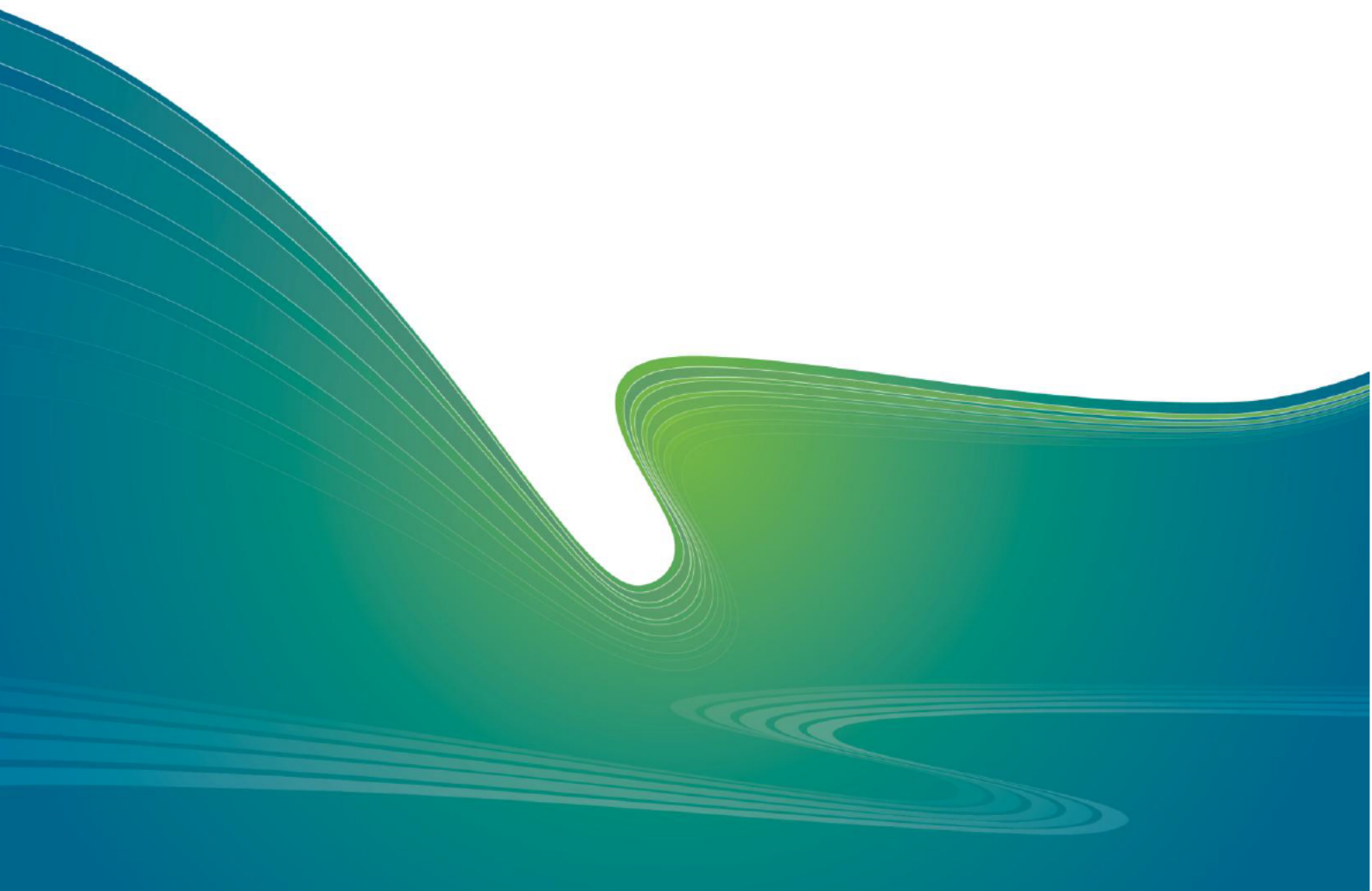
Water quality aspects of Port of Tauranga dredging reconsenting



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Executive Summary

The Port of Tauranga (**PoTL**) is in the process of replacing resource consents 65806 and 65807 which authorise capital and maintenance dredging of Tauranga Harbour.

We understand that there are four activities enabled by the consents, all within the Coastal Marine Area (**CMA**):

1. The disturbance of the seabed by capital dredging.
2. The disturbance of the seabed by maintenance dredging.
3. The deposit of the dredged material to areas of the CMA.
4. The removal of some dredged material from the CMA.

Maintenance dredging has occurred annually since 2013 with the current consent. Stage 1 of capital dredging was completed in 2016 and deepened the channel. Completion of the main channel deepening (Stage 2) will be completed in late 2026. Stage 2 will also include some relatively minor further areas of deepening and widening in the channel and around the wharves. There are multiple areas where the dredged material is currently authorised to be stored on land and/or deposited to the CMA. PoTL requires the renewal of these consents.

PoTL have engaged Streamlined Environmental Ltd (**SEL**) to undertake a water quality assessment to support the application to renew the maintenance and capital dredging consents. This assessment considers the potential significance and scale of effects of the dredging and disposal/deposition of bed sediments from the Tauranga shipping channel on the marine receiving environment water quality.

The dredging and disposal of sediment from the Tauranga Harbour shipping channel has the potential to impact on water quality. The main aspects of water quality that are potentially affected – and in decreasing likelihood of magnitude of effects – are:

- Increased turbidity from dredging and disposal due to resuspension of fine silt particles found in the bed sediment.
- Release of contaminants entrained in the sediment into the water column, leading to estuarine eutrophication (nutrients and organic enrichment), ecotoxicological effects on water and sediment dwelling species (metals and/or organic toxicants), and potential human health effects from consumption of marine species (metals and/or organic toxicants).
- Changes in temperature, pH, salinity, and dissolved oxygen in the water column impacting biota and habitats.

Based on long-term monitoring at 8 sites across Tauranga Harbour water by Bay of Plenty Regional Council (**BoPRC**), the water is generally well oxygenated, has low visual water clarity, but also low turbidity and total suspended solids (**TSS**). Phosphorus concentrations are low, while ammoniacal-nitrogen (**NH_4-N**) and nitrate+nitrite-N (**NNN**) are generally elevated at most sites. Despite this algal growth (based on chlorophyll *a* concentrations) is low at all sites. Nutrient concentrations

have been decreasing at most sites in the harbour over the last 10 years, but chlorophyll *a* concentrations have been static or increasing.

Based on long-term intertidal sediment monitoring at 10 sites in proximity to the Port and wider spatial distribution in Tauranga Harbour, sediments are typified by relatively high silt (mud) content (<63 µm) and low total organic carbon (**TOC**). Metals/metalloids and organic toxicants are generally at low concentrations, with most well below applicable Australian and New Zealand Governments (**ANZG**) default guideline values (**DGVs**).

Measurements undertaken during maintenance dredging campaigns show that surface sediments at dredged sites in the shipping channel are generally sandy with low silt content (<2.5%). Toxicants measured in sediments from the channel and sites of importance (e.g. Te Paritaha pipi bank) and in proximity to the Port to inform this assessment were generally low and below the DGV but increasing with proximity to the Port.

Toxicants measured in shellfish from Tauranga Harbour in 1990 and 2016, and on four occasions in 2023 and 2024 at Te Paritaha pipi bank (collected by Boffa Miskell to inform their assessment for this application), have all been reported at concentrations well below applicable Food Safety Australia New Zealand (**FSANZ**) maximum limits, indicating, based on the toxicant concentrations, they are safe to eat.

Turbidity data were collected by PoTL during maintenance dredging campaigns from October 2015 to July 2022 (n=160). A Mann-Whitney one-way analysis of variance test showed a statistically significant difference (p=0.000) for turbidity upstream and downstream of the dredge. For the majority of the time (93%) there was no exceedance of the Australian and New Zealand Environment and Conservation Council (**ANZECC**) (2000) default trigger level of 10 NTU downstream of the dredge. Therefore, although there is a statistically significant difference between upstream and downstream turbidity during the maintenance dredging, the occurrence is infrequent. Further, the turbidity monitoring undertaken by PoTL is from the active dredge zone 500m upstream of the dredging vessel (control) and 200m downstream, of which the downstream distance represents the mixing zone. The ANZECC (2000) trigger levels are based on long-term monitoring while the effects on turbidity from the dredging campaign are more transient as they relate to the dredging campaign. Therefore, comparison with the ANZECC (2000) default trigger level is conservative.

Turbidity management limits for the dredging process are higher than the ANZECC (2000) default trigger level. The turbidity management limits are set based on a rolling average over 6 hours from data collected at 15 minute intervals from continuous monitoring buoys deployed in the receiving environment. Therefore, these limits are conservative compared to individual spot readings in the active plume as they do not represent the temporary nature of the plume. The level 1 limit of 15 NTU – where an investigation to find the source is required, if breached – was exceeded four times out of 160 monitoring events (2.5%), the level 2 limit (20 NTU) – where a dredging procedure change is required, if breached – exceeded once (0.6%) and the environmental limit (35 NTU) – where no further dredging should occur – was never exceeded.

In summary, based on the conservative ANZECC (2000) approach, for the majority (93%) of the time, the dredging procedure is undertaken in a manner that results in turbidity of the dredge

plume at concentrations below ANZECC (2000) default trigger levels, and, as such, effects are less than minor. For the times (7%) when turbidity exceeds ANZECC (2000) default trigger levels, effects are likely to be transient but minor.

In summary, based on the conservative management limit approach of spot measurements in the active plume, the environmental limit has never been exceeded, while the level 1 and 2 limits were only exceeded on rare occasions. However, there are unlikely to be any exceedances of any limits outside the active plume and once 6 hourly averaging is taken into account.

Hydrodynamic modelling of the dredging process was undertaken by MetOcean Solutions to inform their assessment for this application. Results show that TSS concentrations are highest within a 200m range of the dredging and reduce rapidly outside this zone, with the plume mostly contained within the shipping channels. Spikes in TSS concentrations are rare outside the 200m zone. This supports the empirical data summarised above. Although our assessment is based on turbidity measurements and not TSS, the conclusions are consistent, namely that effects from TSS/turbidity are likely to be less than minor for the majority of the time while short-term spikes may show minor effects but will be transient.

For the sediment monitoring undertaken by PoTL for this assessment, Total Nitrogen (TN) and Total Phosphorus (TP) sediment concentrations appeared to be increasing with proximity to the Port. Therefore, the risk of the release of nutrients from dredged sediment into the water column is higher for sites closer to the Port than those further away. Water quality data for Tauranga Harbour suggests that algal growth is low. Importantly, the Toll Bridge Marina site has median chlorophyll *a* concentrations at the lower end of sites within the harbour, suggesting algal growth (as one indicator of eutrophication) at this site is very low, noting that indicators based on macroalgae coverage are variable. Low chlorophyll *a* concentrations may reduce the risk of the relatively short duration and spatial spread of the dredged plume significantly contributing to eutrophication, with effects likely to be less than minor.

Sediment collected for this assessment from the dredge sites has toxicants present at low concentrations indicative of low toxicity (below ANZG 2018 DGVs) and this is consistent with receiving environment sites in the Tauranga Harbour. Further, shellfish toxicant concentrations are well within safe consumption limits. Therefore, the risk of toxicants entrained in the dredged sediment and leaching into the water column in concentrations above water quality guidelines is extremely low, with the effects on water quality likely to be negligible.

To inform this assessment, water temperature, pH, salinity, and DO were measured by PoTL upstream, downstream and alongside the vessel during the dredging and disposal process.

For dredging, a Mann-Whitney one-way analysis of variance test showed a statistically non-significant difference ($p>0.05$) for all four parameters between upstream and downstream, upstream and alongside, and alongside and downstream sites. Therefore the differences between upstream, alongside, and downstream are negligible for the four parameters measured.

For disposal, one-off measurements were taken at the four corners and centre at the disposal sites D (H1/H2) and B/C. There were insufficient data for statistical analysis. All parameters were well within applicable water quality guidelines with minimal changes between sites.

In summary, the water quality monitoring undertaken for this assessment shows negligible effects for water temperature, pH, salinity, and DO from dredging and disposal.

1. Introduction

The Port of Tauranga (**PoTL**) is in the process of replacing resource consents 65806 and 65807 which authorise capital and maintenance dredging of Tauranga Harbour. Both consents expire on 31 December 2027.

We understand that there are four activities enabled by the consents, all within the Coastal Marine Area (**CMA**):

1. The disturbance of the seabed by capital dredging.
2. The disturbance of the seabed by maintenance dredging.
3. The deposit of the dredged material to areas of the CMA.
4. The removal of some dredged material from the CMA.

Maintenance dredging has occurred annually since 2013 under the current consent.

Stage 1 of capital dredging was completed in 2016 and deepened the channel. Completion of the main channel deepening will be completed in late 2026. Further widening at the swinging or turning basin off the northern end of Sulphur Point (adjacent to the Port's container terminal) will be completed under Stage 2. The size of the swinging basin will be reduced in width by 93m compared with the current consent.

PoTL is applying to renew resource consents related to capital and maintenance dredging in Tauranga Harbour and deposition of the associated material.

It is proposed that the capital dredging will occur within the existing shipping channels and consist of the following:

- Deepening the approach to Berth 1 (approximately 3m);
- Deepening an area of the Passing Lane to smooth the entrance corner (approximately 7 m)
- Deepen the existing Sitting Basins (depths vary from 1 m to 7 m).

There are multiple areas where the dredged material is currently authorised to be stored on land and/or deposited to the CMA. These include sites within Tauranga Harbour, nearshore and further offshore. Dredged material may be used for beach replenishment.

PoTL have engaged Streamlined Environmental Ltd (**SEL**) to undertake a water quality assessment to support the application to renew the maintenance and capital dredging consents.

The dredging and disposal of sediment from the Tauranga Harbour shipping channel has the potential to impact on water quality. The main aspects of water quality that are potentially affected – and in decreasing likelihood of magnitude of effects – are:

- Increased turbidity from dredging and disposal due to resuspension of fine silt particles in the bed sediment. This can lead to aesthetic and physical degradation of the water quality and physical effects on biota through smothering and/or light attenuation (e.g. seagrass and shellfish).

- Release of contaminants entrained in the sediment into the water column, leading to estuarine eutrophication (nutrients and organic enrichment), ecotoxicological effects on water and sediment dwelling species (metals and/or organic toxicants), and potential human health effects from consumption of marine species (metals and/or organic toxicants).
- Changes in temperature, pH, salinity, and dissolved oxygen in the water column.

This water quality assessment considers potential significance and scale of effects of the dredging and disposal of bed sediments from the Tauranga shipping channel on the marine receiving environment. Where the potential effects are assessed as more than minor, additional measures are suggested to avoid, remedy, or mitigate these effects to the point that they would be less than minor.

2. Description of the aquatic receiving environment

2.1 Background

Long-term water and sediment quality monitoring in Tauranga Harbour has been extensively undertaken by Bay of Plenty Regional Council (**BoPRC**), with a targeted survey undertaken in 2019 (Crawshaw, 2021a). **Figure 1** shows the spatial coverage of monitoring sites for the whole harbour (top) and around the Port (bottom). Long-term continuous turbidity monitoring through deployed buoys has been undertaken by PoTL. Further, other water and sediment quality monitoring has been undertaken at times for specific purposes. This includes sediment toxicant analyses undertaken by PoTL for this assessment.

Shellfish contaminant monitoring has been undertaken by BoPRC at a large range of sites in 1990 and 2016, with sites presented in **Figure 1**, with additional shellfish contaminant monitoring in the 2019 survey by Crawshaw (2021a). Further, Boffa Miskell undertook contaminant monitoring of pipi – an important taonga to mana whenua – at Te Paritaha (De Luca, 2025).

Together the data provides an extensive overview of Tauranga Harbour water, sediment, and shellfish quality. These are described in more detail in the following sections.

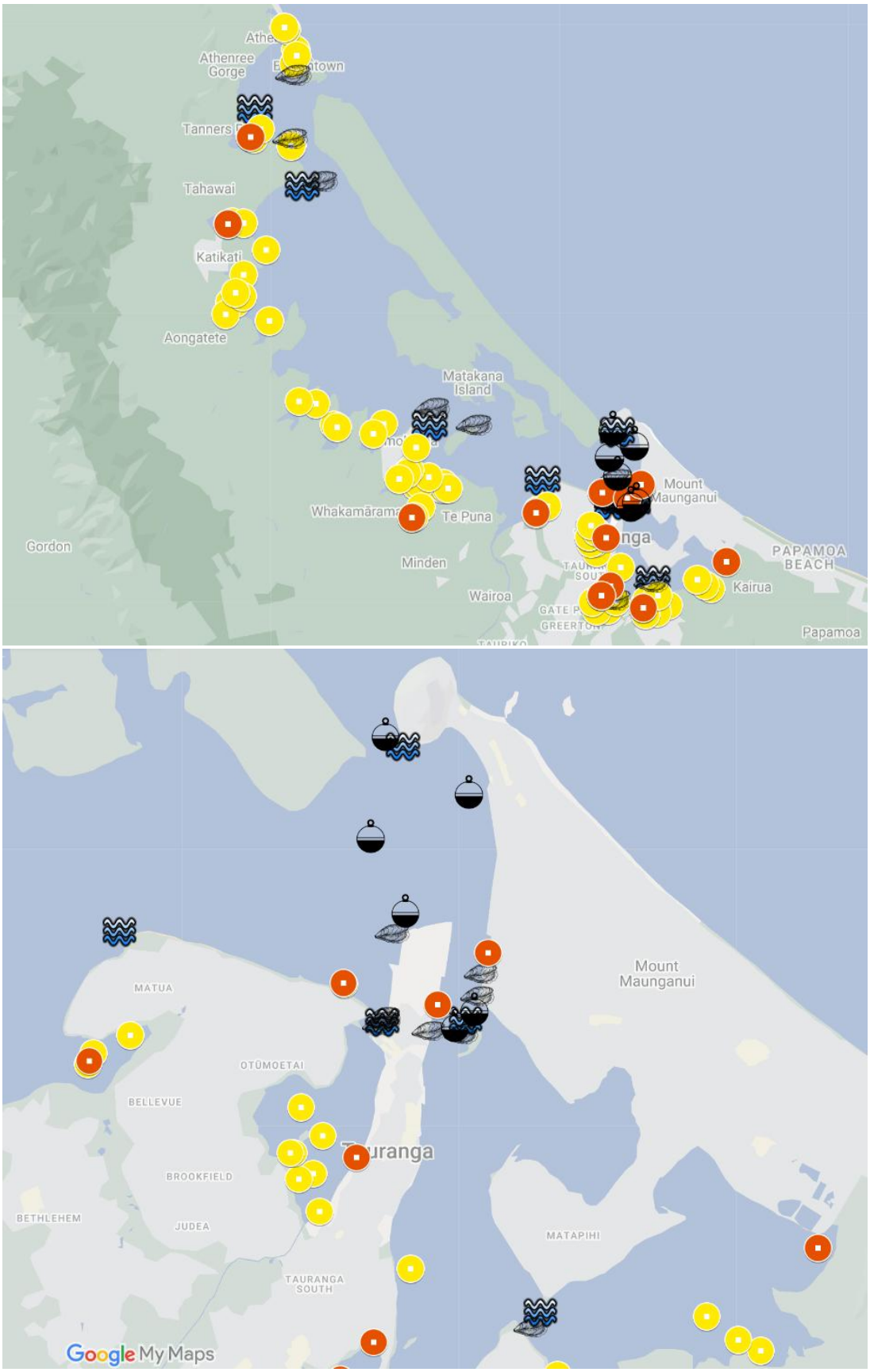


Figure 1. Water, sediment, and shellfish quality and continuous turbidity monitoring sites in Tauranga Harbour (top) and near the Port (bottom). Key: Long-term sediment quality sites designated by yellow circles and 2020 targeted sediment quality sites by red circles; water quality sites are designated waves; shellfish sites as shellfish icons; and turbidity sites are buoys.

2.2 Tauranga Harbour water quality state

2.2.1 Methodology

2.2.1.1 Sites

BoPRC collect long-term water quality data from 8 sites in Tauranga Harbour (**Figure 2**). Three of these sites – Tanners Point Jetty, Kauri Point Jetty, and Ōmokoroa Wharf – are in the western harbour and reflect more rural freshwater inputs. The other 5 sites – Tilby Point, Waikareao, Mount Manganui, Toll Bridge Marina (Port), and Maungatapu Bridge – are in the eastern harbour and reflect more urban freshwater inputs from Tauranga city. The latter three sites are in the Tauranga Harbour channel where the Port is situated and the area is used for shipping and therefore requires capital and maintenance dredging.

Further, PoTL maintain 6 long-term continuous turbidity monitoring stations in and around the shipping channel during dredging campaigns (**Figure 2** inset). Despite issues with biofouling and maintenance of these stations, they provide a valuable dataset of continuous turbidity at these locations.



Figure 2. BoPRC long-term Tauranga Harbour water quality monitoring sites (wave icons) and PoTL continuous turbidity monitoring sites (Inset: buoys).

2.2.1.2 Standard water quality parameters

Water quality parameters measured by BoPRC are water temperature, visual clarity, turbidity, total suspended solids (**TSS**), specific conductivity, salinity, dissolved oxygen (as % saturation and concentration), total and dissolved phosphorus (**TP** and **DRP**), total nitrogen (**TN**), nitrate and nitrite nitrogen (**NNN**), ammoniacal nitrogen (**NH_4-N**), dissolved inorganic nitrogen (**DIN**), faecal coliforms (**FC**), enterococci (**Ent**), *Escherichia coli* (***E. coli***), and chlorophyll *a*.

The timeline of data collection differs for each site and parameter but is predominantly from 2015. Data for eight water quality sites were downloaded from the BoPRC environmental data portal[1]. Data from the last five years (October 2020 to September 2025) were collated and used to describe the current state of the harbour water.

Current state results (2020 to 2025) are presented as box and whisker plots[2], which show the distribution of data into upper and lower quartiles (boxes, which span the interquartile range (**IQR**). The boxes have capped lines extending vertically (whiskers) which indicate the range from the lower quartile minus 1.5 x IQR and the 75 percentile plus 1.5 x IQR. Values outside the whiskers are considered "outliers" and are shown as points. The mean value is presented as a cross.

2.2.1.3 Toxicants

Consistent and spatially extensive monitoring of toxicants in Tauranga Harbour has been primarily for metal/metalloid in estuarine sediment or shellfish. For water, metals/metalloid analyses have been sporadic. Organic toxicants have been measured sporadically in both water and sediment and include legacy organic contaminants (organochlorine pesticides (**OCPs**), polychlorinated biphenyls (**PCBs**), pesticides, and emerging organic contaminants (**EOCs**). These are described in applicable sections of this report.

2.2.1.4 Bay of Plenty Regional Coastal Environment Plan

The Bay of Plenty Regional Coastal Environment Plan (**RCEP**) (Operative 11 August 2021)[3] provides objectives for water quality, specifically:

- Objective 6. Development and implementation of a framework for enhancement of coastal water quality where it has deteriorated so that it is having a significant adverse effect on ecosystems, natural habitats, or water based recreational activities, or is restricting existing uses (including cultural activities) and remedying or mitigating adverse effects on areas of coastal waters that are identified as being of particular interest to tangata whenua.
- Objective 7. Sediment accumulation in harbours and estuaries resulting from land use and accelerated erosion is minimised and reduced over time compared to 2014 levels.
- Objective 8. Discharges of contaminants to the coastal marine area are managed to meet the following goals:

[1] https://envdata.boprc.govt.nz/Data/DataSet. Accessed 10th October 2025.
[2] Other analyses in this report are represented by box and whisker plots, with the same criteria as described here.
[3] https://www.boprc.govt.nz/your-council/plans-and-policies/plans/regional-plans/regional-coastal-environment-plan. Accessed 10th July 2023. No updates to the RCEP applicable to this application have occurred since the access date.

- After reasonable mixing, discharges of contaminants meet the water quality classification of the receiving water bodies as a minimum; and have no more than minor adverse effects on aquatic life, habitats, and recreational uses.
- Discharges of contaminants occur in a manner that recognises and provides for the cultural values of mana whenua acknowledged for that area.
- Cumulative effects of discharges are managed in a way that recognises the sensitivity and assimilative capacity of the receiving environment.

The RCEP also provides water quality classifications (also referred to as water quality standards) under Schedule 10. These standards apply after reasonable mixing of any contaminant or water with the receiving water and disregard the effect of any natural perturbations that may affect the water body. Schedule 10 is provided in **Table 1**, with our assessment of implications to the dredging process discussed below, and appropriate ecological guidelines summarised used to assess against the standards in Schedule 10 provided in **Table 2**.

Table 1. Coastal Water Quality Classifications: Equivalent Qualitative and Quantitative Standards (RCEP Schedule 10).

Qualitative Standard	Quantitative Standard	Matauranga Māori	Coastal Water Classification
There shall be no conspicuous change in the colour or visual clarity.	The decrease in secchi disc vertical depth or black disc horizontal range shall not be greater than 20%.	Te Hauora o te Wai/the health and mauri of water. Coastal waters support a healthy ecosystem appropriate to that locality (open coastal water, lagoon, estuary, coastal wetland, saltmarsh, intertidal areas, rocky reef system etc. Coastal water quality enables ecological processes to be maintained, supports an appropriate range and diversity of indigenous flora and fauna, and there is resilience to change.	All coastal waters. Water managed for aquatic ecosystem purposes.
There shall be no significant adverse effects on aquatic life.	Refer to: Australian and New Zealand Guidelines for Fresh and Marine Water Quality Australian and New Zealand Environment and Conservation Council, 2000.		
There shall be no production of conspicuous oil or grease films, scums or foams, or floatable or suspended materials.	None.		
There shall be no emission of objectionable odour.	Refer to the Bay of Plenty Regional Air Plan.		

Qualitative Standard	Quantitative Standard	Matauranga Māori	Coastal Water Classification
The visual clarity of the water shall be suitable for bathing.	The horizontal sighting distance of a 200 mm black disc should exceed 1.6 metres (in the active surf zone it is not possible to use this method). Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Australian and New Zealand Environment and Conservation Council, 2000.	Kei te ora te mauri (the mauri of the place is intact). Coastal resources are able to be used for customary use and customary practices are able to be exercised to the extent desired. Tikanga and preferred methods are able to be practised.	Within all harbours and estuaries, and into the open coast out to a distance of 400 metres from the line of mean high water springs, and within 500 metres of any consented aquaculture farm. Water managed for contact recreation purposes and for the gathering or cultivating of shellfish for human consumption.
The water shall not be rendered unsuitable for bathing by the presence of contaminants.	Microbiological: The concentration of enterococci must not exceed 280 cfu/100ml. See Microbiological Water Quality Guidelines for methodology (MfE & MoH, 2003).		
Aquatic organisms shall not be rendered unsuitable for human consumption by the presence of contaminants.	Microbiological: The median faecal coliform content of samples taken over a shellfish-gathering season shall not exceed a Most Probable Number (MPN) of 14/100 mL, and not more than 10% of samples should exceed an MPN of 43/100 mL (using a five-tube decimal dilution test). See Microbiological Water Quality Guidelines for methodology (MfE & MoH, 2003).	Kaimoana is safe to harvest and eat.	
There shall be no undesirable biological growths as a result of any discharge of a contaminant into the water.	None.		
The natural temperature of the water shall not be changed by more than 3 degrees C.			
The concentration of dissolved oxygen shall exceed 80% of saturation concentration.			

The RCEP qualitative standards for adverse effects on aquatic life refer to guidelines (default trigger values) provided by the Australian and New Zealand Environment and Conservation Council (**ANZECC**) 2000 Australian and New Zealand Guidelines for Fresh and Marine Water Quality

(ANZECC, 2000a), which are to be used as quantitative standards to assess for significance of effects. We note that many of these default trigger values were updated in 2018 (and others are in the process of being updated since this time) as the Australian and New Zealand Governments (**ANZG**) Guidelines for Fresh and Marine Water Quality, which are provided as an online tool (Australian and New Zealand Governments, 2018). Importantly, for estuarine waters, the updated guidelines include default guideline values (**DGVs**) for toxicants, while physical and chemical stressors revert to the 2000 ANZECC default trigger values (ANZECC, 2000a).

Impacts on visual water clarity and turbidity are a primary concern from the dredging process. PoTL undertake continuous turbidity monitoring through buoy systems as well as on-the-spot turbidity monitoring with a hand-held meter. We note that the RCEP does not specifically include turbidity in Schedule 10 (**Table 1**), however it refers to ANZECC (2000) default trigger values (which include turbidity: **Table 2**) to avoid significant adverse effects on aquatic life. A primary cause of increased turbidity is a high concentration of TSS, and this is a parameter measured by BoPRC. A default trigger value is not provided for TSS by ANZECC (2000). Auckland Council historically used TSS as one of 7 water quality parameters to produce water quality indices of marine water quality (Vaughan, 2017). However, TSS has now been removed from the calculation of these indices (Kelly and Kamke, 2023) but in the absence of any other guideline for TSS this is used as an *indicative* guideline in this assessment (**Table 2**).

The RCEP qualitative standards for contaminants in water (bathing risk) and Kaimoana (food consumption risk) have quantitative standards relating to microbiological contaminants (pathogens) in water (enterococci) and shellfish consumption (faecal coliforms) provided by the Ministry for the Environment and Ministry of Health (2003) (**Table 2**).

The RCEP qualitative standard is that there shall be no undesirable biological growths as a result of any discharge of a contaminant into the water relates to eutrophication but does not have a quantitative standard. The growth of algae is monitored via chlorophyll *a* measurement, which has an ANZECC (2000) default trigger value (**Table 2**).

The RCEP qualitative standard that the natural temperature of the water shall not be changed by more than 3°C (as a result of the activity being undertaken, in this case dredging and disposal of dredge spoils) also functions as a quantitative standard (when compared with the natural water temperature) (**Table 2**).

The RCEP qualitative standard that the concentration of dissolved oxygen (**DO**) shall exceed 80% of saturation concentration also functions as a quantitative standard (minimum DO of 80%) (**Table 2**). We note that the dredging and disposal process is more likely to oxygenate the water due to physical mixing of the water with oxygen. Notwithstanding, there are no current consent requirements to measure DO during these activities.

To provide evidence for the above two standards, POTL have undertaken DO and temperature measurements (along with turbidity, pH, and salinity) during the dredging and disposal process. This is described further in Section 4.3.

2.2.1.5 Ecological and human health guidelines

As stated in the previous section, for physical and chemical stressors there are no ANZG 2018 updates so the ANZECC (2000) default trigger values are used. As there are no guidelines for New Zealand estuaries[4], we have used the default trigger values for South-East Australia for slightly disturbed ecosystems. For toxicant stressors, we have used the 2018 ANZG DGVs. DGVs for toxicants, if exceeded, indicate that further investigation and analyses may be needed and therefore provide a generic starting point for assessing water quality.

Water quality guidelines used in this assessment for physical and chemical stressors are summarised in **Table 2**.

Table 2. Water quality guidelines for physical, chemical, and microbiological stressors used in this assessment, along with their sources.

Stressor	Unit	Statistic	Value	Reference
Turbidity	NTU	Median	10	ANZECC (2000)[1]
Visual clarity	m	Minimum	1.6	RCEP
TSS	mg/L	Average	20	Auckland Council[2]
DO	%	Minimum	80	RCEP[3]
Water Temperature	°C	Change	±3	RCEP
pH		Range	7.0-8.5	ANZECC (2000)[1]
Salinity	ppt	Average	No value[4]	
Ammoniacal-N	mg/L	Median	0.015	ANZECC (2000)[1]
NNN	mg/L	Median	0.015	ANZECC (2000)[1]
TN	mg/L	Median	0.3	ANZECC (2000)[1]
DRP	mg/L	Median	0.005	ANZECC (2000)[1]
TP	mg/L	Median	0.03	ANZECC (2000)[1]
Chlorophyll *a*	µg/L	Median	4	ANZECC (2000)[1]
Enterococci	cfu/100mL	Maximum	280	RCEP[5]
Faecal coliforms	cfu/100mL	Median	14	RECP[6]
Faecal coliforms	cfu/100mL	Percentage of sites >43 cfu/100mL	10	RECP[6]

[1] Default trigger values for South-Eastern Australia for slightly disturbed ecosystems.
[2] Auckland Council historically used TSS as one of 7 water quality parameters to produce water quality indices of marine water quality (Vaughan, 2017). However, TSS has now been removed from the calculation of these indices (Kelly and Kamke, 2023) but in the absence of any other guideline for TSS this is used as an indicative guideline.
[3] Consistent with ANZECC (2000).
[4] Salinity included to provide context of freshwater input to estuarine water quality sites.
[5] Bathing: Action/Red alert level (Ministry for the Environment and Ministry of Health, 2003).
[6] Aquatic organism consumption: (Ministry for the Environment and Ministry of Health, 2003).

[4] Estuarine DGVs are limited to the rate of sedimentation. The DGV is 2 mm of sediment accumulation per year above the natural annual sedimentation rate for the specific estuary, or part of the estuary. https://www.waterquality.gov.au/anz-guidelines/your-location/new-zealand

Smothering of marine biota by sediment is a concern related to the suspended sediment concentrations in the dredged material. ANZG (2018) provide a DGV of 2mm sediment accumulation per year above the natural annual sedimentation rate for the specific estuary, or part of the estuary.[5] Modelling by MetOcean Solutions predicts deposition thickness for both the capital and maintenance dredging campaigns (see Section 4.1.1).

Water quality guidelines used in this assessment for toxicants are provided as DGVs from ANZG (2018). With the exception of recent one-off metal/metalloid and polyfluorinated alkyl substances (**PFAS**) measurements in water at some Tauranga Harbour sites, toxicants have been reported primarily in estuarine sediments from the harbour, with toxicant DGVs provided in the sediment quality section (Section 2.4). Therefore toxicant water DGVs are discussed in the report text only.

For toxicants where no established ecological guidelines are available – such as many EOCs – ecological risk is assessed by comparing the environmental concentration against a Predicted No Effects Concentration (**PNEC**). In this case, as no measurement of these toxicants has been undertaken for this assessment, an assessment of ecological risk is undertaken by citing data from the primary reports or publications.

2.2.2 Results

Water quality current state results were compared to applicable water quality guidelines presented in **Table 2** and summarised in **Table 3**. Discussion in this section refers to **Table 3** and individual figures.

[5] https://www.waterquality.gov.au/anz-guidelines/your-location/new-zealand

Table 3. Water quality at BoPRC Tauranga Harbour sites in comparison with applicable water quality guidelines. Exceedances are bolded red.

Parameter	Unit	Toll Bridge Marina	Mt Maunganui	Maungatapu Bridge	Waikareao	Tilby Point	Ōmokoroa Wharf	Kauri Point Jetty	Tanners Point Jetty	Statistic	Value	Reference
Turbidity	NTU	2.0	2.1	2.9	2.6	3.3	3.5	3.1	2.0	Median	10	ANZECC (2000)[1]
Visual clarity	m	**0.6**	**0.6**	**0.2**	**0.3**	**0.2**	**0.3**	**0.4**	**0.8**	Minimum	1.6	RCEP
TSS	mg/L	10	13	16	12	**34**	17	15	10	Average	20	Auckland Council[2]
DO	%	84	**63**	**51**	87	91	**44**	**31**	**51**	Minimum	80	RCEP[3]
Water Temperature	°C	NA	NA	NA	NA	NA	NA	NA	NA	Change	±3	RCEP
pH		8.0-8.2	8.0-8.3	8.0-8.2	8.0-8.2	7.8-8.4	8.0-8.2	8.0-8.4	8.0-8.3	Range	7.0-8.5	ANZECC (2000)[1]
Salinity	ppt	31	32	30	29	27	30	30	30	Average	No value	None
Conductivity	µS/cm	50845	52419	48222	46821	44671	48594	48771	49171	Average	No value	None
NH_4-N	mg/L	**0.016**	0.011	**0.022**	**0.031**	**0.027**	**0.018**	**0.017**	**0.027**	Median	0.015	ANZECC (2000)[1]
NNN	mg/L	**0.017**	0.013	**0.027**	**0.065**	**0.033**	**0.017**	0.008	0.007	Median	0.015	ANZECC (2000)[1]
TN	mg/L	0.21	0.19	0.23	0.27	0.27	0.22	0.23	0.20	Median	0.30	ANZECC (2000)[1]
DRP	mg/L	0.004	0.004	0.004	0.004	0.003	0.002	0.001	0.003	Median	0.005	ANZECC (2000)[1]
TP	mg/L	0.016	0.015	0.018	0.015	0.019	0.016	0.017	0.014	Median	0.030	ANZECC (2000)[1]
Chlorophyll *a*	µg/L	1.1	1.3	1.1	0.7	1.6	1.6	1.4	0.7	Median	4.0	ANZECC (2000)[1]
Enterococci	cfu/100mL	80	190	**1600**	**2000**	**3640**	70	130	**300**	Maximum	280	RCEP[5]
Faecal coliforms	cfu/100mL	4	5	8	6	**25**	3	2	9	Median	14	RCEP[6]
Faecal coliforms	cfu/100mL	0	8	5	**18**	**29**	0	0	**12**	% of sites >43 cfu/100mL	10	RCEP[6]

[1] Trigger values for South-Eastern Australia for slightly disturbed ecosystems.
[2] Auckland Council historically used TSS as one of 7 water quality parameters to produce water quality indices of marine water quality (Vaughan, 2017). However, TSS has now been removed from the calculation of these indices (Kelly and Kamke, 2023) but in the absence of any other guideline for TSS this is used as an indicative guideline.
[3] Consistent with ANZECC (2000).
[4] Salinity included to provide context of freshwater input to water quality sites.
[5] Action/Red alert level (MfE and MOH, 2003).
[6] Aquatic organism consumption: (Ministry for the Environment and Ministry of Health, 2003).

2.2.2.1 Physical parameters

Turbidity and TSS are generally consistent across Tauranga Harbour (**Figure 3**) and well below ecological effects thresholds (**Table 3**). The more urban sites – Toll Bridge Marina, Mt Maunganui, Maungatapu Bridge, and Waikareao – are at the lower end of the turbidity and TSS scale (**Figure 3**), suggesting the main causes of increased turbidity and suspended solids are from catchment runoff and not stormwater outfalls.

Water visual clarity is more variable across the harbour (**Figure 3**), but at times – as shown by minimum visual clarity of 0.3-0.7 m – is well below the 1.6 m threshold for all sites (**Table 3**). Only Toll Bridge Marina, Mt Maunganui, and Tanners Point sites have median and mean water clarity above 1.6m (**Figure 3**), i.e. are acceptable most of the time.

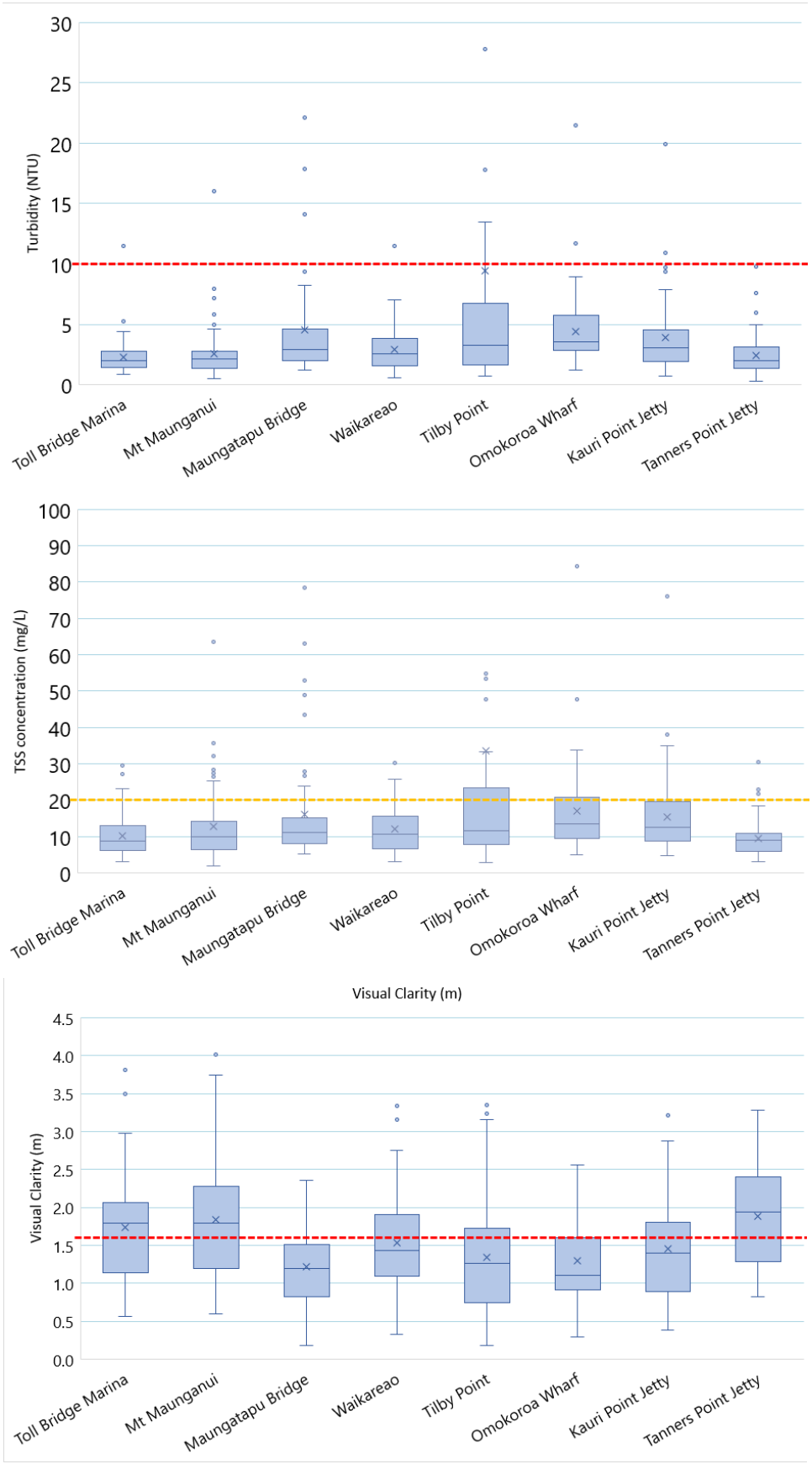


Figure 3. Turbidity (top), TSS (middle), and visual clarity (bottom) current state (2020-2025) box plot for BoPRC water quality sites. Dashed lines are applicable water quality guidelines (red=maximum/minimum; orange=mean) (Table 2).

There are no ecological guidelines for salinity or conductivity and these are included to provide context of freshwater input to estuarine water quality sites (**Figure 4**). The lowest salinity (78% on average) is at Tilby Point, which is at the end of the Wairoa River, the largest freshwater tributary to Tauranga Harbour[6], while the highest salinity (91% on average) is at Mt Maunganui (near open ocean). Conductivity is strongly correlated with salinity so no conclusions are made for conductivity.

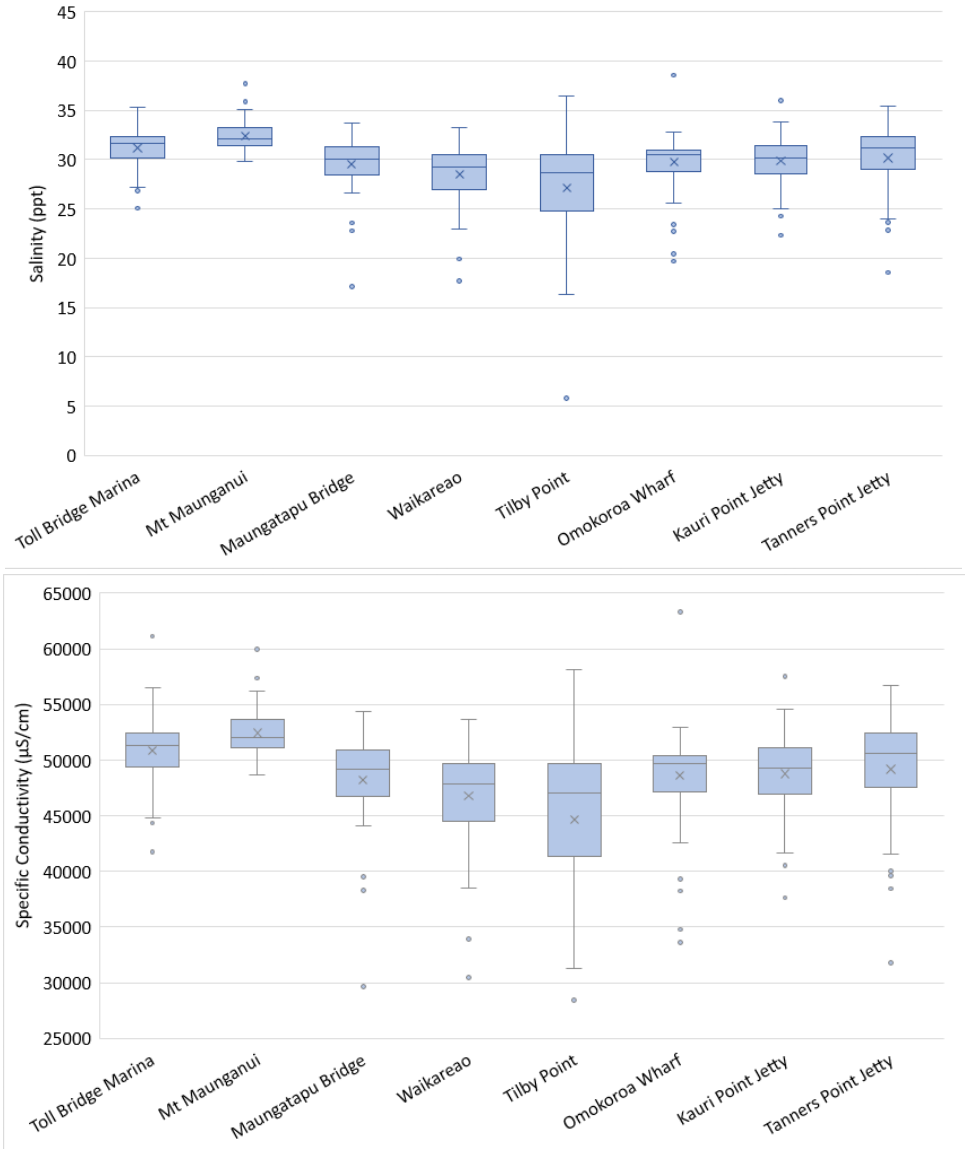


Figure 4. Salinity (top) and specific conductivity (bottom) current state (2020-2025) box plot for BoPRC water quality sites. Note: There are no water quality guidelines for salinity or conductivity.

[6]https://www.westernbay.govt.nz/repository/libraries/id:25p4fe6mo17q9stw0v5w/hierarchy/rules-regulations-licenses/bylaws-and-policies/documents/Wairoa%20River%20Valley%20Strategy.pdf

Water temperature is consistent across all sites with upper quartiles rarely above 20 °C and lower quartiles rarely below 14 °C (**Figure 5**). The RCEP specifies a maximum temperature *change* of ±3 °C, as a result of an activity (**Table 2**).

To assess potential changes in water temperature as a result of dredging and disposal water temperature readings were undertaken during the dredging and disposal process. This is described further in Section 4.3.

Seawater is a good pH buffer, and pH at all sites never exceeds the maximum of 8.5 and minimum of 7.5 specified by ANZECC (2000) (**Table 3** and (**Figure 5**). As for temperature, potential changes in water pH as a result of dredging and disposal are assessed during the dredging process and described further in Section 4.3.

Tauranga Harbour sites are all generally well oxygenated, with all but a few outliers above the 80% minimum DO saturation level specified by the RCEP (**Figure 5**). The outliers are rare – for Kauri Point Jetty and Maungatapu Bridge (<2% of the time) and Mount Maunganui (<4% of the time) – but cause the data to drop below the RCEP minimum threshold of 80% (**Table 3**). As for temperature and pH, potential changes in water DO saturation as a result of dredging and disposal are assessed during the dredging process and described further in Section 4.3.

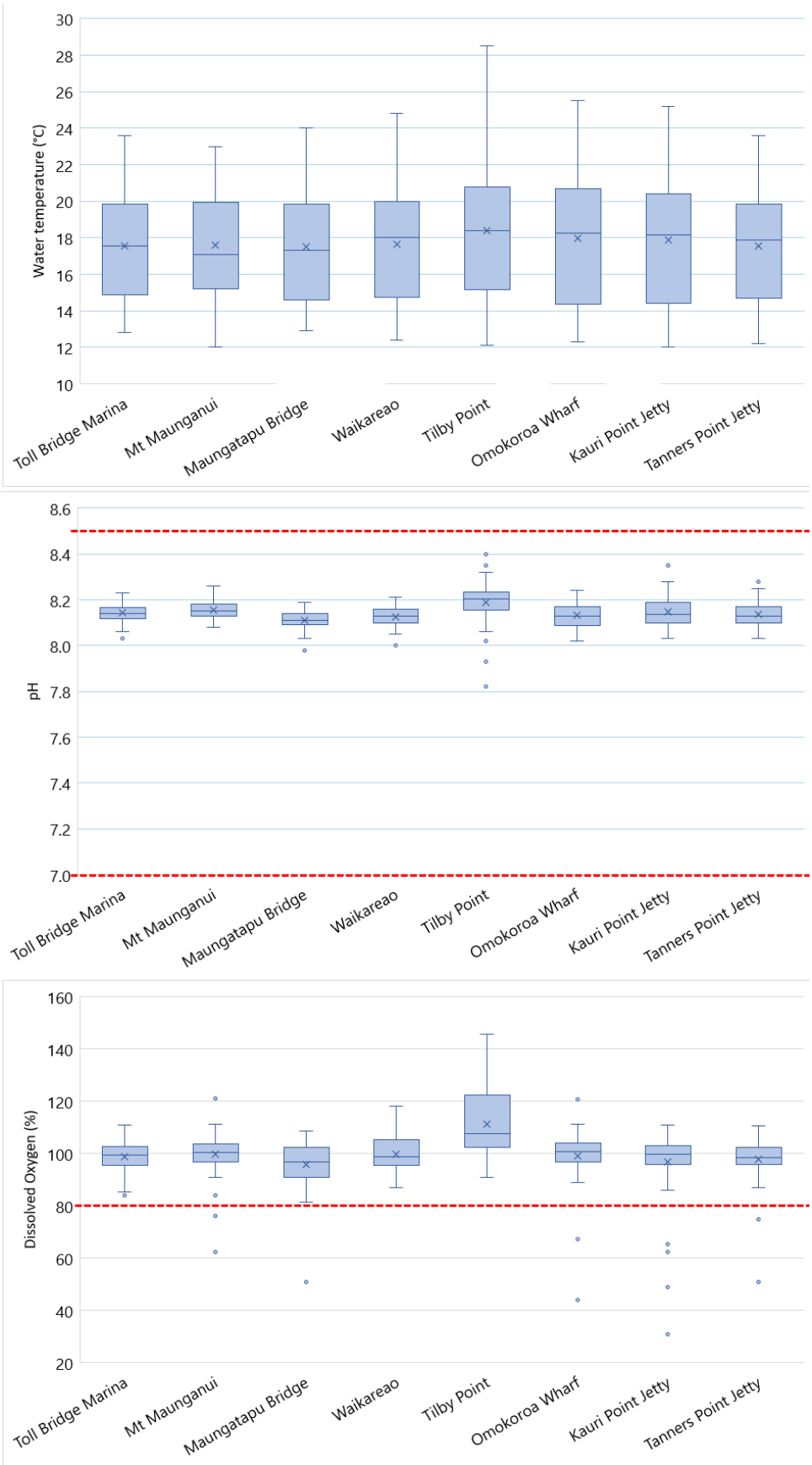


Figure 5. Water temperature (top), pH (middle), and dissolved oxygen (bottom) current state (2020-2025) box plot for BoPRC water quality sites. Red dashed lines are applicable maximum/minimum water quality guidelines (Table 2).

2.2.2.2 Nutrients and chlorophyll a

TP concentrations are generally consistent and low across all Tauranga Harbour sites (**Figure 6**) with median concentrations (0.013-0.018 mg/L) below the ANZECC (2000) default trigger value of 0.03 mg/L (**Table 3**). DRP concentrations are more variable than TP (**Figure 6**) but median values (0.001-0.004 mg/L) are below the ANZECC (2000) default trigger value of 0.005 mg/L at all sites (**Table 3**). Maximum and upper quartile concentrations for urban sites (Toll Bridge Marina, Mt Maunganui, Maungatapu Bridge, and Waikareao) exceed the ANZECC (2000) default trigger value, suggesting at times elevated dissolved phosphorus at these urban sites. The western Tauranga Harbour sites – Tilby Point, Ōmokoroa Wharf, Kauri Point Jetty, and Tanners Point Jetty – have lower DRP concentrations, with upper quartile concentrations below the ANZECC (2000) default trigger value (**Figure 6**).

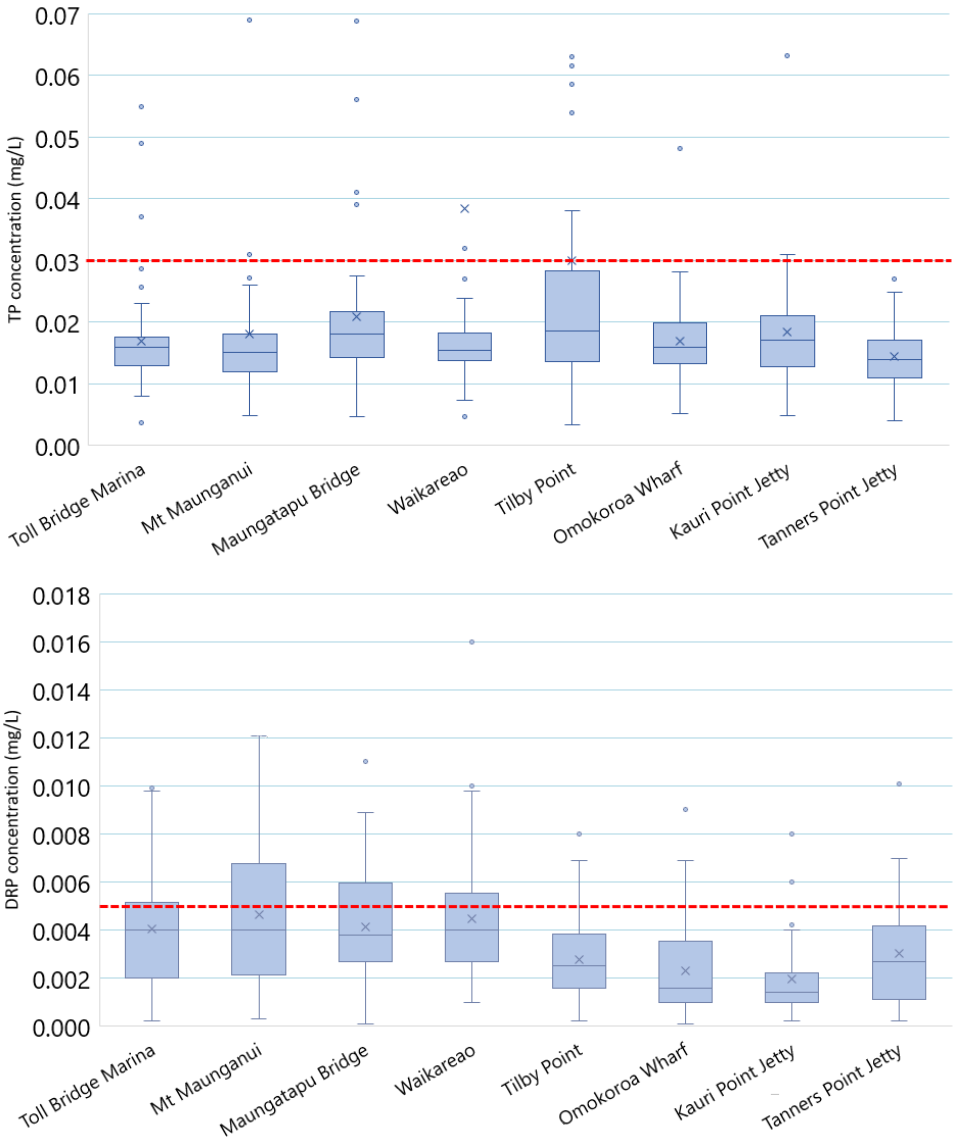


Figure 6. TP (top), and DRP (bottom) current state (2020-2025) box plot for BoPRC water quality sites. Red dashed lines are applicable maximum water quality guidelines (Table 2).

TN concentrations are generally consistent across all Tauranga Harbour sites (**Figure 7**) with median concentrations (0.21-0.27 mg/L) below the ANZECC (2000) default trigger value (0.30 mg/L) (**Table 3**). Highest concentrations are observed at Waikareao and Tilby Point (**Figure 7**).

NNN and NH_4-N Tauranga Harbour concentrations are consistently elevated when compared with guideline values.

For NNN, median concentrations exceed the ANZECC (2000) default trigger value of 0.015 mg/L at Toll Bridge Marina (0.017 mg/L), Maungatapu Bridge (0.027 mg/L), Waikareao (0.065 mg/L), Tilby Point (0.033 mg/L) and Ōmokoroa Wharf (0.017 mg/L) (**Table 3** and **Figure 7**).

For NH_4-N, median concentrations exceed the ANZECC (2000) default trigger value of 0.015 mg/L at all sites (range 0.016-0.031 mg/L) at all sites except Mt Maunganui (0.011 mg/L) (**Table 3** and **Figure 7**).

Elevated nutrients, especially nitrogen and those in the bioavailable form, i.e. DRP and NNN or NH_4-N have the potential to cause estuarine eutrophication. However, this is not supported by measurements of chlorophyll *a*, with median concentrations at all sites (range 0.7-1.6 µg/L) well below the ANZECC (2000) default trigger value of 4.0 µg/L (**Table 3** and **Figure 8**).

Interim chlorophyll *a* thresholds for New Zealand estuaries have been proposed as part of the estuary trophic index (**ETI**) used to assess susceptibility of estuaries to eutrophication (Robertson et al., 2016), but these thresholds are more suitable for estuaries with long residence times (weeks rather than days). Tauranga Harbour is classed as a shallow intertidal dominated estuary (SIDE) (Zygadlo, 2021) with a residence time of <3 days and is therefore not well suited to comparing against the ETI. Nevetheless, BoPRC report chlorophyll *a* concentrations – namely the 90^{th} percentile concentration – against the ETI thresholds. Results (**Table 4**) show that five sites – Toll Bridge Marina (2.1 µg/L), Mt Maunganui (2.5 µg/L), Waikareao (1.2 µg/L), Kauri Point Jetty (2.7 µg/L), and Tanners Point Jetty (1.1 µg/L) are in Band A (<3 µg/L), which equates to ecological communities that are healthy and resilient. Maungatapu Bridge (3.4 µg/L), Tilby Point (6.4 µg/L) and Ōmokoroa Wharf (3.1 µg/L) are in Band B (3-8 µg/L), which corresponds to ecological communities that are slightly impacted by additional phytoplankton growth arising from nutrients levels that are elevated.

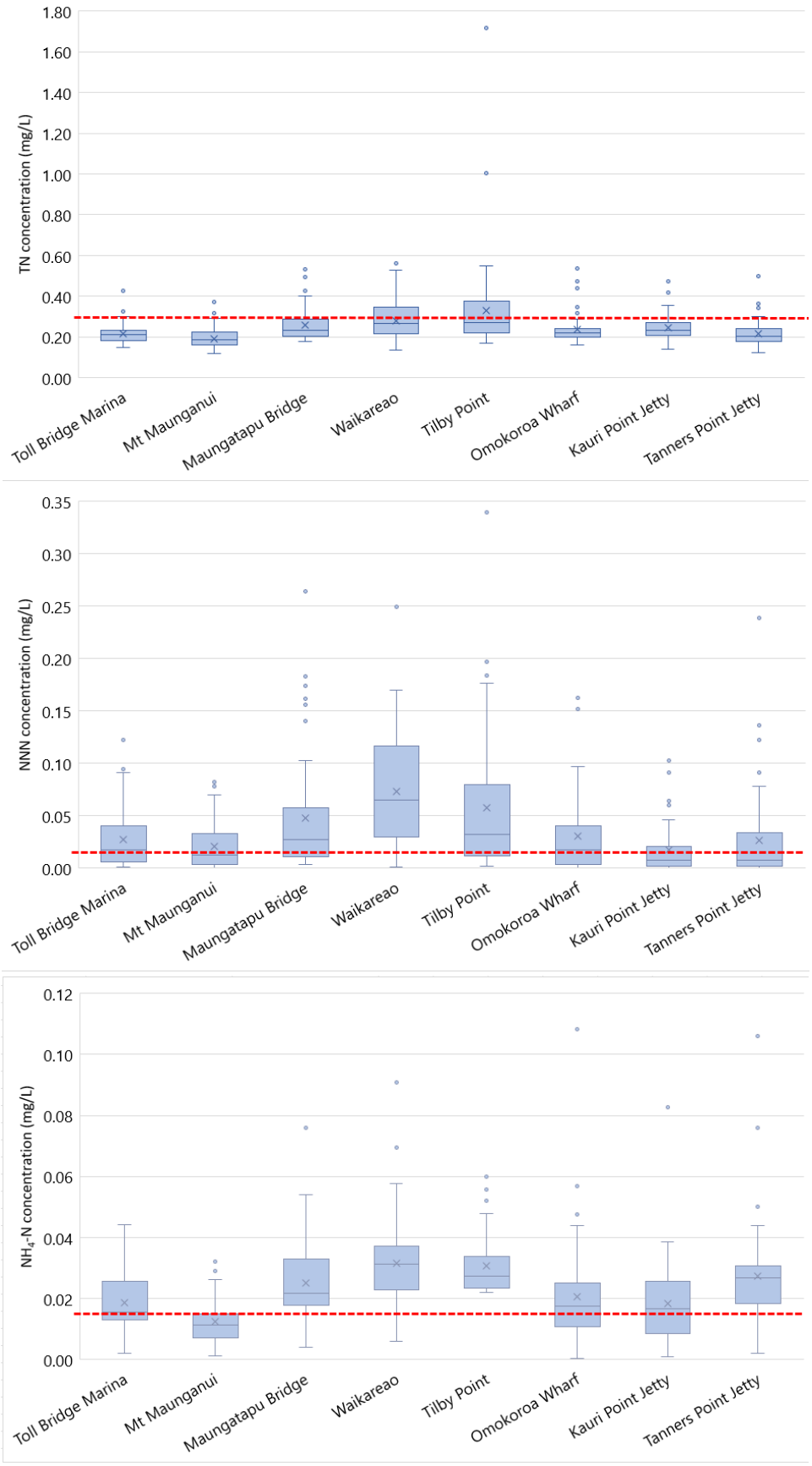


Figure 7. TN (top), NNN (middle), and NH_4-N (bottom) current state (2020-2025) box plot for BoPRC water quality sites. Red dashed lines are applicable maximum water quality guidelines (Table 2).

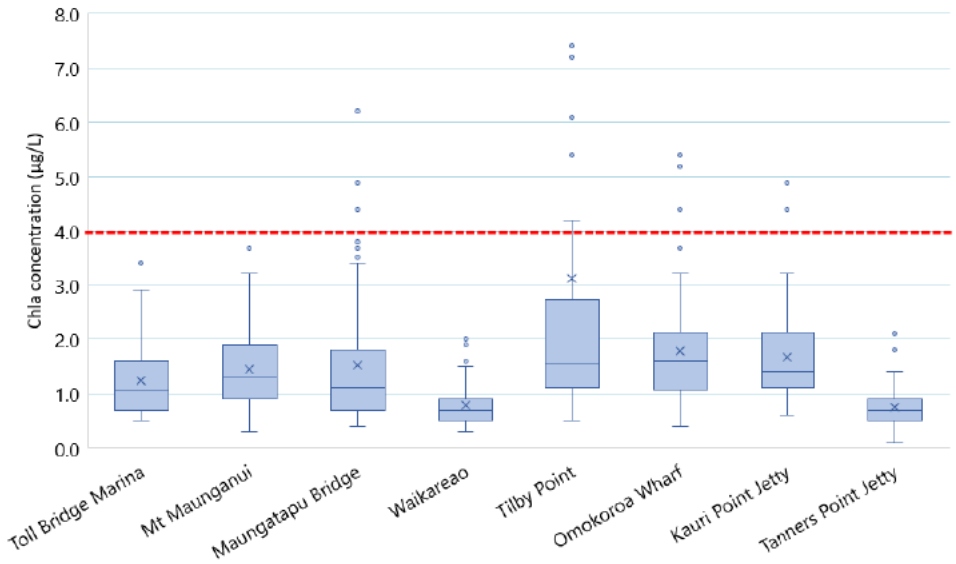


Figure 8. Chlorophyll *a* current state (2020-2025) box plot for BoPRC water quality sites. Red dashed line is the maximum water quality guideline (Table 2).

Table 4. Chlorophyll *a* 90th percentile concentration from 2020-2025 for BoPRC water quality sites and applicable ETI band (Robertson et al., 2016).

Site	Chlorophyll *a* 90th percentile concentration (µg/L)	ETI Band
Toll Bridge Marina	2.1	A
Mt Maunganui	2.5	A
Maungatapu Bridge	3.4	B
Waikareao	1.2	A
Tilby Point	6.4	B
Ōmokoroa Wharf	3.1	B
Kauri Point Jetty	2.7	A
Tanners Point Jetty	1.1	A

The ANZECC (2000) default trigger value chlorophyll *a* results show low susceptibility for Tauranga Harbour to exhibit eutrophication, however the interim threshold values for New Zealand estuaries shows potentially slightly impacted ecological communities at three sites.

For short residence time estuaries, macroalgae are much better suited as primary symptom indicators of eutrophication (Robertson et al., 2016). Crawshaw (2021b) assessed macroalgae cover in the harbour and found that sea lettuce (*Ulva spp.*) dominated the southern harbour and red algae (*Gracilaria chilensis*) dominated the northern harbour. For the southern harbour there was a total 7.2% macroalgae growth present,[7] with 70% cover present at Otumoetai, and 26% cover at Southern Estuary, which includes the town reach area of the Tauranga CBD. For the northern harbour there was 3.8% macroalgae growth present.

Ecological quality status grades were provided based on the ETI. The southern harbour was graded as very poor and the northern harbour as poor based on the total area coverage alone. The

[7] Represented as a percentage of affected area (AA)/available intertidal habitat (AIH).

southern harbour was graded as good overall and northern harbour as very good overall based on the percentage of affected habitat available to intertidal habitat.

2.2.2.3 Microbial

Enterococci concentrations are generally low in Tauranga Harbour (**Figure 9**), however, at times the RCEP bathing standard of 280 cfu/100 mL is exceeded at some sites, with maximum concentrations of 1,600 cfu/100 mL at Maungatapu Bridge, 2,000 cfu/100 mL at Waikareao, 3,640 cfu/100 mL at Tilby Point, and 300 cfu/100 mL at Tanners Point Jetty (**Table 3**). There were no exceedances of this bathing standard for Toll Bridge Marina, Mt Maunganui, Ōmokoroa Wharf, and Kauri Point Jetty sites, with exceedances of 2% of the time at Tanners Point Jetty, 5% of the time at Maungatapu Bridge, 6% of the time at Tilby Point, and 9% of the time at Waikareao.

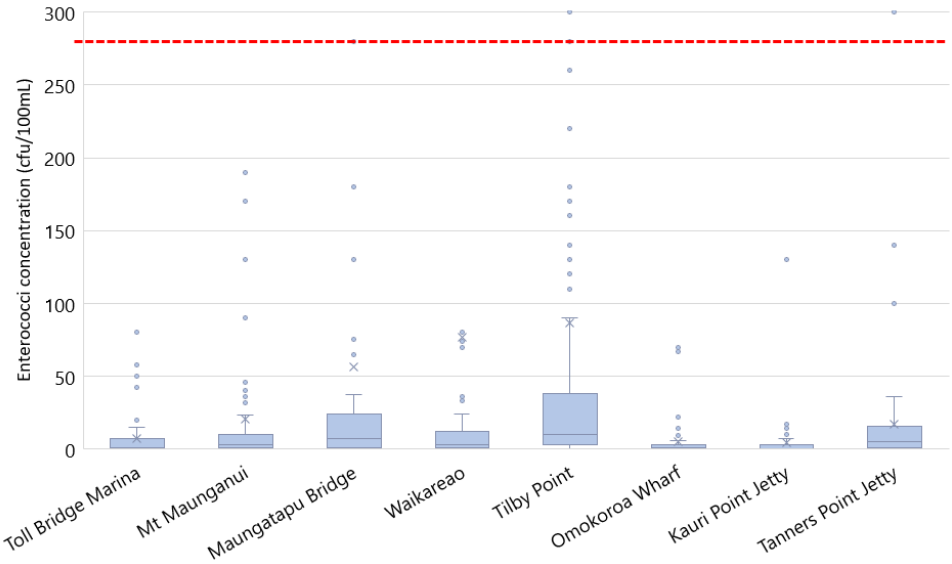


Figure 9. Enterococci current state (2020-2025) box plot for BoPRC water quality sites. Red dashed line is the maximum water quality guideline (Table 2). Note: maximum outliers not shown for ease of interpretation.

Faecal coliforms are generally low in Tauranga Harbour, with the RCEP aquatic organism consumption standard of a median 14 cfu/100mL exceeded only at Tilby Point (25 cfu/100mL) (**Table 3** and **Figure 10**), suggesting most of the time shellfish collection is safe for all sites except Tilby Point. The second measure of shellfish consumption safety is that not more than 10% of samples should exceed 43 cfu/100mL. Under this criterion, Tilby Point exceeded this value 29% of the time, Waikareao exceeded it 18% of the time, and Tanners Point Jetty exceeded it 12% of the time (**Table 3**). Of relevance to this assessment, Toll Bridge Marina does not exceed 43 cfu/100mL at any time (n=60).

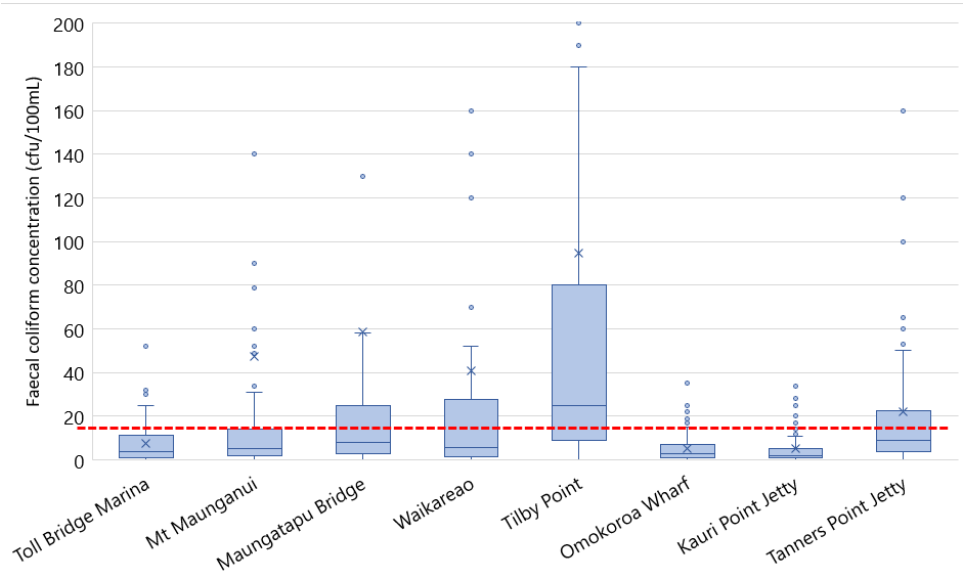


Figure 10. Faecal coliform current state (2020-2025) box plot for BoPRC water quality sites. Red dashed line is the median water quality guideline (Table 2). Note: maximum outliers not shown for ease of interpretation.

2.2.2.4 Toxicants

Metals/metalloids were measured in water samples from Tauranga Harbour collected by BoPRC during a 3-week period in 2019. Average metal/metalloid estuarine water concentrations were generally low and below the ANZG 99% marine DGV. There appeared to be localised elevation of some metal concentrations in Welcome Bay and Rangataua Bay. Copper was reported at both sites at concentrations above the 95% DGV (1.3 µg/L): Welcome Bay (3.2 µg/L); Rangataua Bay (1.7 µg/L), while zinc was reported at Welcome Bay (17.7 µg/L), above the 95% DGV (15 µg/L) (Crawshaw, 2021a).

As part of the above study, emerging organic contaminants (**EOCs**) – namely representative chemicals from classes of flame retardants, plasticisers, surfactants, polyfluorinated alkyl substances (**PFAS**), musk fragrances, pyrethroid insecticides, pesticides, pharmaceuticals, steroid estrogens, personal care products, wastewater markers, preservatives, antifouling agents, and UV filters – were measured in water and sediment from the same sites (Crawshaw, 2021a). An independent ecological risk assessment (Conwell, 2021) concluded that all water concentrations were below effects guidelines (i.e. PNECs).

The Tauranga wastewater treatment plant (**WWTP**) has an ocean outfall discharge, so the low level EOC concentrations (many of which are known to be elevated in wastewater treatment plant discharges) are likely to be from stormwater outlets. Importantly, the Port site had EOC concentrations (water and sediment) below applicable PNECs.

PFAS have also been measured in soil, groundwater, and surface water from multiple studies around the industrial areas near to the Port facility (reviewed in Aurecon, 2022). **Figure 11** shows an overview of the results of these studies.

Sites coloured green reported PFAS in all sample types measured (water, sediment, soil) below applicable ecological and human health effects concentrations. Sites in this category are the BoPRC Port site mentioned earlier in this report, plus Tauranga Airport sites, and Whareroa Marae.

For the Z Energy site (orange), perfluorooctane sulfonate (**PFOS**) and perfluorohexane sulfonic acid (**PFHxS**) concentrations in one of five groundwater sites exceeded human health drinking water standards.

For the Lawter site (red), PFAS were detected in 14 out of 15 soil samples, with one sample exceeding the ecological effects concentration for total PFOS. PFAS were detected in all six groundwater samples, with concentrations of PFOS+PFHxS (all samples) and perfluorooctane sulfonic acid (**PFOA**) (one sample) reported above human health drinking water standards, and total PFOS present in four samples above the 95% ecological guideline value. A second study at the same site targeting contaminated soils around a fire tank detected PFAS in all 24 samples with samples below human health criteria and three samples exceeding ecological standards for total PFOS.

For the PoTL site, PFAS were detected in all eight boreholes sampled, with three at concentrations above human health drinking water standards, four above 99% species protection, and one above 95% species protection.

Terminals NZ reported PFAS in groundwater but no assessment of potential effects was made.

In summary, there appears to be low level PFAS contamination in the industrial area near the Port, however Whareroa Marae and the Port (and other harbour sites) reported concentrations below ecological and/or human health effects levels.

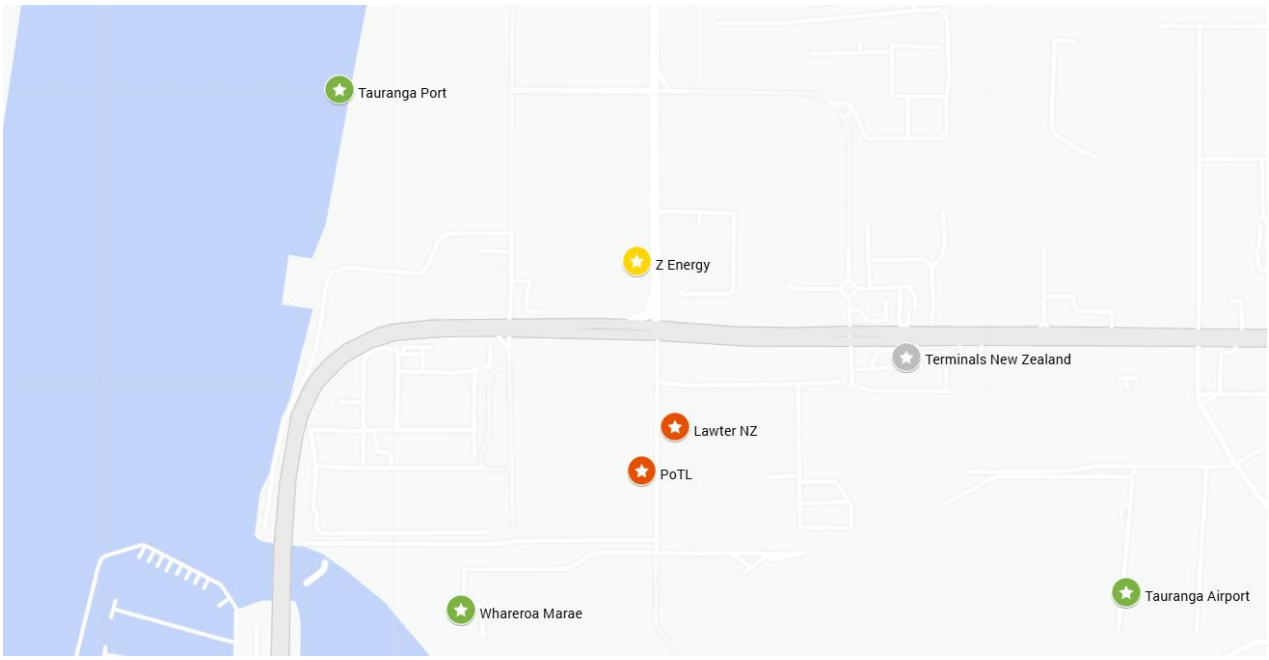


Figure 11. Summary of PFAS contamination around Port of Tauranga. Colours correspond to reported concentrations relative to effects concentrations: green = below effects concentrations for all samples; orange = above effects concentrations for one sample type (water, sediment, soil); red = above effects concentrations for more than one sample type (water, sediment, soil); grey = not assessed.

Further to the above assessment, an extant resource consents analysis undertaken for this application (Gardner, 2023) identified a resource consent (RM22-0252) held by BP Oil New Zealand Ltd for discharging potentially contaminated water to land associated with the installation of a new 80,000L fuel tank at Tauranga Airport. Of relevance is the condition for monitoring PFAS in water and soil (Conditions 6.1-6.3). This consent was not implemented and expired on 31st October 2024, so there are no PFAS data available.

2.2.3 POTL continuous turbidity measurements

PoTL maintain 6 continuous turbidity monitoring stations in the harbour during dredging campaigns. These provide a datapoint every 15 seconds and are used to inform the dredging process by monitoring against set triggers for a management response (providing effective intervention during the dredging process).

The sensors are prone to false readings due to seaweed clumped around the sensors, general marine growth and marine life living in the housing of the sensors. Prolonged swells in the harbour entrance or sea state inside the harbour can prevent safe maintenance of sensors. Overall, this reduces confidence in the sensors for use in compliance. Based on the above, the approach by PoTL was to use the continuous monitoring to inform the dredge and PoTL of any potential issues with turbidity and set triggers for intervention.[8]

Turbidity limits for the dredging process have been set based on analyses undertaken by Bryan et al. (2014) which in turn was (in part) based on dredging studies from other ports. Bryan et al. (2014) proposed three management limits:

1) Level 1 of 15 NTU. If breached an investigation will be undertaken to find the source.
2) Level 2 of 20 NTU. If breached the dredging process will be changed until below this level.
3) Environmental limit of 35 NTU. If exceeded, no further dredging should occur.

These turbidity limits are set based on a rolling average over 6 hours from data collected at 15 minute intervals from continuous monitoring buoys deployed in the receiving environment (see **Figure 1**). Therefore, these limits are conservative compared to individual spot readings in the active plume as they do not represent the temporary nature of the plume and are discussed further in Section 4.1.

2.3 Tauranga Harbour water quality trends

2.3.1 Methodology

Temporal trend analysis were undertaken over the last 10 years, as BoPRC implemented a significant procedural change to sample collection timing in July 2015 (Zygadlo, 2021). Samples had historically been collected at high tide (and some sites low tide), but from July 2015 all samples were collected at mid-ebb tide to capture a greater freshwater influence and therefore more representative of terrestrial inputs that have greater anthropogenic influence.

[8] Rowan Johnstone, PoT, email dated 27/06/23.

Investigations by BoPRC showed that this change in methodology led to unexpected step changes in results of some parameters, and they determined that the data would need to be treated as separate datasets, i.e. pre-July 2015 and post-July 2015. Therefore, temporal trend analyses in this report were undertaken from July 2015 until June 2025 inclusive, i.e. 10 years.[9]

The statistical tool 'Time Trends' (version 10.0) (NIWA, 2023) was used to assess temporal trends of water quality parameters of the receiving environment. Data were tested for seasonality and, if detected, then the Seasonal Kendall test was used to assess the significance of trends over time. If seasonality was not detected, then the Mann-Kendall test was used. In both cases, the direction and magnitude of the significance of any temporal trend in the data is reported.

We based our interpretation of the trend analysis results on Scarsbrook (2006), who considered both the statistical significance of the trend and whether or not it was meaningful. A statistically significant trend does not imply a meaningful trend, which is defined as a trend likely to be relevant from a management perspective. A meaningful trend is defined as one in which the trend is statistically significant ($p < 0.05$) and has an absolute magnitude of change of > 1% per year (which can be either positive or negative). Trends were categorised as follows:

- **No significant change** – The null hypothesis for the test was **not** rejected ($p > 0.05$). In the following results tables, non-significant trends are shown with an arrow to indicate the direction of the trend (increasing ↑; decreasing ↓; no change →).
- **Significant increase/decrease** – The null hypothesis for the test was rejected ($p < 0.05$) and the test statistic value was less than 1% per year. In the following results tables, significant trends are shown with a bold arrow to indicate the direction of the trend (increasing 🡅; decreasing 🡇; no change 🡆).
- **'Meaningful' increase/decrease** – The null hypothesis or the test was rejected ($p < 0.05$) and the test statistic value was greater than 1% per year. Increasing meaningful trends are indicated in the following results tables by being highlighted in **red (🡅)**. Decreasing meaningful trends are indicated in the following results tables by being highlighted in **blue (🡇)**.

2.3.2 BoPRC water quality sites trend results

Water quality trends are summarised in **Table 5**, with full datasets and trend figures presented in **Appendix 2**.

2.3.2.1 Physical parameters

Water clarity in Tauranga Harbour over the last 10 years has been decreasing at all sites except Toll Bridge Marina, where it has been increasing, but not significantly. Only Waikareao had a significant (and also meaningful) decreasing trend. Turbidity has been increasing at all sites except Toll Bridge Marina site, where it has been decreasing although not significantly, with significant and meaningful increases at Waikareao (4.8% annual increase), Kauri Point Jetty (5.6% annual increase), and Tanners Point Jetty (4.8% annual increase). TSS has been variable, decreasing at

[9] We note that significance of trend analyses is highly dependent on the number of datapoints, so we have used the time period of 10 years and not 5 years, as per current state. DIN data collection commenced in July 2021 so there are 4 years for DIN trends.

some sites and increasing at others. Tanners Point Jetty showed a significant and meaningful (4.2% annual) increase, while Toll Bridge Marina had a significant and meaningful (9.4% annual) decrease (**Table 5**).

For five sites (Toll Bridge Marina, Waikareao, Tilby Point, Kauri Point Jetty and Tanners Point Jetty) changes in turbidity appear to be correlated with suspended solids and inversely with water clarity. For these sites, increases in turbidity are correlated with increases in TSS and decreases in water clarity, while decreases in turbidity are correlated with decreases in TSS and increases in water clarity (**Table 5**).

Salinity trends show an increase in freshwater into Tauranga Harbour over the last 10 years. As noted above, all samples are collected on the ebb tide, where the freshwater component will be maximised. Salinity has been decreasing by between 0.2-1.1% across Tauranga Harbour sites with trends at five sites being significant, and Waikareao also meaningful (1.1% annual decrease).

Water temperature has been generally increasing over the last 10 years, however none of the trends have been significant (**Table 5**).

pH has been increasing at all sites over the last 10 years, with all increases significant, but none have been meaningful (<1% annual change) (**Table 5**). The increase in pH may reflect increased freshwater influence and therefore less buffering capacity of the marine water.

Dissolved oxygen (**DO**) has been variable across all sites, with some increases and some decreases (**Table 5**). Of note, DO trends, whether measured as oxygen concentration (mg/L) or saturation (%), have generally been consistent.

2.3.2.2 Nutrients and chlorophyll *a*

Phosphorus concentrations (as total and dissolved) have been decreasing over the last 10 years at all sites except for Kauri Point Jetty, where they have remained static. Many of the trends are significant and meaningful (**Table 5**).

Nitrogen concentrations – TN, NNN, and NH_4-N – have been generally decreasing or static over the last 10 years. Most of the trends are not significant, although significant and meaningful decreases in TN and NH_4-N were detected at Maungatapu Bridge, for TN at Ōmokoroa Wharf, and for NH_4-N at Toll Bridge Marina. The exception to reducing concentrations is Waikareao where N species have been increasing but not significantly. Dissolved inorganic nitrogen (DIN = NNN + NH_4-N) was included in monitoring from July 2021, so trends reflect only 4 years of data. Conversely, DIN has been increasing at all sites except for Tanners Point Jetty (reducing) however none of the changes are significant (**Table 5**). Further, they describe a shorter time period and are not directly comparable with NNN and NH_4-N trends over 10 years. Despite the overall reduction in N species, NH_4-N and NNN remain elevated at most sites (see Section 2.2.2.2).

Despite the generally reducing nutrient concentrations, chlorophyll *a* concentrations have been static or increasing. Significant and meaningful increasing trends occurred at Toll Bridge Marina (4.5% annual increase), Waikareao (4.0% annual increase), and Tanners Point Jetty (4.2% annual increase) (**Table 5**).

2.3.2.3 Microbial

Faecal coliform (**FC**), Enterococci (**Ent**) and *Escherichia coli* (***E. coli***) trends have been variable but largely static at each site. Only enterococci at Toll Bridge Marina and Ōmokoroa Wharf showed significant and meaningful trends (both decreasing) (**Table 5**).

2.3.2.4 Toxicants

We did not undertake temporal trend analyses for toxicants in Tauranga Harbour water, as monitoring has been infrequent (see Section 2.2.2.4).

Table 5. Temporal trend results (July 2015 to June 2025) for water quality parameters from BoPRC water quality sites located in Tauranga Harbour. Significant increasing trends are bold arrows with meaningful increasing trends highlighted in red and meaningful decreasing trends highlighted in blue. Non-bold arrows show direction of non-significant changes.

Variable	Unit	Toll Bridge Marina	Mount Manganui	Maungatapu Bridge	Waikareao	Tilby Point	Ōmokoroa Wharf	Kauri Point Jetty	Tanners Point Jetty
Distance from Toll Bridge Marina[1]	km	0.0	4.0	4.2	1.2	5.1	11.8	24.8	29.5
Water Clarity	m	↑	↓	↓	**↓**	↓	↓	↓	↓
Turbidity	NTU	↓	↑	↑	**↑**	↑	↑	**↑**	**↑**
TSS	mg/L	**↓**	↓	↓	↑	↑	↓	↑	**↑**
Conductivity	µS/cm	↓	**↑**	↑	↓	↑	↑	↑	↑
Salinity	ppt	**↓**	**↓**	**↓**	**↓**	↓	**↓**	↓	↓
Water Temperature	°C	↑	↓	↑	↑	↑	↑	↑	↑
pH		**↑**	**↑**	**↑**	**↑**	**↑**	**↑**	**↑**	**↑**
DO	mg/L	↑	↑	↓	**↑**	↓	↑	↓	**↓**
DO	%	↑	↑	→	↑	↓	↑	→	↓
TP	mg/L	**↓**	**↓**	**↓**	**↓**	↓	↓	→	→
DRP	mg/L	**↓**	↓	**↓**	**↓**	**↓**	**↓**	→	↓
TN	mg/L	↓	↓	**↓**	↑	↓	**↓**	↓	↓
NNN	mg/L	↓	↓	↓	↑	↓	↓	↓	↓
NH_4-N	mg/L	**↓**	→	**↓**	↑	↑	↓	↑	↑
DIN[2]	mg/L	↑	↑	↑	↑	↑	↑	↑	↓
Chlorophyll *a*	µg/L	**↑**	↑	↑	**↑**	→	↑	→	**↑**
Faecal coliforms	cfu/100mL	→	→	→	↑	↑	→	→	↑
Enterococci	cfu/100mL	**↓**	→	↓	→	↓	**↓**	→	↓
E. coli	cfu/100mL	→	→	→	→	↓	→	→	↑

[1] Direct line - Calculated using ruler function in Google Earth.

[2] DIN has been monitored since July 2021.

2.4 Tauranga Harbour sediment quality state and trends

2.4.1 Background

Long-term BoPRC estuarine sediment monitoring sites in Tauranga Harbour are primarily intertidal and at the southern edge of the harbour. The primary aim of these monitoring sites is to assess benthic health and potential freshwater sources of contaminants to the harbour. Parameters measured include mud content (silt: <63 µm), organic content (Total Organic Carbon: **TOC**), heavy metals/metalloids[10], and very occasionally persistent organic pollutants (**POPs**).

Sediment toxicant monitoring within the Port environment is more limited and recent reports include one-off targeted monitoring campaigns, namely:

- Metals, POPs and EOCs from the 2019 targeted sediment contaminant monitoring (Crawshaw, 2021a).
- Metals measured for the Stella Passage development assessment of environmental effects (Leonard et al., 2020).
- Metals measured in sub-tidal sediments in Tauranga Harbour (Clark et al., 2018).

Sediment quality data in and around the Port channel (where dredging occurs) and at the offshore disposal site are very limited and not at sites appropriate for this assessment. PoTL undertook sediment quality toxicant analyses at 7 sites in the channel and 1 at the offshore disposal site (Dec 23 to Feb 24). These data are summarised in Section 2.4.5.1. Further, as part of their marine ecology assessment for this application, Boffa Miskell undertook sediment and shellfish toxicant monitoring in November 2023 at sites around Te Paritaha pipi bank. These data are summarised in Sections 2.4.5.2 (sediment) and 2.5.5 (shellfish).

2.4.2 Methodology

Data from selected BoPRC long-term estuarine intertidal sediment quality monitoring sites (**Figure 12**) were assessed for current state and temporal trends. Toxicant data were compared with ANZG 2018 sediment DGVs (**Table 6**), which is summarised in Section 2.4.3.

One-off sediment quality data within the Port environment are summarised (Section 2.4.4) to provide context with the whole of harbour intertidal data.

Toxicants measured for this assessment – i.e. those undertaken by PoTL and Boffa Miskell are summarised in Section 2.4.5.

[10] Arsenic and antimony are metalloids, which are non-metals with metal properties.

Table 6. ANZG (2018) sediment quality guidelines for toxicant stressors used in this assessment.

Toxicant class	Toxicant[1]	Unit	DGV	GV-High
Metal	Cadmium	mg/kg dry weight[2]	1.5	10
	Chromium		80	370
	Copper		65	270
	Lead		50	220
	Mercury		0.15	1.0
	Nickel		21	52
	Silver		1.0	4.0
	Zinc		200	410
Metalloid	Arsenic	mg/kg dry weight[2]	20	70
	Antimony		2.0	25
Organics	TPH	mg/kg dry weight[3]	280	550
Organometallics	Tributyltin (as Tin)	µg/kg dry weight, 1% OC[4]	9.0	70
Organics	Total PAHs	µg/kg dry weight, 1% OC[3,4]	10,000	50,000
	Total DDT		1.2	5
	p,p'-DDE		1.4	7
	o,p'- + p,p'-DDD		3.5	9
	Chlordane		4.5	9
	Dieldrin		2.8	7
	Endrin		2.7	60
	Lindane		0.9	1.4
	Total PCBs		34	280

[1] DDD = dichlorodiphenyldichloroethane; DDT = Dichlorodiphenyltrichloroethane; DDE = dichlorodiphenyldichloroethylene; DGV = default guideline value; GV-high = additional upper guideline value; PAHs = polycyclic aromatic hydrocarbons; PCBs = polychlorinated biphenyls; TPHs = total petroleum hydrocarbons; OC = organic carbon.

[2] Primarily adapted from the effects range low (ERL) and effects range median (ERM) values of Long et al. (1995).

[3] Primarily adapted from threshold effects level (TEL) and probable effects level (PEL) values of MacDonald et al. (2000) and CCME (2002).

[4] Normalised to 1% OC within the limits of 0.2 to 10%. Thus if a sediment has (i) 2% OC, the '1% normalised' concentration would be the measured concentration divided by 2, (ii) 0.5% OC, then the 1% normalised value is the measured value divided by 0.5, (iii) 0.15% OC, then the 1% normalised value is the measured value divided by the lower limit of 0.2.

2.4.3 BoPRC long-term inter-tidal sediment quality sites

2.4.3.1 Current state

Ten long-term intertidal sediment quality sites (**Figure 12**) were selected from the total number of sites (69). Sites were chosen to provide long-term dataset (primarily for temporal trends analysis) and sites situated around Tauranga and in proximity to the Port, but also including a wider spatial distribution of the harbour. Data are generally collected annually, so current state was calculated as the average of the last 5 data entries (i.e. generally last 5 years). Average metal and metalloid sediment concentrations were compared with ANZG 2018 DGV and summarised in **Table 7**, with average grain size, TOC, TN and TP summarised in **Table 8**.

All metal and metalloid sediment concentrations were well below the ANZG 2018 DGV (**Table 7**), suggesting there is a very low risk of adverse effects occurring from metals/metalloids in the estuarine sediments.

There is virtually no gravel (>2000 µm size) in all sediments (maximum 3.6%, median 0.0%), with the major component being sand (63 µm to 2000 µm) with a range of 59-93% (median 81%) (**Table**

8). Significant mud fractions are noted for P15 (Waikareao: 41%), P1 (Rangataua Bay: 34%), P29 (Te Puna: 28%), P63 (Grace Rd: 21%), P64 (Waimapu: 24%), and P65 (Welcome Bay: 18%), of which Rangataua Bay, Grace Rd and Waimapu are south of the Port channel (**Figure 12**). TOC is generally low at all sites, ranging from 0.23-0.93 g/100g (median 0.44 g/100g). Due to the propensity for organic and metal contaminants to partition to sediments with increasing organic content, ANZG 2018 recommend normalising hydrophobic organic contaminant concentrations to 1% organic carbon.[11] Therefore, these sediments have a lower propensity to accumulate organic contaminants. TN concentrations range from 250-980 mg/kg and TP concentrations from 97-304 mg/kg. We are not aware of any sediment nutrient guidelines, so these are provided to provide context with other data (primarily sediment data collected by PoTL for this assessment: Section 2.4.5).

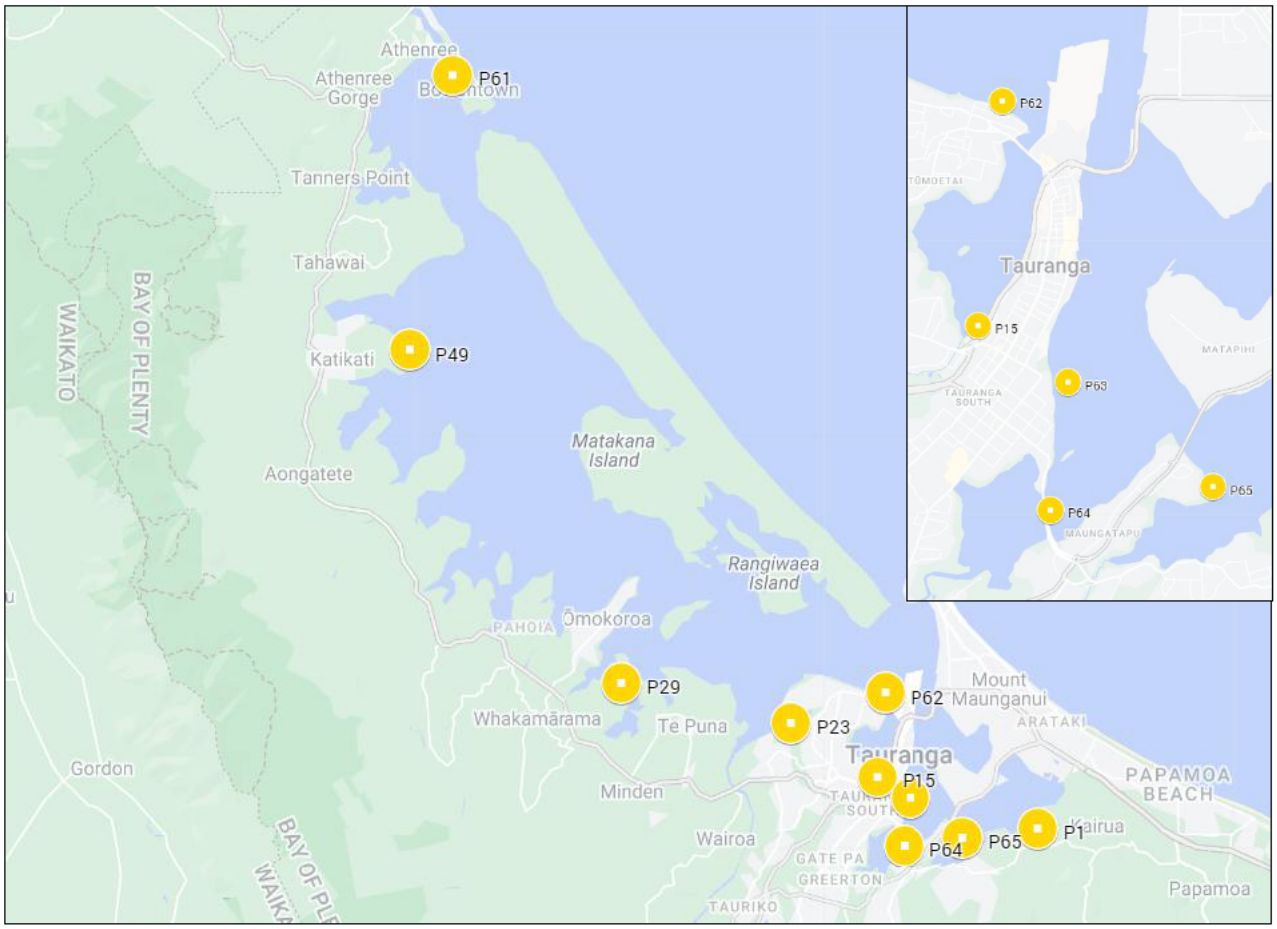


Figure 12. Selected BoPRC long-term Tauranga Harbour sediment quality monitoring sites used for current status and trends analysis. Inset are sites around the Port channel.

[11] https://www.waterquality.gov.au/anz-guidelines/guideline-values/default/sediment-quality-toxicants

Table 7. Average annual metal and *metalloid* sediment concentrations from 2020-2025 for selected BoPRC long-term estuarine monitoring sites and comparison with ANZG 2018 DGV.

Site code	Site name	As	Cd	Cr	Cu	Pb	Hg	Ni	Zn
Unit		mg/kg dry weight							
P61	Poi's	2.1	0.04	3.5	0.8	1.5	0.04	1.2	9
P49	Katikati	2.8	0.05	5.0	1.1	2.1	0.04	1.5	11
P29	Te Puna	4.8	0.04	3.9	1.8	4.0	0.06	1.9	32
P23	Matua	1.6	0.07	2.6	1.1	1.7	0.04	1.1	12
P15	Waikareao	4.7	0.10	10.2	3.8	18.1	0.04	2.4	118
P62	Otumoetai	2.7	0.06	4.4	2.0	1.8	0.06	1.4	12
P64	Waimapu	3.3	0.08	4.9	2.2	3.3	0.05	2.0	30
P63	Grace Rd	4.1	0.08	3.7	2.9	4.3	0.04	1.2	35
P65	Welcome Bay	3.7	0.09	5.2	2.3	3.8	0.04	2.0	29
P1	Rangataua Bay	3.8	0.04	5.6	2.7	4.2	0.03	2.2	30
ANZ DGV		20	1.5	80	65	50	0.15	21	200

Table 8. Average annual grain size, and TOC, TN, TP sediment concentrations (as dry weight) from 2020-2025 for selected BoPRC long-term estuarine monitoring sites.

Site	Site Name	% mud (<63 µm)	% sand (63-2000 µm)	% gravel (>2000 µm)	TOC (g/100g)	TN (mg/kg)	TP (mg/kg)
P61	Poi's	9	91	0.00	0.26	500	109
P49	Katikati	12	88	0.00	0.28	500	101
P29	Te Puna	28	72	0.00	0.63	800	240
P23	Matua	12	88	0.00	0.33	520	97
P15	Waikareao	41	59	0.00	0.93	980	304
P62	Otumoetai	7	93	0.04	0.23	250	117
P64	Waimapu	24	76	0.00	0.46	540	154
P63	Grace Rd	21	79	0.00	0.52	700	209
P65	Welcome Bay	18	83	0.00	0.42	700	181
P1	Rangataua Bay	34	62	3.60	0.87	960	226

2.4.3.2 Temporal trends

The long-term BoPRC estuarine monitoring has some data (% mud and TOC) from early 1990s, metal toxicants from 2005/2006, and TN/TP consistently from 2014. Temporal trend analyses were undertaken on data from 2005 (see **Appendix 3**) and summarised in **Table 9**.

There were 23 significant and meaningful increases and 11 significant and meaningful decreases in sediment parameters, with 1 significant but not meaningful increase.

Percentage mud is increasing at 8 sites – 6 significantly and meaningfully, P61 (Poi's), P49 (Katikati), P29 (Te Puna), P62 (Otumoetai), P63 (Grace Rd), and P1 (Rangataua Bay) – with no sites showing any significant decrease. Significant and meaningful increases coincide with high current mud content (Section 2.4.3.1) for P1 (Rangataua Bay), P29 (Te Puna), P64 (Waimapu), and P63 (Grace Rd).

TN, TP, and TOC changes were variable across sites. P64 (Waimapu) and P65 (Welcome Bay) were consistently decreasing, with TOC and TP significant and meaningful at both sites. For P63 (Grace Rd) all were increasing with only TOC significant, and also meaningful.

Metal and metalloid sediment trends are generally variable, however some conclusions can be made. Increasing concentrations are noted for all 8 metals/metalloids at P1 (Rangataua Bay: 5 significant and meaningful), for 7 at P15 (Waikareao: 4 significant and meaningful), for 6 at P23 (Matua: 4 significant and meaningful), and for 7 at P62 (Otumoetai: 1 significant and meaningful). In contrast, decreasing concentrations are noted for all 8 metals/metalloids at P64 (Waimapu: 5 significant and meaningful), and for 8 at P65 (Welcome Bay: 5 significant and meaningful).

Table 9. Temporal trend results for parameters from selected BoPRC sediment quality sites located in Tauranga Harbour. Significant increasing trends are bold arrows with meaningful increasing trends highlighted in red and meaningful decreasing trends highlighted in blue. Non-bold arrows show direction of non-significant changes.

Site	Site Name	% Mud	TN	TOC	TP	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
P61	Poi's	**↑**	→	↑	↑	↑	↑	↑	↓	↑	→	↑	↑
P49	Katikati	**↑**	→	↓	↑	↑	↓	↑	→	→	↓	↑	**↑**
P29	Te Puna	**↑**	**↓**	→	↓	↑	↑	↑	↓	→	↑	↓	**↑**
P23	Matua	→	→	↓	↓	↑	**↑**	**↑**	↓	**↑**	**↑**	↓	**↑**
P15	Waikareao	↓	↓	↑	→	↑	↑	**↑**	**↑**	→	**↑**	↑	↑
P62	Otumoetai	**↑**	→	↓	↓	**↑**	↑	↑	↑	↑	↑	↓	↑
P64	Waimapu	↑	↓	**↓**	**↓**	↓	↓	↓	**↓**	↓	↓	**↓**	**↓**
P63	Grace Rd	**↑**	↑	**↑**	↑	**↑**	→	↑	↑	↑	↑	↑	↑
P65	Welcome Bay	↑	↓	**↓**	**↓**	↓	↓	↓	**↓**	↓	↓	**↓**	**↓**
P1	Rangataua Bay	**↑**	↑	↑	↑	↑	↑	**↑**	**↑**	↑	**↑**	**↑**	**↑**

2.4.4 Other sediment quality data near the Port

2.4.4.1 POPs and EOCs from targeted sediment contaminant monitoring in 2019

Crawshaw (2021a) reported on targeted toxicant analyses in estuarine sediment samples. Trace acid herbicides, multi-residue pesticides, polychlorinated biphenyls (PCBs), metsulfuron, and semi-volatile organic compounds (SVOCs: haloethers, phenols, plasticisers, halogenated compounds) were reported below detection limits at all sites.

PAHs were measured in sediment from a subset of sites. Sites where PAHs were detected were: the Port site (total PAH 87 µg/kg dry weight); Welcome Bay (total PAH 26 µg/kg dry weight), Waimapu (total PAH 16 µg/kg dry weight) and Katikati (total PAH 9 µg/kg dry weight) (Crawshaw, 2021a). Further, although not reported, sediment from Pilot Bay collected at the same time recorded a total PAH concentration of 103 µg/kg dry weight.[12]

Despite the detection of PAHs, all total PAH concentrations were orders of magnitude below effects concentrations, namely the ANZG 2018 DGV for total PAHs (10,000 µg/kg dry weight, normalised to 1% organic carbon).

A total of 96 EOCs were measured in sediment including: PFAS (33); glyphosate/AMPA; phosphate flame retardants (3), brominated diphenyl ethers (10); phthalate plasticisers (8); bisphenol A; nonylphenol surfactants (2); polycyclic musk fragrances (2); pharmaceuticals (10); steroid estrogens (5); personal care products (4); paraben preservatives (2), pyrethroid insecticides (3); antifouling agents (3); UV filters (5); the wastewater markers caffeine and sucralose; and the anticorrosive benzotriazole. As stated in Section 2.2.2.4, the potential for ecological effects from EOCs was undertaken separately (Conwell, 2021). Of the 96 EOCs measured in sediment, only 2 were reported at concentrations exceeding the marine sediment PNEC: The pyrethroid insecticide *cis*-permethrin at Welcome Bay, Katikati, and Waimapu (exceeding the PNEC between 2.7-fold and 5.0-fold) and the plasticiser di-*n*-butyl phthalate at Waimapu (exceeding the PNEC 1.2-fold) (Conwell, 2021).

2.4.4.2 Metals measured for the Stella Passage development assessment of environmental effects

As part of an effects assessment to carry out dredging and wharf extensions in the Stella Passage of the Port, Leonard et al. (2020) measured metals/metalloids – arsenic, cadmium, chromium, copper, lead, nickel, and zinc – in composite surficial sediment from three sites in proximity to the Port (**Figure 13**). Average concentrations were well below ANZ 2018 DGVs (**Table 10**). Metal concentrations were consistently highest at Butters Wharf site, while the metalloid arsenic had the highest concentration at the Bridge Marina site.

[12] Data provided by email from Josie Crawshaw (BoPRC) on 10th July 2023.

Table 10. Comparison of average metal/metalloid concentrations for surficial sediments collected in proximity to the Port by Leonard et al. (2020) with ANZG 2018 DGVs.

Metal/*metalloid*	Concentration (mg/kg, dry weight)			
	Wharf	Butters Wharf	Bridge Marina	ANZ 2018 DGV
Arsenic	4	6	8	20
Cadmium	0.1	0.1	0.1	1.5
Chromium	5	8	4	80
Copper	15	21	2	65
Lead	4	6	3	50
Nickel	2	3	2	21
Zinc	26	44	28	200



Figure 13. Sites for sediment grab samples collected for metals analysis by Leonard et al. (2020). Key: B = Wharf; Bu = Butters Wharf; Ch = Bridge Marina.

2.4.4.3 Metals measured in sub-tidal sediments in Tauranga Harbour

Sub-tidal sediment metal data were collected for 45 sites in Tauranga Harbour in 2016 (Clark et al., 2018). Sites were selected to provide good spatial coverage of sub-tidal portions of the harbour and to link in with existing sites that are monitored as part of the National Environment Regional Monitoring Network (**NERMN**) Coastal Estuarine Ecology Programme. Of relevance to this assessment, sites 38 and 39 were in proximity to the Port, with sites 40 and 43 further up the channel (**Figure 14**). Consistent with other studies, metal/metalloid sediment concentrations were well below ANZ 2018 DGVs (**Table 11**).

Table 11. Comparison of single composite[13] metal/metalloid concentrations for surficial sediments collected in proximity to the Port by Clark et al. (2018) with ANZG 2018 DGVs.

Site	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Zinc
38	5.2	0.030	4.2	2.1	3.5	0.022	1.3	20
39	4.6	<0.010	2.0	0.8	3.2	0.027	0.7	22
40	4.1	0.010	1.7	1.0	3.8	0.024	0.8	25
43	3.6	0.062	3.5	3.5	6.4	0.041	1.3	37
ANZ 2018 DGV	20	1.5	80	65	50	0.150	21	200

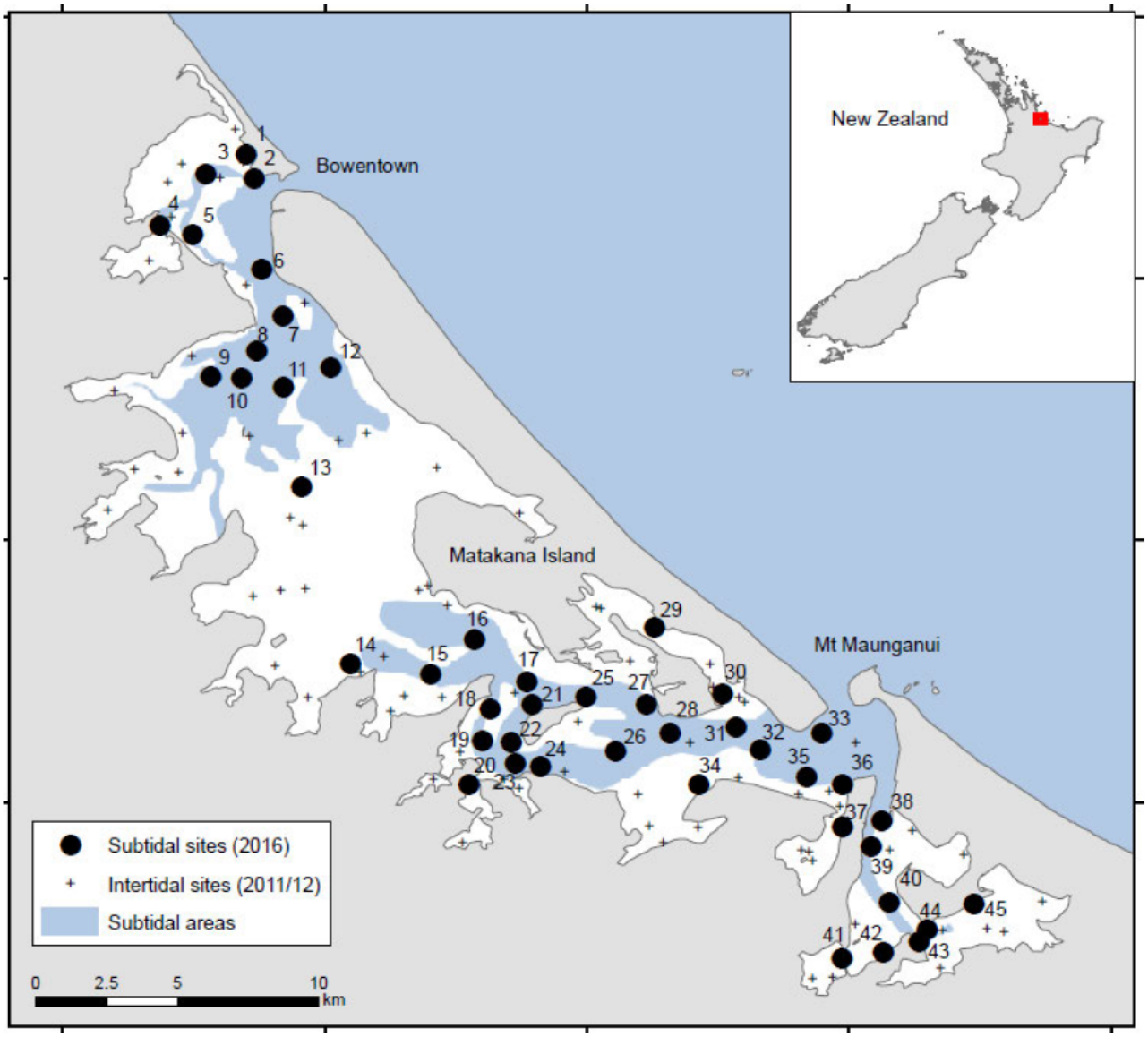


Figure 14. Sites for grab samples collected for metals analysis by Clark et al. (2018)

Further, PoTL measure sediment grain size annually at a location on the eastern side of the entrance channel and another location at Maunganui roads/Cutter channel. The locations change only slightly year to year. These data allow for an assessment of long-term variability of the

[13] Composite was from the top 2 cm of 6 replicate cores.

sediment dredged[14] at these locations, and particularly the proportion of silt (<63 µm). These data are summarised in Section 3.6.

2.4.5 Sediment quality measured for this assessment

2.4.5.1 Port of Tauranga targeted analyses

For sediment toxicants, the analysis of the BoPRC and other data suggests that metals and the few organics measured are generally low in the harbour sediment. However, the sites where monitoring has occurred are primarily in the inter-tidal area around the coastline or provided only a limited one-off dataset on sediment toxicants from the Tauranga Harbour shipping channel undertaken for a specific purpose. These are not appropriate for a robust assessment of the sediment quality in other potentially affected areas, namely the Port channel, especially between the Port and Mt Maunganui or in the coastal dredged area outside Mt Maunganui (where there are no sediment toxicant data).

It is expected that toxicants in sediment may be highest near the Port– due to higher number of ships and longer residence times than the shipping channel, as well as urban stormwater and wastewater inputs – but reduce with distance from the Port.

Sediment grain size analysis from the shipping channel shows very low mud content (silt) (Section 3.6). As toxicants have the tendency to associate with silt particles due to their higher relative surface area compared with larger particles, this may reduce the risk of exceedances of ecological guidelines from toxicants in sediments in the shipping channel. However, the sediment organic content can also have a significant effect on the adsorption of organic toxicants.

To fill this knowledge gap PoTL undertook targeted sediment monitoring[15] at eight selected sites at the Port, in the harbour channel, in the channel entrance, and at the disposal site (**Figure 15**). The following parameters were measured (**Appendix 5**):

- Organic toxicants – organochlorine pesticides (OCPs); PAHs; TPH, PCBs, tributyltin (TBT) and triphenyltin (TPT).
- Metal/metalloid toxicants – Those consistent with other studies i.e., As, Cd, Cr, Cu, Pb, Hg, Ni, and Zn, plus antimony (Sb) and silver (Ag).
- TOC.
- Size fraction (% mud, sand, and gravel).
- TN and Phosphorus.

Further, sediment toxicant data for five sites collected by PoTL as part of their Te Awanui Monitoring programme was provided[16]. Sampling was carried out on 21st and 22nd February 2025, with the same parameters as above measured, except for OCPs, TPH, PCBs, TBT/TPT, antimony, mercury, and silver.

[14] Importantly, these grain size analyses are undertaken on dredged sediment, not bed sediment which is representative of deposited sediment.
[15] Composite was from the top 2 cm of 5 replicate cores.
[16] Email from Dr Sharon De Luca, dated 15/04/2024.

In summary:

- PCBs, TBT/TPT, PAHs, and OCPs were all below detection limits at all sites measured and well below applicable ANZG 2018 DGVs.
- Total TPH was 49 mg/kg dry weight at site 5 (Southern Channel), with the band of total TPH above detection limit being C10-C14[17]. Sites 7 and 8 (Berth basins 5 and 11) had a total TPH concentration of 38 mg/kg, and 65 mg/kg dry weight, respectively, with the band of total TPH above detection limit being the C15-C36 band[18]. Site 4 (Mid Channel) and site 6 (Berth 1 basin) both had a total TPH concentration of <30 mg/kg dry weight, but a C15-C36 band of 20 mg/kg dry weight, and 27 mg/kg dry weight, respectively. All TPH sediment concentrations were well below the ANZG 2018 DGV of 280 mg/L for total TPH.[19]
- Arsenic, chromium, lead, nickel, and zinc were detected at all sites[20], but well below applicable ANZG 2018 DGVs. Antimony, cadmium, copper, mercury, and silver were below detection limits at all or most sites and well below applicable ANZG 2018 DGVs. Metal concentrations were generally higher at Site 5 (Southern Channel) and Site 12 (60m west of PC6a SW discharge).
- TOC at Sites 1-4, Site 6, and Sites 9-11 was <0.13 g/100g, just above detection limit at Sites 7 and 13 (0.13 g/100g, and 0.14 g/100g, respectively), and markedly higher at the remaining sites: Site 8 (0.38 g/100g); Site 5 (0.64 g/100g); and Site 12 (1.00 g/100g).
- Sites 12 and 5 had the highest proportion of mud (28% and 23%, respectively), followed by Site 8 (15%), and Sites 6, 7, and 13 (4.7%, 5.2%, and 4.5%, respectively). The other sites had relatively low mud content (1.4% - 2.5%). Gravel was generally low at all sites (up to 5%). The higher mud component at Sites 12 and 5 is likely contributing to the higher toxicant concentrations measured at these sites.
- TN concentrations were markedly higher at Sites 4 to 8 (340 mg/kg dry weight to 620 mg/kg dry weight), and Sites 11 to 13 (410 mg/kg to 1,300 mg/kg) than sites 1-3 (110-170 mg/kg dry weight). Concentrations are generally comparable with long-term sediment data in the harbour collected by BoPRC (**Table 8**).
- Phosphorus concentrations appeared to be increasing with proximity to the Port, ranging from 91 mg/kg dry weight at site 1 (the disposal site) to 430 mg/kg dry weight at site 12. Concentrations are generally comparable with long-term sediment data in the harbour collected by BoPRC (**Table 8**).

[17] C10-C14 band has hydrocarbons with 10-14 carbon atoms and corresponds loosely to lower boiling point fuel oils (Interstate Technology & Regulatory Council (ITRC), 2018).

[18] C15-C36 band has hydrocarbons with 15-36 carbon atoms and corresponds loosely to higher boiling point fuel oils, lube oil, motor oil, and grease (Interstate Technology & Regulatory Council (ITRC), 2018).

[19] The DGV for TPH is not normalised to 1% TOC.

[20] With one exception, zinc at PoTL mid channel site (4).

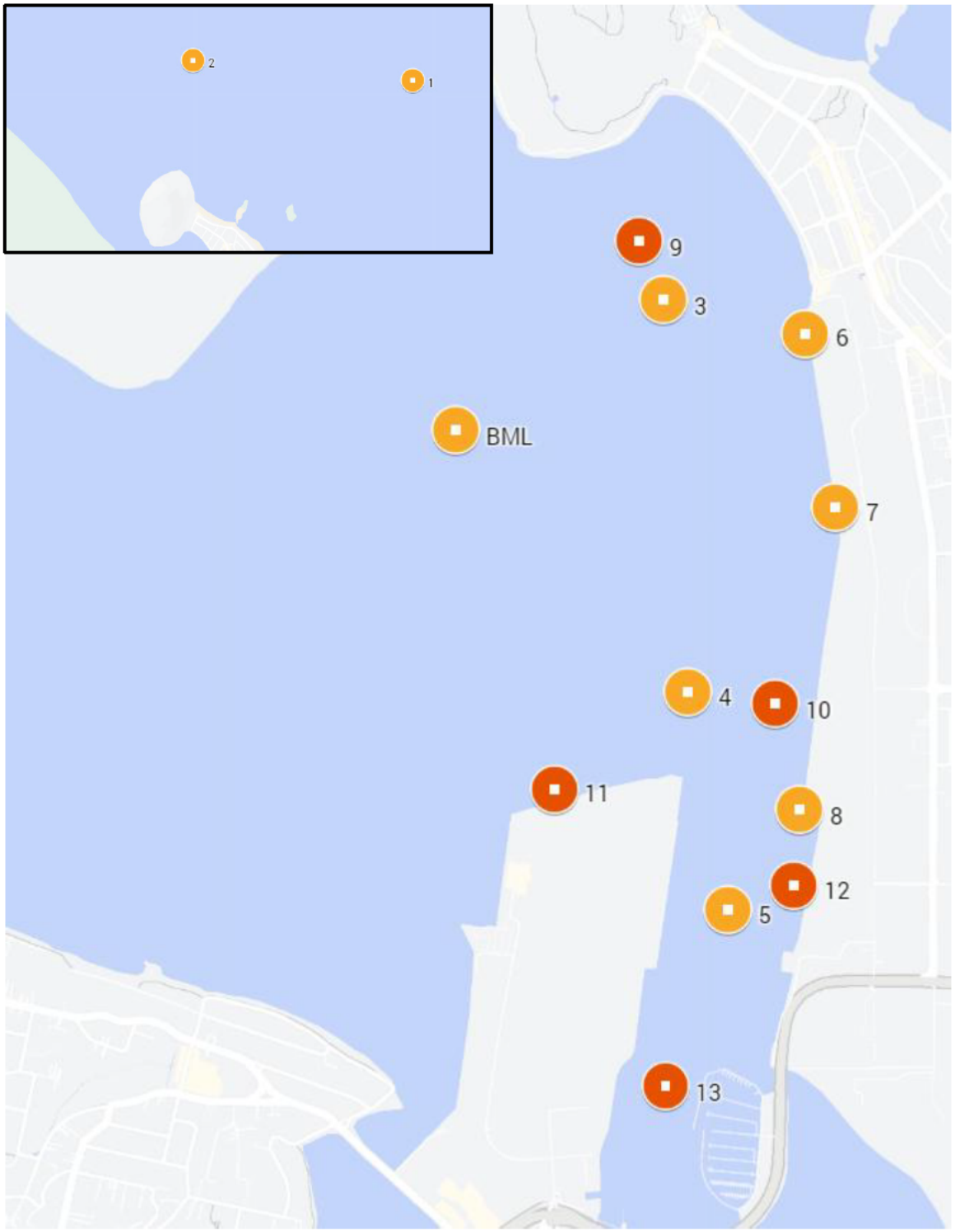


Figure 15. Location of sites where surface sediment were collected for the current assessment (inset are open ocean sites). Orange sites are collected specifically for this assessment, while red sites were collected as part of PoTL Te Awanui monitoring programme. For site descriptions see Table 12.

2.4.5.2 Boffa Miskell sampling at Te Paritaha

Boffa Miskell undertook surface sediment[21] and shellfish (see Section 0) sampling along a series of three Grids and four transects at sites around Te Paritaha in October 2023, March 2024, May 2024, and November 2024 (De Luca, 2025) (**Figure 16**). Composite samples were analysed for organic and metal toxicants consistent with those measured by PoTL (with the exception of TPH, which was not analysed) as described in Section 2.4.5.1.

Data were provided by Boffa Miskell.[22] Organic toxicants were generally below detection limits and well below ANZG 2018 DGVs. TOC of the sediment was also low, generally below 0.13 g/100g, which is consistent with the PoTL data.

Average metal/metalloid sediment concentrations were generally consistent across all sites and well below ANZG 2018 DGVs.

[21] Boffa Miskell also undertook core sampling at 2, 5, 10 and 15m depths however these are not comparable with the surface sediments in this assessment so are not summarised.
[22] Tabulated data were sent by Dr Sharon De Luca by email on 22nd January 2025.

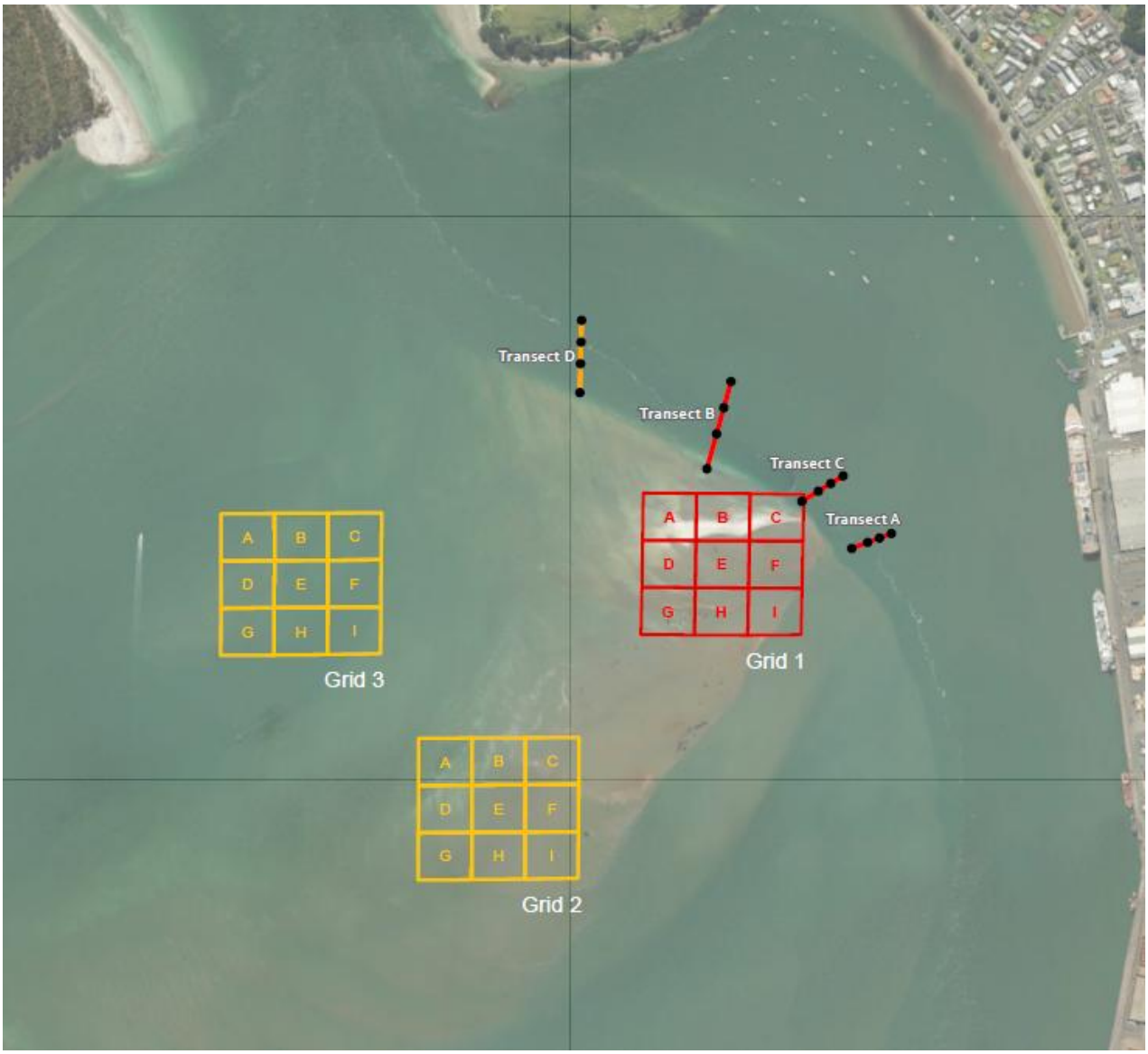


Figure 16. Boffa Miskell sediment and pipi sampling around Te Paritaha in 2023 and 2024. Inter-tidal sampling is marked by grids, while sub-tidal sampling are the four transects in the channel.

2.4.6 Sediment metal/metalloid summary

A summary of the range of metal/metalloid sediment concentrations presented in this report is shown in **Table 12**. All sediment concentrations are below ANZG 2018 DGVs. The highest sediment metal concentrations were spread amongst sites, with chromium, lead and zinc highest concentrations at the BoPRC Waikareao site, cadmium highest concentration at BoPRC Te Puna site, copper and nickel highest concentrations at Butters Wharf and arsenic highest concentration at Te Paritaha Transect D (**Table 12**). In general, Te Paritaha had low sediment metal concentrations compared with other sites in the harbour.

Table 12. Summary of sediment metal/metalloid concentrations for this assessment[23]. Colours represent a relative range of values from green (low) to red (high) for each toxicant. Blank cells have no data.

Site code	Site Name	As	Cd	Cr	Cu	Pb	Hg	Ni	Zn	Reference
1	Disposal site	3.6	<0.10	3.0	<0.5	1.6	<0.05	0.7	8	PoTL 2023/24
2	Entrance Channel	5.0	<0.10	4.5	<0.5	2.2	<0.05	1.1	11	PoTL 2023/24
3	Northern Channel	5.6	<0.10	3.8	<0.5	2.1	<0.05	0.9	10	PoTL 2023/24
4	Mid Channel	4.8	<0.10	3.5	<0.5	1.7	<0.05	0.7	<8	PoTL 2023/24
5	Southern Channel	4.9	<0.10	4.1	3.2	5.3	0.06	2.1	24	PoTL 2023/24
6	Berth 1 basin	3.0	<0.10	2.5	1.6	2.3	<0.05	0.9	12	PoTL 2023/24
7	Berth 5 basin	3.7	<0.10	3.8	1.7	10.0	<0.05	1.2	16	PoTL 2023/24
8	Berth 11 basin	3.1	<0.10	3.1	2.2	3.0	<0.05	1.2	19	PoTL 2023/24
9	No. 6 marker	3.4	<0.09	2.7	<0.5	1.6		0.7	11	PoTL 2024
10	Mid channel west of berth 9	3.2	<0.09	2.1	<0.4	1.6		0.5	8	PoTL 2024
11	50m north of SP SW discharge	3.5	<0.09	2.5	<0.5	2.0		0.6	9	PoTL 2024
12	60m west of PC6a SW discharge	6.4	<0.09	5.5	5.3	6.0		2.5	30	PoTL 2024
13	North of Bridge Marina	4.7	<0.09	2.2	1.0	2.6		0.8	20	PoTL 2024
Grid 1	Te Paritaha	5.9	0.006	2.4	0.3	1.2	0.01	0.7	7	BML 2023/24
Grid 2	Te Paritaha	5.7	0.004	2.6	0.8	1.3	0.01	0.7	12	BML 2023/24
Grid 3	Te Paritaha	6.6	0.006	2.4	0.3	1.3	0.01	0.7	7	BML 2023/24
Transect A	Te Paritaha	5.8	0.007	3.5	0.4	1.6	0.01	0.9	9	BML 2023/24
Transect B	Te Paritaha	5.9	0.005	2.2	0.3	1.2	0.01	0.7	7	BML 2023/24
Transect C	Te Paritaha	6.1	0.007	2.6	0.3	1.4	0.01	0.8	8	BML 2023/24
Transect D	Te Paritaha	7.6	0.007	2.1	0.3	1.3	0.01	0.8	7	BML 2023/24
38	NA	5.2	0.03	4.2	2.1	3.5	0.02	1.3	20	Clark 2018
39	NA	4.6	<0.01	2.0	0.8	3.2	0.03	0.7	22	Clark 2018
40	NA	4.1	0.01	1.7	1.0	3.8	0.02	0.8	25	Clark 2018
43	NA	3.6	0.06	3.5	3.5	6.4	0.04	1.3	37	Clark 2018
B11	Wharf	4.0	0.10	4.7	15.2	4.2		2.0	26	Leonard 2020
BU	Butters Wharf	6.0	0.11	8.3	21.0	6.4		3.3	44	Leonard 2020
Ch	Bridge Marina	7.5	0.10	3.7	2.0	3.3		2.0	28	Leonard 2020
P61	Poi's	2.0	0.03	3.6	0.5	1.6	0.01	0.8	9	BoPRC 2017/22
P49	Katikati	2.3	0.03	4.0	0.7	1.8	0.01	1.0	10	BoPRC 2017/22
P29	Te Puna	4.4	0.22	4.1	1.8	4.0	0.05	1.5	31	BoPRC 2017/22
P23	Matua	1.5	0.18	2.0	0.6	1.7	0.01	0.7	12	BoPRC 2017/22
P15	Waikareao	4.6	0.11	8.9	3.3	18.6	0.03	2.0	122	BoPRC 2017/22
P62	Otumoetai	2.4	0.04	3.8	0.7	1.8	0.01	1.0	12	BoPRC 2017/22
P64	Waimapu	3.4	0.08	3.6	2.5	3.9	0.04	1.3	34	BoPRC 2017/22
P63	Grace Rd	4.1	0.08	3.7	2.9	4.3	0.04	1.2	35	BoPRC 2017/22
P65	Welcome Bay	3.7	0.10	3.4	2.8	4.2	0.03	1.2	30	BoPRC 2017/22
P1	Rangataua Bay	3.7	0.04	5.4	2.7	4.0	0.04	2.2	28	BoPRC 2017/22
ANZG 2018 DGV		20.0	1.5	80	65	50	0.15	21	200	

[23] Clark et al. (2018) and PoTL (2023-2024) data are from a single composite, while BML (2023/24) and BoPRC (2017/22) data are averages.

2.5 Tauranga Harbour shellfish quality

2.5.1 Background

Shellfish contaminant monitoring was undertaken in 1990 and 2016 by BoPRC at a large number of sites in Tauranga Harbour (Park, 2016; Power, 1994) with a targeted survey in 2018/19 (Crawshaw, 2021a). Further, targeted sediment and shellfish surveys at Te Paritaha bank were undertaken by Boffa Miskell in October 2023, March 2024, May 2024, and November 2024 (De Luca, 2025). An overview of shellfish survey sites is provided in **Figure 17**. We note that, for ease of interpretation, only the BoPRC shellfish sites monitored in 2016 are shown as the 1990 sites were similar.

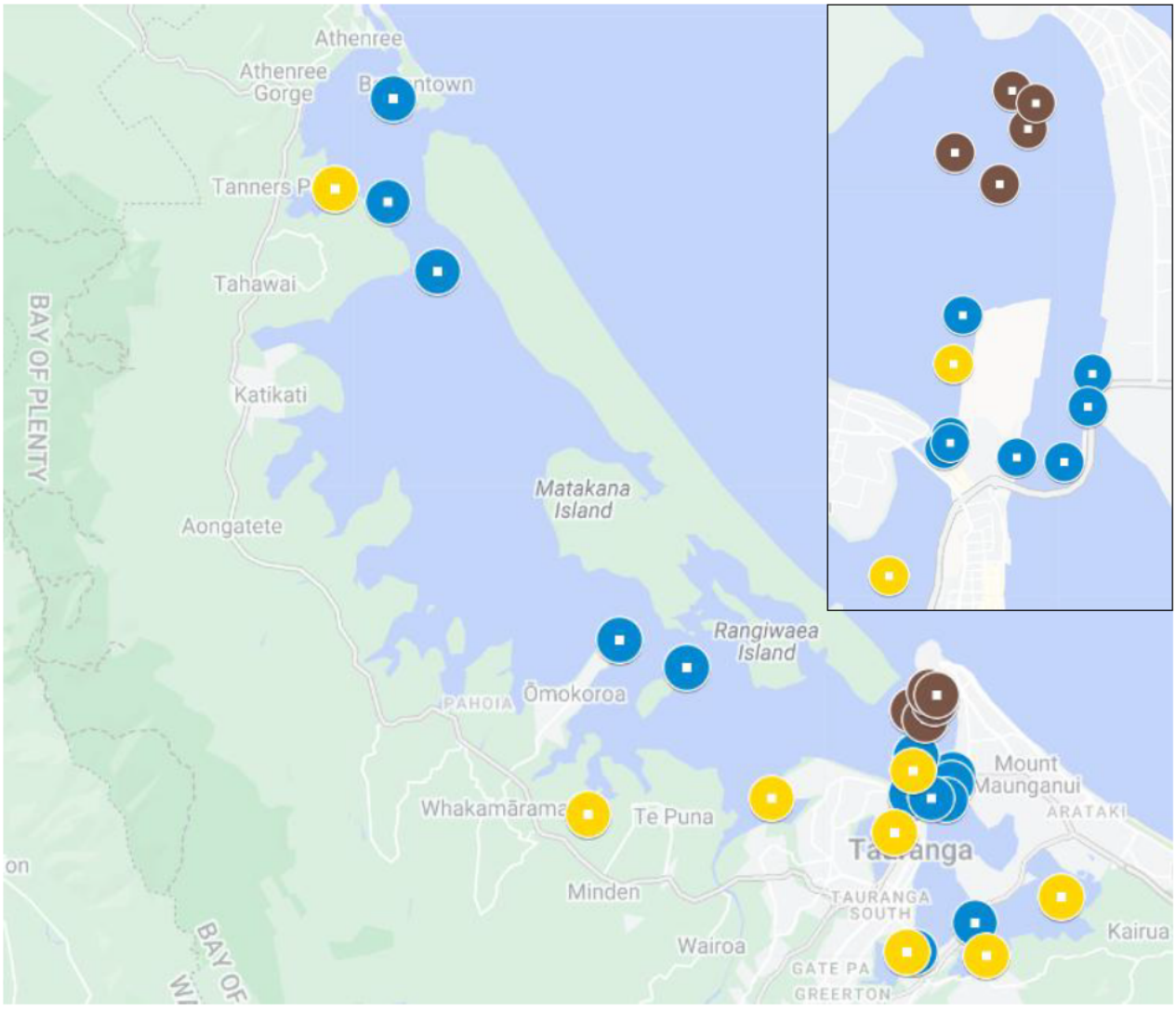


Figure 17. Shellfish contaminant survey sites in Tauranga Harbour covered in this assessment. Blue circles are BoPRC 2016 (Park, 2016), yellow circles are BoPRC 2018/19 (Crawshaw, 2021a), and brown circles are Boffa Miskell 2023. Inset are sites around the Port.

These surveys provide a useful tool to assess potential accumulation of toxicants (metals and some persistent organic pollutants) that may present a risk to human health, through consumption of these shellfish. The surveys provide wide spatial coverage in the harbour (Power in 1994 and Park

in 2016), or more targeted studies (Crawshaw in 2018/19 and Boffa Miskell in 2023). Importantly, some shellfish monitoring sites are located near the Port (and other urban influences, such as stormwater and wastewater runoff) and at other locations in the Harbour more removed from anthropogenic sources (thus providing useful reference data) (**Figure 17**).

2.5.2 Methodology

2.5.2.1 Toxicants measured

A summary of the surveys and toxicants measured in the shellfish is provided in **Table 13**. All studies included metals/metalloids, PAHs, PCBs and OCPs. The BoPRC surveys also included organotins.

Table 13. Summary of shellfish toxicant studies included in this assessment.

Toxicant suite	BoPRC 1990 (Power, 1994) and 2016 (Park, 2016)	BoPRC 2018/19 (Crawshaw, 2021a)	Boffa Miskell 2023/2024
Metals/*metalloids*	*As*, Cd, Cr, Cu, Pb, Hg, Ni, Zn	As, Cd, Cr, Cu, Pb, Ni, Zn	As, Cd, Cr, Cu, Pb, Hg, Ni, Zn
Polycyclic aromatic hydrocarbons (PAHs)	16 congeners[1]	16 congeners[1] (all sites)	16 congeners[1]
Polychlorinated biphenyls (PCBs)	35 congeners	35 congeners (Waikareao only)	35 congeners
Organochlorine pesticides (OCPs)	24 analytes	24 analytes (Waikareao only)	24 analytes
Organotins	DBT, MBT, TBT, TPT[2]	None	None

[1] Standardly called USEPA 16 priority PAHs

[2] DBT = Dibutyltin, MBT = Monobutyltin, TBT = Tributyltin, TPT = Triphenyltin.

2.5.2.2 Human health consumptive risk

The Food Safety Australia New Zealand (FSANZ) Code publishes food safety standards for shellfish. The report has heavy metal limits only for cadmium (2 mg/kg wet weight), lead (2 mg/kg wet weight), and mercury (0.5 mg/kg wet weight). The FSANZ arsenic limit is for inorganic arsenic, whereas the shellfish analyses are total arsenic. To calculate the risk the total arsenic concentration is reduced by a factor of 10 to reflect an approximate inorganic portion of total arsenic of 10% and provide a protective estimate of health risk (USEPA, 2003). The FSANZ standard 1.4.1 is a maximum level of total PCBs of 0.5 mg/kg wet weight for fish (FSANZ, 2015). FSANZ standard 1.4.2 specifies a maximum concentration of total DDT of 1.0 mg/kg wet weight for fish and molluscs (FSANZ, 2014). There are no FSANZ maximum limits for PAHs.

2.5.3 BoPRC shellfish quality monitoring

2.5.3.1 Power 1994 and Park 2016

Extensive shellfish quality monitoring in Tauranga Harbour was undertaken by BoPRC in 1990 (Power, 1994) and 2016 (Park, 2016).

Park (2016) assessed changes in shellfish metal/metalloid concentrations between 1990 and 2016 and concluded:

- The concentration of cadmium, chromium, mercury and zinc in oysters has not changed between 1990 and 2016, indicating that background levels of these metals do not appear to be increasing around any part of the harbour.
- Lead concentrations appear to have reduced in shellfish since 1990, which is likely due to removal of lead in petrol in 1996.
- Copper showed marked increases, particularly near the Port with increases from an average value of 13 mg/kg wet weight for oysters in 1990 to 60 mg/kg in 2016. He noted that the increases are possibly linked to the switch from TBT antifouling on ships in 2008 back to copper based antifouling paint systems, as other areas around the city did not show the same degree of increase.
- Concentrations of PAHs in oysters around Tauranga City were higher in 2016 than 1990 and highest around the city and Port.
- Concentrations of most OCPs in oysters were below detection limits, but DDT showed lower concentrations in 2016 compared to 1990.
- PCBs were below detection limits (10 µg/kg wet weight) for all oysters sampled (imported sentinel oysters) in 2016, with the highest concentration in 1990 at this detection limit.
- TBT concentrations in oysters were markedly lower in 2016 versus 1990, with highest concentrations recorded around the Port.

2.5.3.2 Crawshaw 2020

Crawshaw collected shellfish where possible from the same estuary sites, where passive samplers were deployed (providing a measure of the average water concentration) to indicate the comparative bioavailability of sediment and water column contaminants to the estuary biology. Tuangi (*Austrovenus stuchburyi*; cockle) were collected from eight sites, titiko (*Amphibola crenata*; mud snail) from three sites, and pipi (*Paphies australis*) and hanikura (*Macomona liliana*; wedge shell) from one site. Importantly, this study provides toxicants from a wider range of species than previously.

The heavy metal concentrations in the shellfish were compared against FSANZ guidelines as an indication of food consumption safety. All shellfish collected from Tauranga Harbour had metal/metalloid concentrations well below FSANZ standards (**Table 14**).

PAHs, OCPs, and PCBs were below detection limits for most shellfish sampled.

The sample of Titiko (mud snail) collected at Waimapu had relatively high levels of two PAHs: fluoranthene (0.0028 mg/kg wet weight) and pyrene (0.0024 mg/kg wet weight). These Titiko were collected directly beside a stormwater inflow. Pipi and Titiko collected from Waikareao Estuary had a number of PAHs detected, however, the sum of PAHs were relatively low compared to the Waimapu Titiko.

Four PCBs were detected in the Waikareao Titiko, but these were just above detection limits (0.5 mg/kg wet weight), while the total PCBs (<0.02 mg/kg) were well below the FSANZ maximum level of total PCBs of 0.5 mg/kg (FSANZ, 2015).

Organochlorine pesticides were below detection limits in the Pipi and Hanikura. Two organochlorine pesticides – 4,4'-DDD (0.0012 mg/kg) and 4,4'-DDE (0.0054 mg/kg) were at relatively high concentrations in the Waikareao Titiko – but well below the FSANZ maximum level of total DDT of 1.0 mg/kg (FSANZ, 2014).

Table 14. Concentration of metals/metalloids (mg/kg, wet weight) in shellfish collected from Tauranga Harbour in 2020 and comparison with FSANZ maximum limit (Crawshaw, 2021a).

Site	Shellfish	As	Cd	Cr	Cu	Pb	Ni	Zn
Tuapiro	Tuangi	2.7	0.021	0.36	1.58	0.02	1.24	7.3
Te Puna	Tuangi	3.0	0.021	0.30	3.10	0.039	1.27	5.3
Wairoa	Tuangi	1.6	0.015	0.14	0.75	0.07	0.90	7.1
Otumoetai	Tuangi	2.8	0.028	0.30	1.35	0.02	1.38	6.2
Welcome Bay	Tuangi	1.2	0.014	0.19	1.34	0.03	0.93	6.0
Waimapu	Tuangi	0.66	0.010	0.08	1.39	0.01	0.52	4.6
Waimapu	Titiko	1.3	0.019	2.4	19.6	0.69	1.20	9.7
Rangataua Bay	Tuangi	1.1	0.016	0.14	1.11	0.03	0.64	6.7
Rangataua Bay	Titiko	1.4	0.040	3.0	19.6	0.31	1.42	7.7
Waikareao	Tuangi	2.5	0.021	0.33	1.39	0.03	1.17	6.2
Waikareao	Titiko	0.9	0.014	0.63	10.3	0.24	0.28	6.7
Waikareao	Pipi	3.1	0.04	1.88	23	1.28	1.08	23
Waikareao	Hanikura	2.5	0.053	0.2	1.41	0.06	0.16	10
FSANZ Limit (mg/kg wet weight)		1.0	2.00			2.00		

2.5.4 Shellfish toxicants measured for this assessment

Pipi were collected by Boffa Miskell for their assessment from sites around Te Paritaha in October 2023, March 2024, May 2024, and November 2024 (De Luca, 2025) (see **Figure 16**). Organic toxicants were reported mostly below detection limits and well below effects concentrations. Metal/metalloid concentrations data are reported by De Luca (2025) and summarised here in the shellfish metal/metalloid summary (Section 2.5.5).

2.5.5 Shellfish metal/metalloid summary

A summary of the range of shellfish metal/metalloid concentrations covered in this assessment is shown in **Table 15** with a summary by area shown in **Figure 18**. All shellfish metal concentrations are below applicable FSANZ maximum limits. Consistent with sediment data (**Table 12**), the highest shellfish concentrations are primarily grouped around the urban Port sites. Elevated mercury at Te Paritaha Grid 1 site (0.353 mg/kg) and arsenic at Transect B site (3.16 mg/kg) suggest potential sporadic geothermal sources, although concentrations of both were below FSANZ maximum limits.

Table 15. Summary of shellfish metal/metalloid concentrations (mg/kg, wet weight) by site and area and comparison with applicable FSANZ food safety standards for shellfish. Colours are a relative range from green (low) to red (high) for each toxicant. Blank cells have no data.

Area	Site	Shellfish	As	Inorganic As[1]	Cd	Cr	Cu	Pb	Hg	Ni	Zn	Reference
Main Harbour	Ongare Pt	Sentinel Oyster	1.09	0.11	0.17	0.12	17.9	0.06	0.02	0.11	112	Park 2016
	Bowentown	Sentinel Oyster	1.52	0.15	0.17	0.13	11.6	0.04	0.01	0.05	89	Park 2016
	Kauri Pt	Sentinel Oyster	2.20	0.22	0.15	0.14	13.7	0.06	0.02	0.05	93	Park 2016
	Ōmokoroa D mark	Sentinel Oyster	1.63	0.16	0.10	0.16	18.2	0.08	0.01	0.05	110	Park 2016
	Motuhoa Island	Sentinel Oyster	1.76	0.18	0.11	0.06	16.9	0.05	0.01	0.05	96	Park 2016
	Tuapiro	Tuangi	2.70	0.27	0.02	0.36	1.6	0.02		1.24	7	Crawshaw 2021a
	Te Puna	Tuangi	3.00	0.30	0.02	0.30	3.1	0.03		1.27	5	Crawshaw 2021a
	Wairoa	Tuangi	1.60	0.16	0.02	0.14	0.8	0.07		0.90	7	Crawshaw 2021a
Te Paritaha	Grid 1	Pipi	1.94	0.19	0.13	0.26	1.0	0.08	0.353	0.02	12	De Luca 2025b
	Grid 2	Pipi	1.87	0.19	0.12	0.15	0.7	0.19	0.006	0.43	9	De Luca 2025b
	Grid 3	Pipi	1.79	0.18	0.15	0.28	0.8	0.07	0.01	0.19	9	De Luca 2025b
	Transect B	Pipi	3.16	0.32	0.11	0.47	0.8	0.04	0.01	0.54	10	De Luca 2025b
	Transect C	Pipi	1.76	0.18	0.11	0.65	0.7	0.02	0.01	0.29	9	De Luca 2025b
	Transect D	Pipi	1.89	0.19	0.20	0.10	0.9	0.01	0.005	0.11	11	De Luca 2025b
Urban Non-Port	Maungatapu Bridge	Wild Oyster	2.20	0.22	0.42	0.06	54	0.05		0.14	800	Park 2016
	Waimapu Hairini Bridge	Wild Oyster	1.80	0.18	0.25	0.07	44	0.07		0.12	830	Park 2016
	Waikareao	Tuangi/Cockle	2.50	0.25	0.02	0.33	1.4	0.03		1.17	6	Crawshaw 2021a
	Waimapu Hairini Bridge	Tuangi/Cockle	0.66	0.07	0.01	0.08	1.4	0.01		0.52	5	Crawshaw 2021a
	Welcome Bay	Tuangi/Cockle	1.24	0.12	0.01	0.19	1.3	0.03		0.93	6	Crawshaw 2021a
	Rangataua Bay	Tuangi/Cockle	1.10	0.11	0.02	0.14	1.1	0.03		0.64	7	Crawshaw 2021a
Urban Port	Port Fuel Berth	Sentinel Oyster	1.93	0.19	0.25	0.11	37	0.07		0.05	250	Park 2016
	Port Butters wharf	Sentinel Oyster	1.46	0.15	0.24	0.14	50	0.10	0.01	0.05	340	Park 2016
	Port Bridge Marina	Wild Oyster	1.14	0.11	0.10	0.10	45	0.09	0.01	0.05	220	Park 2016
	Port Cross Road	Sentinel Oyster	4.30	0.43	0.93	0.10	92	0.07		0.15	1250	Park 2016
	Sulphur Point Marina	Sentinel Oyster	1.66	0.17	0.07	0.04	77	0.07	0.01	0.05	186	Park 2016
	Waikareao Rail Bridge	Sentinel Oyster	0.96	0.10	0.15	0.09	26	0.12	0.02	0.05	177	Park 2016
	Waikareao Rail Bridge	Wild Oyster	2.70	0.27	1.06	0.21	49	0.05		0.40	940	Park 2016
	Waikareao Ramp	Wild Mussel	1.88	0.19	0.14	0.09	1.1	0.12		0.16	14	Park 2016
	Otumoetai	Tuangi/Cockle	2.80	0.28	0.03	0.30	1.4	0.02		1.38	6	Crawshaw 2021a
FSANZ				1.00[1]	2.00			2.00	0.5			

[1]The FSANZ arsenic limit is for inorganic arsenic, whereas the shellfish analyses are total arsenic. To calculated risk the total arsenic concentration is reduced by a factor of 10 to reflect an approximate inorganic portion of total arsenic of 10% and provide a protective estimate of health risk (USEPA, 2003).

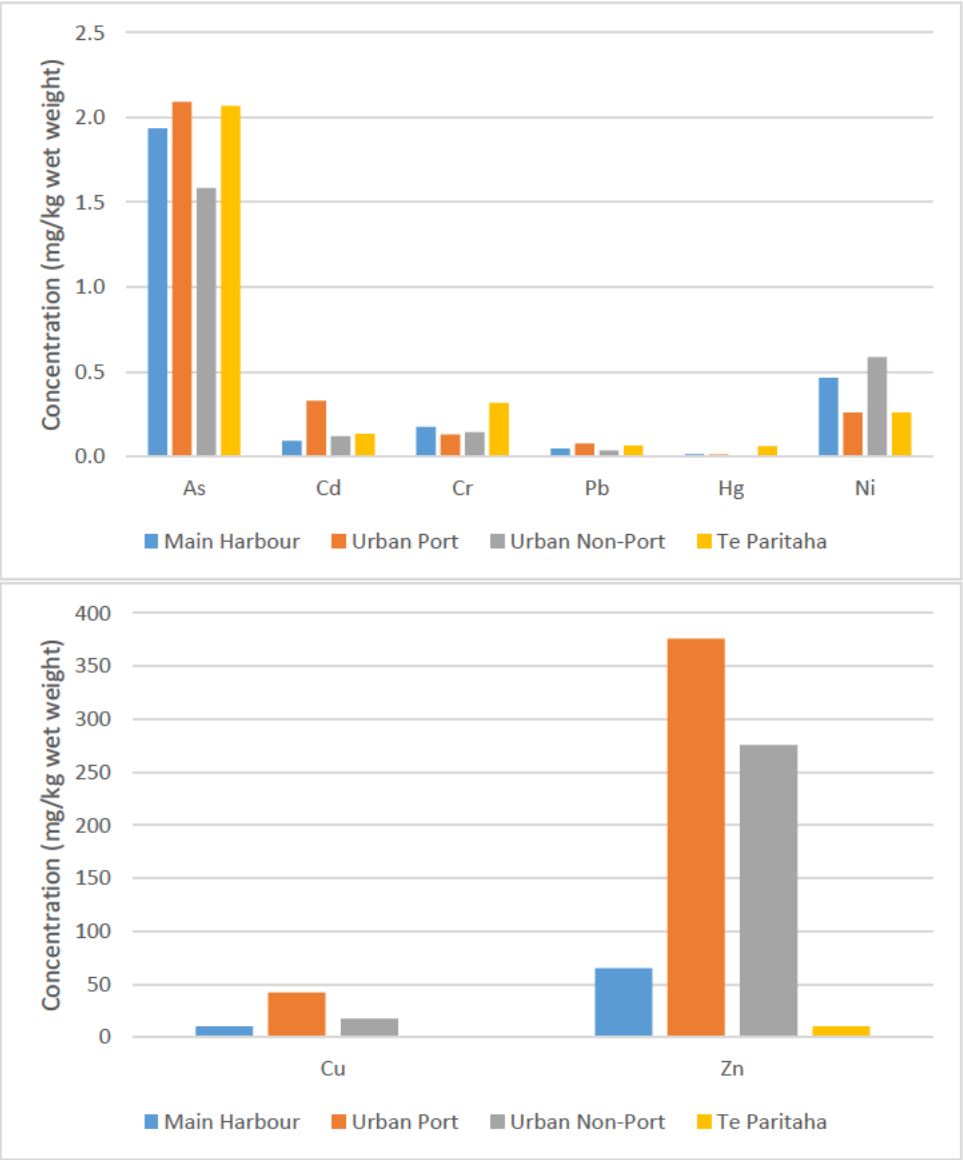


Figure 18. Graphs of shellfish metal/metalloid concentrations by area.

3. Description of the dredging process

3.1 Background

3.1.1 Capital dredging

The proposed capital dredging areas are shown in **Figure 19**.

PoTL completed Stage 1 of capital dredging to deepen and widen the shipping channels in 2016. This allowed deeper draught vessels to safely navigate the shipping channel. To minimise the amount of dredging, PoTL only dredged the amount required to meet shipping demands at the time.

The existing consent allows PoTL to dredge to 16.0 metres below chart datum inside the harbour, and 17.4 metres below chart datum outside the harbour. Stage 1 of the capital dredging deepened the channel to 14.5 metres inside the harbour and 15.8 metres below chart datum outside the harbour. Stage 2, due to commence in late 2025, will complete the deepening in the main shipping channel. PoTL is also applying to dredge the existing basins alongside the wharves, as well as the approach to berth 1, both of which will only be required to be dredged once the respective wharves are upgraded or replaced in the future.

An additional area of deepening, of approximately 2,786 sqm, is also to be included in the application. This work is in the existing passing lane of the entrance channel, and will effectively widen the channel by 19 metres. The purpose of this modification is to smooth the corner and enhance navigational safety.

The existing consent allows PoTL to create a swinging or turning basin off the northern end of Sulphur Point (adjacent to the container terminal) and this will be completed in stage 2 of the capital dredging. The swinging basin will give the space required to safely turn a large container vessel when there is already a vessel on the northernmost berth of the terminal. PoTL has reviewed the size of the swinging basin and have reduced it in width by 93m compared with the existing consent.

The existing consent allows up to 15 million cubic metres of capital dredging to be deposited in the dredging grounds (see **Figure 21**). In stage 1 approximately 6 million cubic metres of material was dredged and deposited. Stage 2 is expected to involve a similar quantity. To complete the remaining required dredging (including the volume from the Stella Passage Development), PoTL need to dredge and deposit the balance of 2.5 million cubic metres.

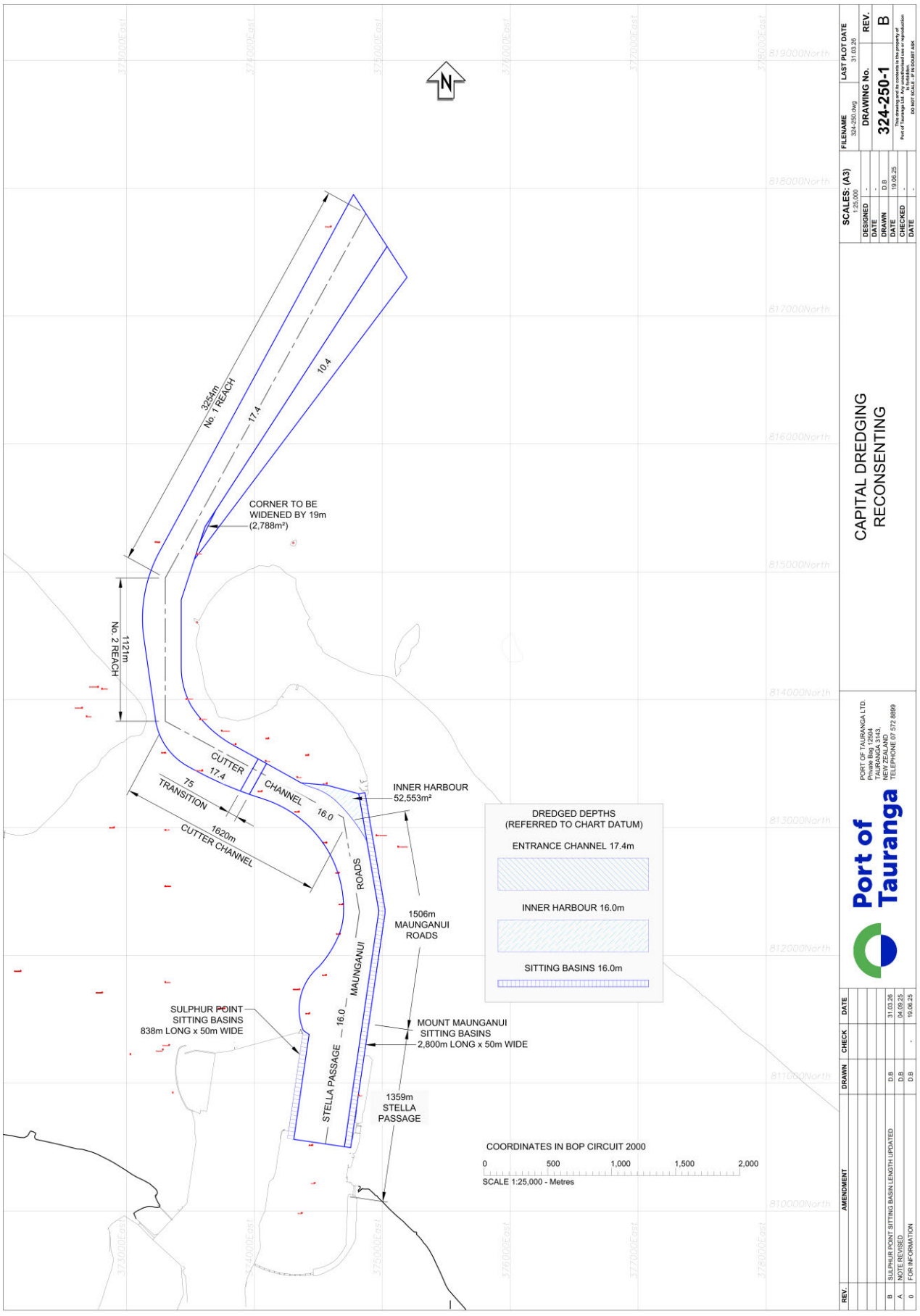


Figure 19. Proposed capital dredging area.

3.1.2 Maintenance dredging

The proposed maintenance dredging areas are shown in **Figure 20**.

Most ports require maintenance dredging and, without regular dredging, the shipping channel would infill and become shallower. PoTL wishes to continue its current level of maintenance dredging. The existing consents allow up to 185,000 cubic metres to be dredged on average every year. However, increases in storm activity due to climate change mean that more dredging is required to maintain the shipping channels. Therefore, PoTL wishes to increase the allowable annual average volume to 250,000 cubic metres. Although the current average is below the consent limits, in 2024 and 2025 PoTL experienced significant infill, challenging the 185,000 cubic metres limit in order to clear the channel.

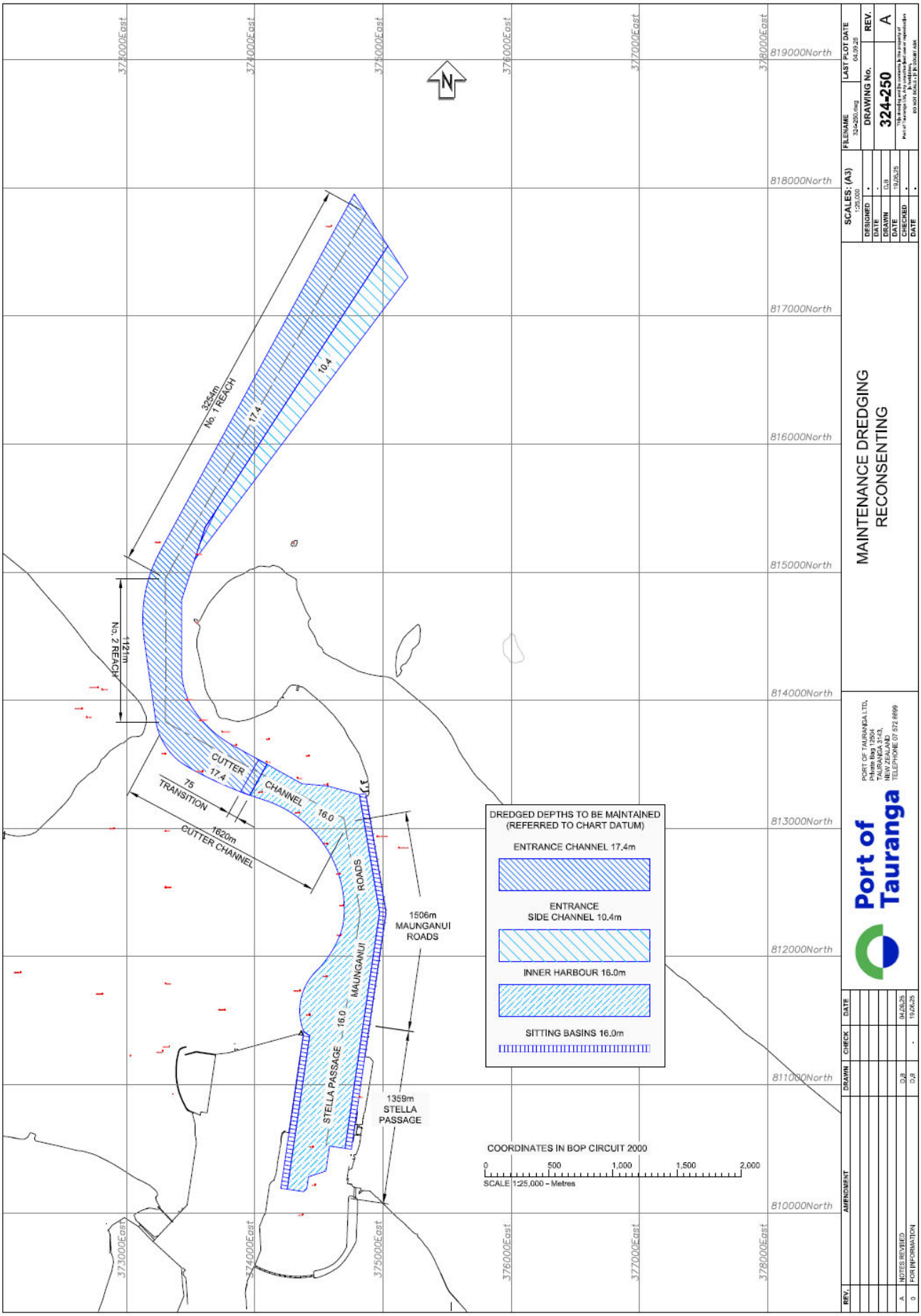


Figure 20. Proposed maintenance dredging area.

3.2 Disposal areas

The existing consent includes multiple sites for the deposition of dredged material, including offshore and nearshore, and replenishment sites within Tauranga Harbour (**Figure 21**).

3.2.1 Offshore

The existing offshore deposition ground is in water 20 to 30 metres deep. It is divided into two sections - the deeper half (H2) is used when silt is >25%, while the shallower half (H1) is used for sandy material. The site has been used since the 1970s and expanded several times to now encompass 900 hectares. PoTL wishes to retain the existing site.

3.2.2 Nearshore

The nearshore deposition sites (A, B, and C) are used for clean sand dredged from the harbour entrance channel. The material is rapidly dispersed under natural wave and swell action. This natural process provides a buffer from erosion. Dredged sand is also brought ashore and stored in stockpiles where it can be used to replenish harbour beaches, such as Pilot Bay.

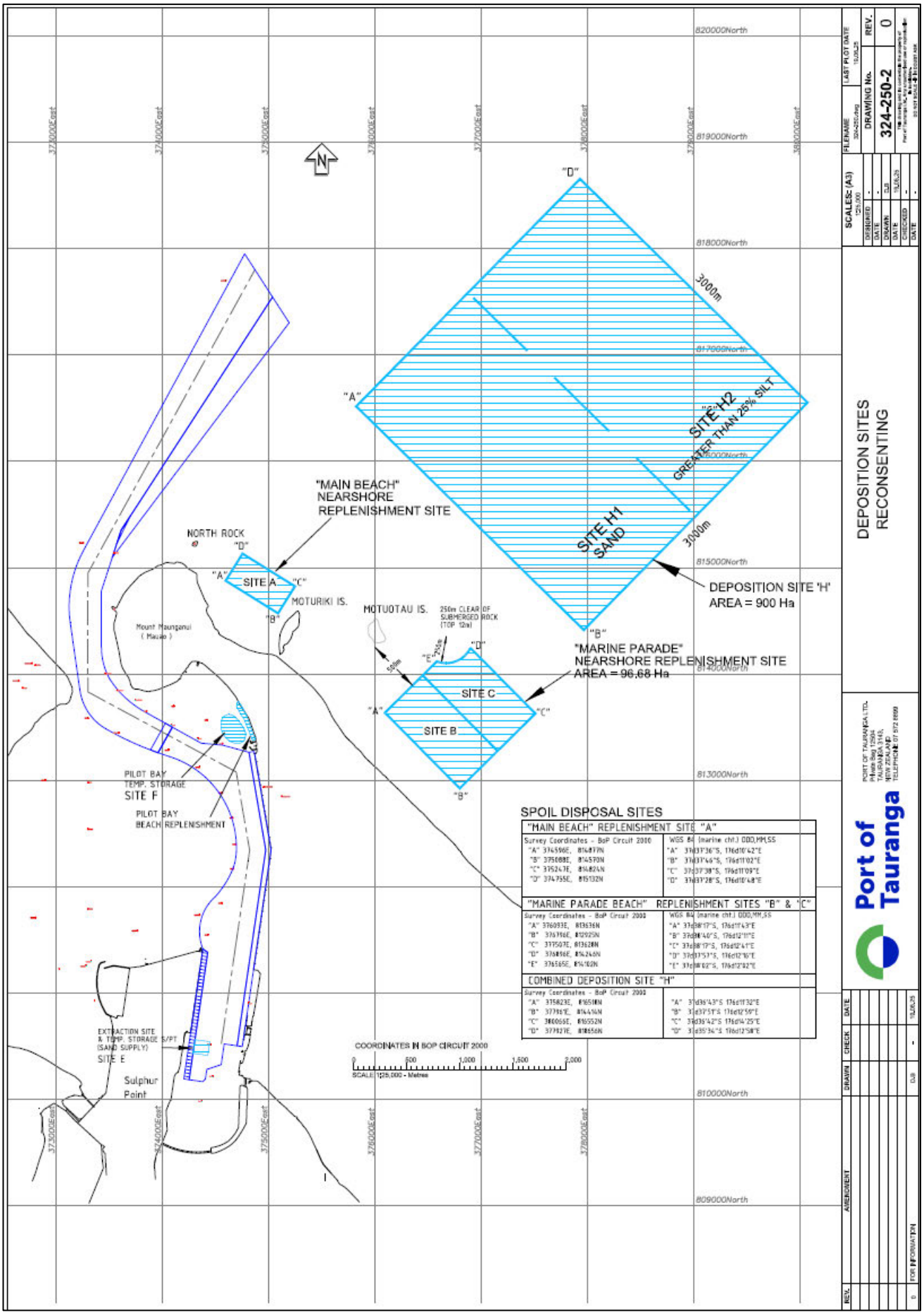


Figure 21. Deposition sites.

3.3 The dredging methodology

Dredging has been occurring for a long time in the Tauranga Harbour shipping channel. Most of the dredging will be undertaken using a Trailing Suction Hopper Dredge (**TSHD**) with a Back-Hoe Dredge (**BHD**) to be used for localised dredging work throughout the channel (**Figure 22**).

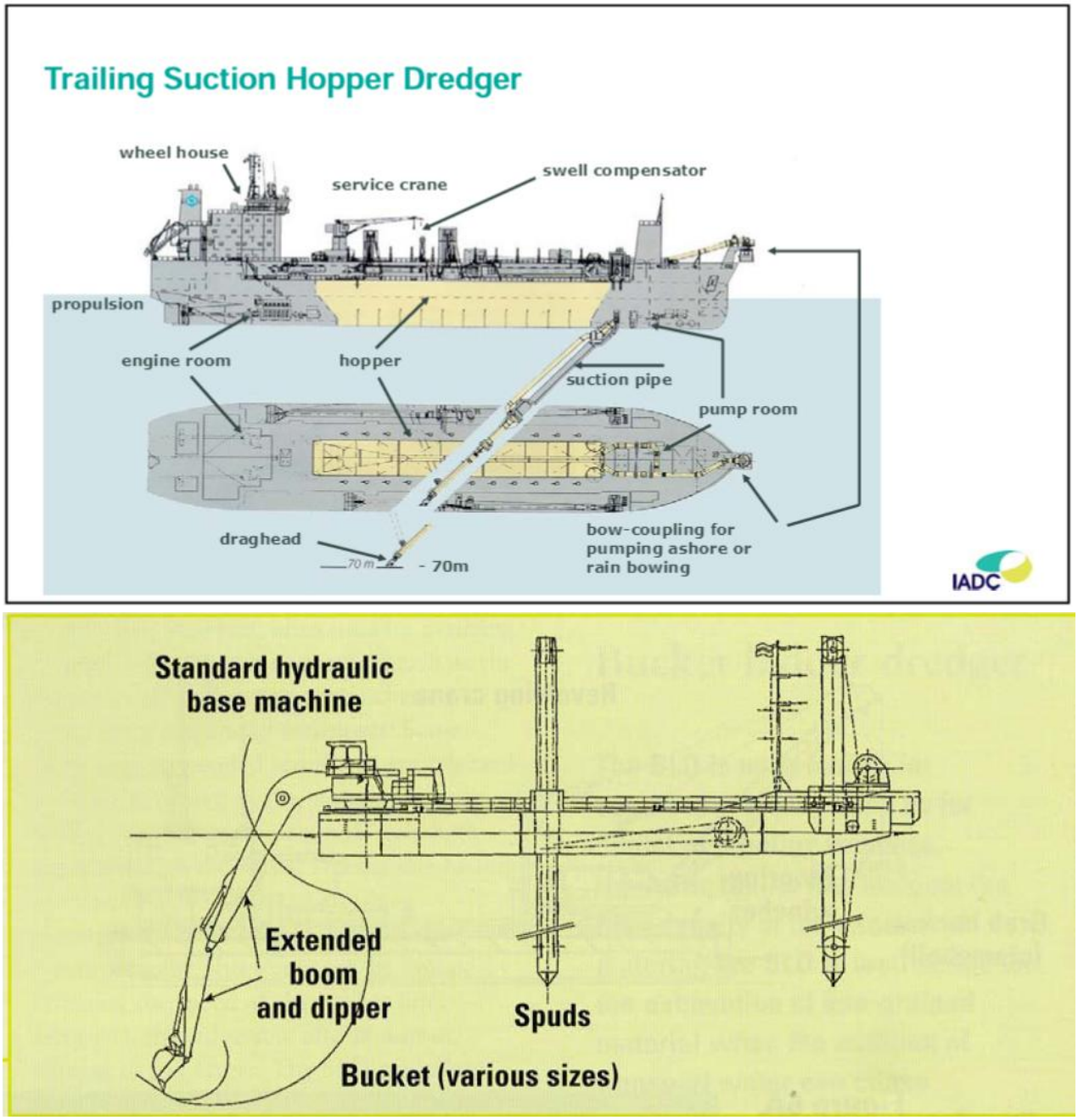


Figure 22. Trailing Suction Hopper Dredger (top) and Back-Hoe Dredger (bottom).

3.3.1 TSHDs

TSHDs are self-propelled ships that operate a vacuum set-up via a long pipe. They range from small (<4,000 m^3 capacity) to mega (≥30,000 m^3 capacity). In Tauranga Harbour shipping channel, small or mid-sized TSHDs are used. Maintenance dredging is usually undertaken with a small TSHD with capital dredging undertaken with mid-sized TSHDs.

The dredging cycle involves loading sand at the area being dredged, sailing (loaded) to the deposition area, unloading (either by bottom opening or pumping), and sailing (empty) back to the dredging area.

TSHD normally operate at low speed (ca. 2 knots), skimming the top 100-300mm of the bed over a width of approximately 2-3m. It can use passive dredging, using the weight of the drag-head to ensure contact with the seabed, or active dredging, using cutting teeth or water jets to break up the material.

Once the dredged material is in the hopper, solids are allowed to settle, and the excess water discharged via a controlled process to minimise turbidity and limit the plume caused by TSS, particular the fine fraction (<63 µm). Other factors of lesser impact include elevated turbidity and TSS at the seabed by the drag-head, and turbulence from the ship's propeller.

Turbidity may be controlled by only dredging on the outgoing tides, but this doubles the operational costs. Alternating between dredged areas allows time for the plume to settle at each site.

The deposition area is strictly controlled by use of daily track plots showing the location of the vessel for each deposition. An even coverage in the deposition area is achieved by undertaken a sequence of depositions within smaller grids.

3.3.2 BHDs

BHDs use a hydraulically controlled single digging bucket, drawing material backwards into the bucket. BHDs are generally used for clays, sands, pebbles, boulders, and soft rocks.

A BHD is mounted on a barge and secured to the seabed using spuds (**Figure 22**) providing stability and allowing accurate excavation. The spuds have the ability to move laterally allowing the barge to move short distances, with tugs required to move them longer distances. Material is deposited in separate barges that can travel to the deposition ground.

The main source of turbid water is material spilling from the top of the bucket as it emerges from the sea, and hopper or barge overflow. The bucket may also wash residual material into the water on re-entering. By controlling the excavation process – including slowing the rate of excavation – BHDs generally produce less turbidity and TSS than TSHDs.

BHDs are less efficient than TSHDs for bulk material removal and used only in areas where TSHDs cannot reach, targeting isolated high spots, or in areas where suction alone isn't sufficient.

3.3.3 Other dredges

Other dredges used at times include a Grab Dredge that comprises a clam shell grab suspended from a crane. These have low productivity and are primarily used in confined areas and wharfs. Grab Dredges would only undertake a small fraction of dredging.

The Bucket Ladder Dredge has been used historically but is noisy, has low productivity and creates turbid water. Bucket Ladder Dredges are uncommon now and unlikely to be used in dredging the Port channel.

The Cutter Suction Dredge uses a cutting tool which allows for excavation of hard rock. Suction at the cutter head reduces turbidity. The Cutter Suction Dredge would only be used for specialised dredging, where the TSHD and BHD cannot function.

Levelling bars may be used to smooth the seabed after the TSHD is used. They are towed by a tug and may produce localised turbidity and TSS production at the sea floor.

3.3.4 Pump ashore operations

TSHDs are used to pump material ashore for Port development or beach nourishment. The operation has the potential to produce turbidity and TSS, with settlement ponds required to mitigate this risk. Previous work has shown that the appropriately sized settlement ponds effectively mitigate turbidity and TSS.

3.4 Disposal volumes

Between 2021 and 2023 the annual amount of material dredged and disposed while undertaking maintenance dredging was between 162,466 m^3 and 228,400 m^3 (**Table 16**). Virtually all of the dredged material was disposed to offshore sites B, C, D/H1, and G/H2, with 1% disposed temporarily at Pilot Bay in 2021 (**Table 16**).

Table 16. Description of dredge disposal volumes and sites from 2021 to 2023.

Site (Figure 19)	Description	2023		2022		2021	
		Volume	%	Volume	%	Volume	%
Area B	Nearshore "marine parade"	64,050	28	38,240	21	55,215	34
Area C	Nearshore "marine parade"	64,050	28	38,240	21	55,215	34
Area D/ H1	Main Ocean	76,200	33	64,740	36	44,158	27
Area F	Pilot bay directly ashore					830	1
Area G/ H2	Silt dump	24,100	11	39,950	22	7,048	4
TOTAL		**228,400**	**100**	**181,170**	**100**	**162,466**	**100**

3.5 Dredging water quality data

3.5.1 Data collected for consent monitoring

Handheld turbidity data are collected during dredging and disposal campaigns to ensure compliance with consent conditions. Turbidity measurements undertaken by PoTL during capital & maintenance dredging campaigns from October 2015 to July 2022 (n=160) were provided in excel format (dataset in **Appendix 1**). While dredging, turbidity measurements were taken 500m upstream of the dredging vessel (control) and 200m downstream. While disposing of material, turbidity measurements were taken at the four corners of Deposition site H (**Figure 21**). A summary of these data are provided below.

3.5.1.1 Maintenance dredging

Turbidity statistics for upstream and downstream of the dredge, and the difference between them for maintenance dredging campaigns between 2015 and 2022 are shown in **Table 17**. A box and whisker plot of the same data is shown in **Figure 23**.

ANZECC (2000) set a median turbidity of 10 NTU as an estuarine and marine default trigger level indicative of slightly disturbed ecosystems in south-east Australia (see **Table 2**).

The median downstream and upstream turbidity readings were 4.1 NTU and 2.7 NTU, respectively. There was a median increase of 0.8 NTU downstream compared with upstream (**Table 17**).

During dredging, exceedance of the ANZECC (2000) default trigger level of 10 NTU occurred downstream on 11 occasions (7% of the time).

A Mann-Whitney one-way analysis of variance test showed a statistically significant difference (p=0.000) between upstream and downstream turbidity. This suggests that the dredging activity is having a significant and measurable effect on turbidity downstream relative to upstream. The scale of the effect on turbidity as a result of the maintenance dredging activity is discussed in Section 4.1.

Table 17. Turbidity statistics for upstream, downstream of the dredge and the difference between them for maintenance dredging campaigns between 2015 and 2022.

Statistic	500m Upstream	200m Downstream	Downstream – Upstream
Minimum	0.4	0.6	-4.2
25th percentile	2.0	2.6	0.1
Median	2.7	4.1	0.8
75th percentile	4.2	6.2	2.3
90th percentile	5.3	8.5	5.3
Maximum	8.6	25.1	21.1

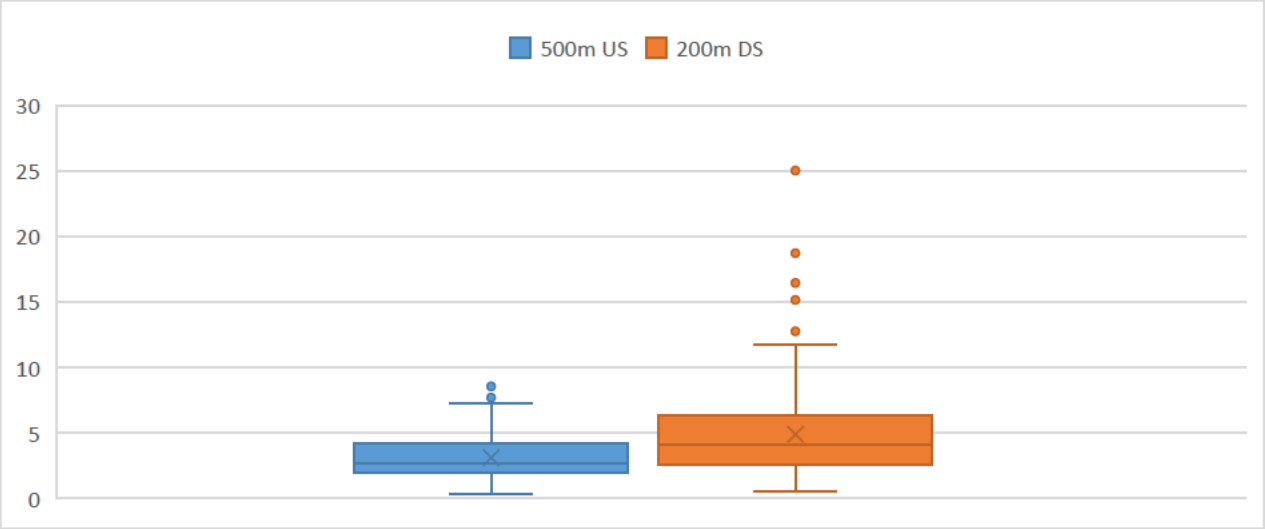


Figure 23. Box and whisker plot of turbidity measurements upstream and downstream of dredge during maintenance dredging between 2015-2022. The boxes denote 75th (top), 50th (middle), and 25th (bottom) percentiles, with whiskers extending 1.5 x 25th/75th percentiles. The mean value is presented as a cross. "Outliers" are shown as points.

3.5.1.2 Disposal

During deposition to the ocean site H1/H2, there were no exceedances of either the ANZECC (2000) default trigger level, or the level 1 management response level. All four sites had median turbidity of 1.4 NTU to 1.8 NTU (**Figure 24**). A Kruskal-Wallis one-way analysis of variance test showed there was no significant difference in the turbidity measurements between the four corners of deposition site H (p=0.195).

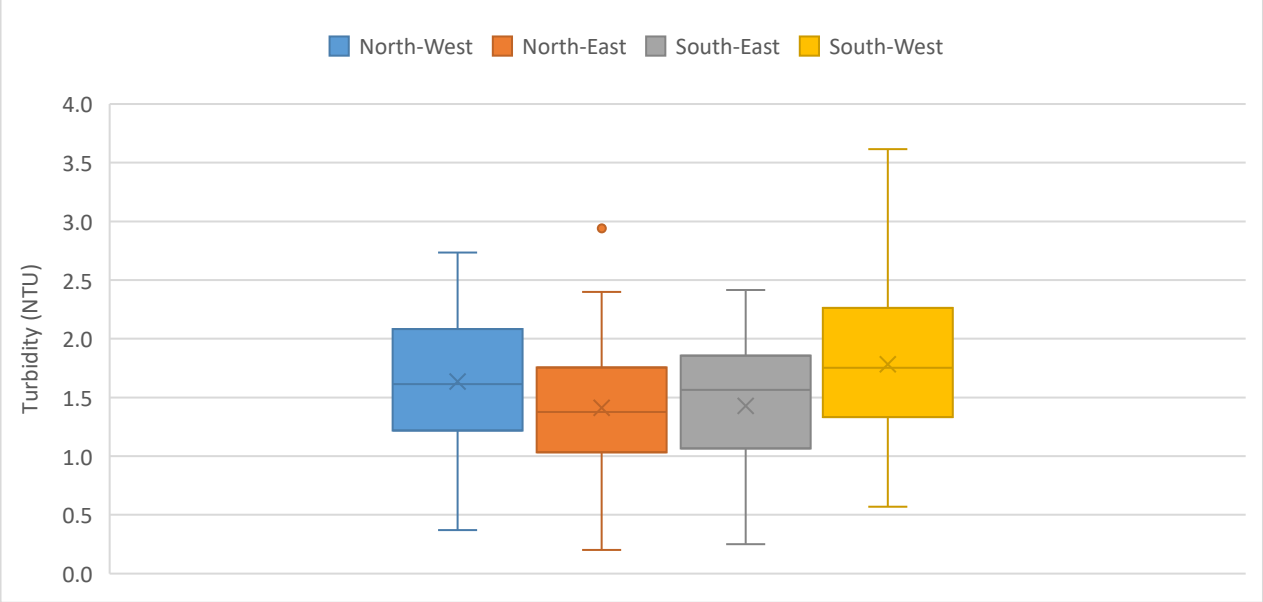


Figure 24. Box and whisker plot of turbidity measurements at the four corners of Deposition site H1/H2 during maintenance dredging between 2015-2022. The boxes denote 75th (top), 50th (middle), and 25th (bottom) percentiles, with whiskers extending 1.5 x 25th/75th percentiles. The mean value is presented as a cross. "Outliers" are shown as points.

3.5.2 Data collected for this assessment

PoTL undertook water quality measurements in August 2023 at five dredging sites and two disposal sites (**Figure 25**). For dredging sites, measurements were taken 500m upstream, alongside, and 200m downstream of the vessel. For disposal site D[24], measurements were taken alongside the vessel, at the four corners and in the centre. For disposal site B/C measurements were taken alongside the vessel and at the four corners (**Figure 25**).

Turbidity, water temperature, DO (as % saturation and concentration in mg/L), salinity, and pH were measured at all sites. The data are summarised below, with the full dataset provided in **Appendix 4.**

[24] Disposal site D is a historic site that sits within disposal sites H1/H2.

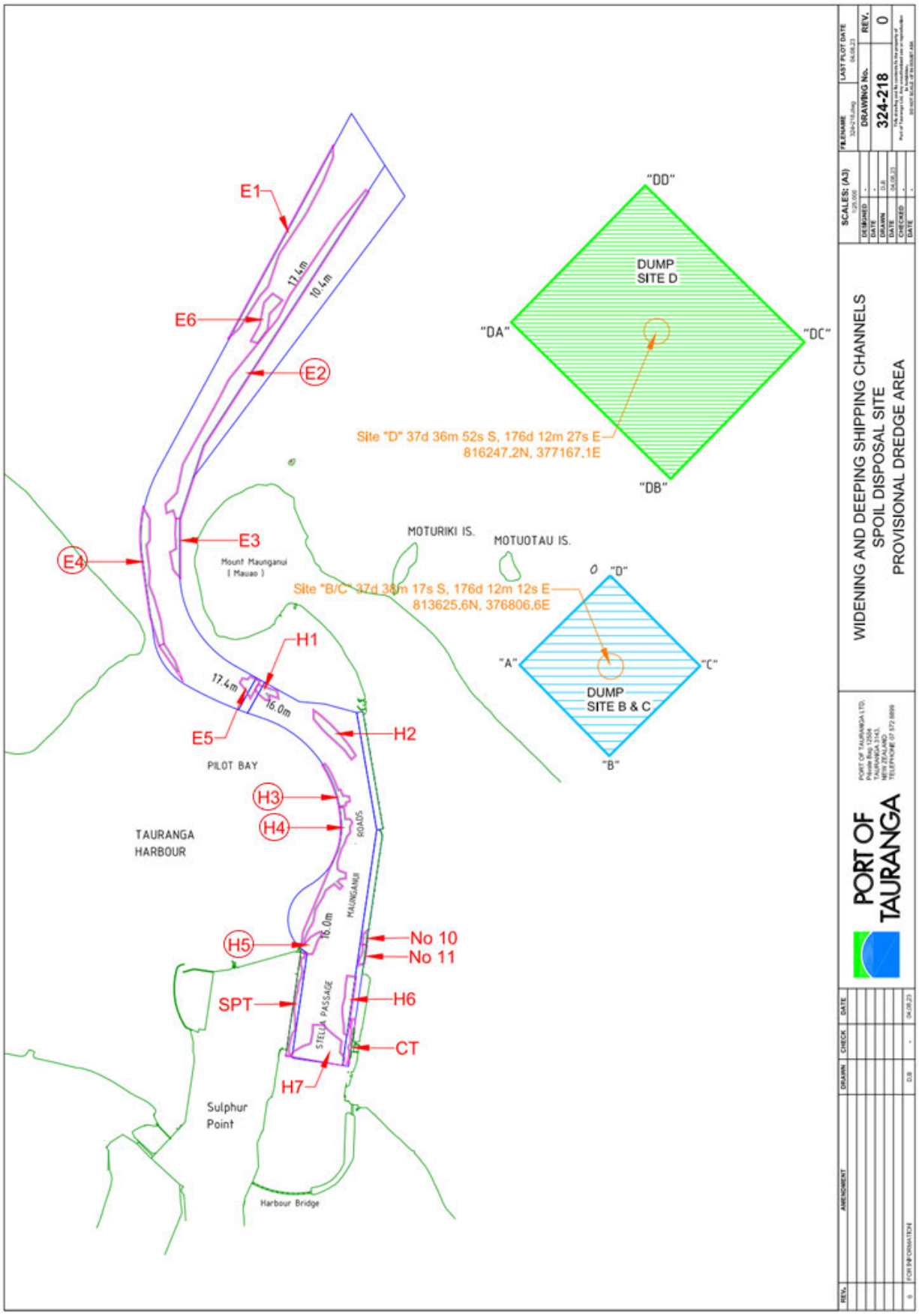


Figure 25. Location of water quality measurements for this assessment. Sites where measurements were undertaken during dredging are circled red.

3.5.2.1 Maintenance dredging

Turbidity was compared with the consent monitoring data (Section 3.5.1) and summarised in **Figure 26**.

The 2023 data collected for this assessment had fewer outliers than the consent data, with lower medians. For the 2023 data, a Mann-Whitney one-way analysis of variance test showed a statistically non-significant difference for turbidity between upstream and downstream (p=0.32), upstream and alongside (p=0.32), and alongside and downstream (p=0.62) (**Table 18**).

Temperature, DO, salinity, and pH upstream, alongside and downstream of the dredging are summarised by box and whisker plots in **Figure 27**. Mean temperature was 13.2°C, 13.2°C, and 13.3°C, upstream, alongside and downstream, respectively. Mean DO was 101%, 98%, and 104% upstream, alongside and downstream, respectively. Mean salinity was 32.5 ppt, 32.7 ppt, and 32.9 ppt upstream, alongside and downstream, respectively. Mean pH was 8.3 for all three locations.

A Mann-Whitney one-way analysis of variance test showed a statistically non-significant difference (p>0.05) between upstream and downstream, upstream and alongside, and alongside and downstream, for all four parameters (**Table 18**). The lack of significance and the scale of the effect of temperature, DO, salinity and pH as a result of the maintenance dredging activity is discussed in Section 4.3.

Table 18. Mann-Whitney one-way analysis of variance test (p values) for water quality data collected during maintenance dredging in 2023 for this assessment.

Scenario	Turbidity (NTU)	Temperature (°C)	DO (%)	Salinity (ppt)	pH
Upstream/Downstream	0.32	0.34	0.45	0.82	0.71
Upstream /alongside	0.32	0.90	0.17	0.74	0.53
Alongside/ Downstream	0.62	0.34	0.09	0.74	0.38

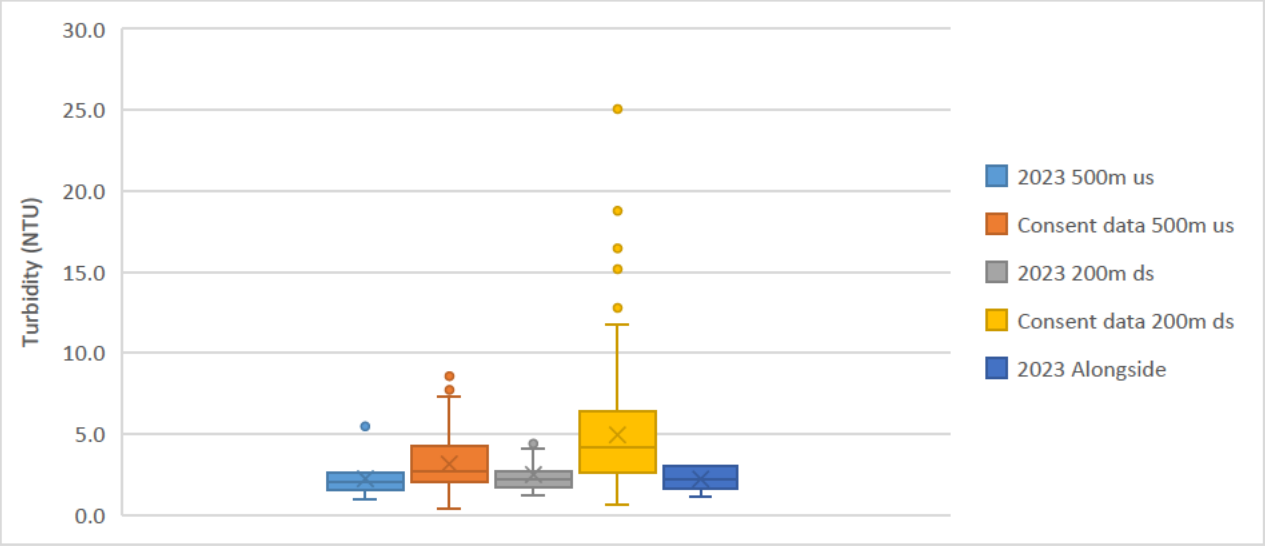


Figure 26. Box and whisker plot of turbidity measurements upstream (us), downstream (ds) and alongside of the dredge during maintenance dredging in 2023 and comparison with consent data (us and ds only). The boxes denote 75th (top), 50th (middle), and 25th (bottom) percentiles, with whiskers extending 1.5 x 25th/75th percentiles. The mean value is presented as a cross. "Outliers" are shown as points.

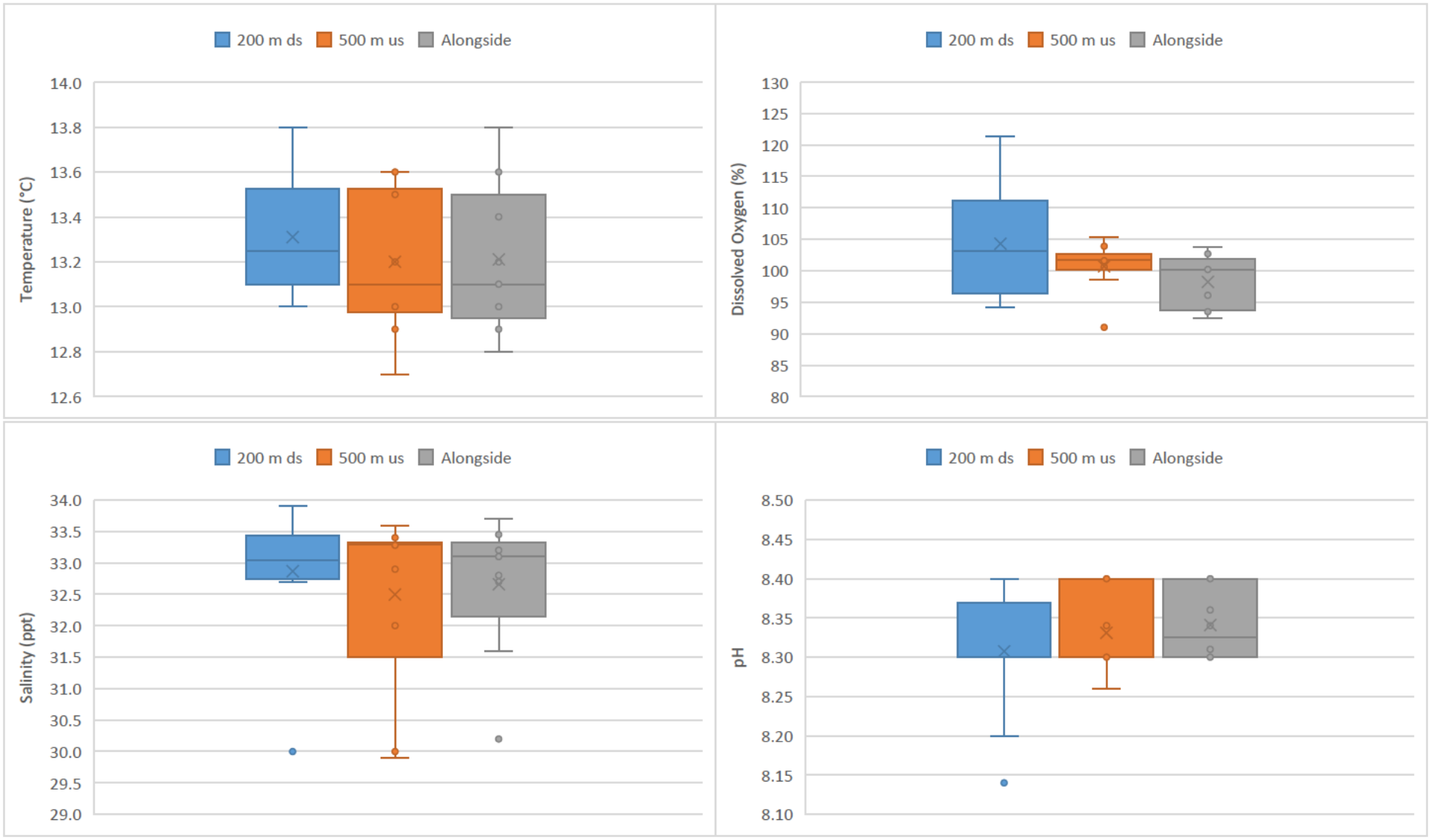


Figure 27. Box and whisker plots of temperature, dissolved oxygen, salinity, and pH measurements upstream (us), downstream (ds) and alongside of the dredge during maintenance dredging in 2023. The boxes denote 75th (top), 50th (middle), and 25th (bottom) percentiles, with whiskers extending 1.5 x 25th/75th percentiles. The mean value is presented as a cross. "Outliers" are shown as points.

3.5.2.2 Disposal

One-off water quality measurements were undertaken at the disposal sites D (H1/H2) and B/C on 3rd August 2023, and 7th August 2023, respectively. There were insufficient data for statistical analysis so data were compared between locations and against relevant water quality guidelines (see **Table 2**) as shown in **Figure 28**.

The water at both disposal sites was highly oxygenated, with DO well above the 80% specified in the RCEP. There was more variability in DO at disposal site B/C (96.2-113.0%) compared with site D (H1/H2) (103.2-104.8%), however minimal difference between the alongside and four corners of each site (and centre for site D (H1/H2)) (**Figure 28**).

Water temperature varied between 13.4°C and 13.7°C at disposal site B/C and between 13.3°C and 13.6°C at disposal site D (H1/H2) (**Figure 28**). The RCEP specifies a change of ±3°C (**Table 2**) as a result of an activity, and these data are well within this range.

Salinity was marginally higher at disposal site D (H1/H2) (33.6-33.7 ppt) than disposal site B/C (33.3-33.5 ppt) (**Figure 28**). This may be because Site D (H1/H2) is offshore and further from freshwater influences from land. There are no water quality guidelines for salinity (**Table 2**).

pH was consistent within and between the two sites ranging from 8.37-8.38 at disposal site D (H1/H2) and 8.30-8.38 at disposal site B/C (**Figure 28**). All pH readings were well above the ANZECC (2000) lower limit of 7.0 and marginally below the upper limit of 8.5.

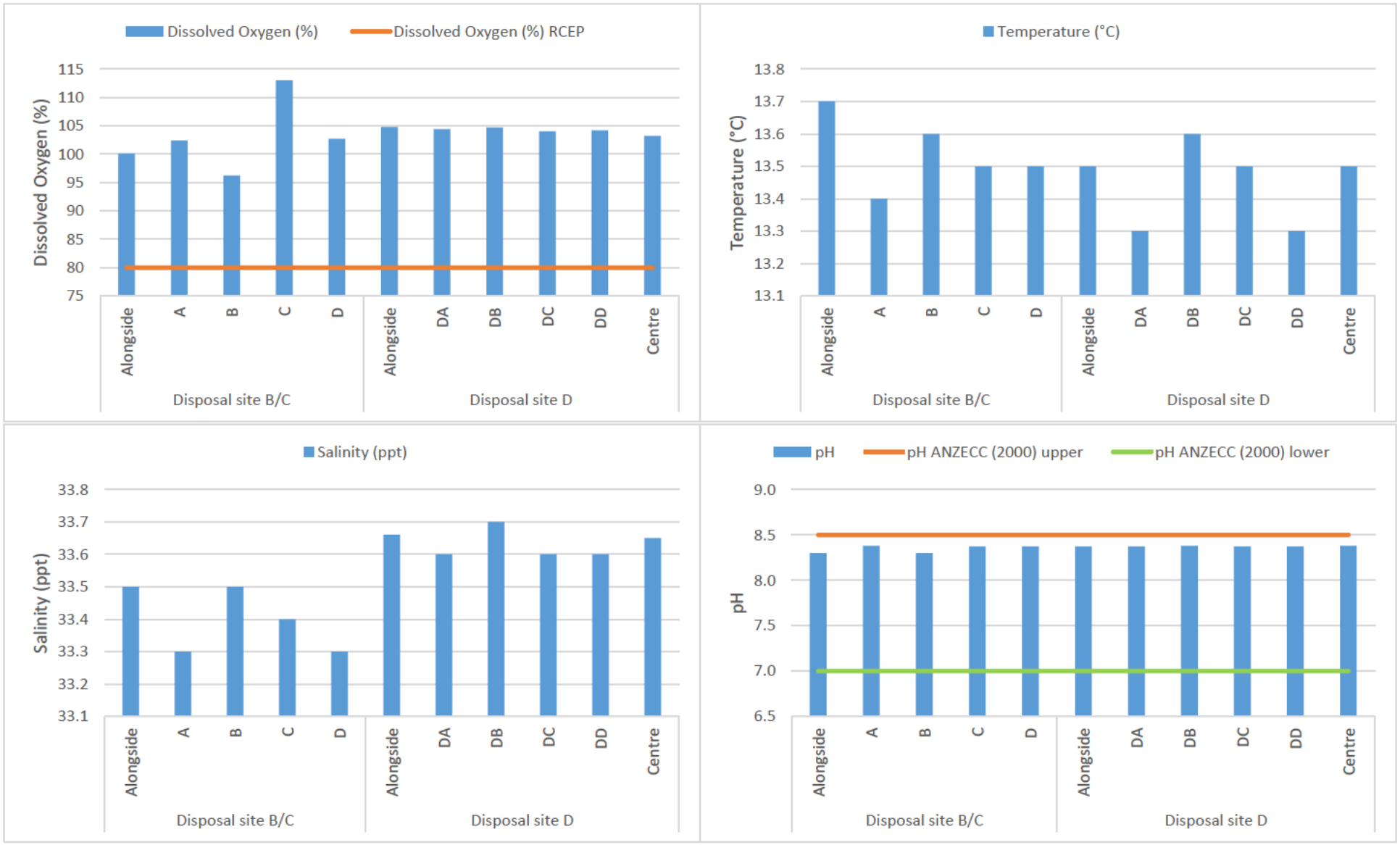


Figure 28. Graphs of temperature, dissolved oxygen, salinity, and pH measurements undertaken at two disposal sites in August 2023. Lines are applicable water quality guidelines in summarised in Table 2.

3.6 Dredged sediment size data

While deposition is occurring, PoTL undertake monthly sediment sampling of a representative dredged sediment sample for grain size analysis and specifically the proportion silt by weight (Resource Consent 65807: condition 10.11). The proportion of silt allowed for deposition sites B/C is 5% (Resource Consent 60078: condition 6.3 (a)).

PoTL provided technical reports from October 2012 to August 2022 (n=10) of the sediment grain size analyses.[25] These are summarised in **Table 19**, which shows that between 2012 and 2022 – while maintenance dredging has been undertaken – the sediment has low silt content (<2.5%) and is compliant with the 5% limit stipulated in Resource Consent 60078: condition 6.3 (a).

The silt content (<2.5%) is well below the estuarine sites monitored by BoPRC, which range from 6-37% (**Table 8**). The higher energy environment of the dredged shipping channel and the fine sediment inputs from freshwater sources to the estuarine sites are a likely reason for this large difference in silt reported.

Table 19. Summary of percent silt and compliance for sites dredged from 2012 to 2022.

Date	Site (see Figure 25)	% silt	Compliant with RC 60078, condition 6.3a?
29/09/2012	H	0.00	Yes
3/10/2012	G	0.00	Yes
8/08/2013	I5	0.00	Yes
8/08/2013	O7	0.00	Yes
15/10/2014	H4	0.00	Yes
15/10/2014	E3	0.00	Yes
26/08/2015	E1	0.00	Yes
27/08/2015	H1	0.00	Yes
14/06/2017	H3	2.06	Yes
15/06/2017	E1	0.00	Yes
20/06/2018	H1	0.03	Yes
23/06/2018	E1	2.32	Yes
14/06/2019	E1	2.23	Yes
20/06/2019	H2	1.92	Yes
10/07/2020	H4	0.00	Yes
10/07/2020	E1	1.65	Yes
13/07/2021	H1	0.00	Yes
14/07/2021	E1	0.00	Yes
19/07/2022	H2	0.58	Yes
19/07/2022	E2-load 111	1.78	Yes
19/07/2022	E2-load 121	2.33	Yes

[25] Reports are produced by the University of Waikato and authored by Annette Rodgers and Willem de Lange.

4. Assessment of effects of dredging and disposal on receiving environment water quality

4.1 Increased turbidity and suspended solids and reduced water clarity

As stated throughout this report, the impacts on visual water clarity and turbidity are the most likely effects to be of concern from the dredging and disposal process. Suspended solids (measured as total suspended solids: **TSS**) are a primary contributor to increased turbidity and reduced water clarity. TSS – also called suspended particulate matter (**SPM**) – may influence aquatic ecosystems while in suspension and when it settles out. In suspension, the main impact of SPM is to reduce light penetration and thus affect primary production. Adverse effects can also occur on fish due to mechanical and abrasive impairment of gills. When it settles, SPM can cause adverse effects by smothering of benthic organisms and their habitats (ANZECC, 2000b).

The RCEP has two qualitative standards for visual clarity (as a result of an activity and after reasonable mixing). The first is that "*there shall be no conspicuous change in the colour or visual clarity*", with a quantitative standard that "*the decrease in secchi disc vertical depth or black disc horizontal range shall not be greater than 20%*". The second is that "*the visual clarity of the water shall be suitable for bathing*", with a quantitative standard that "*the horizontal sighting distance of a 200 mm black disc should exceed 1.6 metres*'.

Black horizontal disc measurements are routinely undertaken by BoPRC in Tauranga Harbour and at times visual clarity is low in Tauranga Harbour, with all sites routinely monitored by BoPRC returning minimum water clarity of 0.2-0.8m (**Table 3**), well below the RCEP of 1.6m (Zygadlo, 2021). However, these data only described the receiving environment and are not related to a specific activity. PoTL do not measure black disc during dredging and disposal campaigns. Therefore, this water clarity measure of the RCEP cannot be assessed from the data available.

However, as stated above, reduced water clarity is intrinsically linked with increased turbidity and suspended sediment. BoPRC data shows that turbidity and TSS in the harbour are low across all sites. Median turbidity ranges from 2.0-3.5 NTU across all sites, well below the ANZECC (2000) default trigger value of 10 NTU, while average TSS concentrations range from 10-34 mg/L. For all sites except Tilby Point (34 mg/L) average TSS concentrations are below the Auckland Council *indicative* water quality guideline value of 20 mg/L (**Table 3**)[26].

In the context of the above, there are two pertinent points:

1) PoTL undertake sediment size data measurements, providing an indication of the percentage of mud (silt) in the dredged sample that is likely to have a larger effect on turbidity than larger particle such as sand and gravel.
2) PoTL routinely measure turbidity during dredging and disposal campaigns.

Addressing the first point, the sediment size data between 2012 and 2022 from the PoTL consent monitoring shows that the proportion of silt in dredged sediment is very low (<2.5%) (**Table 19**)

[26] See discussion in Section 2.2.1.4.

and has always been compliant with Resource Consent 60078: condition 6.3 (a) (<5%) for disposal at Sites B/C. Therefore, the bed sediment being dredged has low silt content which reduces the risk of increased turbidity and reduced visual clarity in the water.

Addressing the second point, a Mann-Whitney one-way analysis of variance test of turbidity measurements undertaken by PoTL during maintenance dredging campaigns from October 2015 to July 2022 (n=160) showed a statistically significant difference (p=0.000) for turbidity upstream and downstream of the dredge. This suggests that the dredging activity is having a statistically significant and measurable effect on turbidity downstream relative to upstream.

A closer inspection of these turbidity exceedances is shown in **Table 20**. The upstream turbidity during these exceedances is markedly lower than downstream (range of 4.5-21.1 NTU), suggesting the increased turbidity is due to the dredging and not ambient water turbidity.

Table 20. Turbidity measurement exceedances of 10 NTU downstream of the dredge.

Date	Time	Location	Vessel	500m upstream	200m downstream	Downstream - Upstream
11/03/2016	8:30	S/Pt Wharf	Gungner R	3.9	25.1	21.1
25/06/2018	10:50	H9	Albatros	4.1	18.8	14.7
27/04/2016	11:15	B Buoy	Balder R	2.5	16.5	13.9
8/07/2021	8:30	E3	Albatros	6.5	15.2	8.7
9/02/2016	8:20	Maunganui Rds	Balder R	4.7	12.8	8.1
4/04/2016	14:30	Tanker Berth	Gungner R	3.4	11.7	8.4
6/04/2016	14:30	S/Pt toeline	Gungner R	3.4	11.7	8.4
30/05/2016	8:40	Maunganui Rds	Balder R	4.5	11.6	7.1
30/05/2016	8:40	Stella Passage	Gungner R	4.8	11.5	6.8
21/03/2016	8:30	Stella - toe line	Gungner R	4.2	10.2	6.0
6/05/2016	8:50	Stella Passage	Balder R	5.7	10.1	4.5

For the majority of the time (93%) there was no exceedance of the ANZECC (2000) default trigger level of 10 NTU downstream of the dredge. Therefore, although there is a statistically significant difference between upstream and downstream turbidity during the maintenance dredging when considered over the entire sampling period (i.e. October 2015 – July 2022), exceedances of the default trigger value are infrequent. Further, the turbidity monitoring undertaken by PoTL is from the active dredge zone 500m upstream of the dredging vessel (control) and 200m downstream, of which the downstream distance represents the mixing zone. The ANZECC (2000) trigger levels are based on long-term monitoring and the effects on turbidity from the dredging campaign are transient. Therefore, comparison with the ANZECC (2000) default trigger level is conservative.

As stated in Section 2.2.3, there are established turbidity management limits for the dredging process, which have been set based on analyses undertaken by Bryan et al. (2014) which in turn were (in part) based on dredging studies from other ports. There are three management limits:

1) Level 1 of 15 NTU. If breached an investigation will be undertaken to find the source.
2) Level 2 of 20 NTU. If breached the dredging process will be changed until below this level.
3) Environmental limit of 35 NTU. If exceeded, no further dredging should occur.

These management limits are set based on a rolling average over 6 hours from data collected at 15 minute intervals from continuous monitoring buoys deployed in the receiving environment. Therefore, these limits are conservative compared to individual spot readings in the active plume as they do not represent the temporary nature of the plume. These management limits are higher than the ANZECC (2000) default trigger level, which as noted above, is also conservative. When comparing the turbidity measurements in the active plume and not over the averaging period (which allows for the temporary nature of the plume) the level 1 limit of 15 NTU was exceeded four times out of 160 monitoring events (2.5%), the level 2 limit (20 NTU) exceeded once (0.6%) and the environmental limit (35 NTU) was never exceeded.

In summary, based on a conservative ANZECC (2000) approach, for the majority (93%) of the time, the dredging procedure is undertaken in a manner that produces turbidity of the plume below ANZECC (2000) default trigger levels, and effects are less than minor. For the times (7%) when turbidity is elevated to above ANZECC (2000) default trigger levels, effects are likely to be transient but minor.

In summary, based on the conservative management limit approach designed for the dredging procedure, the environmental limit has never been exceeded. Exceedance of the level 2 limit – where a dredging procedure change is required, if breached – only occurred on one occasion (0.6% of the time) even when comparing individual isolated readings in the active plume at 200m downstream. Exceedance of the level 1 limit – where an investigation to find the source is required, if breached – occurred four times (2.5% of the time) even when comparing individual isolated readings in the active plume at 200m downstream. Therefore, although conservative, isolated spot measurements within the active plume show rare exceedances of level 1 or 2 management limits, this is unlikely to occur outside the active plume and once 6 hourly averaging is taken into account.

4.1.1 Hydrodynamic modelling of the dredge and disposal plumes

MetOcean Solutions undertook hydrodynamic modelling of the dredge plumes from a large Trailer Suction Hopper Dredge (**TSHD**) for specific sites within the shipping channel and the disposal sites (MetOcean Solutions, 2024). The modelled dredge is significantly larger than that intended to be used for the maintenance and capital dredging associated with this application. The productivity rate of large TSHD is larger than a small TSHD and therefore the modelling can be considered conservative. Six release sites for TSHD dredging and 1 for Back-Hoe Dredge (**BHD**) dredging were modelled (**Figure 29**). The release of sediment during dredging was simulated over a 2-month period for La Niña summer and La Niña winter. Bottom and surface water modelling was undertaken using the existing bathymetry and proposed bathymetry (after dredging is completed). Outputs of the modelling included TSS concentrations[27] (mean and 90th percentile), sediment deposition thickness, total number of days when peak TSS exceeded 75 mg/L (to provide protection for pipi from suspended sediment), and contribution of each dredge site to these parameters at Te Paritaha, Bridge Marina and Whareroa Marae.

[27] MetOcean Solutions used the term suspended sediment concentration (**SSC**) which is analogous to TSS used in this report. For consistency with other sections of this report I have used TSS.

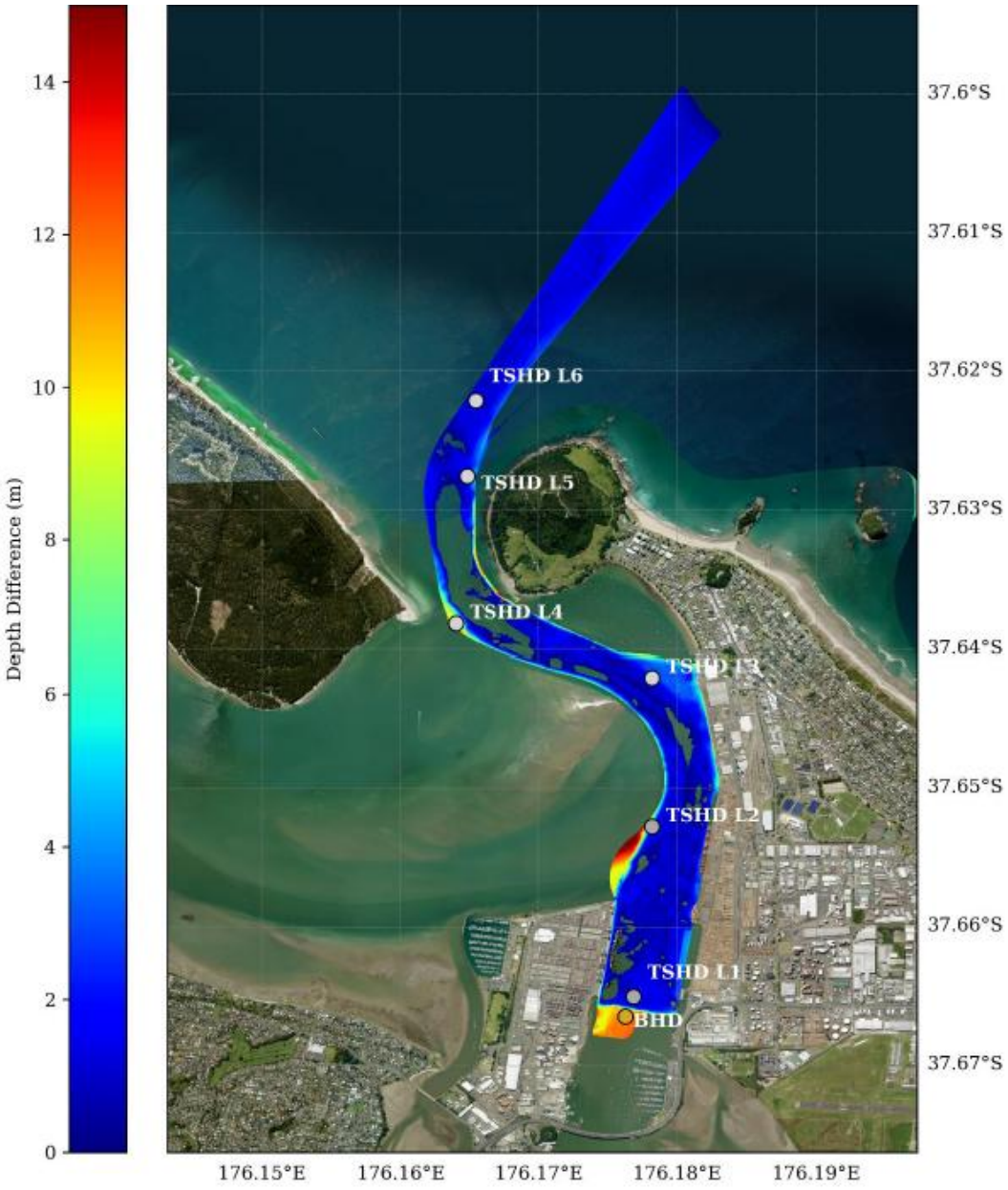


Figure 29. Map showing the locations for each of the release sites considered along the Port of Tauranga. The colour bar indicates the depth difference along the channel between the existing bathymetry and the proposed bathymetry in the region of interest (MetOcean Solutions, 2024).

Results showed that highest TSS concentrations would be at the bottom layer (seafloor) rather than the surface layer for both TSHD and BHD and at the disposal site. The bathymetry modelling shows a similar plume extent to the existing bathymetry. The dredged plume extent is slightly larger in winter than summer. Dispersal patterns are different at each site, with sites L2 and L4 exhibiting the largest plume extent. To illustrate this, mean TSS concentrations at sites L1 and L4 are provided in **Figure 30** and **Figure 31**, respectively. These show the higher concentrations at the bottom layer (seafloor) compared with the surface layer and that the plume is contained within the shipping channel for L1 (and also L3, L5 and L6, not shown) (**Figure 30**) but that for L4 plume is entrained into the Western Channel and the channel entrance (**Figure 31**).

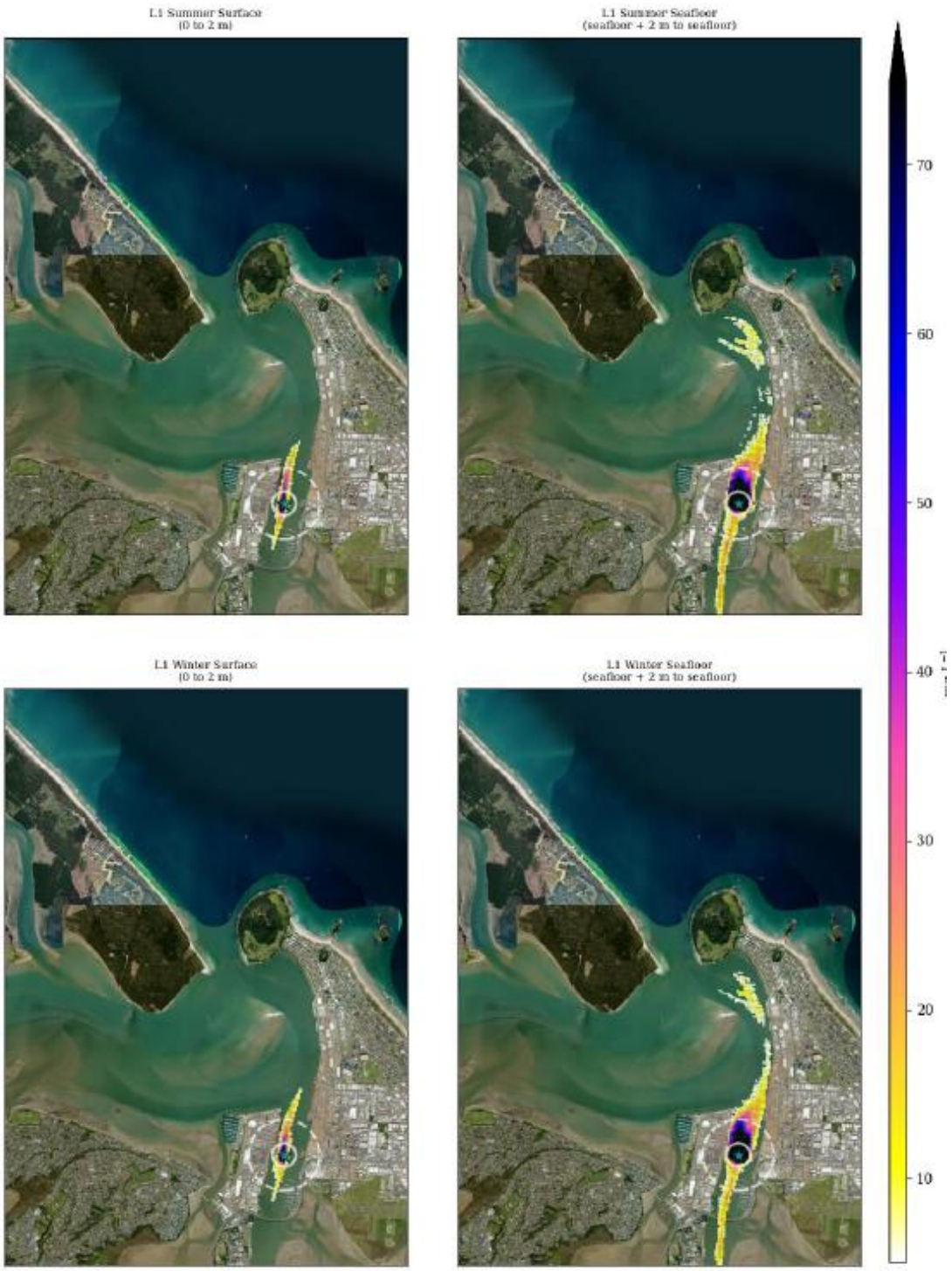


Figure 30. Mean TSS (mg/L) for site L1 at the surface and bottom layers during La Niña Summer and Winter conditions for the combined sediments dispersed by TSHD using the existing bathymetry. Concentrations below 5 mg/L are not shown. The circles surrounding the release locations represent a 200 m (solid line) and a 600m (dashed line) circumference to identify the mixing zone (MetOcean Solutions, 2024).

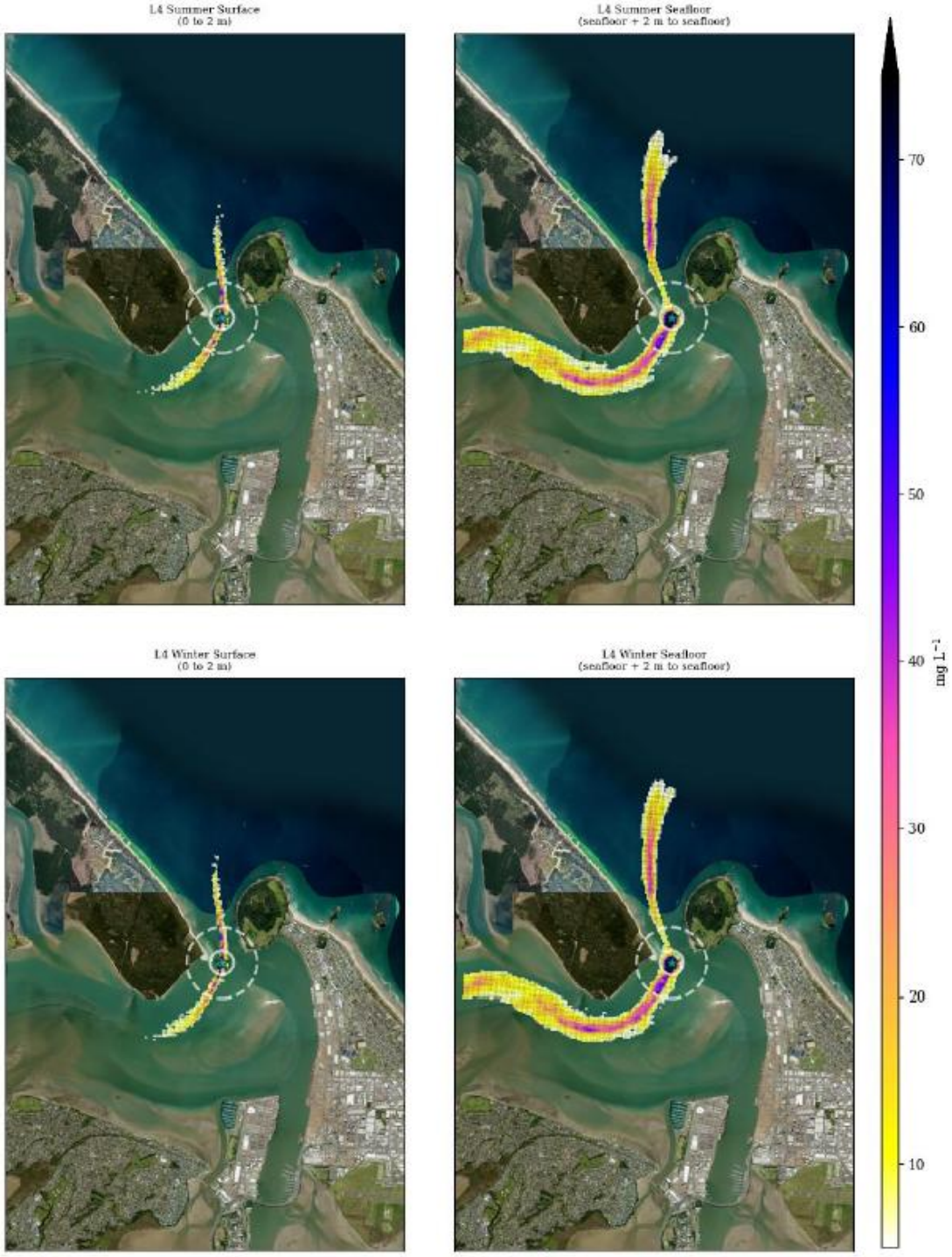


Figure 31. Mean TSS (mg/L) for site L4 at the surface and bottom layer during La Niña Summer and Winter conditions for the combined sediments dispersed by TSHD using the existing bathymetry. Concentrations below 5 mg/L are not shown. The circles surrounding the release locations represent a 200 m (solid line) and a 600m (dashed line) circumference to identify the mixing zone (MetOcean Solutions, 2024).

Outside the 200m dredging zone, deposition thickness is below 1cm regardless of the season. As stated in Section 2.2.1.5, smothering of marine biota by sediment is a concern related to the suspended sediment concentrations in the dredged material with ANZG (2018) providing a DGV of

2mm sediment accumulation per year above the natural annual sedimentation rate for the specific estuary, or part of the estuary. The modelling data show that deposition thickness is low outside the mixing zone and the channels (**Figure 32**), however the threshold of 5mm used in the modelling precludes fine scale assessment of very low sediment deposition thickness rates. Therefore, dredging may be contributing at a small scale to smothering of marine biota at areas outside the channels. MetOcean noted that sediment tends to deposit around Te Paritaha (MetOcean Solutions, 2024). Dr De Luca (Boffa Miskell Limited, 2025) stated that filter feeding species present are already somewhat influenced by fine sediment smothering events from storm runoff and these species have behavioural mechanisms to counter temporary increases in sediment flows. Effects on Te Paritaha pipi beds have been assessed as a low level of effect due to suspended sediment being almost entirely below effects thresholds.

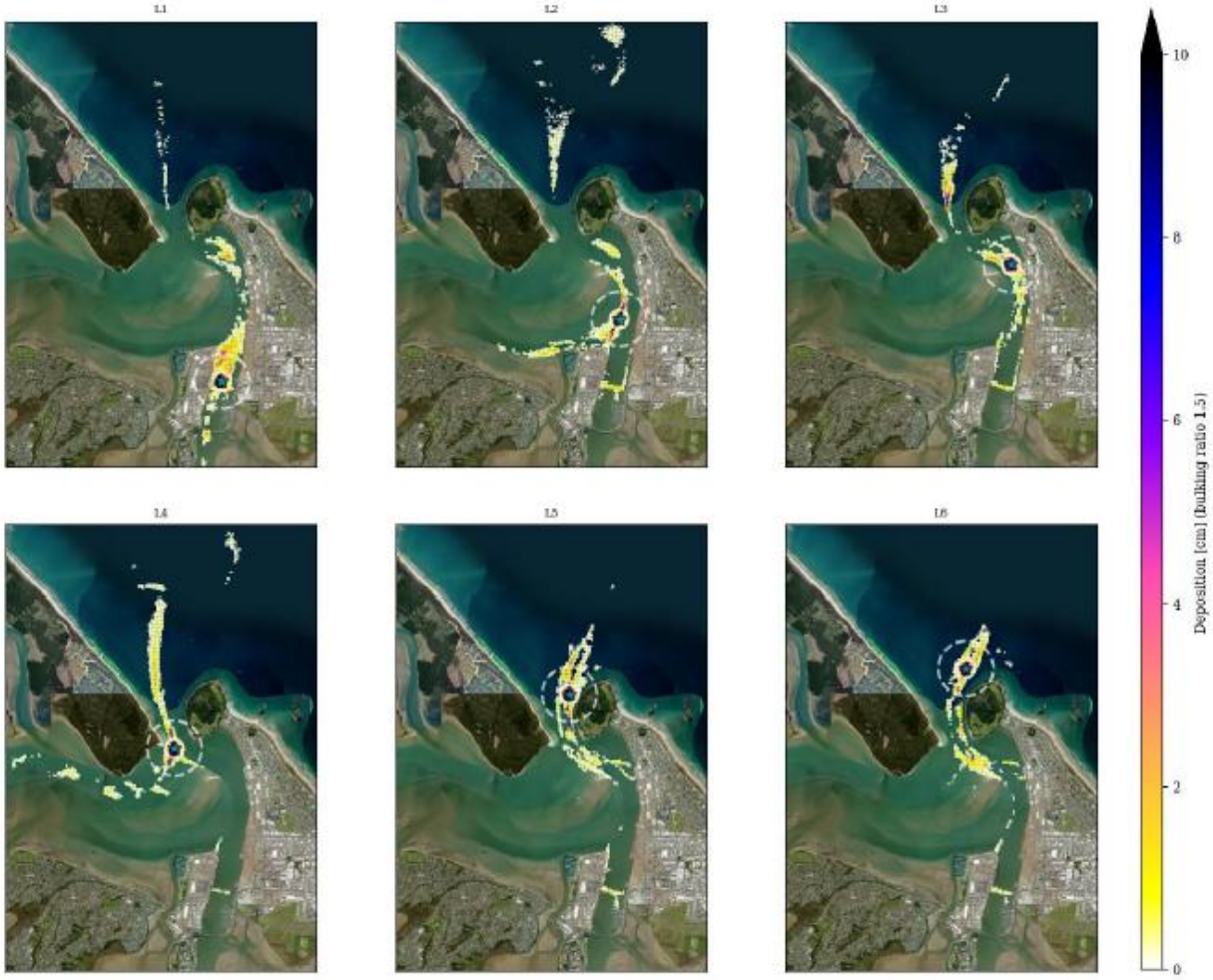


Figure 32. Sediment deposition thickness at the seabed (cm) during La Niña 2011 Winter conditions for the combined sediment of the 6 Large TSHD simulations using the existing bathymetry. Sediment thickness below 5 mm is not shown. The circles surrounding the release locations represent a 200 m (solid line) and a 600 m (dashed line) circumference to identify the mixing zone (MetOcean Solutions, 2024).

The modelling also shows that although the 75 mg/L threshold of TSS can be reached at times at Te Paritaha and Bridge Marina, these are not persistent and for the majority of the time concentrations are very low.

In summary, the hydrodynamic modelling shows that TSS concentrations are highest within a 200m range of the dredging and reduce rapidly outside this zone, with the plume mostly contained within the channels. Spikes in TSS concentrations are rare outside the 200m zone. This supports the empirical data summarised in this report. Although our assessment is based on turbidity measurements and not TSS the conclusions are consistent, namely that effects from TSS/turbidity on water quality are likely to be less than minor for the majority of the time while short-term spikes may show minor effects but these will be transient.

4.2 Release of contaminants entrained in the dredged sediment into the water column

As stated throughout this report, the release of contaminants entrained in the dredged sediment into the water column may lead to estuarine eutrophication (nutrients and organic enrichment), ecotoxicological effects on water and sediment dwelling species (metals/metalloids and/or organic toxicants), and potential human health effects from consumption of marine species (metals/metalloids and/or organic toxicants, and microbial pathogens). There are historic data available to provide an understanding of potential risk of release of sediment contaminants. Where this is incomplete, or not appropriate for this assessment, these data have been supplemented with sediment nutrient and toxicant analyses undertaken specifically for this assessment.

4.2.1 Eutrophication

For the sediment monitoring undertaken by PoTL for this assessment, TN and P sediment concentrations appeared to be increasing with proximity to the Port . The higher sediment nutrient concentrations (600mg/kg for TN and 210 mg/kg for P) are similar to the upper limit of Tauranga estuarine sites (980 mg/kg for TN and 292 mg/kg for P). Therefore, the risk of the release of nutrients from dredged sediment into the water column is higher for sites closer to the Port than those further away.

Water quality data for Tauranga Harbour suggests that algal growth is low, with median chlorophyll *a* concentrations ranging from 0.6-1.5 µg/L, well below the ANZECC 2000 trigger value of 4.0 µg/L (**Table 3**). Importantly, the Toll Bridge Marina site has median chlorophyll *a* concentrations at the lower end (0.8 µg/L) of sites within the harbour, suggesting algal growth (as one indicator of eutrophication) at this site is very low. Low chlorophyll *a* concentrations may reduce the risk of relatively short duration and spatial spread of the dredged plume significantly contributing to eutrophication, with effects likely to be less than minor.

4.2.2 Toxicity

An assessment of sediment toxicity data shows that organic toxicants are generally very low, below detection limits and well below ANZ 2018 DGV. TOC is very low in sediments in the dredging

channel far from the Port, which may partially contribute to low organic toxicant concentrations. Metal/metalloid sediment concentrations are all below ANZ 2018 DGV.

Toxicant concentrations are higher at urban sites presumably due to stormwater outflows. Tauranga WWTP has an ocean discharge, so wastewater will only enter the harbour through broken pipes and/or wastewater overflows into stormwater drains.

Shellfish monitoring in the harbour and around Te Paritaha (De Luca, 2025) shows that risk of toxicity to humans from ingestion of chemical contaminants from consumption of shellfish is very low. Further, the BoPRC studies in 1990 and 2016 showed that toxicant concentrations were generally stable, or reduced in 2016 relative to 1990, with the main exceptions being increases in copper and PAHs around the Port in 2016 relative to 1990.

In summary, sediment from the dredge sites generally has low ecotoxicity and is consistent with receiving environment sites. Further, shellfish toxicant concentrations are well within safe consumption limits. Therefore, the risk of toxicants entrained in the dredged sediment and leaching into the water column in concentrations above water quality and human health guidelines is extremely low, with the effects on water quality likely to be negligible.

4.3 Changes in temperature, pH, salinity, and dissolved oxygen in the water column

Changes in temperature, pH, salinity, and DO may occur in the water column as a result of the dredging and disposal process. Although the Bay of Plenty Regional Council (BoPRC) routinely monitor water quality of Tauranga Harbour, the dredging process is confined to a small area or footprint relative to the harbour. To provide suitable data to inform this assessment, temperature, pH, salinity, and DO[28] were measured by PoTL upstream, downstream and alongside the vessel during the dredging and disposal process.

For dredging, there was negligible differences between upstream, alongside, and downstream for the four parameters measured. Further, a Mann-Whitney one-way analysis of variance test showed a statistically non-significant difference ($p>0.05$) for all four parameters between upstream and downstream, upstream and alongside, and alongside and downstream sites.

For disposal, one-off measurements were taken at the four corners and at the centre of the disposal sites D (H1/H2) and B/C. There were insufficient data for statistical analysis. The water was highly oxygenated at all sites with DO well above the 80% specified in the RCEP. Water temperature had minimal changes (0.3°C) between the sites, well within the change of ±3°C specified in the RCEP. Salinity was slightly higher at disposal site D (H1/H2) than B/C, presumably because Site D (H1/H2) is further from freshwater influences from land. Differences between pH readings were negligible with all readings well above the ANZECC (2000) lower limit of 7.0 and marginally below the upper limit of 8.5.

[28] Turbidity was also measured at the same time however effects of turbidity have been assessed on the larger dataset collected as a consent requirement.

In summary, the water quality monitoring undertaken for this assessment shows negligible effects for water temperature, pH, salinity, and DO from dredging and disposal.

5. Response to cultural values reports

Assessments of cultural values potentially impacted by this application were undertaken by 16 Hapū/Iwi groups, with reports of findings provided to PoTL. Issues identified which are related specifically to water quality are summarised in **Table 21**.

Common concerns have been identified and a response provided in Section 5.1. A response to specific concerns not covered in the common response section is provided in Section 5.2.

Table 21. Summary of Cultural Values potentially impacted by this application specifically relating to water quality.

Hapū/Iwi	Report reference	Issue identified
Ngāti Ranginui Fisheries Trust	Section E: Cultural Effects Assessment (Paragraph 99(b))	Dredging can mobilise contaminants including heavy metals and hydrocarbons. This presents a risk to kai species, undermining confidence and safety of Te Awanui and raising concerns about intergenerational effects. POTL notes that sediment contains low levels of contaminants (below guidelines) with some increasing closer to the Port. When nutrients are released this contributes to algal growth, and toxicants can cause harm to marine life as well as human health via seafood. However, POTL considers that because contaminant levels are low, shellfish are considered safe to eat.
	Section F: Proposed Recommendations and Mitigation (Paragraph 102: Table)	Turbidity and water quality are monitored before, during and after dredging campaigns. POTL commission a cumulative effects assessment of the Port on the environment, including from a cultural perspective.
Ngāi Tukairangi	Page 43	...the water quality assessment undertaken by Mike Stewart (see Stewart, 2026) confirmed that heavy metals, PAHs, TPH, and PCBs are already detectable in shellfish within Te Awanui. This is a current documented finding. Stewart confirmed his assessment scope did not include disposal sites and he stated that, "the information [he] was provided did not include deposition; and he therefore couldn't assess deposition." Water quality and contaminant effects at nearshore disposal sites including Site A (Main Beach), Sites B and C (Marine Parade), and Site F (Waikorire) were therefore not assessed by the water quality expert. Dispersal modelling and shellfish effects were considered by other experts, but no integrated assessment combining contamination, dispersal, and kaimoana exposure pathways at those sites was assessed.
	Appendix 1: Table	Fate of contaminated material at deposition sites including those adjacent to Te Paritaha pipi beds not assessed by any expert.
Tauwhao/Otawhiwhi	Review of technical reports (Pages 24 – 25)	General review of technical reports including issues with overstatement of conclusions, reliance on assumptions over evidence, inadequate treatment of uncertainty, weak assessment of cumulative and long-term effects, over reliance on regulatory compliance, dependence on dated, indirect, or non-local evidence, and limited or deferred mitigation.
	Cause-effect pathway matrix (Tauranga Moana System) (Pages 29 - 34)	Dredging and Disposal: Water Quality – Cultural Value Impacts Manaakitanga compromised (unsafe food) Mauri reduced/degraded

Hapū/Iwi	Report reference	Issue identified
		Sediment contamination and disposal – Cultural Value Impacts Manaakitanga and health impacts
Ngāti Pukenga	Section 6.2 Effects on Taonga Species and Kaimoana (Pages 32 - 34)	The Port's own expert evidence acknowledges scientific uncertainty about cumulative effects on seagrass, on water quality over the duration of an ongoing dredging programme. ...water quality must be improved rather than further compromised.
	International Standards: UNEP Finance Initiative (2022) on Dredging Impacts and Governance (Section 5.9.1 – 5.9.3)	Interpretation and application of UNEP FI (2022) needs reassessment regarding the scale and permanence of dredging impacts.
Ngāi Tamarawaho	Recommendation 5.1 – Mauri-based water quality framework (Page 74)	Water quality monitoring must be expanded to include a mauri-based framework designed with Ngāi Tamarāwaho. The framework must include: scientific parameters such as turbidity, suspended sediment, dissolved oxygen, nutrients, contaminants and deposition. cultural indicators such as water clarity, smell, colour, visual plume presence, kai confidence, observable sediment on kai areas, and hapū assessment of mauri.
Waitaha	Waitaha Cultural Assessment (Page 26)	Water quality is not only a technical matter. For Waitaha, water quality is tied to wai ora, mauri, mahinga kai, cultural safety, whānau confidence and the spiritual relationship between people and Te Awanui. The cultural risk is assessed as Mauri Oho (unsettled) where there are visible plumes, unexplained changes, whānau concern, reduced confidence in kaimoana, or uncertainty about cumulative effects. Waitaha position: Waitaha requires water quality reporting that is transparent, plain-language and connected to cultural indicators. Monitoring data should not sit only in technical compliance reports. It must be made available to Waitaha in a form that supports kaitiaki assessment and decision-making.
Ngāti Hangarau	Cultural Response to Project Technical Assessments (Table 1, row 13: water quality aspects).	Ngāti Hangarau Cultural Response & Expectations Safe Mahinga Kai is not just the absence of toxins; it is the absolute vitality of the water. Short-term degradation is a cultural offense. We expect ongoing, hapū-led water quality monitoring that relates to this dredging in the first instance, but allows for the monitoring of cumulative effects from multiple development projects.

5.1 Response to common issues

Issues in common from the CVRs specifically related to water quality included a lack of assessment on cumulative and long-term (even inter-generational) effects, uncertainty, the potential for mahinga kai to be unsafe to eat, and a western-science centred approach in the assessment and proposed conditions without consideration of cultural values.

5.1.1 Cumulative and long-term effects

Cumulative and long-term effects are a valid concern over a proposed 35 year consent term. Water quality in the harbour has been routinely monitored by BoPRC for a long time and this will be continued. These data allow for current status and long-term temporal change assessments, which inform BoPRC of potential issues with water quality and potential remediation required. This is a catchment-scale approach so considers all inputs to Tauranga Harbour. The effects of the dredging on water quality are localised and transient due to the rapid exchange of water through tidal and wind processes. During dredging and disposal, controls are in place (through proposed consent turbidity monitoring conditions) that ensure the plume is contained and does not adversely affect water quality in the wider environment.

As the dredging campaigns will be sporadic and not continuous, and effects on water quality are transient, there will be considerable time between campaigns for an equilibration of the water quality around the dredging and disposal areas, effectively "resetting" the baseline water quality. Therefore, I consider that the risk of cumulative effects on water quality over the long-term to be low.

Long-term deposition and accumulation of sediment from dredging or disposal may have the potential to lead to cumulative effects from contaminants entrained in the sediment leaching into the water column. However, the sediment plume from dredging is well contained within the channel, so the likelihood of sediment accumulation at sites further afield is low. Proposed consent conditions ensure that high silt sediment (with the potential for dispersal and to contain the highest concentrations of contaminants) is deposited on the seaward side of the ocean site H. Further, contaminants in the dredged sediment are currently at concentrations well below effects concentrations. Therefore, I consider that cumulative effects of sediment deposition leading to adverse effects on water quality to be low.

5.1.2 Uncertainty

Where appropriate – i.e. for differences "upstream" and "downstream" in turbidity data from multiple dredging campaigns, and long-term temporal trends of the wider receiving environment – I have used statistical analyses to show a significant (or lack of significant) difference. This defines uncertainty in these analyses and clearly puts into context the significance of assumptions and conclusions drawn from that data.

Further, where there is real or perceived uncertainty in an assessment, conservatism is required to mitigate this uncertainty. Conservatism has been built into the assessment in this report. This report clearly sets out the use of conservative approaches used, specifically for turbidity with using the ANZECC (2000) guideline and management limit approaches.

5.1.3 Mahinga kai may be unsafe to eat

Shellfish were used as species to assess potential human health risks from sediment-associated contaminants the shellfish may bioaccumulate. Shellfish are sessile commonly consumed species that are known to accumulate contaminants in suspended solids through filter feeding. As they are sessile filter feeders they are highly effective sentinel species and indicators of environmental

stress and contamination at specific sites. A such, they are a worst-case scenario compared to other species that are mobile and/or do not bioaccumulate contaminants through filtration of water and the associated suspended solids.

Further, these analyses are benchmarked by previous studies (1990, 2016, and 2018/19: Section 2.5.1), allowing for an assessment of changes over time.

A wide range of metals and organic contaminants were measured and these have been generally consistent through time (see **Table 13**). All studies included metals/metalloids, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs) and organochlorine pesticides (OCPs). The BoPRC temporal dataset showed that many organic contaminants (PCBs, the organochlorine pesticide DDT, and antifouling biocide tributyl tin (TBT)) and the metal lead have been reducing over time, due to historical bans imposed for these chemicals.

Importantly, FSANZ food safety standards are only available for a selection of the contaminants measured for which there are sufficient toxicological data to provide robust consumptive risk. The results show that concentrations in the shellfish (in the Harbour and also at Paritaha) are well below FSANZ maximum limits, and as such the shellfish are considered safe to eat.

5.1.4 Western-science centred assessment and conditions

The proposed conditions are based on western science assessments as these are quantitative metrics that can be measured and assessed by BoPRC with clear avenues for enforcement of non-compliance issue by BoPRC, if required.

5.2 Response to specific issues

5.2.1 Ngāti Ranginui Fisheries Trust recommendation

Issue

Turbidity and water quality are monitored before, during and after dredging campaigns.

Response

As shown in this report, turbidity is the key parameter to assess the effectiveness of control measures for dredging and disposal. Turbidity monitoring has been undertaken for previous campaigns (See Section 3.5) and is provided for in future campaigns by proposed consent conditions 15.1 – 15.13.

Further, monitoring of other water quality parameters – temperature, pH, salinity, and dissolved oxygen – was undertaken as part of this assessment (see Section 4.3) with no significant differences observed between upstream and downstream of the dredging. Therefore, I consider that turbidity monitoring is sufficient and required by the proposed consent conditions.

5.2.2 Ngāi Tukairangi

Issue

Water quality and contaminant effects at nearshore disposal sites including Site A (Main Beach), Sites B and C (Marine Parade), and Site F (Waikorire) were therefore not assessed by the water quality expert.

The fate of contaminated material at deposition sites including those adjacent to Te Paritaha pipi beds not assessed by any expert.

Response

Responding to the second point, Te Paritaha was assessed robustly and is considered the worst-case scenario as it is close to the dredging channel so is likely to receive a higher sediment deposition load than other areas. Further, there are a lot of data that have been collected on sediment toxicant loads and pipi condition and their toxicant loads. Therefore, conclusions can be drawn for other sites adjacent to Te Paritaha, but further away from the channel, with risks being lower than for Te Paritaha.

In terms of assessment of water quality and contaminant effects at disposal sites other than site H (first point), I consider that the assessment at site H is the worst-case scenario for deposition, with water quality analysis undertaken during deposition at this site, and negligible differences noted at the four corners of this site.

Site H is the worst-case scenario for disposal as it has historically, and will in the future, receive almost all of the dredged sediment (Condition 10.9) and will be the only site to receive sediment that will contain high silt content. The high volume of sediment disposal is important as this site is a very large ocean site that is subjected to large tidal and wind driven mixing and dilution of the deposited sediment. High silt increases the risk of turbidity and contaminant related effects, and condition 10.10 states that the high silt content sediment (>25%) will be deposited at site H on the seaward side, mitigating this risk. Further, the assessment of dredged sediment shows low levels of contaminants within these sediments.

Clean material from maintenance dredging of reach 1 and 2 (outside the harbour entrance) shall be deposited at Sites B and C (Condition 10.12) with high shell content to be deposited at site H.

On other occasions, and only as directed by the CEO of BoPRC, sediment shall be deposited at Sites A, B, or C (Condition 10.13) or be used for beach nourishment purposes (with nourishment occurring above and below mean high water springs) (Condition 10.14).

Therefore, as site H is the worst-case scenario, I consider that effects from deposition at other sites will be less than for those at site H.

5.2.3 Ngāti Pukenga

Issue

Uncertainty about cumulative effects over the term of the consent has been acknowledged by the Port's experts but water quality must be improved rather than further compromised.

Response

Uncertainty and cumulative effects are discussed in the response to common issues (Section 5.1). The conclusions from this report on effects of the dredging and disposal activity range from negligible to less than minor. Due to the restricted and sporadic nature of these activities, wider catchment effects are the primary cause of long-term changes in water quality in Tauranga Harbour.

Issue

Interpretation and application of UNEP FI (2022) needs reassessment regarding the scale and permanence of dredging impacts.

In terms of water quality, Ngāti Pukenga, in citing UNEP FI (2022), raised specific concerns:

1. Toxicants being released from sediment plumes (Section 5.9.2) – "The Port's experts rely on a narrow suite of analytes (primarily mercury in pipi tissue) to conclude that contaminant risks are negligible."
2. Seabed disturbance from bottom dredging can release stored carbon into the water column – a climate-relevant impact not considered in any of the Port's technical assessments.

Response

1. As described in Section 2.4 of this report, there has been a considerable assessment of toxicants in sediment for this assessment. This has included historic harbour-wide studies and supplementary studies undertaken specifically for this assessment. Further the range of toxicants assessed has been broad and exceeds[29] those recommended by UNEP FI (2022), including:
    a. Organic toxicants – organochlorine pesticides (OCPs); polycyclic aromatic hydrocarbons (PAHs);total petroleum hydrocarbons (TPH), polychlorinated biphenyls (PCBs), tributyltin (TBT) and triphenyltin (TPT).
    b. Metal/metalloid toxicants – arsenic, cadmium, chromium, copper, lead, mercury, nickel, zinc Zn, antimony, and silver.
    c. Total organic carbon.
    d. Size fraction (% mud, sand, and gravel).
    e. Nitrogen and Phosphorus.
    f. Emerging organic contaminants.

[29] Further, in scoping the information required to complete this water quality assessment, technical reports undertaken in Auckland, Napier and Gisborne were read to provide national relevance and context.

2. Organic carbon was measured in sediment collected for this assessment, ranging from the Port to sites near the ocean deposition site H (see **Figure 15**). For the majority of the sites (11/14), organic carbon was very low and below or at the detection limit (around 0.13g/100g). Three sites near the Port had higher organic carbon (0.38-1.00g/100g), however these are localised areas and the organic carbon concentration is still low. Therefore, I consider that risks associated with release of carbon into the water column will be very low.

5.2.4 Ngāi Tamarawaho

Issue

Water quality monitoring must be expanded to include a mauri-based framework designed with Ngāi Tamarāwaho. This framework would include scientific parameters and cultural indicators.

Response

In the proposed conditions, condition 15 (Water Quality), specifies measurement and management of turbidity only. I consider turbidity to be the most pragmatic and appropriate parameter for assessing real-time effects of dredging and disposal and allowing intervention, if required. Turbidity also encompasses suspended solids and water clarity.

Other parameters suggested by Ngāi Tamarawaho including dissolved oxygen, nutrients and contaminants have been assessed in this report, with potential for adverse effects concluded to be low to negligible. Therefore, I do not agree that these should be measured along with turbidity in consent conditions.

Inclusion of cultural indicators – including smell, colour, visual plume presence, kai confidence, observable sediment on kai areas, and hapū assessment of mauri – as water quality conditions would require assessment methods and qualitative or quantitative metrics to assess compliance. As far as I am aware these have not been provided by Ngāi Tamarawaho.

5.2.5 Waitaha

Issue

Waitaha requires water quality reporting that is transparent, plain-language and connected to cultural indicators. Monitoring data should not sit only in technical compliance reports. It must be made available to Waitaha in a form that supports kaitiaki assessment and decision-making.

Response

BoPRC water quality data are publicly available with periodic reports written and posted on their website. Data collected for this assessment are provided in Appendices of this report.

5.2.6 Ngāti Hangarau

Issue

We expect ongoing, hapū-led water quality monitoring that relates to this dredging in the first instance but allows for the monitoring of cumulative effects from multiple development projects.

Response

The water quality monitoring undertaken to date is related to the wider Tauranga Harbour (BoPRC) and the dredging activity (PoT). Cumulative effects from the dredging activities is discussed in Section 5.1.1. The assessment has considered effects from other activities that contribute to the current water quality state (or baseline).

6. Compliance with the Environment Court Practice Note 2023

I have read and agree to comply with the Code of Conduct for Expert Witnesses as set out in the Environment Court Consolidated Practice Note 2023.

7. References

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Appendix 1: PoTL turbidity measurements for dredging and disposal between 2015 and 2022.

Dredging

Date	Time	Location	Vessel	500m US	200m DS	Tide	Weather	Sea Condition	Wind Speed (Speed /Gust)	Wind Direction	Wave Height (Sig/Max)	Wave Period (Sec)
1/10/2015	10:55	Entrance	Brage R	0.4	0.6	Ebb	Fine	Calm		NE	0.5/1	7.5
3/10/2015	15:00	Entrance	Brage R	0.8	1.5	Ebb	Fine	Calm	5/5	NNE	.6/.8	6.7
5/10/2015	11:30	Entrance	Brage R	0.5	6.0	Flood	Fine	Choppy	3/4	SW	0.4/0.6	8
15/10/2015	11:35	Stella Passage	Brage R	1.5	5.8	Ebb	Fine	Calm	20/24	SW	N/A	N/A
19/10/2015	13:30	Entrance	Brage R	1.5	4.3	Ebb	Cloudy	Choppy	10/12	WSW	0.4/0.8	7.5
22/10/2015	14:00	Entrance	Brage R	1.1	1.6	Flood	Cloudy	Choppy	30/40	WNW	0.4/0.5	6.4
23/10/2015	13:45	Entrance	Brage R	0.8	0.9	Flood	Fine	Choppy	17/18	W	0.4/0.7	6.2
2/11/2015	12:30	Entrance	Brage R	0.6	9.9	Flood	Fine	Calm	16/18	NNW	0.4/0.6	10.1
5/11/2015	10:30	Cutter Channel	Brage R	1.6	2.4	Flood	Fine	Calm	7/7	S	0.1/0.2	0
6/11/2015	17:15	Entrance	Brage R	0.5	0.7	Ebb	Fine	Slight Chop	12/16	NW	0.5/0.8	7.1
16/11/2015	10:45	Entrance	Brage R	1.1	3.1	Flood	Rain	Calm / Swell	5/5	NNE	0.5/0.7	7.3
18/11/2015	8:30	Cutter Channel	Brage R	2.3	2.9	Flood	Fine	Choppy	8/9	WSW	0.2/0.3	0
20/11/2015	13:00	Maunganui Rds	Brage R	3.0	4.1	Flood	Fine	Choppy	24/27	NNW	0.3/0.4	0
1/12/2015	8:30	Cutter Channel	Brage R	2.2	5.2	Flood	Fine	Calm	24/29	ENE	Flat	0
3/12/2015	12:15	Cutter Channel	Brage R	2.5	4.4	Flood	Fine	Calm	10/12	NE	Flat	0
4/12/2015	16:05	Cutter Channel	Brage R	2.9	2.0	Flood	Fine	Calm	7/8	NE	Flat	0
29/12/2015	9:00	Maunganui Rds	Brage R	2.2	2.5	Flood	Fine	Choppy		W	0.3/0.4	0
5/01/2016	14:10	Entrance	Brage R	2.6	3.1	Flood	Fine	swell		NE	1	7.8
7/01/2016	14:25	Entrance	Brage R	2.6	2.5	Flood	Fine	1.1m swell	7/9	NE	1	7.1
8/01/2016	8:15	Maunganui Rds	Brage R	3.1	2.7	Ebb	Rain	Choppy	14/14	NNW	0.4/0.8	N/A
11/01/2016	13:15	Stella Passage	Balder R	7.3	7.2	Ebb	Cloudy	Calm		ENE	N/A	N/A
14/01/2016	8:15	Stella Passage	Balder R	5.9	6.8	Ebb	Fine	Calm	15/18	N	N/A	N/A
15/01/2016	10:59	S. Maunganui Roads	Balder R	2.3	2.1	Flood	Cloudy	Calm	9/12	NW	N/A	N/A
19/01/2016	9:15	Cutter Channel	Brage R	4.5	5.2	Ebb	Fine	Calm	2/3	W	Flat	0
19/01/2016	9:40	Stella Passage	Balder R	6.3	8.5	Ebb	Fine	Calm		W	Flat	0

Date	Time	Location	Vessel	500m US	200m DS	Tide	Weather	Sea Condition	Wind Speed (Speed /Gust)	Wind Direction	Wave Height (Sig/Max)	Wave Period (Sec)
20/01/2016	9:25	Entrance	Brage R	2.5	2.6	Ebb	Fine	1.2 m Swell	2/3	SSE	1	9.5
20/01/2016	9:45	Stella Passage	Balder R	4.7	4.2	Ebb	Fine	Calm		W	Flat	0
22/01/2016	9:20	Entrance	Brage R	4.8	5.2	Ebb	Fine	1.6 m Swell	2/3	N	1	9.5
22/01/2016	9:50	Stella Passage	Balder R	4.2	9.1	Ebb	Fine	Calm		N	Flat	0
25/01/2016	16:30	Entrance	Brage R	1.8	5.4	Flood	Fine	1.7 m Swell		NNE	1.7/2.8	9.4
25/01/2016	8:15	Maunganui Rds	Balder R	2.3	2.5	Flood	Fine	Calm	8/9	NE	N/A	N/A
25/01/2016	8:25	Stella Passage	Gungner R	3.8	7.6	Flood	Fine	Calm	7/8	NE	N/A	N/A
27/01/2016	8:20	Entrance	Brage R	3.8	5.8	Flood	Fine	2.4 m Swell	8/10	E	2.4/3.5	9.4
27/01/2016	9:20	Maunganui Rds	Balder R	5.1	4.6	Flood	Fine	Calm		E	N/A	N/A
29/01/2016	1358	Entrance	Brage R	3.9	9.5	Ebb	Fine	Choppy, 1.5m Swell		N	1.1/1.7	8.5
29/01/2016	1336	Sulphur Pt	Gungner R	4.8	5.8	Ebb	Fine	Calm	10/12	N	N/A	N/A
30/01/2016	17:45	Maunganui Rds	Balder R	5.9	6.1	Ebb	Fine	Choppy		NNW	0.3/0.4	N/A
9/02/2016	8:40	Entrance	Brage R	2.8	3.3	Flood	Fine	1.5 m Swell	5/6	S	1.2/1.7	7.7
9/02/2016	8:20	Maunganui Rds	Balder R	4.7	12.8	Flood	Fine	Slight chop		S	N/A	N/A
10/02/2016	9:15	Entrance	Brage R	1.0	1.1	Flood	Fine	1.0 m Swell	5/6	S	1.2/1.7	7.7
10/02/2016	9:25	Maunganui Rds	Balder R	3.8	2.9	Flood	Fine	Slight chop		S	N/A	N/A
12/02/2016	10:45	Entrance	Brage R	1.5	1.0	Flood	Fine	1.0 m Swell		ENE	0.6/0.9	7.9
15/02/2016	9:00	Entrance	Balder R	2.7	6.8	Flood	Fine	1.5 m Swell	13/18	ENE	1.4/1.9	7.9
15/02/2016	8:35	Stella Passage	Gungner R	3.8	7.6	Flood	Fine	Slight chop		ENE	0.2/0.3	N/A
22/02/2016	9:30	Entrance	Balder R	1.9	2.3	Ebb	Fine	1.5 m Swell	8/11	SE	1.2/1.7	9
22/02/2016	10:20	Stella Passage	Gungner R	3.9	7.9	Ebb	Fine	Calm		E	N/A	N/A
24/02/2016	9:30	Stella Passage	Balder R	3.0	8.5	Ebb	Fine	Calm	8/11	N	Flat	0
24/02/2016	10:20	Stella Passage	Gungner R	4.8	5.9	Ebb	Fine	Calm		E	N/A	N/A
26/02/2016	10:40	Pane Pane	Brage R	3.7	5.9	Ebb	Fine	Calm		SW	Flat	0
26/02/2016	11:55	Stella Passage	Balder R	5.1	4.8	Ebb	Fine	Calm	2/3	SW	Flat	0
26/02/2016	11:30	Stella Passage	Gungner R	5.4	8.1	Ebb	Fine	Calm	2/3	SW	Flat	0
7/03/2016	8:40	Pane Pane	Brage R	5.3	4.7	Ebb	Fine	Calm		SW	Flat	0
7/03/2016	9:25	S/Pt Wharf	Gungner R	4.5	7.1	Ebb	Fine	Calm	2/3	SW	Flat	0
7/03/2016	10:00	Stella Passage	Balder R	5.8	7.2	Ebb	Fine	Calm	2/3	SW	Flat	0

Date	Time	Location	Vessel	500m US	200m DS	Tide	Weather	Sea Condition	Wind Speed (Speed /Gust)	Wind Direction	Wave Height (Sig/Max)	Wave Period (Sec)
9/03/2016	8:30	Pane Pane	Brage R	5.0	2.9	Flood	Fine	Calm		SW	Slight Chop	0
9/03/2016	14:20	S/Pt Wharf	Gungner R	8.2	8.1	Slack	Fine	Calm	12/13	NNW	Flat	0
9/03/2016	10:00	Stella Passage	Balder R	5.8	7.2	Ebb	Fine	Calm	7/9	SW	Flat	0
11/03/2016	8:45	Cutter Channel	Balder R	3.0	2.7	Flood	Cloudy	Calm	7/9	W	Flat	0
11/03/2016	8:55	Entrance	Brage R	2.6	2.7	Flood	Cloudy	Slight Chop		WNW	Slight Chop	0
11/03/2016	8:30	S/Pt Wharf	Gungner R	3.9	25.1	Flood	Cloudy	Calm	8/9	W	Flat	0
21/03/2016	8:30	Stella - toe line	Gungner R	4.2	10.2	Ebb	Cloudy	Calm		E	Flat	0
22/03/2016	8:15	Pane Pane/Cutter	Brage R	4.8	4.0	Flood	Fine	Slight Chop		ENE	Slight Chop	0
23/03/2016	8:15	Otumoetai	Brage R	5.5	7.1	Flood	Fine	Slight Chop	12/13	NE	Slight Chop	0
4/04/2016	15:00	Cutter Channel	Balder R	4.0	3.4	Flood	Fine	Calm	7/9	W	Slight Chop	0
4/04/2016	15:10	Entrance	Brage R	2.5	4.4	Flood	Fine	Calm		W	Slight Chop	0
4/04/2016	14:30	Tanker Berth	Gungner R	3.4	11.7	Flood	Fine	Calm	12/13	W	Slight Chop	0
6/04/2016	13:05	Entrance	Balder R	3.1	3.7	Flood	Fine	Calm	12/13	W	Slight Chop	0
6/04/2016	13:15	Entrance	Brage R	2.0	9.7	Flood	Fine	Calm	7/9	W	Slight Chop	0
6/04/2016	14:30	S/Pt toeline	Gungner R	3.4	11.7	Flood	Fine	Calm		W	Slight Chop	0
8/04/2016	8:35	Entrance	Brage R	2.4	2.3	Ebb	Fine	Mod. Chop	7/9	NNW	0.4/0.5	8.8
8/04/2016	14:14	Maunganui Rds	Balder R	5.3	6.7	Ebb	Fine	N/A	12/13	NNW	0	0
8/04/2016	9:05	S/Pt toeline	Gungner R	4.6	5.2	Ebb	Fine	N/A		NNW	0	0
13/04/2016	14:50	Entrance	Gungner R	2.6	3.6	Ebb	Fine	N/A		NNW	0	0
18/04/2016	13:15	Entrance	Brage R	2.5	2.9	Ebb	Fine	Mod. Chop		NNW	0.4/0.5	8.8
18/04/2016	13:00		Balder R	3.6	4.3	Ebb	Fine	N/A	12/13	NNW	0	0
20/04/2016	14:00	Cutter Channel	Balder R	3.0	2.6	Flood	Fine	N/A	09/10	SW	0	0
20/04/2016	13:30	Entrance	Brage R	2.2	2.5	Flood	Fine	1m Swell	9/10	SW	1.2/0.9	7.4
20/04/2016	13:00	Entrance	Gungner R	2.8	2.6	Flood	Fine	1m Swell		SW	1.2/0.9	7.4
22/04/2016	11:00	Stella Passage (South)	Balder R	4.4	4.4	Ebb	Fine	Calm		E	Flat	0
27/04/2016	11:15	B Buoy	Balder R	2.5	16.5	Flood	Fine	Calm		W	Slight swell	0
2/05/2016	13:05	Pane Pane	Balder R	1.8	6.7	Flood	Fine	Calm		NNW	0	0
3/05/2016	13:20	Entrance	Balder R	1.5	2.4	Flood	Fine	Calm	7/9	NNW	0	0
3/05/2016	13:15	Entrance	Gungner R	1.6	2.1	Flood	Fine	Calm		NNW	0	0
4/05/2016	8:50	Entrance	Balder R	2.2	3.4	Flood	Fine	Calm		SW	Flat	0

Date	Time	Location	Vessel	500m US	200m DS	Tide	Weather	Sea Condition	Wind Speed (Speed /Gust)	Wind Direction	Wave Height (Sig/Max)	Wave Period (Sec)
6/05/2016	8:50	Stella Passage	Balder R	5.7	10.1	Ebb	Fine	Calm	2/3	SW	Flat	0
13/05/2016	8:50	Entrance	Balder R	3.0	8.2	Flood	Fine	Sharp swell & chop		WNW	1	0
16/05/2016	13:20	Entrance	Balder R	3.0	8.3	Flood	Fine	Calm	11/10	NW	0.5/0.4	0
16/05/2016	13:15	Entrance	Gungner R	2.4	2.2	Flood	Fine	Calm		NW	0.5/0.4	0
20/05/2016	9:05	Entrance	Balder R	5.0	5.0	Flood	Fine	Calm		NW	0.7/0.6	0
27/05/2016	9:20	Entrance	Gungner R	1.8	2.4	Flood	Fine	Swell & chop		NW	0.5/0.4	0
30/05/2016	8:40	Maunganui Rds	Balder R	4.5	11.6	Flood	Fine	Slight chop	16/15	WNW	0.5/0.4	0
30/05/2016	8:40	Stella Passage	Gungner R	4.8	11.5	Flood	Fine	Slight chop		WNW	0.5/0.4	0
1/06/2016	12:20	Entrance	Gungner R	1.6	5.7	Flood	Fine	Calm		E	Flat	0
1/06/2016	12:00	Maunganui Rds	Balder R	3.2	4.0	Flood	Fine	Calm	12/13	ESE	0.6/0.3	0
7/06/2016	9:45	North West rock	Gungner R	4.1	3.7	Ebb	Fine	Swell		E	Flat	0
7/06/2016	9:45	Pane Pane	Balder R	3.9	3.0	Ebb	Fine	Calm	12/13	ESE	0.6/0.3	0
15/06/2016	12:20	North West rock	Gungner R	7.7	3.5	Flood	Fine	Flat		WSW	Flat	0
17/06/2016	13:00	North West rock	Gungner R	2.0	2.3	Flood	Fine	Flat	12/13	WSW	Flat	0
20/06/2016	12:00	Tanea	Gungner R	3.1	3.0	Ebb	Fine	Flat		calm	Flat	0
21/06/2016	10:00	Tanea	Gungner R	1.8	2.0	Ebb	Overcast	Flat	0	ESE	Flat	0
24/06/2016	9:00	Nth end S/Pt	Gungner R	8.6	5.9	Flood	Fine	Flat	11/13	WSW	Flat	0
30/06/2016	11:00	Tanea	Gungner R	4.3	4.2	Ebb	Overcast	Flat	10/12	ESE	Flat	0
7/07/2016	14:30	Stella Passage	Balder R	5.4	5.2	Ebb	Overcast	Calm		E	Slight chop	0
11/07/2016	11:05	Widening	Balder R	2.6	5.1	Ebb	Fine	Calm	19/20	SE	Flat	0
12/07/2016	13:40	8/9 Berth - Maunganui	Gungner R	2.5	3.7	Ebb	Fine	Calm		E	Flat	0
12/07/2016	13:50	Pane Pane	Balder R	1.9	3.6	Ebb	Fine	Swell	10/11	E	Swell	0
13/07/2016	14:30	8/9 Berth - Maunganui	Gungner R	2.2	6.5	Ebb	Overcast	Calm		E	Flat	0
13/07/2016	14:20	Pane Pane	Balder R	3.5	4.1	Ebb	Overcast	Swell	10/11	E	Swell	0
25/07/2016	14:25	Widening	Balder R	4.3	6.8	Ebb	Fine	Calm		SE	Flat	0
2/08/2016	8:40	Stella Passage	Gungner R	4.8	4.6	Ebb	Fine	Slight chop	7/8	WSW	Flat	0
2/08/2016	10:30	Widening	Balder R	3.0	8.7	Ebb	Fine	Slight chop	7/8	WSW	Flat	0
5/08/2016	10:30	Widening	Balder R	2.2	3.3	Ebb	Fine	Calm		ESE	Flat	0
9/08/2016	13:30	Widening	Balder R	2.5	2.8	Ebb	Fine	Calm		ESE	Flat	0

Date	Time	Location	Vessel	500m US	200m DS	Tide	Weather	Sea Condition	Wind Speed (Speed /Gust)	Wind Direction	Wave Height (Sig/Max)	Wave Period (Sec)
2/06/2017	15:50	E1	Pelican	2.5	2.5	Ebb		1.5m Steep swell		ESE	1.5m Steep swell	5.4
6/06/2017	15:30	E1	Pelican	1.4	4.0	Flood		0.6 Swell	16/19	W	0.6 Swell	
8/06/2017	11:30	H2	Pelican	2.8	3.6	Ebb		Calm		SW	Slight chop	
19/06/2017	11:30	H3	Pelican	1.9	2.6	Flood		Calm		ESE	Slight chop	
27/09/2017	10:30	Tanker Berth	Albatros	2.9	5.5	Flood		Calm		SW	Flat	
1/06/2018	11:10	E2	Albatros	2.2	2.9	Ebb		Slight Chop	15/13	ESE	0.3/0.5	
5/06/2018	16:20	E5	Albatros	5.0	5.4	Ebb		Slight Chop	21/25	WSW	1.06/1.82	
8/06/2018	11:20	E2	Albatros	2.5	4.7	Flood		Calm		SE	0.2/0.3	
20/06/2018	10:30	H4	Albatros	3.4	6.9	Flood		Slight Chop	7/10	ESE	0.1/0.2	
22/06/2018	9:30	H1	Albatros	4.3	7.2	Ebb		Slight Chop	8/9	SSW	0.1/0.2	
25/06/2018	10:50	H9	Albatros	4.1	18.8	Ebb		Slight Chop	8/9	SSW	0.1/0.2	
27/06/2018	9:40	E1	Albatros	3.4	5.5	Ebb		Glassy		W	0.1/0.2	
29/06/2018	9:40	E5	Albatros	2.7	2.4	Ebb		Glassy		W	0.1/0.2	
2/07/2018	11:10	E5	Albatros	1.6	2.9	Ebb		Slight Chop	7/10	NNW	0.2/0.3	
5/07/2018	10:45	H2	Albatros	2.9	7.6	Ebb		Glassy		W	0.1/0.2	
7/06/2019	12:15	E2	Albatros	2.3	3.6	Ebb		Slight Chop	7/10	W	0.1/0.2	
10/06/2019	8:45	H2	Albatros	1.2	1.3	Flood		Slight Chop	8/9	W	0.1/0.2	
13/06/2019	11:30	E1	Albatros	1.9	1.3	Flood		Slight Chop	4/5	S	Flat	
14/06/2019	13:00	H5	Albatros	2.9	4.2	Flood		Slight Chop	7/10	SW	0.1/0.1	
17/06/2019	10:00	E2	Albatros	2.0	2.5	Ebb		Slight Chop	10/13	WNW	0.2/0.3	
20/06/2019	9:15	H2	Albatros	1.2	1.1	Flood		Slight Chop	3/4	SE	0.1/0.1	
30/06/2020	14:35	E1	Albatros	1.7	3.5	Flood		1m Swell	14/16	SSE	0.9/1.3	
1/07/2020	14:35	E2	Albatros	4.7	4.2	Ebb		Slight Chop	13/15	SW	0.6/0.7	
2/07/2020	14:35	E2	Albatros	1.7	3.5	Ebb		Slight Chop	19/22	WSW	0.3/0.5	
8/07/2020	8:45	E1	Albatros	4.7	7.0	Flood		1m Swell	20/22	NW	1.1/1.75	
9/07/2020	8:50	E1	Albatros	2.3	3.3	Flood		Flat	20/22	NW	1.1/1.75	
10/07/2020	8:30	H4	Albatros	2.3	2.7	Flood		Flat/calm	8/9	SSW	Flat	
13/07/2020	9:25	E1	Albatros	2.3	1.9	Flood		Slight Chop	15/16	NNW	0.6/0.9	
15/07/2020	8:40	E1	Albatros	1.9	1.6	Ebb		FLAT	6/7	SE	0.3/0.5	

Date	Time	Location	Vessel	500m US	200m DS	Tide	Weather	Sea Condition	Wind Speed (Speed /Gust)	Wind Direction	Wave Height (Sig/Max)	Wave Period (Sec)
17/07/2020	8:30	H2	Albatros	2.3	3.0	Ebb		Slight Chop	14/17	ESE	0.3/0.5	
20/07/2020	8:30	E2	Albatros	2.3	3.0	Ebb		0.5m Swell	14/17	ESE	0.3/0.5	
1/07/2021	12:50	E1	Albatros	1.4	1.9	Flood		FLAT	15/16	NNW	0.3/0.4	
2/07/2021	11:50	E1	Albatros	1.5	1.6	Flood		FLAT	15/16	NNW	0.6/0.9	
5/07/2021	13:25	E1	Albatros	2.3	4.2	Flood		FLAT	15/16	NNW	0.6/0.9	
5/07/2021	13:25	E1	Albatros	2.3	4.2	Flood		FLAT	15/16	NNW	0.6/0.9	
5/07/2021	13:25	E1	Albatros	2.3	4.2	Flood		FLAT	15/16	NNW	0.6/0.9	
5/07/2021	13:25	E1	Albatros	2.3	4.2	Flood		FLAT	15/16	NNW	0.6/0.9	
8/07/2021	8:30	E3	Albatros	6.5	15.2	Flood		FLAT	15/16	NNW	0.6/0.9	
9/07/2021	13:25	E1	Albatros	2.3	4.2	Flood		FLAT	15/16	NNW	0.6/0.9	
27/06/2022	11:00	E2	Albatros	1.4	1.6	Ebb		FLAT	10/10	SW	0.5/0.9	
4/07/2022	9:45	E2	Albatros	1.0	3.0	Ebb		FLAT	6/7	W	0.4/0.6	
5/07/2022	9:30	E2	Albatros	1.0	0.9	Flood		FLAT	10/13	SEE	0.4/0.7	
6/07/2022	8:40	E5	Albatros	1.2	2.0	Flood		FLAT	7/10	W	0.9/1.3	
7/07/2022	8:30	E5	Albatros	1.6	1.7	Flood		FLAT	7/8	SSE	0.9/1.3	
13/07/2022	14:00	E5	Albatros	5.3	6.1	Flood		FLAT	10/15	NNW	1.8/2.5	
15/07/2022	8:50	SPT	Albatros	3.5	3.7	Flood		slight swell	9/11	SWW	1.3/2.1	
20/07/2022	8:30	H3	Albatros	3.1	2.6	Flood		FLAT	5/6	NNW	1.8/2.3	

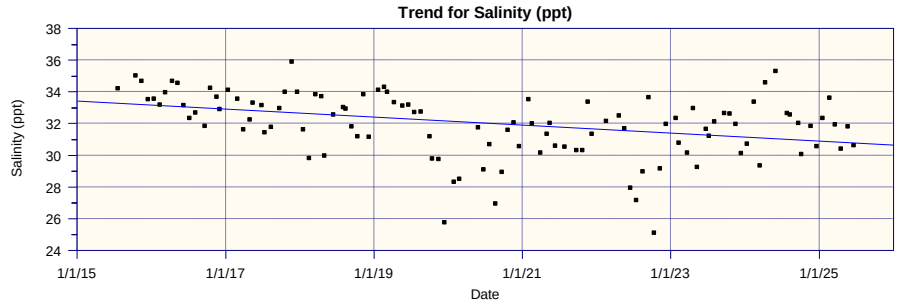
Deposition

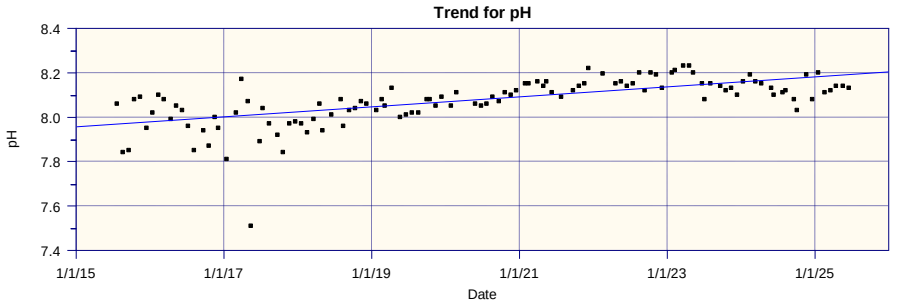
Date	North-West	North-East	South-East	South-West
6-Oct-15	0.5	0.2	0.3	0.6
14-Oct-15	0.4	0.6	0.8	1.3
19-Oct-15	0.6	0.7	0.5	0.6
16-Nov-15	0.9	0.6	0.5	0.9
23-Nov-15	1.7	1.2	1.3	1.5
29-Dec-15	1.7	1.6	1.5	1.5
5-Jan-16	2.1	2.1	1.9	1.8
12-Jan-16	1.4	1.2	1.8	3.2
10-Feb-16	1.0	0.7	1.1	1.1
22-Feb-16	1.2	1.4	0.7	0.9
26-Feb-16	2.6	1.6	2.1	2.6
30-Mar-16	2.3	2.0	2.4	3.6
6-Apr-16	1.4	2.1	1.7	1.7
14-Apr-16	1.1	2.9	1.9	1.8
13-May-16	2.7	1.9	2.1	2.5
19-May-16	2.6	1.1	1.0	1.8
27-May-16	1.6	1.0	1.2	1.4
15-Jun-16	2.0	1.7	1.6	2.3
21-Jun-16	1.6	1.4	1.7	1.7
30-Jun-16	1.5	1.1	1.1	1.5
25-Jul-16	2.3	2.4	2.0	2.8
5-Aug-16	2.1	1.6	1.6	2.0
1-Jun-18	1.8	1.5	1.6	1.8
28-Jun-18	1.6	1.7	1.7	1.8
14-Jun-19	1.5	1.0	1.2	1.3
10-Jul-20	2.0	1.3	1.4	2.3
27-Jun-22	2.1	1.8	1.9	1.9

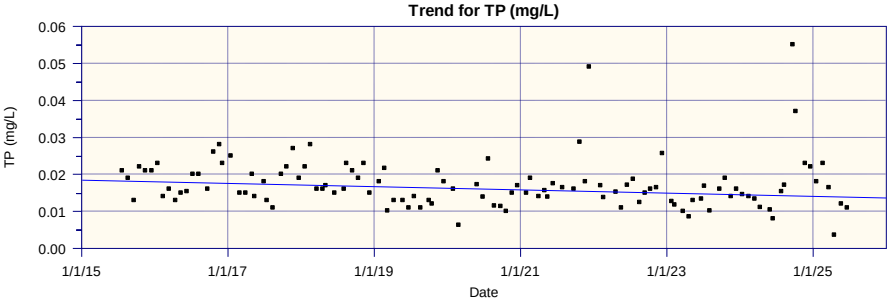
Appendix 2: Tauranga Harbour water quality temporal trend statistics and significant trend graphs (significant trends highlighted green and meaningful trends highlighted red (increasing) or blue (decreasing).

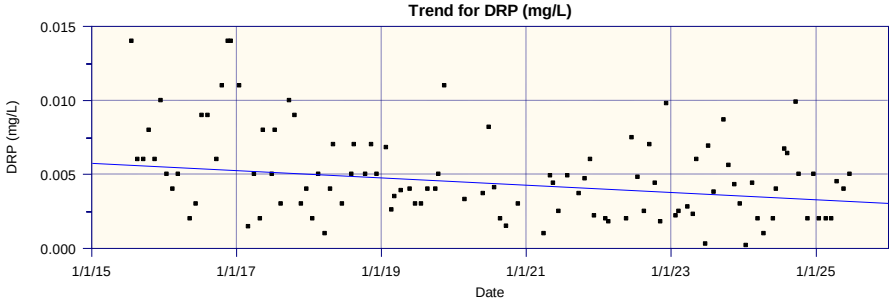
Toll Bridge Marina

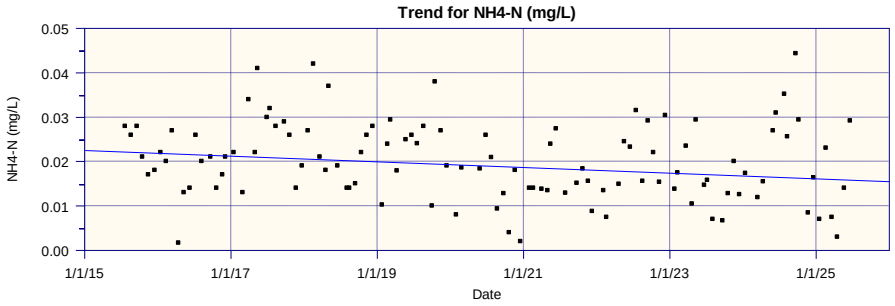
Site	Variable	Unit	Method	Mean	Maximum	Minimum	Median value	P	Percent annual change	Trend
Toll Bridge Marina	Clarity	m	Mann-Kendall	1.8	5.4	0.4	1.7	0.336	1.9	↑
Toll Bridge Marina	Turbidity	NTU	Mann-Kendall	2.1	5.9	0.7	2.0	0.877	-0.2	↓
Toll Bridge Marina	TSS	mg/L	Mann-Kendall	10.8	42.0	3.4	9.4	0.000	-8.0	↓
Toll Bridge Marina	Sp Cond	µS/cm	Mann-Kendall	50181	54190	41759	50600	0.054	-0.4	↓
Toll Bridge Marina	Salinity	ppt	Mann-Kendall	31.9	35.9	25.1	32.0	0.000	-0.8	↓
Toll Bridge Marina	Temp	°C	Seasonal Kendal	17.3	23.6	12.4	17.2	0.238	0.3	↑
Toll Bridge Marina	pH		Mann-Kendall	8.07	8.23	7.51	8.08	0.000	0.3	↑
Toll Bridge Marina	DO	mg/L	Seasonal Kendal	7.8	10.5	6.3	7.8	0.092	0.4	↑
Toll Bridge Marina	DO	%	Mann-Kendall	98	113	84	98	0.098	0.3	↑
Toll Bridge Marina	TP	mg/L	Seasonal Kendal	0.017	0.055	0.004	0.016	0.003	-2.7	↓
Toll Bridge Marina	DRP	mg/L	Seasonal Kendal	0.005	0.014	0.000	0.004	0.003	-5.6	↓
Toll Bridge Marina	TN	mg/L	Seasonal Kendal	0.222	0.426	0.149	0.214	0.439	-0.6	↓
Toll Bridge Marina	NNN	mg/L	Seasonal Kendal	0.029	0.106	0.001	0.021	0.123	-2.8	↓
Toll Bridge Marina	NH_4-N	mg/L	Mann-Kendall	0.020	0.044	0.002	0.019	0.022	-3.3	↓
Toll Bridge Marina	DIN	mg/L	Seasonal Kendal	0.044	0.123	0.002	0.033	0.650	3.8	↑
Toll Bridge Marina	*Chla*	µg/L	seasonal Kendal	1.10	3.40	0.30	0.90	0.006	4.5	↑
Toll Bridge Marina	FC	cfu/100mL	Seasonal Kendal	10	210	0	4	0.640	0.0	→
Toll Bridge Marina	Ent	cfu/100mL	Seasonal Kendal	7	80	0	1	0.005	-14.1	↓
Toll Bridge Marina	*E coli*	cfu/100mL	Mann-Kendall	8	198	0	2	0.312	0.0	→

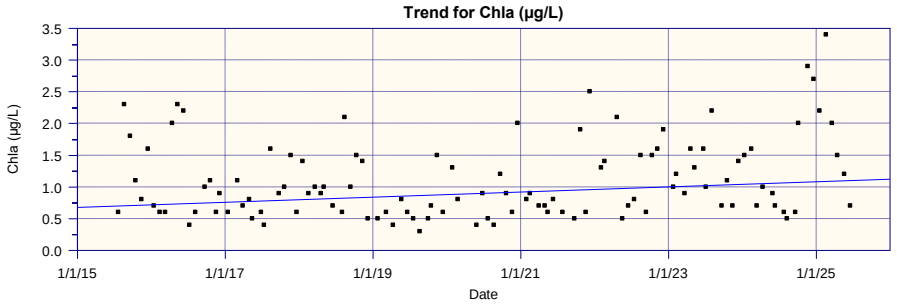

Trend for Salinity (ppt)
Salinity (ppt)
38
36
34
32
30
28
26
24
1/1/15
1/1/17
1/1/19
1/1/21
1/1/23
1/1/25
Date

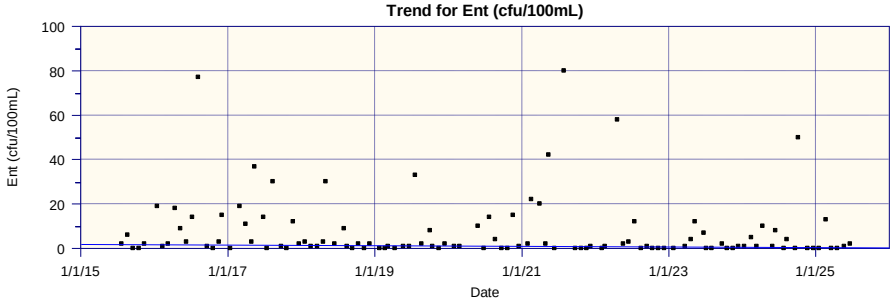

Trend for pH
pH
8.4
8.2
8.0
7.8
7.6
7.4
1/1/15
1/1/17
1/1/19
1/1/21
1/1/23
1/1/25
Date


Trend for TP (mg/L)
TP (mg/L)
0.06
0.05
0.04
0.03
0.02
0.01
0.00
1/1/15
1/1/17
1/1/19
1/1/21
1/1/23
1/1/25
Date


Trend for DRP (mg/L)
DRP (mg/L)
0.015
0.010
0.005
0.000
1/1/15
1/1/17
1/1/19
1/1/21
1/1/23
1/1/25
Date

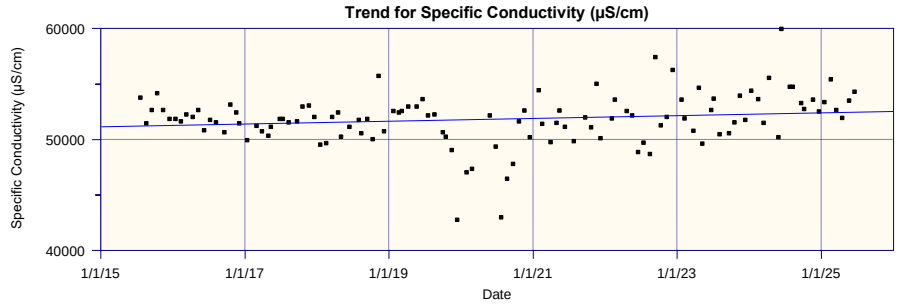

Trend for NH4-N (mg/L)
NH4-N (mg/L)
0.05
0.04
0.03
0.02
0.01
0.00
1/1/15
1/1/17
1/1/19
1/1/21
1/1/23
1/1/25
Date

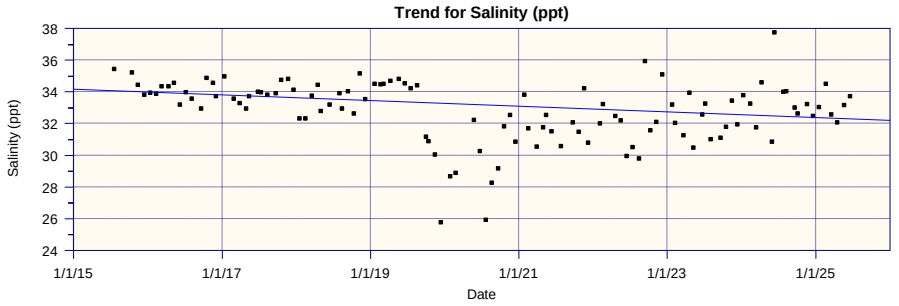

Trend for Chla (µg/L)
Chla (µg/L)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1/1/15
1/1/17
1/1/19
1/1/21
1/1/23
1/1/25
Date

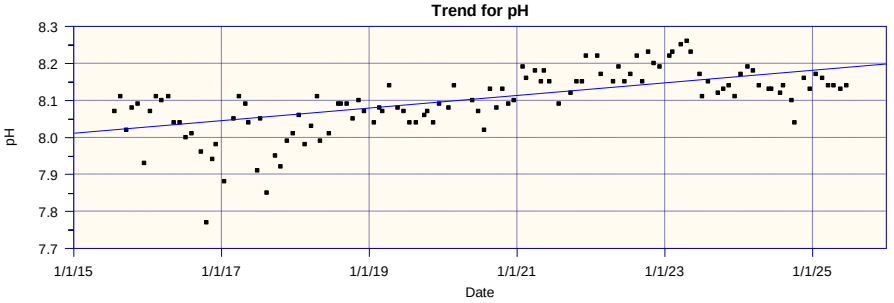

Trend for Ent (cfu/100mL)
Ent (cfu/100mL)
100
80
60
40
20
0
1/1/15
1/1/17
1/1/19
1/1/21
1/1/23
1/1/25
Date

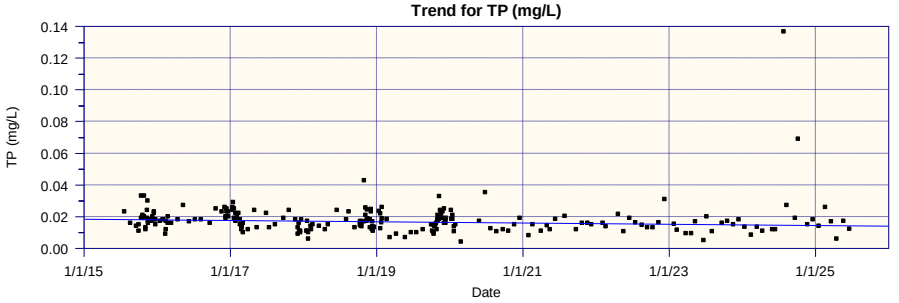
Mount Manganui

Site	Variable	Unit	Method	Mean	Maximum	Minimum	Median value	P	Percent annual change	Trend
Mount Manganui	Clarity	m	Seasonal Kendall	1.9	6.4	0.5	1.7	0.563	-0.9	↓
Mount Manganui	Turbidity	NTU	Seasonal Kendall	2.4	16.0	0.4	1.9	0.061	3.2	↑
Mount Manganui	TSS	mg/L	Seasonal Kendall	13.3	63.5	2.0	10.6	0.262	-1.8	↓
Mount Manganui	Sp Cond	µS/cm	Mann-Kendall	51773	59931	42700	51815	0.031	0.2	↑
Mount Manganui	Salinity	ppt	Mann-Kendall	32.8	37.7	25.8	33.2	0.001	-0.5	↓
Mount Manganui	Temp	°C	Seasonal Kendall	18.0	24.9	12.0	17.8	0.686	-0.1	↓
Mount Manganui	pH		Seasonal Kendall	8.10	8.26	7.77	8.11	0.000	0.2	↑
Mount Manganui	DO	mg/L	Seasonal Kendall	8.0	10.6	5.3	7.9	0.274	0.3	↑
Mount Manganui	DO	%	Mann-Kendall	102	130	63	100	0.655	0.1	↑
Mount Manganui	TP	mg/L	Seasonal Kendall	0.018	0.137	0.004	0.017	0.007	-2.3	↓
Mount Manganui	DRP	mg/L	Seasonal Kendall	0.005	0.019	0.000	0.005	0.170	-2.4	↓
Mount Manganui	TN	mg/L	Seasonal Kendall	0.216	0.374	0.119	0.208	0.104	-1.4	↓
Mount Manganui	NNN	mg/L	Seasonal Kendall	0.024	0.120	0.000	0.016	0.266	-2.1	↓
Mount Manganui	NH_4-N	mg/L	Seasonal Kendall	0.015	0.050	0.000	0.014	0.992	0.0	→
Mount Manganui	DIN	mg/L	Seasonal Kendall	0.031	0.089	0.000	0.023	0.053	13.0	↑
Mount Manganui	*Chla*	µg/L	Mann-Kendall	1.36	3.70	0.30	1.10	0.173	2.3	↑
Mount Manganui	FC	cfu/100mL	Mann-Kendall	32	1300	0	5	0.569	0.0	→
Mount Manganui	Ent	cfu/100mL	Seasonal Kendall	17	190	0	3	0.337	0.0	→
Mount Manganui	*E coli*	cfu/100mL	Seasonal Kendall	20	620	0	2	0.357	0.0	→


Trend for Specific Conductivity (µS/cm)
Specific Conductivity (µS/cm)
60000
50000
40000
1/1/15
1/1/17
1/1/19
1/1/21
1/1/23
1/1/25
Date

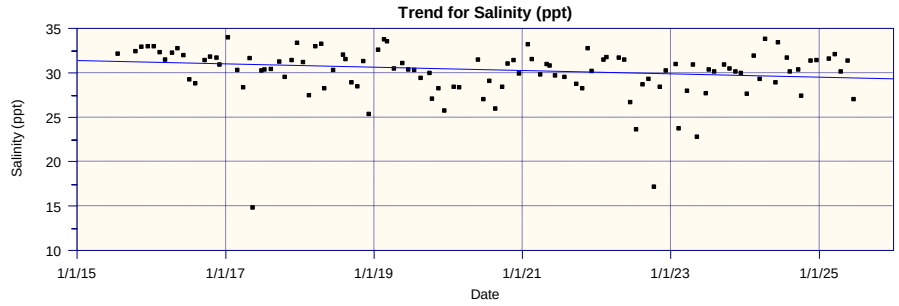

Trend for Salinity (ppt)
Salinity (ppt)
38
36
34
32
30
28
26
24
1/1/15
1/1/17
1/1/19
1/1/21
1/1/23
1/1/25
Date

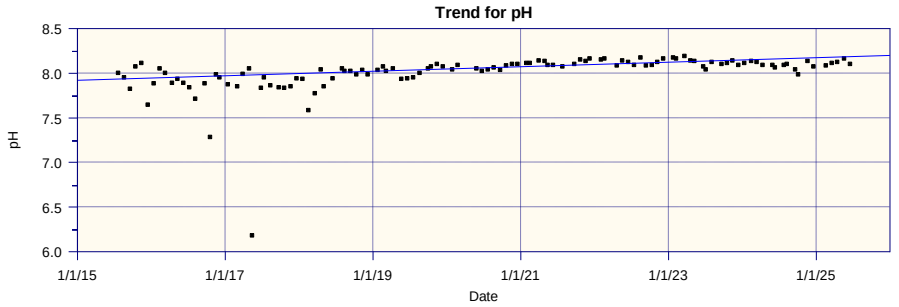

Trend for pH
pH
8.3
8.2
8.1
8.0
7.9
7.8
7.7
1/1/15
1/1/17
1/1/19
1/1/21
1/1/23
1/1/25
Date

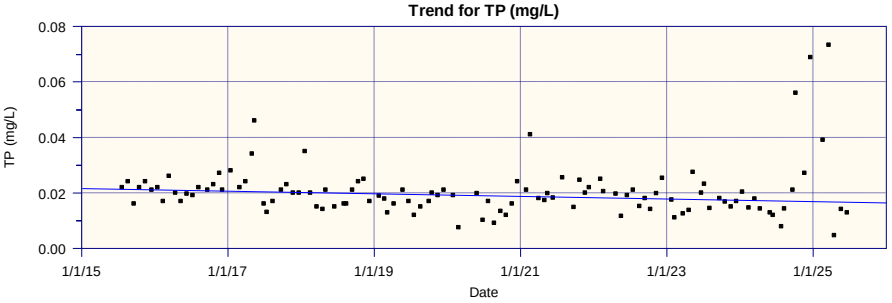

Trend for TP (mg/L)
TP (mg/L)
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
1/1/15
1/1/17
1/1/19
1/1/21
1/1/23
1/1/25
Date

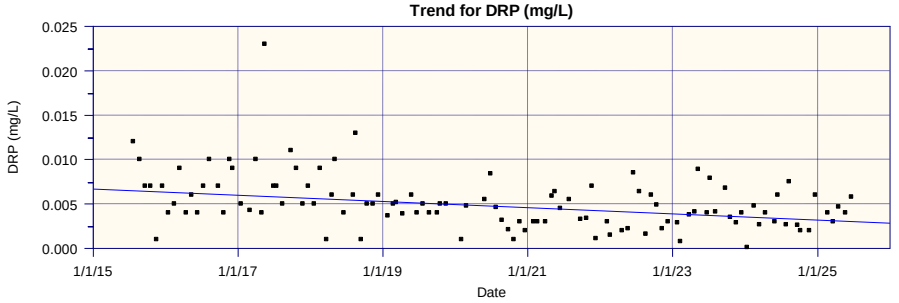
Maungatapu Bridge

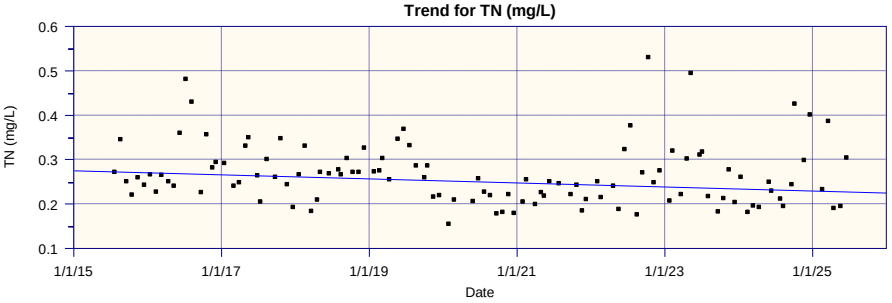
Site	Variable	Unit	Method	Mean	Maximum	Minimum	Median value	P	Percent annual change	Trend
Maungatapu Bridge	Clarity	m	Mann-Kendall	1.3	3.3	0.2	1.2	0.090	-2.8	↓
Maungatapu Bridge	Turbidity	NTU	Seasonal Kendall	3.9	34.8	0.9	2.9	0.318	1.7	↑
Maungatapu Bridge	TSS	mg/L	Mann-Kendall	14.6	78.5	2.8	11.0	0.908	-0.2	↓
Maungatapu Bridge	Sp Cond	µS/cm	Mann-Kendall	47747	54365	17700	48800	0.251	0.2	↑
Maungatapu Bridge	Salinity	ppt	Mann-Kendall	30.0	34.0	14.8	30.4	0.005	-0.6	↓
Maungatapu Bridge	Temp	°C	Seasonal Kendall	17.3	24.0	11.5	17.3	0.305	0.3	↑
Maungatapu Bridge	pH		Mann-Kendall	8.01	8.19	6.18	8.06	0.000	0.3	↑
Maungatapu Bridge	DO	mg/L	Seasonal Kendall	7.8	11.0	4.4	7.8	0.083	-0.5	↓
Maungatapu Bridge	DO	%	Seasonal Kendall	96	124	51	96	0.885	0.0	→
Maungatapu Bridge	TP	mg/L	Seasonal Kendall	0.020	0.073	0.005	0.019	0.010	-2.4	↓
Maungatapu Bridge	DRP	mg/L	Seasonal Kendall	0.005	0.023	0.000	0.005	0.000	-7.3	↓
Maungatapu Bridge	TN	mg/L	Mann-Kendall	0.265	0.530	0.155	0.250	0.019	-1.8	↓
Maungatapu Bridge	NNN	mg/L	Seasonal Kendall	0.046	0.264	0.001	0.029	0.229	-2.4	↓
Maungatapu Bridge	NH_4-N	mg/L	Seasonal Kendall	0.027	0.076	0.004	0.026	0.004	-3.4	↓
Maungatapu Bridge	DIN	mg/L	Seasonal Kendall	0.075	0.302	0.011	0.054	0.786	1.8	↑
Maungatapu Bridge	*Chla*	µg/L	Seasonal Kendall	1.38	6.20	0.30	1.10	0.180	1.8	↑
Maungatapu Bridge	FC	cfu/100mL	Mann-Kendall	88	5700	0	6	0.771	0.0	→
Maungatapu Bridge	Ent	cfu/100mL	Mann-Kendall	116	8900	0	7	0.256	-2.7	↓
Maungatapu Bridge	*E coli*	cfu/100mL	Mann-Kendall	276	29500	0	4	0.799	0.0	→

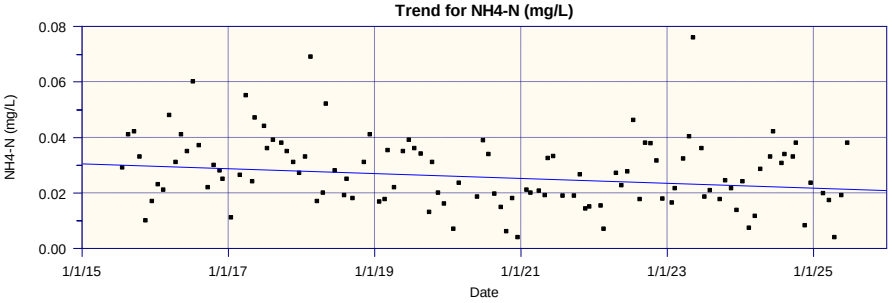

Trend for Salinity (ppt)
Salinity (ppt)
35
30
25
20
15
10
1/1/15
1/1/17
1/1/19
1/1/21
1/1/23
1/1/25
Date


Trend for pH
pH
8.5
8.0
7.5
7.0
6.5
6.0
1/1/15
1/1/17
1/1/19
1/1/21
1/1/23
1/1/25
Date


Trend for TP (mg/L)
TP (mg/L)
0.08
0.06
0.04
0.02
0.00
1/1/15
1/1/17
1/1/19
1/1/21
1/1/23
1/1/25
Date

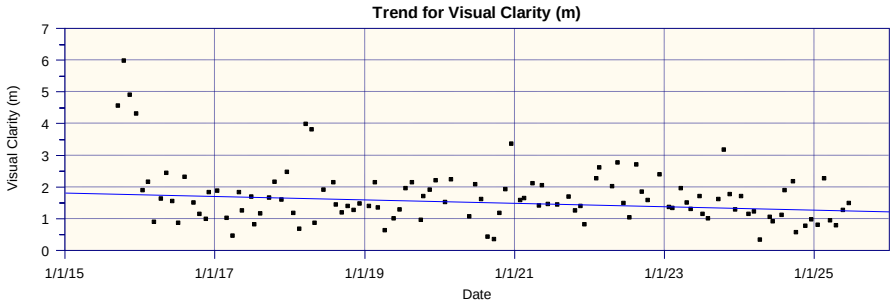

Trend for DRP (mg/L)
DRP (mg/L)
0.025
0.020
0.015
0.010
0.005
0.000
1/1/15
1/1/17
1/1/19
1/1/21
1/1/23
1/1/25
Date

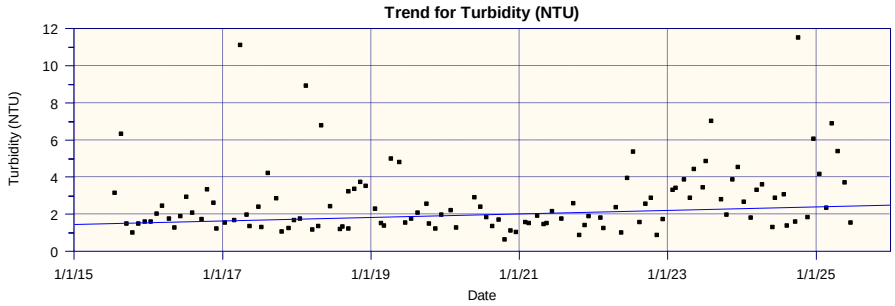

Trend for TN (mg/L)
TN (mg/L)
0.6
0.5
0.4
0.3
0.2
0.1
1/1/15
1/1/17
1/1/19
1/1/21
1/1/23
1/1/25
Date

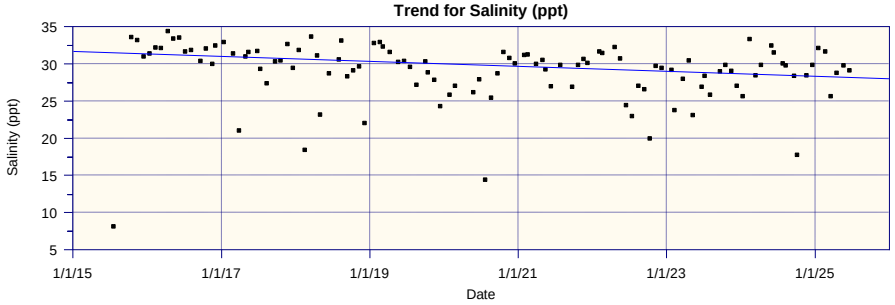

Trend for NH4-N (mg/L)
NH4-N (mg/L)
0.08
0.06
0.04
0.02
0.00
1/1/15
1/1/17
1/1/19
1/1/21
1/1/23
1/1/25
Date

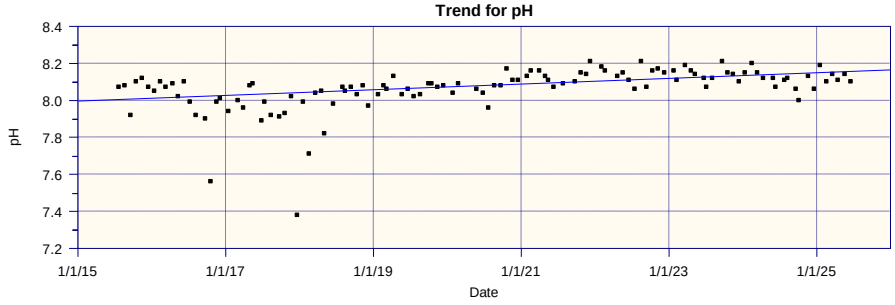
Waikareao

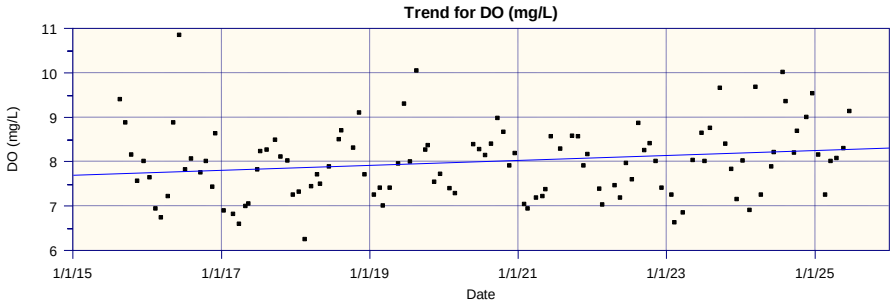
Site	Variable	Unit	Method	Mean	Maximum	Minimum	Median value	P	Percent annual change	Trend
Waikareao	Clarity	m	Mann-Kendall	1.7	6.0	0.3	1.5	0.021	-3.6	↓
Waikareao	Turbidity	NTU	Mann-Kendall	2.6	11.5	0.6	2.0	0.006	4.8	↑
Waikareao	TSS	mg/L	Mann-Kendall	11.2	36.8	1.4	10.0	0.372	1.6	↑
Waikareao	Sp Cond	µS/cm	Seasonal Kendall	46579	53611	25214	47618	0.155	-0.3	↓
Waikareao	Salinity	ppt	Mann-Kendall	28.9	34.3	8.1	29.8	0.000	-1.1	↓
Waikareao	Temp	°C	Seasonal Kendall	17.4	24.8	11.9	17.4	0.330	0.3	↑
Waikareao	pH		Mann-Kendall	8.06	8.21	7.38	8.08	0.000	0.2	↑
Waikareao	DO	mg/L	Seasonal Kendall	8.0	10.8	6.2	8.0	0.007	0.7	↑
Waikareao	DO	%	Seasonal Kendall	98	118	81	98	0.068	0.4	↑
Waikareao	TP	mg/L	Seasonal Kendall	0.017	0.036	0.005	0.016	0.034	-2.0	↓
Waikareao	DRP	mg/L	Seasonal Kendall	0.005	0.016	0.000	0.005	0.000	-6.8	↓
Waikareao	TN	mg/L	Seasonal Kendall	0.282	0.563	0.137	0.268	0.327	0.7	↑
Waikareao	NNN	mg/L	Seasonal Kendall	0.073	0.249	0.001	0.062	0.423	1.6	↑
Waikareao	NH_4-N	mg/L	Mann-Kendall	0.032	0.091	0.002	0.030	0.769	0.3	↑
Waikareao	DIN-calc	mg/L	Seasonal Kendall	0.112	0.300	0.014	0.112	0.242	9.2	↑
Waikareao	*Chla*	µg/L	Mann-Kendall	0.73	3.20	0.20	0.60	0.006	4.0	↑
Waikareao	FC	cfu/100mL	Mann-Kendall	49	740	0	4	0.274	3.3	↑
Waikareao	Ent	cfu/100mL	Seasonal Kendall	58	2000	0	4	0.618	0.0	→
Waikareao	*E coli*	cfu/100mL	Mann-Kendall	34	590	0	2	0.355	0.0	→

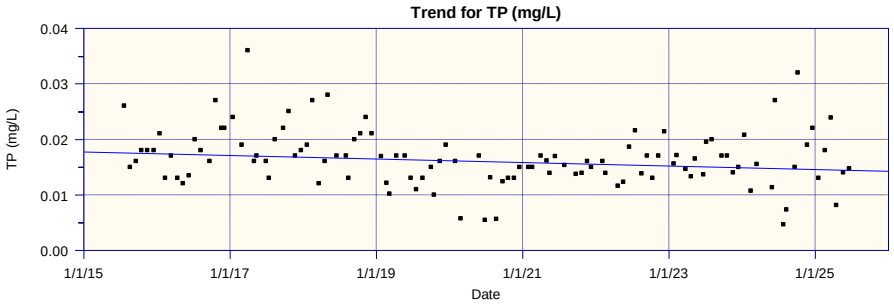

Trend for Visual Clarity (m)
Visual Clarity (m)
0
1
2
3
4
5
6
7
1/1/15
1/1/17
1/1/19
1/1/21
1/1/23
1/1/25
Date

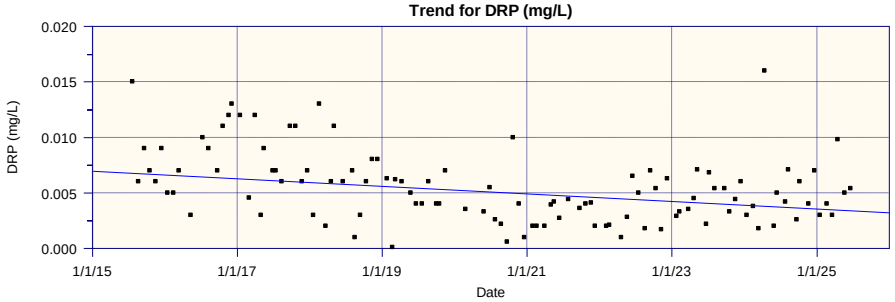

Trend for Turbidity (NTU)
Turbidity (NTU)
0
2
4
6
8
10
12
1/1/15
1/1/17
1/1/19
1/1/21
1/1/23
1/1/25
Date

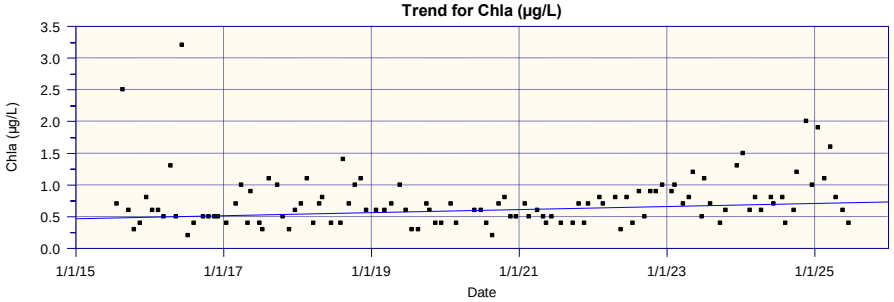

Trend for Salinity (ppt)
Salinity (ppt)
5
10
15
20
25
30
35
1/1/15
1/1/17
1/1/19
1/1/21
1/1/23
1/1/25
Date


Trend for pH
pH
7.2
7.4
7.6
7.8
8.0
8.2
8.4
1/1/15
1/1/17
1/1/19
1/1/21
1/1/23
1/1/25
Date


Trend for DO (mg/L)
DO (mg/L)
11
10
9
8
7
6
1/1/15
1/1/17
1/1/19
1/1/21
1/1/23
1/1/25
Date

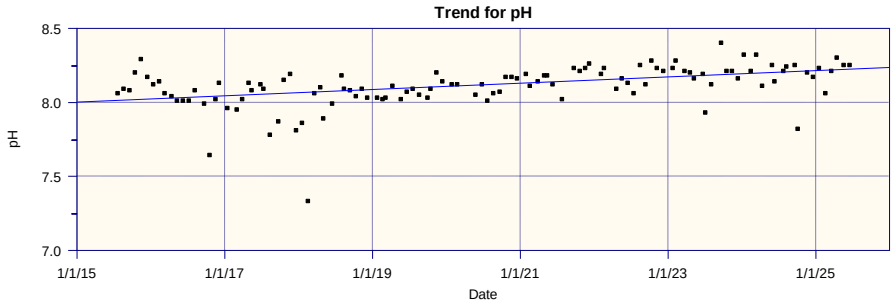

Trend for TP (mg/L)
TP (mg/L)
0.04
0.03
0.02
0.01
0.00
1/1/15
1/1/17
1/1/19
1/1/21
1/1/23
1/1/25
Date

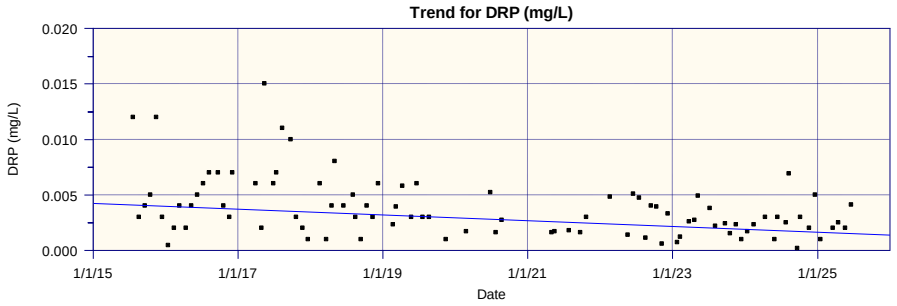

Trend for DRP (mg/L)
DRP (mg/L)
0.020
0.015
0.010
0.005
0.000
1/1/15
1/1/17
1/1/19
1/1/21
1/1/23
1/1/25
Date


Trend for Chla (µg/L)
Chla (µg/L)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1/1/15
1/1/17
1/1/19
1/1/21
1/1/23
1/1/25
Date

Tilby Point

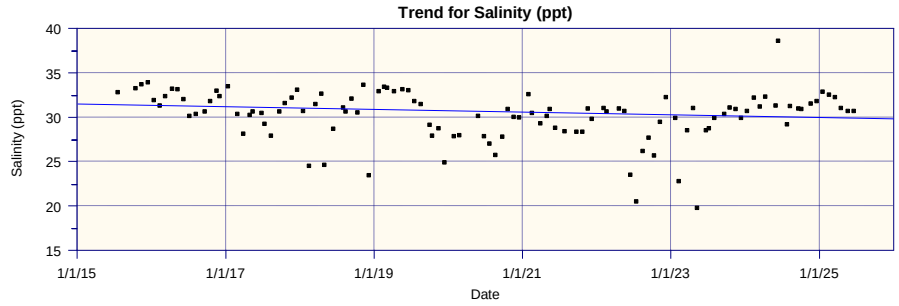
Site	Variable	Unit	Method	Mean	Maximum	Minimum	Median value	P	Percent annual change	Trend
Tilby Point	Clarity	m	Mann-Kendall	1.4	5.1	0.2	1.3	0.069	-3.7	↓
Tilby Point	Turbidity	NTU	Mann-Kendall	7.1	169.0	0.7	2.7	0.069	4.6	↑
Tilby Point	TSS	mg/L	Mann-Kendall	27.6	498.0	1.1	11.2	0.159	3.8	↑
Tilby Point	Sp Cond	µS/cm	Seasonal Kendall	44263	58129	11011	46111	0.828	0.1	↑
Tilby Point	Salinity	ppt	Seasonal Kendall	27.4	36.4	5.8	29.1	0.068	-0.6	↓
Tilby Point	Temp	°C	Seasonal Kendall	18.1	28.5	12.0	18.3	0.515	0.2	↑
Tilby Point	pH		Mann-Kendall	8.11	8.40	7.33	8.12	0.000	0.3	↑
Tilby Point	DO	mg/L	Seasonal Kendall	9.0	12.2	6.9	9.0	0.428	-0.2	↓
Tilby Point	DO	%	Seasonal Kendall	110	146	91	108	0.612	-0.2	↓
Tilby Point	TP	mg/L	Mann-Kendall	0.029	0.297	0.003	0.019	0.139	-2.3	↓
Tilby Point	DRP	mg/L	Mann-Kendall	0.004	0.015	0.000	0.003	0.000	-8.7	↓
Tilby Point	TN	mg/L	Mann-Kendall	0.333	1.718	0.169	0.292	0.282	-1.0	↓
Tilby Point	NNN	mg/L	Seasonal Kendall	0.060	0.339	0.002	0.041	0.411	-1.8	↓
Tilby Point	NH_4-N	mg/L	Seasonal Kendall	0.018	0.060	0.001	0.017	0.316	1.8	↑
Tilby Point	DIN	mg/L	Mann-Kendall	0.083	0.356	0.012	0.053	0.426	8.1	↑
Tilby Point	*Chla*	µg/L	Mann-Kendall	2.94	34.30	0.20	1.70	0.724	0.0	→
Tilby Point	FC	cfu/100mL	Seasonal Kendall	94	2870	0	24	0.574	1.0	↑
Tilby Point	Ent	cfu/100mL	Mann-Kendall	98	9999	0	12	0.183	-2.0	↓
Tilby Point	*E coli*	cfu/100mL	Mann-Kendall	66	2400	0	14	0.223	-3.0	↓

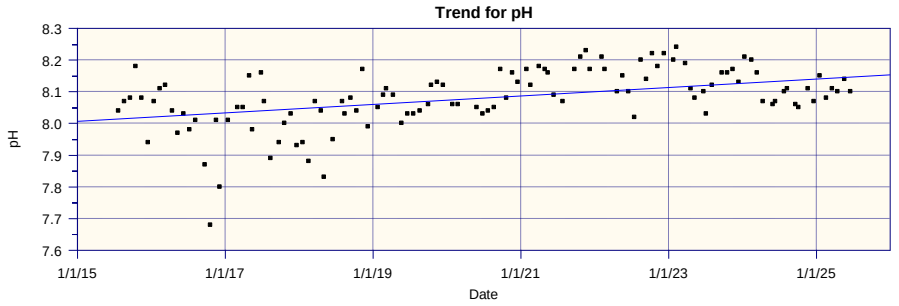

Trend for pH
8.5
8.0
7.5
7.0
pH
1/1/15
1/1/17
1/1/19
1/1/21
1/1/23
1/1/25
Date

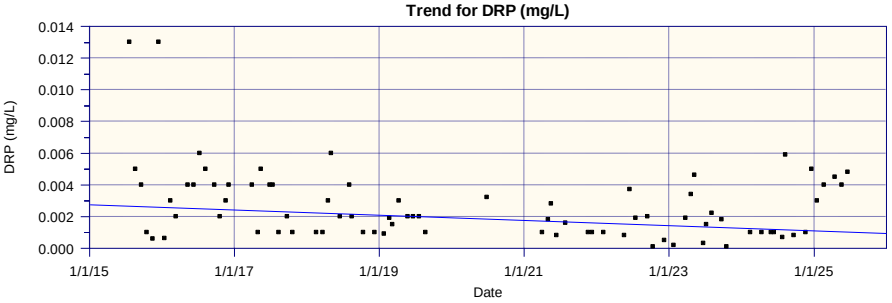

Trend for DRP (mg/L)
0.020
0.015
0.010
0.005
0.000
DRP (mg/L)
1/1/15
1/1/17
1/1/19
1/1/21
1/1/23
1/1/25
Date

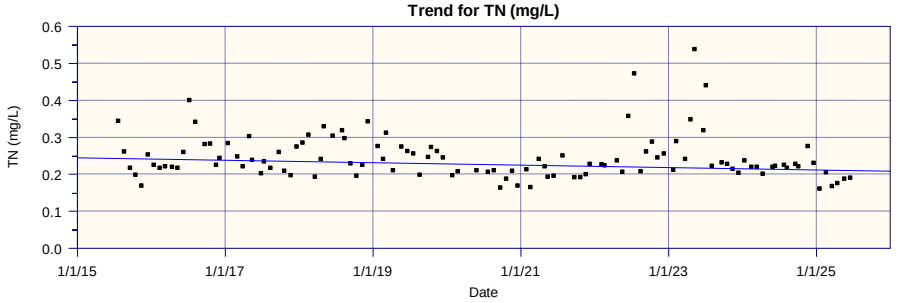
Ōmokoroa Wharf

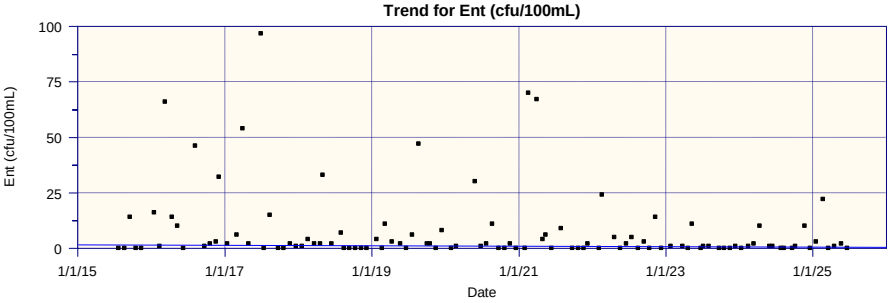
Site	Variable	Unit	Method	Mean	Maximum	Minimum	Median value	P	Percent annual change	Trend
Omokoroa Wharf	Clarity	m	Seasonal Kendall	1.3	5.3	0.3	1.1	0.221	-1.3	↓
Omokoroa Wharf	Turbidity	NTU	Seasonal Kendall	4.0	21.5	0.5	3.5	0.089	2.4	↑
Omokoroa Wharf	TSS	mg/L	Mann-Kendall	16.3	84.3	3.4	13.7	0.935	-0.1	↓
Omokoroa Wharf	Sp Cond	µS/cm	Seasonal Kendall	48098	63289	33630	48900	0.127	0.3	↑
Omokoroa Wharf	Salinity	ppt	Seasonal Kendall	30.2	38.6	19.7	30.6	0.040	-0.5	↓
Omokoroa Wharf	Temp	°C	Seasonal Kendall	17.8	25.5	11.5	17.9	0.699	0.1	↑
Omokoroa Wharf	pH		Seasonal Kendall	8.08	8.24	7.68	8.08	0.000	0.2	↑
Omokoroa Wharf	DO	mg/L	Seasonal Kendall	8.0	10.5	3.9	8.0	0.675	0.1	↑
Omokoroa Wharf	DO	%	Seasonal Kendall	99	121	44	100	0.155	0.2	↑
Omokoroa Wharf	TP	mg/L	Mann-Kendall	0.017	0.054	0.005	0.016	0.057	-1.7	↓
Omokoroa Wharf	DRP	mg/L	Seasonal Kendall	0.003	0.013	0.000	0.002	0.006	-8.3	↓
Omokoroa Wharf	TN	mg/L	Mann-Kendall	0.254	1.477	0.161	0.226	0.023	-1.4	↓
Omokoroa Wharf	NNN	mg/L	Seasonal Kendall	0.030	0.162	0.000	0.019	0.543	-1.0	↓
Omokoroa Wharf	NH_4-N	mg/L	Seasonal Kendall	0.019	0.108	0.000	0.016	0.702	-0.9	↓
Omokoroa Wharf	DIN	mg/L	Seasonal Kendall	0.052	0.260	0.001	0.040	0.427	6.8	↑
Omokoroa Wharf	*Chla*	µg/L	Seasonal Kendall	1.68	5.40	0.30	1.50	0.260	1.3	↑
Omokoroa Wharf	FC	cfu/100mL	Mann-Kendall	8	147	0	2	0.075	0.0	→
Omokoroa Wharf	Ent	cfu/100mL	Seasonal Kendall	12	240	0	1	0.006	-11.0	↓
Omokoroa Wharf	*E coli*	cfu/100mL	Mann-Kendall	7	153	0	1	0.157	0.0	→


Trend for Salinity (ppt)
Salinity (ppt)
40
35
30
25
20
15
1/1/15
1/1/17
1/1/19
1/1/21
1/1/23
1/1/25
Date


Trend for pH
pH
8.3
8.2
8.1
8.0
7.9
7.8
7.7
7.6
1/1/15
1/1/17
1/1/19
1/1/21
1/1/23
1/1/25
Date

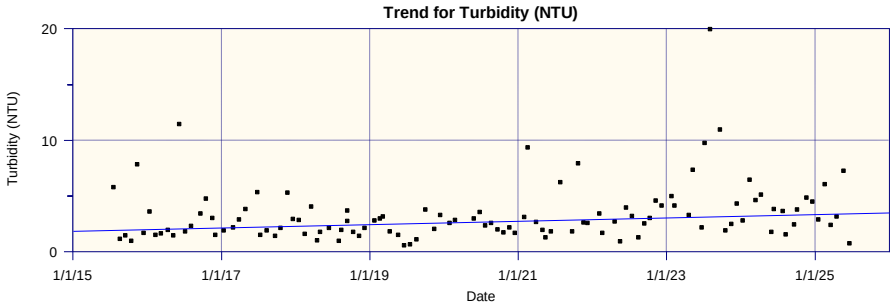

Trend for DRP (mg/L)
DRP (mg/L)
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
1/1/15
1/1/17
1/1/19
1/1/21
1/1/23
1/1/25
Date

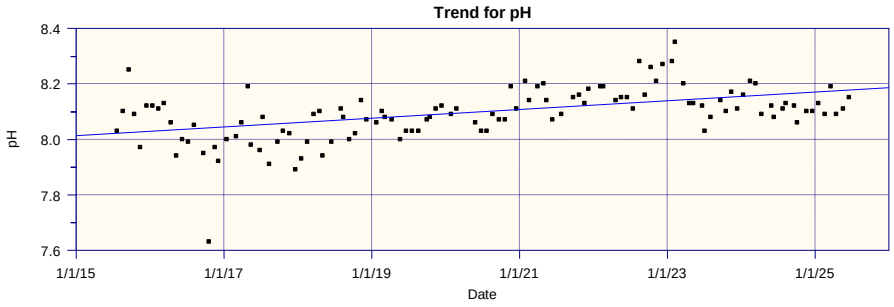

Trend for TN (mg/L)
TN (mg/L)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1/1/15
1/1/17
1/1/19
1/1/21
1/1/23
1/1/25
Date


Trend for Ent (cfu/100mL)
Ent (cfu/100mL)
100
75
50
25
0
1/1/15
1/1/17
1/1/19
1/1/21
1/1/23
1/1/25
Date

Kauri Point Jetty

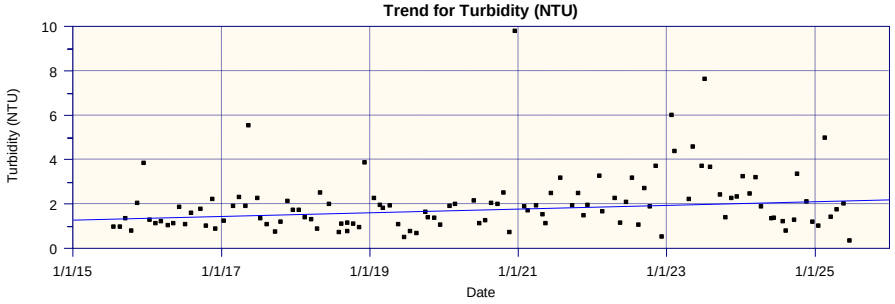
Site	Variable	Unit	Method	Mean	Maximum	Minimum	Median value	P	Percent annual change	Trend
Kauri Point Jetty	Clarity	m	Mann-Kendall	1.5	5.9	0.2	1.4	0.138	-2.3	↓
Kauri Point Jetty	Turbidity	NTU	Mann-Kendall	4.0	66.6	0.5	2.7	0.002	5.6	↑
Kauri Point Jetty	TSS	mg/L	Mann-Kendall	16.2	165.6	2.9	11.7	0.513	1.5	↑
Kauri Point Jetty	Sp Cond	µS/cm	Seasonal Kendall	48006	57531	26200	48802	0.067	0.4	↑
Kauri Point Jetty	Salinity	ppt	Seasonal Kendall	30.2	36.0	18.6	30.5	0.310	-0.2	↓
Kauri Point Jetty	Temp	°C	Seasonal Kendall	17.6	26.3	10.5	18.0	0.479	0.2	↑
Kauri Point Jetty	pH		Mann-Kendall	8.09	8.35	7.63	8.10	0.000	0.2	↑
Kauri Point Jetty	DO	mg/L	Seasonal Kendall	7.9	10.9	2.5	7.9	0.338	-0.2	↓
Kauri Point Jetty	DO	%	Mann-Kendall	98	127	31	99	0.899	0.0	→
Kauri Point Jetty	TP	mg/L	Seasonal Kendall	0.017	0.063	0.005	0.015	0.962	0.0	→
Kauri Point Jetty	DRP	mg/L	Mann-Kendall	0.002	0.010	0.000	0.002	0.918	0.0	→
Kauri Point Jetty	TN	mg/L	Mann-Kendall	0.262	1.316	0.141	0.244	0.152	-1.0	↓
Kauri Point Jetty	NNN	mg/L	Seasonal Kendall	0.022	0.174	0.000	0.008	0.183	-6.6	↓
Kauri Point Jetty	NH_4-N	mg/L	Mann-Kendall	0.018	0.124	0.001	0.015	0.721	0.6	↑
Kauri Point Jetty	DIN	mg/L	Mann-Kendall	0.033	0.147	-0.001	0.024	0.747	3.3	↑
Kauri Point Jetty	*Chla*	µg/L	Seasonal Kendall	1.60	4.90	0.60	1.40	0.744	0.0	→
Kauri Point Jetty	FC	cfu/100mL	Seasonal Kendall	68	4100	0	2	0.985	0.0	→
Kauri Point Jetty	Ent	cfu/100mL	Seasonal Kendall	66	3680	0	1	0.004	0.0	→
Kauri Point Jetty	*E coli*	cfu/100mL	Mann-Kendall	61	3840	0	1	0.343	0.0	→

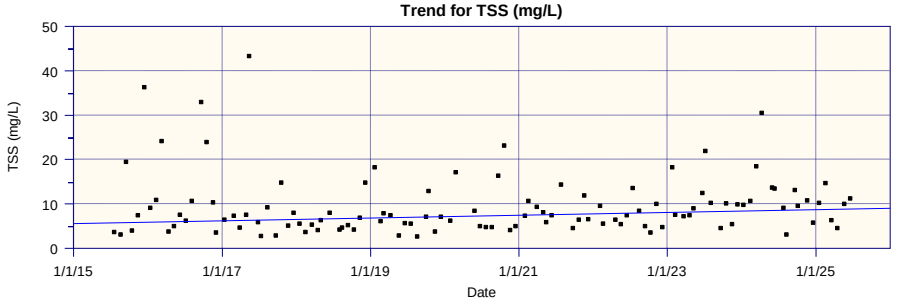

Trend for Turbidity (NTU)
Turbidity (NTU)
20
10
0
1/1/15
1/1/17
1/1/19
1/1/21
1/1/23
1/1/25
Date

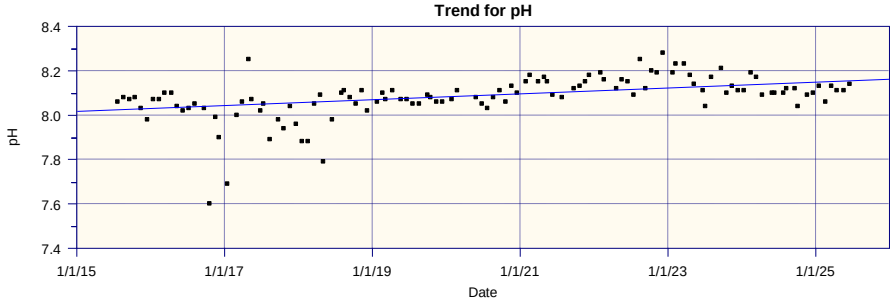

Trend for pH
pH
8.4
8.2
8.0
7.8
7.6
1/1/15
1/1/17
1/1/19
1/1/21
1/1/23
1/1/25
Date

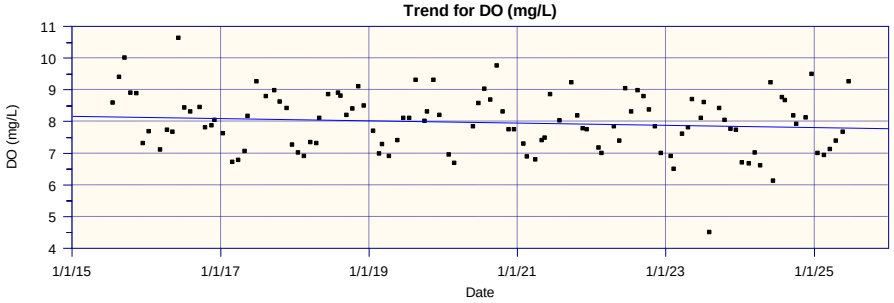
Tanners Point Jetty

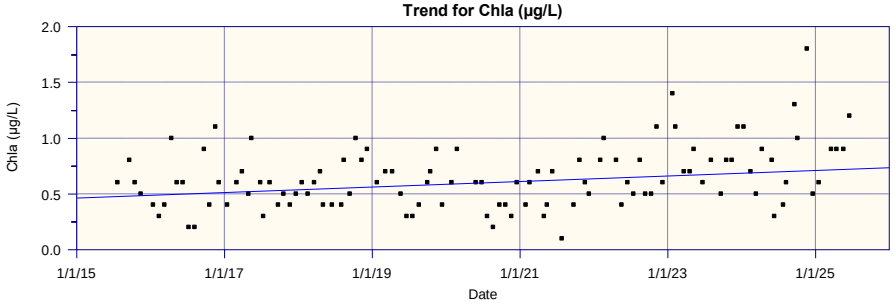
Site	Variable	Unit	Method	Mean	Maximum	Minimum	Median value	P	Percent annual change	Trend
Tanners Point Jetty	Clarity	m	Mann-Kendall	2.1	8.3	0.3	1.9	0.078	-2.8	↓
Tanners Point Jetty	Turbidity	NTU	Mann-Kendall	2.0	9.8	0.3	1.7	0.001	4.8	↑
Tanners Point Jetty	TSS	mg/L	Mann-Kendall	9.4	43.2	2.6	7.3	0.025	4.2	↑
Tanners Point Jetty	Sp Cond	µS/cm	Seasonal Kendall	48169	56704	22400	50506	0.124	0.3	↑
Tanners Point Jetty	Salinity	ppt	Mann-Kendall	30.2	35.4	13.4	31.7	0.125	-0.4	↓
Tanners Point Jetty	Temp	°C	Seasonal Kendall	17.4	24.4	12.0	17.5	0.839	0.1	↑
Tanners Point Jetty	pH		Mann-Kendall	8.08	8.28	7.60	8.09	0.000	0.2	↑
Tanners Point Jetty	DO	mg/L	Seasonal Kendall	8.0	10.6	4.5	8.0	0.035	-0.4	↓
Tanners Point Jetty	DO	%	Seasonal Kendall	99	123	51	99	0.199	-0.2	↓
Tanners Point Jetty	TP	mg/L	Seasonal Kendall	0.014	0.027	0.004	0.014	0.701	0.0	→
Tanners Point Jetty	DRP	mg/L	Seasonal Kendall	0.003	0.015	0.000	0.003	0.344	-1.1	↓
Tanners Point Jetty	TN	mg/L	Mann-Kendall	0.222	0.499	0.122	0.210	0.141	-1.1	↓
Tanners Point Jetty	NNN	mg/L	Seasonal Kendall	0.032	0.239	0.000	0.008	0.261	-3.1	↓
Tanners Point Jetty	NH_4-N	mg/L	Mann-Kendall	0.025	0.076	0.002	0.025	0.756	0.3	↑
Tanners Point Jetty	DIN	mg/L	Mann-Kendall	0.054	0.269	0.004	0.035	0.123	-13.2	↓
Tanners Point Jetty	*Chla*	µg/L	Mann-Kendall	0.72	6.50	0.10	0.60	0.003	4.2	↑
Tanners Point Jetty	FC	cfu/100mL	Seasonal Kendall	27	690	0	7	0.065	5.0	↑
Tanners Point Jetty	Ent	cfu/100mL	Seasonal Kendall	23	790	0	5	0.266	-2.9	↓
Tanners Point Jetty	*E coli*	cfu/100mL	Mann-Kendall	22	730	0	4	0.247	3.9	↑


Trend for Turbidity (NTU)
Turbidity (NTU)
10
8
6
4
2
0
1/1/15
1/1/17
1/1/19
1/1/21
1/1/23
1/1/25
Date


Trend for TSS (mg/L)
TSS (mg/L)
50
40
30
20
10
0
1/1/15
1/1/17
1/1/19
1/1/21
1/1/23
1/1/25
Date


Trend for pH
pH
8.4
8.2
8.0
7.8
7.6
7.4
1/1/15
1/1/17
1/1/19
1/1/21
1/1/23
1/1/25
Date


Trend for DO (mg/L)
DO (mg/L)
11
10
9
8
7
6
5
4
1/1/15
1/1/17
1/1/19
1/1/21
1/1/23
1/1/25
Date


Trend for Chla (µg/L)
Chla (µg/L)
2.0
1.5
1.0
0.5
0.0
1/1/15
1/1/17
1/1/19
1/1/21
1/1/23
1/1/25
Date

Appendix 3: Tauranga Harbour sediment quality temporal trend statistics. Significant trends are bolded, with meaningful trends highlighted red (increasing) or blue (decreasing).

Site	Parameter	P	% annual change	Trend direction and confidence	Trend arrow
P1	% Mud	0.019	7.6	Increasing trend very likely	↑
P15	% Mud	0.065	-1.8	Decreasing trend likely	↓
P23	% Mud	1.000	0.0	Trend exceptionally unlikely	→
P29	% Mud	0.000	3.8	Increasing trend virtually certain	↑
P49	% Mud	0.000	8.4	Increasing trend virtually certain	↑
P61	% Mud	0.000	10.9	Increasing trend virtually certain	↑
P62	% Mud	0.000	6.9	Increasing trend virtually certain	↑
P63	% Mud	0.003	9.3	Increasing trend virtually certain	↑
P64	% Mud	0.058	2.5	Increasing trend likely	↑
P65	% Mud	0.058	2.5	Increasing trend likely	↑
P1	As	0.146	2.1	Increasing trend possible	↑
P15	As	0.096	1.0	Increasing trend likely	↑
P23	As	0.218	0.9	Increasing trend possible	↑
P29	As	0.148	1.4	Increasing trend possible	↑
P49	As	0.677	0.4	Trend unlikely	↑
P61	As	0.133	1.5	Increasing trend possible	↑
P62	As	0.032	1.7	Increasing trend very likely	↑
P63	As	0.022	3.9	Increasing trend very likely	↑
P64	As	0.648	-0.4	Decreasing trend about as likely as not	↓
P65	As	0.648	-0.4	Decreasing trend about as likely as not	↓
P1	Cd	0.057	3.6	Increasing trend likely	↑
P15	Cd	0.881	0.3	Trend unlikely	↑
P23	Cd	0.007	2.6	Increasing trend virtually certain	↑
P29	Cd	0.447	2.3	Increasing trend about as likely as not	↑
P49	Cd	0.804	0.2	Trend unlikely	↓
P61	Cd	0.494	1.8	Increasing trend about as likely as not	↑
P62	Cd	0.068	2.5	Increasing trend likely	↑
P63	Cd	0.960	0.0	Trend exceptionally unlikely	→
P64	Cd	0.063	-2.5	Decreasing trend likely	↓
P65	Cd	0.063	-2.5	Decreasing trend likely	↓
P1	Cr	0.047	9.3	Increasing trend very likely	↑
P15	Cr	0.002	4.6	Increasing trend virtually certain	↑
P23	Cr	0.017	4.2	Increasing trend very likely	↑
P29	Cr	0.254	0.8	Increasing trend possible	↑
P49	Cr	0.679	0.4	Trend unlikely	↑
P61	Cr	0.765	0.4	Trend unlikely	↑
P62	Cr	0.709	0.8	Trend unlikely	↑

Site	Parameter	P	% annual change	Trend direction and confidence	Trend arrow
P63	Cr	0.125	3.3	Increasing trend possible	↑
P64	Cr	0.108	-2.7	Decreasing trend possible	↓
P65	Cr	0.108	-2.7	Decreasing trend possible	↓
P1	Cu	0.012	6.5	Increasing trend very likely	↑
P15	Cu	0.016	3.6	Increasing trend very likely	↑
P23	Cu	0.522	-0.6	Decreasing trend about as likely as not	↓
P29	Cu	0.618	-0.9	Decreasing trend about as likely as not	↓
P49	Cu	0.927	0.0	Trend extremely unlikely	→
P61	Cu	0.439	-0.8	Decreasing trend about as likely as not	↓
P62	Cu	0.271	3.2	Increasing trend possible	↑
P63	Cu	0.099	3.9	Increasing trend likely	↑
P64	Cu	0.037	-3.2	Decreasing trend very likely	↓
P65	Cu	0.037	-3.2	Decreasing trend very likely	↓
P1	Hg	0.076	5.7	Increasing trend likely	↑
P15	Hg	1.000	0.0	No detectable trend	→
P23	Hg	0.009	4.5	Increasing trend virtually certain	↑
P29	Hg	0.899	0.0	Trend unlikely	→
P49	Hg	0.726	0.0	Trend unlikely	→
P61	Hg	0.079	1.1	Increasing trend likely	↑
P62	Hg	0.102	1.9	Increasing trend possible	↑
P63	Hg	0.690	0.8	Trend unlikely	↑
P64	Hg	0.054	-2.8	Decreasing trend likely	↓
P65	Hg	0.054	-2.8	Decreasing trend likely	↓
P1	Ni	0.023	13.6	Increasing trend very likely	↑
P15	Ni	0.004	4.3	Increasing trend virtually certain	↑
P23	Ni	0.014	6.0	Increasing trend very likely	↑
P29	Ni	0.567	1.1	Increasing trend about as likely as not	↑
P49	Ni	0.454	-1.2	Decreasing trend about as likely as not	↓
P61	Ni	0.771	0.0	Trend unlikely	→
P62	Ni	0.587	0.8	Increasing trend about as likely as not	↑
P63	Ni	0.371	1.9	Increasing trend about as likely as not	↑
P64	Ni	0.159	-3.7	Decreasing trend possible	↓
P65	Ni	0.159	-3.7	Decreasing trend possible	↓
P1	Pb	0.037	5.8	Increasing trend likely	↑
P15	Pb	0.272	2.3	Increasing trend possible	↑
P23	Pb	0.243	-0.5	Decreasing trend possible	↓
P29	Pb	0.590	-0.5	Decreasing trend about as likely as not	↓
P49	Pb	0.385	1.0	Increasing trend about as likely as not	↑
P61	Pb	0.457	0.6	Increasing trend about as likely as not	↑
P62	Pb	0.856	-0.2	Trend unlikely	↓
P63	Pb	0.519	1.7	Increasing trend about as likely as not	↑
P64	Pb	0.004	-3.8	Decreasing trend virtually certain	↓

Site	Parameter	P	% annual change	Trend direction and confidence	Trend arrow
P65	Pb	0.004	-3.8	Decreasing trend virtually certain	↓
P1	TN	0.272	3.0	Increasing trend possible	↑
P15	TN	0.133	-1.1	Decreasing trend possible	↓
P23	TN	0.160	0.0	No detectable trend	→
P29	TN	0.010	-4.6	Decreasing trend very likely	↓
P49	TN	1.000	0.0	Trend exceptionally unlikely	→
P61	TN	0.041	0.0	No detectable trend	→
P62	TN	0.238	0.0	No detectable trend	→
P63	TN	0.130	10.4	Increasing trend possible	↑
P64	TN	0.257	-3.4	Decreasing trend possible	↓
P65	TN	0.257	-3.4	Decreasing trend possible	↓
P1	TOC	0.057	6.3	Increasing trend likely	↑
P15	TOC	0.134	2.2	Increasing trend possible	↑
P23	TOC	0.120	-1.9	Decreasing trend possible	↓
P29	TOC	0.928	0.0	Trend extremely unlikely	→
P49	TOC	0.709	-0.5	Trend unlikely	↓
P61	TOC	0.280	1.0	Increasing trend possible	↑
P62	TOC	0.282	-2.9	Decreasing trend possible	↓
P63	TOC	0.007	3.0	Increasing trend virtually certain	↑
P64	TOC	0.003	-3.9	Decreasing trend virtually certain	↓
P65	TOC	0.003	-3.9	Decreasing trend virtually certain	↓
P1	TP	0.057	3.1	Increasing trend likely	↑
P15	TP	1.000	0.0	Trend exceptionally unlikely	→
P23	TP	0.467	-1.7	Decreasing trend about as likely as not	↓
P29	TP	0.188	-1.7	Decreasing trend possible	↓
P49	TP	0.624	0.8	Increasing trend about as likely as not	↑
P61	TP	0.273	1.4	Increasing trend possible	↑
P62	TP	0.362	-2.6	Decreasing trend about as likely as not	↓
P63	TP	0.155	4.2	Increasing trend possible	↑
P64	TP	0.012	-4.6	Decreasing trend very likely	↓
P65	TP	0.012	-4.6	Decreasing trend very likely	↓
P1	Zn	0.023	4.4	Increasing trend very likely	↑
P15	Zn	0.052	2.5	Increasing trend likely	↑
P23	Zn	0.031	0.8	Increasing trend very likely	↑
P29	Zn	0.003	1.8	Increasing trend virtually certain	↑
P49	Zn	0.047	1.4	Increasing trend very likely	↑
P61	Zn	0.448	0.5	Increasing trend about as likely as not	↑
P62	Zn	0.590	0.6	Increasing trend about as likely as not	↑
P63	Zn	0.109	2.7	Increasing trend possible	↑
P64	Zn	0.028	-1.7	Decreasing trend very likely	↓
P65	Zn	0.028	-1.7	Decreasing trend very likely	↓

Appendix 4: PoTL turbidity, temperature, DO, salinity, and pH data collected for this assessment during dredging and disposal

Dredging

Date	Time	Site	Location	Vessel	Turbidity (NTU)	Temp (°C)	DO (%)	DO (mg/L)	Salinity (ppt)	pH		Tide	Weather	Sea Condition	Wind Speed	Wind Direction	Wave Height
23/08/2023	11:40	H4	200 m ds	Albatros	2.73	13.6	95.8	8.1	33.5	8.40		Flood	Fine	Flat	4/5	N	0.1/0.2
22/08/2023	14:00	H4	200 m ds	Albatros	2.73	13.8	104.0	8.8	32.7	8.40		Flood	Fine	Flat	4/5	N	0.1/0.2
18/08/2023	13:30	H4	200 m ds	Albatros	2.73	13.2	103.6	8.9	32.8	8.30		Flood	Fine	Flat	4/5	N	0.1/0.2
16/08/2023	11:30	H5	200 m ds	Albatros	1.42	13.0	99.2	8.6	30.0	8.20		EBB	Fine	Flat	13/14	WSW	0.2/0.3
15/08/2023	15:30	H4	200 m ds	Albatros	1.72	13.3	94.1	8.1	33.0	8.30		EBB	Fine	Flat	13/14	WSW	0.2/0.3
14/08/2023	13:00	E2	200 m ds	Albatros	2.10				33.1	8.30		EBB	Fine	Flat	13/14	WSW	0.2/0.3
11/08/2023	15:30	H4	200 m ds	Albatros	4.06	13.2	96.6	8.2	33.0	8.30		EBB	Fine	Flat	5/6	NW	0.1/0.2
7/08/2023	9:30	E2	200 m ds	Albatros	1.19	13.5	102.7	8.7	33.3	8.37		EBB	Fine	Flat	5/6	NW	0.1/0.2
4/08/2023	13:00	E2	200 m ds	Albatros	2.24	13.3	121.4	10.3	33.4	8.35		EBB	Fine	Flat	5/6	NW	0.1/0.2
3/08/2023	8:45	E4	200 m ds	Albatros	1.97	13.1	116.0	9.5	33.9	8.32		EBB	Fine	Flat	4/5	S	0.1/0.2
2/08/2023	10:30	H3	200 m ds	Albatros	4.39	13.1	109.6	9.7		8.14		EBB	Fine	Flat	4/5	S	0.1/0.2
23/08/2023	11:40	H4	500 m us	Albatros	2.58	13.6	91.0	7.7	33.4	8.40		EBB	Fine	Flat	4/5	S	0.1/0.2
22/08/2023	14:00	H4	500 m us	Albatros	2.58	13.5	102.2	8.7	32.0	8.30		EBB	Fine	Flat	14/15	SW	0.1/0.2
18/08/2023	13:30	H4	500 m us	Albatros	2.58	12.9	101.6	8.9	30.0	8.40		EBB	Fine	Flat	14/15	SW	0.1/0.2
16/08/2023	11:30	H5	500 m us	Albatros	2.10	12.7	98.6	8.7	29.9	8.30		EBB	Fine	Flat	14/15	SW	0.1/0.2
15/08/2023	15:30	H4	500 m us	Albatros	1.53	13.2	105.3	8.9	32.9	8.30		Flood	Fine	Chop / swell	14/15	N	0.6/0.8
14/08/2023	13:00	E2	500 m us	Albatros	1.67				33.3	8.30		Flood	Fine	Chop / swell	14/15	N	0.6/0.8
11/08/2023	15:30	H4	500 m us	Albatros	1.50	13.6	100.6	8.5	33.6	8.30		Flood	Fine	Chop / swell	14/15	N	0.6/0.8
7/08/2023	9:30	E2	500 m us	Albatros	0.99	13.5	103.9	8.8	33.3	8.40		Flood	Fine	Chop	21/24	SW	0.2/0.3
4/08/2023	13:00	E2	500 m us	Albatros	1.98	13.0	101.7	8.7	33.3	8.34		Flood	Fine	Chop	21/24	SW	0.2/0.3
3/08/2023	8:45	E4	500 m us	Albatros	1.54	13.0	101.7	8.7	33.3	8.34		Flood	Fine	Chop	21/24	SW	0.2/0.3
2/08/2023	10:30	H3	500 m us	Albatros	5.47	13.0	100.6	8.8		8.26		EBB	Fine	Flat	15/18	SW	0.1/0.2
23/08/2023	11:40	H4	Alongside	Albatros	3.00	13.6	100.2	8.5	33.7	8.40		EBB	Fine	Flat	15/18	SW	0.1/0.2
22/08/2023	14:00	H4	Alongside	Albatros	3.00	13.8	94.0	8.0	32.7	8.40		EBB	Fine	Flat	15/18	SW	0.1/0.2
18/08/2023	13:30	H4	Alongside	Albatros	3.00	12.9	100.2	8.7	31.6	8.40		EBB	Fine	Chop	15/18	SW	0.1/0.2
16/08/2023	11:30	H5	Alongside	Albatros	2.67	12.8	92.4	8.1	30.2	8.30		EBB	Fine	Chop	15/18	SW	0.1/0.2
15/08/2023	15:30	H4	Alongside	Albatros	1.61	13.2	93.5	8.0	33.1	8.30		EBB	Fine	Chop	15/18	SW	0.1/0.2
14/08/2023	13:00	E2	Alongside	Albatros	2.61				33.2	8.30		EBB	Fine	Flat	15/18	SW	0.1/0.2
11/08/2023	15:30	H4	Alongside	Albatros	1.69	13.1	96.1	8.2	32.8	8.30		EBB	Fine	Flat	15/18	SW	0.1/0.2
7/08/2023	9:30	E2	Alongside	Albatros	1.14							EBB	Fine	Flat	15/18	SW	0.1/0.2
4/08/2023	13:00	E2	Alongside	Albatros	1.62	13.4	101.1	8.6	33.5	8.36		EBB		FLAT	28/30	W	0.6/0.8
3/08/2023	8:45	E4	Alongside	Albatros	1.75	13.1	102.7	8.7	33.2	8.34		EBB		FLAT	28/30	W	0.6/0.8
2/08/2023	10:30	H3	Alongside	Albatros		13.0	103.8	9.0		8.31		EBB		FLAT	28/30	W	0.6/0.8

Disposal

Date	Time	Site	Location	Turbidity (NTU)	Temperature (°C)	Dissolved Oxygen (%)	DO (mg/L)	Salinity (ppt)	pH	Tide	Weather	Sea Condition	Wind Speed	Wind Direction	Wave Height
7/08/2023	9:30		Alongside		13.7	100.1	8.4	33.5	8.30	EBB	Fine	Chop	20/23	SW	0.3/0.5
7/08/2023	9:30		A	1.6	13.4	102.4	8.7	33.3	8.38	EBB	Fine	Chop	20/23	SW	0.3/0.5
7/08/2023	9:30	Disposal site B/C	B	1.3	13.6	96.2	8.1	33.5	8.30	EBB	Fine	Chop	20/23	SW	0.3/0.5
7/08/2023	9:30		C	4.8	13.5	113.0	9.6	33.4	8.37	EBB	Fine	Chop	20/23	SW	0.3/0.5
7/08/2023	9:30		D	1.4	13.5	102.7	8.7	33.3	8.37	EBB	Fine	Chop	20/23	SW	0.3/0.5
3/08/2023	8:45		Alongside	1.3	13.5	104.8	8.9	33.7	8.37	EBB	Fine	Chop	20/23	SW	0.3/0.5
3/08/2023	8:45		DA	1.6	13.3	104.4	8.9	33.6	8.37	EBB	Fine	Chop	20/23	SW	0.3/0.5
3/08/2023	8:45	Disposal site D	DB	1.3	13.6	104.7	8.9	33.7	8.38	EBB	Fine	Chop	20/23	SW	0.3/0.5
3/08/2023	8:45		DC	1.2	13.5	104.0	8.8	33.6	8.37	EBB	Fine	Chop	20/23	SW	0.3/0.5
3/08/2023	8:45		DD	1.3	13.3	104.2	8.9	33.6	8.37	EBB	Fine	Chop	20/23	SW	0.3/0.5
3/08/2023	8:45		Centre	1.4	13.5	103.2	8.8	33.7	8.38	EBB	Fine	Chop	20/23	SW	0.3/0.5

Appendix 5: PoTL sediment quality laboratory datasheets

Datasheets available from the following link.

[redacted]