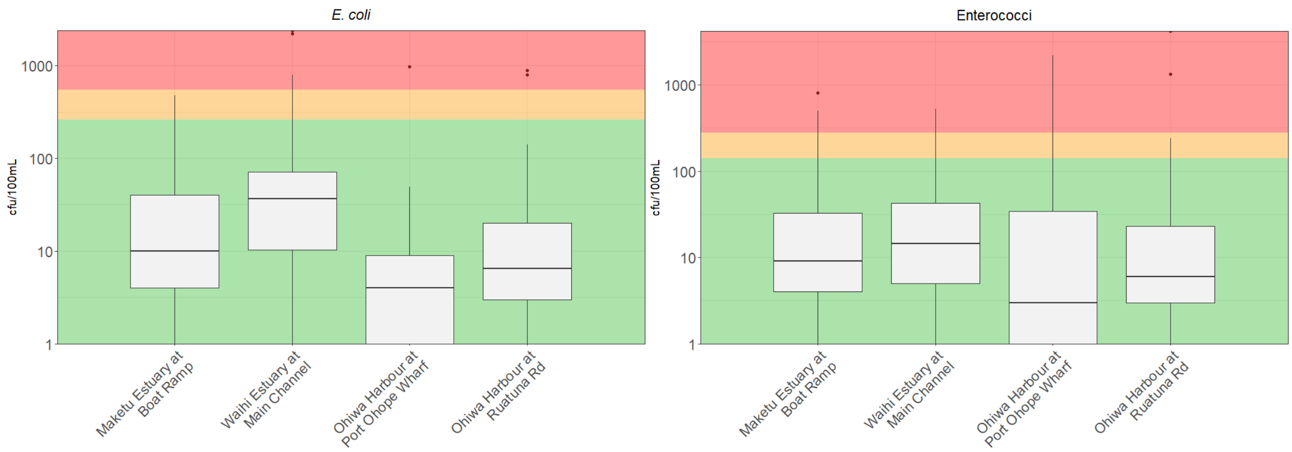

Figure 6.13 Box and whisker plots of E. coli and enterococci concentrations at central and eastern estuaries between mid-2015 and mid-2020. Green = Safe, Orange = Amber, Red = Action.

6.3 Tauranga Harbour

It is clear that the sub-estuaries of Tauranga Harbour, particularly those further away from the harbour entrance, are more likely to accumulate sediments and contaminants (Crawshaw, 2021a). It is in these areas that benthic macrofauna have been found to be negatively impacted as determined by species response curves (Ellis et al., 2013).

6.3.1 Nutrients

Nitrogen concentrations are reasonably consistent throughout the Tauranga Harbour (Figure 6.14). They are lower than the likes of Maketū, Waihī, Rangitāiki and Tarawera. Compared to the other estuaries, there is a smaller proportion as nitrate, which could indicate lower nutrient contamination in the catchment compared to the other estuaries, or faster uptake of nitrate by primary producers or microbial processing (denitrification). Considering that only 27% of Tauranga Moana is in agriculture and horticulture (Lawton & Conroy, 2019) compared to approximately 50% in the Kaituna, Maketū and Pongakawa catchments, this isn't surprising. Within Tauranga Harbour, nitrogen concentrations are highest at Tilby Point and Waikareao.

Figure 6.14 shows that total phosphorus has the largest range at Tilby Point. Chlorophyll-*a* concentrations are also highest at Tilby Point, however it is still in the 'A' band indicating that it is in healthy state in relation to chlorophyll-*a* growth (Figure 6.16). As discussed above, chlorophyll-*a* is not necessarily a good indicator of eutrophication in estuaries with short residence times, which Tauranga Harbour has. Crawshaw (2020) assesses the macroalgal cover and other ecological sub-estuary health indicators. Most sites across the harbour show low nutrient concentrations in the sediment. Tilby Point is generally elevated compared to the other Tauranga Harbour sites. The Wairoa River is the largest freshwater input into the harbour and discharges into this sub-estuary area. Therefore, the elevated concentrations at Tilby Point possibly reflect surface water contamination.

Crawshaw (2020) reports Waikareao is the worst ranked in terms of macroalgae cover. River water quality data for Tauranga Moana show some of the highest ammoniacal-N concentrations in the lower Kopurererua River that feeds into the Waikareao estuary (Hamill et al., 2020). This is consistent with the estuary water quality results that shows ammoniacal-N concentrations at Tauranga Harbour at Waikareao to be generally higher than the other water quality sites in Tauranga Harbour (Figure 6.15). The Waikareao sub-estuary is also the most impounded sub-estuary in the harbour which would contribute to the containment of contaminants.

Groundwater inputs have recently been identified to be a large source of nutrient loading to the harbour, often greater than that of surrounding rivers (Stewart et al., 2018). The groundwater can have long lag times from initial nutrient deposition onto land, to appearance in the harbour. Thus, there may be the potential for nutrient rich groundwater to be an ongoing source of nutrients to the harbour, even if the water quality in the rivers improve (Crawshaw, 2021b).

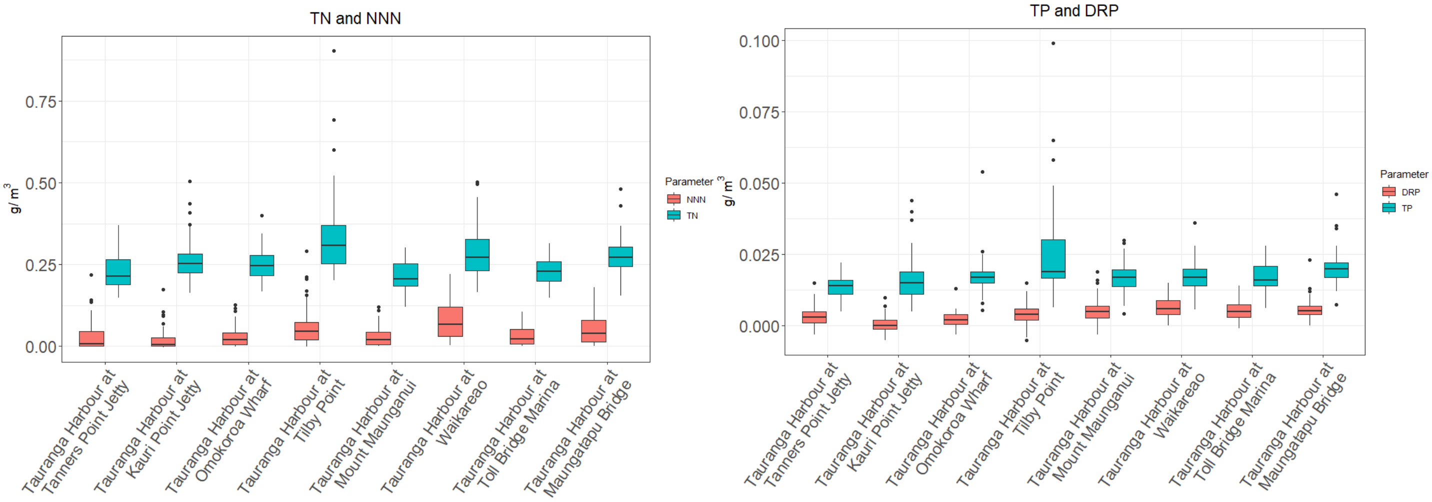

Figure 6.14 Box and whisker plots for Tauranga Harbour total nitrogen and nitrate-nitrite-nitrogen; and total phosphorus and dissolved reactive phosphorus. Data from mid-2015 to mid-2020.

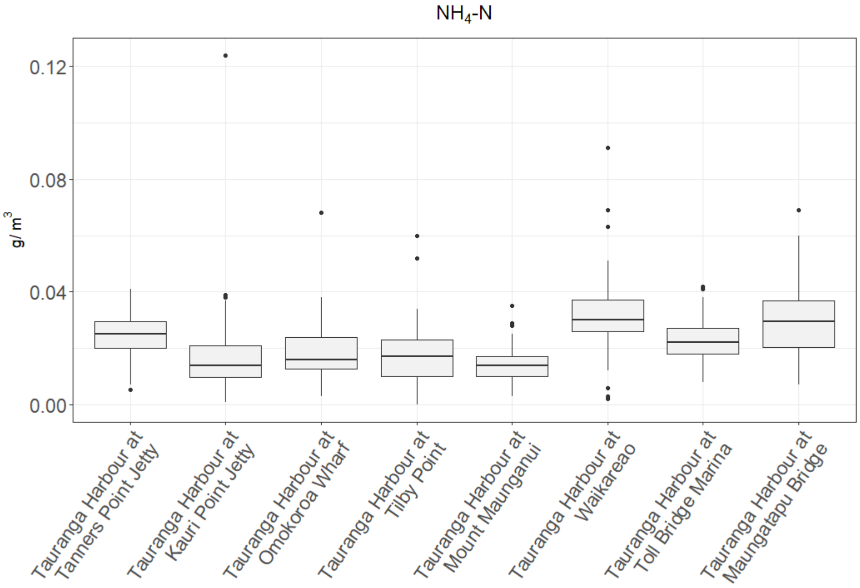

Figure 6.15 Box and whisker plots for Tauranga Harbour ammoniacal-N concentrations between mid-2015 to mid-2020.

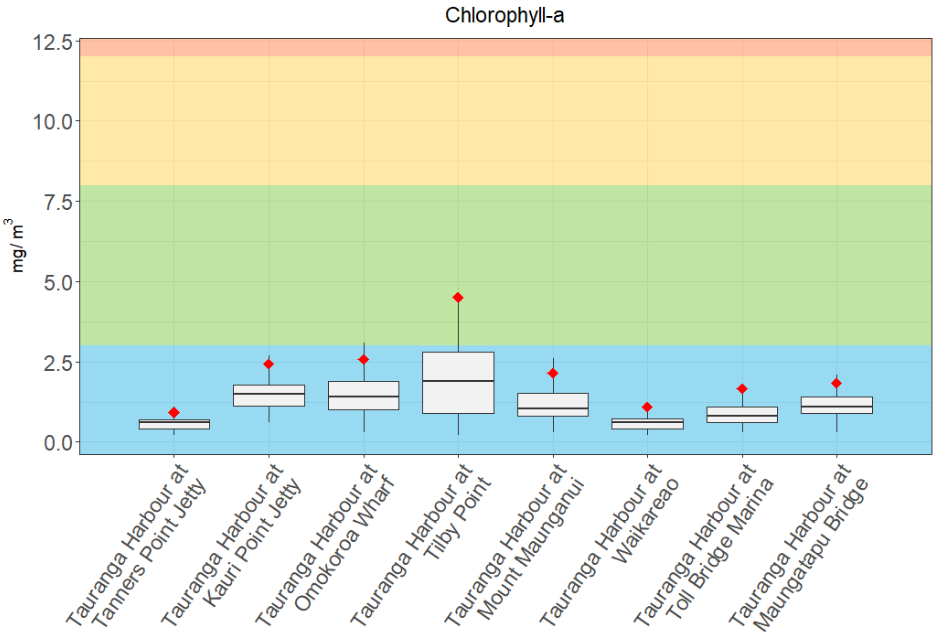

Figure 6.16 Box and whisker plots for Tauranga Harbour chlorophyll-a concentrations between mid-2015 to mid-2020. Blue = A band, Green = B band, Orange = C band, Red = D band.

6.3.2 Sediment

Mud content in Tauranga Harbour is monitored as part of the NERMN programme. Fine sediments are accumulating at a higher rate than background levels at 59% of sites monitored (Lawton & Conroy, 2019). Less than half of the sites monitored in Tauranga Harbour (65 out of 141) have a mud level graded as good or very good. The muddy sites are generally isolated to the low energy sub-estuaries around Tauranga Harbour, where fine sediments are accumulating and changing the sediment composition (Crawshaw, 2020). The Uretara and Mangawhai Estuaries are rated as 'poor' in terms of mud content (Crawshaw et al., 2021). This is not necessarily reflected in the water quality results with all sites being reasonably consistent for both TSS and turbidity. Scholes (2015) reported the southern sub-estuaries to have the highest turbidity and TSS maximums, whereas the 2015–2020 results show the northern sites (Kauri Point Jetty and Tilby Point) to have the highest maximums (Figure 6.17). This may be a result of the change in sample time, but also a reflection of the change in site locations around Tauranga Harbour. Tilby Point is often turbid at the sample location due to the shallow depth accessible to the sampler. Efforts are made to sample beyond the area of where the water and substrate is stirring, but this is not always achievable. This is likely to contribute to the large range in TSS and turbidity results for Tilby Point. Overall however, turbidity is generally low and below 10 NTU at all sites indicating water clarity is good.

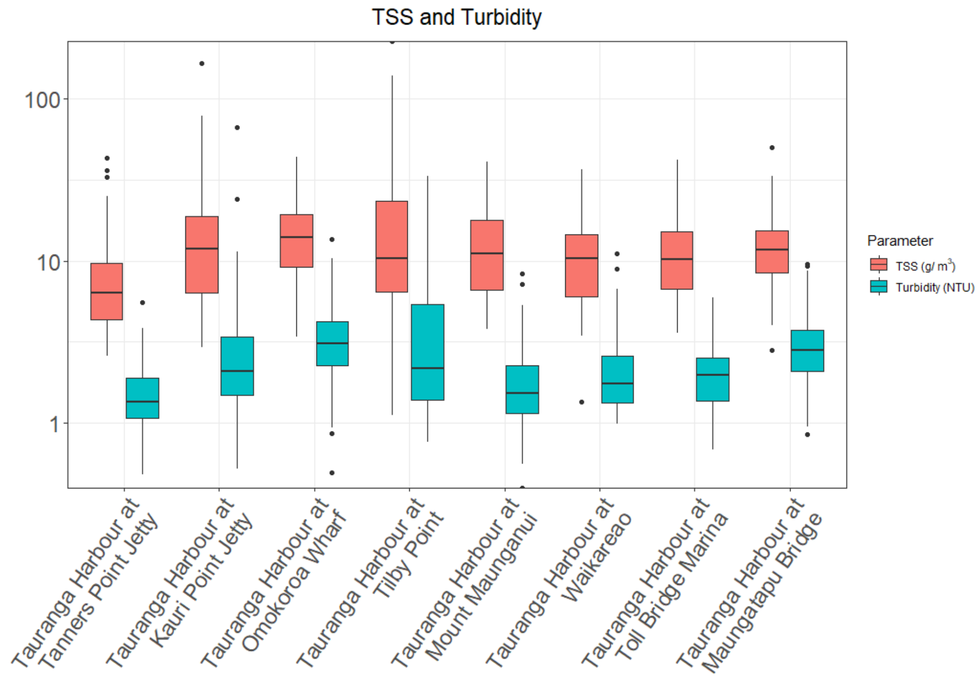

Figure 6.17 Box and whisker plots of Tauranga Harbour TSS concentrations and turbidity between 2015 and 2020.

6.3.3 Bacteria

Enterococci would be the preferred indicator for the Tauranga Harbour sites for bacterial contamination as salinity medians range from 29.7 ppt–33.9 ppt. Faecal indicator bacteria results show that the recreational water quality of Tauranga Harbour is generally good (Figure 6.18). Tilby Point shows higher bacterial contamination on average. Over the period 2015 to 2020 five out of the eight sites exceeded the Microbiological Guideline red alert mode (Enterococci greater than 280 cfu/100 ml) on at least one occasion. The median enterococci levels for all sites were well below the orange alert level (140 cfu/100 ml) indicating that the Harbour is generally safe for contact recreation.

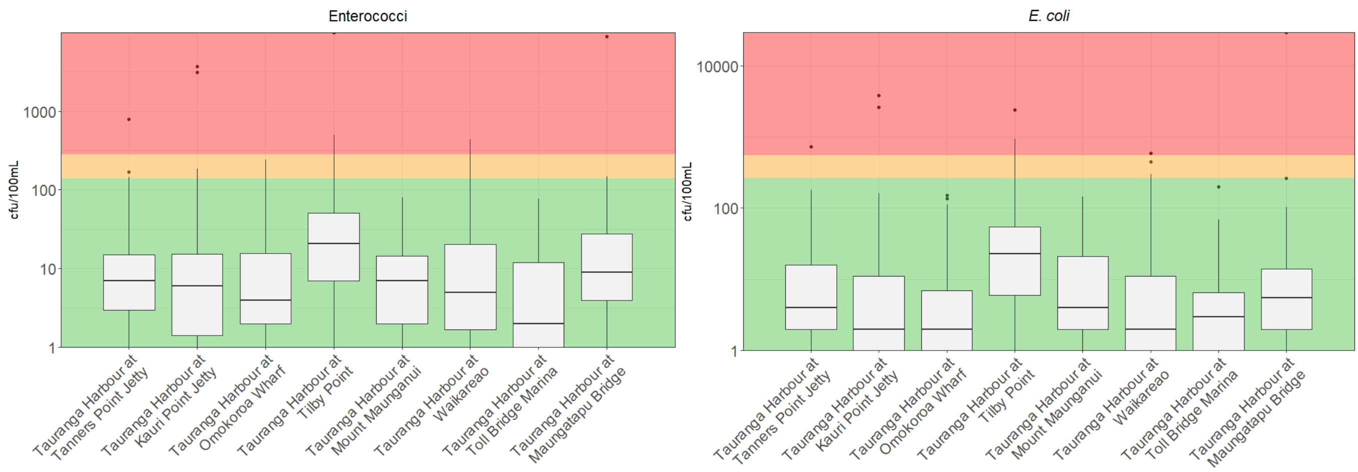

Figure 6.18 Box and whisker plots of E. coli and enterococci concentrations at Tauranga Harbour between mid-2015 and mid-2020. Green = Safe, Orange = Amber, Red = Action.

6.3.4 Continuous monitoring

A new water quality continuous monitoring site (EXO Sonde) was installed in June 2020 at Tauranga Toll Bridge Marina. This meter measures continuous data including specific conductance (ms/cm), salinity (ppt), water temperature (°C), dissolved oxygen (mg/l and % saturation), blue-green algae phycoerythrin (RFU), chlorophyll (RFU), turbidity (FNU), and pH. This instrument will provide real time data to provide a better assessment of water quality within the harbour, particularly under rainfall events. Data is currently being reviewed and processes streamlined for calibration and cleaning of the sensor. An analysis of the data will be reported on separately to this report.

7 Summary

The following summarises water quality state in the Bay of Plenty estuaries. Trends are not discussed here in detail due to the split of the data discussed in Section 3.2.

7.1 River estuaries

Tarawera River Estuary

- Improving trends in turbidity suspended solids, bacterial contamination and ammoniacal-N - this is likely largely due to improvements in industrial discharges.
- Total nitrogen and nitrate-nitrogen are second highest in the river estuaries, while TP and DRP are the highest.
- The nitrogen to phosphorus ratio suggests the estuary is nitrogen limited. But there has been no indication of an increase in chlorophyll-*a* which might indicate that light limitation may still be impacting the river.

Rangitāiki River Estuary

- Highest TN and NNN concentrations out of the river estuaries.
- Lowest bacterial contamination out of the river estuaries. Although, all the river estuaries have relatively low bacterial contamination.
- The nitrogen to phosphorus ratio suggests co-limitation for phytoplankton growth.
- Chlorophyll-*a* is the highest out of the river estuaries, reaching in to the ‘B’ band, corresponding to the higher nutrient levels.

Whakatāne River Estuary

- Highest bacterial contamination out of the river estuaries, along with trends indicating this may be worsening. Although, the median is still within the ‘Safe’ category for contact recreation.
- The nitrogen to phosphorus ratio suggests co-limitation for phytoplankton growth.

Waiōtahe River Estuary

- Highest ammoniacal-N out of the river estuaries. This is higher than the ANZECC (2000) guidelines, but these guidelines are considered low for New Zealand estuarine waters.
- The nitrogen to phosphorus ratio suggests co-limitation for phytoplankton growth.
- TSS and turbidity have the highest median out of the river estuaries.
- Bacterial contamination in the water column is not the highest even though there are shellfish contamination issues here.

Ōpōtiki River Estuary

- Largest range for TSS and turbidity out of the river estuaries, suggesting strong effects from discharges or resuspension during rainfall or tidal movements.
- The nitrogen to phosphorus ratio suggests co-limitation for phytoplankton growth.
- Ammoniacal-N is the lowest out of the river estuaries.

7.2 Central and eastern estuaries

Maketū Estuary

- Results reported here do not reflect the state post the Kaituna re-diversion.
- The bacterial guidelines for recreational use are rarely exceeded (this is excluding faecal coliforms for shellfish harvesting).

Waihī Estuary

- Highest concentrations for all nutrients.
- Nutrient ratios suggest nitrogen limitation for phytoplankton growth. Chlorophyll-*a* is not a great indicator for eutrophication in these types of estuaries, explaining why chlorophyll-*a* is low in the Waihī Estuary.

Ōhiwa Harbour

- Chlorophyll-*a* is higher than the other central and eastern estuaries. Ohiwa is in the 'B' band for eutrophication based on the ETI Tool 2 (Park, 2020).
- Does not have highest TSS or turbidity even though there are known issues around sedimentation. This could be because the sampling largely captures baseflow conditions.
- Bacterial contamination is generally low in terms of contact recreations. Although the shellfish guidelines are often exceeded.

7.3 Tauranga Harbour

- Nutrient parameters are relatively consistent across the harbour.
- Tilby Point has the highest nitrogen and phosphorus levels as well as chlorophyll-*a*. This may be a result of site conditions being shallow and sediment easily re-suspended when windy, as well as the major inflow from the Wairoa River.
- Ecological data indicates many sites are accumulating fine sediment faster than background levels. The water quality results here do not necessarily show this. This could be due to the monitoring programme largely capturing baseflow conditions.

8 Discussion and recommendations

The analysis and conclusions from this report are limited due to the sample time change in 2015. As highlighted in the above sections, trend analysis on five years' worth of data generally provide unreliable results as the time period does not adequately account for climatic variation or the inherent variation observed in water quality data. Water quality guidelines for estuaries are also limited, providing little context to the values measured. This section discusses usefulness of estuary water quality monitoring and the factors to consider when assessing the effectiveness of the current monitoring programme. This discussion should inform the review of monitoring triggered through the Essential Freshwater Policy Programme (EFPP) to implement the NPS-FM.

8.1 Usefulness of estuarine water quality monitoring

To understand the state of an estuary, bio-indicators and sediment characteristics are generally favoured over water quality as is exemplified in the data that informs the ETI (Barr et al., 2013; Dudley et al., 2018; Hewitt et al., 2012; B. P. Robertson et al., 2016). This is because there are many factors that cause high temporal and spatial variability in estuarine water quality. Factors include dilution, retention time, and biological processes affecting nutrient cycling and productivity.

The ANZECC guidelines for south-eastern Australia are often used to provide context to the data as an interim in the absence of more appropriate guidelines. Developing water quality guidelines that can be broadly adopted is therefore difficult and would likely need to be developed at a regional scale and if not estuary specific, at least estuary type specific (e.g. SIDE). Furthermore, the spatial variability within an estuary also makes it difficult to apply guidelines when one part of the estuary may be more sheltered and naturally hold higher concentrations of contaminants and another is well-flushed. State of the Environment monitoring (our NERMN programmes) is generally focused around determining state and trends. While estuary water quality may not provide much insight into the state of an estuary, it is considered that relatively frequent estuarine water quality monitoring over sufficient duration can show water quality changes that can be linked to changes in estuarine values and catchment processes (Boyer et al., 2006; Dudley et al., 2017, 2018). A review conducted for Horizon's Regional Council on their estuarine monitoring programme (Dudley et al., 2018) suggests that the best use of estuarine water quality monitoring is for comparison with long-term change in land use and pollutant loads, not as spatially representative measure of trophic state. It should be considered however that the Horizon's region has different estuarine systems compared to the Bay of Plenty (Horizon's region are largely river estuaries – SSRTE's).

Outside of New Zealand, a range of approaches are taken to estuary water quality monitoring. The New South Wales (NSW) government do not measure for nutrients due to the difficulties in relating measured nutrient levels in the water column to bio-indicators (OEH, 2016). Queensland on the other hand, do monitor for nutrients (and a full suite of water quality parameters) using a longitudinal format with multiple sites down the estuaries (Moss, 2018).

The data collected from NERMN programmes is often used for purposes outside of interpreting state and trends. A common use of the estuarine water quality data is to inform the development of models. While this data has proved useful for that purpose, targeted monitoring would likely provide more useful information and often targeted monitoring for storm events is required in addition to the NERMN data anyhow. There are likely many other potential outcomes desired by stakeholders from our monitoring programmes. An understanding of what these outcomes may be is required to determine if the current estuarine monitoring programme is fit for purpose.

8.2 Recommendations for estuary water quality monitoring

It is acknowledged that to make full recommendations for the estuarine water quality monitoring programme input from tangata whenua and stakeholders would be required. Here we make recommendations from the perspective of what the NERMN programme was initially designed to achieve in regards to State of the Environment monitoring - state and trends of our estuarine environments. Future designs should take these recommendations in to consideration along with input from tangata whenua and stakeholders.

Dudley et al (2017) undertook an investigation to collate, review and analyse existing coastal water quality data gathered by the 16 regional and unitary authorities. This was the first national-scale compilation and analysis for New Zealand coastal water quality. As a result, it highlighted some areas needing consistency to provide its purpose of state of the environment nationally and regionally. Table 8.1 below summarises the recommendations made in Dudley et al (2017) and where BOPRC sit in relation to that recommendation. Key points from Table 8.1 and other sources (e.g. Dudley et al., 2018; Ingley, 2021) are also discussed below.

Dudley et al (2017) highlights that monitoring for nutrients should occur in terminal river reaches, within estuaries and adjacent coasts. Longitudinal monitoring in riverine estuaries is a common approach as recommended in Dudley et al. (2018) and the approach taken by the Department of Environment and Science in Queensland (Moss, 2018). Our monitored estuaries have at least one river water quality site close to river terminal reaches, generally upstream of any saltwater wedge influence. However, the approach taken in Queensland and recommended for Horizon's, is to have more sites closer together from the freshwater environment, through the salt water wedge, to the open coast. This would provide an understanding of how the water quality changes through the estuarine environment and the relationship between trends in the river to trends in the estuary.

The benefits of holding onto current sites should not be disregarded, especially as being able to conduct trend analysis is a key objective of the monitoring (from an SoE perspective). If any changes were recommended, it would therefore likely involve additional sites rather than moving current site locations, unless a strong argument can be made that outweigh the benefits of long term datasets.

The tidal state that is targeted for monitoring is also inconsistent across regional councils. As discussed in this report, BOPRC changed the sample timing to be on the mid-ebb tide in 2015. This change has meant that we have not been able to undertake trend analysis for more than five years, but the results are now more consistent with what is seen in the river environment and the biological state of the estuaries (e.g. Waihī Estuary). The most appropriate method for assessing state may be randomising sample time with tidal state, however, for assessing trends, consistent tidal state sampling time would provide the most statistical power (Dudley et al., 2018). Dudley et al. (2018) recommend two approaches that achieve both state and trend outcomes. One being regular monthly monitoring at both high and low tide, the other sampling regularly without regard to tidal state, but noting the tide at the time of sampling. Neither of these are the approaches we take at BOPRC, but as Dudley et al (2017) highlights, different approaches may be suitable for different regional monitoring and reporting. The inconsistencies between regions can however, result in issues for national reporting. The best approach for regional monitoring will be determined by the desired outcomes of the monitoring programme. Our current programme is best set up to monitor long term trends in the estuary water quality. While monitoring at mid-ebb tide wouldn't provide information on the 'average' water quality state, it is providing information on when water quality is most likely at its worst in the estuary. Hence providing a 'worst-case' understanding.

As alluded to in the above discussions, there are many inconsistencies across regions in how estuary water quality monitoring is done. For instance, Waikato Regional Council only begun regular monitoring in some estuaries in 2017, with other estuaries beginning in 2019 and 2020 (WRC, n.d.). Northland Regional Council have been monitoring for a long period of time in various major estuaries, but similar to BOPRC, sampling frequency and timing has changed over time to provide more streamlined monitoring programmes (NRC, n.d.). There is as yet no national consensus on tide or time standardisation

The recommendation for SoE monitoring would be to focus on data collection for trend information. The current sample frequency and timing are appropriate for this. Consideration could be given to creating sites that assist in more longitudinal monitoring of inputs into estuaries, however as highlighted above, changing site locations should be considered carefully given the benefits of long-term datasets.

Table 8.1 Dudley et al (2017) Recommendations for national consistency and how our Estuary water quality programme measures on it.

Recommendation	BOPRC Status
Sites included in a national network should be replicated sufficiently with respect to environmental classes of catchment land use.	This has not been specifically assessed before, but we monitor at all significant estuaries. Some smaller river estuaries (particularly along the East Cape) are not monitored. It is recommended that this be reviewed as part of the EFPP. It would also need to be considered what is representative regionally for the purposes of BOPRC and seeing how this might align with national representativeness.
Sites included in a national network should be split proportionally across hydrosystem types.	This has not been specifically assessed before, but we monitor at all significant estuaries. Some smaller river estuaries (particularly along the East Cape) are not monitored. It is recommended that this be reviewed as part of the EFPP. It would also need to be considered what is representative regionally for the purposes of BOPRC and seeing how this might align with national representativeness.
Nutrients affecting coastal hydrosystems should be assessed by monitoring water quality in terminal river reaches, within estuaries and on their adjacent coasts.	This approach is adopted in some cases, but it is not consistent. Adjacent coasts are not regularly monitored alongside the estuary or river water quality sample runs.
There should be unified use of the NEMS core water quality variables.	All recommended core water quality variables are currently monitored.
An integrated index of hydrosystem ecological health should be included in future state and trend analysis to facilitate setting of water quality thresholds (i.e. boundaries between bands of environmental state) and increase the utility of monitoring.	Will be taken into account within the EFPP for the NPS-FM.

There should be unified use of NEMS protocols with regard to metadata collection, reporting of measurement uncertainty and quality coding.	NEMS protocols have either been adopted or in the process of being adopted.
There should be unified use of NEMS protocols with regard to water sample collection and analytical methods.	
Reporting uncensored data values by laboratories is strongly recommended.	This is already done by BOPRC lab.
The setting of water quality thresholds should account for characteristics of different hydrosystem types – some hydrosystem types are more sensitive to stressors than others.	Will be taken into account within the EFPP for the NPS-FM.
We recommend that thresholds for water quality and contaminant loads are set by comparing hydrosystem water quality with scores of ecosystem health and other values.	Will be taken into account within the EFPP for the NPS-FM.
We recommend further development of relationships between contaminant loading rates, water quality, and hydrosystem ecological health to inform water quality threshold setting.	Will be taken into account within the EFPP for the NPS-FM.

8.3 Reporting framework recommendations

Currently the reporting framework for all our NERMN networks is that each programme is reported on separately i.e. ecology and water quality are separate as well as rivers, lakes and estuarine programmes. The estuary water quality reporting framework provides little context currently as there are no suitable guidelines for water quality thresholds. It is important to understand if trends are apparent for water quality parameters in our estuaries. However, in this report this is difficult due to the sample time change. The estuary water quality reporting framework would benefit from either following the same format as the NERMN Rivers or the NERMN Coastal Ecology programmes. The NERMN Rivers programme produces site reports for water quality parameters. Having the estuary and rivers reported on the same timeframe would be beneficial as many estuaries have water quality sampling sites at the river terminals (or close to) discharging to the estuary. This would allow for more context as to the results observed in the estuaries, both in terms of state (concentrations) and trends. Although this would not be as beneficial in the Tauranga Harbour, where inputs and estuary sites are not well aligned.

Consideration could also be given to combining the reporting for the NERMN Coastal Ecology programme and water quality programme. The ecology data can be used to inform the ETI Tool and hence the state of the estuary. Water quality guidelines for estuaries are difficult to develop on a broad scale due to the range of hydrosystem classes and as a result differing sensitivities to eutrophication and sedimentation. The water quality data supports what is observed in the ecology data and water quality trends may indicate issues before the ecology responds. Interpreting this connection may be clearer if the two are analysed and reported together. This would require either the estuary water quality data to be reported in line with how the NERMN Coastal Ecology reporting is undertaken (by estuary rather than all at once), or the NERMN Coastal Ecology programme change its reporting to be in line with the Rivers and Estuary water quality reporting.

The recommendation is therefore to investigate what reporting framework would be of most use for interpreting the data, whether that is aligning with the NERMN Rivers or the NERMN Coastal Ecology reporting framework.

8.4 Additional recommendations

Additional recommendations for the NERMN Estuary water quality programme are;

- Develop automatic site report generation for all NERMN Estuary water quality sites to show state and trends on an annual basis.
- Establish Waiōtahe River officially as a NERMN site to include chlorophyll-*a* analysis.
- Investigate best site for monitoring in Kaituna and Maketū area since the re-diversion has occurred.
- Compiling the influence of freshwater inputs for each site.
- Additional work that would be important, but perhaps not within the scope of the NERMN programme includes an understanding of storm loads to the estuaries.

These recommendations are based on the current monitoring network. If major changes are made as part of the EFFP, then these recommendations should also be revisited to determine if they are still necessary.

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Appendices

Appendix A: Data plots

River estuaries

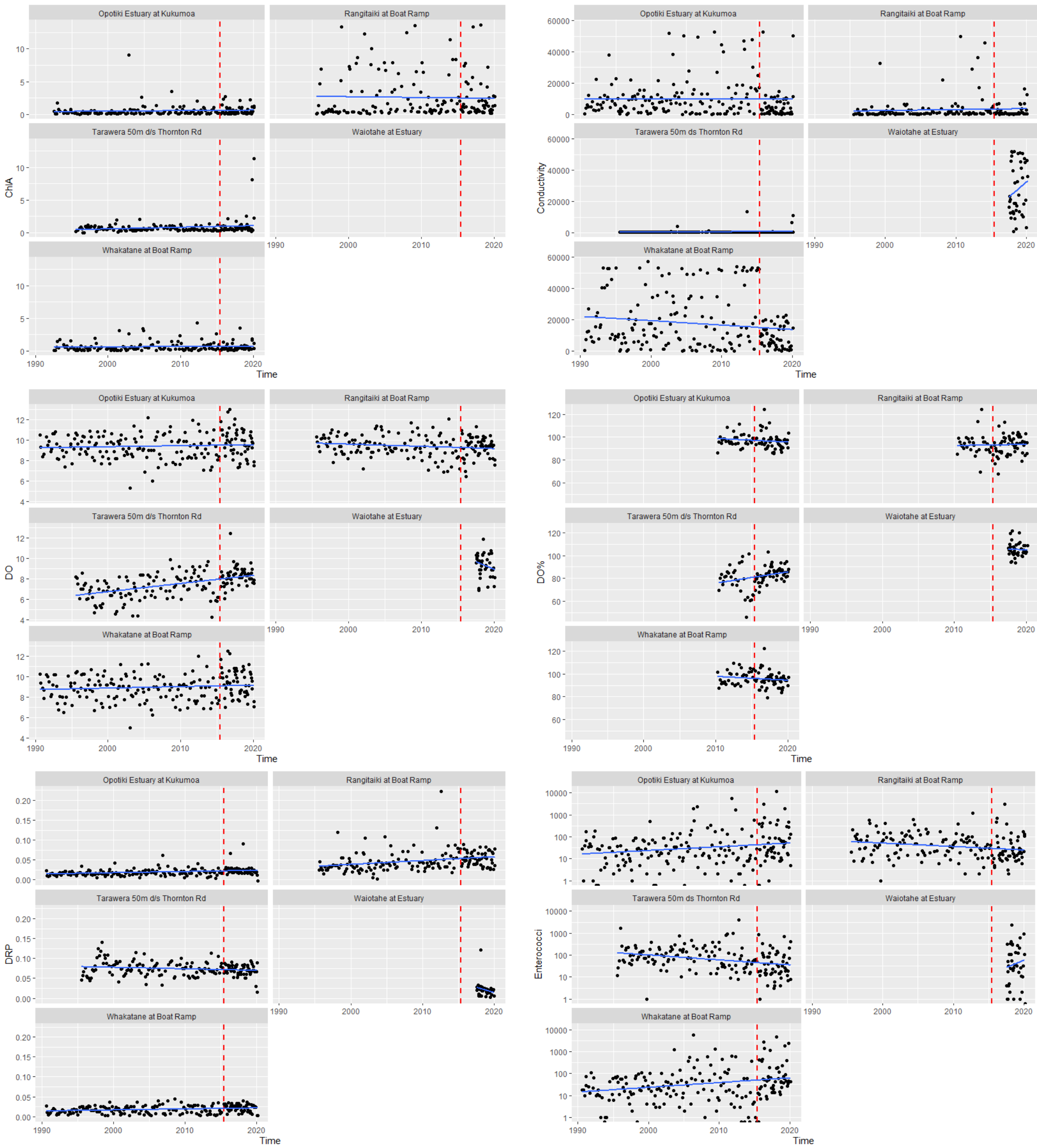

Figure 9.1 River estuary compact time-series plots for chlorophyll-a, conductivity, dissolved oxygen (mg/l), dissolved oxygen (%), dissolved reactive phosphorus, and enterococci. Red dashed line is when the sample time change occurred.

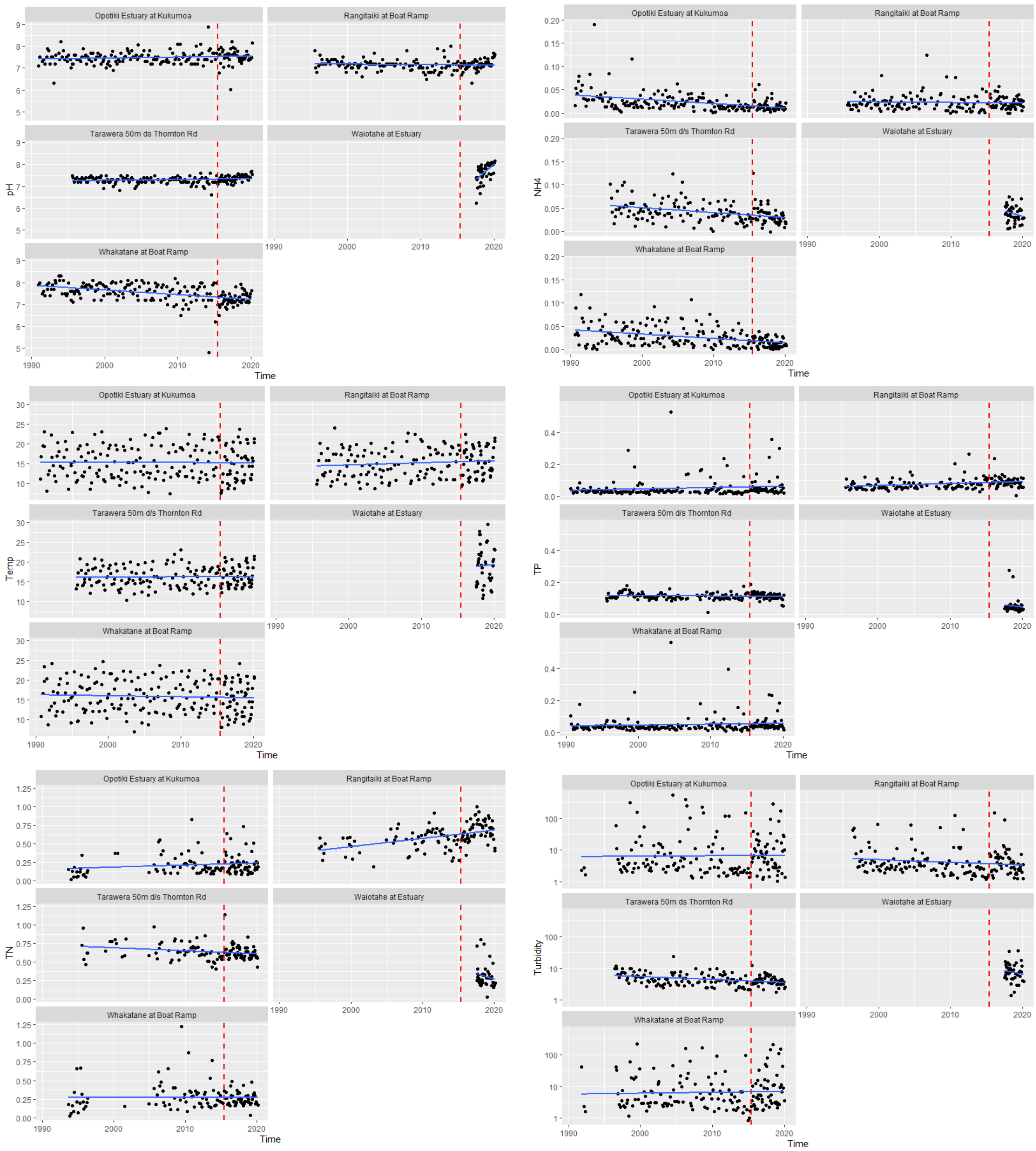

Figure 9.2 River estuary compact time-series plots for pHa, ammoniacal-N, water temperature, total phosphorus, total nitrogen, and turbidity. Red dashed line is when the sample time change occurred.

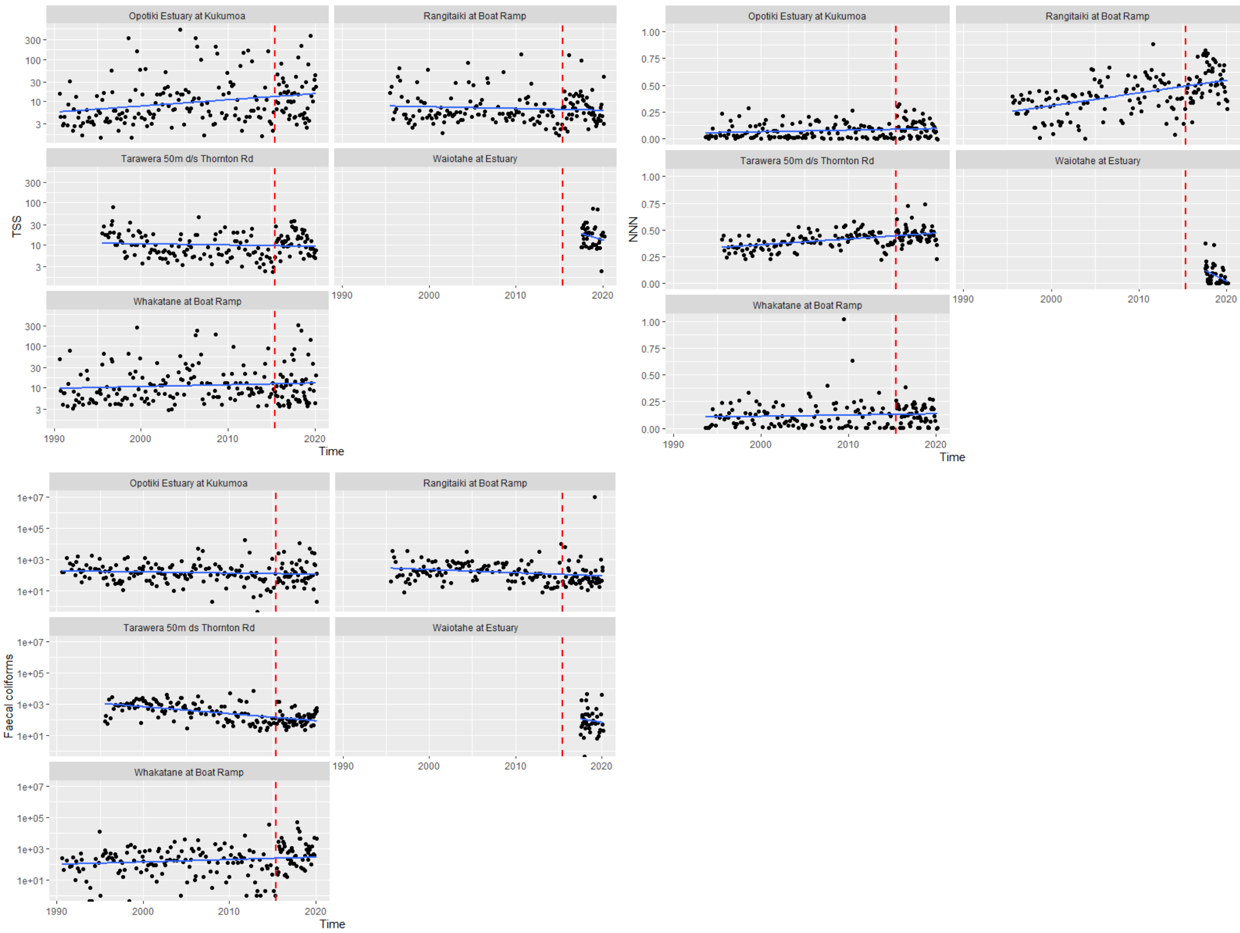

Figure 9.3 River estuary compact time-series plots for TSS, nitrate-nitrite-N, and faecal coliforms. Red dashed line is when the sample time change occurred.

Central and eastern estuaries

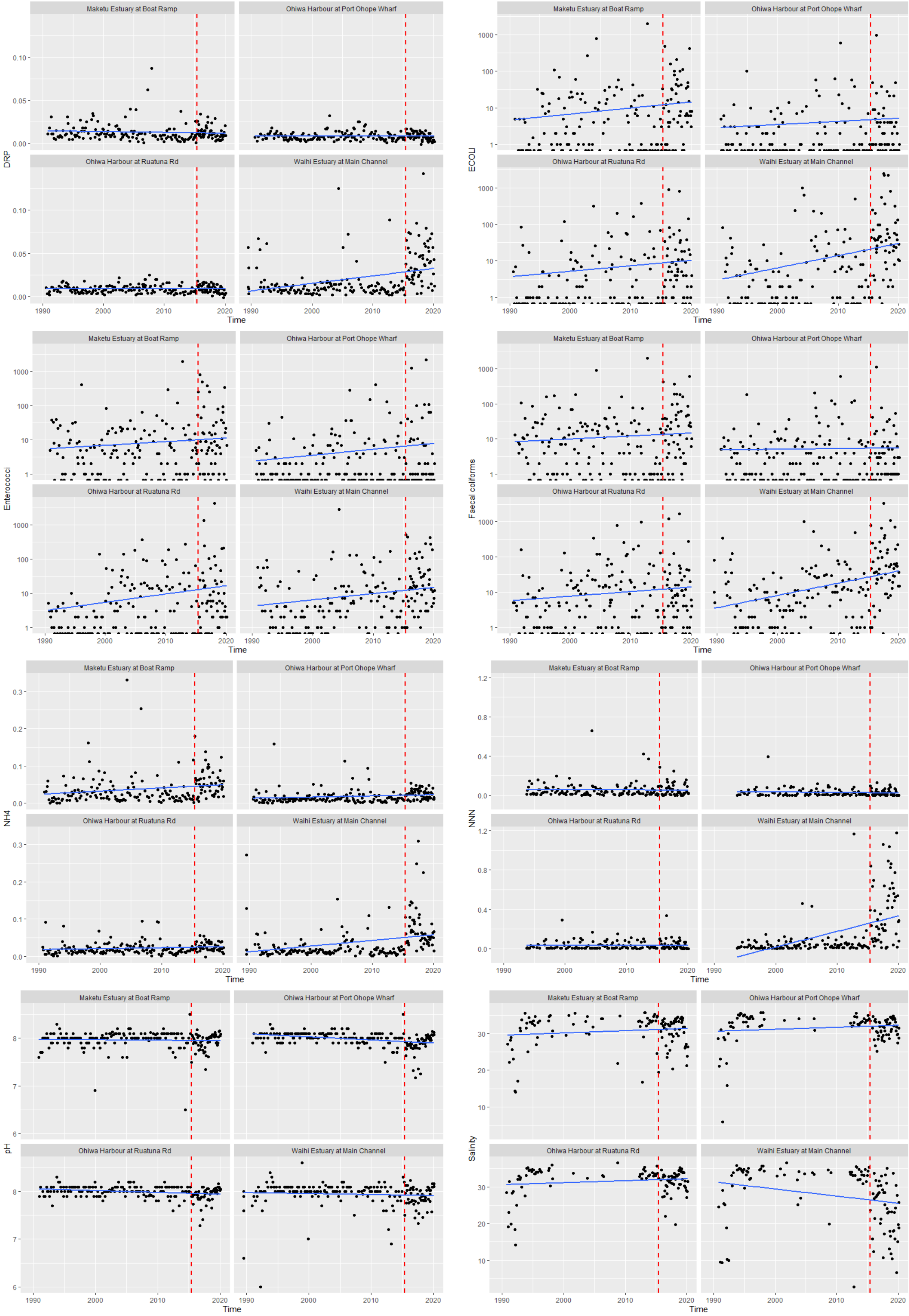

Figure 9.4 *Central and eastern estuary compact time-series plots for dissolved reactive phosphorus, E. coli, enterococci, faecal coliforms, ammoniacal-N, nitrate-nitrite-N, pH, and Salinity. Red dashed line is when the sample time change occurred.*

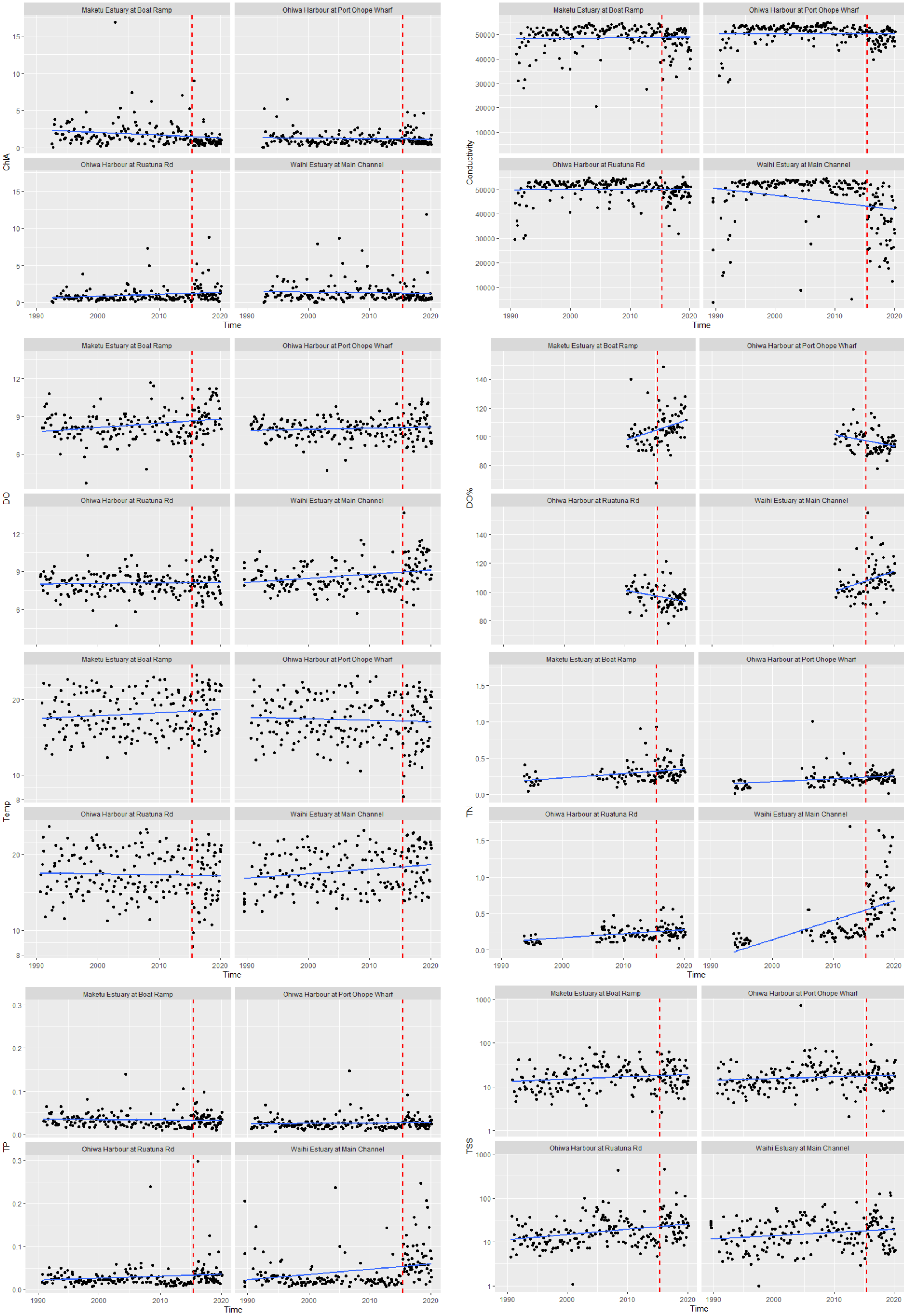

Figure 9.5 *Central and eastern estuary compact time-series plots for chlorophyll-a, conductivity, dissolved oxygen (mg/l), dissolved oxygen (%), water temperature, total nitrogen, total phosphorus, and TSS.. Red dashed line is when the sample time change occurred.*

Tauranga Harbour

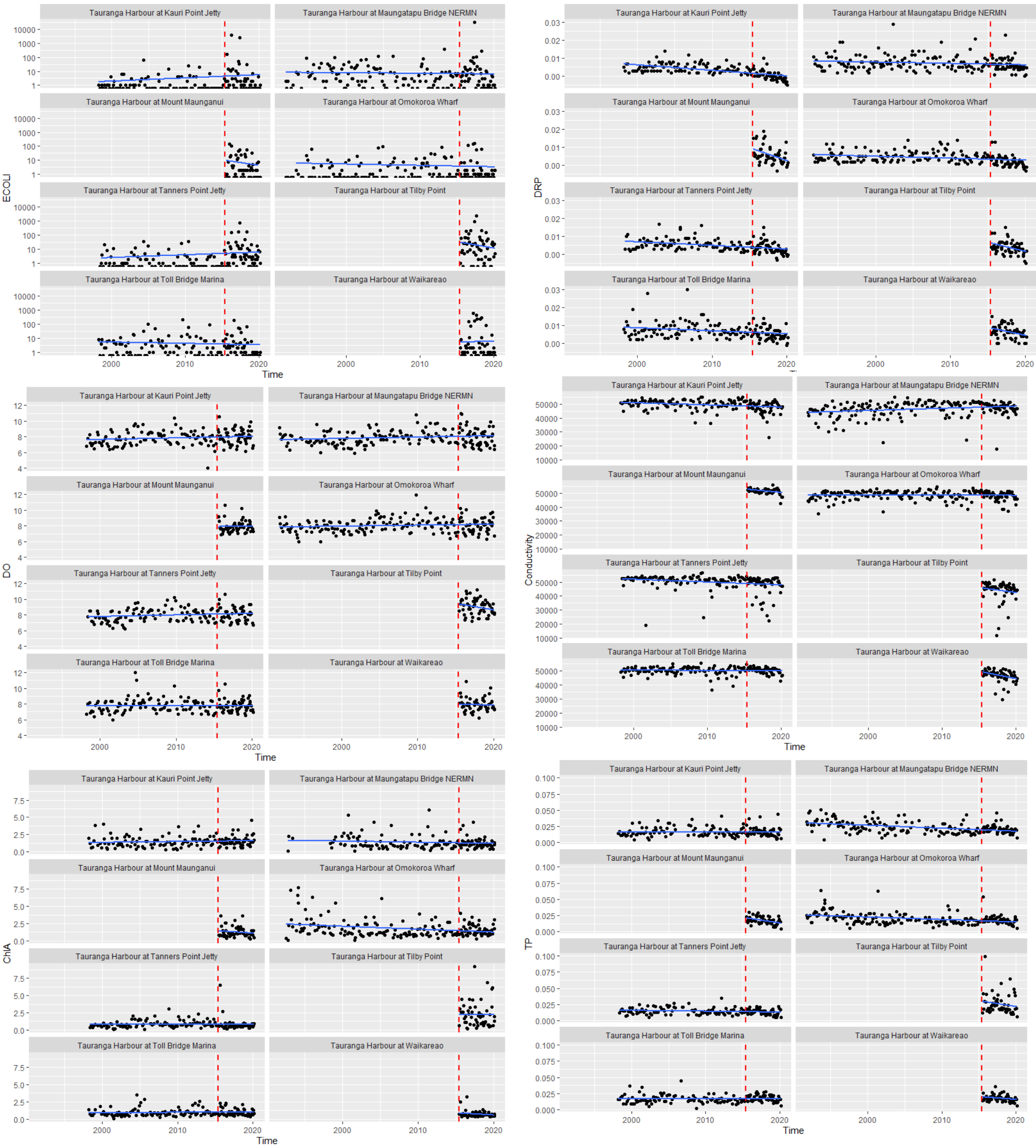

Figure 9.6 *Tauranga Harbour compact time-series plots E. coli, dissolved reactive phosphorus, dissolved oxygen (mg/l), .conductivity, chlorophyll-a, and total phosphorus . Red dashed line is when the sample time change occurred.*

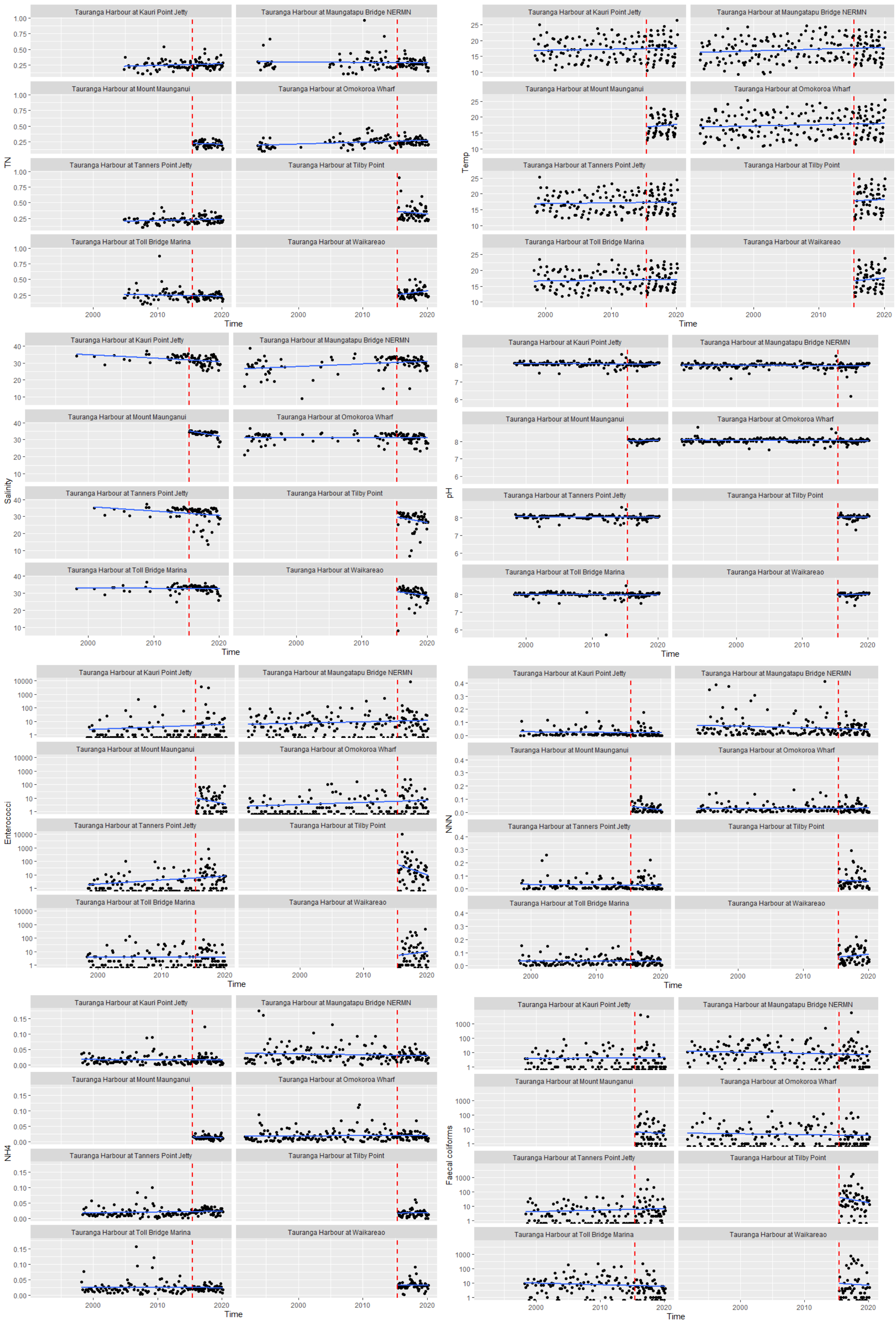

Figure 9.7 Tauranga Harbour compact time-series total nitrogen, water temperature, salinity, pH, enterococci, nitrate-nitrite-N, ammoniacal-N, and faecal coliforms . Red dashed line is when the sample time change occurred.

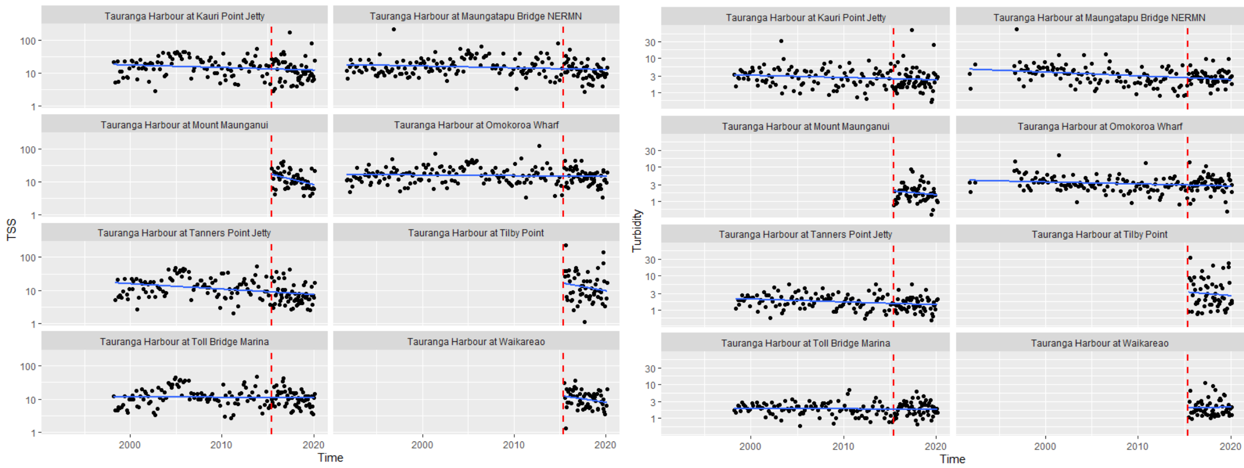

Figure 9.8 Tauranga Harbour compact time-series plots TSS and turbidity. Red dashed line is when the sample time change occurred.

Appendix B: Trend results

Table 9.1 Tarawera River Estuary trend results (Site: Tarawera 50 m d/s Thornton Road).

Parameter	Trend timeframe	Annual Sen Slope	% annual change	p value	Trend Category
Ammoniacal-N	Pre-2015	0.00	-5.0	0.000	Very Likely Improving
	5 year	0.00	-10.5	0.003	Very Likely Improving
Chlorophyll-*a*	Pre-2015	0.00	-0.6	0.536	Likely Improving
	5 year	0.01	1.9	0.713	Indeterminate/Uncertain
DIN	Pre-2015	-0.01	-1.2	0.021	Very Likely Improving
	5 year	-0.01	-1.5	0.152	Likely Improving
DO	Pre-2015	0.00	0.0	0.866	Indeterminate/Uncertain
	5 year	0.09	1.1	0.258	Likely Improving
DRP	Pre-2015	0.00	0.3	0.510	Likely Worsening
	5 year	0.00	1.3	0.397	Likely Worsening
ECOLI	Pre-2015	-0.08	-3.2	0.000	Very Likely Improving
	5 year	-0.01	-0.8	0.635	Likely Improving
Enterococci	Pre-2015	-0.03	-1.6	0.023	Very Likely Improving
	5 year	0.04	2.8	0.304	Likely Worsening
Faecal coliforms	Pre-2015	-0.06	-2.3	0.002	Very Likely Improving
	5 year	0.01	0.6	0.748	Indeterminate/Uncertain
NNN	Pre-2015	0.00	-0.3	0.374	Likely Improving
	5 year	0.00	-0.6	0.498	Likely Improving
TN	Pre-2015	NA	NA	NA	NA
	5 year	-0.01	-1.9	0.083	Very Likely Improving
TP	Pre-2015	0.00	-0.2	0.475	Likely Improving
	5 year	0.00	-2.8	0.021	Very Likely Improving
TSS	Pre-2015	-0.03	-3.5	0.000	Very Likely Improving
	5 year	-0.05	-4.9	0.003	Very Likely Improving
Turbidity	Pre-2015	-0.27	-6.0	0.000	Very Likely Improving
	5 year	-0.25	-6.5	0.009	Very Likely Improving
Water Clarity	Pre-2015	NA	NA	NA	NA
	5 year	0.05	4.1	0.076	Very Likely Improving

Table 9.2 Rangitāiki River Estuary trend results (Site Rangitāiki at Boat Ramp).

Parameter	Trend timeframe	Annual Sen Slope	% annual change	p value	Trend Category
Ammoniacal-N	Pre-2015	0.0	-3.5	0.127	Likely Improving
	5 year	0.00	-3.6	0.708	Indeterminate/Uncertain
Chlorophyll-*a*	Pre-2015	-0.1	-10.2	0.243	Likely Improving
	5 year	-0.10	-9.6	0.541	Likely Improving
DIN	Pre-2015	0.0	-1.1	0.159	Likely Improving
	5 year	0.03	6.3	0.009	Very Likely Worsening
DO	Pre-2015	-0.1	-0.7	0.017	Very Likely Worsening
	5 year	0.10	1.1	0.284	Likely Improving
DRP	Pre-2015	0.0	2.0	0.103	Very Likely Worsening
	5 year	0.00	-2.2	0.169	Likely Improving
ECOLI	Pre-2015	0.0	-0.7	0.137	Likely Improving
	5 year	-0.04	-2.6	0.531	Likely Improving
Enterococci	Pre-2015	0.0	-0.9	0.103	Likely Improving
	5 year	-0.01	-0.4	1.000	Indeterminate/Uncertain
Faecal coliforms	Pre-2015	-0.03	-1.2	0.010	Very Likely Improving
	5 year	0.01	0.6	0.748	Indeterminate/Uncertain
NNN	Pre-2015	0.0	-0.9	0.248	Likely Improving
	5 year	0.03	5.0	0.072	Very Likely Worsening
TN	Pre-2015[1]	NA	NA	NA	NA
	5 year	0.02	3.2	0.050	Very Likely Worsening
TP	Pre-2015	0.0	1.7	0.078	Very Likely Worsening
	5 year	0.00	-5.7	0.060	Very Likely Improving
TSS	Pre-2015	0.0	-0.8	0.061	Very Likely Improving
	5 year	-0.04	-4.3	0.100	Very Likely Improving
Turbidity	Pre-2015	-0.1	-2.4	0.445	Likely Improving
	5 year	-0.70	-19.3	0.065	Very Likely Improving
Water Clarity	Pre-2015[1]	NA	NA	NA	NA
	5 year	0.07	4.7	0.269	Likely Improving

[1]less than three non-NA values in a season, so trend analysis not conducted.

Table 9.3 Whakatāne River Estuary up to 2015 trends (Site: Whakatāne at Boat Ramp).

Parameter	Trend timeframe	Annual Sen Slope	% annual change	p value	Trend Category
Ammoniacal-N	Pre-2015	0.000	-0.35	0.872	Indeterminate/Uncertain
	5 year	0.00	-9.1	0.253	Likely Improving
Chlorophyll-*a*	Pre-2015	-0.002	-0.36	0.653	Likely Improving
	5 year	0.04	9.7	0.078	Very Likely Worsening
DIN	Pre-2015	0.001	1.02	0.360	Likely Worsening
	5 year	-0.01	-4.4	0.248	Likely Improving
DO	Pre-2015	0.001	0.01	0.903	Indeterminate/Uncertain
	5 year	-0.13	-1.3	0.043	Very Likely Worsening
DRP	Pre-2015	0.000	1.17	0.046	Very Likely Worsening
	5 year	0.00	-6.3	0.002	Very Likely Improving
ECOLI	Pre-2015	0.003	0.19	0.672	Indeterminate/Uncertain
	5 year	0.04	2.2	0.451	Likely Worsening
Enterococci	Pre-2015	0.007	0.56	0.195	Very Likely Worsening
	5 year	0.09	5.5	0.233	Likely Worsening
Faecal coliforms	Pre-2015	0.01	0.4	0.244	Likely Worsening
	5 year	0.06	2.2	0.267	Likely Worsening
NNN	Pre-2015	0.001	0.63	0.558	Likely Worsening
	5 year	0.00	-3.3	0.133	Likely Improving
TN	Pre-2015[1]	NA	NA	NA	NA
	5 year	-0.01	-3.5	0.236	Likely Improving
TP	Pre-2015	0.000	0.75	0.383	Likely Worsening
	5 year	0.00	-4.1	0.104	Likely Improving
TSS	Pre-2015	0.002	0.22	0.624	Likely Worsening
	5 year	-0.02	-1.8	0.412	Likely Improving
Turbidity	Pre-2015	-0.197	-4.92	0.416	Likely Improving
	5 year	0.00	0.0	0.988	Indeterminate/Uncertain
Water Clarity	Pre-2015[1]	NA	NA	NA	NA
	5 year	-0.07	-6.7	0.317	Likely Worsening

[1]less than three non-NA values in a season, so trend analysis not conducted.

Table 9.4 Ōpōtiki Estuary trend results (Site: Ōpōtiki Estuary at Kukumoa).

Parameter	Trend timeframe	Annual Sen Slope	% annual change	p value	Trend Category
Ammoniacal-N	Pre-2015	0.00	-3.0	0.086	Very Likely Improving
	5 year	0.00	-5.3	0.363	Likely Improving
Chlorophyll-*a*	Pre-2015	0.01	3.0	0.027	Very Likely Worsening
	5 year	-0.04	-12.1	0.266	Likely Improving
DIN	Pre-2015	0.00	-0.3	0.960	Indeterminate/Uncertain
	5 year	-0.01	-6.7	0.342	Likely Improving
DO	Pre-2015	0.02	0.2	0.467	Likely Improving
	5 year	-0.12	-1.2	0.356	Likely Worsening
DRP	Pre-2015	0.00	0.6	0.273	Likely Worsening
	5 year	0.00	-7.4	0.000	Very Likely Improving
ECOLI	Pre-2015	-0.02	-1.0	0.083	Very Likely Improving
	5 year	-0.04	-2.2	0.597	Likely Improving
Enterococci	Pre-2015	-0.01	-0.8	0.448	Likely Improving
	5 year	0.04	2.6	0.684	Indeterminate/Uncertain
Faecal coliforms	Pre-2015	-0.02	-0.9	0.009	Very Likely Improving
	5 year	0.03	1.5	0.603	Likely Worsening
NNN	Pre-2015	0.00	-0.2	0.981	Indeterminate/Uncertain
	5 year	-0.01	-11.0	0.165	Likely Improving
TN	Pre-2015[1]	NA	NA	NA	NA
	5 year	-0.01	-4.4	0.429	Likely Improving
TP	Pre-2015	0.00	-0.1	0.849	Indeterminate/Uncertain
	5 year	0.00	-7.0	0.253	Likely Improving
TSS	Pre-2015	0.01	0.9	0.034	Very Likely Worsening
	5 year	-0.03	-2.9	0.348	Likely Improving
Turbidity	Pre-2015	-0.03	-0.9	0.638	Likely Improving
	5 year	-1.18	-17.9	0.369	Likely Improving
Water Clarity	Pre-2015[1]	0.01	0.7	0.769	Indeterminate/Uncertain
	5 year	-0.01	-0.6	0.950	Indeterminate/Uncertain

[1]less than three non-NA values in a season, so trend analysis not conducted.

Table 9.5 Ōhiwa Harbour trend results (Site: Ōhiwa Harbour at Ruatuna Road).

Parameter	Trend timeframe	Annual Sen Slope	% annual change	p value	Trend Category
Ammoniacal-N	Pre-2015	0.000	0.5	0.438	Likely Worsening
	5 year	0.00	-0.3	0.959	Indeterminate/Uncertain
Chlorophyll-*a*	Pre-2015	0.002	0.3	0.715	Indeterminate/Uncertain
	5 year	-0.13	-11.8	0.115	Likely Improving
DIN	Pre-2015	-0.001	-1.5	0.605	Likely Improving
	5 year	0.00	-5.1	0.477	Likely Improving
DO	Pre-2015	0.007	0.1	0.353	Likely Improving
	5 year	0.13	1.6	0.304	Likely Improving
DRP	Pre-2015	0.000	-0.2	0.886	Indeterminate/Uncertain
	5 year	0.00	-15.2	0.001	Very Likely Improving
ECOLI	Pre-2015	0.000	0.0	0.064	Very Likely Worsening
	5 year	0.02	3.1	0.632	Likely Worsening
Enterococci	Pre-2015	0.002	0.4	0.005	Very Likely Worsening
	5 year	0.03	3.3	0.817	Indeterminate/Uncertain
Faecal coliforms	Pre-2015	0.02	2.2	0.052	Very Likely Worsening
	5 year	0.09	9.6	0.147	Very Likely Worsening
NNN	Pre-2015	0.000	-1.5	0.754	Indeterminate/Uncertain
	5 year	0.00	-7.5	0.589	Likely Improving
TN	Pre-2015[1]	NA	NA	NA	NA
	5 year	-0.01	-2.0	0.475	Likely Improving
TP	Pre-2015	0.000	-1.4	0.008	Very Likely Improving
	5 year	0.00	-1.6	0.772	Indeterminate/Uncertain
TSS	Pre-2015	-0.008	-0.7	0.130	Likely Improving
	5 year	-0.03	-2.1	0.191	Likely Improving
Turbidity	Pre-2015	-0.071	-1.5	0.079	Very Likely Improving
	5 year	0.60	5.9	0.646	Likely Worsening
Water Clarity	Pre-2015	0.322	24.7	0.002	Very Likely Improving
	5 year	0.02	2.6	0.607	Likely Improving

[1]less than three non-NA values in a season, so trend analysis not conducted.

Table 9.6 Ōhiwa Harbour trend results (Site: Ōhiwa Harbour at Port Ōhope Wharf).

Parameter	Trend timeframe	Annual Sen Slope	% annual change	p value	Trend Category
Ammoniacal-N	Pre-2015	0.000	0.6	0.437	Likely Worsening
	5 year	0.00	-0.3	0.977	Indeterminate/Uncertain
Chlorophyll-*a*	Pre-2015	-0.006	-0.6	0.378	Likely Improving
	5 year	-0.18	-20.0	0.000	Very Likely Improving
DIN	Pre-2015[1]	NA	NA	NA	NA
	5 year	0.00	-4.4	0.487	Likely Improving
DO	Pre-2015	0.011	0.1	0.277	Likely Improving
	5 year	0.17	2.1	0.048	Very Likely Improving
DRP	Pre-2015	0.000	-0.8	0.346	Likely Improving
	5 year	0.00	-18.4	0.000	Very Likely Improving
ECOLI	Pre-2015	0.003	0.9	0.317	Likely Worsening
	5 year	-0.07	-15.0	0.120	Likely Improving
Enterococci	Pre-2015	0.006	1.9	0.255	Likely Worsening
	5 year	0.00	-0.8	1.000	Indeterminate/Uncertain
Faecal coliforms	Pre-2015	0.00	0.5	0.550	Likely Worsening
	5 year	0.06	9.6	0.177	Very Likely Worsening
NNN	Pre-2015[1]	NA	NA	NA	NA
	5 year	0.00	-2.0	0.939	Indeterminate/Uncertain
TN	Pre-2015[1]	NA	NA	NA	NA
	5 year	-0.01	-2.3	0.312	Likely Improving
TP	Pre-2015	0.000	-1.7	0.016	Very Likely Improving
	5 year	0.00	-10.7	0.002	Very Likely Improving
TSS	Pre-2015	0.004	0.4	0.344	Likely Worsening
	5 year	-0.04	-3.6	0.027	Very Likely Improving
Turbidity	Pre-2015	0.006	0.1	0.899	Indeterminate/Uncertain
	5 year	-0.40	-7.0	0.063	Very Likely Improving
Water Clarity	Pre-2015[1]				
	5 year	0.01	1.8	0.647	Likely Improving

[1]less than three non-NA values in a season, so trend analysis not conducted.

Table 9.7 Waihī Estuary trend results (Site: Waihī Estuary at Main Channel).

Parameter	Trend timeframe	Annual Sen Slope	% annual change	p value	Trend Category
Ammoniacal-N	Pre-2015	0.000	0.7	0.484	Likely Worsening
	5 year	-0.01	-17.3	0.009	Very Likely Improving
Chlorophyll-*a*	Pre-2015	0.004	0.4	0.676	Indeterminate/Uncertain
	5 year	-0.12	-17.5	0.044	Very Likely Improving
DIN	Pre-2015	0.000	0.0	1.000	Indeterminate/Uncertain
	5 year	0.00	0.0	0.977	Indeterminate/Uncertain
DO	Pre-2015	-0.010	-0.1	0.257	Likely Worsening
	5 year	0.05	0.5	0.664	Indeterminate/Uncertain
DRP	Pre-2015	0.000	0.5	0.517	Likely Worsening
	5 year	0.00	-4.5	0.057	Very Likely Improving
ECOLI	Pre-2015	0.017	3.6	0.009	Very Likely Worsening
	5 year	-0.01	-0.6	0.848	Indeterminate/Uncertain
Enterococci	Pre-2015	0.019	3.1	0.003	Very Likely Worsening
	5 year	0.00	0.0	1.000	Indeterminate/Uncertain
Faecal coliforms	Pre-2015	-0.002	-0.2	0.788	Indeterminate/Uncertain
	5 year	-0.02	-1.0	0.893	Indeterminate/Uncertain
NNN	Pre-2015	0.000	1.1	0.526	Likely Worsening
	5 year	0.01	4.8	0.316	Likely Worsening
TN	Pre-2015[1]	NA	NA	NA	NA
	5 year	0.00	0.4	1.000	Indeterminate/Uncertain
TP	Pre-2015	0.000	-0.9	0.147	Likely Improving
	5 year	-0.01	-10.0	0.006	Very Likely Improving
TSS	Pre-2015	0.006	0.5	0.119	Very Likely Worsening
	5 year	-0.10	-7.5	0.003	Very Likely Improving
Turbidity	Pre-2015	0.000	0.0	0.994	Indeterminate/Uncertain
	5 year	-1.20	-19.3	0.006	Very Likely Improving
Water Clarity	Pre-2015	-0.040	-1.7	0.522	Likely Worsening
	5 year	0.03	3.6	0.422	Likely Improving

[1]less than three non-NA values in a season, so trend analysis not conducted.

Table 9.8 Tauranga Harbour trend results (Site: Tauranga Harbour at Maungatapu Bridge).

Parameter	Trend timeframe	Annual Sen Slope	% annual change	p value	Trend Category
Ammoniacal-N	Pre-2015	0.000	0.66	0.334	Likely Worsening
	5 year	-0.002	-5.75	0.060	Very Likely Improving
Chlorophyll-*a*	Pre-2015	-0.008	-0.78	0.594	Likely Improving
	5 year	-0.013	-1.21	0.821	Indeterminate/Uncertain
DIN	Pre-2015	0.001	1.02	0.276	Likely Worsening
	5 year	-0.005	-7.44	0.060	Very Likely Improving
DO	Pre-2015	0.008	0.10	0.591	Likely Improving
	5 year	-0.038	-0.48	0.598	Likely Worsening
DRP	Pre-2015	0.000	0.10	0.869	Indeterminate/Uncertain
	5 year	-0.001	-14.49	0.001	Very Likely Improving
ECOLI	Pre-2015	0.000	0.06	0.936	Indeterminate/Uncertain
	5 year	-0.103	-17.09	0.023	Very Likely Improving
Enterococci	Pre-2015	-0.002	-0.32	0.633	Likely Improving
	5 year	-0.052	-6.16	0.367	Likely Improving
Faecal coliforms	Pre-2015	0.000	0.05	0.942	Indeterminate/Uncertain
	5 year	-0.098	-14.05	0.052	Very Likely Improving
NNN	Pre-2015	0.001	1.92	0.217	Likely Worsening
	5 year	-0.006	-13.90	0.065	Very Likely Improving
TN	Pre-2015	0.001	0.47	0.344	Likely Worsening
	5 year	-0.008	-3.13	0.084	Very Likely Improving
TP	Pre-2015	0.000	-1.83	0.000	Very Likely Improving
	5 year	-0.001	-5.73	0.003	Very Likely Improving
TSS	Pre-2015	0.001	0.08	0.750	Indeterminate/Uncertain
	5 year	-0.038	-3.46	0.038	Very Likely Improving
Turbidity	Pre-2015	-0.058	-1.71	0.055	Very Likely Improving
	5 year	-0.097	-3.46	0.295	Likely Improving
Water Clarity	Pre-2015[1]	NA	NA	NA	NA
	5 year	0.019	1.57	0.800	Indeterminate/Uncertain

[1]less than three non-NA values in a season, so trend analysis not conducted.

Table 9.9 Tauranga Harbour trend results (Site: Tauranga Harbour at Ōmokoroa Wharf).

Parameter	Trend timeframe	Annual Sen Slope	% annual change	p value	Trend Category
Ammoniacal-N	Pre-2015	0.000	1.78	0.374	Likely Worsening
	5 year	-0.001	-6.69	0.338	Likely Improving
Chlorophyll-*a*	Pre-2015	-0.057	-4.07	0.001	Very Likely Improving
	5 year	-0.019	-1.37	0.939	Indeterminate/Uncertain
DIN	Pre-2015[1]	NA	NA	NA	NA
	5 year	-0.005	-13.24	0.013	Very Likely Improving
DO	Pre-2015	0.015	0.19	0.312	Likely Improving
	5 year	0.036	0.45	0.598	Likely Improving
DRP	Pre-2015	0.000	0.09	0.801	Indeterminate/Uncertain
	5 year	-0.001	-39.29	0.001	Very Likely Improving
ECOLI	Pre-2015	NA	NA	NA	NA
	5 year	-0.041	-13.57	0.058	Very Likely Improving
Enterococci	Pre-2015	0.006	2.12	0.031	Very Likely Worsening
	5 year	-0.065	-13.61	0.289	Likely Improving
Faecal coliforms	Pre-2015	0.003	0.54	0.631	Likely Worsening
	5 year	-0.086	-28.66	0.002	Very Likely Improving
NNN	Pre-2015[1]	NA	NA	NA	NA
	5 year	-0.003	-16.50	0.019	Very Likely Improving
TN	Pre-2015[1]	NA	NA	NA	NA
	5 year	-0.003	-1.04	0.546	Likely Improving
TP	Pre-2015	-0.001	-3.90	0.000	Very Likely Improving
	5 year	-0.001	-6.40	0.010	Very Likely Improving
TSS	Pre-2015	0.001	0.04	0.726	Indeterminate/Uncertain
	5 year	-0.040	-3.33	0.015	Very Likely Improving
Turbidity	Pre-2015	-0.107	-3.47	0.001	Very Likely Improving
	5 year	-0.206	-6.48	0.136	Likely Improving
Water Clarity	Pre-2015	0.005	0.29	0.978	Indeterminate/Uncertain
	5 year	0.011	0.89	0.800	Indeterminate/Uncertain

[1]less than three non-NA values in a season, so trend analysis not conducted.

Table 9.10 Tauranga Harbour trend results (Site: Tauranga Harbour at Toll Bridge Marine).

Parameter	Trend timeframe	Annual Sen Slope	% annual change	p value	Trend Category
Ammoniacal-N	Pre-2015	0.000	0.69	0.370	Likely Worsening
	5 year	-0.001	-3.20	0.375	Likely Improving
Chlorophyll-*a*	Pre-2015	-0.001	-0.16	0.951	Indeterminate/Uncertain
	5 year	-0.028	-3.46	0.433	Likely Improving
DIN	Pre-2015	0.001	1.47	0.706	Indeterminate/Uncertain
	5 year	-0.005	-11.04	0.113	Likely Improving
DO	Pre-2015	-0.002	-0.03	0.951	Indeterminate/Uncertain
	5 year	0.019	0.25	0.498	Likely Improving
DRP	Pre-2015	0.000	-1.19	0.208	Likely Improving
	5 year	-0.001	-12.82	0.048	Very Likely Improving
ECOLI	Pre-2015	0.001	0.26	0.894	Indeterminate/Uncertain
	5 year	-0.145	-37.24	0.000	Very Likely Improving
Enterococci	Pre-2015	0.000	-0.01	0.952	Indeterminate/Uncertain
	5 year	-0.064	-13.48	0.109	Likely Improving
Faecal coliforms	Pre-2015	0.002	0.26	0.755	Indeterminate/Uncertain
	5 year	-0.086	-13.29	0.017	Very Likely Improving
NNN	Pre-2015	0.000	1.56	0.525	Likely Worsening
	5 year	-0.001	-5.59	0.338	Likely Improving
TN	Pre-2015	-0.001	-0.53	0.644	Likely Improving
	5 year	0.006	2.71	0.105	Very Likely Worsening
TP	Pre-2015	0.000	-0.44	0.576	Likely Improving
	5 year	-0.001	-6.34	0.161	Likely Improving
TSS	Pre-2015	0.006	0.58	0.301	Likely Worsening
	5 year	-0.029	-2.74	0.102	Likely Improving
Turbidity	Pre-2015	-0.035	-1.91	0.019	Very Likely Improving
	5 year	0.003	0.14	0.989	Indeterminate/Uncertain
Water Clarity	Pre-2015	0.585	19.49	0.289	Likely Improving
	5 year	0.002	0.11	0.988	Indeterminate/Uncertain

Table 9.11 Tauranga Harbour trend results (Site: Tauranga Harbour at Kauri Point Jetty).

Parameter	Trend timeframe	Annual Sen Slope	% annual change	p value	Trend Category
Ammoniacal-N	Pre-2015	-0.001	-4.18	0.133	Likely Improving
	5 year	-0.002	-11.82	0.033	Very Likely Improving
Chlorophyll-*a*	Pre-2015	0.007	0.54	0.606	Likely Worsening
	5 year	0.045	3.01	0.378	Likely Worsening
DIN	Pre-2015[1]	NA	NA	NA	NA
	5 year	-0.005	-21.19	0.052	Very Likely Improving
DO	Pre-2015	-0.008	-0.10	0.753	Indeterminate/Uncertain
	5 year	0.100	1.24	0.143	Likely Improving
DRP	Pre-2015	0.000	-2.13	0.067	Very Likely Improving
	5 year	NA	NA	NA	NA
ECOLI	Pre-2015	NA	NA	NA	NA
	5 year	-0.106	-35.28	0.007	Very Likely Improving
Enterococci	Pre-2015	0.002	0.59	0.702	Indeterminate/Uncertain
	5 year	-0.005	-1.67	0.705	Indeterminate/Uncertain
Faecal coliforms	Pre-2015	-0.004	-0.92	0.503	Likely Improving
	5 year	-0.073	-15.23	0.047	Very Likely Improving
NNN	Pre-2015	NA	NA	NA	NA
	5 year	-0.003	-52.69	0.137	Likely Improving
TN	Pre-2015	0.002	0.99	0.457	Likely Worsening
	5 year	0.000	0.02	0.995	Indeterminate/Uncertain
TP	Pre-2015	0.000	-2.34	0.021	Very Likely Improving
	5 year	-0.001	-8.77	0.012	Very Likely Improving
TSS	Pre-2015	-0.002	-0.13	0.765	Indeterminate/Uncertain
	5 year	-0.055	-4.97	0.123	Likely Improving
Turbidity	Pre-2015	-0.026	-0.90	0.507	Likely Improving
	5 year	-0.032	-1.55	0.799	Indeterminate/Uncertain
Water Clarity	Pre-2015	4.363	218.17	0.302	Likely Improving
	5 year	-0.038	-2.71	0.718	Indeterminate/Uncertain

Table 9.12 Tauranga Harbour trend results (Site: Tauranga Harbour at Mount Maunganui).

Parameter	Trend timeframe	Annual Sen Slope	% annual change	p value	Trend Category
Ammoniacal-N	Pre-2015	-	-	-	-
	5 year	-0.001	-3.59	0.325	Likely Improving
Chlorophyll-*a*	Pre-2015	-	-	-	-
	5 year	-0.045	-4.25	0.329	Likely Improving
DIN	Pre-2015	-	-	-	-
	5 year	-0.005	-12.63	0.067	Very Likely Improving
DO	Pre-2015	-	-	-	-
	5 year	0.123	1.58	0.054	Very Likely Improving
DRP	Pre-2015	-	-	-	-
	5 year	-0.001	-16.62	0.054	Very Likely Improving
ECOLI	Pre-2015	-	-	-	-
	5 year	-0.054	-11.41	0.189	Likely Improving
Enterococci	Pre-2015	-	-	-	-
	5 year	-0.053	-8.80	0.454	Likely Improving
Faecal coliforms	Pre-2015	-	-	-	-
	5 year	-0.061	-10.08	0.342	Likely Improving
NNN	Pre-2015	-	-	-	-
	5 year	-0.001	-7.46	0.589	Likely Improving
TN	Pre-2015	-	-	-	-
	5 year	0.001	0.65	0.687	Indeterminate/Uncertain
TP	Pre-2015	-	-	-	-
	5 year	-0.002	-9.49	0.006	Very Likely Improving
TSS	Pre-2015	-	-	-	-
	5 year	-0.060	-5.56	0.013	Very Likely Improving
Turbidity	Pre-2015	-	-	-	-
	5 year	-0.030	-1.98	0.695	Indeterminate/Uncertain
Water Clarity	Pre-2015	-	-	-	-
	5 year	-0.084	-5.03	0.447	Likely Worsening

Table 9.13 Tauranga Harbour trend results (Tauranga Harbour at Tanners Point Jetty).

Parameter	Trend timeframe	Annual Sen Slope	% annual change	p value	Trend Category
Ammoniacal-N	Pre-2015	0.000	-0.83	0.427	Likely Improving
	5 year	0.000	-1.03	0.707	Indeterminate/Uncertain
Chlorophyll-*a*	Pre-2015	-0.010	-1.25	0.439	Likely Improving
	5 year	0.002	0.36	0.912	Indeterminate/Uncertain
DIN	Pre-2015[1]	NA	NA	NA	NA
	5 year	-0.005	-13.87	0.051	Very Likely Improving
DO	Pre-2015	-0.016	-0.21	0.395	Likely Worsening
	5 year	-0.061	-0.75	0.487	Likely Worsening
DRP	Pre-2015	0.000	-3.35	0.019	Very Likely Improving
	5 year	-0.001	-28.46	0.000	Very Likely Improving
ECOLI	Pre-2015	-0.004	-2.36	0.037	Very Likely Improving
	5 year	-0.018	-2.92	0.573	Likely Improving
Enterococci	Pre-2015	0.000	0.05	1.000	Indeterminate/Uncertain
	5 year	-0.003	-0.49	0.869	Indeterminate/Uncertain
Faecal coliforms	Pre-2015	-0.013	-2.83	0.183	Likely Improving
	5 year	-0.012	-1.70	0.717	Indeterminate/Uncertain
NNN	Pre-2015[1]	NA	NA	NA	NA
	5 year	-0.003	-34.41	0.069	Very Likely Improving
TN	Pre-2015	0.002	0.89	0.270	Likely Worsening
	5 year	-0.001	-0.60	0.799	Indeterminate/Uncertain
TP	Pre-2015	0.000	-2.88	0.019	Very Likely Improving
	5 year	-0.001	-9.53	0.001	Very Likely Improving
TSS	Pre-2015	-0.007	-0.60	0.235	Likely Improving
	5 year	-0.025	-2.89	0.260	Likely Improving
Turbidity	Pre-2015	-0.033	-1.82	0.073	Very Likely Improving
	5 year	0.012	0.93	0.851	Indeterminate/Uncertain
Water Clarity	Pre-2015	2.652	80.38	0.486	Likely Improving
	5 year	-0.063	-3.18	0.531	Likely Worsening

[1]less than three non-NA values in a season, so trend analysis not conducted.

Table 9.14 Tauranga Harbour trend results (Tauranga Harbour at Tilby Point).

Parameter	Trend timeframe	Annual Sen Slope	% annual change	p value	Trend Category
Ammoniacal-N	Pre-2015	-	-	-	-
	5 year	0.000	-0.03	1.000	Indeterminate/Uncertain
Chlorophyll-*a*	Pre-2015	-	-	-	-
	5 year	-0.144	-7.56	0.338	Likely Improving
DIN	Pre-2015	-	-	-	-
	5 year	-0.001	-1.29	0.706	Indeterminate/Uncertain
DO	Pre-2015	-	-	-	-
	5 year	-0.134	-1.47	0.236	Likely Worsening
DRP	Pre-2015	-	-	-	-
	5 year	-0.001	-15.02	0.008	Very Likely Improving
ECOLI	Pre-2015	-	-	-	-
	5 year	-0.071	-5.91	0.231	Likely Improving
Enterococci	Pre-2015	-	-	-	-
	5 year	-0.096	-8.18	0.221	Likely Improving
Faecal coliforms	Pre-2015	-	-	-	-
	5 year	-0.072	-5.42	0.208	Likely Improving
NNN	Pre-2015	-	-	-	-
	5 year	-0.001	-1.99	0.821	Indeterminate/Uncertain
TN	Pre-2015	-	-	-	-
	5 year	0.001	0.45	0.842	Indeterminate/Uncertain
TP	Pre-2015	-	-	-	-
	5 year	0.000	-1.78	0.761	Indeterminate/Uncertain
TSS	Pre-2015	-	-	-	-
	5 year	-0.055	-5.17	0.100	Very Likely Improving
Turbidity	Pre-2015	-	-	-	-
	5 year	-0.316	-14.52	0.382	Likely Improving
Water Clarity	Pre-2015	-	-	-	-
	5 year	-0.031	-2.38	0.654	Likely Worsening

Table 9.15 Tauranga Harbour trend results (Tauranga Harbour at Waikareao).

Parameter	Trend timeframe	Annual Sen Slope	% annual change	p value	Trend Category
Ammoniacal-N	Pre-2015	-	-	-	-
	5 year	0.000	-1.42	0.640	Likely Improving
Chlorophyll-*a*	Pre-2015	-	-	-	-
	5 year	0.009	1.45	0.724	Indeterminate/Uncertain
DIN	Pre-2015	-	-	-	-
	5 year	-0.008	-8.22	0.082	Very Likely Improving
DO	Pre-2015	-	-	-	-
	5 year	0.007	0.09	1.000	Indeterminate/Uncertain
DRP	Pre-2015	-	-	-	-
	5 year	-0.001	-14.24	0.003	Very Likely Improving
ECOLI	Pre-2015	-	-	-	-
	5 year	-0.073	-24.32	0.073	Very Likely Improving
Enterococci	Pre-2015	-	-	-	-
	5 year	0.041	6.87	0.484	Likely Worsening
Faecal coliforms	Pre-2015	-	-	-	-
	5 year	-0.094	-13.49	0.054	Very Likely Improving
NNN	Pre-2015	-	-	-	-
	5 year	-0.005	-7.79	0.262	Likely Improving
TN	Pre-2015	-	-	-	-
	5 year	0.002	0.71	0.757	Indeterminate/Uncertain
TP	Pre-2015	-	-	-	-
	5 year	-0.001	-5.14	0.042	Very Likely Improving
TSS	Pre-2015	-	-	-	-
	5 year	-0.043	-4.11	0.100	Very Likely Improving
Turbidity	Pre-2015	-	-	-	-
	5 year	-0.079	-4.51	0.250	Likely Improving
Water Clarity	Pre-2015	-	-	-	-
	5 year	0.018	1.13	0.835	Indeterminate/Uncertain

Appendix C

Site	Parameter	Pre-2015 Data starts	Pre-2015 Data End	Pre-2015 Seasonal adjustment	Pre-2015 Conductivity adjustment	5-year Data starts	5-year Data End	5-year Seasonal adjustment	5-year conductivity adjustment
Ōpōtiki Estuary at Kukumoa	NH4	28/09/1990	8/04/2015	YES	YES	13/07/2015	13/02/2020	NO	YES
Ōpōtiki Estuary at Kukumoa	ChlA	28/09/1990	8/04/2015	NO	YES	13/07/2015	13/02/2020	NO	YES
Ōpōtiki Estuary at Kukumoa	DRP	28/09/1990	8/04/2015	YES	YES	13/07/2015	13/02/2020	NO	YES
Ōpōtiki Estuary at Kukumoa	ECOLI	28/09/1990	8/04/2015	NO	YES	13/07/2015	13/02/2020	NO	YES
Ōpōtiki Estuary at Kukumoa	Enterococci	28/09/1990	8/04/2015	YES	YES	13/07/2015	13/02/2020	NO	YES
Ōpōtiki Estuary at Kukumoa	Faecal coliforms	28/09/1990	8/04/2015	NO	YES	13/07/2015	13/02/2020	NO	YES
Ōpōtiki Estuary at Kukumoa	TN	NA	NA	NA	NA	13/07/2015	13/02/2020	NO	YES
Ōpōtiki Estuary at Kukumoa	NNN	28/09/1990	8/04/2015	YES	YES	13/07/2015	13/02/2020	YES	YES
Ōpōtiki Estuary at Kukumoa	DO	28/09/1990	8/04/2015	YES	YES	13/07/2015	13/02/2020	YES	YES
Ōpōtiki Estuary at Kukumoa	TP	28/09/1990	8/04/2015	NO	YES	13/07/2015	13/02/2020	NO	YES
Ōpōtiki Estuary at Kukumoa	pH	28/09/1990	8/04/2015	YES	YES	13/07/2015	13/02/2020	NO	YES
Ōpōtiki Estuary at Kukumoa	TSS	28/09/1990	8/04/2015	NO	YES	13/07/2015	13/02/2020	NO	YES
Ōpōtiki Estuary at Kukumoa	Turbidity	28/09/1990	8/04/2015	NO	YES	13/07/2015	13/02/2020	NO	YES
Ōpōtiki Estuary at Kukumoa	Water Clarity	28/09/1990	8/04/2015	NO	YES	13/07/2015	13/02/2020	NO	YES
Ōpōtiki Estuary at Kukumoa	Temp	28/09/1990	8/04/2015	YES	YES	13/07/2015	13/02/2020	YES	YES
Ōpōtiki Estuary at Kukumoa	DIN	28/09/1990	8/04/2015	YES	YES	13/07/2015	13/02/2020	YES	YES
Rangitāiki at Boat Ramp	NH4	12/09/1995	9/04/2015	YES	YES	10/06/2015	11/02/2020	NO	NO
Rangitāiki at Boat Ramp	ChlA	12/09/1995	9/04/2015	YES	YES	10/06/2015	11/02/2020	YES	YES
Rangitāiki at Boat Ramp	DRP	12/09/1995	9/04/2015	YES	YES	10/06/2015	11/02/2020	YES	YES
Rangitāiki at Boat Ramp	ECOLI	12/09/1995	9/04/2015	NO	YES	10/06/2015	11/02/2020	YES	YES
Rangitāiki at Boat Ramp	Enterococci	12/09/1995	9/04/2015	NO	YES	10/06/2015	11/02/2020	YES	YES
Rangitāiki at Boat Ramp	Faecal coliforms	12/09/1995	9/04/2015	NO	YES	10/06/2015	11/02/2020	YES	YES
Rangitāiki at Boat Ramp	TN	NA	NA	NA	NA	10/06/2015	11/02/2020	NO	YES
Rangitāiki at Boat Ramp	NNN	12/09/1995	9/04/2015	YES	YES	10/06/2015	11/02/2020	NO	YES
Rangitāiki at Boat Ramp	DO	12/09/1995	9/04/2015	YES	YES	10/06/2015	11/02/2020	YES	YES
Rangitāiki at Boat Ramp	TP	12/09/1995	9/04/2015	YES	YES	10/06/2015	11/02/2020	YES	YES
Rangitāiki at Boat Ramp	pH	12/09/1995	9/04/2015	NO	YES	10/06/2015	11/02/2020	NO	YES
Rangitāiki at Boat Ramp	TSS	12/09/1995	9/04/2015	NO	YES	10/06/2015	11/02/2020	NO	YES
Rangitāiki at Boat Ramp	Turbidity	12/09/1995	9/04/2015	YES	YES	10/06/2015	11/02/2020	NO	YES
Rangitāiki at Boat Ramp	Water Clarity	NA	NA	NA	NA	10/06/2015	11/02/2020	NO	YES
Rangitāiki at Boat Ramp	Temp	12/09/1995	9/04/2015	YES	YES	10/06/2015	11/02/2020	YES	YES
Rangitāiki at Boat Ramp	DIN	12/09/1995	9/04/2015	YES	YES	10/06/2015	11/02/2020	YES	YES
Tarawera 50 m ds Thornton Road	NH4	12/09/1995	9/04/2015	YES	YES	10/06/2015	11/02/2020	YES	YES
Tarawera 50m ds Thornton Road	ChlA	12/09/1995	9/04/2015	NO	YES	10/06/2015	11/02/2020	NO	YES
Tarawera 50 m ds Thornton Road	DRP	12/09/1995	9/04/2015	NO	YES	10/06/2015	11/02/2020	NO	YES
Tarawera 50 m ds Thornton Road	ECOLI	12/09/1995	9/04/2015	YES	YES	10/06/2015	11/02/2020	NO	YES
Tarawera 50 m ds Thornton Road	Enterococci	12/09/1995	9/04/2015	YES	YES	10/06/2015	11/02/2020	YES	YES
Tarawera 50 m ds Thornton Road	Faecal coliforms	12/09/1995	9/04/2015	YES	YES	10/06/2015	11/02/2020	NO	YES
Tarawera 50 m ds Thornton Road	TN	NA	NA	NA	NA	10/06/2015	11/02/2020	YES	YES
Tarawera 50 m ds Thornton Road	NNN	12/09/1995	9/04/2015	YES	YES	10/06/2015	11/02/2020	YES	YES
Tarawera 50 m ds Thornton Road	DO	12/09/1995	9/04/2015	YES	YES	10/06/2015	11/02/2020	YES	YES
Tarawera 50 m ds Thornton Road	TP	12/09/1995	9/04/2015	NO	YES	10/06/2015	11/02/2020	NO	YES
Tarawera 50 m ds Thornton Road	pH	12/09/1995	9/04/2015	NO	YES	10/06/2015	11/02/2020	NO	YES

Site	Parameter	Pre-2015 Data starts	Pre-2015 Data End	Pre-2015 Seasonal adjustment	Pre-2015 Conductivity adjustment	5-year Data starts	5-year Data End	5-year Seasonal adjustment	5-year conductivity adjustment
Tarawera 50 m ds Thornton Road	TSS	12/09/1995	9/04/2015	YES	YES	10/06/2015	11/02/2020	NO	YES
Tarawera 50 m ds Thornton Road	Turbidity	12/09/1995	9/04/2015	YES	YES	10/06/2015	11/02/2020	NO	YES
Tarawera 50 m ds Thornton Road	Water Clarity	NA	NA	NA	NA	10/06/2015	11/02/2020	NO	YES
Tarawera 50 m ds Thornton Road	Temp	12/09/1995	9/04/2015	YES	YES	10/06/2015	11/02/2020	YES	YES
Tarawera 50 m ds Thornton Road	DIN	12/09/1995	9/04/2015	YES	YES	10/06/2015	11/02/2020	YES	YES
Whakatāne at Boat Ramp	NH4	28/09/1990	8/04/2015	YES	YES	15/06/2015	22/01/2020	NO	YES
Whakatāne at Boat Ramp	ChlA	28/09/1990	8/04/2015	YES	YES	15/06/2015	22/01/2020	NO	NO
Whakatāne at Boat Ramp	DRP	28/09/1990	8/04/2015	YES	YES	15/06/2015	22/01/2020	NO	YES
Whakatāne at Boat Ramp	ECOLI	28/09/1990	8/04/2015	NO	YES	15/06/2015	22/01/2020	NO	NO
Whakatāne at Boat Ramp	Enterococci	28/09/1990	8/04/2015	NO	YES	15/06/2015	22/01/2020	YES	NO
Whakatāne at Boat Ramp	Faecal coliforms	28/09/1990	8/04/2015	NO	YES	15/06/2015	22/01/2020	YES	NO
Whakatāne at Boat Ramp	TN	NA	NA	NA	NA	15/06/2015	22/01/2020	YES	YES
Whakatāne at Boat Ramp	NNN	28/09/1990	8/04/2015	YES	YES	15/06/2015	22/01/2020	YES	YES
Whakatāne at Boat Ramp	DO	28/09/1990	8/04/2015	YES	YES	15/06/2015	22/01/2020	YES	YES
Whakatāne at Boat Ramp	TP	28/09/1990	8/04/2015	YES	YES	15/06/2015	22/01/2020	NO	YES
Whakatāne at Boat Ramp	pH	28/09/1990	8/04/2015	YES	YES	15/06/2015	22/01/2020	NO	YES
Whakatāne at Boat Ramp	TSS	28/09/1990	8/04/2015	YES	YES	15/06/2015	22/01/2020	NO	YES
Whakatāne at Boat Ramp	Turbidity	28/09/1990	8/04/2015	YES	YES	15/06/2015	22/01/2020	NO	YES
Whakatāne at Boat Ramp	Water Clarity	NA	NA	NA	NA	15/06/2015	22/01/2020	NO	YES
Whakatāne at Boat Ramp	Temp	28/09/1990	8/04/2015	YES	YES	15/06/2015	22/01/2020	YES	YES
Whakatāne at Boat Ramp	DIN	28/09/1990	8/04/2015	YES	YES	15/06/2015	22/01/2020	YES	YES
Maketū Estuary at Boat Ramp	NH4	25/02/1991	9/04/2015	NO	YES	4/06/2015	10/02/2020	NO	YES
Maketū Estuary at Boat Ramp	ChlA	25/02/1991	9/04/2015	NO	NO	4/06/2015	10/02/2020	NO	YES
Maketū Estuary at Boat Ramp	DRP	25/02/1991	9/04/2015	NO	YES	4/06/2015	10/02/2020	NO	YES
Maketū Estuary at Boat Ramp	ECOLI	25/02/1991	9/04/2015	NO	YES	4/06/2015	10/02/2020	NO	YES
Maketū Estuary at Boat Ramp	Enterococci	25/02/1991	9/04/2015	NO	YES	4/06/2015	10/02/2020	NO	YES
Maketū Estuary at Boat Ramp	Faecal coliforms	25/02/1991	9/04/2015	NO	YES	4/06/2015	10/02/2020	NO	YES
Maketū Estuary at Boat Ramp	TN	NA	NA	NA	NA	4/06/2015	10/02/2020	NO	YES
Maketū Estuary at Boat Ramp	NNN	25/02/1991	9/04/2015	YES	YES	4/06/2015	10/02/2020	YES	YES
Maketū Estuary at Boat Ramp	DO	25/02/1991	9/04/2015	YES	YES	4/06/2015	10/02/2020	NO	NO
Maketū Estuary at Boat Ramp	TP	25/02/1991	9/04/2015	YES	YES	4/06/2015	10/02/2020	NO	YES
Maketū Estuary at Boat Ramp	pH	25/02/1991	9/04/2015	NO	YES	4/06/2015	10/02/2020	NO	YES
Maketū Estuary at Boat Ramp	TSS	25/02/1991	9/04/2015	NO	YES	4/06/2015	10/02/2020	YES	YES
Maketū Estuary at Boat Ramp	Turbidity	25/02/1991	9/04/2015	NO	YES	4/06/2015	10/02/2020	NO	YES
Maketū Estuary at Boat Ramp	Water Clarity	25/02/1991	9/04/2015	NO	YES	4/06/2015	10/02/2020	NO	YES
Maketū Estuary at Boat Ramp	Temp	25/02/1991	9/04/2015	YES	YES	4/06/2015	10/02/2020	YES	YES
Maketū Estuary at Boat Ramp	DIN	25/02/1991	9/04/2015	YES	YES	4/06/2015	10/02/2020	NO	YES
Ōhiwa Harbour at Port Ōhope Wharf	NH4	28/09/1990	8/04/2015	NO	NO	15/06/2015	13/02/2020	NO	YES
Ōhiwa Harbour at Port Ōhope Wharf	ChlA	28/09/1990	8/04/2015	NO	NO	15/06/2015	13/02/2020	NO	NO
Ōhiwa Harbour at Port Ōhope Wharf	DRP	28/09/1990	8/04/2015	YES	YES	15/06/2015	13/02/2020	NO	YES
Ōhiwa Harbour at Port Ōhope Wharf	ECOLI	28/09/1990	8/04/2015	NO	YES	15/06/2015	13/02/2020	NO	YES
Ōhiwa Harbour at Port Ōhope Wharf	Enterococci	28/09/1990	8/04/2015	NO	YES	15/06/2015	13/02/2020	YES	YES

Site	Parameter	Pre-2015 Data starts	Pre-2015 Data End	Pre-2015 Seasonal adjustment	Pre-2015 Conductivity adjustment	5-year Data starts	5-year Data End	5-year Seasonal adjustment	5-year conductivity adjustment
Ōhiwa Harbour at Port Ōhope Wharf	Faecal coliforms	28/09/1990	8/04/2015	NO	YES	15/06/2015	13/02/2020	NO	YES
Ōhiwa Harbour at Port Ōhope Wharf	TN	NA	NA	NA	NA	15/06/2015	13/02/2020	NO	YES
Ōhiwa Harbour at Port Ōhope Wharf	NNN	NA	NA	NA	NA	15/06/2015	13/02/2020	YES	YES
Ōhiwa Harbour at Port Ōhope Wharf	DO	28/09/1990	8/04/2015	YES	YES	15/06/2015	13/02/2020	YES	YES
Ōhiwa Harbour at Port Ōhope Wharf	TP	28/09/1990	8/04/2015	YES	YES	15/06/2015	13/02/2020	NO	NO
Ōhiwa Harbour at Port Ōhope Wharf	pH	28/09/1990	8/04/2015	YES	YES	15/06/2015	13/02/2020	NO	YES
Ōhiwa Harbour at Port Ōhope Wharf	TSS	28/09/1990	8/04/2015	YES	YES	15/06/2015	13/02/2020	NO	YES
Ōhiwa Harbour at Port Ōhope Wharf	Turbidity	28/09/1990	8/04/2015	NO	YES	15/06/2015	13/02/2020	NO	NO
Ōhiwa Harbour at Port Ōhope Wharf	Water Clarity	NA	NA	NA	NA	15/06/2015	13/02/2020	NO	YES
Ōhiwa Harbour at Port Ōhope Wharf	Temp	28/09/1990	8/04/2015	YES	YES	15/06/2015	13/02/2020	YES	YES
Ōhiwa Harbour at Port Ōhope Wharf	DIN	28/09/1990	8/04/2015	YES	Attempted	15/06/2015	13/02/2020	YES	YES
Ōhiwa Harbour at Ruatuna Road	NH4	28/09/1990	8/04/2015	NO	YES	15/06/2015	13/02/2020	NO	YES
Ōhiwa Harbour at Ruatuna Road	ChlA	28/09/1990	8/04/2015	NO	YES	15/06/2015	13/02/2020	NO	YES
Ōhiwa Harbour at Ruatuna Road	DRP	28/09/1990	8/04/2015	YES	YES	15/06/2015	13/02/2020	NO	YES
Ōhiwa Harbour at Ruatuna Road	ECOLI	28/09/1990	8/04/2015	NO	NO	15/06/2015	13/02/2020	NO	YES
Ōhiwa Harbour at Ruatuna Road	Enterococci	28/09/1990	8/04/2015	NO	NO	15/06/2015	13/02/2020	YES	YES
Ōhiwa Harbour at Ruatuna Road	Faecal coliforms	28/09/1990	8/04/2015	NO	YES	15/06/2015	13/02/2020	NO	YES
Ōhiwa Harbour at Ruatuna Road	TN	NA	NA	NA	NA	15/06/2015	13/02/2020	NO	YES
Ōhiwa Harbour at Ruatuna Road	NNN	28/09/1990	8/04/2015	YES	YES	15/06/2015	13/02/2020	YES	YES
Ōhiwa Harbour at Ruatuna Road	DO	28/09/1990	8/04/2015	YES	YES	15/06/2015	13/02/2020	YES	YES
Ōhiwa Harbour at Ruatuna Road	TP	28/09/1990	8/04/2015	NO	NO	15/06/2015	13/02/2020	NO	YES
Ōhiwa Harbour at Ruatuna Road	pH	28/09/1990	8/04/2015	NO	YES	15/06/2015	13/02/2020	NO	YES
Ōhiwa Harbour at Ruatuna Road	TSS	28/09/1990	8/04/2015	YES	YES	15/06/2015	13/02/2020	NO	YES
Ōhiwa Harbour at Ruatuna Road	Turbidity	28/09/1990	8/04/2015	NO	NO	15/06/2015	13/02/2020	NO	YES
Ōhiwa Harbour at Ruatuna Road	Water Clarity	28/09/1990	8/04/2015	NO	YES	15/06/2015	13/02/2020	NO	YES
Ōhiwa Harbour at Ruatuna Road	Temp	28/09/1990	8/04/2015	YES	YES	15/06/2015	13/02/2020	YES	YES
Ōhiwa Harbour at Ruatuna Road	DIN	28/09/1990	8/04/2015	YES	YES	15/06/2015	13/02/2020	YES	YES
Waihī Estuary at Main Channel	NH4	13/07/1989	9/04/2015	NO	YES	4/06/2015	10/02/2020	NO	YES
Waihī Estuary at Main Channel	ChlA	13/07/1989	9/04/2015	NO	YES	4/06/2015	10/02/2020	NO	YES
Waihī Estuary at Main Channel	DRP	13/07/1989	9/04/2015	NO	YES	4/06/2015	10/02/2020	NO	YES
Waihī Estuary at Main Channel	ECOLI	13/07/1989	9/04/2015	NO	YES	4/06/2015	10/02/2020	NO	YES
Waihī Estuary at Main Channel	Enterococci	13/07/1989	9/04/2015	NO	YES	4/06/2015	10/02/2020	NO	YES
Waihī Estuary at Main Channel	Faecal coliforms	13/07/1989	9/04/2015	YES	YES	4/06/2015	10/02/2020	NO	YES
Waihī Estuary at Main Channel	TN	NA	NA	NA	NA	4/06/2015	10/02/2020	YES	YES
Waihī Estuary at Main Channel	NNN	13/07/1989	9/04/2015	YES	YES	4/06/2015	10/02/2020	NO	YES
Waihī Estuary at Main Channel	DO	13/07/1989	9/04/2015	NO	YES	4/06/2015	10/02/2020	NO	YES
Waihī Estuary at Main Channel	TP	13/07/1989	9/04/2015	NO	YES	4/06/2015	10/02/2020	NO	YES
Waihī Estuary at Main Channel	pH	13/07/1989	9/04/2015	NO	YES	4/06/2015	10/02/2020	NO	YES
Waihī Estuary at Main Channel	TSS	13/07/1989	9/04/2015	NO	NO	4/06/2015	10/02/2020	NO	YES

Site	Parameter	Pre-2015 Data starts	Pre-2015 Data End	Pre-2015 Seasonal adjustment	Pre-2015 Conductivity adjustment	5-year Data starts	5-year Data End	5-year Seasonal adjustment	5-year conductivity adjustment
Waihī Estuary at Main Channel	Turbidity	13/07/1989	9/04/2015	NO	YES	4/06/2015	10/02/2020	NO	YES
Waihī Estuary at Main Channel	Water Clarity	13/07/1989	9/04/2015	NO	YES	4/06/2015	10/02/2020	YES	YES
Waihī Estuary at Main Channel	Temp	13/07/1989	9/04/2015	YES	YES	4/06/2015	10/02/2020	YES	YES
Waihī Estuary at Main Channel	DIN	13/07/1989	9/04/2015	YES	YES	4/06/2015	10/02/2020	NO	YES
Tauranga Harbour at Kauri Point Jetty	NH4	18/05/1998	9/04/2015	YES	YES	9/04/2015	24/02/2020	YES	YES
Tauranga Harbour at Kauri Point Jetty	ChlA	18/05/1998	9/04/2015	YES	YES	9/04/2015	24/02/2020	NO	YES
Tauranga Harbour at Kauri Point Jetty	DRP	18/05/1998	9/04/2015	NO	YES	NA	NA	NA	NA
Tauranga Harbour at Kauri Point Jetty	ECOLI	NA	NA	NA	NA	9/04/2015	24/02/2020	NO	YES
Tauranga Harbour at Kauri Point Jetty	Enterococci	18/05/1998	9/04/2015	NO	YES	9/04/2015	24/02/2020	NO	YES
Tauranga Harbour at Kauri Point Jetty	Faecal coliforms	18/05/1998	9/04/2015	NO	YES	9/04/2015	24/02/2020	YES	YES
Tauranga Harbour at Kauri Point Jetty	TN	18/05/1998	9/04/2015	NO	YES	9/04/2015	24/02/2020	NO	YES
Tauranga Harbour at Kauri Point Jetty	NNN	NA	NA	NA	NA	9/04/2015	24/02/2020	NO	YES
Tauranga Harbour at Kauri Point Jetty	DO	18/05/1998	9/04/2015	YES	YES	9/04/2015	24/02/2020	YES	YES
Tauranga Harbour at Kauri Point Jetty	TP	18/05/1998	9/04/2015	YES	YES	9/04/2015	24/02/2020	NO	YES
Tauranga Harbour at Kauri Point Jetty	pH	18/05/1998	9/04/2015	NO	YES	9/04/2015	24/02/2020	NO	NO
Tauranga Harbour at Kauri Point Jetty	TSS	18/05/1998	9/04/2015	NO	YES	9/04/2015	24/02/2020	NO	YES
Tauranga Harbour at Kauri Point Jetty	Turbidity	18/05/1998	9/04/2015	NO	YES	9/04/2015	24/02/2020	NO	YES
Tauranga Harbour at Kauri Point Jetty	Water Clarity	18/05/1998	9/04/2015	NO	YES	9/04/2015	24/02/2020	NO	YES
Tauranga Harbour at Kauri Point Jetty	Temp	18/05/1998	9/04/2015	YES	YES	9/04/2015	24/02/2020	YES	YES
Tauranga Harbour at Kauri Point Jetty	DIN	NA	NA	NA	NA	9/04/2015	24/02/2020	YES	YES
Tauranga Harbour at Maungatapu Bridge NERMN	NH4	8/11/1991	9/04/2015	YES	YES	9/04/2015	24/02/2020	YES	YES
Tauranga Harbour at Maungatapu Bridge NERMN	ChlA	8/11/1991	9/04/2015	NO	YES	9/04/2015	24/02/2020	YES	YES
Tauranga Harbour at Maungatapu Bridge NERMN	DRP	8/11/1991	9/04/2015	YES	YES	9/04/2015	24/02/2020	NO	YES
Tauranga Harbour at Maungatapu Bridge NERMN	ECOLI	8/11/1991	9/04/2015	NO	YES	9/04/2015	24/02/2020	NO	YES
Tauranga Harbour at Maungatapu Bridge NERMN	Enterococci	8/11/1991	9/04/2015	YES	YES	9/04/2015	24/02/2020	NO	YES
Tauranga Harbour at Maungatapu Bridge NERMN	Faecal coliforms	8/11/1991	9/04/2015	NO	YES	9/04/2015	24/02/2020	NO	YES
Tauranga Harbour at Maungatapu Bridge NERMN	TN	8/11/1991	9/04/2015	NO	YES	9/04/2015	24/02/2020	NO	YES
Tauranga Harbour at Maungatapu Bridge NERMN	NNN	8/11/1991	9/04/2015	YES	YES	9/04/2015	24/02/2020	YES	YES
Tauranga Harbour at Maungatapu Bridge NERMN	DO	8/11/1991	9/04/2015	YES	YES	9/04/2015	24/02/2020	YES	YES

Site	Parameter	Pre-2015 Data starts	Pre-2015 Data End	Pre-2015 Seasonal adjustment	Pre-2015 Conductivity adjustment	5-year Data starts	5-year Data End	5-year Seasonal adjustment	5-year conductivity adjustment
Tauranga Harbour at Maungatapu Bridge NERMN	TP	8/11/1991	9/04/2015	NO	YES	9/04/2015	24/02/2020	NO	YES
Tauranga Harbour at Maungatapu Bridge NERMN	pH	8/11/1991	9/04/2015	NO	YES	9/04/2015	24/02/2020	NO	YES
Tauranga Harbour at Maungatapu Bridge NERMN	TSS	8/11/1991	9/04/2015	NO	YES	9/04/2015	24/02/2020	NO	YES
Tauranga Harbour at Maungatapu Bridge NERMN	Turbidity	8/11/1991	9/04/2015	NO	YES	9/04/2015	24/02/2020	NO	YES
Tauranga Harbour at Maungatapu Bridge NERMN	Water Clarity	NA	NA	NA	NA	9/04/2015	24/02/2020	NO	YES
Tauranga Harbour at Maungatapu Bridge NERMN	Temp	8/11/1991	9/04/2015	YES	YES	9/04/2015	24/02/2020	YES	YES
Tauranga Harbour at Maungatapu Bridge NERMN	DIN	8/11/1991	9/04/2015	YES	YES	9/04/2015	24/02/2020	YES	YES
Tauranga Harbour at Mount Maunganui	NH4	NA	NA	NA	NA	18/06/2015	24/02/2020	NO	YES
Tauranga Harbour at Mount Maunganui	ChlA	NA	NA	NA	NA	18/06/2015	24/02/2020	NO	YES
Tauranga Harbour at Mount Maunganui	DRP	NA	NA	NA	NA	18/06/2015	24/02/2020	YES	YES
Tauranga Harbour at Mount Maunganui	ECOLI	NA	NA	NA	NA	18/06/2015	24/02/2020	NO	YES
Tauranga Harbour at Mount Maunganui	Enterococci	NA	NA	NA	NA	18/06/2015	24/02/2020	NO	YES
Tauranga Harbour at Mount Maunganui	Faecal coliforms	NA	NA	NA	NA	18/06/2015	24/02/2020	NO	YES
Tauranga Harbour at Mount Maunganui	TN	NA	NA	NA	NA	18/06/2015	24/02/2020	NO	YES
Tauranga Harbour at Mount Maunganui	NNN	NA	NA	NA	NA	18/06/2015	24/02/2020	YES	YES
Tauranga Harbour at Mount Maunganui	DO	NA	NA	NA	NA	18/06/2015	24/02/2020	YES	YES
Tauranga Harbour at Mount Maunganui	TP	NA	NA	NA	NA	18/06/2015	24/02/2020	NO	YES
Tauranga Harbour at Mount Maunganui	pH	NA	NA	NA	NA	18/06/2015	24/02/2020	NO	YES
Tauranga Harbour at Mount Maunganui	TSS	NA	NA	NA	NA	18/06/2015	24/02/2020	NO	YES
Tauranga Harbour at Mount Maunganui	Turbidity	NA	NA	NA	NA	18/06/2015	24/02/2020	NO	YES
Tauranga Harbour at Mount Maunganui	Water Clarity	NA	NA	NA	NA	18/06/2015	24/02/2020	NO	YES
Tauranga Harbour at Mount Maunganui	Temp	NA	NA	NA	NA	18/06/2015	24/02/2020	YES	YES
Tauranga Harbour at Mount Maunganui	DIN	NA	NA	NA	NA	18/06/2015	24/02/2020	YES	YES
Tauranga Harbour at Ōmokoroa Wharf	NH4	8/11/1991	9/04/2015	YES	YES	9/04/2015	24/02/2020	YES	YES
Tauranga Harbour at Ōmokoroa Wharf	ChlA	8/11/1991	9/04/2015	YES	YES	9/04/2015	24/02/2020	YES	YES
Tauranga Harbour at Ōmokoroa Wharf	DRP	8/11/1991	9/04/2015	YES	YES	9/04/2015	24/02/2020	YES	YES
Tauranga Harbour at Ōmokoroa Wharf	ECOLI	NA	NA	NA	NA	9/04/2015	24/02/2020	NO	YES
Tauranga Harbour at Ōmokoroa Wharf	Enterococci	8/11/1991	9/04/2015	NO	YES	9/04/2015	24/02/2020	NO	YES

Site	Parameter	Pre-2015 Data starts	Pre-2015 Data End	Pre-2015 Seasonal adjustment	Pre-2015 Conductivity adjustment	5-year Data starts	5-year Data End	5-year Seasonal adjustment	5-year conductivity adjustment
Tauranga Harbour at Ōmokoroa Wharf	Faecal coliforms	8/11/1991	9/04/2015	NO	YES	9/04/2015	24/02/2020	NO	YES
Tauranga Harbour at Ōmokoroa Wharf	TN	NA	NA	NA	NA	9/04/2015	24/02/2020	NO	YES
Tauranga Harbour at Ōmokoroa Wharf	NNN	NA	NA	NA	NA	9/04/2015	24/02/2020	YES	YES
Tauranga Harbour at Ōmokoroa Wharf	DO	8/11/1991	9/04/2015	YES	YES	9/04/2015	24/02/2020	YES	YES
Tauranga Harbour at Ōmokoroa Wharf	TP	8/11/1991	9/04/2015	YES	YES	9/04/2015	24/02/2020	NO	NO
Tauranga Harbour at Ōmokoroa Wharf	pH	8/11/1991	9/04/2015	YES	YES	9/04/2015	24/02/2020	NO	YES
Tauranga Harbour at Ōmokoroa Wharf	TSS	8/11/1991	9/04/2015	NO	NO	9/04/2015	24/02/2020	NO	YES
Tauranga Harbour at Ōmokoroa Wharf	Turbidity	8/11/1991	9/04/2015	YES	NO	9/04/2015	24/02/2020	NO	YES
Tauranga Harbour at Ōmokoroa Wharf	Water Clarity	8/11/1991	9/04/2015	NO	YES	9/04/2015	24/02/2020	NO	YES
Tauranga Harbour at Ōmokoroa Wharf	Temp	8/11/1991	9/04/2015	YES	YES	9/04/2015	24/02/2020	YES	YES
Tauranga Harbour at Ōmokoroa Wharf	DIN	NA	NA	NA	NA	9/04/2015	24/02/2020	YES	YES
Tauranga Harbour at Tanners Point Jetty	NH4	29/07/1998	9/04/2015	NO	YES	9/04/2015	24/02/2020	NO	YES
Tauranga Harbour at Tanners Point Jetty	ChlA	29/07/1998	9/04/2015	YES	YES	9/04/2015	24/02/2020	NO	YES
Tauranga Harbour at Tanners Point Jetty	DRP	29/07/1998	9/04/2015	YES	NO	9/04/2015	24/02/2020	NO	YES
Tauranga Harbour at Tanners Point Jetty	ECOLI	29/07/1998	9/04/2015	NO	YES	9/04/2015	24/02/2020	NO	YES
Tauranga Harbour at Tanners Point Jetty	Enterococci	29/07/1998	9/04/2015	YES	YES	9/04/2015	24/02/2020	NO	YES
Tauranga Harbour at Tanners Point Jetty	Faecal coliforms	29/07/1998	9/04/2015	NO	YES	9/04/2015	24/02/2020	NO	YES
Tauranga Harbour at Tanners Point Jetty	TN	29/07/1998	9/04/2015	NO	YES	9/04/2015	24/02/2020	NO	YES
Tauranga Harbour at Tanners Point Jetty	NNN	NA	NA	NA	NA	9/04/2015	24/02/2020	NO	YES
Tauranga Harbour at Tanners Point Jetty	DO	29/07/1998	9/04/2015	YES	YES	9/04/2015	24/02/2020	YES	YES
Tauranga Harbour at Tanners Point Jetty	TP	29/07/1998	9/04/2015	YES	YES	9/04/2015	24/02/2020	YES	NO
Tauranga Harbour at Tanners Point Jetty	pH	29/07/1998	9/04/2015	NO	YES	9/04/2015	24/02/2020	NO	YES
Tauranga Harbour at Tanners Point Jetty	TSS	29/07/1998	9/04/2015	NO	YES	9/04/2015	24/02/2020	NO	YES
Tauranga Harbour at Tanners Point Jetty	Turbidity	29/07/1998	9/04/2015	NO	YES	9/04/2015	24/02/2020	NO	YES
Tauranga Harbour at Tanners Point Jetty	Water Clarity	29/07/1998	9/04/2015	NO	YES	9/04/2015	24/02/2020	NO	YES
Tauranga Harbour at Tanners Point Jetty	Temp	29/07/1998	9/04/2015	YES	YES	9/04/2015	24/02/2020	YES	YES
Tauranga Harbour at Tanners Point Jetty	DIN	NA	NA	NA	NA	9/04/2015	24/02/2020	NO	YES
Tauranga Harbour at Tilby Point	NH4	NA	NA	NA	NA	18/06/2015	24/02/2020	YES	YES
Tauranga Harbour at Tilby Point	ChlA	NA	NA	NA	NA	18/06/2015	24/02/2020	NO	YES

Site	Parameter	Pre-2015 Data starts	Pre-2015 Data End	Pre-2015 Seasonal adjustment	Pre-2015 Conductivity adjustment	5-year Data starts	5-year Data End	5-year Seasonal adjustment	5-year conductivity adjustment
Tauranga Harbour at Tilby Point	DRP	NA	NA	NA	NA	18/06/2015	24/02/2020	YES	YES
Tauranga Harbour at Tilby Point	ECOLI	NA	NA	NA	NA	18/06/2015	24/02/2020	NO	YES
Tauranga Harbour at Tilby Point	Enterococci	NA	NA	NA	NA	18/06/2015	24/02/2020	NO	YES
Tauranga Harbour at Tilby Point	Faecal coliforms	NA	NA	NA	NA	18/06/2015	24/02/2020	NO	YES
Tauranga Harbour at Tilby Point	TN	NA	NA	NA	NA	18/06/2015	24/02/2020	NO	YES
Tauranga Harbour at Tilby Point	NNN	NA	NA	NA	NA	18/06/2015	24/02/2020	YES	YES
Tauranga Harbour at Tilby Point	DO	NA	NA	NA	NA	18/06/2015	24/02/2020	YES	YES
Tauranga Harbour at Tilby Point	TP	NA	NA	NA	NA	18/06/2015	24/02/2020	NO	YES
Tauranga Harbour at Tilby Point	pH	NA	NA	NA	NA	18/06/2015	24/02/2020	NO	YES
Tauranga Harbour at Tilby Point	TSS	NA	NA	NA	NA	18/06/2015	24/02/2020	NO	YES
Tauranga Harbour at Tilby Point	Turbidity	NA	NA	NA	NA	18/06/2015	24/02/2020	NO	YES
Tauranga Harbour at Tilby Point	Water Clarity	NA	NA	NA	NA	18/06/2015	24/02/2020	NO	YES
Tauranga Harbour at Tilby Point	Temp	NA	NA	NA	NA	18/06/2015	24/02/2020	YES	YES
Tauranga Harbour at Tilby Point	DIN	NA	NA	NA	NA	18/06/2015	24/02/2020	YES	YES
Tauranga Harbour at Toll Bridge Marina	NH4	18/05/1998	9/04/2015	NO	YES	9/04/2015	24/02/2020	NO	YES
Tauranga Harbour at Toll Bridge Marina	ChlA	18/05/1998	9/04/2015	YES	YES	9/04/2015	24/02/2020	NO	YES
Tauranga Harbour at Toll Bridge Marina	DRP	18/05/1998	9/04/2015	YES	NO	9/04/2015	24/02/2020	NO	YES
Tauranga Harbour at Toll Bridge Marina	ECOLI	18/05/1998	9/04/2015	NO	YES	9/04/2015	24/02/2020	NO	YES
Tauranga Harbour at Toll Bridge Marina	Enterococci	18/05/1998	9/04/2015	YES	YES	9/04/2015	24/02/2020	NO	YES
Tauranga Harbour at Toll Bridge Marina	Faecal coliforms	18/05/1998	9/04/2015	NO	YES	9/04/2015	24/02/2020	NO	YES
Tauranga Harbour at Toll Bridge Marina	TN	18/05/1998	9/04/2015	NO	YES	9/04/2015	24/02/2020	NO	YES
Tauranga Harbour at Toll Bridge Marina	NNN	18/05/1998	9/04/2015	YES	YES	9/04/2015	24/02/2020	YES	YES
Tauranga Harbour at Toll Bridge Marina	DO	18/05/1998	9/04/2015	YES	YES	9/04/2015	24/02/2020	YES	YES
Tauranga Harbour at Toll Bridge Marina	TP	18/05/1998	9/04/2015	NO	YES	9/04/2015	24/02/2020	YES	YES
Tauranga Harbour at Toll Bridge Marina	pH	18/05/1998	9/04/2015	NO	YES	9/04/2015	24/02/2020	NO	YES
Tauranga Harbour at Toll Bridge Marina	TSS	18/05/1998	9/04/2015	NO	YES	9/04/2015	24/02/2020	NO	YES
Tauranga Harbour at Toll Bridge Marina	Turbidity	18/05/1998	9/04/2015	NO	YES	9/04/2015	24/02/2020	NO	YES
Tauranga Harbour at Toll Bridge Marina	Water Clarity	18/05/1998	9/04/2015	NO	YES	9/04/2015	24/02/2020	NO	YES
Tauranga Harbour at Toll Bridge Marina	Temp	18/05/1998	9/04/2015	YES	YES	9/04/2015	24/02/2020	YES	YES
Tauranga Harbour at Toll Bridge Marina	DIN	18/05/1998	9/04/2015	YES	YES	9/04/2015	24/02/2020	YES	YES
Tauranga Harbour at Waikareao	NH4	NA	NA	NA	NA	18/06/2015	24/02/2020	NO	YES
Tauranga Harbour at Waikareao	ChlA	NA	NA	NA	NA	18/06/2015	24/02/2020	NO	YES
Tauranga Harbour at Waikareao	DRP	NA	NA	NA	NA	18/06/2015	24/02/2020	NO	YES
Tauranga Harbour at Waikareao	ECOLI	NA	NA	NA	NA	18/06/2015	24/02/2020	NO	YES
Tauranga Harbour at Waikareao	Enterococci	NA	NA	NA	NA	18/06/2015	24/02/2020	NO	YES
Tauranga Harbour at Waikareao	Faecal coliforms	NA	NA	NA	NA	18/06/2015	24/02/2020	NO	YES

Site	Parameter	Pre-2015 Data starts	Pre-2015 Data End	Pre-2015 Seasonal adjustment	Pre-2015 Conductivity adjustment	5-year Data starts	5-year Data End	5-year Seasonal adjustment	5-year conductivity adjustment
Tauranga Harbour at Waikareao	TN	NA	NA	NA	NA	18/06/2015	24/02/2020	NO	YES
Tauranga Harbour at Waikareao	NNN	NA	NA	NA	NA	18/06/2015	24/02/2020	NO	YES
Tauranga Harbour at Waikareao	DO	NA	NA	NA	NA	18/06/2015	24/02/2020	YES	YES
Tauranga Harbour at Waikareao	TP	NA	NA	NA	NA	18/06/2015	24/02/2020	NO	YES
Tauranga Harbour at Waikareao	pH	NA	NA	NA	NA	18/06/2015	24/02/2020	NO	YES
Tauranga Harbour at Waikareao	TSS	NA	NA	NA	NA	18/06/2015	24/02/2020	NO	YES
Tauranga Harbour at Waikareao	Turbidity	NA	NA	NA	NA	18/06/2015	24/02/2020	NO	YES
Tauranga Harbour at Waikareao	Water Clarity	NA	NA	NA	NA	18/06/2015	24/02/2020	NO	YES
Tauranga Harbour at Waikareao	Temp	NA	NA	NA	NA	18/06/2015	24/02/2020	YES	YES
Tauranga Harbour at Waikareao	DIN	NA	NA	NA	NA	18/06/2015	24/02/2020	NO	YES

Appendix D

River estuaries summary statistics

	Ōpōtiki Estuary at Kukumoa (N=53)	Rangitāiki at Boat Ramp (N=56)	Tarawera 50 m ds Thornton Rd (N=57)	Waiōtahe at Estuary (N=42)	Whakatāne at Boat Ramp (N=55)
NH4					
Mean (SD)	0.02 (0.01)	0.02 (0.01)	0.03 (0.02)	0.04 (0.02)	0.01 (0.01)
Median (Q1, Q3)	0.01 (0.01, 0.02)	0.02 (0.01, 0.03)	0.03 (0.02, 0.04)	0.04 (0.03, 0.05)	0.01 (0.01, 0.02)
Min - Max	0.00 - 0.06	0.00 - 0.06	-0.00 - 0.12	0.00 - 0.07	0.00 - 0.04
ChlA					
Mean (SD)	0.58 (0.61)	2.17 (2.92)	1.07 (1.76)	NA	0.57 (0.58)
Median (Q1, Q3)	0.30 (0.20, 0.80)	1.00 (0.47, 2.52)	0.60 (0.50, 0.92)	NA	0.40 (0.30, 0.60)
Min - Max	0.10 - 2.70	0.20 - 13.70	0.20 - 11.30	NA	0.05 - 3.50
Conductivity					
Mean (SD)	6243.58 (9934.05)	1811.58 (3115.80)	637.18 (1640.63)	27157.38 (16630.06)	8898.63 (6932.37)
Median (Q1, Q3)	3460.00 (1040.00, 8060.00)	549.00 (326.75, 1152.50)	332.00 (305.00, 358.00)	21050.00 (12925.00, 45275.00)	6870.00 (3220.00, 14050.00)
Min - Max	104.00 - 52800.00	98.40 - 16400.00	237.00 - 11200.00	990.00 - 52100.00	60.90 - 23000.00
DO%					
Mean (SD)	96.40 (7.16)	92.99 (8.30)	83.86 (6.27)	105.14 (6.38)	94.81 (6.95)
Median (Q1, Q3)	95.50 (92.10, 98.05)	94.30 (87.18, 98.43)	83.90 (80.88, 87.08)	104.40 (101.30, 108.75)	94.80 (91.20, 97.60)
Min - Max	85.50 - 124.60	68.00 - 112.90	68.00 - 102.90	93.70 - 121.70	79.30 - 122.50
DRP					
Mean (SD)	0.02 (0.01)	0.05 (0.02)	0.07 (0.01)	0.02 (0.02)	0.02 (0.01)
Median (Q1, Q3)	0.02 (0.02, 0.03)	0.05 (0.04, 0.07)	0.07 (0.06, 0.08)	0.02 (0.01, 0.02)	0.02 (0.01, 0.03)
Min - Max	-0.00 - 0.09	0.03 - 0.09	0.01 - 0.09	0.00 - 0.12	0.00 - 0.04
ECOLI					
Mean (SD)	475.07 (1275.59)	104.35 (209.23)	115.88 (159.17)	224.05 (540.03)	365.27 (738.96)
Median (Q1, Q3)	73.18 (45.50, 260.00)	37.00 (23.00, 58.00)	62.00 (43.00, 110.00)	43.50 (18.50, 128.50)	91.67 (60.00, 282.50)
Min - Max	1.00 - 8000.00	4.00 - 1100.00	14.00 - 1033.33	0.00 - 2700.00	17.00 - 4200.00

	Ōpōtiki Estuary at Kukumoa (N=53)	Rangitāiki at Boat Ramp (N=56)	Tarawera 50 m ds Thornton Rd (N=57)	Waiōtahe at Estuary (N=42)	Whakatāne at Boat Ramp (N=55)
Enterococci					
Mean (SD)	425.00 (1695.55)	116.59 (431.39)	88.78 (156.84)	181.88 (402.35)	328.09 (812.70)
Median (Q1, Q3)	34.00 (13.00, 130.00)	17.00 (10.00, 52.25)	26.00 (14.00, 92.00)	33.00 (10.00, 210.00)	47.00 (22.00, 170.00)
Min - Max	0.00 - 12000.00	2.00 - 3100.00	1.00 - 833.33	0.00 - 2400.00	0.00 - 4600.00
Faecal coliforms					
Mean (SD)	643.66 (1666.41)	185443.02 (1360790.77)	190.83 (272.03)	379.90 (944.04)	2403.65 (7168.60)
Median (Q1, Q3)	100.00 (50.00, 360.00)	56.50 (34.25, 170.00)	96.67 (53.00, 190.00)	59.00 (29.00, 200.00)	410.00 (110.00, 1385.00)
Min - Max	2.00 - 10400.00	11.00 - 9999990.00	22.00 - 1400.00	0.00 - 4300.00	16.00 - 49000.00
TN					
Mean (SD)	0.23 (0.14)	0.68 (0.14)	0.63 (0.10)	0.31 (0.16)	0.26 (0.09)
Median (Q1, Q3)	0.19 (0.14, 0.26)	0.69 (0.60, 0.78)	0.61 (0.57, 0.68)	0.28 (0.21, 0.34)	0.25 (0.20, 0.29)
Min - Max	0.08 - 0.74	0.34 - 1.00	0.44 - 1.14	0.03 - 0.80	0.03 - 0.48
NNN					
Mean (SD)	0.10 (0.08)	0.54 (0.15)	0.46 (0.08)	0.08 (0.09)	0.13 (0.09)
Median (Q1, Q3)	0.10 (0.02, 0.15)	0.52 (0.43, 0.64)	0.46 (0.41, 0.49)	0.04 (0.01, 0.12)	0.13 (0.06, 0.19)
Min - Max	-0.00 - 0.33	0.16 - 0.83	0.23 - 0.74	0.00 - 0.37	0.00 - 0.38
DO					
Mean (SD)	9.77 (1.36)	9.31 (0.98)	8.31 (0.90)	9.34 (1.12)	9.47 (1.28)
Median (Q1, Q3)	9.81 (8.83, 10.72)	9.44 (8.70, 9.92)	8.32 (7.88, 8.66)	9.58 (8.88, 10.20)	9.52 (8.43, 10.48)
Min - Max	7.33 - 13.03	6.42 - 11.29	6.07 - 12.47	6.90 - 11.89	7.03 - 12.52
TP					
Mean (SD)	0.06 (0.06)	0.09 (0.03)	0.11 (0.02)	0.05 (0.05)	0.05 (0.04)
Median (Q1, Q3)	0.04 (0.03, 0.05)	0.08 (0.07, 0.11)	0.12 (0.10, 0.13)	0.04 (0.03, 0.05)	0.04 (0.04, 0.05)
Min - Max	0.02 - 0.35	0.00 - 0.24	0.05 - 0.18	0.01 - 0.27	0.02 - 0.24
pH					
Mean (SD)	7.51 (0.34)	7.17 (0.23)	7.37 (0.14)	7.62 (0.42)	7.25 (0.27)
Median (Q1, Q3)	7.52 (7.41, 7.65)	7.17 (7.08, 7.28)	7.38 (7.27, 7.48)	7.71 (7.39, 7.96)	7.22 (7.09, 7.42)
Min - Max	6.01 - 8.22	6.32 - 7.68	7.04 - 7.69	6.22 - 8.17	6.51 - 7.92
Salinity					
Mean (SD)	3.80 (6.53)	0.94 (1.75)	0.26 (0.90)	NA	5.14 (4.28)

	Ōpōtiki Estuary at Kukumoa (N=53)	Rangitāiki at Boat Ramp (N=56)	Tarawera 50 m ds Thornton Rd (N=57)	Waiōtahe at Estuary (N=42)	Whakatāne at Boat Ramp (N=55)
Median (Q1, Q3)	1.99 (0.47, 5.11)	0.19 (0.08, 0.56)	0.09 (0.07, 0.11)	NA	3.83 (1.53, 8.07)
Min - Max	0.00 - 34.75	0.00 - 8.94	0.04 - 5.90	NA	0.03 - 14.00
TKN					
Mean (SD)	NA	NA	NA	NA	NA
Median (Q1, Q3)	NA	NA	NA	NA	NA
Min - Max	NA	NA	NA	NA	NA
TSS					
Mean (SD)	29.49 (59.68)	11.82 (20.60)	13.59 (8.08)	18.83 (13.96)	25.59 (53.47)
Median (Q1, Q3)	11.85 (5.30, 24.45)	6.97 (4.03, 11.31)	12.00 (8.00, 15.60)	16.70 (9.80, 23.00)	8.35 (4.67, 15.10)
Min - Max	2.40 - 374.00	1.90 - 128.00	4.00 - 37.30	2.30 - 72.00	3.40 - 304.00
Turbidity					
Mean (SD)	20.57 (45.78)	8.53 (22.16)	4.29 (1.65)	9.23 (7.06)	20.91 (40.98)
Median (Q1, Q3)	6.62 (2.89, 15.30)	3.62 (2.35, 6.29)	3.89 (3.41, 4.89)	7.56 (5.07, 10.55)	5.33 (2.97, 11.90)
Min - Max	1.04 - 280.00	1.24 - 146.50	1.74 - 12.40	1.43 - 36.30	1.76 - 207.00
Water Clarity					
Mean (SD)	1.23 (1.06)	1.53 (0.71)	1.29 (0.36)	0.77 (0.35)	1.23 (0.62)
Median (Q1, Q3)	1.00 (0.42, 1.69)	1.51 (1.04, 1.94)	1.30 (1.13, 1.51)	0.70 (0.52, 1.05)	1.06 (0.78, 1.57)
Min - Max	0.01 - 4.70	0.11 - 3.62	0.44 - 2.12	0.21 - 1.62	0.39 - 2.97
Temp					
Mean (SD)	14.76 (4.21)	15.41 (3.64)	16.32 (2.52)	19.08 (4.88)	15.01 (4.24)
Median (Q1, Q3)	14.70 (11.05, 17.35)	15.20 (12.10, 18.92)	15.80 (14.30, 18.30)	19.30 (14.90, 22.25)	14.55 (11.33, 18.65)
Min - Max	7.60 - 23.70	9.40 - 22.40	12.30 - 21.50	10.80 - 29.60	8.20 - 24.30
DIN					
Mean (SD)	0.12 (0.09)	0.56 (0.15)	0.49 (0.09)	0.12 (0.10)	0.15 (0.09)
Median (Q1, Q3)	0.12 (0.04, 0.17)	0.55 (0.46, 0.66)	0.49 (0.43, 0.53)	0.08 (0.04, 0.17)	0.15 (0.07, 0.22)
Min - Max	0.01 - 0.38	0.17 - 0.85	0.25 - 0.76	0.00 - 0.43	0.00 - 0.41

Eastern and central estuaries summary statistics

	Maketū Estuary at Boat Ramp (N=55)	Ōhiwa Harbour at Port Ōhope Wharf (N=56)	Ōhiwa Harbour at Ruatuna Rd (N=56)	Waihī Estuary at Main Channel (N=55)
NH4				
Mean (SD)	0.06 (0.03)	0.02 (0.01)	0.03 (0.01)	0.07 (0.06)
Median (Q1, Q3)	0.05 (0.03, 0.07)	0.02 (0.01, 0.03)	0.02 (0.02, 0.04)	0.06 (0.04, 0.09)
Min - Max	0.00 - 0.18	0.00 - 0.05	-0.00 - 0.06	0.01 - 0.31
ChlA				
Mean (SD)	1.09 (1.28)	1.29 (1.03)	1.48 (1.42)	1.10 (1.68)
Median (Q1, Q3)	0.80 (0.60, 1.08)	0.90 (0.68, 1.45)	1.10 (0.67, 1.90)	0.70 (0.50, 1.00)
Min - Max	0.30 - 9.00	0.40 - 4.80	0.20 - 8.80	0.30 - 11.90
Conductivity				
Mean (SD)	47034.55 (5134.50)	48571.43 (2995.07)	48441.07 (3961.16)	36989.09 (10203.15)
Median (Q1, Q3)	48500.00 (44750.00, 50700.00)	48700.00 (46725.00, 51125.00)	48950.00 (47250.00, 50850.00)	38200.00 (29150.00, 44350.00)
Min - Max	31700.00 - 52600.00	39800.00 - 53200.00	31900.00 - 55100.00	12400.00 - 52700.00
DO%				
Mean (SD)	109.28 (10.80)	94.42 (6.78)	94.44 (7.34)	112.27 (12.03)
Median (Q1, Q3)	106.60 (103.00, 115.60)	93.00 (90.60, 97.25)	93.50 (89.30, 97.62)	111.50 (105.30, 117.30)
Min - Max	87.00 - 148.70	77.70 - 116.30	78.00 - 121.20	84.90 - 155.10
DRP				
Mean (SD)	0.01 (0.01)	0.01 (0.00)	0.01 (0.00)	0.04 (0.03)
Median (Q1, Q3)	0.01 (0.01, 0.01)	0.01 (0.01, 0.01)	0.01 (0.00, 0.01)	0.04 (0.02, 0.06)
Min - Max	0.00 - 0.03	-0.00 - 0.02	-0.00 - 0.02	0.00 - 0.14
ECOLI				
Mean (SD)	42.22 (91.49)	23.73 (130.46)	45.05 (158.94)	202.87 (530.35)
Median (Q1, Q3)	8.00 (3.00, 38.00)	2.00 (0.00, 4.50)	5.00 (2.00, 19.00)	37.00 (11.00, 72.00)
Min - Max	0.00 - 476.92	0.00 - 970.00	0.00 - 890.00	0.00 - 2400.00
Enterococci				
Mean (SD)	61.04 (145.86)	73.73 (335.65)	122.77 (583.81)	63.10 (116.32)
Median (Q1, Q3)	8.50 (2.00, 30.50)	1.00 (0.00, 8.25)	5.00 (2.00, 22.25)	15.00 (6.00, 46.25)
Min - Max	0.00 - 800.00	0.00 - 2200.00	0.00 - 4200.00	1.00 - 520.00

	Maketū Estuary at Boat Ramp (N=55)	Ōhiwa Harbour at Port Ōhope Wharf (N=56)	Ōhiwa Harbour at Ruatuna Rd (N=56)	Waihī Estuary at Main Channel (N=55)
Faecal coliforms				
Mean (SD)	57.15 (110.69)	27.52 (146.62)	70.90 (275.92)	188.66 (484.79)
Median (Q1, Q3)	16.00 (3.25, 47.00)	3.00 (1.00, 6.25)	7.50 (2.00, 22.25)	47.00 (19.75, 142.50)
Min - Max	0.00 - 590.00	0.00 - 1100.00	0.00 - 1700.00	0.00 - 3300.00
TN				
Mean (SD)	0.34 (0.13)	0.24 (0.06)	0.27 (0.10)	0.72 (0.38)
Median (Q1, Q3)	0.31 (0.26, 0.39)	0.25 (0.21, 0.28)	0.26 (0.20, 0.30)	0.63 (0.43, 0.90)
Min - Max	0.16 - 0.93	0.02 - 0.40	0.03 - 0.58	0.19 - 1.64
NNN				
Mean (SD)	0.05 (0.06)	0.03 (0.03)	0.03 (0.05)	0.37 (0.31)
Median (Q1, Q3)	0.03 (0.01, 0.08)	0.01 (0.00, 0.04)	0.02 (0.00, 0.05)	0.28 (0.10, 0.59)
Min - Max	0.00 - 0.29	-0.00 - 0.13	-0.00 - 0.34	0.00 - 1.18
DO				
Mean (SD)	9.09 (1.18)	8.22 (1.08)	8.18 (1.14)	9.48 (1.31)
Median (Q1, Q3)	8.98 (8.22, 10.15)	8.20 (7.32, 8.86)	8.10 (7.32, 8.65)	9.37 (8.77, 10.54)
Min - Max	6.77 - 11.21	6.22 - 10.39	6.21 - 10.71	6.35 - 13.65
TP				
Mean (SD)	0.04 (0.02)	0.03 (0.01)	0.04 (0.04)	0.07 (0.05)
Median (Q1, Q3)	0.04 (0.03, 0.04)	0.03 (0.02, 0.03)	0.03 (0.02, 0.04)	0.06 (0.04, 0.09)
Min - Max	0.01 - 0.10	0.01 - 0.09	0.01 - 0.30	0.01 - 0.25
pH				
Mean (SD)	7.93 (0.17)	7.88 (0.20)	7.93 (0.16)	7.88 (0.21)
Median (Q1, Q3)	7.98 (7.85, 8.04)	7.92 (7.83, 8.00)	7.96 (7.89, 8.02)	7.90 (7.79, 8.04)
Min - Max	7.35 - 8.18	7.17 - 8.15	7.28 - 8.17	7.33 - 8.23
Salinity				
Mean (SD)	30.36 (3.90)	31.38 (2.31)	31.28 (2.98)	23.63 (7.10)
Median (Q1, Q3)	31.76 (28.67, 33.23)	31.66 (29.71, 33.16)	31.90 (30.31, 33.00)	24.17 (18.00, 28.41)
Min - Max	19.44 - 34.53	25.23 - 34.75	19.78 - 35.25	6.61 - 35.02
TKN				
Mean (SD)	NA	NA	NA	NA

	Maketū Estuary at Boat Ramp (N=55)	Ōhiwa Harbour at Port Ōhope Wharf (N=56)	Ōhiwa Harbour at Ruatuna Rd (N=56)	Waihī Estuary at Main Channel (N=55)
Median (Q1, Q3)	NA	NA	NA	NA
Min - Max	NA	NA	NA	NA
TSS				
Mean (SD)	20.82 (13.16)	19.21 (13.40)	38.11 (61.20)	28.40 (27.85)
Median (Q1, Q3)	16.10 (12.32, 26.15)	16.40 (10.70, 21.00)	24.80 (16.19, 37.71)	21.85 (10.90, 35.02)
Min - Max	2.60 - 62.80	2.80 - 90.40	8.50 - 451.00	5.29 - 134.40
Turbidity				
Mean (SD)	5.59 (3.68)	7.07 (5.44)	15.75 (23.59)	7.67 (6.65)
Median (Q1, Q3)	4.51 (3.08, 6.93)	5.66 (4.55, 8.08)	10.28 (6.24, 15.90)	6.23 (3.35, 8.98)
Min - Max	1.41 - 22.50	1.95 - 41.60	2.77 - 162.00	1.20 - 38.90
Water Clarity				
Mean (SD)	1.33 (0.54)	0.89 (0.41)	0.74 (0.40)	1.12 (0.64)
Median (Q1, Q3)	1.22 (0.88, 1.68)	0.82 (0.64, 0.98)	0.68 (0.50, 0.97)	0.92 (0.68, 1.51)
Min - Max	0.54 - 2.61	0.43 - 3.07	0.01 - 1.88	0.21 - 3.18
Temp				
Mean (SD)	18.49 (3.54)	16.36 (3.92)	16.52 (3.91)	18.46 (3.60)
Median (Q1, Q3)	17.70 (15.28, 21.65)	16.30 (13.15, 19.80)	16.50 (13.35, 20.00)	18.55 (15.35, 21.60)
Min - Max	12.40 - 25.00	8.20 - 23.40	8.60 - 24.10	13.10 - 24.50
DIN				
Mean (SD)	0.11 (0.09)	0.05 (0.04)	0.06 (0.06)	0.45 (0.32)
Median (Q1, Q3)	0.07 (0.05, 0.15)	0.04 (0.02, 0.07)	0.05 (0.03, 0.08)	0.37 (0.22, 0.63)
Min - Max	0.00 - 0.47	0.00 - 0.16	0.00 - 0.37	0.02 - 1.37

Tauranga Estuary summary statistics

	Tauranga Harbour at Kauri Point Jetty (N=57)	Tauranga Harbour at Maungatapu Bridge NERMN (N=57)	Tauranga Harbour at Mount Maunganui (N=57)	Tauranga Harbour at Ōmokoroa Wharf (N=57)	Tauranga Harbour at Tanners Point Jetty (N=57)	Tauranga Harbour at Tilby Point (N=57)	Tauranga Harbour at Toll Bridge Marina (N=57)	Tauranga Harbour at Waikareao (N=57)
NH4								
Mean (SD)	0.02 (0.02)	0.03 (0.01)	0.01 (0.01)	0.02 (0.01)	0.02 (0.01)	0.02 (0.01)	0.02 (0.01)	0.03 (0.01)
Median (Q1, Q3)	0.01 (0.01, 0.02)	0.03 (0.02, 0.04)	0.01 (0.01, 0.02)	0.02 (0.01, 0.02)	0.02 (0.02, 0.03)	0.02 (0.01, 0.02)	0.02 (0.02, 0.03)	0.03 (0.03, 0.04)
Min - Max	0.00 - 0.12	0.01 - 0.07	0.00 - 0.04	0.00 - 0.07	0.01 - 0.04	0.00 - 0.06	0.01 - 0.04	0.00 - 0.09
ChlA								
Mean (SD)	1.55 (0.72)	1.26 (0.75)	1.26 (0.74)	1.57 (0.78)	0.72 (0.86)	2.23 (1.84)	0.97 (0.52)	0.71 (0.50)
Median (Q1, Q3)	1.50 (1.10, 1.73)	1.05 (0.90, 1.40)	1.05 (0.80, 1.52)	1.40 (1.00, 1.95)	0.60 (0.40, 0.70)	1.90 (0.90, 2.80)	0.80 (0.60, 1.15)	0.60 (0.40, 0.72)
Min - Max	0.60 - 4.60	0.30 - 4.30	0.30 - 3.60	0.30 - 4.00	0.20 - 6.50	0.20 - 9.20	0.30 - 2.30	0.20 - 3.20
Conductivity								
Mean (SD)	47505.26 (4365.55)	47170.18 (4720.24)	51417.54 (1882.92)	47794.74 (3180.94)	47708.77 (7091.45)	43947.37 (7372.13)	50349.12 (2065.03)	46800.00 (4448.11)
Median (Q1, Q3)	48400.00 (45700.00, 50400.00)	47900.00 (46400.00, 49600.00)	51800.00 (50700.00, 52400.00)	48600.00 (46800.00, 50100.00)	50200.00 (48000.00, 51800.00)	46100.00 (44000.00, 47300.00)	50600.00 (49400.00, 51700.00)	47600.00 (45700.00, 49400.00)
Min - Max	26200.00 - 53000.00	17700.00 - 52600.00	42700.00 - 55700.00	37100.00 - 51900.00	22400.00 - 53200.00	11700.00 - 51800.00	42700.00 - 54000.00	29800.00 - 52400.00
DO%								
Mean (SD)	98.75 (7.95)	97.01 (9.08)	98.63 (5.27)	98.78 (6.36)	99.69 (5.93)	110.09 (11.50)	97.26 (5.27)	97.29 (6.17)
Median (Q1, Q3)	98.00 (93.00, 102.95)	96.10 (91.92, 100.78)	98.90 (96.00, 102.65)	98.85 (94.35, 101.50)	99.00 (95.35, 102.60)	110.10 (101.40, 116.05)	96.10 (93.95, 100.45)	97.50 (93.30, 101.05)

	Tauranga Harbour at Kauri Point Jetty (N=57)	Tauranga Harbour at Maungatapu Bridge NERMN (N=57)	Tauranga Harbour at Mount Maunganui (N=57)	Tauranga Harbour at Ōmokoroa Wharf (N=57)	Tauranga Harbour at Tanners Point Jetty (N=57)	Tauranga Harbour at Tilby Point (N=57)	Tauranga Harbour at Toll Bridge Marina (N=57)	Tauranga Harbour at Waikareao (N=57)
Min - Max	84.10 - 126.80	76.00 - 124.20	80.80 - 109.00	87.50 - 116.20	91.10 - 120.00	92.50 - 144.30	88.00 - 112.60	81.10 - 113.00
DRP								
Mean (SD)	0.00 (0.00)	0.01 (0.00)	0.01 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.01 (0.00)	0.01 (0.00)
Median (Q1, Q3)	0.00 (-0.00, 0.00)	0.00 (0.00, 0.01)	0.00 (0.00, 0.01)	0.00 (0.00, 0.00)	0.00 (0.00, 0.00)	0.00 (0.00, 0.01)	0.00 (0.00, 0.01)	0.01 (0.00, 0.01)
Min - Max	-0.00 - 0.01	0.00 - 0.02	-0.00 - 0.02	-0.00 - 0.01	-0.00 - 0.01	-0.00 - 0.01	-0.00 - 0.01	0.00 - 0.01
ECOLI								
Mean (SD)	119.95 (608.23)	532.25 (3905.58)	11.61 (25.55)	10.25 (31.74)	28.14 (102.00)	90.61 (337.56)	9.33 (28.65)	42.13 (113.16)
Median (Q1, Q3)	1.00 (0.00, 3.00)	3.00 (1.00, 12.00)	2.00 (0.00, 8.00)	1.00 (0.00, 2.00)	3.00 (1.00, 11.00)	15.00 (2.00, 41.00)	1.00 (0.00, 4.00)	1.00 (0.00, 4.00)
Min - Max	0.00 - 3840.00	0.00 - 29500.00	0.00 - 146.00	0.00 - 152.50	0.00 - 730.00	0.00 - 2400.00	0.00 - 198.00	0.00 - 590.00
Enterococci								
Mean (SD)	129.12 (636.18)	176.13 (1187.30)	12.60 (20.12)	17.87 (47.05)	28.09 (108.12)	230.76 (1333.53)	7.26 (13.14)	31.93 (79.72)
Median (Q1, Q3)	1.00 (0.00, 7.00)	6.00 (1.00, 18.50)	3.00 (1.00, 13.25)	2.00 (0.00, 10.25)	4.00 (1.00, 11.75)	14.00 (3.00, 43.31)	2.00 (1.00, 9.00)	3.00 (1.00, 19.00)
Min - Max	0.00 - 3680.00	0.00 - 8900.00	0.00 - 80.00	0.00 - 240.00	0.00 - 790.00	0.00 - 9999.00	0.00 - 77.00	0.00 - 440.00
Faecal coliforms								
Mean (SD)	133.63 (681.92)	117.30 (753.74)	15.34 (31.28)	9.80 (28.07)	28.71 (96.99)	97.50 (274.52)	11.13 (30.22)	54.76 (138.66)
Median (Q1, Q3)	2.00 (0.00, 4.00)	4.00 (2.00, 15.00)	3.00 (1.00, 16.00)	1.00 (1.00, 3.00)	4.00 (2.00, 9.00)	20.00 (7.00, 60.00)	3.00 (1.00, 6.00)	4.00 (1.00, 13.00)
Min - Max	0.00 - 4100.00	0.00 - 5700.00	0.00 - 176.67	0.00 - 146.67	0.00 - 690.00	0.00 - 1700.00	0.00 - 210.00	0.00 - 740.00

	Tauranga Harbour at Kauri Point Jetty (N=57)	Tauranga Harbour at Maungatapu Bridge NERMN (N=57)	Tauranga Harbour at Mount Maunganui (N=57)	Tauranga Harbour at Ōmokoroa Wharf (N=57)	Tauranga Harbour at Tanners Point Jetty (N=57)	Tauranga Harbour at Tilby Point (N=57)	Tauranga Harbour at Toll Bridge Marina (N=57)	Tauranga Harbour at Waikareao (N=57)
TN								
Mean (SD)	0.26 (0.07)	0.28 (0.06)	0.21 (0.05)	0.25 (0.05)	0.23 (0.05)	0.34 (0.12)	0.23 (0.04)	0.29 (0.07)
Median (Q1, Q3)	0.25 (0.22, 0.28)	0.27 (0.24, 0.30)	0.21 (0.18, 0.25)	0.25 (0.22, 0.28)	0.21 (0.19, 0.27)	0.31 (0.25, 0.37)	0.23 (0.20, 0.26)	0.27 (0.23, 0.33)
Min - Max	0.16 - 0.50	0.15 - 0.48	0.12 - 0.30	0.17 - 0.40	0.15 - 0.37	0.20 - 0.90	0.15 - 0.31	0.17 - 0.50
NNN								
Mean (SD)	0.02 (0.03)	0.05 (0.04)	0.03 (0.03)	0.03 (0.03)	0.03 (0.05)	0.06 (0.06)	0.03 (0.03)	0.08 (0.05)
Median (Q1, Q3)	0.01 (0.00, 0.03)	0.04 (0.01, 0.08)	0.02 (0.00, 0.04)	0.02 (0.00, 0.04)	0.01 (0.00, 0.05)	0.05 (0.02, 0.07)	0.03 (0.01, 0.05)	0.07 (0.03, 0.12)
Min - Max	-0.00 - 0.17	0.00 - 0.18	0.00 - 0.12	-0.00 - 0.13	-0.00 - 0.22	-0.00 - 0.29	0.00 - 0.11	0.00 - 0.22
DO								
Mean (SD)	8.03 (0.95)	8.01 (1.12)	7.92 (0.76)	8.05 (0.92)	8.10 (0.88)	8.98 (1.01)	7.77 (0.77)	7.89 (0.85)
Median (Q1, Q3)	8.03 (7.38, 8.80)	8.06 (7.07, 8.62)	7.79 (7.43, 8.19)	8.09 (7.33, 8.60)	8.10 (7.31, 8.70)	9.13 (8.20, 9.71)	7.65 (7.20, 8.21)	7.81 (7.35, 8.26)
Min - Max	6.18 - 10.60	6.30 - 11.00	6.90 - 10.61	6.34 - 10.20	6.68 - 10.62	7.16 - 11.23	6.50 - 10.51	6.24 - 10.84
TP								
Mean (SD)	0.02 (0.01)	0.02 (0.01)	0.02 (0.01)	0.02 (0.01)	0.01 (0.00)	0.03 (0.02)	0.02 (0.00)	0.02 (0.01)
Median (Q1, Q3)	0.01 (0.01, 0.02)	0.02 (0.02, 0.02)	0.02 (0.01, 0.02)	0.02 (0.01, 0.02)	0.01 (0.01, 0.02)	0.02 (0.02, 0.03)	0.02 (0.01, 0.02)	0.02 (0.01, 0.02)
Min - Max	0.00 - 0.04	0.01 - 0.05	0.00 - 0.03	0.01 - 0.05	0.00 - 0.02	0.01 - 0.10	0.01 - 0.03	0.01 - 0.04
pH								
Mean (SD)	8.03 (0.09)	7.90 (0.27)	8.04 (0.07)	8.02 (0.09)	8.03 (0.10)	8.04 (0.14)	8.00 (0.10)	8.00 (0.13)

	Tauranga Harbour at Kauri Point Jetty (N=57)	Tauranga Harbour at Maungatapu Bridge NERMN (N=57)	Tauranga Harbour at Mount Maunganui (N=57)	Tauranga Harbour at Ōmokoroa Wharf (N=57)	Tauranga Harbour at Tanners Point Jetty (N=57)	Tauranga Harbour at Tilby Point (N=57)	Tauranga Harbour at Toll Bridge Marina (N=57)	Tauranga Harbour at Waikareao (N=57)
Median (Q1, Q3)	8.03 (7.99, 8.09)	7.95 (7.85, 8.03)	8.05 (8.01, 8.09)	8.04 (7.99, 8.08)	8.05 (8.00, 8.08)	8.06 (8.01, 8.12)	8.02 (7.96, 8.06)	8.03 (7.98, 8.08)
Min - Max	7.63 - 8.25	6.18 - 8.11	7.77 - 8.14	7.68 - 8.18	7.60 - 8.25	7.33 - 8.29	7.51 - 8.17	7.38 - 8.13
Salinity								
Mean (SD)	30.78 (2.51)	30.41 (2.93)	33.46 (1.76)	30.85 (2.51)	30.73 (5.18)	27.83 (5.26)	32.64 (1.86)	29.64 (4.44)
Median (Q1, Q3)	31.02 (29.26, 32.86)	31.05 (29.30, 32.14)	33.91 (33.17, 34.47)	31.44 (30.14, 32.87)	32.93 (30.06, 33.99)	29.74 (26.72, 30.57)	33.13 (31.78, 33.89)	30.92 (28.91, 32.22)
Min - Max	25.15 - 34.97	14.81 - 33.96	25.75 - 35.40	23.39 - 33.89	13.42 - 35.06	6.60 - 32.85	25.74 - 35.88	8.06 - 34.30
TKN								
Mean (SD)	NA	NA	NA	NA	NA	NA	NA	NA
Median (Q1, Q3)	NA	NA	NA	NA	NA	NA	NA	NA
Min - Max	NA	NA	NA	NA	NA	NA	NA	NA
TSS								
Mean (SD)	17.56 (23.62)	13.54 (8.38)	13.50 (8.27)	15.95 (8.95)	9.53 (8.62)	22.12 (35.28)	12.18 (7.29)	11.57 (6.88)
Median (Q1, Q3)	11.85 (6.40, 19.73)	11.67 (8.42, 15.50)	11.07 (6.60, 17.79)	14.80 (9.60, 19.57)	6.40 (4.59, 10.20)	10.36 (6.46, 23.40)	10.28 (6.94, 15.40)	10.36 (6.00, 14.53)
Min - Max	2.91 - 165.60	2.80 - 50.00	3.80 - 41.20	3.40 - 43.80	2.60 - 43.20	1.12 - 228.79	3.58 - 42.00	1.35 - 36.80
Turbidity								
Mean (SD)	4.09 (9.07)	3.19 (1.71)	2.04 (1.46)	3.61 (2.17)	1.57 (0.85)	4.87 (6.28)	2.12 (0.98)	2.46 (1.92)
Median (Q1, Q3)	2.08 (1.46, 3.26)	2.81 (2.19, 3.74)	1.52 (1.14, 2.25)	3.25 (2.40, 4.24)	1.33 (1.06, 1.90)	2.18 (1.39, 5.42)	2.00 (1.37, 2.54)	1.75 (1.33, 2.60)

	Tauranga Harbour at Kauri Point Jetty (N=57)	Tauranga Harbour at Maungatapu Bridge NERMN (N=57)	Tauranga Harbour at Mount Maunganui (N=57)	Tauranga Harbour at Ōmokoroa Wharf (N=57)	Tauranga Harbour at Tanners Point Jetty (N=57)	Tauranga Harbour at Tilby Point (N=57)	Tauranga Harbour at Toll Bridge Marina (N=57)	Tauranga Harbour at Waikareao (N=57)
Min - Max	0.52 - 66.60	0.95 - 9.51	0.40 - 8.30	0.50 - 13.60	0.48 - 5.53	0.77 - 33.60	0.69 - 5.93	0.98 - 11.10
Water Clarity								
Mean (SD)	1.64 (0.95)	1.37 (0.62)	1.97 (1.20)	1.35 (0.73)	2.40 (1.51)	1.53 (0.94)	1.78 (0.97)	1.86 (1.11)
Median (Q1, Q3)	1.41 (1.07, 1.98)	1.20 (1.00, 1.66)	1.68 (1.17, 2.40)	1.19 (0.99, 1.50)	1.97 (1.60, 2.84)	1.31 (0.84, 2.05)	1.60 (1.32, 2.02)	1.60 (1.17, 2.14)
Min - Max	0.42 - 5.86	0.44 - 3.29	0.47 - 6.41	0.45 - 5.25	0.55 - 8.30	0.34 - 5.14	0.57 - 5.36	0.45 - 5.97
Temp								
Mean (SD)	17.39 (3.81)	17.13 (3.45)	17.25 (2.91)	17.63 (3.81)	17.31 (3.39)	17.95 (3.69)	17.11 (3.06)	17.15 (3.23)
Median (Q1, Q3)	17.40 (14.00, 19.80)	17.45 (14.05, 19.95)	16.62 (14.79, 20.20)	17.90 (14.13, 20.40)	17.20 (14.10, 20.05)	18.30 (14.09, 20.64)	16.96 (14.51, 19.40)	17.10 (14.31, 19.90)
Min - Max	10.50 - 26.30	11.50 - 23.40	12.80 - 22.90	11.50 - 25.40	12.00 - 24.40	12.00 - 24.80	12.40 - 23.10	11.90 - 23.80
DIN								
Mean (SD)	0.04 (0.05)	0.08 (0.05)	0.05 (0.03)	0.05 (0.04)	0.06 (0.05)	0.08 (0.07)	0.06 (0.03)	0.11 (0.06)
Median (Q1, Q3)	0.02 (0.01, 0.05)	0.07 (0.04, 0.11)	0.04 (0.02, 0.06)	0.04 (0.02, 0.06)	0.04 (0.02, 0.07)	0.06 (0.03, 0.09)	0.05 (0.03, 0.08)	0.10 (0.06, 0.15)
Min - Max	0.00 - 0.22	0.01 - 0.24	0.01 - 0.14	0.00 - 0.16	0.01 - 0.26	0.00 - 0.32	0.01 - 0.13	0.01 - 0.31