Beachlands Wastewater Treatment Plant – water quality, ecological and human health effects assessment

Action	Personnel	Version	Date
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Executive Summary

Introduction

The Beachlands Wastewater Treatment Plant (**WWTP**) operated by Watercare Services Limited (**Watercare**) currently services around 11,000 people and discharges treated wastewater via an overland flow system to a tributary of Te Puru Stream where it flows downstream and joins other tributaries to form the Te Puru Stream which subsequently flows into the estuary at Te Puru Park approximately 7km downstream.

Upgrades to the existing Beachlands WWTP and an expansion of the overland flow system are required due to the projected future growth (up to 30,000 people) in Beachlands and Maraetai communities and the WWTP coming to the end of its design life. The current WWTP discharge consent expires on 31st December 2025.[1]

Therefore, Watercare is submitting an application to Auckland Council (**Council**) to renew the Beachlands WWTP discharge consent, which includes proposed changes to discharge quality and overland flow system expansion and requires an ecological effects assessment to support this application. This report provides an assessment of the potential ecological effects of treated wastewater discharges into a tributary of Te Puru Stream, via an overland flow system, associated with the continued operation of the Beachlands WWTP.

The existing WWTP discharge

For the existing WWTP discharge:

- There has been full compliance with the current consent (number 26875) conditions between 2018-2023 for all parameters except discharge volume, which has exceeded the maximum consented volume of 2,800 m^3/day each year.
- Dissolved reactive phosphorus (**DRP**) and nitrate-N have shown a marked increase in concentration between 2018-2023, with median annual increases of 24% and 77%, respectively.
- Annual median decreases of 5-day carbonaceous Biochemical Oxygen Demand (**$cBOD_5$**) (1.6%), conductivity (16%), total suspended solids (**TSS**) (7.4%), and pH (0.5%) have been observed between 2018-2023.
- Ammoniacal-N, nitrite-N, faecal coliforms, and *Escherichia coli* (***E. coli***) have remained unchanged over this time.
- Based on limited sampling, total copper and total and dissolved zinc are at concentrations above the Australian and New Zealand Guidelines (**ANZG**) 2018 default guideline values (**DGVs**), suggesting some dilution and/or attenuation is required in the wastewater treatment system prior to discharge into the receiving environment.
- Emerging organic contaminant (**EOC**) concentrations were acquired from limited sampling and literature.

[1] https://www.watercare.co.nz/About-us/Projects-around-Auckland/Beachlands-WWTP-discharge-consent-renewal

- After attenuation through the existing overland flow and stream system, Total Nitrogen (**TN**) and Total Phosphorus (**TP**) loads contribute 34% and 46% of total load from the catchment to the marine coastal environment.
- Viruses have not been measured in the Beachlands WWTP. A quantitative microbial risk assessment (**QMRA**) was undertaken to assess the enteric illness risk of viruses in the discharge.

The proposed WWTP discharge

For the proposed WWTP discharge:

- Th consent application relates to WWTP discharges over four stages: Current and Short-Term with the existing WWTP treatment; and Long-Term Stages 1 and 2 planned with a new Membrane Bioreactor (**MBR**) WWTP treatment. Concentrations of various parameters are not expected to change between Current and Short-Term, and between Long Term Stages 1 and Stage 2.
- The population being serviced and the annual daily flows are expected to increase from current (11,000 people and 2,200 m^3/day average daily flow (**ADF**)) to Long-Term Stage 2 (30,000 people and 6,000 m^3/day ADF). Maximum wastewater daily flows (also called peak wet weather flow (**PWWF**)) are expected to increase from current (4,500 m^3/day) to Long-Term Stage 2 (36,200 m^3/day). We note that the assessment of effects uses the ADF and not the PWWF. We have approached it this way because the overland flow system (current and proposed expansion) will buffer wet weather flows, primarily in the pond, effectively removing effects from wet weather discharges.
- The overland flow expansion to accommodate the increased flows will likely require a new area to the south of the stream for overland treatment and collection system to convey the discharge into the stream and avoid erosion. For nutrients we have assumed that this expanded overland system would provide the same level of attenuation that is achieved with the current system.
- The Current and Short-Term stages will upgrade components of the current WWTP are provided in the AEE, however major improvements in discharge quality will be through commissioning of the MBR WWTP.
- After commissioning of the MBR WWTP new operational limits[2] will apply as follows:
    - Median $cBOD_5$ and TSS concentrations will be < 5.0 mg/L (compared with <7.0 mg/L for the Current and Short-Term stages and up to 5.7 mg/L and 11 mg/L currently measured, respectively).
    - Median TN will be < 5.0 mg/L (compared with <7.0 mg/L for the Current and Short-Term stages).
    - 95th percentile $cBOD_5$ and TSS concentrations will reduce from 15 mg/L to 9 mg/L, while TN concentrations will reduce from 16 mg/L to 11 mg/L for the Current and Short-Term stages.
    - Ammoniacal-N concentrations will be similar to those for the Current and Short-Term stages.

[2] Following conservative principles, we have used these operational limits for our assessment of effects. However, it is expected that actual concentrations will be less than these operational limits and no worse than current concentrations, i.e. no deterioration in discharge quality from current state.

  - NO_x-N concentrations will see a large reduction, with median concentrations reducing to <2.0 mg/L (compared with <3.5 mg/L for the Current and Short-Term stages and 5.1 mg/L currently measured) and 95th percentile concentrations reducing from 11 mg/L to 4.5 mg/L for the Current and Short-Term stages and 6.4 mg/L currently measured.
  - DIN concentrations will see a large reduction, with median concentrations reducing to <2.5 mg/L (compared with operational limits of <4.1 mg/L for the Current and Short-Term stages and 5.5 mg/L currently measured), and 95th percentile concentrations reducing from 14 mg/L to 7.5 mg/L for the Current and Short-Term stages and 6.8 mg/L currently measured.
  - TP/DRP concentrations will see a reduction, with median concentration concentrations reducing to <0.5 mg/L (compared with <1 mg/L for the Current and Short-Term stages and 0.73 mg/L currently measured), and 95th percentile concentrations reducing from 3.0 mg/L to 1.0 mg/L for the Current and Short-Term stages and 1.09 mg/L currently measured.
  - Faecal coliform (**FC**) concentrations will remain unchanged throughout the staged upgrade.
  - TN and TP loads will contribute 50% and 70% of total catchment load to the marine coastal environment, respectively, including accounting for attenuation.
- It is unlikely to be possible to expand the existing overland flow discharge system proportional to the predicted rise in WWTP effluent flows due to capacity issues. Potentially suitable land for an appropriately sized overland flow system is available if land on the south side of the stream within WSL's property is utilised, however engineering solutions are required to manage this.

The existing freshwater environment

For the <u>existing</u> freshwater environment (upstream sites are regarded as the "existing environment" i.e. without the WWTP):

- The catchment is low relief, rural pasture with areas of exotic forestry and regenerating native bush in stream gullies.
- There is a clear demarcation of freshwater and saline environments (tidal influence) below the Quarry site approximately 3km downstream of the discharge location.
- The flows in the Te Puru Stream network appear to be highly dependent on rainfall.
- Pattle Delamore Partners (**PDP**) derived theoretical stream flows from water level sensor and stream gauging to inform the potential for erosion under a 3-fold increase in wastewater flows.
- Water is generally well oxygenated, with dissolved oxygen (**DO**) similar upstream and downstream of the WWTP discharge.
- $cBOD_5$ is at low concentrations and similar upstream and downstream of the WWTP discharge.
- Water temperature is slightly elevated at sites downstream relative to sites upstream of the WWTP discharge.
- Low pH appears to be more an issue than high pH in the receiving environment and appears to be driven by the upstream farm pond site, not the WWTP discharge.

- Conductivity at all sites is above ANZG DGV but there is a clear influence of the WWTP discharge on conductivity in sites downstream.
- There is evidence of minor salinity ingress into the WWTP (influent maximum 2.4 parts per thousand (**ppt**) and discharge maximum 1.4 ppt) and environment sites upstream (maximum salinity 1.4 ppt) of Te Puru Park which has a known saline influence (maximum salinity 32.4 ppt). There is a clear linear relationship between salinity and conductivity so elevated conductivity observed is likely to be due to saline water intrusion into Beachlands WWTP.
- TSS and turbidity are low and at similar concentrations in receiving environment sites upstream of the Quarry site and unrelated to the WWTP discharge.
- Nitrogen concentrations are elevated at sites downstream of the WWTP discharge relative to concentrations observed upstream. Ammoniacal-N and nitrate-N concentrations at the potential mixing zone[3] –site 15 (hereafter called the Bridge site) approximately 350 m below the pond discharge – place them in NPS-FM attribute band B for toxicity. Dissolved inorganic nitrogen (**DIN**) at the same site is above levels that would be expected to contribute to eutrophication.
- Phosphorus shows a similar pattern to nitrogen with concentrations downstream markedly higher than concentrations upstream of the WWTP discharge.
- Chlorophyll *a* (**Chla**) is not measured in the influent or discharge. Concentrations are slightly elevated at the farm pond and the next downstream site, but back to upstream levels by the Bridge site.
- Bacteria – *E. coli*, FC, and enterococci – concentrations are higher upstream of the WWTP discharge, suggesting catchment sources dominate.
- All metal concentrations measured were below the applicable ANZG 95% DGV.
- Pharmaceutical and personal care products (**PPCPs**) measured show an average attenuation of 2.9-fold from the WWTP outlet to the Bridge site (15).
- Sediment phosphorus appears to be higher at the Bridge site than the farm pond. However, other studies show that sediment P appears to be relatively static over decadal timeframes.
- Temporal trend analysis was undertaken on water quality data collected from the upstream farm pond (A) and farm pond (B) sites from February 2020 to March 2023. Only nitrate in the farm pond showed a meaningful (>1% annual change) and significant ($p<0.05$) trend.
- Stream ecology surveys were undertaken by Bioresearches in 2016, 2019, 2022, and 2024. Sites were grouped into 'reference' sites (above the WWTP discharge) and 'effect' sites (below the WWTP discharge). For the most recent survey:
    - Macrophyte diversity and the percentage of macrophyte and algae cover generally increased downstream of the discharge. However, the majority of the substrates in the tributary are soft bottom and thus unlikely to develop nuisance levels of periphyton.

[3] We have identified the Bridge (Site 15) as the potential mixing zone site as it is sufficiently downstream to accommodate reasonable mixing from the existing farm pond and diffuse discharge from the proposed areas identified as potentially suitable for an expansion of the Beachlands overland flow system (see Section 3.2.2: **Figure 10**). Between the farm pond and the Bridge site is also Watercare land.

- Higher numbers of macroinvertebrate species were noted at the reference sites. Species numbers in the effects sites increased with distance from the WWTP discharge.
- The percentage of sensitive species **(%EPT**) ranged from 22-30% at the reference sites, with either no EPT taxa recorded or virtually 0% EPT at effect sites.
- The Macroinvertebrate Community Index (**MCI**) indices placed reference sites on the border between 'good' and 'fair' (and above the AUP (**Auckland Unitary Plan**) minimum of 94 for rural areas) with effect sites in 'fair' and 'poor' categories (and below the AUP minimum of 94 for rural areas).
- The Semi-Quantitative Macroinvertebrate Community Index (**SQMCI**) showed similar results to MCI with reference sites in the 'fair' or 'excellent' category (and above the NPS-FM NBL of 4.5) and effect sites in the 'poor' or 'fair' category (with only site F below the NPS-FM NBL of 4.5).
- Bioresearches noted that the poor macroinvertebrate scores downstream of the discharge are likely due to a combination of stressors, including the decreased riparian vegetation and hard substrate at downstream sites. The relatively high level of nutrients and conductivity downstream, as a result of the current discharge, would contribute to increased plant growth and poor macroinvertebrate communities.
- Native fish species abundance and diversity were higher at reference sites than effect sites.
- A fish Index of Biotic Integrity (**IBI**) allows comparison with other Auckland streams and rated reference sites in 'poor' or 'fair' categories and effect sites in 'very poor' or 'poor' categories.
- For trends from 2016-2024:
  - For most sites the number of macrophyte and algae taxa appear to be stable or increasing since 2016, with generally more taxa recorded at effects sites. A similar trend is noted for percentage macrophyte/algae cover.
  - For macroinvertebrates the number of taxa appear to be stable or declining at the reference sites and generally lower but stable or increasing at the effect sites.
  - %EPT has remained very low and between 0% and 3% for effect sites.
  - MCI scores for reference sites have been relatively consistent and mostly above the AUP minimum for rural areas of 94.
  - In contrast to the reference sites, at the effects sites all but one MCI value has been below the AUP minimum for rural areas of 94. Sites F and G have shown signs of improvement since 2016, with site G showing a general decline.
  - As for MCI there is a general increasing trend in the SQMCI scores (i.e. improving) for the effect sites.
  - Numbers of native fish species were generally low (1-5) for reference sites and 0-4 for effect sites with no apparent temporal trends observed.
  - The number of native fish at reference site H was declining from 2016 (38) to 2022 (14) but returned to near 2016 numbers in 2024 (36). Reference sites E and A showed a general increase in the number of native fish. Site F had consistently very low numbers of native fish with the other effect sites variable.

        - Fish IBI appears to be reducing at reference site H, but stable or increasing at reference sites E and A. For effect sites, site F has either no fish or a very low Fish IBI, while sites S2 and G appear to be generally improving.
    - The improvement in MCI and SQMCI scores at site F (closest to the WWTP discharge) is promising, however improved water quality in the future WWTP discharge (primarily lower concentrations of toxic nitrate and ammonia, and conductivity) is required to further improve the macroinvertebrate communities downstream.

The existing marine coastal environment

For the existing marine coastal environment:

- The lower, estuarine reaches of Te Puru Stream are strongly influenced by seawater inflow during high tide, with salinities of 20–35 ppt at high tide but decreasing to 5–15 ppt during low tide.
- The mouth of Te Puru Stream is designated as a Significant Ecological Area–Marine 1 (**SEA-M1**) due to the variety of saline vegetation and coastal vegetation present and the intact ecological sequence from estuarine to freshwater wetlands.
- Te Maraetai/Kellys Beach and the surrounding coastal area is designated as a Significant Ecological Area–Marine 2 (**SEA-M2**) due to the variety of intertidal habitats present that provide a habitat for a wide variety of marine organisms. An intertidal survey of Te Maraetai/Kellys Beach found that:
    - The upper shore is very muddy with abundant crustacean burrows. Mangroves line the stream bank around the entrance to Te Puru Stream.
    - The mid to lower shore is sandy with scattered shell/rock. Low lying shell banks are present in some areas.
    - Juvenile cockles and pipi were present in low to high densities across the mid to lower sandflats, but no shellfish were found that were near harvestable size.
    - Three small patches (each 2 m × 1 m) of moderately dense seagrass were observed near the low tide mark.
    - Intertidal sandstone reef platforms are present on either side of the bay that provide a habitat for a range of common intertidal species.
- The area between west Beachlands and Motukaraka/Flat is designated as a SEA-M1 due to the presence of large shellbanks that are used as high tide roosts by wading and coastal birds. Extensive seagrass beds have developed over this area over the last decade.
- Most of Whitford embayment, including the area around Motukaraka is designated as a SEA-M2 due to the presence of large areas of intertidal flats that provide a habitat for a wide range of marine species. The intertidal flats also provide feeding and roosting areas for a variety of coastal and wading birds. The intertidal macrofaunal community is typical of sheltered northern estuaries.
- Sunkist Bay, west of Te Maraetai/Kellys Beach, grades from sand at the high tide mark to shell and bedrock on the lower intertidal area. Shellfish (cockles, pipis and wedge shells) abundances in this bay were low.
- Omana Beach, east of Te Maraetai/Kellys Beach, is a sandy/shelly beach with no shellfish beds.

- Maraetai Beach is a popular recreational beach that is designated as a SEA-M2 due to the long sandy beach that provides extensive feeding areas for wading and coasting birds.
- Subtidal areas approximately 3 km offshore of Te Maraetai/Kellys Beach were surveyed by underwater video. Substrates comprised sandy-mud to muddy-sand, interspersed with patches of dense shell. The Mediterranean fan worm, an unwanted organism, was the only common epifaunal species observed. Other species that were occasionally observed included sponges, hydroids, bryozoans, horse mussels, 11-armed starfish, and sea cucumbers. No rocky reefs, living biogenic habitats, or regionally significant benthic species were observed in the survey.

Effects of discharges during the Current Stage

The actual and potential ecological effects of the proposed discharge on the freshwater and marine receiving environment during the Current Stage can be summarised as follows:

- The proposed annual average discharge volume is 2,200 m^3/day at this stage, which is a slight increase, but comparable, to the existing annual median for 2022 (1,947 m^3/day) and 2023 (2,038 m^3/day). A discharge at this slightly increased flow is likely to result in a <u>low effect</u> on stream bank erosion, and <u>negligible</u> effects on the coastal marine environment.
- Based on monitoring at receiving environment sites occasional low DO in the current discharge does not appear to be impacting on DO in the pond or further downstream. $cBOD_5$ in the current WWTP discharge does not appear to be impacting on receiving environment sites. A proposed maximum operational discharge limit of 7 mg/L is marginally higher than the WWTP discharge in 2023/24 (median 5.7 mg/L). A discharge with this potential increase in $cBOD_5$ (noting the operational limit is a maximum concentration) is not expected to impact significantly on $cBOD_5$ (or DO) in the pond or further downstream.
- The current Beachlands WWTP discharge is showing minimal effects on water temperature in the farm pond. There are no water temperature standards proposed for the upgraded WWTP discharge, but the proposed discharge is expected to result in <u>low</u> impacts on temperature at downstream sites compared with upstream sites.
- Low pH appears to be more an issue than high pH in the receiving environment. The current Beachlands WWTP discharge appears to be having <u>negligible</u> impacts on pH at sites downstream and this is expected to remain the same for the proposed discharge during the Current stage.
- There is a clear influence of the current Beachlands WWTP discharge on conductivity downstream, with all sites showing conductivity manyfold above the ANZG DGV, indicating a 'potential risk' of adverse effects. The NIWA Stream Health Monitoring and Assessment Kit (**SHMAK**) report suggests that direct effects from conductivity on stream life does not occur until conductivity reaches levels found in brackish water or seawater, well above conductivity at these sites. Further, elevated conductivity may lead to reduced DO, but there are no apparent effects on DO downstream attributable to the current WWTP discharge. As stated earlier there was evidence of minor salinity in the current WWTP discharge. There are no proposed new discharge standards for conductivity and salinity but concentrations of salts are not expected to increase as a result of the proposed discharge. Accordingly, it is expected that conductivity in the proposed discharge will

contribute to low/moderate effects on stream ecology downstream compared with upstream. Riparian planting and installation of new pipes for the network along with a trigger for further work on causes should also reduce the effects of conductivity.

- The current Beachlands WWTP discharge has consistently low TSS (mean from 2018-2023 of 7.4 mg/L) and there appears to be little difference in TSS for the receiving environment sites upstream and downstream of the wastewater discharge. The discharge concentration limits under the Current Stage (7 mg/L) should see a decrease in TSS of approximately 1.06-fold compared to the current discharge and contribute to improved water quality downstream of the discharge.
- Between 2018 and 2023 ammoniacal-N has been consistently around 0.40 mg/L in discharges from the Beachlands WWTP, reflected by equal median and 95th percentile concentrations of 0.40 mg/L. However, recent measurements with a more sensitive detection limit show that the median is more like 0.04 mg/L in the discharge.
    - Ammoniacal-N makes up around 0.5% of TN being discharged from the WWTP and is unlikely to be significantly contributing to ammoniacal-N concentrations downstream.
    - Processes in the pond will continue to increase ammoniacal-N levels downstream but would be expected to meet the NBL for ammoniacal-N toxicity and be unlikely to impact on species found downstream.
    - For these reasons we have not estimated ammoniacal-N concentrations downstream for any of the proposed discharge stages.
- A maximum operational median nitrate-N concentration (3.5 mg/L) will likely result in an NPS-FM attribute band B for toxicity at the Bridge site (1.1 mg/L). This is the same attribute band as the Bridge site currently.
- For DIN – and assuming the same attenuation as for nitrate-N – a maximum operational median concentration of 4.1 mg/L would mean a DIN concentration at the Bridge site of 1.3 mg/L, above the accepted threshold for eutrophication.
- For DRP, a maximum operational median concentration of 1.000 mg/L would mean a DRP concentration at the Bridge site of 0.251 mg/L, resulting in an NPS-FM attribute band D and potentially an increase of DRP concentration at Bridge site currently (0.182 mg/L: also NPS-FM attribute band D). Note that 1.0 mg/L is an operational limit and we would not expect concentrations to get this high in the discharge and change from the existing levels.
- After attenuation through the overland and stream system, TN and TP loads will contribute 34% and 46% of total load from the catchment to the marine coastal environment.
- Risks from bacteria are negligible compared to catchment sources.
- Although based on only two monitoring events water metal concentrations are currently at 50% or below the ANZG DGV at the Bridge site and would be expected to be the same during the Current Stage. Zinc, copper and chromium appear to be increasing at the farm pond site (and to a lesser extent at the Bridge site) to near ecological guideline values as a result of the influence of Beachlands WWTP discharge.
- All sediment metal concentrations were below the ANZG DGV, with only zinc reported at concentrations that were increased downstream of the influence of Beachlands WWTP relative to upstream.

- Further monitoring, through consent conditions is warranted to ensure metals are not increasing to above DGVs downstream.
- The majority of EOCs will present negligible ecological effects based on measured and literature treated WWTP discharge concentrations. Most of the few EOCs that are present in concentrations above ecological effects concentrations will likely be significantly attenuated and/or diluted in the freshwater and marine environments and present with low risk of adverse effects. Concentrations of EOCs, and hence risks, are not expected to increase during the Current Stage. Further monitoring, through consent conditions is warranted to better understand the risks of EOCs.
- A QMRA assessed mean infection risks, which are summarised as:
    - For watercress consumption, a log reduction of 5 (100,000-fold reduction) is required to reduce the current risk of infection to <1% at the Te Puru stream sites.
    - For swimming, a log reduction of >4 (<10,000-fold) is required to reduce risks to below 1% at Te Puru stream sites. It was noted that swimming is unlikely at these sites.
    - For marine sites, swimming health risks were currently low with a log reduction of <2 (<100-fold) required at Kelly's Beach transect sites, and <1 (<10-fold) for those further out in the bay.
    - For shellfish consumption, a log reduction of 1 (10-fold) is sufficient to provide a risk of <1% currently at all marine sites.
    - We note that the QMRA looks at the added risk from the WWTP, there is still existing risks from other sources but these are not part of QMRA.

Effects of discharges during the Short-Term Stage

The actual and potential ecological effects of the proposed discharge on the freshwater and marine receiving environment during the Short-Term Stage can be summarised as follows:

- The proposed annual average discharge volume is 3,600 m^3/day at this stage, compared to the existing annual median for 2023 of 2,038 m^3/day. A discharge at this increased annual average discharge volume is likely to result in a low effect on stream bank erosion, and negligible effects on the coastal marine environment.
- Based on monitoring at receiving environment sites occasional low DO in the current discharge does not appear to be impacting on DO in the pond or further downstream. $cBOD_5$ in the current WWTP discharge does not appear to be impacting on receiving environment sites. A proposed maximum operational discharge limit of 7 mg/L during the Short-Term Stage is marginally higher than the WWTP discharge in 2023/24 (median 5.7 mg/L). A discharge with this potential increase in concentration (noting the operational limit is a maximum concentration) is not expected to impact significantly on $cBOD_5$ (or DO) in the pond or further downstream.
- The current Beachlands WWTP discharge is showing minimal effects on water temperature in the farm pond. There are no water temperature standards proposed for the upgraded WWTP discharge, but the proposed discharge during the Short-Term Stage is expected to continue to result in low impacts on temperature at downstream sites compared with upstream sites.
- Low pH appears to be more an issue than high pH in the receiving environment. The current Beachlands WWTP discharge appears to be having negligible impacts on pH at

sites downstream and this is expected to remain the same for the proposed discharge during the Short-Term Stage.

- There is a clear influence of the current Beachlands WWTP discharge on conductivity downstream, with all sites showing conductivity manyfold above the ANZG DGV, indicating a 'potential risk' of adverse effects. Implications of increased conductivity are discussed in relation to the Current stage and not repeated here. It is expected that conductivity in the proposed discharge during the Short-Term Stage will contribute to <u>low/moderate</u> effects on stream ecology downstream compared with upstream. Riparian planting and installation of new pipes for the network along with a trigger for further work on causes should reduce the effects of conductivity.
- The current Beachlands WWTP discharge has consistently low TSS (mean from 2018-2023 of 7.4 mg/L) and there appears to be little difference in TSS for the receiving environment sites upstream and downstream of the wastewater discharge. The maximum operational discharge concentrations under the Short-Term Stage (7 mg/L) should see a decrease in TSS of approximately1.06-fold compared to the current discharge and contribute to <u>improved</u> water quality downstream of the discharge.
- For ammoniacal-N – and the reasons discussed in relation to the Current stage – we have not estimated ammoniacal-N concentrations downstream
- A maximum operational median nitrate-N concentration (3.5 mg/L) for the Short-Term Stage will likely result in an NPS-FM attribute band B for toxicity at the Bridge site (1.1 mg/L). This is the same attribute band as the Bridge site currently.
- For DIN – and assuming the same attenuation as for nitrate-N – a maximum operational median concentration of 4.1 mg/L for the Short-Term Stage would mean a DIN concentration at the Bridge site of 1.3 mg/L, above the accepted threshold for eutrophication.
- For DRP, a maximum operational median concentration of 1.000 mg/L for the Short-Term Stage would mean a DRP concentration at the Bridge site of 0.251 mg/L, resulting in an NPS-FM attribute band D and potentially an increase of DRP concentration at Bridge site currently (0.182 mg/L: also NPS-FM attribute band D). Note that 1.0 mg/L is an operational limit and we would not expect concentrations to get this high in the discharge and change from the existing levels.
- After attenuation through the overland and stream system, TN and TP loads will contribute 46% and 59% of total load from the catchment to the marine coastal environment.
- Risks from bacteria are negligible compared to catchment sources now and with future upgrades.
- Although based on only two monitoring events water metal concentrations are currently at 50% or below the ANZG DGV at the Bridge site and would be expected to be the same for the Short-Term Stage. Zinc, copper and chromium appear to be increasing at the farm pond site (and to a lesser extent at the Bridge site) to near ecological guideline values as a result of the influence of Beachlands WWTP discharge.
- All sediment metal concentrations were, and will continue to be for the Short-Term Stage, below the ANZG DGV, with only zinc reported at concentrations that were increased downstream of the influence of Beachlands WWTP relative to upstream.
- Further monitoring, through consent conditions is warranted to ensure metals are not increasing to above DGVs downstream for each stage of the proposed future discharge.

- The majority of EOCs will present negligible ecological effects based on measured and literature treated WWTP discharge concentrations. Most of the few EOCs that are present in concentrations above ecological effects concentrations will likely be significantly attenuated and/or diluted in the freshwater and marine environments and present with low risk of adverse effects. Concentrations of EOCs, and hence risks, are not expected to increase for the Short-Term Stage. Further monitoring, through consent conditions is warranted to better understand the risks of EOCs.
- A QMRA assessed mean infection risks, which are summarised as:
    - For watercress consumption, a log reduction of 5 (100,000-fold reduction) is required to reduce the risk of infection to <1% at the Te Puru stream sites. There was little difference in risk between the discharge stages.
    - For swimming, a log reduction of >4 (<10,000-fold) is required to reduce risks to below 1% at Te Puru stream sites. There was little difference in risk between the discharge stages and it was noted that swimming is unlikely at these sites. For marine sites, swimming health risks were low with a log reduction of <2 (<100-fold) required at Kelly's Beach transect sites, and <1 (<10-fold) for those further out in the bay.
    - For shellfish consumption, a log reduction of 1-2 (10-fold to 100-fold) is sufficient to provide a risk of <1% at all marine sites.
    - We note that the QMRA looks at the added risk from the WWTP, there is still existing risks from other sources but these are not part of QMRA.

Effects of discharges during Long-Term Stage 1

The actual and potential ecological effects of the proposed discharge on the freshwater and marine receiving environment during Long-Term Stage 1 Stage can be summarised as follows:

- The proposed annual average discharge volume limit is 4,800 m^3/day at this stage, compared to the existing annual median for 2023 of 2,038 m^3/day. With this increase in annual average discharge volume the discharge is still likely to result in a low effect on stream bank erosion, and negligible effects on the coastal marine environment.
- Based on monitoring at receiving environment sites occasional low DO in the current discharge does not appear to be impacting on DO in the pond or further downstream. $cBOD_5$ in the current WWTP discharge does not appear to be impacting on receiving environment sites. A maximum proposed operational discharge limit of 5 mg/L for Long-Term Stage 1 is marginally lower than the WWTP discharge in 2023/24 (median 5.7 mg/L). This potential decrease (noting the operational limit is a maximum concentration) is not expected to change the impact significantly on $cBOD_5$ (or DO) in the pond or further downstream.
- The current WWTP discharge is showing minimal effects on water temperature in the farm pond. There are no water temperature standards proposed for the upgraded WWTP discharge, but the proposed discharge during Long-Term Stage 1 is expected to continue to result in low impacts on temperature at downstream sites compared with upstream sites.
- Low pH appears to be more an issue than high pH in the receiving environment. The current WWTP discharge appears to be having negligible impacts on pH at sites

downstream and this is expected to remain the same for the proposed discharge during Long-Term Stage 1.

- There is a clear influence of the current Beachlands WWTP discharge on conductivity downstream, with all sites showing conductivity manyfold above the ANZG DGV, indicating a 'potential risk' of adverse effects. Implications of increased conductivity are discussed in for the Current stage and not repeated here. It is expected that conductivity in the proposed discharge will have to low/moderate effects on stream ecology downstream compared with upstream during Long-Term Stage 1. Riparian planting and installation of new pipes for the network along with a trigger for further work on causes should reduce the effects of conductivity.
- The current Beachlands WWTP discharge has consistently low TSS (median 7.8 mg/L) and there appears to be little difference in TSS for the receiving environment sites upstream and downstream of the wastewater discharge. The discharge concentrations under Long-Term Stage 1 (5 mg/L) should see a decrease in TSS of approximate 1.6-fold compared to the existing discharge and contribute to improved water quality downstream of the discharge.
- For ammoniacal-N – and the reasons discussed in relation to the Current stage – we have not estimated ammoniacal-N concentrations downstream under any stage of the proposed WWTP upgrade.
- A maximum operational median limit of nitrate-N concentrations (2.0 mg/L) for Long-Term Stage 1 will likely result in an NPS-FM attribute band A for toxicity at the Bridge site. This is an improvement on the attribute band (B) for the Bridge site currently and would satisfy the requirement for an improvement under the NPS-FM.
- For DIN – and assuming the same attenuation as for nitrate-N – a maximum operational median of 2.5 mg/L for Long-Term Stage 1 would mean a DIN concentration at the Bridge site from the proposed discharge of around 0.8 mg/L, below the accepted threshold for eutrophication and a major improvement on DIN for the Bridge site currently (1.7 mg/L).
- For DRP, a maximum operational median concentration of 0.500 mg/L for Long-Term Stage 1 would mean a DRP concentration at the Bridge site of 0.125 mg/L, resulting in an NPS-FM attribute band D but a decrease of DRP concentration at this site compared to the Bridge site currently (0.182 mg/L (also NPS-FM attribute band D). The proposed median DRP concentrations during Long-Term Stage 1 will contribute to improved water quality downstream compared with the current WWTP discharge, satisfying the intent of the NPS-FM.
- After attenuation through the proposed expanded overland and stream system, TN and TP loads will contribute 45% and 49% of total load from the catchment to the marine coastal environment.
- Risks from bacteria are negligible compared to catchment sources currently and with the future upgrades.
- Although based on only two monitoring events water metal concentrations are currently at 50% or below the ANZG DGV at the Bridge site and would be expected to be the same, or reduced, during Long-Term Stage 1, with the MBR upgrade.
- All sediment metal concentrations are currently and will be expected to be for Long-Term Stage 1, below the ANZG DGV.
- Further monitoring, through consent conditions is warranted to ensure metals are not increasing to above DGVs downstream as a result of the proposed discharge.

- The majority of EOCs will present negligible ecological effects based on measured and literature treated WWTP discharge concentrations. Most of the few EOCs that are present in concentrations above ecological effects concentrations will likely be significantly attenuated and/or diluted in the freshwater and marine environments and present with low risk of adverse effects. Concentrations of EOCs, and hence risks, are not expected to increase for Long-Term Stage 1, and with the MBR upgrade there may be a reduction in concentrations. Further monitoring, through consent conditions is warranted to better understand the risks of EOCs.
- A QMRA for Long-Term Stage 1 upgrade was not undertaken. At the time the QMRA was undertaken there were 3 discharge stages proposed for the WWTP upgrade, with no Long-Term Stage 1 stage. Further, the interim stage (in the QMRA report) terminology was subsequently updated to Short-Term stage. No QMRA modelling has been undertaken for the Long-Term Stage 1 stage with risks, due to the installation of the MBR at Long-Term Stage 1, similar but lower than the Long-Term Stage 2 stage.

Effects of discharges during Long-Term Stage 2

The actual and potential ecological effects of the proposed discharge on the freshwater and marine receiving environment during Long-Term Stage 2 can be summarised as follows:

- The proposed annual average discharge volume is 6,000 m^3/day at this stage, compared to the existing annual median for 2023 of 2,038 m^3/day. With this increase in annual average discharge volume the discharge is still likely to result in a low effect on stream bank erosion, and negligible effects on the coastal marine environment.
- Based on monitoring at receiving environment sites occasional low DO in the current discharge does not appear to be impacting on DO in the pond or further downstream. $cBOD_5$ in the current WWTP discharge also does not appear to be impacting on receiving environment sites. A proposed maximum operational discharge limit of 5 mg/L for Long-Term Stage 2 is marginally lower than the WWTP discharge in 2023/24 (median 5.7 mg/L). This potential decrease (noting the operational limit is a maximum concentration) is not expected to change significantly on $cBOD_5$ (or DO) in the pond or further downstream.
- The current Beachlands WWTP discharge is showing minimal effects on water temperature in the farm pond. There are no water temperature standards proposed for the upgraded WWTP discharge, but the proposed discharge is expected to result in low impacts on temperature at downstream sites compared with upstream sites.
- Low pH appears to be more an issue than high pH in the receiving environment. The current Beachlands WWTP discharge appears to be having negligible impacts on pH at sites downstream and this is expected to remain the same for the proposed discharge during Long-Term Stage 2.
- There is a clear influence of the current Beachlands WWTP discharge on conductivity downstream, with all sites showing conductivity manyfold above the ANZG DGV, indicating a 'potential risk' of adverse effects. Implications of increased conductivity are discussed in relation to the Current stage and not repeated here. It is expected that conductivity in the proposed discharge will continue to contribute to low/moderate effects on stream ecology downstream compared with upstream during Long-Term Stage 2. Riparian planting and installation of new pipes for the network along with a trigger for further work on causes should also reduce the effects of conductivity.

- The current WWTP discharge has consistently low TSS (median 7.8 mg/L) and there appears to be little difference in TSS for the receiving environment sites upstream and downstream of the wastewater discharge. The discharge concentrations during Long-Term Stage 2 (5 mg/L) should see a decrease in TSS of approximate 1.6-fold compared to the existing discharge and contribute to improved water quality downstream of the discharge.
- For ammoniacal-N – and the reasons discussed in the Current stage – we have not estimated ammoniacal-N concentrations downstream under any stage of the proposed WWTP upgrade.
- A maximum operational median nitrate-N concentration (2.0 mg/L) during Long-Term Stage 2 will likely result in an NPS-FM attribute band A for toxicity at the Bridge site. This is an improvement on the attribute band (B) for the Bridge site currently and would satisfy the requirement for an improvement under the NPS-FM.
- For DIN – and assuming the same attenuation as for nitrate-N – a maximum operational median of 2.5 mg/L during Long-Term Stage 2 would mean a DIN concentration at the Bridge site from the proposed discharge of around 0.8 mg/L, below the accepted threshold for eutrophication and a major improvement on DIN for the Bridge site currently (1.7 mg/L).
- For DRP, a maximum operational median concentration of 0.500 mg/L during Long Term Stage 2 would mean a DRP concentration at the Bridge site of 0.125 mg/L, resulting in an NPS-FM attribute band D but a decrease of DRP concentration at this site compared to the Bridge site currently (0.182 mg/L: also NPS-FM attribute band D). The proposed median DRP concentrations under the Long-Term Stage 2 WWTP upgrade will contribute to improved water quality downstream compared with the current WWTP, satisfying the intent of the NPS-FM.
- After attenuation through the proposed expanded overland and stream system, TN and TP loads will contribute 50% and 54% of total load from the catchment to the marine coastal environment.
- Risks from bacteria are negligible compared to catchment sources currently and with the future upgrades.
- Although based on only two monitoring events water metal concentrations are currently at 50% or below the ANZG DGV at the Bridge site and would be expected to be the same, or reduced, for Long-Term Stage 2, with the MBR upgrade.
- All sediment metal concentrations are currently and will be expected to be for Long-Term Stage 2, below the ANZG DGV.
- Further monitoring, through consent conditions is warranted to ensure metals are not increasing to above DGVs downstream as a result of the proposed discharge.
- The majority of EOCs will present negligible ecological effects based on measured and literature treated WWTP discharge concentrations. Most of the few EOCs that are present in concentrations above ecological effects concentrations will likely be significantly attenuated and/or diluted in the freshwater and marine environments and present with low risk of adverse effects. Concentrations of EOCs, and hence risks, are not expected to increase for Long-Term Stage 2, and with the MBR upgrade there may be a reduction in concentrations. Further monitoring, through consent conditions is warranted to better understand the risks of EOCs.
- A QMRA assessed mean infection risks, which are summarised as:

- For watercress consumption, a log reduction of 5 (100,000-fold reduction) is required to reduce the risk of infection to <1% at the Te Puru stream sites. There was little difference in risk between the discharge stages.
- For swimming, a log reduction of >4 (<10,000-fold) is required to reduce risks to below 1% at Te Puru stream sites. There was little difference in risk between the discharge stages and it was noted that swimming is unlikely at these sites. For marine sites, swimming health risks were low with a log reduction of <3 (<1000-fold) required at Kelly's Beach transect sites, and <1 (<10-fold) for those further out in the bay.
- For shellfish consumption, a log reduction of <2 (<10-fold) is sufficient to provide a risk of <1% at all marine sites.
- We note that the QMRA looks at the added risk from the WWTP, there is still existing risks from other sources but these are not part of QMRA.

Overall summary and conclusions

- The reference sites upstream provide a basis for considering the existing environment without the input of the WWTP noting that there can be changes in habitat as one moves downstream. The reference sites would be currently classified as degraded based on microbial contaminants and DRP is close to band D. With the WWTP contaminants added downstream the stream would be considered to be degraded on the basis of microbial contaminants, TN, nitrate-N, DIN, DRP and macroinvertebrate indices.
- The intertidal marine community at Kelly's Beach is typical of sheltered beaches around the Auckland region. The only threatened marine species (excluding birds) observed during the survey was seagrass, which was present in three very small patches on the lower shore. The area of seagrass cover is too small to meet the criteria of biogenic habitat.
- Overall, the potential ecological effects of the discharge on the freshwater ecological communities under the four proposed stages can be summarised as follows:
    - The proposed discharge operational limits for the Current and Short-Term Stages will likely result in similar water quality compared to the current water quality results and is highly likely to result in no significant change in the overall macroinvertebrate and fish community downstream compared to the most recent survey results.
    - The proposed discharge operational limits for Long-Term Stages 1 and 2, following the MBR upgrade, will result in an improvement in water quality compared to the current water quality results and is highly likely to result in an improvement in the overall macroinvertebrate and fish community downstream compared to the most recent survey results although the improvements may not be measurable. The overall magnitude of this effect will likely continue to be moderate but the effect from the WWTP cannot be easily separated from other variables (i.e. higher quality riparian vegetation and shading upstream) and stressors (sedimentation and nutrient input from adjacent farmland and side tributaries).
- Overall, the potential ecological effects of the discharge on the coastal marine environment under the 4 Stages covered by the consent application can be summarised as follows:
    - The proposed discharge rates under all four stages will have negligible effects on the salinity and the marine communities of Te Maraetai/Kellys Beach due to the

relatively low discharge rates compared to other nearby streams and rivers, the rapid dilution, and the tolerance of intertidal biota to low salinities. There will effectively be no change in salinity under any of the four stages from the existing WWTP.

- Nitrogen, and to a lesser extent, phosphorus, are the two primary limiting nutrients of concern in coastal waters. Proposed median TN and TP discharge concentrations will be 7 mg/L and 1.0 mg/L for the Current and Short-Term Stages, and 5 mg/L and 0.5 mg/L for Long-Term Stages 1 and 2. The WWTP discharge flow will increase over the term of the consent, therefore concentrations of these nutrients will be diluted (50% percentile) by 13,018× (Current), 1,352× (Short-Term), 831× (Long-Term Stage 1), and 309× (Long-Term stage 2) by the time they reach the Te Puru Stream mouth. This will result in nutrient concentrations being well below background concentrations in coastal waters under all four stages. Given the rapid dilution rate under all four stages, no increase in nutrient concentrations in coastal waters, or related adverse effects from increased nutrients, are likely to occur. Other minor contaminants that are present in the treated wastewater at low concentrations will be diluted at a similar rate to TN and TP. There will effectively be no change from the current WWTP.
- Potential effects on SEA-M1 site at Te Puru Stream estuary and SEA-M2 site at Te Maraetai/Kellys Beach are anticipated to be low given the level of influence the treated wastewater discharge under all four stages will have on nutrient concentrations and salinity in coastal waters. There will effectively be no change from the existing WWTP.
- Mean annual attenuated TN and TP loads from the existing WWTP by the time they reach the mouth of the Te Puru Stream are currently 1,979 kg/year and 233 kg/year, respectively. With respect to the proposed discharge:
  - For the Short-Term Stage, mean annual attenuated TN loads are estimated to increase 1.6-fold from current to 3,239 kg/year, and mean annual attenuated TP loads are estimated to increase 1.6-fold from current to 382 kg/year.
  - For Long-Term Stage 1, mean annual attenuated TN loads are estimated to increase 1.6-fold from current to 3,085 kg/year, and mean annual attenuated TP loads are estimated to increase 1.1-fold from current to 255 kg/year.
  - For Long-Term Stage 2, mean annual attenuated TN loads are estimated to increase 1.9-fold from current to 3,856 kg/year, and mean annual attenuated TP loads are estimated to increase 1.4-fold from current to 318 kg/year.

In comparison, TN loads for the Tamaki River, Wairoa River, Piako River, and Waihou River are around 60,000, 160,000, 1,415,000 and 2,168,000 kg/year, respectively, while TP loads for the Piako River, and Waihou River are 74,000 and 121,000 kg/year, respectively. Given that the estimated loads from the proposed discharge from the expanded and upgraded WWTP represent a very small percentage of the TN and TP loads entering the inner Hauraki Gulf and Firth of Thames, the effects of the increased loads from the proposed discharge for all stages assessed are expected to be less than minor.

1. Introduction

Watercare provides the majority of Auckland's urban area and satellite townships with wastewater services in the form of a public wastewater network and associated wastewater treatment and discharge facilities.

The WWTP currently services around 11,000 people and discharges treated wastewater via an overland flow system to a tributary of Te Puru Stream where it flows downstream and joins other tributaries to form the Te Puru Stream which subsequently flows into the estuary at Te Puru Park.

Upgrades to the existing Beachlands WWTP and an expansion of the overland flow system are required due to the projected future growth (up to 30,000 people) in Beachlands and Maraetai communities and the WWTP coming to the end of its design life. The WWTP discharge consent expires on 31st December 2025.[4]

Therefore, Watercare is submitting an application to renew the Beachlands WWTP discharge consent, which includes the proposed changes to discharge quality and overland flow system expansion and requires an ecological effects assessment for this application.

2. Scope of this report

This report provides an assessment of the potential ecological effects of treated wastewater discharges into a tributary of Te Puru Stream associated with the continued operation of an expanded Beachlands WWTP. Our assessment includes:

- A summary of the existing and proposed future (upgraded) WWTP operations and discharges, including consent compliance and discharge quality state and trends (**Section 3**).
- A summary of the existing water quality and ecology in the freshwater and marine receiving environments (**Section 4**).
- A description of the effects of the continued discharge of treated wastewater on the receiving environments currently and with the proposed future expanded and upgraded system (**Section 5**).

[4] https://www.watercare.co.nz/About-us/Projects-around-Auckland/Beachlands-WWTP-discharge-consent-renewal

3. Description of the existing and proposed future (upgraded) WWTP

3.1 Existing WWTP

3.1.1 Location, treatment, and monitoring sites

The Beachlands-Maraetai (Beachlands) WWTP is at 100 Okaroro Drive, Beachlands, approximately 3 km from Beachlands and 6 km from Maraetai (by road). The Beachlands WWTP is an activated sludge plant with biological nutrient removal (**BNR**) (Watercare, 2023). The following main unit processes are:

- Screenings and grit removal;
- Four-stage Bardenpho lagoon;
- Clarifier;
- Disk filtration;
- UV disinfection;
- Staged sludge digestion lagoons;
- Sludge drying beds;
- Stormflow buffer lagoon for raw wastewater; and
- Post-treatment lagoon for storm events.

The treated effluent is trickled through long pipes with holes, about 30 cm off the ground. The treated effluent then flows overland through grasses and bush towards a pond (**Figure 2**). The pond is formed by a small tributary of the Te Puru Stream (Site A) and dammed near Site B at the downstream end. From there the tributary flows downstream and joins other tributaries to form the Te Puru Stream (at the Bridge site (15))[5] (see **Figure 1** for locations and **Figure 3** for photos of Sites B and the Bridge (15)**)**. The Te Puru Stream flows into the estuary at Te Puru Park. Higher salinity water is detected up as far as just below the quarry site (**Figure 1**).

[5] We have identified the Bridge (Site 15) as the potential mixing zone site as it is sufficiently downstream to accommodate reasonable mixing from the existing farm pond and the proposed areas identified as potentially suitable for an expansion of the Beachlands overland flow system (see Section 3.2.2: **Figure 10**).

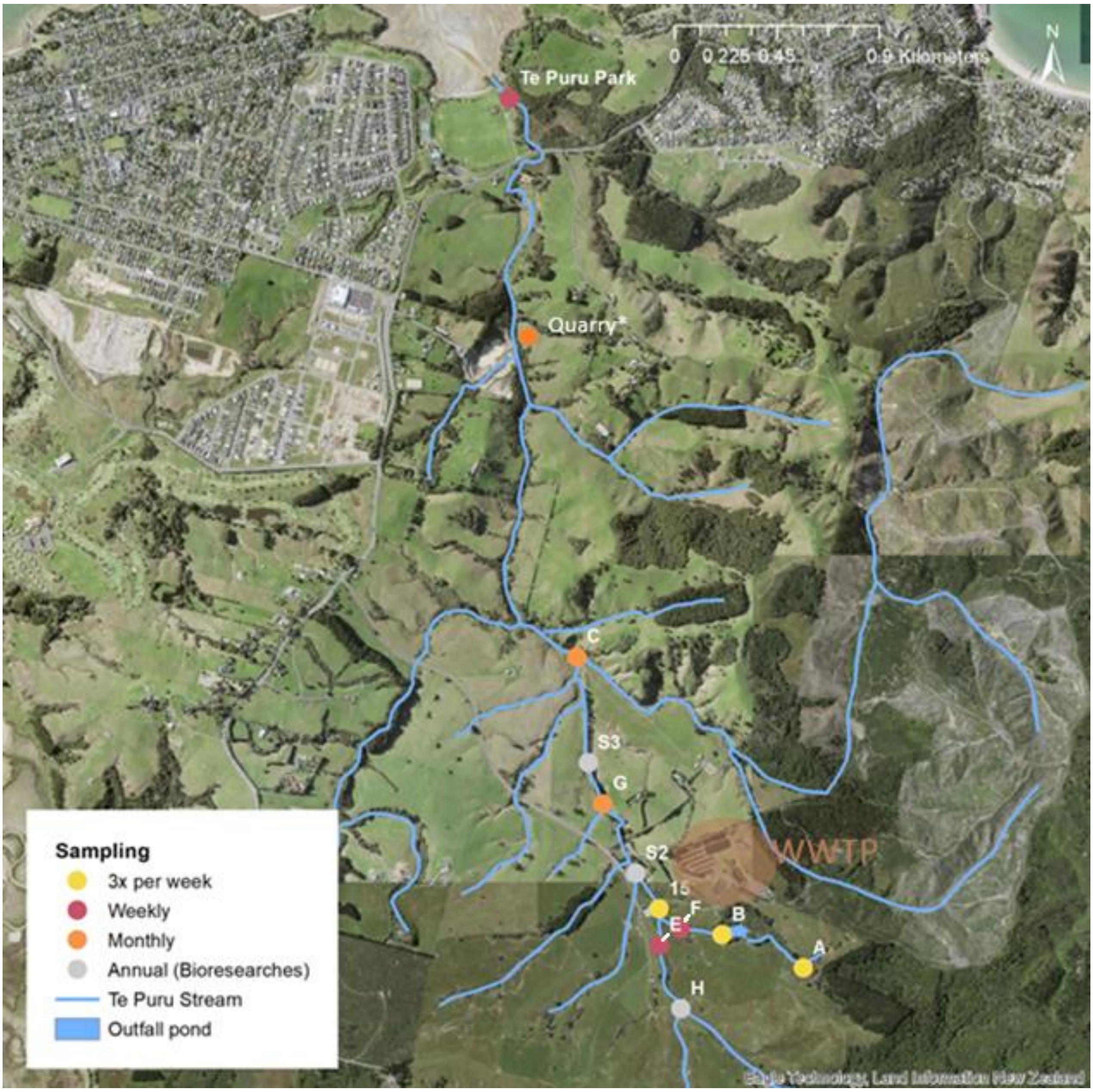

Figure 1. Location of Beachlands WWTP (brown oval), stream and river networks and water quality and annual ecology (Bioresearches) monitoring sites.

Figure 2. Trickle feed pipes (top) and farm pond (bottom).

Figure 3. Farm pond (B) (left) and Bridge (15) (right) sites.

3.1.2 Monitoring data

Watercare supplied discharge monitoring data for the Beachlands WWTP from January 2018 to December 2023 in excel format. These data were used for comparison with consent conditions (compliance: Section 3.1.3), to describe the discharge quality state (Section 3.1.4) and temporal trend changes (Section 3.1.5) from 2018-2023.

Further, Watercare have been undertaking extensive water quality monitoring of the WWTP influent and discharge and receiving environment sites since early September 2023[6]. Monitoring is ongoing at the time of writing, however data from 11th September to 24th January 2024 (inclusive)[7,8] were appended to the existing data from 2018-2023 and used to describe a more detailed current state for the discharge (this section) and receiving environment (Section 4).

[6] These data are collected in parallel to compliance monitoring data and are treated separately in this assessment.
[7] Monitoring data is being updated and maintained by Coast & Catchment Environmental Consultants in an online excel spreadsheet. Data were downloaded on 7th February 2024.
[8] A separate assessment of the dataset from 11th September to 19th February (inclusive) showed that apart from slightly higher variability for most parameters there was minimal difference between the two datasets. In the extended dataset, conductivity appears to have increased slightly in the outlet and also at the Bridge site, while nitrate has reduced slightly in the outlet but there is no change at Bridge site.

The sites monitored and frequency of monitoring are (**Figure 1**):

- WWTP influent and effluent (3 times per week).
- Farm Pond Tributary: Upstream of farm pond (Site A), farm pond (Site B), downstream of farm pond at confluence with Te Puru Stream (The farm pond tributary confluence (site 15); hereafter called the Bridge site) (3 times per week).
- Te Puru Stream: Upstream of Farm Pond Tributary (Site E) (weekly).
- Farm pond tributary: Between farm pond and confluence (Site F) (weekly).
- Two sites in Te Puru Stream downstream of confluence with farm pond tributary (Sites G and C: monthly).
- Te Puru Park: Where Te Puru Stream discharges into the marine environment (weekly).
- Quarry (weekly).[9]

The parameters measured were:

- Conductivity (mS/m).
- Temperature (°C).
- pH.
- Dissolved oxygen (DO: mg/L).
- Total Suspended Solids (TSS: mg/L).
- Volatile Suspended Solids (VSS: mg/L).
- 5-day carbonaceous Biochemical Oxygen Demand ($cBOD_5$: mg/L).
- Turbidity (NTU).
- Total nitrogen (TN: mg/L).
- Total phosphorus (TP: mg/L).
- *Escherichia coli* (*E. coli*: cfu/100mL).
- Faecal coliforms (FC: cfu/100mL).
- Enterococci (cfu/100mL).
- Ammoniacal-N (NH_4-N: mg/L)
- Nitrate-N (NO_3-N: mg/L).
- Nitrite-N (NO_2-N: mg/L)
- Dissolved reactive phosphorus (DRP: mg/L).
- Chlorophyll *a* (Chla: mg/L).

Further, metals and the metalloid arsenic[10], and pharmaceutical and personal care products (PPCPs) were measured in water on 10th and 11th December 2023 at WWTP influent and effluent sites, and the three sites in the Farm Pond Tributary (A, B, 15). Metals and phosphorus were also measured in surface sediment from the three sites in Farm Pond Tributary (A, B, 15). Metals are discussed in Section 3.1.6 and PPCPs in Section 3.1.7.

[9] Quarry monitoring only from late November 2023.
[10] Arsenic is a metalloid, which is a non-metal with metal properties. For simplicity arsenic will be described as a metal throughout this report.

3.1.3 Compliance with consent conditions

Performance of the Beachlands WWTP against relevant parameters specified in the wastewater discharge permit (consent number 26875) from 2018-2023 is shown in **Table 1**.

Discharge volume has been the only non-compliant discharge parameter over this time period, and consistently above the consent limit of 2,800 m^3/day. TSS has, at times, been very close to the 90th percentile consent limit of ≤15 mg/L (**Table 1**).

In 2019 ammoniacal-N was close to the 95th percentile winter limit of ≤5 mg/L but has been very low (<1 mg/L) over the last 3 winter periods (**Table 1**).

90th percentile DRP concentrations ranged from 0.47 mg/L in 2020 to 0.96 mg/L in 2023, well below the consent limit of ≤5 mg/L (**Table 1**).

Table 1. Summary of annual discharge compliance for Beachlands WWTP from 2018-2023. Cells bolded red exceed consent limit and show non-compliance.

Parameter	Units	Statistic	Consent limit	2018	2019	2020	2021	2022	2023
Discharge volume	m^3/day	Maximum	2,800	**5,619**	**3,420**	**3,801**	**3,601**	**4,257**	**4,331**
$cBOD_5$	mg/L	90th percentile	≤15	3.3	3.4	7.2	4.6	2.6	2.5
TSS	mg/L	90th percentile	≤15	13.4	11.0	15.0	13.2	10.1	10.8
FC	cfu/100mL	Median	≤14	2	2	2	2	2	2
DRP	mg/L	90th percentile	≤5	0.62	0.70	0.47	0.90	0.74	0.96
NO_3-N	mg/L	90th percentile	≤15	2.8	3.6	4.3	5.6	6.9	8.4
NH_4-N	mg/L	95th percentile	≤4 (Nov-Apr)	1.3	1.5	1.8	0.9	2.1	1.4
NH_4-N	mg/L	95th percentile	≤5 (May-Oct)	3.4	4.2	3.6	0.9	0.5	0.4

3.1.4 Discharge quality state (2018-2024)

The annual median discharge characteristics for the Beachlands WWTP for each calendar year from January 2018 to December 2023 are summarised in **Table 2**, along with the extensive monitoring undertaken for this assessment (2023/24). We note the latter data, although extensive (n=59 for most parameters), it is not for a full year and does not include data for winter and autumn seasons. Importantly it covers some of the drier parts of the year (see Section 4.2). A graphical presentation of these data (normalised to 2018 data) is provided in **Figure 4**.

DRP and nitrate-N have shown a marked increase in concentration since 2018. DRP has been increasing regularly over the 6 years and at 2023 (full year of data) was 2.93-fold higher than in 2018, while in 2023/24 (incomplete year of data) was 4.65-fold higher than 2018 (**Table 2** and **Figure 4**). The nitrate-N discharge concentration showed a large stepwise increase in 2022 (8.24-fold higher than 2018), which has been maintained over 2023 and 2023/24 (**Table 2** and **Figure 4**). The NH_4-N median is biased by many values below detection limit (0.4 mg/L) between 2018-2023. These high detection limits were present in the 2023-24 data from September until 4th December. When these data are included (value set at detection limit) the median was 0.40 mg/L.

However, when these data were not included the median (0.04 mg/L) was 10-fold lower. The reason for the change since 2018 was operational changes and constraints (pers. comm. Tanvir Bhamji, Watercare).

$cBOD_5$ and conductivity have shown a marked increase in 2023/24 compared to 2018 (4.75-fold and 4.15-fold increase, respectively), which was not seen in the intervening years (maximum of 1.6-fold and 1.8-fold increase, respectively) (**Table 2** and **Figure 4**). We note that the 2023/24 data is incomplete and is indicative only and temporal trends show that both have been decreasing between 2018 and 2023 (Section 3.1.5.).

The remaining parameters have remained reasonably static over the 6-year time period (**Table 2** and **Figure 4**).

The significance and non-significance of these temporal trends is investigated further in Section 3.1.5.

Table 2. Beachlands WWTP discharge annual medians from 2018-2023.

Parameter	Units	2018	2019	2020	2021	2022	2023	2023-24[1]
Discharge volume	m^3/day	1895	1772	1523	1716	1947	2038	1786
$cBOD_5$	mg/L	1.20	0.97	1.95	1.50	1.00	1.15	5.7
Conductivity	µS/cm	334	384	609	179	125	117	1385
DRP	mg/L	0.19	0.22	0.16	0.37	0.36	0.54	0.73
NO_3-N	mg/L	0.48	0.24	0.16	0.78	3.96	5.66	5.10
NO_2-N	mg/L	0.02	0.02	0.02	0.02	0.02	0.02	0.02
NNN	mg/L	0.48	0.24	0.19	0.78	4.00	5.85	5.12
NH_4-N[2]	mg/L	0.40	0.52	0.40	0.40	0.40	0.40	0.04
pH		7.10	7.10	7.00	7.10	7.00	6.90	7.2
TSS	mg/L	7.00	7.00	11.00	9.00	5.50	5.10	7.8

[1] Based on extensive Watercare monitoring described in Section 3.1.2. Note this is indicative as it is not for a full year and does not include winter and autumn data.

[2] Note: NH_4-N median data for 2018-2023 is biased by many values below detection limit (0.4 mg/L). These were not included in 2023-24 data, resulting in a median 10-fold lower.

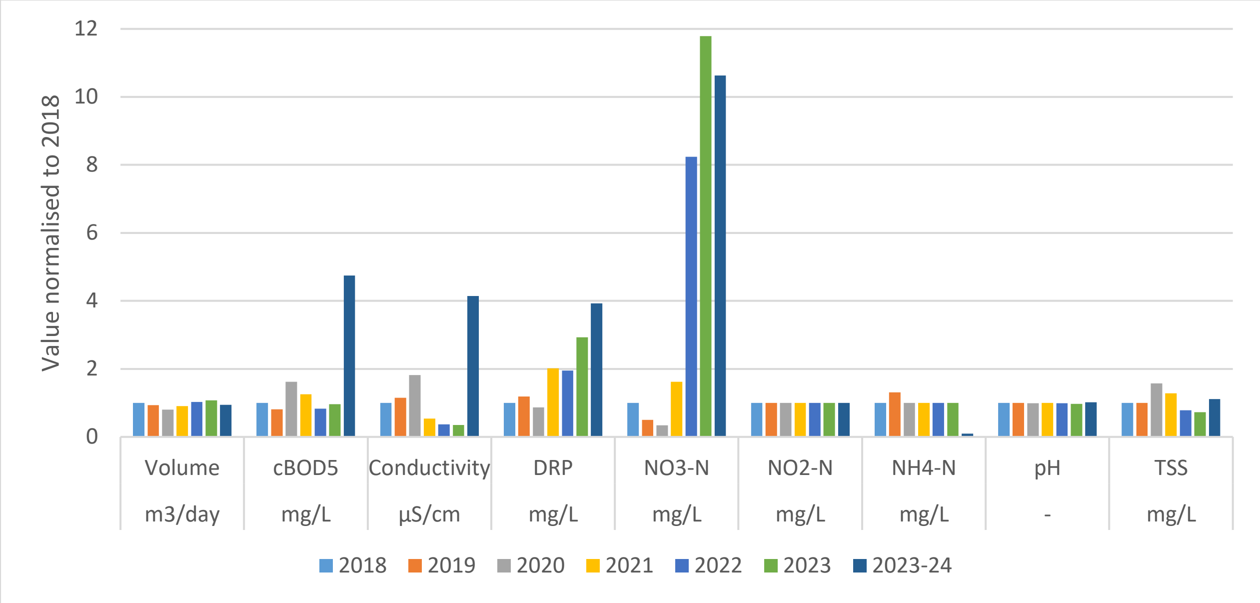

Figure 4. Beachlands WWTP discharge annual medians for 2018 to 2024 normalised to 2018 data.

3.1.5 Discharge quality trends (2018-2023)

3.1.5.1 Methods

Temporal trend analysis were undertaken using data from over the last 6 years.

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 (↓)**.

3.1.5.2 Results and discussion

Table 3 summarises the results of the temporal trend analyses of the Beachlands WWTP discharge between January 2018 and December 2023, with full results presented in Appendix 1.

Despite the discharge volume being non-compliant since 2018 (Section 3.1.3), there has been a slight (although not significant: p=0.894) decrease over this time period of -0.2% per year (**Table 3**).

$cBOD_5$ has also been reducing since 2018 by around 1.6% per year, although this has not been significant (p=0.626) (**Table 3**). We note the 2023/24 monitoring data (although an incomplete year) has shown an increase of 4.75-fold for $cBOD_5$ on 2018 data (see Section 3.1.4).

Conductivity has been decreasing significantly (p=0.000) and meaningfully (16.4% median annual decrease) in the discharge since 2018 (**Table 3** and **Figure 5: Top**). The decrease is consistent with that of the influent which is decreasing significantly (p=0.000) and meaningfully (18.7% median annual decrease) (**Figure 5: Bottom**). We note the 2023/24 monitoring data (although an incomplete year) has shown an increase of 4.15-fold for conductivity on 2018 data (see Section 3.1.4). This marked increase requires further investigation by Watercare as conductivity is a potential stressor of ecological communities downstream of the discharge. A trigger for conductivity should be considered that would result in further work to establish the cause and what can be done to mitigate the issue. It should also be noted that new piping for an expanded network will reduce risk of saltwater ingress.

TSS has been decreasing significantly (p=0.012) and meaningfully (7.4% median annual decrease) in the discharge since 2018 (**Table 3** and **Figure 6: Top**). The decrease is consistent with that of the influent in terms of the direction of the trend (decreasing) and the magnitude (4.5% median annual decrease) (**Figure 6: Bottom**) but the trend is not significant (p=0.402).

pH has been decreasing significantly (p=0.000) but not meaningfully (0.5% median annual decrease in the discharge since 2018 (**Table 3**). pH is not measured in the influent, so no comparison could be undertaken.

As discussed above DRP has been increasing significantly (p=0.000) and meaningfully (23.5% median annual increase) in the discharge since 2018 (**Table 3** and **Figure 7**).

Nitrate-N has been increasing significantly (p=0.000) and meaningfully (77.4% median annual increase) in the discharge since 2018 (**Table 3** and **Figure 8**). Prior to mid-2020 concentrations were relatively static but have been ramping up consistently since this time (**Figure 8**). Nitrate-N (and NH_4N) concentrations in the discharge are a function of nitrification/denitrification processes occurring in the WWTP, so it appears that a significant change to the WWTP process may have occurred since mid-2020, leading to marked increases in nitrate-N since this time.

Ammoniacal-N concentrations have remained static since 2018 with a percent median annual change of 0.0% (**Table 3**). We noted previously that these data are skewed by too many censored data (below detection limit).

Faecal coliforms and *E. coli* concentrations in the discharge have remained very low and static (percent median annual change is 0) since 2018 (**Table 3**).

Table 3. Summary of trend analysis between 2018 and 2023 for parameters measured in the Beachlands WWTP discharge.[11] Significant increasing trends are bold arrows with meaningful decreasing and increasing trends highlighted in blue and red, respectively. Non-bold arrows show direction of non-significant changes.

Parameter	Unit	Method	Mean	Median	P	Percent median annual change	Trend
Discharge volume	m^3/day	Seasonal Kendall	1854	1843	0.894	-0.2	↓
$cBOD_5$	mg/L	Seasonal Kendall	1.6	1.3	0.626	-1.6	↓
Conductivity		Seasonal Kendall	359	320	0.000	-16.4	**↓**
TSS	mg/L	Mann-Kendall	7.5	6.9	0.012	-7.4	**↓**
pH		Seasonal Kendall	7.0	7.0	0.000	-0.5	**↓**
DRP	mg/L	Seasonal Kendall	0.35	0.28	0.000	23.5	**↑**
NO_3-N	mg/L	Mann-Kendall	2.09	1.18	0.000	77.4	**↑**
NO_2-N	mg/L	Mann-Kendall	0.09	0.02	0.199	0.0	→
NH_4-N[1]	mg/L	Seasonal Kendall	0.54	0.40	0.001	0.0	→
FC	cfu/100mL	Mann-Kendall	3	2	0.025	0	→
E. coli	cfu/100mL	Mann-Kendall	2	2	0.503	0	→

[1] A trend for NH4-N was not possible due to too many censored data (below detection limit).

[11] Seasonal Kendall method used for all parameters except for TSS for which a Mann Kendall method was used.

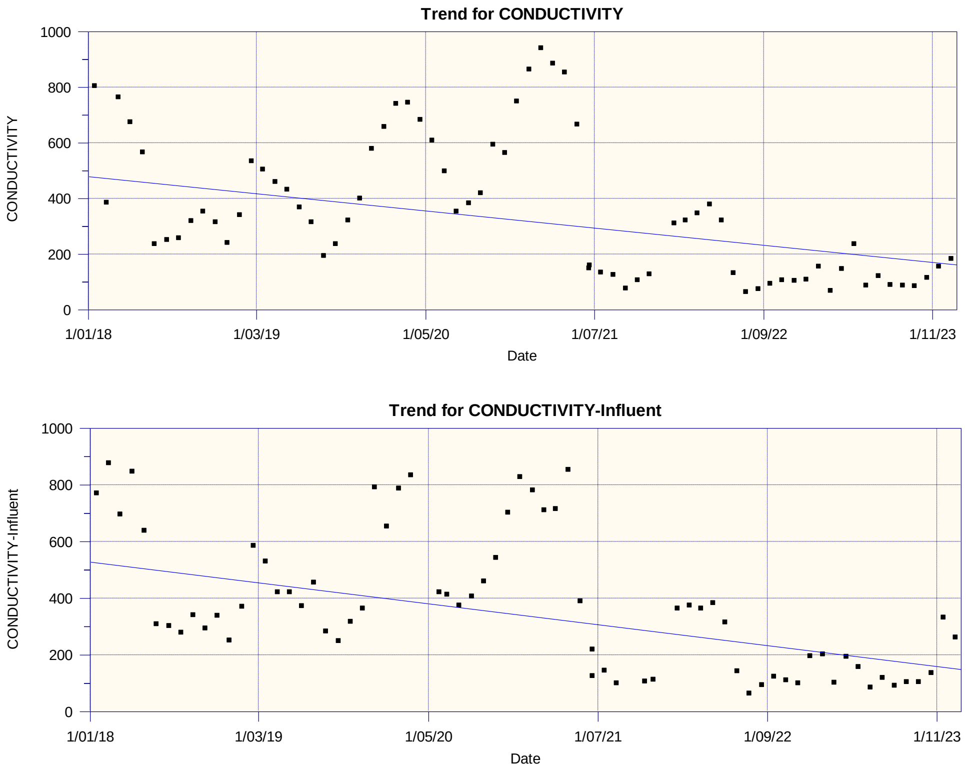

Figure 5. Significant and meaningful decrease in conductivity in discharge (top) and influent (bottom) from Beachlands WWTP discharge between 2018 and 2023. Values are monthly medians, and the line represents the median annual slope.

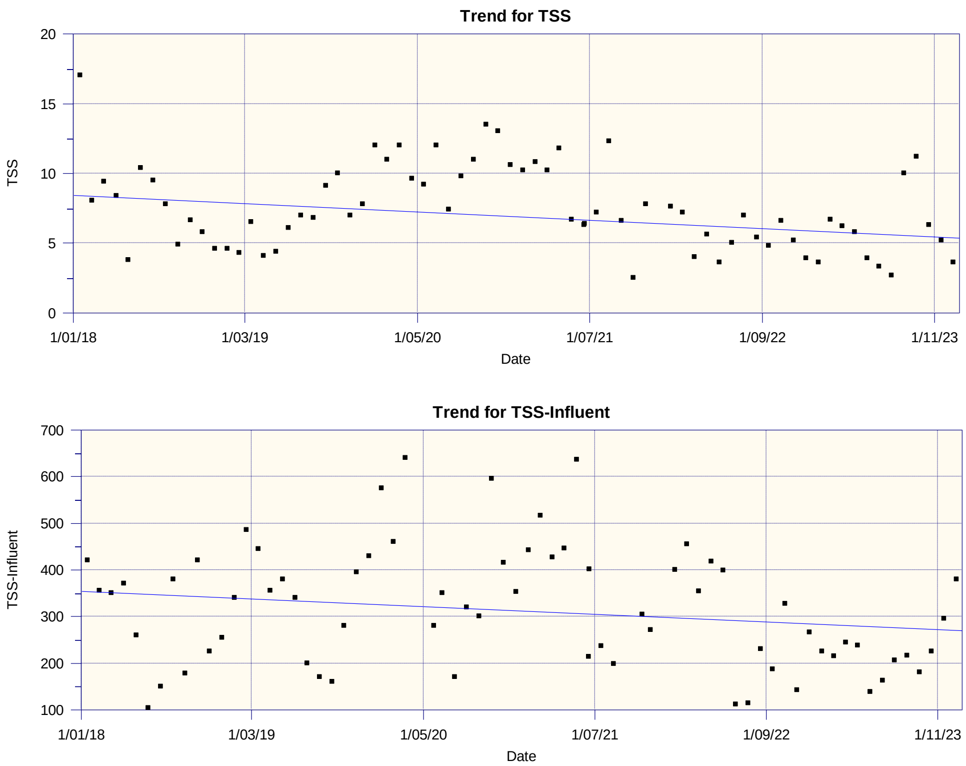

Figure 6. Significant and meaningful decrease in TSS in discharge (top) and non-significant decrease in influent (bottom) from Beachlands WWTP discharge between 2018 and 2023. Values are monthly medians, and the line represents the median annual slope.

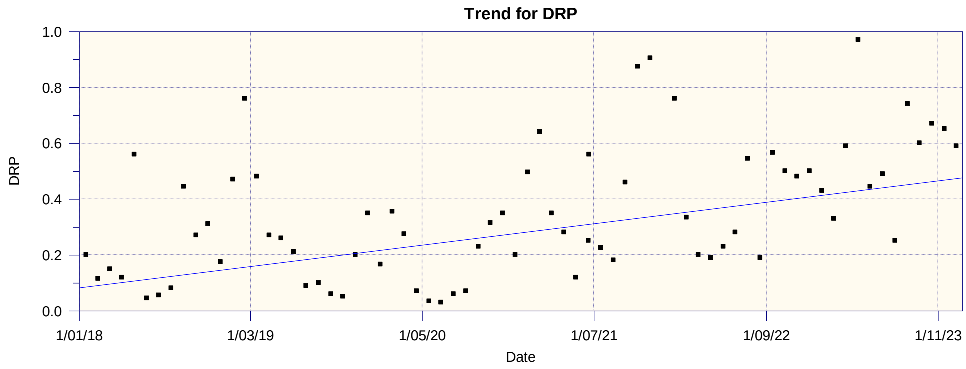

Figure 7. Significant and meaningful increase in DRP in discharge from Beachlands WWTP discharge between 2018 and 2023. Values are monthly medians, and the line represents the median annual slope.

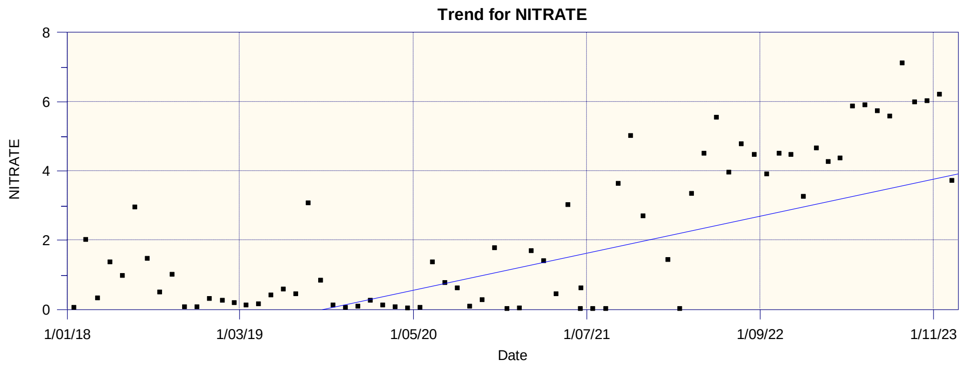

Figure 8. Significant and meaningful increase in nitrate-N in discharge from Beachlands WWTP discharge between 2018 and 2023. Values are monthly medians, and the line represents the median annual slope.

3.1.6 Metals

Total and dissolved metal concentrations were measured on 10th and 11th December 2023 from the WWTP inlet and outlet. Mean and standard deviations of each concentration are presented in **Table 4**, with comparison against the ANZG 2018 95% freshwater DGV. We note the DGV is not designed for wastewater samples and is included to provide context only.

For the inlet, total and dissolved chromium, copper, mercury, and zinc exceed the DGV by around 2-fold to 33-fold (total copper) (**Table 4**).

For the outlet, only total copper, and total and dissolved zinc exceed the DGV, at 1.3-fold, 2.0-fold, and 3.4-fold, respectively (**Table 4**). These data suggest that, based on limited sampling, minimal attenuation and/or dilution of copper and zinc would be required in the wastewater treatment system prior to discharge into the receiving environment. Receiving environment metal concentrations were measured at the same time and are described in Section 4.4.1.4.

Table 4. Mean and standard deviation (n=2) of total and dissolved metal concentrations reported from the inlet and outlet of Beachlands WWTP on 10th/11th December 2023 and comparison with ANZG (2018) DGVs. Bolded values exceed the guideline.

Location	Parameter	Unit	Mean	Standard Deviation	ANZG 95% DGV
Inlet	Arsenic-dissolved	µg/L	0.70	0.03	13
	Arsenic-total	µg/L	1.20	0.14	13
	Cadmium-dissolved	µg/L	<0.05	NA	0.2
	Cadmium-total	µg/L	0.08	0.01	0.2
	Chromium-dissolved	µg/L	**1.5**	0.4	1.0
	Chromium-total	µg/L	**4.0**	1.5	1.0
	Copper-dissolved	µg/L	**2.9**	0.4	1.4
	Copper-total	µg/L	**46.0**	1.4	1.4
	Lead-dissolved	µg/L	0.2	NA	3.4
	Lead-total	µg/L	1.7	0.4	3.4
	Mercury-dissolved	µg/L	**0.10**	0.06	0.06
	Mercury-total	µg/L	**0.10**	0.06	0.06
	Nickel-dissolved	µg/L	1.5	0.4	11
	Nickel-total	µg/L	2.8	0.1	11
	Zinc-dissolved	µg/L	**18**	11	8
	Zinc-total	µg/L	**115**	7	8
Outlet	*Arsenic-dissolved*	µg/L	0.53	0.01	13
	Arsenic-total	µg/L	0.56	0.01	13
	Cadmium-dissolved	µg/L	<0.05	NA	0.2
	Cadmium-total	µg/L	<0.05	NA	0.2
	Chromium-dissolved	µg/L	<0.5	NA	1.0
	Chromium-total	µg/L	0.6	0.1	1.0
	Copper-dissolved	µg/L	1.4	0.0	1.4
	Copper-total	µg/L	**1.9**	0.1	1.4
	Lead-dissolved	µg/L	<0.1	NA	3.4
	Lead-total	µg/L	<0.1	NA	3.4
	Mercury-dissolved	µg/L	<0.05	NA	0.06
	Mercury-total	µg/L	<0.05	NA	0.06
	Nickel-dissolved	µg/L	1.1	0.0	11
	Nickel-total	µg/L	1.3	0.2	11
	Zinc-dissolved	µg/L	**16**	11	8
	Zinc-total	µg/L	**28**	1	8

NA = Not applicable.

3.1.7 EOCs

3.1.7.1 PPCPs

Watercare have developed an analytical suite of pharmaceutical and personal care products and wastewater markers (**PPCPs**). PPCPs were measured in the inlet (influent) and outlet (discharge) of Beachlands WWTP on 10th and 11th November 2023, with the results summarised in **Figure 9**. The concentrations are generally markedly lower in the discharge than the influent. Potential effects of these PPCPs are described in Section 5.3.5.

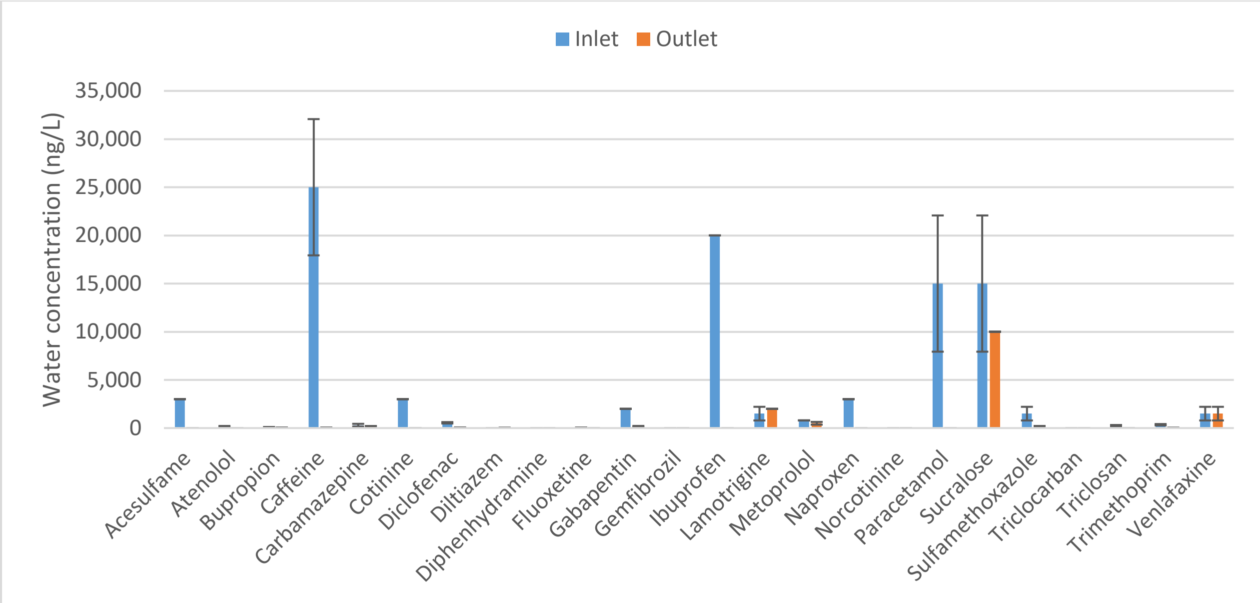

Figure 9. Mean and standard deviation (n=2) of PPCP concentrations reported from the inlet and outlet of Beachlands WWTP on 10th/11th December 2023.

3.1.7.2 EOCs from literature review

The Watercare PPCP analyte suite does not include other EOCs of potential risk, especially those of industrial origin. Therefore EOC data have been appended from recent surveys of three similar sized WWTPs in Auckland. To fulfil resource consent condition requirements for the proposed South-West, Omaha and Wellsford WWTP discharges, Watercare contracted SEL to undertake an ecological risk assessment on EOCs (Stewart, 2022). The assessment included measuring 125 EOCs in the treated wastewater of Waiuku, Omaha, and Wellsford WWTPs. Mean concentrations of the 35 EOCs that were detected in at least one of the three are summarised in **Table 5**. Potential effects of these PPCPs are described in Section 5.3.5.

Table 5. Mean concentration of EOCs of the treated discharge from Waiuku, Omaha, and Wellsford WWTPs undertaken in 2022 (Stewart, 2022).

Class	Analyte[1]	Auckland 2022 Mean concentration (ng/L)
Akylphosphate flame retardant	TBEP	79
	TBP	32
	TCEP	63
	TCPP	896
	TDCP	53
	TiBP	20
	TPP	2.3
Alkylphenol	Tech-NP-equivalents	108
Antimicrobial	Chlorophene	3.6
	Chloroxylenol	7.2
Insecticide	DEET	56
Nitro and polycyclic musk fragrance	Cashmeran	14
	Galaxolide	276
	Tonalide	15
Pharmaceutical	Acetaminophen	19
	Carbamazepine	163

Class	Analyte[1]	Auckland 2022 Mean concentration (ng/L)
	Diclofenac	60
	Ibuprofen	11
	Naproxen	75
	Salicylic acid	43
Plasticiser	BBP	3.9
	Bisphenol A	16
	DBP	16
	DEHP	29
	DEP	9.5
	DMP	3.6
Plasticiser metabolite	MBP	14
	MEHP	32
	MMP	3.9
PFAS	PFOS	7.9
	PFHxA	9.1
	PFHpA	3.2
	PFOA	6.6
	PFNA	1.9
	PFDA	1.6

[1] TBEP = Tris-(2-butoxyethyl) phosphate; TBP = Tributyl-phosphate; TCEP= Tris(2-chloroethyl) phosphate; TCPP = Tris (1-chloro-2-propyl) phosphate; TDCP = Tris[2-chloro-1-(chloromethyl)ethyl] phosphate; TiBP = Tri-isobutyl-phosphate; TPP = Triphenylphosphate; Tech-NP-equivalents = Technical nonylphenol equivalents; DEET = N, N-Diethyl-meta-toluamide; BBP = Butylbenzylphthalate; DBP = Di-n-butylphthalate; DEHP = Diethylphthalate; DEP = Diethylphthalate; DMP = Dimethylphthalate; MBP = Monobutyl-phthalate acid ester; MEHP = Monoethylhexyl phthalate acid ester; MMP = Monomethyl phthalate acid ester; PFOS = Perfluorooctanesulfonic acid; PFHxA = Perfluorohexanoic acid; PFHpA = Perfluoroheptanoic acid; PFOA = perfluorooctanoic acid; PFNA = Perfluorononanoic acid; PFDA = Perfluorodecananoic acid.

3.1.8 Viruses (QMRA)

Viruses have not been measured in wastewater at the Beachlands WWTP but NIWA undertook a quantitative microbial risk assessment (QMRA) as part of an overall assessment of microbial health risks (Wood and Stott, 2024) to assess potential human health risks from viruses in the treated wastewater. This is summarised in Section 5.3.6.

3.2 Future (upgraded) WWTP

3.2.1 Discharge quality

The proposed WWTP discharge will occur over four stages. The first (Current) stage will involve discharges from the WWTP in its present form. Next comes the Short-Term Stage involving discharges following an upgrade of the existing WWTP, and finally Long-Term Stages 1 and 2 involving new Membrane Bioreactor (**MBR**) WWTP treatment.

The WWTP is currently operating at its design capacity and has limited scope to accept any additional growth. The short-term upgrade will alleviate this constraint by upgrading components of the existing WWTP[12]. The long-term upgrade will involve construction of a new WWTP replacing the existing one, albeit using the same biological treatment process. The current bioreactor lagoon will be replaced with new concrete tanks termed activated sludge reactors (**ASR's**). The secondary clarifier and disc filters will be replaced by new ultrafiltration (**UF**) MBR's.

[12] See AEE Section 2.7.1 to 2.7.3 for full description of the upgrades.

The upgrades will include increased capacity with the MBR also providing improved discharge concentrations for some contaminants. The predicted characteristics for the staged approach for the upgrades is shown in **Table 6**. These are operational limits thus represent the maximum expected concentration and load for the type of treatment plant in operation. Following conservative principles, we have used these operational limits for our assessment of effects. However, it is expected that actual concentrations to be less than these operational limits and no worse than current concentrations, i.e. no deterioration in discharge quality from current state.

The population being serviced and the annual daily flows (ADF) are expected to increase from current (11,000 people and 2,200 m^3/day ADF) to Long-Term Stage 2 (30,000 people and 6,000 m^3/day ADF). Maximum wastewater daily flows (also called peak wet weather flow (**PWWF**)) are expected to increase from current (4,500 m^3/day) to Long-Term Stage 2 (36,200 m^3/day). We note that the assessment of effects (Section 5) uses the ADF and not the maximum treated PWWF. We have approached it this way because the overland flow system (current and proposed expansion) will buffer wet weather flows, primarily in the pond, effectively removing effects from wet weather discharges.

After commissioning of the new MBR WWTP, operational limits for median $cBOD_5$ and TSS concentration will reduce from 7.0 mg/L to 5.0 mg/L, or 71% of the existing WWTP operational limits (compared with current measured values of 5.7 and 11 mg/L). 95^{th} percentile $cBOD_5$ and TSS concentrations will reduce from 15 mg/L to 9 mg/L (60% of existing operational limits), while TN concentrations will reduce from 16 mg/L to 11 mg/L (69% of existing operational limits) (**Table 6**).

Operational limits for ammoniacal-N concentrations will see a small reduction from existing, with median concentrations reducing from 0.6 mg/L to 0.5 mg/L (83% of existing operational limit), while 95^{th} percentile concentrations will remain unchanged (3.0 mg/L) (**Table 6**).

NO_x-N is the sum of nitrate-N and nitrite-N (NNN) which is predominantly nitrate-N (88.9%-99.6% of NNN, see **Table 2**). After commissioning of the new MBR WWTP, operational limits for NO_x-N concentrations will see a large reduction, with median concentrations reducing from 3.5 mg/L to 2.0 mg/L (57% of existing operational limits) and 95^{th} percentile concentrations reducing from 11 mg/L to 4.5 mg/L (41% of existing operational limit) (**Table 6**). This compares with a current measured median discharge concentration of 5.1 mg/L and 95^{th}%ile of 6.4 mg/L

Dissolved inorganic nitrogen (DIN) is the sum of NNN and ammoniacal-N which is reflected in the discharge characteristics. After commissioning of the new MBR WWTP, the operational limits for DIN concentrations will see a large reduction, with median concentrations reducing from 4.1 mg/L to 2.5 mg/L (61% of existing operational limit), and 95^{th} percentile concentrations reducing from 14 mg/L to 7.5 mg/L (54% of existing operational limit) (**Table 6**). This compares with a current measured median discharge concentration of 5.5 mg/L and 95^{th}%ile of 6.8 mg/L.

After commissioning of the new MBR WWTP, operational limits for TP/DRP concentrations will see a large reduction from 1.0 mg/L to 0.5 mg/L (50% of existing operational limits), and 95^{th} percentile concentrations reducing from 3.0 mg/L to 1.0 mg/L (54% of existing operational limits) (**Table 6**). This compares with a current measured median discharge concentration of 0.73 mg/L and 95^{th}%ile of 1.09 mg/L.

FC concentrations will remain unchanged throughout the staged upgrade.

Table 6. Current, short-term and long-term staged Beachlands WWTP operational limits predicted based on the type of treatment system.[13]

Influent Flows and Loads	Units	Existing WWTP		New WWTP (MBR)	
		Current	Short-Term	Long-Term Stage 1	Long-Term Stage 2
Design population	P.E.	11,000	18,000	24,000	30,000
Annual average daily flow	m^3/day	2,200	3,600	4,800	6,000
Maximum treated wastewater daily flow	m^3/day	4,500	8,700	28,900	36,200

Effluent Median concentrations	Units	Existing WWTP	New WWTP (MBR)
		Current and Short-Term	Long-Term Stage 1 and Stage 2
$cBOD_5$	mg/L	7.0	5.0
TSS	mg/L	7.0	5.0
NH_4-N	mg/L	0.6	0.5
NO_x-N (NNN)	mg/L	3.5	2.0
DIN	mg/L	4.1	2.5
TN	mg/L	7.0	5.0
DRP and TP	mg/L	1.0	0.5
Faecal coliform	cfu/100mL	<10	<10

Effluent 95th percentile concentrations	Units	Existing WWTP	New WWTP (MBR)
		Current and Short-Term	Long-Term Stage 1 and Stage 2
$cBOD_5$	mg/L	15	9
TSS	mg/L	15	9
NH_4-N	mg/L	3.0	3.0
NO_x-N (NNN)	mg/L	11	4.5
DIN	mg/L	14	7.5
TN	mg/L	16	11
DRP and TP	mg/L	3.0	1.0
Faecal coliform	cfu/100mL	100	100

Effluent Loads	Units	Existing WWTP		New WWTP (MBR)	
		Current	Short-Term	Long-Term Stage 1	Long-Term Stage 2
Median $cBOD_5$ load	kg/day	15	25	24	30
Median TSS load	kg/day	15	25	24	30
Median NH_4-N load	kg/day	1.3	2.2	2.4	3.0
Median NO_x-N load	kg/day	7.7	13	10	12
Median DIN load	kg/day	9.0	15	12	15
Median TN load	kg/day	15	25	24	30
Median DRP and TP load	kg/day	2.2	3.6	2.4	3.0[14]

[13] Provided by Andrew Slaney (Stantec) by email on 12th April 2024, and after further discussions with Watercare. The 95th percentiles were based on observed performance and also literature values of similar BNR plants. FC and *E. coli* numbers are interchangeable.

[14] The median DRP/TP load provided in **Table 6** at Long-Term Stage 2 (3.0 kg/day) is 50% of the load used by DHI (2024) to calculate WWTP loads relative to catchment (see Section 3.3). This was a result of more recent follow-up work leading to the revisions. The outcome will be less of an effect from P loads to the marine receiving environment than concluded in this report.

3.2.2 Overland flow expansion

The proposed 3-fold increase in discharge volumes requires an appropriate scaled expansion of the overland flow system. PDP (2024a) have undertaken a preliminary assessment of the current overland flow system, determined if the system can be expanded, and identified potential expansion areas for further investigation (**Figure 10**).

PDP consider that it is unlikely to be possible to expand the existing overland flow discharge area proportional to the predicted rise in WWTP effluent flows. This is primarily due to the steeply incised banks of the stream which exist throughout the entire reach except for the pond area where the current system operates. Due to the steep banks the overland flow is at a higher risk of causing erosion/damage to the stream banks.

Potentially suitable land for an appropriately sized overland flow system is available if land on the south side of the stream within Watercare's property is utilised (see **Figure 10**). However, the new overland flow system would require a collection system to safely convey the discharge into the stream and avoid erosion. Diffuse discharge to the stream will be challenging without significant earthworks and riparian vegetation disturbance.

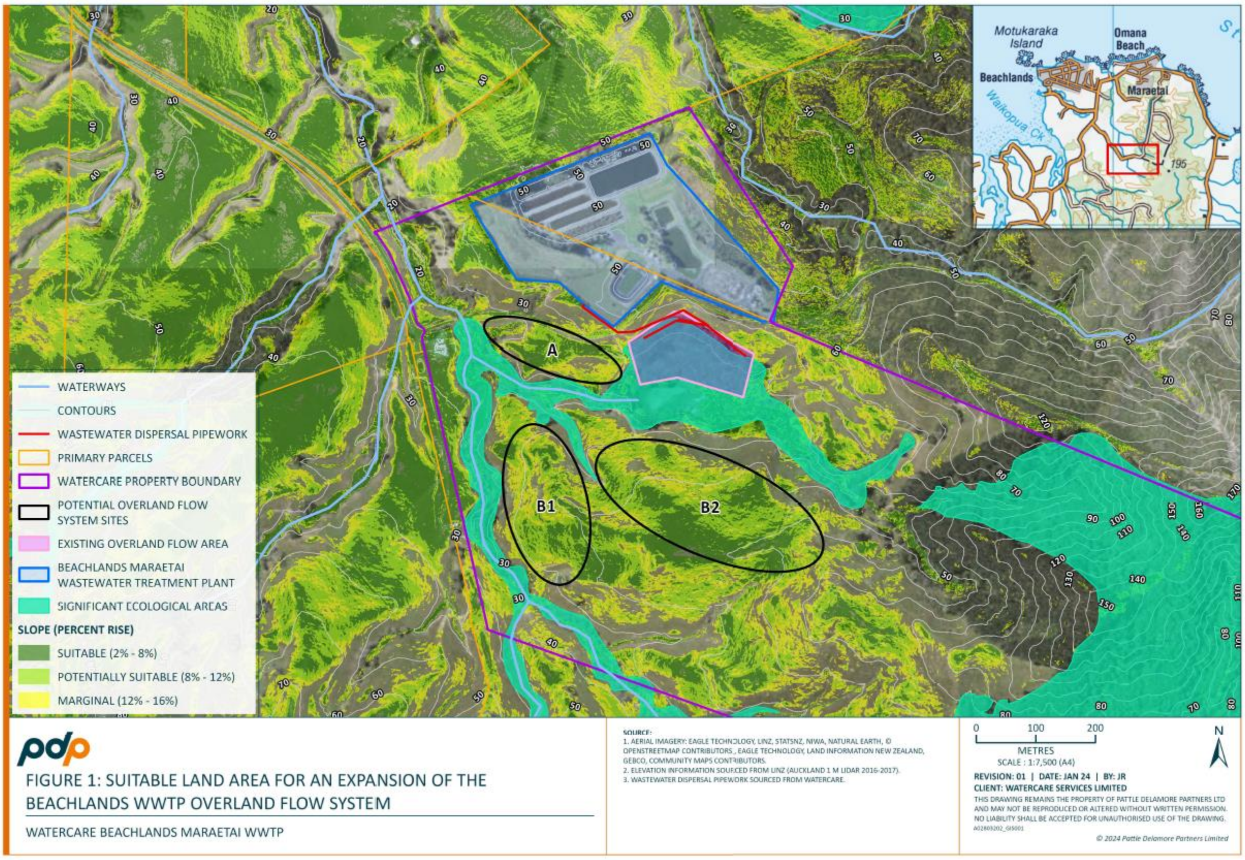

Figure 10. Suitable land area for an expansion of the Beachlands WWTP overland flow system (PDP, 2024a).

3.3 WWTP loads and proportion of catchment loads

DHI provided attenuated TN and TP loads[15] for the Current and Short-Term stages and Long-Term Stages 1 and 2, along with catchment loads (**Table 7**) (DHI, 2024).

Attenuated TN annual loads from the proposed discharge are expected to increase from the current load of 1,979 kg/year to 3,239 kg/year, 3,085 kg/year and 3,856 kg/year for Short-Term stage, Long-Term Stage 1 and Long-Term Stage 2, respectively, an approximate 1.6-fold to 2-fold increase. The contribution of Beachlands WWTP TN loads to the total load entering the estuarine environment is currently 34%, which will increase to 46%, 45%, and 50% at Short-Term stage, Long-Term Stage 1, and Long-Term Stage 2 respectively (**Table 7**).

Attenuated TP annual loads from the proposed discharge are expected to increase from the current load of 233 kg/year to 382 kg/year, 255 kg/year and 318 kg/year for Short-Term stage, Long-Term Stage 1 and Long-Term Stage 2, respectively, an approximate 1.1-fold to 1.4-fold increase. The contribution of Beachlands WWTP TP loads to the total load entering the estuarine environment is currently 46%, which will increase to 59%, 49%, and 54% at the Short-Term stage, Long-Term Stage 1, and Long-Term Stage 2 respectively (**Table 7**).

Table 7. Mean annual TN and TP loads for Beachlands WWTP outlet and Te Puru catchment.

Scenario	Unit	WWTP stage			
WWTP		**Current**	**Short-Term**	**Long-Term Stage 1**	**Long-Term Stage 2**
TN	kg/year	1,979	3,239	3,085	3,856
TP	kg/year	233	382	255	318
Te Puru Catchment		**Current**	**Short-Term**	**Long-Term Stage 1**	**Long-Term Stage 2**
TN	kg/year	3,825	3,825	3,825	3,825
TP	kg/year	270	270	270	270
Combined		**Current**	**Short-Term**	**Long-Term Stage 1**	**Long-Term Stage 2**
TN	kg/year	5,805	7,064	6,910	7,681
TP	kg/year	504	652	525	589
WWTP percentage of total load		**Current**	**Short-Term**	**Long-Term Stage 1**	**Long-Term Stage 2**
TN	%	34%	46%	45%	50%
TP	%	46%	59%	49%	54%

3.4 Summary of the existing and proposed discharge

For the existing WWTP discharge:

- There has been full compliance with the current consent (number 26875) conditions between 2018–2023 for all parameters except discharge volume, which has exceeded the maximum consented volume of 2,800 m^3/day each year.

[15] WWTP loads are calculated from the discharge with attenuation through the overland and stream system.

- Dissolved reactive phosphorus (DRP) and nitrate-N have shown a marked increase in concentration between 2018–2023, with annual increases of 24% and 77%, respectively due to operational changes and constraints.
- Annual median decreases of 5-day carbonaceous Biochemical Oxygen Demand ($cBOD_5$) (1.6%), conductivity (16%), total suspended solids (TSS) (7.4%), and pH (0.5%) have been observed between 2018–2023.
- Ammoniacal-N, nitrite-N, faecal coliforms, and *Escherichia coli* (*E. coli*) have remained unchanged over this time.
- Based on limited sampling, total copper, and total and dissolved zinc are at concentrations above the ANZG 2018 default guideline values (DGVs), suggesting some dilution and/or attenuation is required in the wastewater treatment system prior to discharge into the receiving environment.
- Emerging organic contaminant (EOC) concentrations were acquired from limited sampling and literature.
- After attenuation through the overland and stream system, TN and TP loads contribute 32% and 44% of total catchment load to the marine coastal environment.
- Viruses have not been measured in Beachlands WWTP. A quantitative microbial risk assessment (QMRA) was undertaken to assess the enteric illness risk of viruses in the discharge.

For the proposed discharge from the WWTP:

- The existing WWTP will initially undergo a capacity upgrade before the start of the Short-Term stage.
- The existing WWTP will undergo upgrades for water quality when a new MBR WWTP is commissioned for Long-Term Stages 1 and 2.
- The population being serviced and the annual daily flows are expected to increase from current (11,000 people and 2,200 m^3/day ADF) to Short-Term (18,000 people and 3,600 m^3/day ADF), to Long-Term Stage 1 (24,000 people and 4,800 m^3/day ADF), and finally Long-Term Stage 2 (30,000 people and 6,000 m^3/day ADF).
- The overland flow expansion to accommodate the increased flows will likely require a new area to the south of the stream and a collection drain to convey the discharge into the stream and avoid erosion.
- After commissioning of the new MBR WWTP (Long-Term Stages 1 and 2) new operational limits will be introduced that will have the following effect:
    - Median $cBOD_5$ and TSS concentrations will be < 5.0 mg/L (compared with <7.0 mg/L for the Current and Short-Term stages and up to 5.7 mg/L and 11 mg/L currently measured, respectively).
    - 95^{th} percentile $cBOD_5$ and TSS concentrations will be <9 mg/L and TN concentrations be <11 mg/L (compared with <15 mg/L and 16 mg/L for the Current and Short-Term stages, respectively).
    - Operational limits for median TN will be < 5.0 mg/L (compared with <7.0 mg/L for the Current and Short-Term stages and 6.4 mg/L currently measured).
    - Ammoniacal-N concentrations (<0.5 mg/L) will be similar to those for the Current and Short-Term stages (0.6 mg/L).

- NO_x-N concentrations will see a large reduction, with median concentrations reducing to <2.0 mg/L (compared with <3.5 mg/L for the operation limits for Current and Short-Term stages and 5.1 mg/L currently measured) and 95th percentile concentrations reducing to 4.5 mg/L (compared with 11 mg/L for the Current and Short-Term stages and 6.4 mg/L currently measured).
- DIN concentrations will see a large reduction, with operation limits for median concentrations reducing to <2.5 mg/L (compared with <4.1 mg/L for the Current and Short-Term stages and 5.5 mg/L currently measured), and 95th percentile concentrations reducing from 14 mg/L to 7.5 mg/L for the Current and Short-Term stages and 6.8 mg/L currently measured.
- Operational TP/DRP concentration limits will see a reduction, with median concentration concentrations reducing to <0.5 mg/L (compared with <1 mg/L for the Current and Short-Term stages and 0.73 mg/L currently measured), and 95th percentile operation limits for concentrations reducing from 3.0 mg/L to 1.0 mg/L for the Current and Short-Term stages and 1.09 mg/L currently measured.
- Faecal coliform (**FC**) concentrations will remain unchanged throughout the staged upgrade.
- TN and TP loads will contribute 50% and 70% of total catchment load to the marine coastal environment, respectively, including accounting for attenuation.

4. Description of the existing environment

4.1 Physical setting

The catchment surrounding Beachlands WWTP is low relief, mainly in dairy and sheep pasture, with areas of exotic forestry on open land and regenerating native bush in stream gullies and some open slopes (Zeldis et al., 2001).

4.2 Hydrology

The hydrological profile of the discharge stream network is shown in **Figure 1**. A series of tributaries join Te Puru Stream at various locations above and below the wastewater discharge.

The entrance of Te Puru Stream to the estuary is over a riffle section of steeply inclined stream bed at all tidal stages, clearly defining the upper limit of saline influence to below the Quarry site (Zeldis et al., 2001).

Rainfall is continuously monitored by the Council at Clevedon Coast RAWS @ Forest site.[16] Between 2019 and 2023 annual rainfall ranged from 867 mm to 1803 mm, with an average of 1272 mm.

2023 was the wettest year in the last five, with 1803mm of rain (average of 150mm per month). Rainfall between 11th September 2023 and 19th February 2024 (consistent with collection of water quality data) was 514mm or around 100mm per month. October 2023 (66mm), January 2024 (57mm), and February 2024 (6mm) were particularly dry months.

4.3 Hydrodynamics

The flows in the Te Puru Stream network appear to be highly dependent on rainfall. As part of an assessment of the effects of the Beachlands WWTP discharge on Te Puru Stream, estuary and Tamaki Straight, Zeldis et al. (2001) undertook a hydrological assessment of the stream network, including stream gauging. The survey was undertaken during a dry period with low catchment inflow and high WWTP discharge, approximating a worst-case scenario. The Quarry site had reduced flow over time once effects of rainfall runoff had cleared and stabilised at 48 L/s, while the farm pond increased and stabilised to 10 L/s, concluding that over dry periods the farm pond contributed around 20% of the total stream system flow at the Quarry site.

PDP installed a water level sensor downstream side of the bridge culvert on 27th October 2023 and supplemented this with stream flow gauging at various cross sections between the Farm Pond and Bridge sites on 27th October 2023, 15th November 2023, and 18th January 2024 (PDP, 2024b). Flow duration curves were calculated at the Bridge site, a point between the Farm Pond and the Bridge site, and at the Quarry site. Flow curves were used to derive theoretical stream flows and particularly the contribution of the WWTP discharge in the stream during storm events, to inform

16 https://environmentauckland.org.nz/Data/DataSet/Export/Location/659012/DataSet/Rainfall/Continuous/Interval/Latest

the potential for erosion from the proposed discharge (which represents a 3-fold increase in wastewater flows compared to the existing discharge consent).

4.4 Water and sediment quality state

4.4.1 Comparison of existing water quality between sites and with applicable standards and guidelines

Results from the extensive receiving environment data measured by Watercare between September 2023 and January 2024 (see Section 3.1.2) are presented as box and whisker plots, 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 25th percentile minus 1.5 x IQR and the 75th 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. The Beachlands WWTP discharge data are included in the box and whisker plots for context.

Water quality statistics appropriate for comparison with the applicable guidelines were calculated on the same data and summarised in **Table 8** along with the applicable guideline, which is discussed below.

DO, ammoniacal-N, nitrate-N, DRP, and *E. coli* concentrations were compared to the numeric attribute state thresholds for rivers defined by the 2020 National Policy Statement for Freshwater Management (NPS-FM: MfE, 2024) to classify the 'state' of the studied waterways into attribute bands of A, B, C, or D. Specific reference is made to the national bottom line (**NBL**) where the concentrations exhibit the most significant effects. We note that ammoniacal-N and nitrate-N are focused on toxicity rather than potential for eutrophication.

Where no NPS-FM numeric attribute state thresholds are available – namely for conductivity, TSS, and TP – comparisons were made to relevant ANZG (2018) default guideline values (DGV) for physical and chemical stressors.[17] The ANZG Guidelines for Fresh and Marine Water Quality superseded the previous ANZECC (2000) guidelines in 2018 and are provided as an online tool (Australian and New Zealand Governments, 2018). Physical and chemical stressor DGVs for aquatic ecosystems are now classified by climate and source of river flow, allowing for natural variation in environmental conditions (Hale et al., 2012; McDowell et al., 2013). For this assessment we have used the REC classification of 'warm-wet low elevation' watercourses.

For DIN we have assessed levels against a median threshold of 1 mg/L. At present there is no agreed attribute state for DIN in the NPS-FM but general consensus is that waterbodies that are >1 mg/L are degraded and an appropriate threshold for lowland streams in agricultural settings (Expert Conferencing for proposed Southland Water and Land Plan: Southland Regional Council, 2019).

A temperature guideline was obtained from the Council's water quality index guideline values for freshwater sites throughout the region.

[17] DGVs have been defined as indicating that there is a 'potential risk' of adverse effects at a site.

Table 8. Comparison of receiving environment water quality parameters from September 2023 to January 2024 with applicable guideline. Exceedances of AC and ANZG (2018) guidelines and NPS-FM national bottom line (NBL) are bolded red.

Site/Parameter		WWTP Inlet	WWTP Outlet	Upstream Farm Pond (A)	Farm Pond (B)	Farm Pond downstream (F)	Bridge (15)	Tributary upstream (E)	Quarry	Te Puru Park[1]	Statistic	Guideline Value	Source[2]
Number of data	N	57	58	57	57	19	58	19	11	19			
DO	mg/L	0.1	0.8	**1.2**	**3.6**	7.4	5.2	5.9	7.0	5.6	1-day minimum (summer)[3]	4.0	NPS-FM NBL
Temperature	°C	23.0	25.7	**22.3**	**25.4**	**25.5**	**23.2**	**21.6**	**21.9**	23.3	Maximum (summer)[3]	17.7	AC
pH	unitless	7.40	7.30	6.80	7.50	7.70	7.40	7.24	7.50	7.74	80^{th} %ile	7.70	ANZG WWLE
pH	unitless	7.10	7.04	**6.60**	**7.20**	7.56	**7.20**	**7.00**	**7.10**	7.26	20^{th} %ile	7.26	ANZG WWLE
$cBOD_5$	mg/L	230	5.7	1.1	1.1	1.1	0.7	0.5	0.9	0.7	Median	No guideline	
Volatile Solids	mg/L	237	7.0	4.6	5.2	6.0	4.9	4.4	11.6	10.4	Median	No guideline	
Conductivity	µS/cm	2,442	2,072	**213**	**1,552**	**1,236**	**965**	**176**	**557**	18,760	80^{th} %ile	115	ANZG WWLE
Salinity	ppt	0.9	0.7	0.1	0.6	0.6	0.3	0.1	0.2	5.6	Median	No guideline	
TSS	mg/L	395	10.2	**12.4**	**12.0**	**13.9**	**9.5**	8.3	**50.8**	66.0	80^{th} %ile	8.8	ANZG WWLE
Turbidity	NTU	160	2.0	**15.0**	**7.0**	**6.2**	**10.4**	**13.4**	**60.0**	55.0	80^{th} %ile	5.2	ANZG WWLE
TN	mg/L	71.0	7.3	0.23	**4.6**	**4.7**	**2.4**	**0.31**	**1.10**	1.10	80^{th} %ile	0.292	ANZG WWLE
NH_4-N		51.5	0.04	0.03	0.29	0.21	0.07	0.02	0.04	0.04	Median		
NH_4-N@pH8[4] (Attribute Band)	mg/L	24.6	0.02	0.01	0.14	0.13	0.03	0.01	0.02	0.02	Median	0.24	NPS-FM NBL
		NA	NA	(A)	(B)	(B)	(A)	(A)	(A)	NA			
NH_4-N		63.1	0.32	0.05	0.48	0.35	0.24	0.03	0.10	0.22	95^{th} %ile		
NH_4-N@pH8[4] (Attribute Band)	mg/L	30.2	0.14	0.02	0.23	0.22	0.11	0.01	0.05	0.11	95^{th} %ile	0.40	NPS-FM NBL
		NA	NA	(A)	(B)	(B)	(B)	(A)	(A)	NA			
NO_3-N (Attribute Band)	mg/L	0.02	5.1	0.02	**2.8**	**3.2**	1.6	0.1	0.6	0.5	Median	2.4	NPS-FM NBL
		NA	NA	(A)	**(C)**	**(C)**	(B)	(A)	(A)	NA			
NO_3-N (Attribute Band)	mg/L	1.3	6.4	0.1	**3.8**	**3.8**	2.1	0.1	0.9	0.8	95^{th} %ile	3.5	NPS-FM NBL
		NA	NA	(A)	**(C)**	**(C)**	(B)	(A)	(A)	NA			
NO_2-N	mg/L	0.020	0.020	0.002	0.002	0.002	0.002	0.002	0.002	0.002	Median	No guideline	
DIN (mg/L)	mg/L	52.67	5.52	0.05	**3.19**	**3.42**	**1.72**	0.14	0.47	0.54	Median	1.00	SRC
TP	mg/L	9.07	1.12	**0.045**	**0.580**	**0.596**	**0.297**	**0.030**	**0.100**	0.087	80^{th} %ile	0.024	ANZG WWLE
DRP[5] (Attribute Band)	mg/L	4.92	0.73	0.014	**0.374**	**0.370**	**0.182**	0.014	**0.034**	0.027	Median	0.018	NPS-FM
		NA	NA	(C)	**(D)**	**(D)**	**(D)**	(C)	**(D)**	NA			

Site/Parameter		WWTP Inlet	WWTP Outlet	Upstream Farm Pond (A)	Farm Pond (B)	Farm Pond downstream (F)	Bridge (15)	Tributary upstream (E)	Quarry	Te Puru Park[1]	Statistic	Guideline Value	Source[2]
Number of data	**N**	**57**	**58**	**57**	**57**	**19**	**58**	**19**	**11**	**19**			
DRP[5] (Attribute Band)	mg/L	6.51	1.09	0.026	**0.499**	**0.503**	**0.251**	0.026	**0.066**	0.046	95th %ile	0.054	NPS-FM NBL
		NA	NA	(B)	**(D)**	**(D)**	**(D)**	(B)	**(D)**	NA			
Chla	mg/L	ND	ND	0.0009	0.0019	0.0023	0.0007	0.0006	0.0018	0.0014	Median	No guideline	
E. Coli	cfu/100mL	4,800,000	2	**1,250**	**510**	**540**	**540**	**930**	**480**	530	Median	130	NPS-FM NBL
E. Coli	cfu/100mL	10,200,000	17	**4,815**	**2,460**	**1,530**	**3,415**	**3,780**	**2,650**	6,320	95th %ile	1200	NPS-FM NBL
FC	cfu/100mL	8,200,000	2	1,750	650	770	715	1,300	590	690	Median	No guideline	
Enterococci	cfu/100mL	1,400,000	2	97	86	130	230	480	365	110	Median	No guideline	

[1] Te Puru Park has saline influence so is shown for perspective only.
[2] NPS FM = National Policy Statement for Freshwater Management (2020); AC = Auckland Council water quality index guideline; ANZG WWLE = Australian and New Zealand Governments default guideline values for REC classification of warm-wet low elevation; SRC = Southland Regional Council (2019).
[3] Summer defined as November-April. The NPS-FM attribute states require are a 7-day mean minimum (the mean value of 7 consecutive daily minimum values), and a 1-day minimum that is the lowest daily minimum across an entire summer period. The data provided do not fulfil these requirements so are indicative only.
4 Ammoniacal-N adjusted to pH 8 using the methodology in (Ministry for the Environment, 2018). The NPS-FM attribute state for ammoniacal-N toxicity is based on pH 8 and a temperature of 20°C and compliance with the numeric attribute states should be undertaken after pH adjustment to pH 8.
[5] DRP does not have a NBL in the NPS-FM, however for consistency with other parameters the threshold is between attribute state C and D.

4.4.1.1 Physical stressors

DO

DO data are indicative as they do not fulfil the requirements in the NPS-FM for which derivation of attribute states require a 7-day mean minimum (the mean value of 7 consecutive daily minimum values), and a 1-day minimum that is the lowest daily minimum across an entire summer period.

The existing Beachlands WWTP discharge has low DO as a minimum, with DO of 0.8 mg/L (**Table 8**). The median DO across sites ranges between 7-9 mg/L and is increasing with distance down Te Puru Stream (**Figure 11**). The minimum DO for the Bridge site (5.2 mg/L) is higher than upstream of the farm pond (3.6 mg/L). Based on these data, the existing discharge from the Beachlands WWTP does not appear to be impacting on DO in the pond or further downstream.

The NPS-FM numeric attribute state for DO is for a summer minimum of 4.0 mg/L when it is more likely to be an issue (**Table 8**) and the 2023/24 data are limited, with monitoring up to 24th January only. The 5-year data included parameters for upstream farm pond (A) and farm pond (B), although with a shorter time frame (February 2020 to March 2023). Minimum DO over the summer months ranged from 6.4-8.1 mg/L upstream of the farm pond (A) and between 7.4-10.9 mg/L at the farm pond (B) (data not shown). Based on the 5-year monitoring data, both sites are well oxygenated and above the NPS-FM summer minimum numeric attribute state of 4.0 mg/L. However, as shown in **Figure 11**, minimum DO for the WWTP outlet (0.8 mg/L), upstream farm pond (A) (1.2 mg/L) and farm pond (B) (3.6 mg/L), indicating that low DO is exhibited upstream of the existing WWTP discharge and in the farm pond during summer.

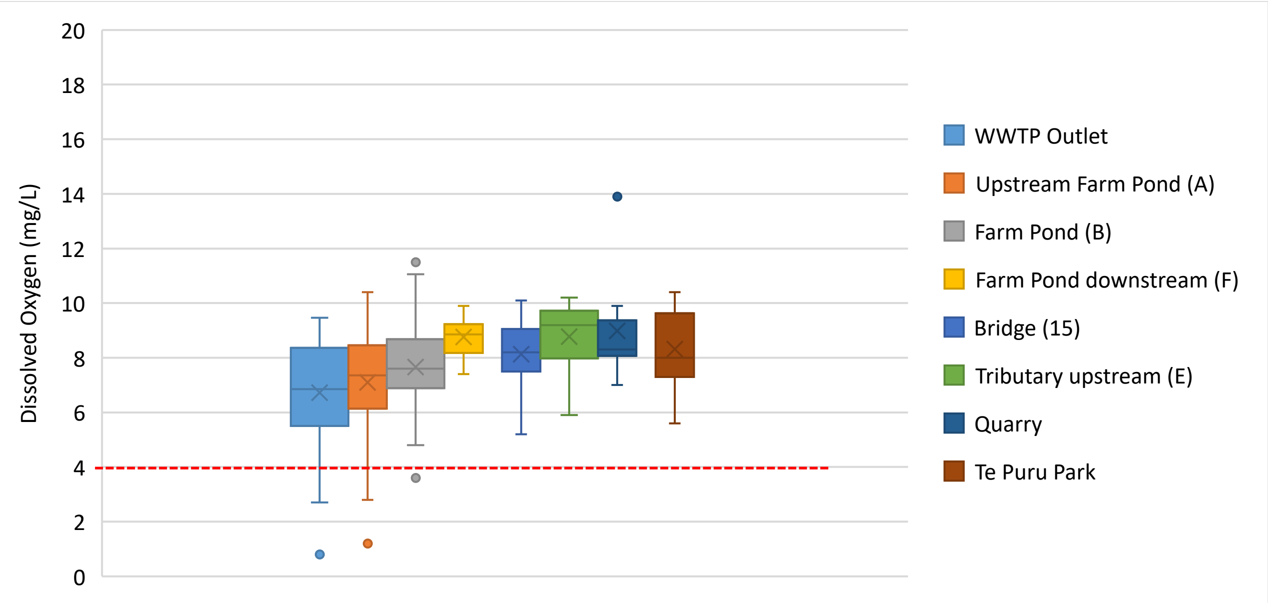

Figure 11. Box and whisker plot of dissolved oxygen (mg/L) measured from Beachlands WWTP outlet and receiving environment sites from 11th September 2023 to 24th January 2024. The boxes denote 75th (top), 50th (middle), and 25th (bottom) percentiles, with whiskers extending 1.5 x 25th/75th percentiles. The mean value is presented as a cross. "Outliers" are shown as points. The NPS-FM summer minimum DO (4 mg/L) is shown by a dashed red line.

Further, these data support the 2023/24 data that the existing Beachlands WWTP does not appear to be impacting on DO in the pond.

$cBOD_5$

$cBOD_5$ is a measure of oxygen depletion from carbonaceous sources, where increased BOD can result in reduced dissolved oxygen. $cBOD_5$ from the existing Beachlands WWTP discharge is variable (**Figure 12**) with a median value of 5.7 mg/L, which is at least 5-fold higher than the median of the receiving environment sites (**Table 8**). For receiving environment sites there is generally low variability of $cBOD_5$ and negligible difference between the upstream farm pond (A) site and the farm pond (B) site (**Figure 12**). The Bridge site (15) reported very low $cBOD_5$ (median 0.7 mg/L). Elevated $cBOD_5$ in the existing discharge from the Beachlands WWTP do not appear to be impacting on $cBOD_5$ (nor DO) in the pond.

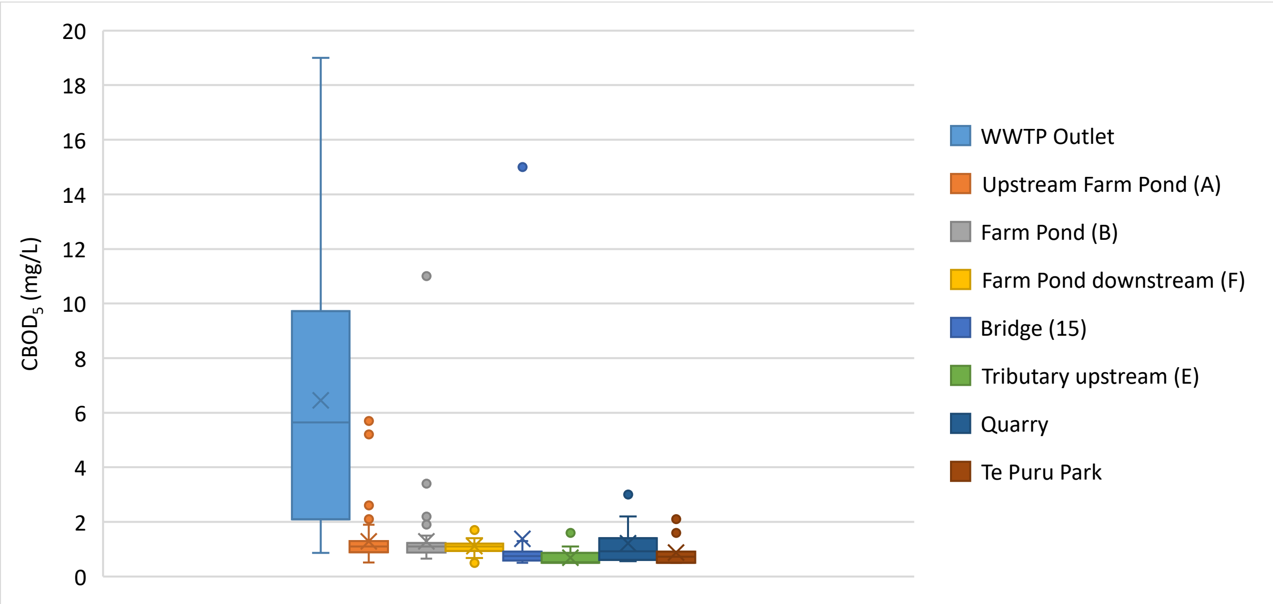

Figure 12. Box and whisker plot of $cBOD_5$ (mg/L) measured from Beachlands WWTP outlet and receiving environment sites from 11th September 2023 to 24th January 2024. The boxes denote 75th (top), 50th (middle), and 25th (bottom) percentiles, with whiskers extending 1.5 x 25th/75th percentiles. The mean value is presented as a cross. "Outliers" are shown as points. Note: upper outliers are not shown in the graph.

Water temperature

The existing Beachlands WWTP discharge has a median temperature (18.4°C) similar to the farm pond (B) (18.4°C) and downstream of the farm pond (F) (19.3°C). The upstream sites – Farm Pond upstream (A) (15.4°C) and Tributary upstream (E) (15.0°C) have markedly lower median temperatures, while the Bridge site (15) (17.3°C) is intermediate (**Figure 13**). Further downstream (Quarry and Te Puru Park) water temperature is variable. Based on these data, the existing Beachlands WWTP discharge appears to be having a slight impact on temperature in the pond and downstream as far as the Bridge site.

The Council set a water temperature guideline of 17.7°C during summer (**Table 8**) and the 2023/24 data are limited, with monitoring up to 24th January 2024 only. As for above, the 5-year data provided a maximum water temperature over the summer months of between 20.6-22.7°C upstream of the farm pond (A) and between 21.0-23.1°C at the farm pond (B) (data not shown). For both sites water temperatures are high in summer and well above the AC guideline of 17.7°C. Further, these data show that during times of heat stress there is very little difference between water temperatures in the upstream and downstream sites suggesting the existing Beachlands WWTP discharge is having only low impacts on water temperature in the farm pond.

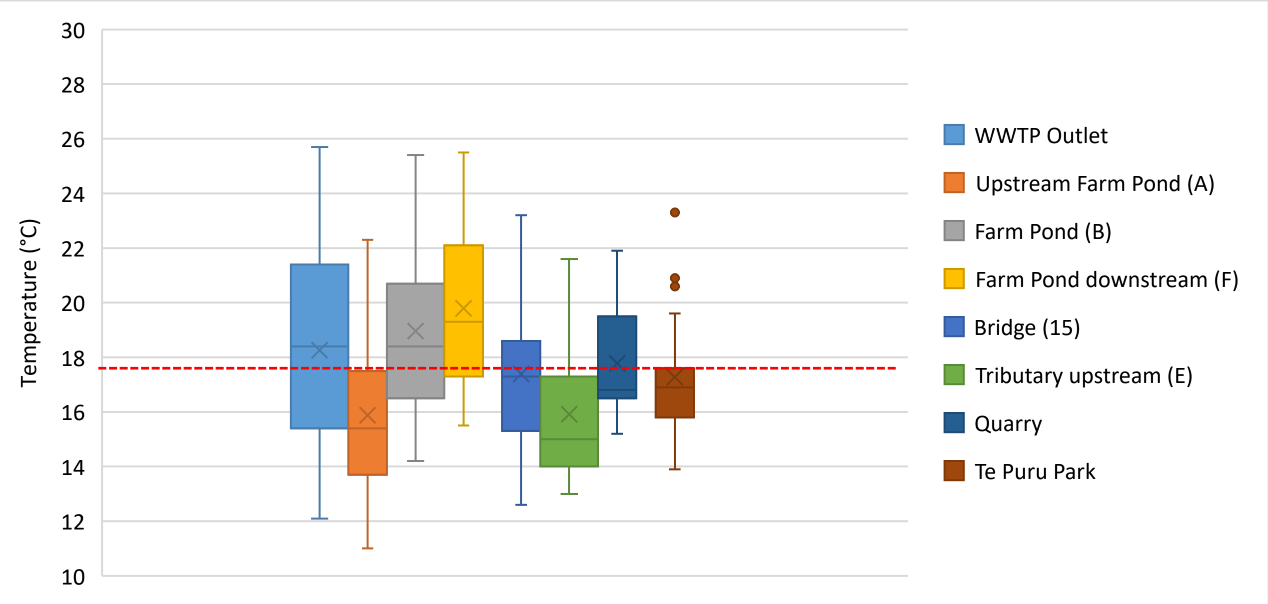

Figure 13. Box and whisker plot of temperature (°C) measured from Beachlands WWTP outlet and receiving environment sites from 11th September 2023 to 24th January 2024. The boxes denote 75th (top), 50th (middle), and 25th (bottom) percentiles, with whiskers extending 1.5 x 25th/75th percentiles. The mean value is presented as a cross. "Outliers" are shown as points. The AC summer water temperature guideline of 17.7°C is shown by a dashed red line.

pH

Low pH appears to be more an issue than high pH in the receiving environment, with most sites showing a 20th percentile pH below the ANZG DGV of 7.26, with only Te Puru Park (80th percentile 7.74) marginally exceeding the ANZG DGV 80th percentile of 7.70 (**Table 8**). The low pH appears to be driven by the upstream farm pond site (A) which has a consistently lower pH than the other sites (**Figure 14**) and a 20th percentile pH of 6.60. The existing Beachlands WWTP discharge appears to be having a negligible impact on pH at the farm pond and sites further downstream.

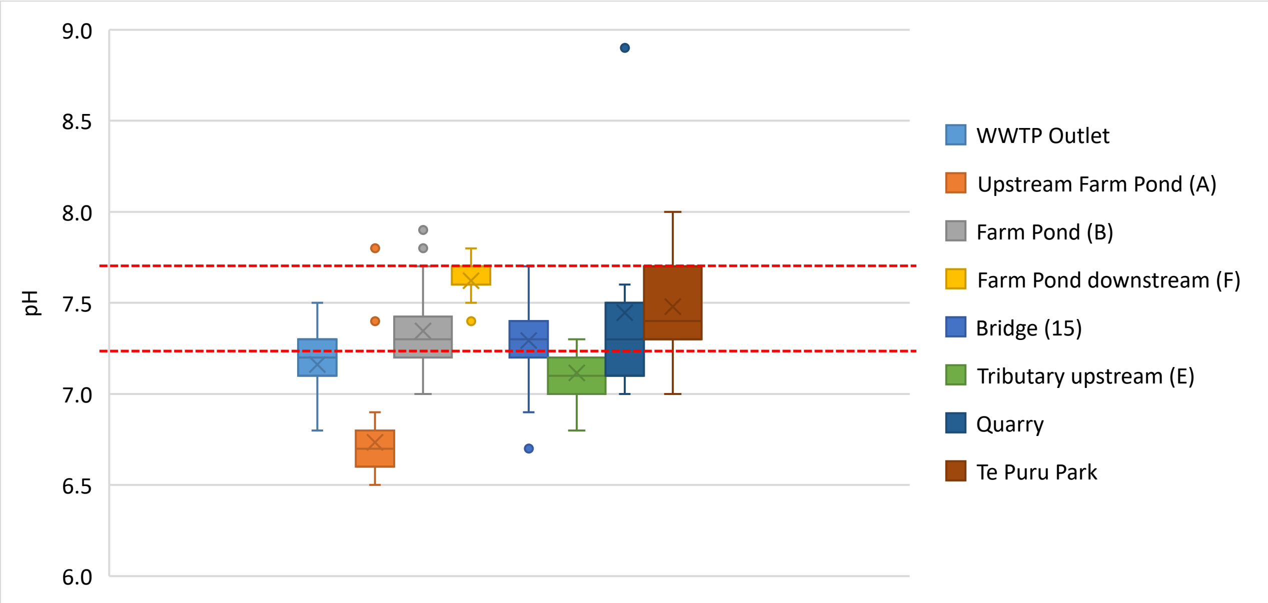

Figure 14. Box and whisker plot of pH measured from Beachlands WWTP outlet and receiving environment sites from 11th September 2023 to 24th January 2024. The boxes denote 75th (top), 50th (middle), and 25th (bottom) percentiles, with whiskers extending 1.5 x 25th/75th percentiles. The mean value is presented as a cross. "Outliers" are shown as points. The ANZG 80th/20th percentile DGVs for pH (7.70/7.26) are shown by a dashed red lines.

Conductivity and salinity

The ANZG 80th percentile DGV for conductivity is 155 µS/cm. All receiving environment sites are above this DGV (**Table 8**). 80th percentile conductivity for sites upstream of the Beachlands WWTP discharge influence – Upstream Farm Pond (A) (213 µS/cm) and Tributary upstream (E) (176 µS/cm) – marginally exceed the DGV. In contrast, the Beachlands WWTP discharge 80th percentile conductivity value (2,072 µS/cm) is very high, and is reflected in sites downstream of its influence: Farm Pond (B) (1552 µS/cm); Farm Pond downstream (F) (1236 µS/cm); Bridge site (15) (965 µS/cm); and the Quarry site (557 µS/cm) (**Table 8**). There is a clear influence of the existing Beachlands WWTP discharge on conductivity downstream (**Figure 15**). By the confluence (the Bridge site) the 80th percentile conductivity value (965 mg/L) exceeds the ANZG 80th percentile DGV of 115 mg/L by 8.4-fold.

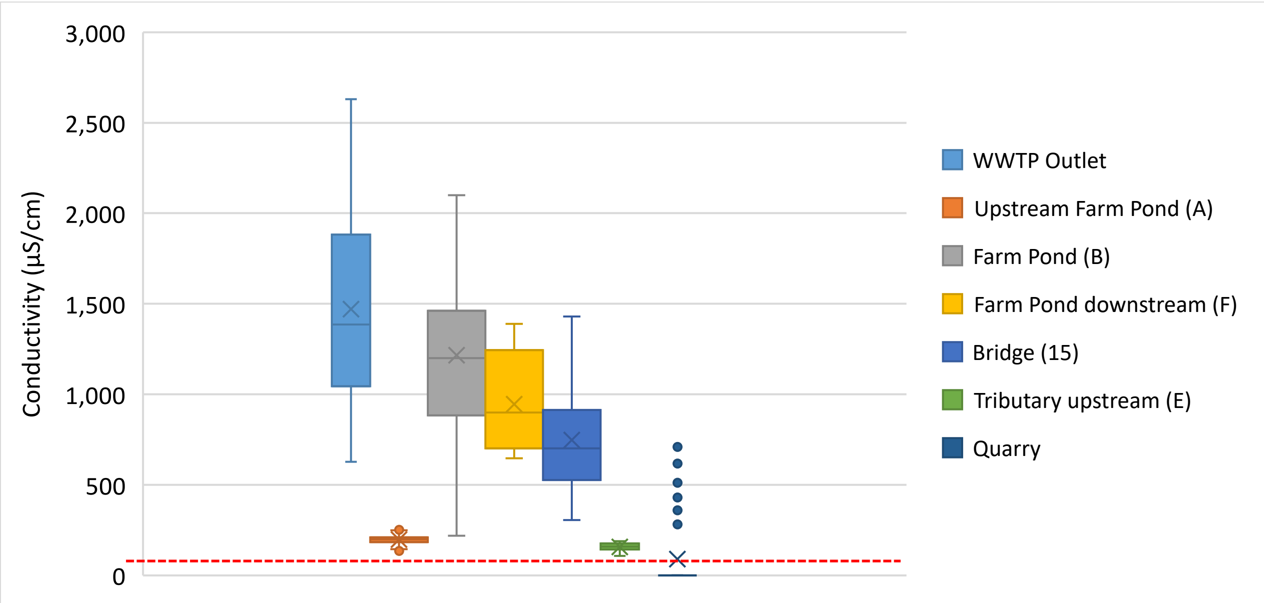

Figure 15. Box and whisker plot of conductivity measured from Beachlands WWTP outlet and receiving environment sites from 11th September 2023 to 24th January 2024. The boxes denote 75th (top), 50th (middle), and 25th (bottom) percentiles, with whiskers extending 1.5 x 25th/75th percentiles. The mean value is presented as a cross. "Outliers" are shown as points. Note: Te Puru site not included as it has a significant saline influence. The ANZG 80th percentile DGV for conductivity is 155 µS/cm is shown by a dashed red line.

In terms of salinity, there was evidence of minor salinity ingress into the WWTP (influent maximum 2.4 ppt and discharge maximum 1.4 ppt) and environment sites upstream (maximum salinity 1.4 ppt) of Te Puru Park which has a known saline influence (maximum salinity 32.4 ppt).

TSS and turbidity

The ANZG DGV 80th percentile for TSS is 8.8 mg/L. All receiving environment sites downstream of the discharge and site A upstream of the discharge exceed this DGV. Only the tributary upstream (E) site is below this DGV (**Table 8**). The existing discharge from the Beachlands WWTP has consistently low TSS (median 7.8 mg/L and 80th percentile 10.2 mg/L). There appears to be little difference in TSS between receiving sites, until a large increase at Quarry and Te Puru Park (**Figure 16**). The Quarry site increase is presumably due to the activities at that site, while Te Puru Park has tidal flushing that will stir up fine sediment.

Turbidity shows a consistent pattern to TSS. The ANZG DGV 80th percentile for turbidity is 5.2 NTU, and all receiving environment sites, including those upstream of the discharge, exceed this DGV (**Table 8**). The existing discharge from the Beachlands WWTP has consistently low turbidity (median 1.6 NTU and 80th percentile 2.0 NTU). The elevated receiving environment turbidity appears to be due to catchment effects with consistently higher turbidity noted at the sites upstream of the WWTP discharge influence (**Figure 17**). As for TSS, markedly higher turbidity is observed at the Quarry and Te Puru Park sites, which are likely to be catchment and/or activity related.

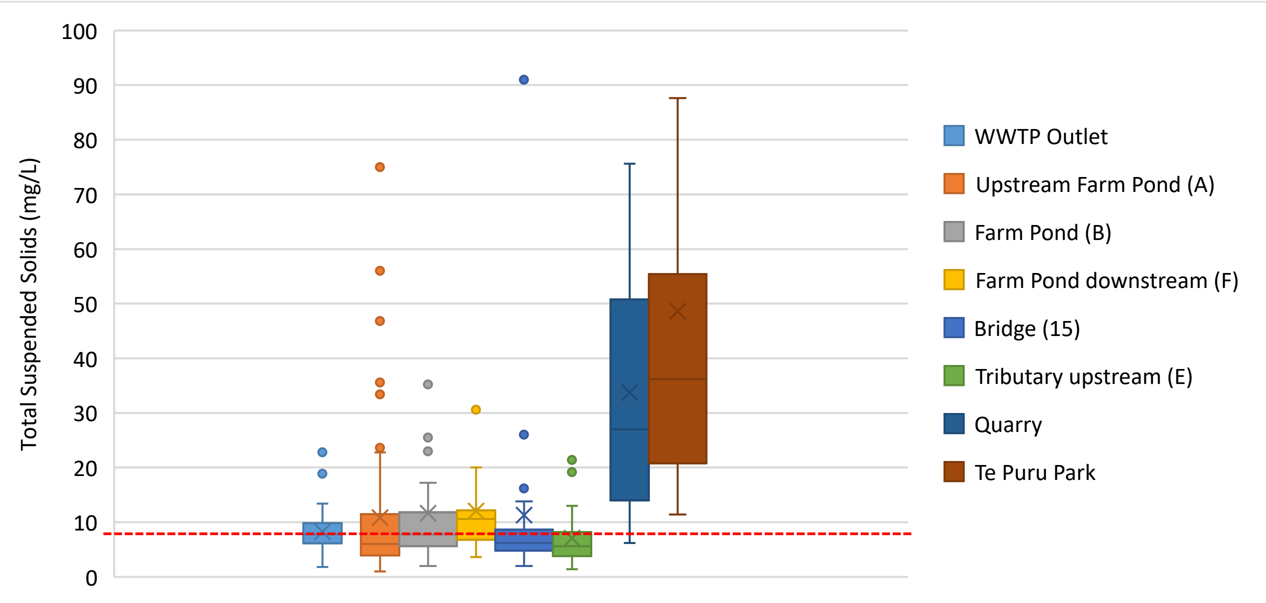

Figure 16. Box and whisker plot of TSS (mg/L) measured from Beachlands WWTP outlet and receiving environment sites from 11th September 2023 to 24th January 2024. The boxes denote 75th (top), 50th (middle), and 25th (bottom) percentiles, with whiskers extending 1.5 x 25th/75th percentiles. The mean value is presented as a cross. "Outliers" are shown as points. Note: upper outliers are not shown in the graph. The ANZG DGV 80th percentile for TSS (8.8 mg/L) is shown by a dashed red line.

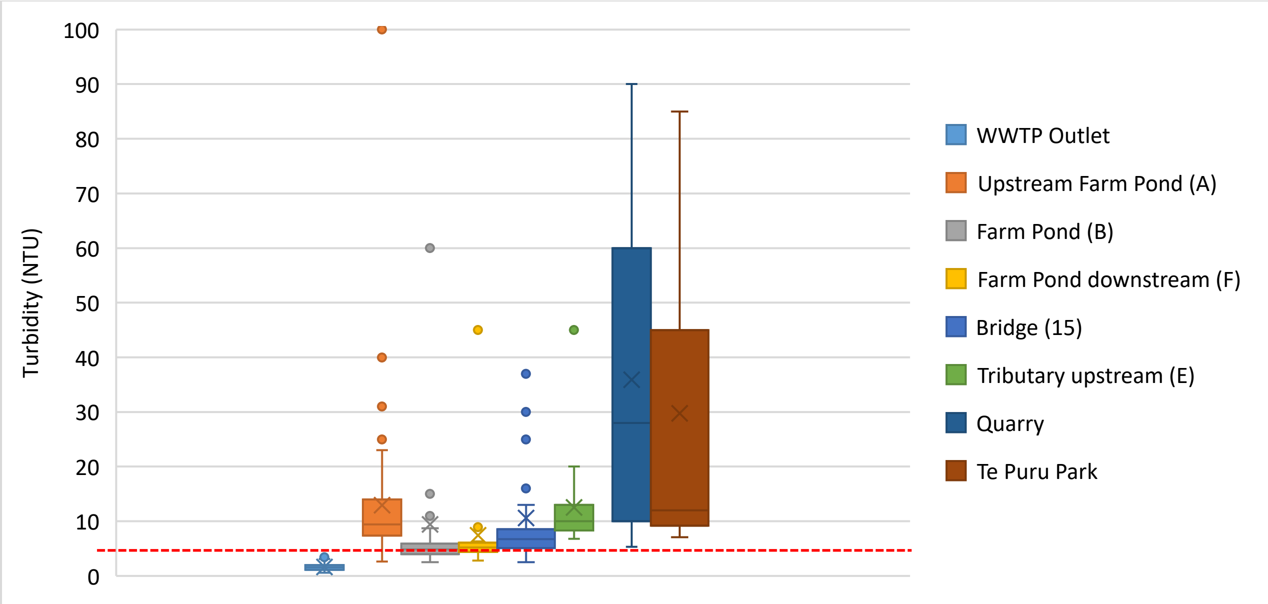

Figure 17. Box and whisker plot of turbidity (NTU) measured from Beachlands WWTP outlet and receiving environment sites from 11th September 2023 to 24th January 2024. The boxes denote 75th (top), 50th (middle), and 25th (bottom) percentiles, with whiskers extending 1.5 x 25th/75th percentiles. The mean value is presented as a cross. "Outliers" are shown as points. Note: upper outliers are not shown in the graph. The ANZG DGV 80th percentile for turbidity (5.2 NTU) is shown by a dashed red line.

4.4.1.2 Nutrients

Nitrogen

The nitrogen cycle is complex with multiple species of N present, such as inorganic nitrogen – ammoniacal-N, nitrate-N, and nitrite-N – and organic nitrogen (consisting of many organic nitrogenous chemicals including amino acids, proteins, and other biological metabolites). Further, the nitrogen cycle will interconvert inorganic nitrogen species through processes such as nitrification, denitrification, and dissimilatory nitrate reduction to ammoniacal-N. Ammoniacal-N can also be formed from ammonification of organic nitrogen formed from decomposition of organic material.

The ANZG DGV 80th percentile for TN is 0.292 mg/L. The 80th percentile values for site A upstream of the farm pond (0.23 mg/L) and the tributary upstream (E) site (0.31 mg/L) are marginally below and above this DGV, respectively (**Table 8**), suggesting catchment TN concentrations are relatively low. In contrast, sites that are influenced by the existing Beachlands WWTP discharge have markedly elevated TN compared to the upstream sites, ranging from 8-fold above the DGV at site Bridge site (15) to 16-fold at the farm pond (B). TN concentrations are reducing with distance from the WWTP (**Figure 18**).

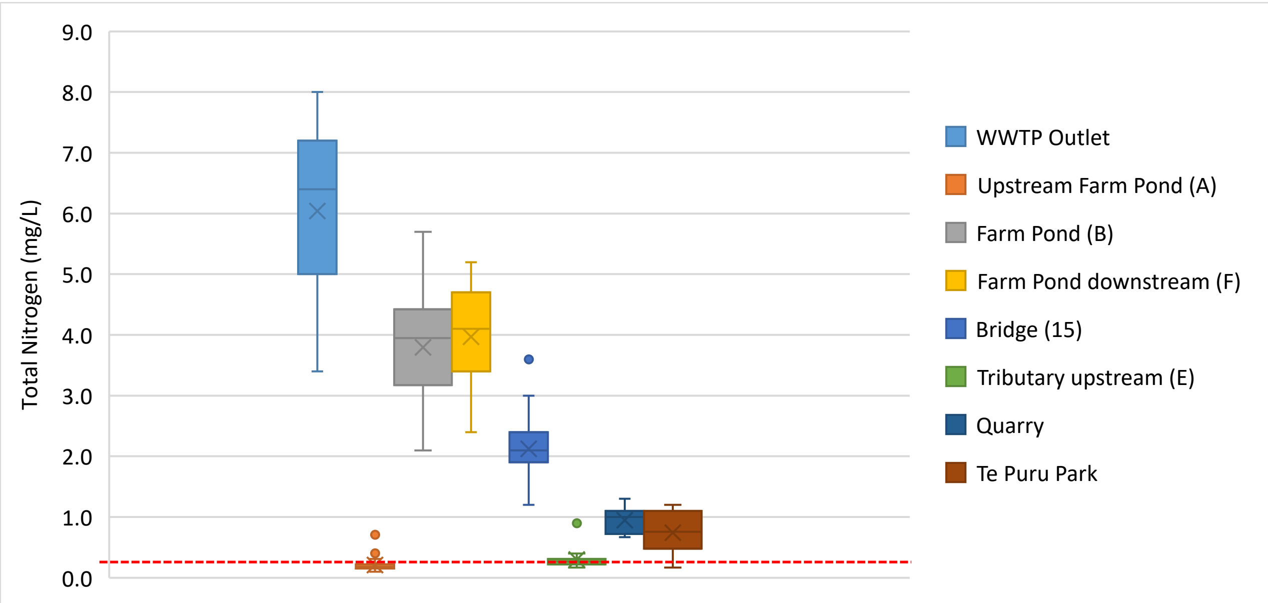

Figure 18. Box and whisker plot of TN (mg/L) measured from Beachlands WWTP outlet and receiving environment sites from 11th September 2023 to 24th January 2024. The boxes denote 75th (top), 50th (middle), and 25th (bottom) percentiles, with whiskers extending 1.5 x 25th/75th percentiles. The mean value is presented as a cross. "Outliers" are shown as points. The ANZG DGV 80th percentile for TN (0.292 mg/L) is shown by a dashed red line.

Ammoniacal-N concentrations are similar between the WWTP outlet and concentrations upstream of the influence of Beachlands WWTP (**Figure 19**). The farm pond (B) site has elevated ammoniacal-N concentrations but these reduce further downstream (**Figure 19**).

Median and 95th percentile ammoniacal-N concentrations from the WWTP discharge values are 0.04 mg/L and 0.38 mg/L, respectively (**Table 8**). The farm pond (B) site has median and 95th percentile values of 0.29 mg/L and 0.48 mg/L, respectively, placing it in NPS-FM attribute band C for ammonia toxicity for both metrics, impacting regularly on the 20% most sensitive species. The farm pond downstream (F) and Bridge site (15) sites are both in NPS-FM attribute band B for ammonia toxicity impacting occasionally on the 5% most sensitive species. Both upstream sites have ammoniacal-N concentrations that would place them in NPS-FM attribute band A, a 99% species protection level, with no observed effect on any species tested.

With low concentrations of ammoniacal-N in the existing WWTP discharge it is clear that the farm pond is forming ammoniacal-N, presumably from nitrogen cycling processes such as ammonification of organic nitrogen formed from decomposition in the pond. It is only in the farm pond that concentrations of ammoniacal-N could be potentially toxic. Further, the WWTP is providing a low proportion of ammoniacal-N to total nitrogen (ca. 0.5%) being discharge from the WWTP. Therefore, the existing discharge from the Beachlands WWTP is unlikely to be significantly contributing to ammoniacal-N concentrations downstream.

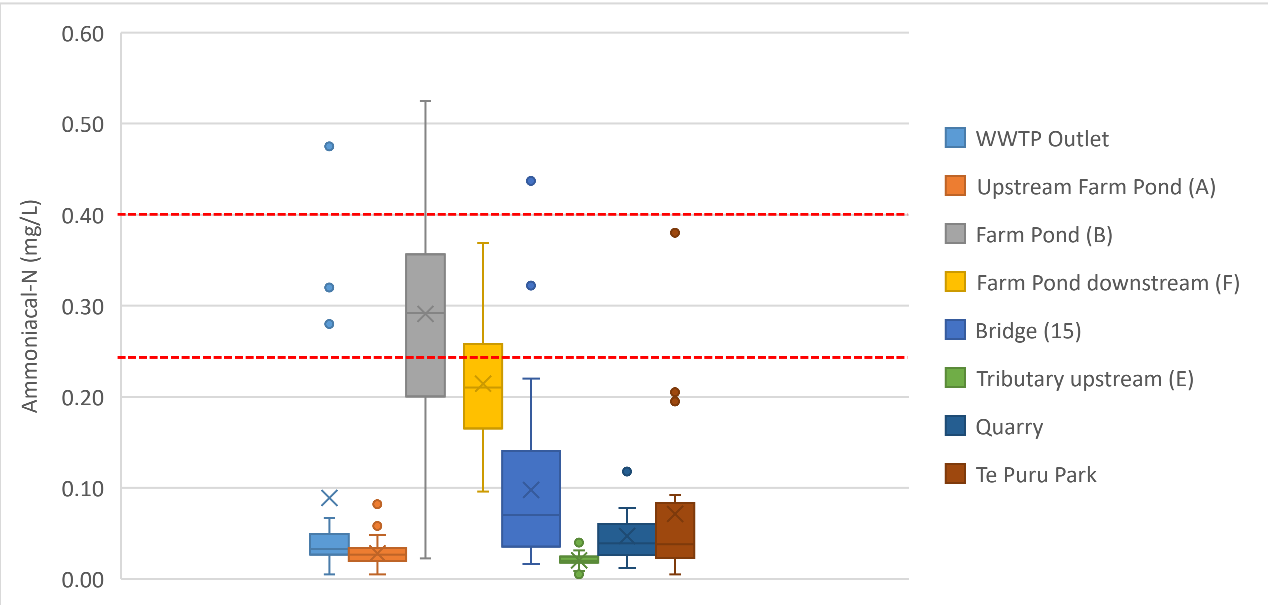

Figure 19. Box and whisker plot of ammoniacal-N (mg/L) measured from Beachlands WWTP outlet and receiving environment sites from 11th September 2023 to 24th January 2024. The boxes denote 75th (top), 50th (middle), and 25th (bottom) percentiles, with whiskers extending 1.5 x 25th/75th percentiles. The mean value is presented as a cross. "Outliers" are shown as points. The NPS-FM 95th percentile (0.4 mg/L) and median (0.24 mg/L) NBL for ammoniacal-N are shown by dashed red lines.

Nitrate-N with a median of 5.1 mg/L and a 95th percentile of 6.4 mg/L (**Table 8**) shows a similar trend to TN (**Figure 18**). Based on median and 95th percentile metrics, both the farm pond site (B) and next site downstream (F) would be placed in NPS-FM attribute band C for nitrate toxicity, not meeting the NBL (2.4 mg/L and 3.5 mg/L, for median and 95th percentile, respectively). Concentrations of nitrate-N above the NBL will show growth effects on up to 20% of species, mainly sensitive species such as fish, but no acute effects. The Bridge site (15) site would be placed in attribute band B for nitrate toxicity showing some growth effect on up to 5% of species. Both upstream sites have nitrate-N concentrations that would place them in NPS-FM attribute band A, which would be unlikely to show effects even on sensitive species.

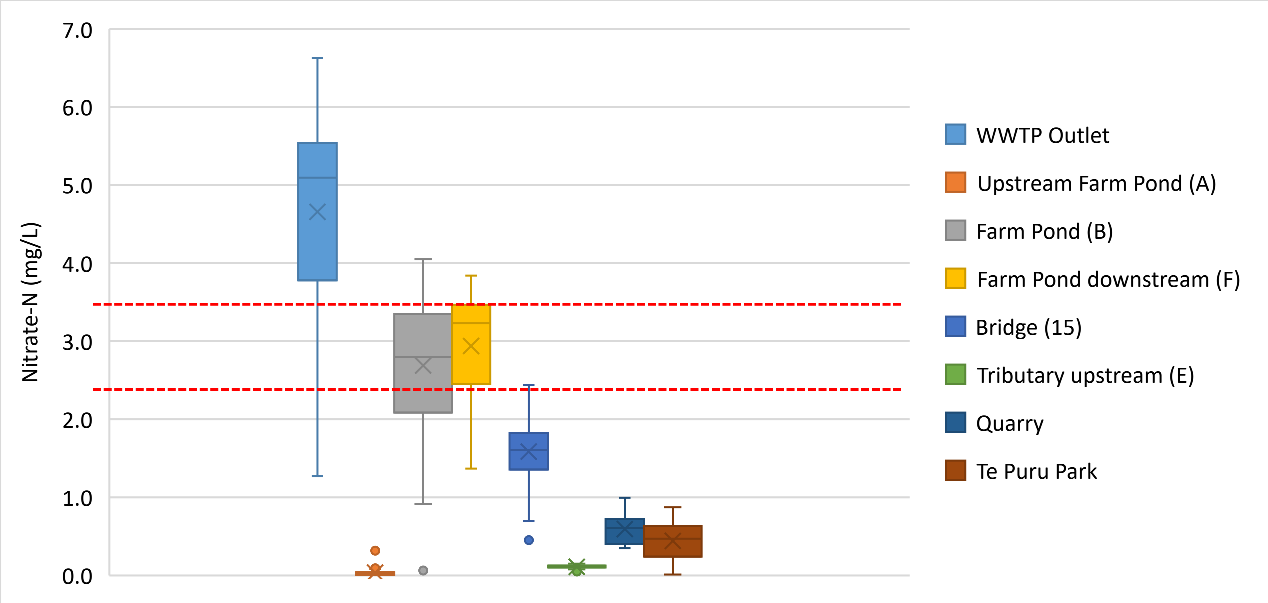

Figure 20. Box and whisker plot of nitrate-N (mg/L) measured from Beachlands WWTP outlet and receiving environment sites from 11th September 2023 to 24th January 2024. The boxes denote 75th (top), 50th (middle), and 25th (bottom) percentiles, with whiskers extending 1.5 x 25th/75th percentiles. The mean value is presented as a cross. "Outliers" are shown as points. The NPS-FM 95th percentile (3.5 mg/L) and median (2.4 mg/L) NBL for nitrate-N toxicity are shown by dashed red lines.

DIN is calculated from the sum of ammoniacal-N, nitrate-N, and nitrite-N and summarised in **Figure 21**. The concentration profile for DIN is very similar to nitrate-N (**Figure 20**) which is due to DIN in WWTP outlet and receiving environment sites generally consisting of over 90% nitrate-N. The Bridge site (15) median concentration (1.72 mg/L) exceeds the level considered to be degraded in terms of potential for eutrophication of 1.0 mg/L applied in some recent expert caucusing for regional plans.

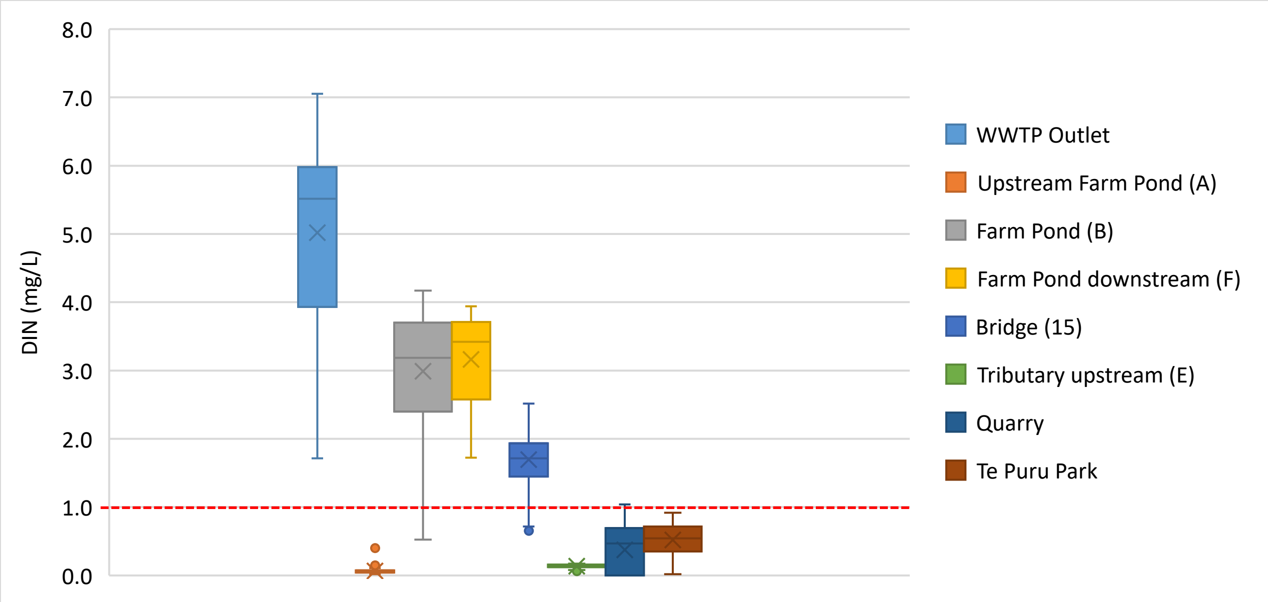

Figure 21. Box and whisker plot of DIN (mg/L) calculated[18] from monitoring of Beachlands WWTP outlet and receiving environment sites from 11th September 2023 to 24th January 2024. The boxes denote 75th (top), 50th (middle), and 25th (bottom) percentiles, with whiskers extending 1.5 x 25th/75th percentiles. The mean value is presented as a cross. "Outliers" are shown as points. A eutrophication guideline (1.0 mg/L) for DIN is shown by dashed red line.

[18] DIN calculated as the sum of ammoniacal-N, nitrate-N, and nitrite-N.

Phosphorus

The 80th percentile TP concentrations are above the ANZG DGV (0.024 mg/L) at all receiving environment sites, although only marginally (<2-fold above DGV) at upstream sites. There is a general reduction in TP with distance from the Beachlands WWTP (**Figure 22**). The WWTP discharge has median and 80th percentile concentrations of 0.86 mg/L and 1.12 mg/L. TP is relatively consistent at the farm pond site (B) and next downstream site (F) with 80th percentile concentrations of 0.580 mg/L and 0.596 mg/L, respectively, around 25-fold higher than the DGV. The Bridge site (15) has 80th percentile concentration of 0.297 mg/L, 12-fold higher than the DGV (**Table 8**).

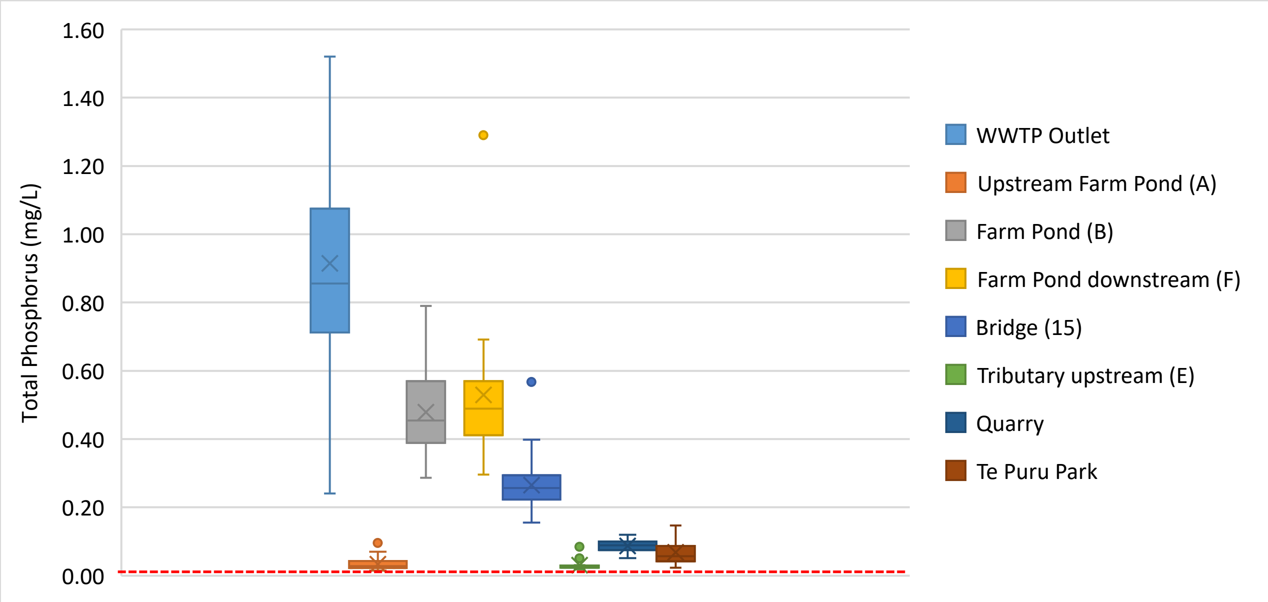

Figure 22. Box and whisker plot of TP (mg/L) measured from Beachlands WWTP outlet and receiving environment sites from 11th September 2023 to 24th January 2024. The boxes denote 75th (top), 50th (middle), and 25th (bottom) percentiles, with whiskers extending 1.5 x 25th/75th percentiles. The mean value is presented as a cross. "Outliers" are shown as points. Note: upper outliers are not shown in the graph. The ANZG DGV 80th percentile for TP (0.024 mg/L) is shown by a dashed red line.

DRP shows a similar trend to TP, with relatively low concentrations upstream of the influence of Beachlands WWTP and elevated concentrations downstream but reducing with distance from the discharge (**Figure 23**).

The NPS-FM attribute states for all sites downstream of the discharge are consistent between the metric (median or 95th percentile), with all in attribute band D (**Table 8**). Attribute band D corresponds to ecological communities impacted by substantial DRP above natural reference conditions and, when in combination with other conditions, can favour eutrophication which in turn drives excessive primary production, potentially leading to anoxic conditions with significant changes in hypoxia sensitive macroinvertebrate and fish communities.

Both upstream sites would be placed in attribute band C (median) or B (95th percentile). Ecological communities are slightly impacted by minor DRP elevation (B) or impacted by moderate DRP elevation (C) above natural reference conditions.

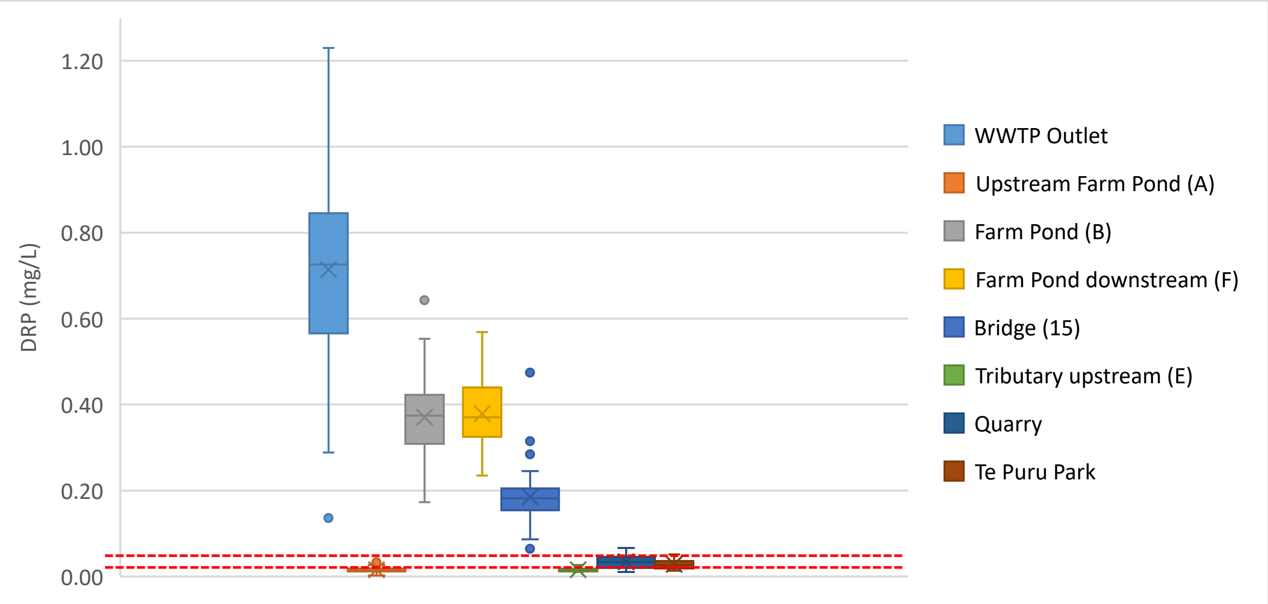

Figure 23. Box and whisker plot of DRP (mg/L) measured from Beachlands WWTP outlet and receiving environment sites from 11th September 2023 to 24th January 2024. The boxes denote 75th (top), 50th (middle), and 25th (bottom) percentiles, with whiskers extending 1.5 x 25th/75th percentiles. The mean value is presented as a cross. "Outliers" are shown as points. Note: upper outliers are not shown in the graph. The NPS-FM 95th percentile (0.054 mg/L) and median (0.018 mg/L) attribute band C threshold for DRP are shown by dashed red lines.

Chla

Chla is not measured in the Beachlands WWTP influent or discharge. Concentrations are slightly elevated at the farm pond (B) and farm pond downstream (F) site, but back to upstream levels by the Bridge (15) site. The Quarry site has high variability and relatively high values but this does not appear to be as a consequence of the existing wastewater discharge.

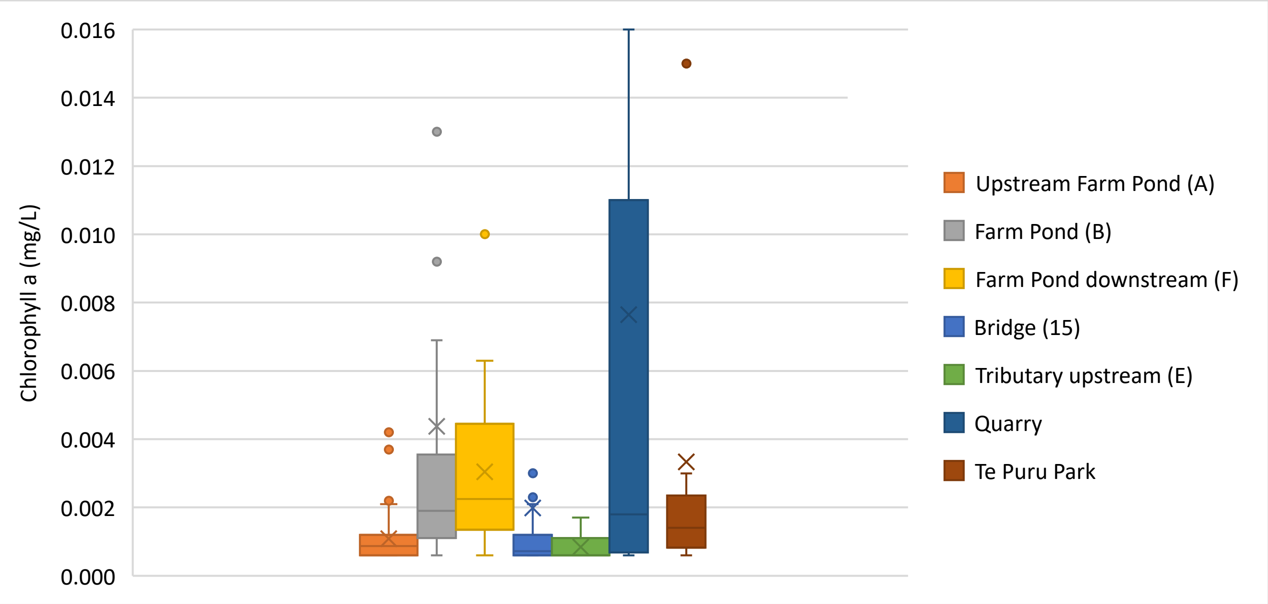

Figure 24. Box and whisker plot of Chla (mg/L) measured from receiving environment sites from 11th September 2023 to 24th January 2024. The boxes denote 75th (top), 50th (middle), and 25th (bottom) percentiles, with whiskers extending 1.5 x 25th/75th percentiles. The mean value is presented as a cross. "Outliers" are shown as points.

4.4.1.3 Bacteria

A full Quantitative Microbial Risk Assessment (QMRA) has been carried out by NIWA and is reported separately. In this report we focus on the data from monitoring in terms of concentrations and changes further down the stream.

Bacteria – *E. coli*, FC, and enterococci – are at extremely low concentrations (median 2 cfu/100 mL for all three) in the existing Beachlands WWTP discharge (**Table 8**). For the receiving environment sites, bacteria concentrations are highly variable (**Figure 25**) and higher upstream of the WWTP, suggesting catchment sources dominate. Based on median and 95th percentile concentrations, *E. coli* is in NPS-FM attribute band E (Red) for all sites, which corresponds to an average infection risk (from Campylobacter) of >7%.

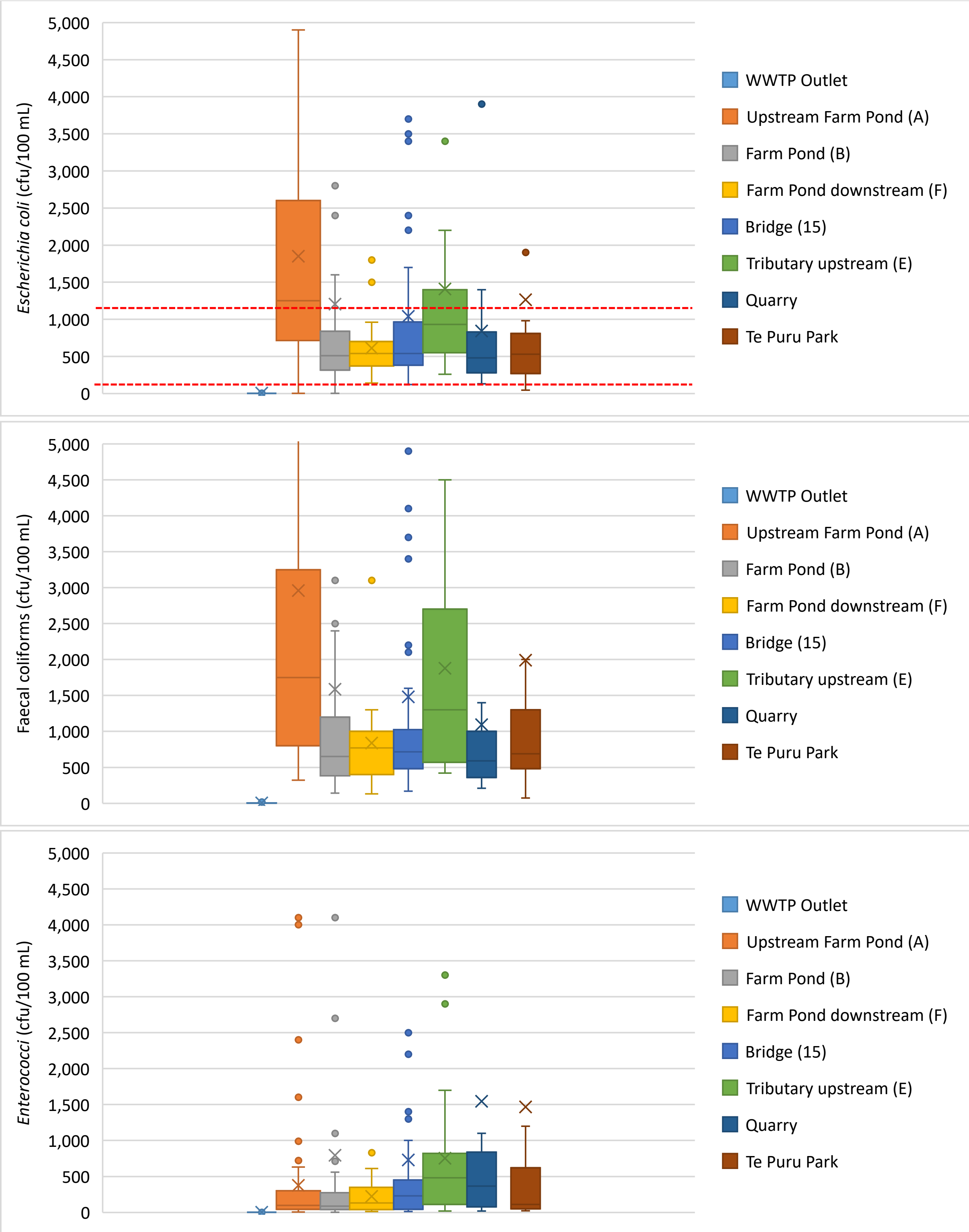

Figure 25. Box and whisker plots of *E. coli*, FC, and *enterococci* (cfu/100mL) measured from receiving environment sites from 11th September 2023 to 24th January 2024. The boxes denote 75th (top), 50th (middle), and 25th (bottom) percentiles, with whiskers extending 1.5 x 25th/75th percentiles. The mean value is presented as a cross. "Outliers" are shown as points. Note: upper outliers are not shown in the graph. The 95th percentile (1200 cfu/100 mL) and median (130 cfu/100 mL) NPS-FM attribute band E (Red) for *E. coli* are shown by dashed red lines.

4.4.1.4 Metals

Total and dissolved metal concentrations were measured at the upstream farm pond (site A), farm pond (site B), and Bridge site (site 15) on 10th and 11th December 2023, with results summarised in **Table 9**. All metal concentrations were below the applicable ANZG 95% DGV. Chromium (total only), copper (total and dissolved) and zinc (total and dissolved) concentrations at the farm pond (B) site were more than 50% of the ANZG 95% DGV, but all had reduced to 50% or below by the Bridge site (15) site. For the WWTP outlet, only total copper, and total and dissolved zinc exceeded the DGV (see **Table 4**).

Table 9. Mean and standard deviation (n=2) of total and dissolved metal concentrations reported from receiving environment sites on 10th/11th December 2023 and comparison with ANZG (2018) DGVs.

Site	Parameter	Unit	Mean	Standard Deviation	ANZG 95% DGV
Upstream Farm Pond (A)	Arsenic-dissolved	µg/L	0.36	0.02	13
	Arsenic-total	µg/L	0.48	0.07	13
	Cadmium-dissolved	µg/L	<0.05	NA	0.2
	Cadmium-total	µg/L	<0.05	NA	0.2
	Chromium-dissolved	µg/L	<0.50	NA	1.0
	Chromium-total	µg/L	0.57	NA	1.0
	Copper-dissolved	µg/L	0.21	NA	1.4
	Copper-total	µg/L	0.40	0.08	1.4
	Lead-dissolved	µg/L	0.11	NA	3.4
	Lead-total	µg/L	<0.10	NA	3.4
	Mercury-dissolved	µg/L	<0.05	NA	0.06
	Mercury-total	µg/L	<0.05	NA	0.06
	Nickel-dissolved	µg/L	0.23	0.01	11
	Nickel-total	µg/L	0.34	0.04	11
	Zinc-dissolved	µg/L	<1.0	NA	8
	Zinc-total	µg/L	1.3	NA	8
Farm Pond (B)	Arsenic-dissolved	µg/L	0.76	0.03	13
	Arsenic-total	µg/L	0.95	0.06	13
	Cadmium-dissolved	µg/L	<0.05	NA	0.2
	Cadmium-total	µg/L	<0.05	NA	0.2
	Chromium-dissolved	µg/L	<0.50	NA	1.0
	Chromium-total	µg/L	0.57	NA	1.0
	Copper-dissolved	µg/L	0.87	0.12	1.4
	Copper-total	µg/L	1.14	0.23	1.4
	Lead-dissolved	µg/L	<0.10	NA	3.4
	Lead-total	µg/L	<0.10	NA	3.4
	Mercury-dissolved	µg/L	<0.05	NA	0.06
	Mercury-total	µg/L	<0.05	NA	0.06
	Nickel-dissolved	µg/L	0.89	0.15	11
	Nickel-total	µg/L	1.04	0.09	11
	Zinc-dissolved	µg/L	5.8	1.6	8
	Zinc-total	µg/L	7.4	2.1	8

Site	Parameter	Unit	Mean	Standard Deviation	ANZG 95% DGV
Bridge (15)	Arsenic-dissolved	µg/L	0.57	0.11	13
	Arsenic-total	µg/L	0.70	0.12	13
	Cadmium-dissolved	µg/L	<0.05	NA	0.2
	Cadmium-total	µg/L	<0.05	NA	0.2
	Chromium-dissolved	µg/L	<0.50	NA	1.0
	Chromium-total	µg/L	0.50	NA	1.0
	Copper-dissolved	µg/L	0.60	0.04	1.4
	Copper-total	µg/L	0.80	0.03	1.4
	Lead-dissolved	µg/L	<0.10	NA	3.4
	Lead-total	µg/L	<0.10	NA	3.4
	Mercury-dissolved	µg/L	<0.05	NA	0.06
	Mercury-total	µg/L	<0.05	NA	0.06
	Nickel-dissolved	µg/L	0.6	0.0	11
	Nickel-total	µg/L	0.7	0.1	11
	Zinc-dissolved	µg/L	2.2	0.2	8
	Zinc-total	µg/L	2.8	0.3	8

NA = Not applicable.

Surficial sediments were measured for metals and phosphorus at the upstream farm pond (A), farm pond (B), and Bridge (15) sites on 10th November 2023. Metal results are summarised in **Figure 27**, with phosphorus in **Figure 28**.

All sediment metal concentrations were below the ANZG DGV, and, with the exception of zinc which appears to be increasing downstream of the influence of the Beachlands WWTP, metal concentrations appear to be relatively similar for the three sites (**Figure 27**).

4.4.1.5 EOCs

Watercare measured PPCPs on 10th/11th November 2023 at the upstream farm pond (A), farm pond (B), and Bridge (15) sites with mean (±1 SD) concentrations shown in Figure 26.

Concentrations at the upstream farm pond (A) were very low, with most PPCPs below detection limits. Mean concentrations of those detected were caffeine (50 ng/L), lamotrigine (10 ng/L), sucralose (90 ng/L), and triclosan (10 ng/L). The presence of low levels of wastewater markers caffeine and sucralose suggest sources of wastewater to the upstream site, probably from septic tanks.

Concentrations of PPCPs from the farm pond (B) site were consistently higher than the Bridge (15) site, suggesting significant attenuation between the farm pond discharge point and the Bridge site. Further, the attenuation from the outlet to the Bridge site (for PPCPs above detection limits for all sites) ranged from 0.9-fold (caffeine) to 5.3-fold (metoprolol), with an average of 2.9-fold (data not shown). In the absence of any other EOC data measured, this provides an indication of attenuation by the current overland and stream system.

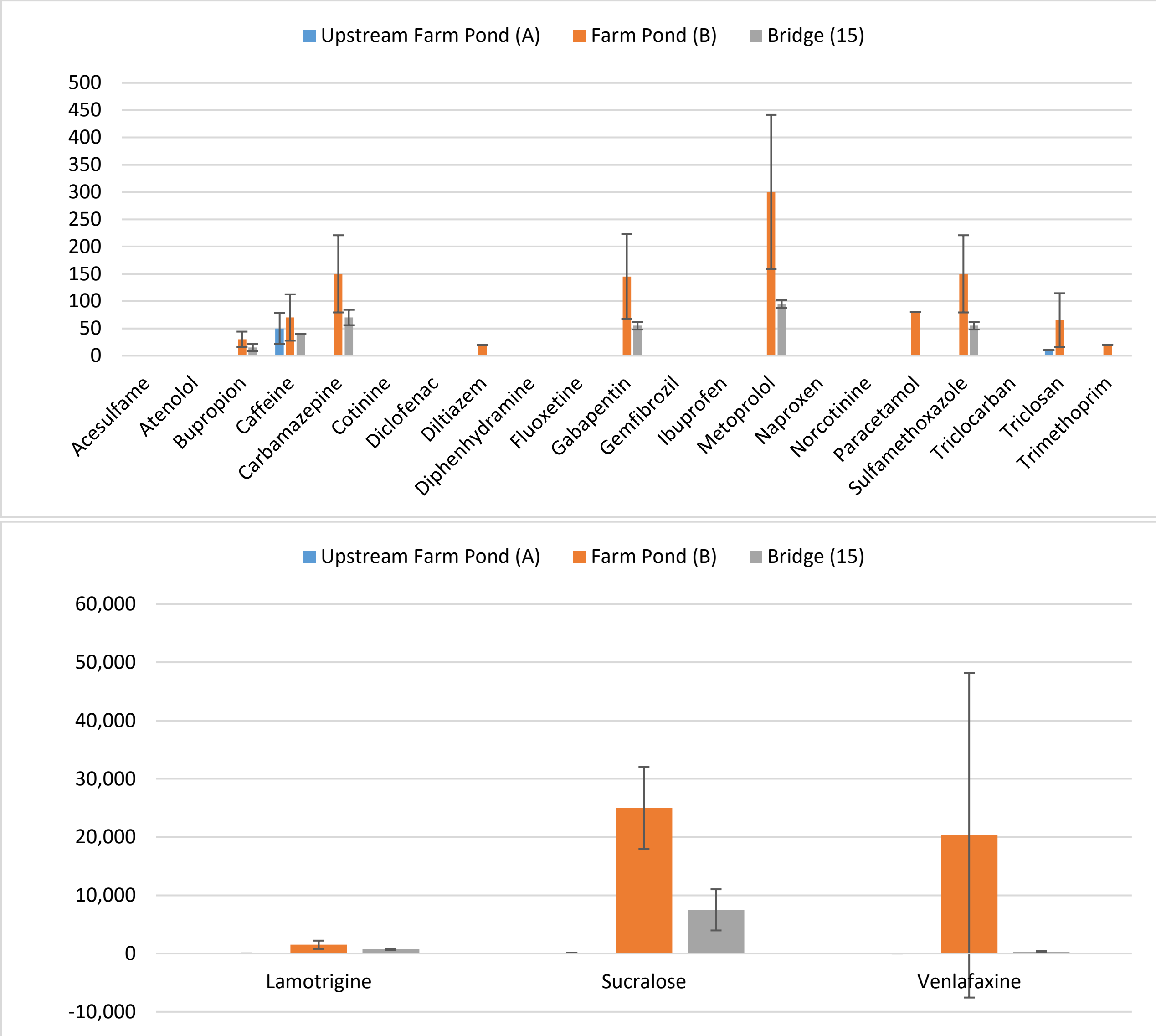

Figure 26. Mean and standard deviation (ng/ml, n=2) of PPCP concentrations reported from receiving environment sites sampled on 10th/11th December 2023. Note: different concentration scales. Blanks indicate concentrations below DL.

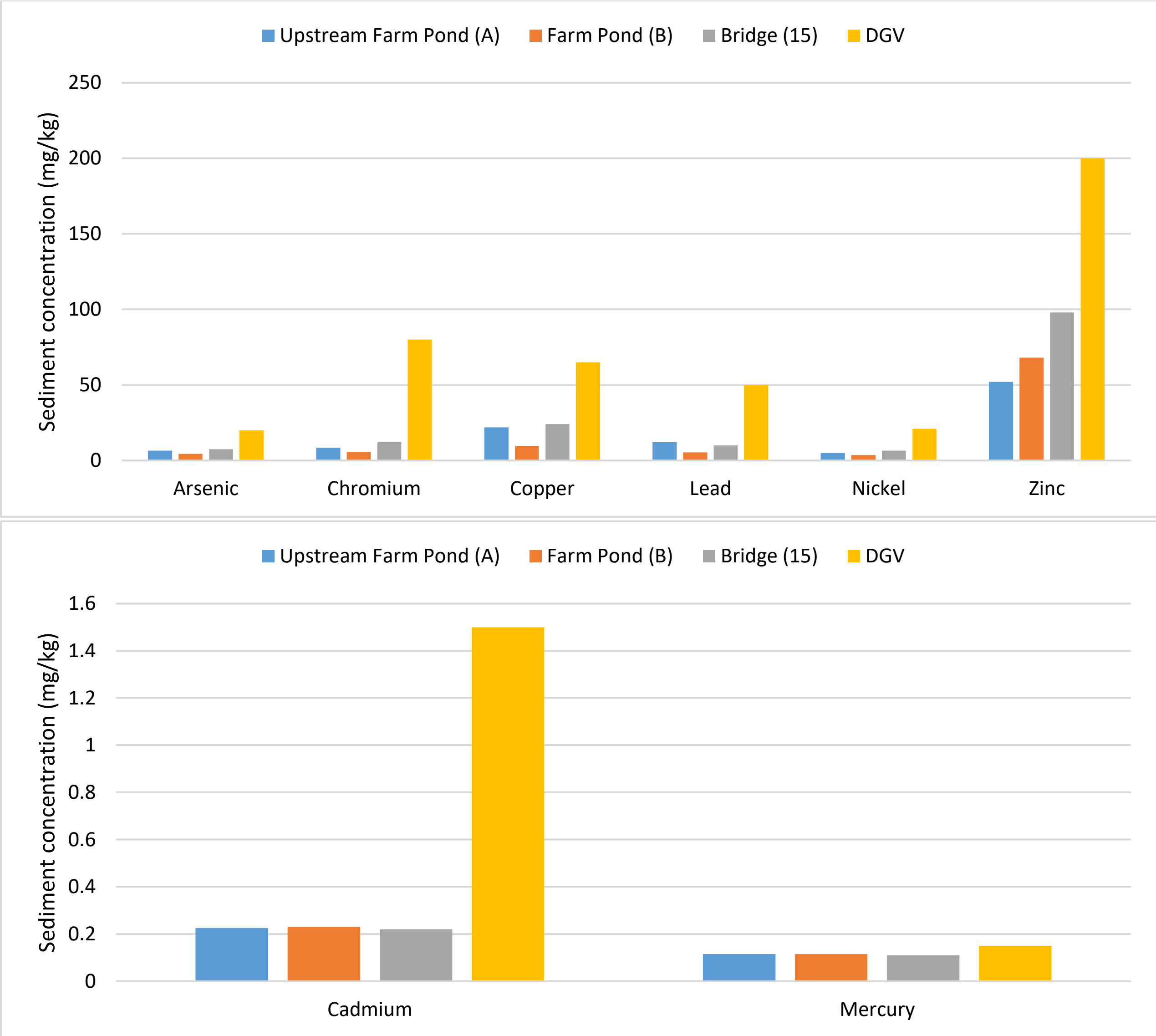

Figure 27. Sediment metal concentrations (mg/kg, dry weight) for receiving environment sites sampled on 10th November 2023.

4.4.1.6 Sediment phosphorus

There are no ecological effects guidelines for P in sediment. Sediment P concentrations are increasing from upstream of the farm pond (860 mg/kg), to the farm pond (1,500 mg/kg) and Bridge site (15) (2,000 mg/kg) (**Figure 28**). Previously, sediment P concentrations were measured in 2000 and 2010 (summarised in Earth Consult, 2010). Average TP concentrations in 2000 and 2010 were similar, at 9440 mg/kg, and 10,020 mg/kg, respectively. The authors concluded that despite a continued flux of phosphorus entering the pond between 2000 and 2010, the static concentrations suggest the pond sediment has the capacity to adsorb additional phosphorus from the water column. Concentrations in 2000 and 2010 were around 5-fold to 10-fold higher than the current TP sediment concentrations. Variability may be due to differences in collection methodologies.

Further, Bioresearches have measured sediment P on 6 occasions between 2002 and 2024. At Site F (between pond and the Bridge site), TP has remained relatively stable, ranging from 1,890 mg/kg to 3,500 mg/kg (Bioresearches, 2024a). Importantly, there is no observable trend in sediment P concentrations at this site.

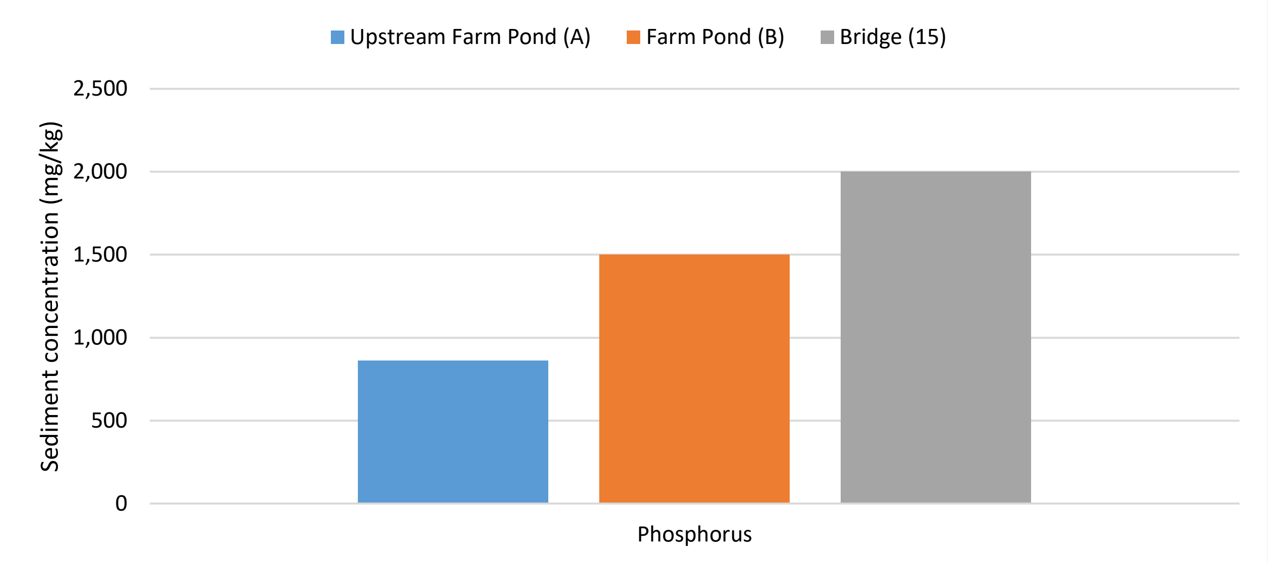

Figure 28. Phosphorus concentrations (mg/kg, dry weight) for receiving environment sites sampled on 10th November 2023.

4.5 Water and sediment quality trends

Temporal trend analysis was undertaken on water quality data collected from the upstream farm pond (A) and farm pond (B) sites from February 2020 to March 2023. Only selected parameters that are likely to be impacted by the existing Beachlands WWTP discharge, namely water temperature, ammoniacal-N, nitrate-N, TP, and DRP were assessed. Full results are presented in **Appendix 2**.

For the upstream farm pond (A) site there were no significant trends for all parameters, suggesting changes to catchment land use that may affect water quality at this site are not occurring on this time scale.

For the farm pond (B) site there was a significant (p=0.002) and meaningful (43% annual change) increase in nitrate-N. All other trends were not statistically significant. The large annual increase in nitrate-N observed at the farm pond (B) site is consistent with a large annual increase (77%) in nitrate-N in the discharge (albeit over a longer time period of 2018-2023: **Table 3**). There has been a large step-wise increase in nitrate-N in the discharge since 2020 (see **Table 2**).

4.6 Stream ecology

4.6.1 Sites and methods

Bioresearches have undertaken water quality and ecological surveys at selected Te Puru Stream and tributaries. For Watercare, surveys have been undertaken in September 2016 (Bioresearches, 2016), September 2019 (Bioresearches, 2019), December 2022 (Bioresearches, 2022), and February 2024 (Bioresearches, 2024a).

Sites and sampling undertaken are summarised in **Figure 29** and **Table 10**. Water quality has been described in Section 4.4, which is bed on the extensive monitoring undertaken, so only biological indicators are summarised in this section.

Sites are grouped in Reference Tributary (H and E), Farm Pond Tributary (A and F), and Te Puru Stream Tributary (S2, G, S3, and C) (**Figure 29**).

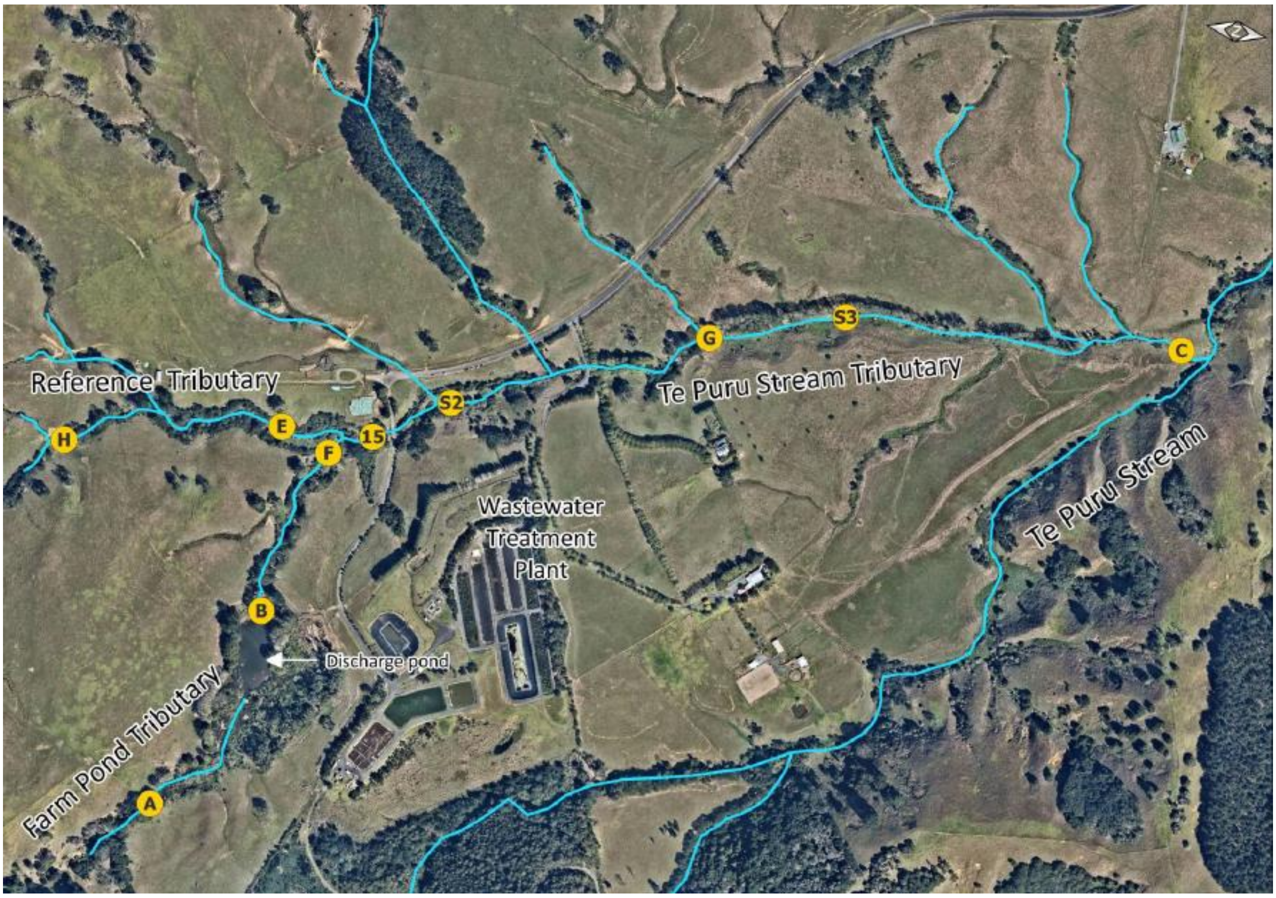

Figure 29. Bioresearches sampling site locations in Te Puru Stream tributaries (blue lines – Reference Tributary, Farm Pond Tributary and Te Puru Stream Tributary), site locations (yellow circles) and the location of the wastewater treatment plant (Bioresearches, 2024a).

Table 10. Sample types taken at each site (Bioresearches, 2024a).

Site	Sample types
A	Water Quality, Macroinvertebrates and Fish, Macrophytes
B	Water Quality
F	Water Quality, Sediment, Quality, Macroinvertebrates and Fish, Macrophytes
H	Macroinvertebrates and Fish, Macrophytes
E	Water Quality, Sediment Quality, Macroinvertebrates and Fish, Macrophytes
15	Water Quality
S2	Macrophytes, macroinvertebrates
G	Water Quality, Sediment Quality, Macroinvertebrates and Fish, Macrophytes
S3	Macrophytes
C	Water Quality, Sediment Quality, Macroinvertebrates and Fish, Macrophytes

Methods are described in detail in Bioresearches (2024a) and summarised here.

At each site the percentage cover (proportion of the total line width impinged) of algae and/or macrophytes was recorded along twelve random replicate transects which ran from bank to bank.

Macroinvertebrates were sampled from instream habitats to obtain semi-quantitative data in accordance with Stark et al. (2001). For all sites except the upper reference Site H sampling was undertaken using protocol 'C2: soft-bottomed, semi-quantitative'. Macroinvertebrates were preserved and identified to the lowest practicable level and counted to enable biotic indices to be calculated.

Several biotic indices were calculated, namely the number of taxa, the number and percentage of Ephemeroptera (mayflies); Plecoptera (stoneflies) and Trichoptera (caddisflies) recorded in a sample (%EPT), the Macroinvertebrate Community Index (MCI) and the Semi-Quantitative Macroinvertebrate Community Index (SQMCI) (Stark and Maxted, 2007a). EPT are three orders of insects that are generally sensitive to organic or nutrient enrichment but exclude Oxyethira and Paroxyethira as these taxa are not sensitive and can proliferate in degraded habitats. The MCI and SQMCI are based on the average sensitivity score for individual taxa recorded within a sample, although the SQMCI is calculated using coded abundances instead of actual scores.

Stark and Maxted (2007b) defined the following habitat quality for the MCI and SQMCI scores, respectively:

- ≥ 120 and ≥ 6.0 are indicative of excellent habitat quality.
- 100 – 119 and 5.0 – 5.9 are indicative of good habitat quality.
- 80 – 99 and 4.0 – 4.9 are indicative of fair habitat quality.
- < 80 and < 4.0 are indicative of poor habitat quality

These metrics were used by Bioresearches to describe habitat quality.

MCI and QMCI are also included in the NPS-FM 2020 (MfE, 2024) with corresponding Attribute States. The NBL sits between attribute states C and D and is 90 (MCI) and 4.5 (QMCI). We note that the NPS-FM attribute bands are determined using annual samples taken between December and March (inclusive) with either fixed counts of at least 200 individuals, or full counts, and with current state calculated as the five-year median score. Therefore, MCI and QMCI reported here are indicative only.

MCI is also a requirement in the Auckland Unitary Plan (operative in part) (hereafter AUP) with an applicable minimum MCI for Auckland rivers and streams of 94 in rural areas, marginally above the NPS-FM NBL of 90 (see Section 5.1 and **Table 12** for further discussion).

Freshwater fish were sampled using three baited Gee's minnow traps which were deployed overnight at each site. Electric fishing was only effective at Sites A, H and E as the high conductivity at sites downstream of the pond prevented effective operation of the machine. All fish captured by electric fishing were identified and counted, and their size estimated before being returned to their habitats. A Fish Index of Biotic Integrity (IBI) for the Auckland Region was calculated for each site based on fish species present, altitude and distance inland (Joy and Henderson, 2004). New Zealand Freshwater Fish Database forms were completed for each site.

The current (2024) survey results (31st January to 2nd February 2024) are summarised in the following sections, with previous results provided as further context of changes.

4.6.2 Current (2024) results

4.6.2.1 Macrophytes and algae

In 2024, willow weed (*Persicaria* sp.) was the most prevalent, identified at six sites, with water forget-me-not (*Myosotis laxa*) found at five sites, and watercress (*Nasturtium officinale*) and water celery (*Apium nodiflorum*), each present at four sites (**Figure 30**). Macrophyte diversity and the percentage of macrophyte and algae cover generally increased downstream. Differences in macrophyte/algae community composition were observed between reference and effect sites, with Nitella and filamentous algae being largely absent at reference sites H and A but a significant proportion of sites G, S3, and C (**Figure 30**).

Note that the majority of the substrates in the lower tributary and Te Puru Stream are soft bottom, therefore not suitable for assessing periphyton biomass and periphyton blooms would be unlikely to occur or would be short-lived.

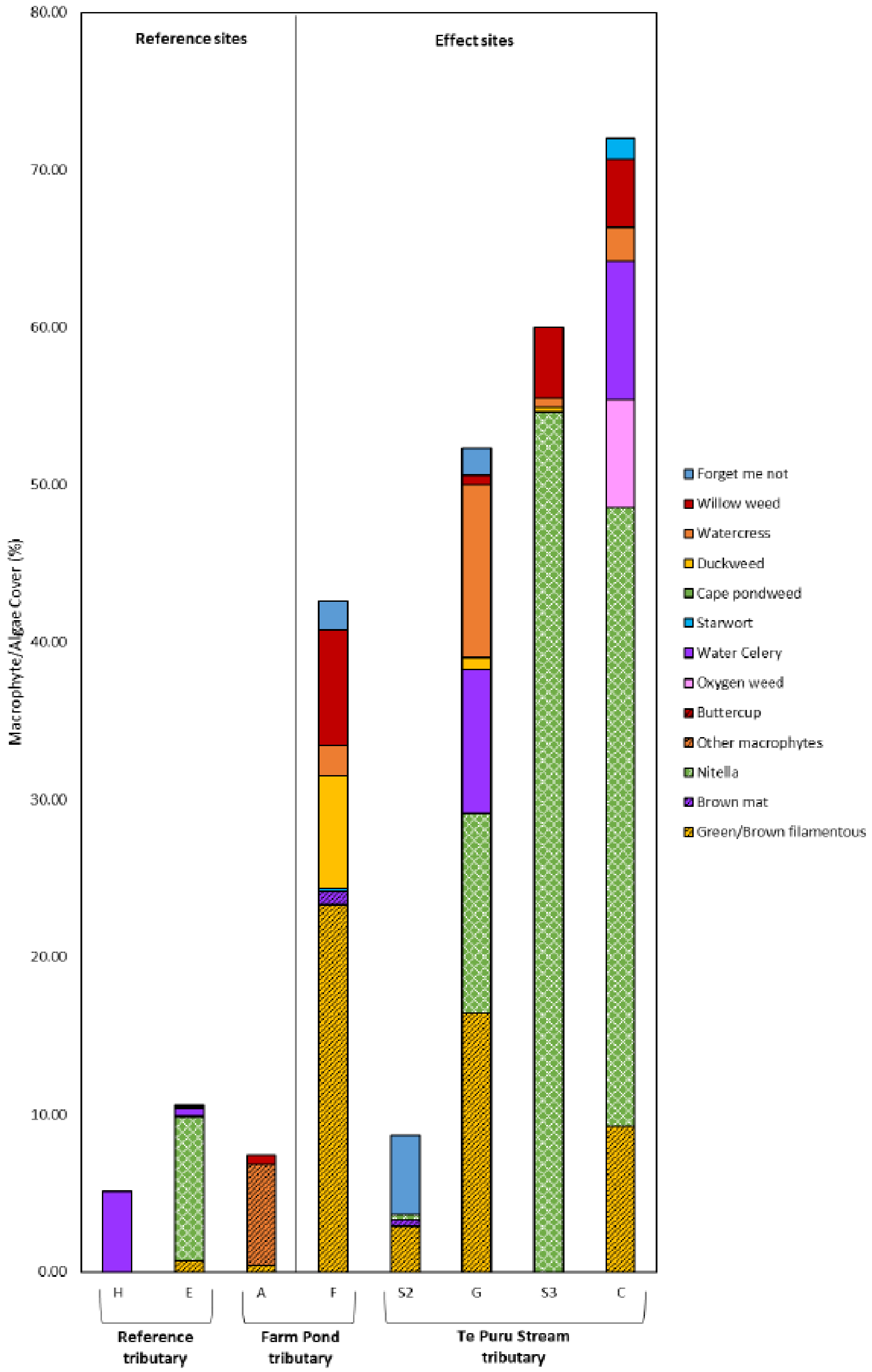

Figure 30. Macrophyte and algae % cover by species for the Te Puru Stream Tributaries (Bioresearches, 2024a).

The percentage of macrophyte and algae cover generally increased downstream, with the highest percentage of bare substrate recorded at Site H (94.9 %), Site A (92.6 %), and Site E (88.6%). Notably, three sites downstream of the farm pond (G, S3, and C) displayed macrophyte and algae cover exceeding 50 %. Watercress (see QMRA, section 5.3.6) was found at F, G, S3, and C effect sites.

4.6.2.2 Macroinvertebrates

A summary of number of taxa, % EPT, MCI, and SQMCI indices for 2024 sampling sorted by reference sites (H, E, A) and effect sites (F, G, C) is shown in **Figure 31**.

Macroinvertebrate diversity is identified by number of species present. Higher numbers of taxa (15-22 species) were present at the reference sites, with site F (closest to the pond discharge) recording only 3 species. Species numbers increased further downstream with sites G and C both recording 12 taxa (**Figure 31**). With the exception of reference Site A and effect Site C, macroinvertebrates were dominated by the freshwater snail (*Potamopyrgus antipodarum*), ranging from 28% (Site H) to 98% (Site F). Sites A and C were dominated by the freshwater amphipod (*Paracalliope fluviatilis*), comprising 63 % and 80 % of the individuals, respectively.

The percentage of sensitive species (%EPT) ranged from 22-30% at the reference sites, with no EPT taxa recorded at Site F and virtually 0% at effect sites further downstream (Sites G and C) (**Figure 31**).

MCI indices place reference sites (98-105) on the border between 'good' (>100) and 'fair' (80-99) quality habitat. In contrast, Site F had the lowest MCI of 63 well into the 'poor' quality habitat (<80), while sites G (82: fair) and C (67: poor) showed some improvement further downstream (**Figure 31**). The relatively low MCI of 98 for Site E was attributed to low water levels and potentially a lack of aquatic habitat at the time of sampling. In summary, all the reference sites has MCI indices above and all the effect sites had MCI indices below the AUP MCI minimum of 94.

SQMCI, which considers the relative abundance of taxa as well as the MCI score, showed similar results to MCI, with reference Sites H and E reported as 4.8, and 4.5 in the 'fair' category (4.0-4.9), and Site A (6.0) just into the 'excellent' category (≥6.0). Site F showed the lowest SQMCI (2.1; poor), while sites G (4.5) and C (4.8) in the 'fair' category (**Figure 31**). Only site F had a SQMCI value below the NPS-FM NBL of 4.5.

Bioresearches noted that the poor macroinvertebrate scores downstream of the discharge are likely due to a combination of stressors, such as the decreased riparian vegetation and hard substrate at downstream sites, along with effects caused by the discharge itself such as increased temperature, nutrient input (including potentially toxic nutrients such as ammonium), and suspended sediment. Macroinvertebrate and native fish communities did not appear to fully recover at the most downstream sites and lacked more sensitive taxa. The overall magnitude of effect of all activities on the tributary and stream environment can be classified as moderate.

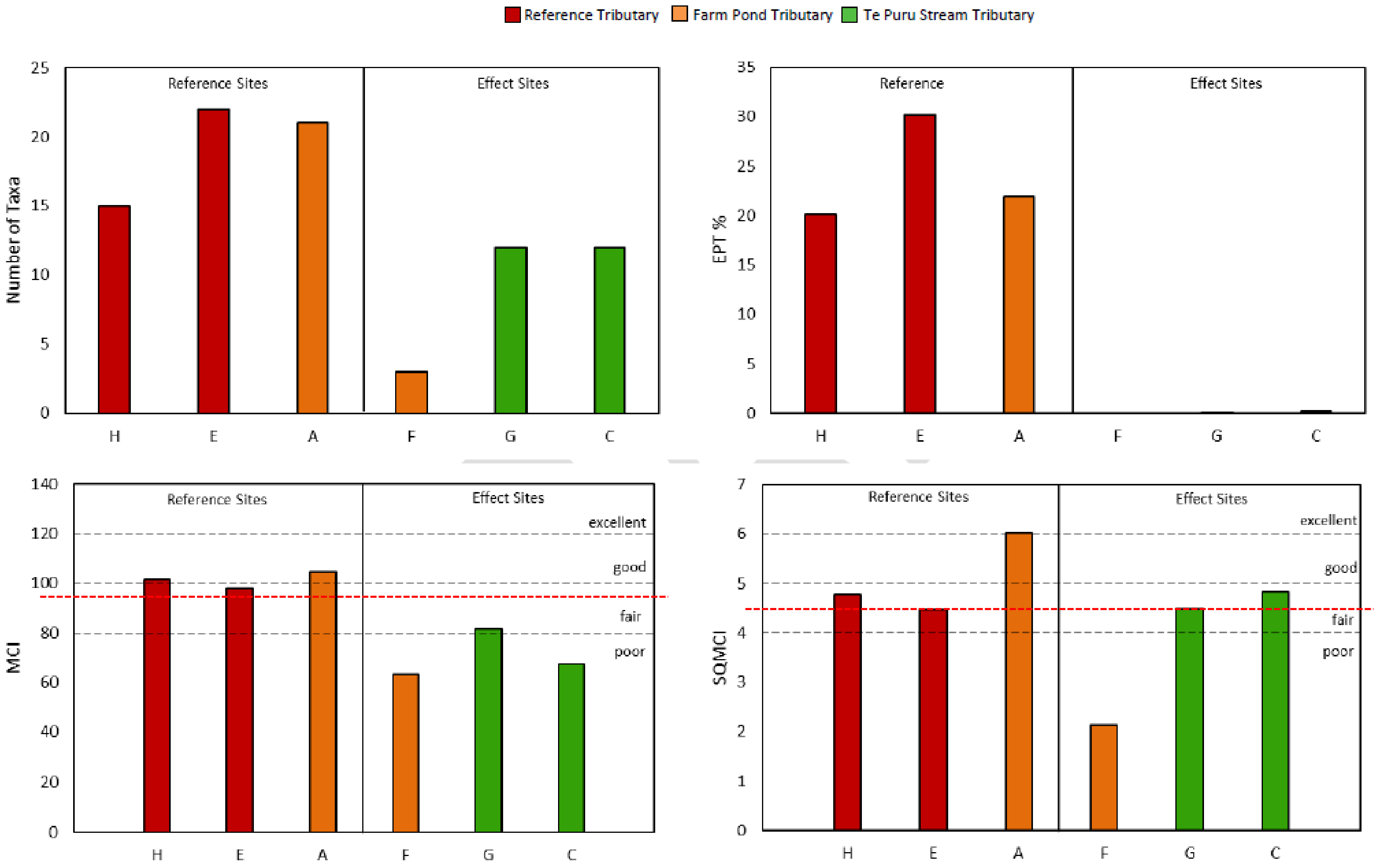

Figure 31. Macroinvertebrate community results for 2024 – number of taxa, EPT%, MCI and SQMCI (Bioresearches, 2024a). AUP minimum MCI for rural areas (94) and NPS-FM SQMCI NBL (4.5) are designated by a red dashed line.

4.6.2.3 Fish

Between 3 and 4 native fish species – an unidentified eel species (*Anguilla* spp.), and three species listed at 'Not Threatened' (Dunn et al., 2017): banded kōkopu (*Galaxias fasciatus*); common bully (*Gobiomorphus cotidianus*); and Cran's bully (*G. basalis*) – were recorded at the reference sites (H, E, and A). The number of native fish at these sites ranged from 19 (Site E) to 36 (Site H).

At effect sites the high conductivity precluded electric fishing, with gee minnow and hand nets used to sample native fish communities. Both native fish species biodiversity and abundance decreased at the effect Sites C and F compared to the reference sites. Effect site F recorded only one unidentified eel, while Sites C and F recorded only common bully, tuna (eels), and the introduced mosquito fish (*Gambusia affinis*), with total numbers of fish 14 at Site C and 25 at Site G (with 21 of these common bully).

Fish IBI are shown in **Figure 32.** In comparison to other Auckland streams, given the altitude and distance from the sea, reference sites rated as 'fair' for species diversity at Sites H and A (both 34), and 'poor' for site E (26). Site F was rated as 'very poor' (14), while Sites G and C were both poor' (26) (**Figure 32**).

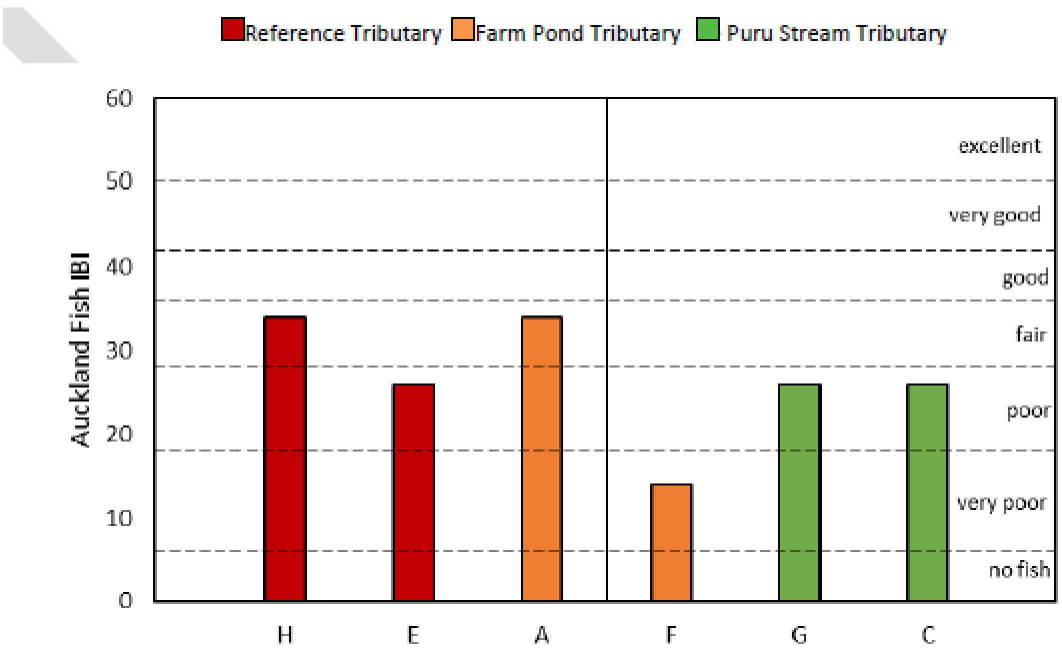

Figure 32. Auckland Fish IBI scores for sites on the Te Puru Stream Tributaries (Bioresearches, 2024a).

A search of fish records from the New Zealand Freshwater Fish Database for the Te Puru Stream catchment recorded seven native and one introduced fish species (*Gambusia affinis*) around the wider Te Puru Stream catchment between 1991 and 2022. No additional species were recorded in the 2024 study, however. Cran's bully (recorded at Site H in 2024) was last recorded in 1991.

4.6.3 Trends

4.6.3.1 Macrophytes and algae

Number of taxa and percentage macrophyte/algae cover for 2016, 2019, 2022, and 2024 are shown in **Figure 33**. For most sites the number of taxa appear to be stable or increasing since 2016, with generally more taxa recorded at downstream sites. A similar trend is noted for percentage macrophyte/algae cover.

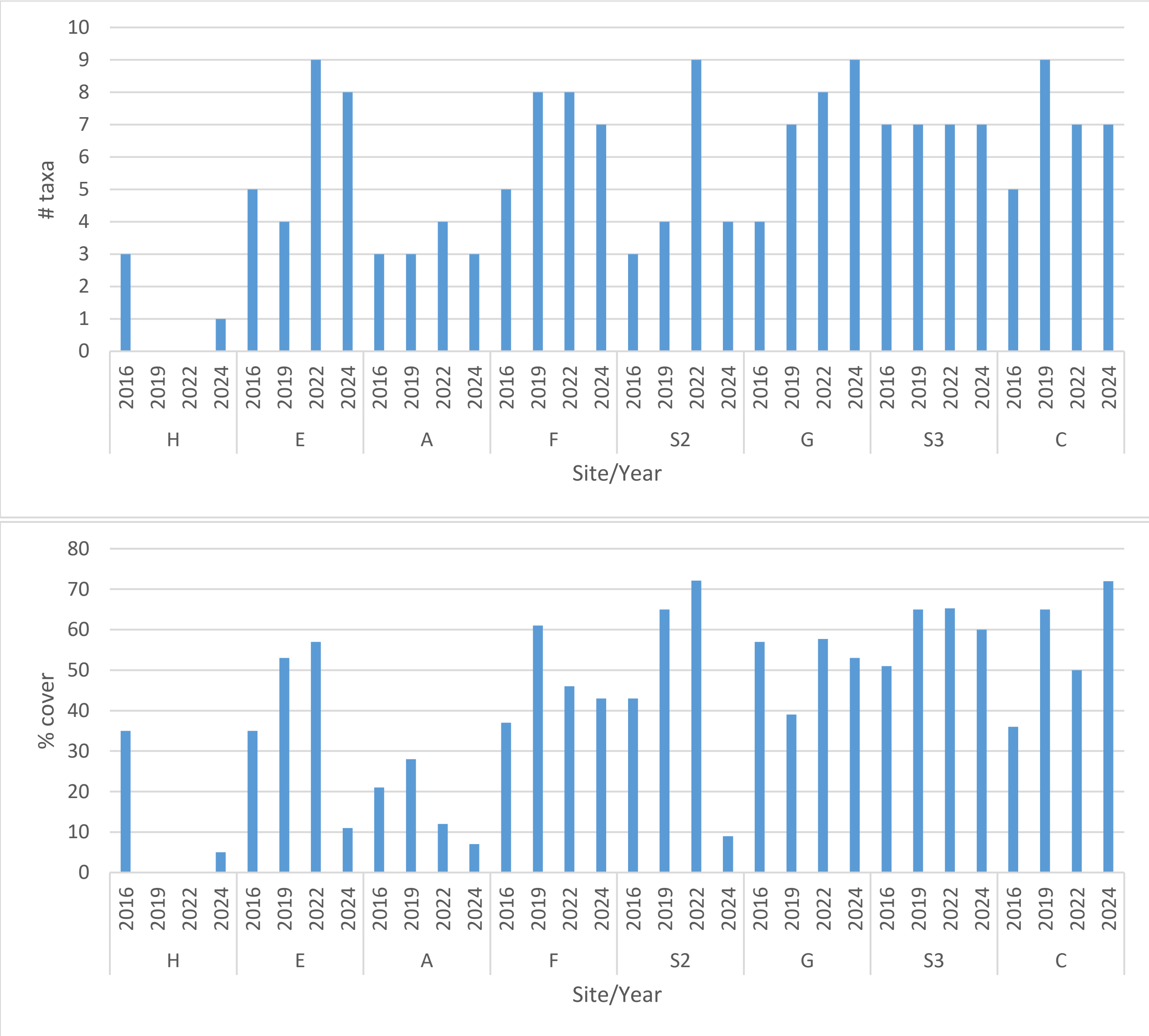

Figure 33. Number of taxa and percentage cover of macrophytes and algae for 2016, 2019, 2022, and 2024.

4.6.3.2 Macroinvertebrates

Number of taxa, % EPT, MCI, and SQMCI for 2016, 2019, 2022, and 2024 are shown in **Figure 34**.

The number of taxa appear to be stable or declining at the reference sites (H, E, A) and generally lower but stable or increasing at the effect sites (F, S2, G) (**Figure 34**).

%EPT have been highest for reference site H, although very variable (4%-48%), with a marked decrease in 2024 compared to previous years. Reference site A has had intermediate and relatively stable %EPT (6%-18%), while site E has had the lowest of the reference sites (0%-9%). The three effect sites have had 0% EPT between 2018-2022, with this trend continuing for site F, but minor recovery observed at site S2 (3%) and G (2%) in 2024 (**Figure 34**). As stated earlier, EPT are three orders of insects that are generally sensitive to organic or nutrient enrichment.

MCI scores for reference sites H, E, and A have been relatively consistent and mostly above the AUP minimum for rural areas of 94. Site E was showing a decline from 2016 (MCI 96) in 2019 (MCI 91) and 2022 (MCI 70) but has since recovered to a value of 98 in 2024. Similarly, effect site MCI have been relatively consistent since 2016, but in contrast to the reference sites, all but one MCI value has been below the AUP minimum for rural areas of 94 (**Figure 34**). Site F (MCI 46-63) has always been well below 94 but has been increasing from 46 in 2016 to 63 in 2024. Site S2 has shown a general improvement in MCI scores and in 2019 was above 94. Site G has shown a general decline in scores from 82 in 2016 to 67 in 2024.

SQMCI show a similar pattern to MCI, with reference sites generally above and effect sites generally below the NPS-FM NBL of 4.5 (**Figure 34**). Reference site E was an exception, being below 4.5 in 2016, 2019, and 2022, but at 4.5 in 2024. As for MCI there is a general increasing trend in the SQMCI scores for the effect sites.

The improvement in MCI and SQMCI scores at site F (closest to the WWTP discharge) are promising, however improved water quality in the proposed WWTP discharge (primarily lower concentrations of toxic nitrate and ammonia, and conductivity), and riparian planting downstream is required to contribute to further improving the macroinvertebrate communities downstream.

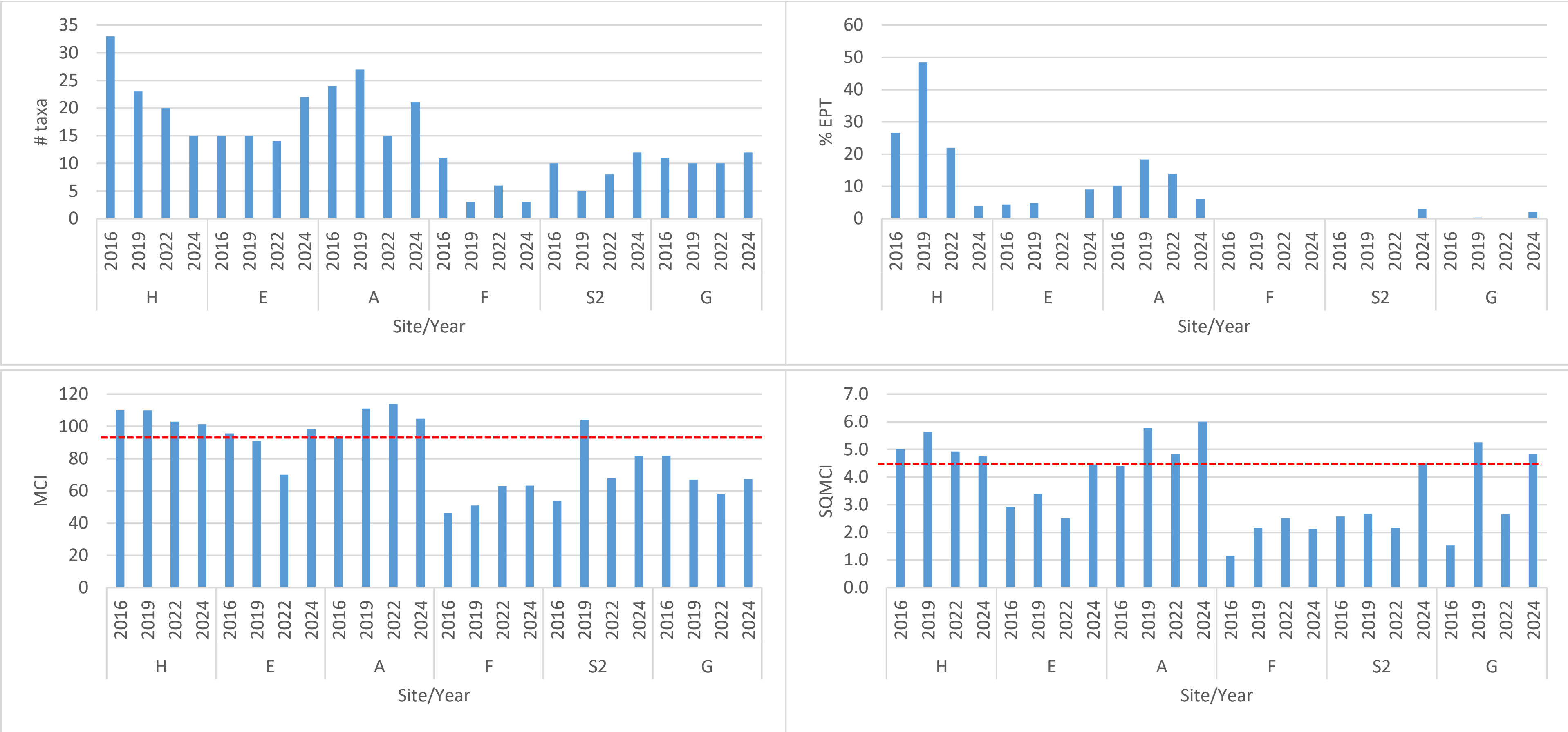

Figure 34. Number of taxa, % EPT, MCI and SQMCI of macroinvertebrates for 2016, 2019, 2022, and 2024. AUP minimum MCI for rual areas (94) and NPS-FM SQMCI NBL (4.5) are designated by a red dashed line.

4.6.3.3 Fish

The number of native species, number of native fish, and fish IBI for 2016, 2019, 2022, and 2024 are shown in **Figure 35**.

The number of native species and native fish were generally higher at reference sites (H,E,A) than effect sites (F,S2,G). Numbers of native species were generally low (1-5) for reference sites and 0-4 for effect sites with no apparent temporal trends were observed. The number of native fish at reference site H was declining from 2016 (38) to 2022 (14) but returned to near 2016 numbers in 2024 (36) (**Figure 35**). Reference sites E and A showed a general increase in the number of native fish. As for other ecological metrics, site F had the lowest native species (0 or 1) and number of native fish (0-2). Site S2 showed a marked increase in the number of native fish in 2024 (25) from previous (maximum 6 in 2022) but as noted in the previous section 21 of these were common bully. Site G had variable fish numbers ranging from 4 in 2019 to 25 in 2016 (**Figure 35)**.

Fish IBI showed a similar pattern with a consistently higher index for the reference sites – site H (34-52); site E (14-34); and site A (28-38) – higher than effect sites: site F (0-14); site S2 (14-28); and site G (14-28) (**Figure 35)**. Fish IBI appears to be reducing at reference site H, but stable or increasing at reference sites E and A. For effect sites, site F has either no fish or a very low Fish IBI, while sites S2 and G appear to be generally improving.

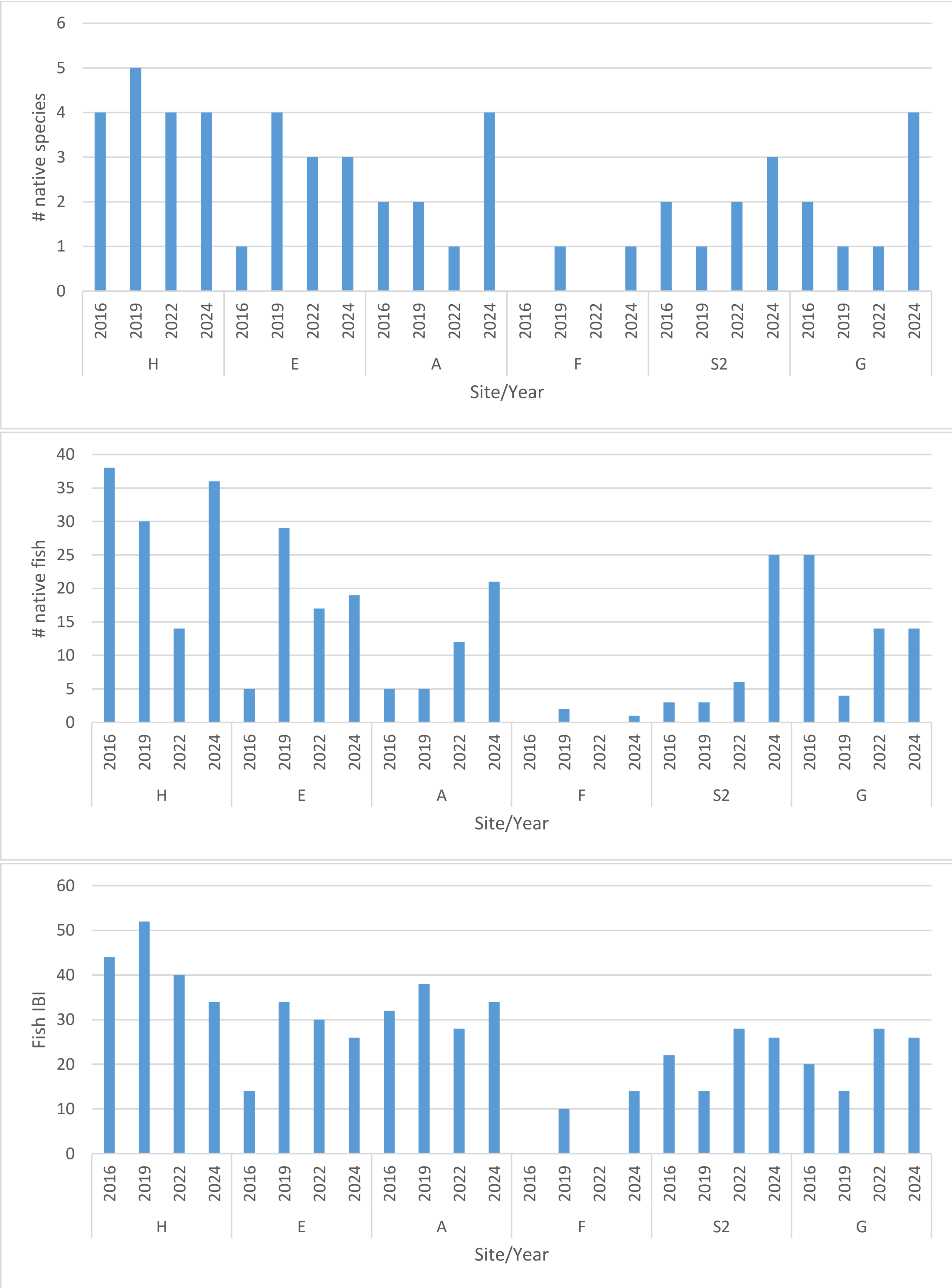

Figure 35. Number of native species, native fish, and Fish IBI for 2016, 2019, 2022, and 2024.

4.7 Marine coastal receiving environment

4.7.1 Te Maraetai/Kellys Beach & Te Puru Stream entrance

Te Puru Stream enters the marine coastal environment at Te Maraetai/Kellys Beach, which is located between Beachlands and Maraetai (**Figure 36**). The lower, estuarine reaches of Te Puru Stream north of the Whitford-Maraetai Rd are strongly influenced by seawater inflow during high tide, with salinities of 20–35 (ppt) at high tide, but decreasing to 5–15 ppt during low tide (Zeldis *et al.*, 2001). The entrance to Te Puru Stream is designated as a Significant Ecological Area (SEA)–Marine 1 (**Figure 36** (SEA-M1-42b)) in the AUP due to the variety of saline vegetation and coastal vegetation present (e.g., raupo (*Typha orientalis*), clubrush (*Bolboschoenus* sp.), sedges (*Schoenoplectus* sp.)), and the intact ecological sequence from estuarine to freshwater wetlands. Various threatened birds utilise the area including banded rail (*Gallirallus philippensis*), Caspian tern (*Hydroprogne caspia*), South Island pied oystercatchers (*Haematopus finschi*), and pied shags (*Phalacrocorax varius*).

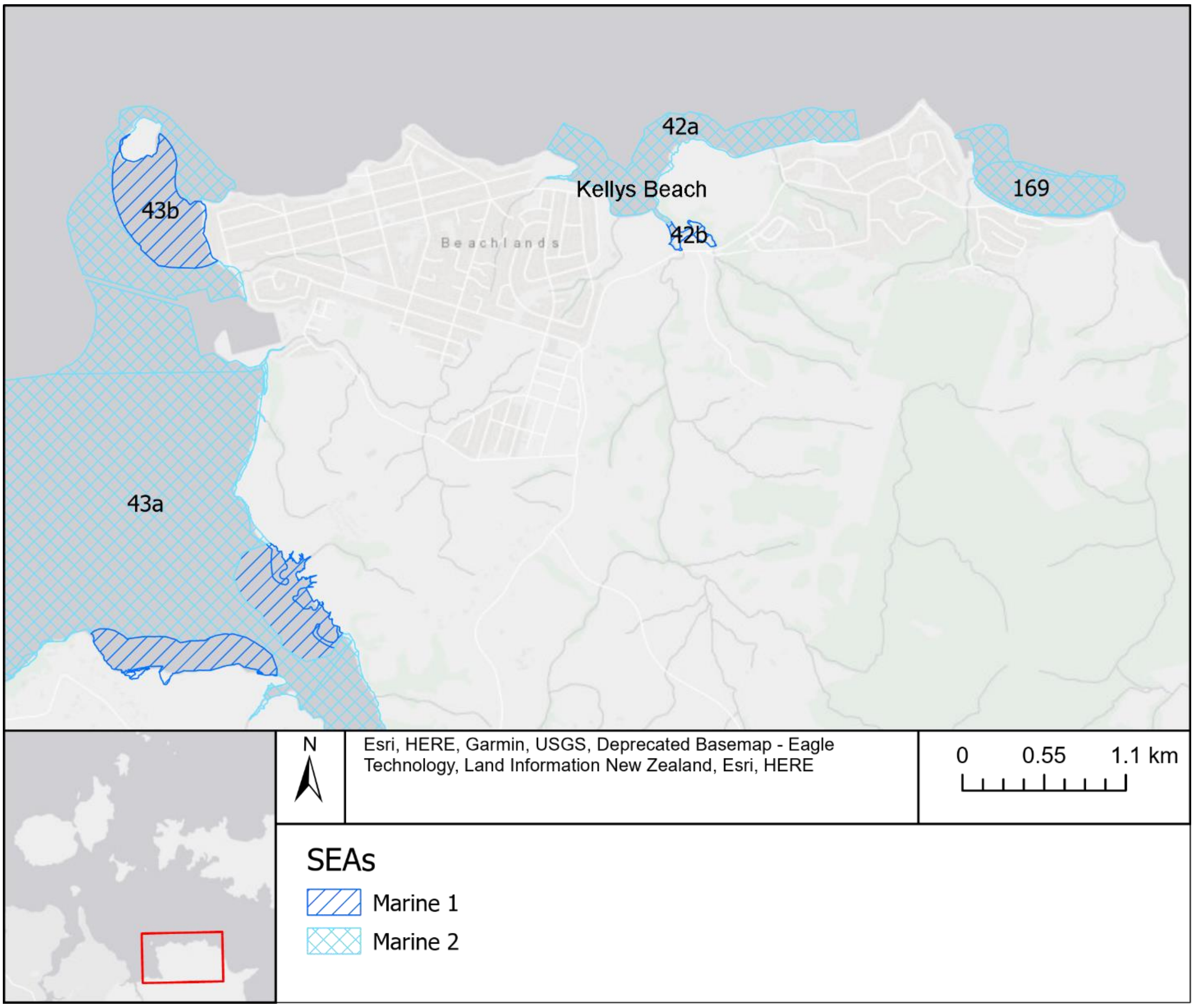

Figure 36. Auckland Unitary Plan Significant Marine Ecological Areas around Te Maraetai/Kellys Beach.

4.7.1.1 Intertidal survey of Te Maraetai/Kellys Beach

Te Maraetai/Kellys Beach and the surrounding coastal area is designated as a SEA-Marine 2 (**Figure 36**, (SEA-M2-42a)) due to the variety of intertidal habitats present (mudflats, sandflats, rock platforms) that provide a habitat for a wide variety of marine organisms. A survey of the intertidal area around Te Maraetai/Kellys Beach was conducted on 21st December 2023 around low tide to describe the intertidal marine community of the coastal receiving environment. The survey involved:

- Investigation of shellfish and seagrass abundance at 14 pre-planned stations around the bay. At each station a 0.25 m^2 quadrat was placed on the seabed and the density of shellfish and seagrass were semi-qualitatively assessed as follows:
    - shellfish—none, low (<10), moderate (10–30), high (>30)).
    - seagrass—none, sparse (<20% cover), moderate (20–50% cover), dense (>50% cover).
- A walkover of the sandstone platform reefs that are present on either side of the bay. General observations were made on the abundance and type of biota present on the reefs, particularly any kai moana species that were present.

The stream banks either side of the entrance to Te Puru stream are around 1–2 m above the water level and are densely covered with medium sized (2–3 m high) mangroves (**Figure 37A**). The substrate around the stream on the upper half of the beach is very soft, knee-deep mud with abundant crustacean burrows (**Figure 37B** & **Figure 39A**). Half-way down the beach the substrate becomes sandy with mixed shell and pebble (**Figure 39C**). Low lying shell banks are present in some areas that mainly comprised cockle and pipi shells (**Figure 37C–D**), and an area of plain sand was present near the low tide mark (**Figure 37F**).

Three small patches of moderately dense seagrass (*Zostera muelleri* subsp. *novazelandica*) were observed on the lower intertidal flats outside of the survey stations. These patches were each approximately 2 m × 1 m in size (**Figure 37E** & **Figure 38**).

Seagrass is listed as an "At Risk: Declining" species under the New Zealand Threat Classification System (NZTCS) due to the overall seagrass population being very large, but subject to low to high ongoing or predicted decline. The NZTCS includes the following qualifier for its classification of seagrass:

a) it is a non-endemic species that is secure overseas; and
b) the seagrass population experiences extreme fluctuations (de Lange et al., 2017).

Seagrass meadows, which are defined as >60% coverage over an area larger than 10,000 m^2, are an important biogenic habitat (Anderson et al., 2019). However, the patches of seagrass present were much too small to meet the criteria of biogenic habitat.

Very small cockles (*Austrovenus stutchburyi*) and pipis (*Paphies australis*) were found at all the survey stations apart from the two uppermost stations on the shore (**Figure 38** & **Figure 39E–F**). Densities ranged from low to high. No shellfish were found that were near harvestable sizes of approximately 30 mm for cockles and 50 mm for pipis.

Intertidal sandstone reef platforms are present on either side of the bay. The upper portions of the reefs on the eastern side of the bay were densely covered with modest barnacles (*Austrominius modestus*) and small Pacific oysters (*Crassostrea gigas*), none of which were considered to be of harvestable size (**Figure 40A, E**). Dense patches of Neptune's necklace (*Hormosira banksii;* **Figure 40B**) and small clumps of *Codium fragile* subsp. *novae-zelandiae* (**Figure 40C**) were present in the rock pools and on the lower portions of the reef. A range of common intertidal species were present on the reef and in rock pools including cat's eyes (*Lunella smaragda*), spotted black top shells (*Diloma aethiops*), mud whelks (*Cominella glandiformis;* **Figure 40E**), spotted whelks (*Cominella maculosa*), dark rock shells (*Haustrum haustorium*), blue mussels (*Mytilus planulatus*; **Figure 40F**), mud crabs (*Austrohelice crassa*), glass shrimps (*Palaemon affinis*) and triplefins.

The sandstone reefs on the western side of the bay were lower in height than those on the eastern side (**Figure 41A–B**), and the areas near the stream were covered in a layer of fine mud (**Figure 41C**). Abundances of Pacific oysters and Neptune's necklace were much lower on the western reef (**Figure 41D**). On the midshore, clumps of brown filamentous algae (**Figure 41E**) and coralline turf were present in the rock pools. Near the low tide mark the rocks were covered in the blue tube worm (*Spirobranchus cariniferus;* **Figure 41F**). A similar suite of invertebrates to the eastern reef were present on the western reef.

Several coastal and seabirds were observed on the intertidal flats during the survey. These included New Zealand dotterels (*Charadrius obscurus*), variable oystercatchers (*Haematopus unicolor*), black-backed gulls (*Larus dominicus*), and white-faced herons (*Egretta novaehollandiae*). A nesting area for New Zealand dotterels on the upper beach west of Te Puru Stream had been cordoned off.

In summary, the intertidal marine community at Kelly's Beach is typical of sheltered beaches around the Auckland region. The only threatened marine species (excluding birds) observed during the survey was seagrass, which was present in three very small patches on the lower shore well away from the stream entrance.

Several kai moana species were observed to be present on Kelly's Beach (cockles, pipis, oysters, mussels), however, all were too small to be deemed of harvestable size. Given their very small size it is unlikely that shellfish are harvested from Kelly's Beach for human consumption.

Figure 37. Habitats present on the intertidal mud/sand flats in Kelly's Beach: A. Mangroves surrounding the entrance to Te Puru Stream. B. Deep, soft mud with abundant crustacean burrows on the stream banks of the upper shore. C–D. Shell banks on the mid to lower shore. E. Small patches of seagrass on the lower shore. F. Sandy areas on the lower shore.

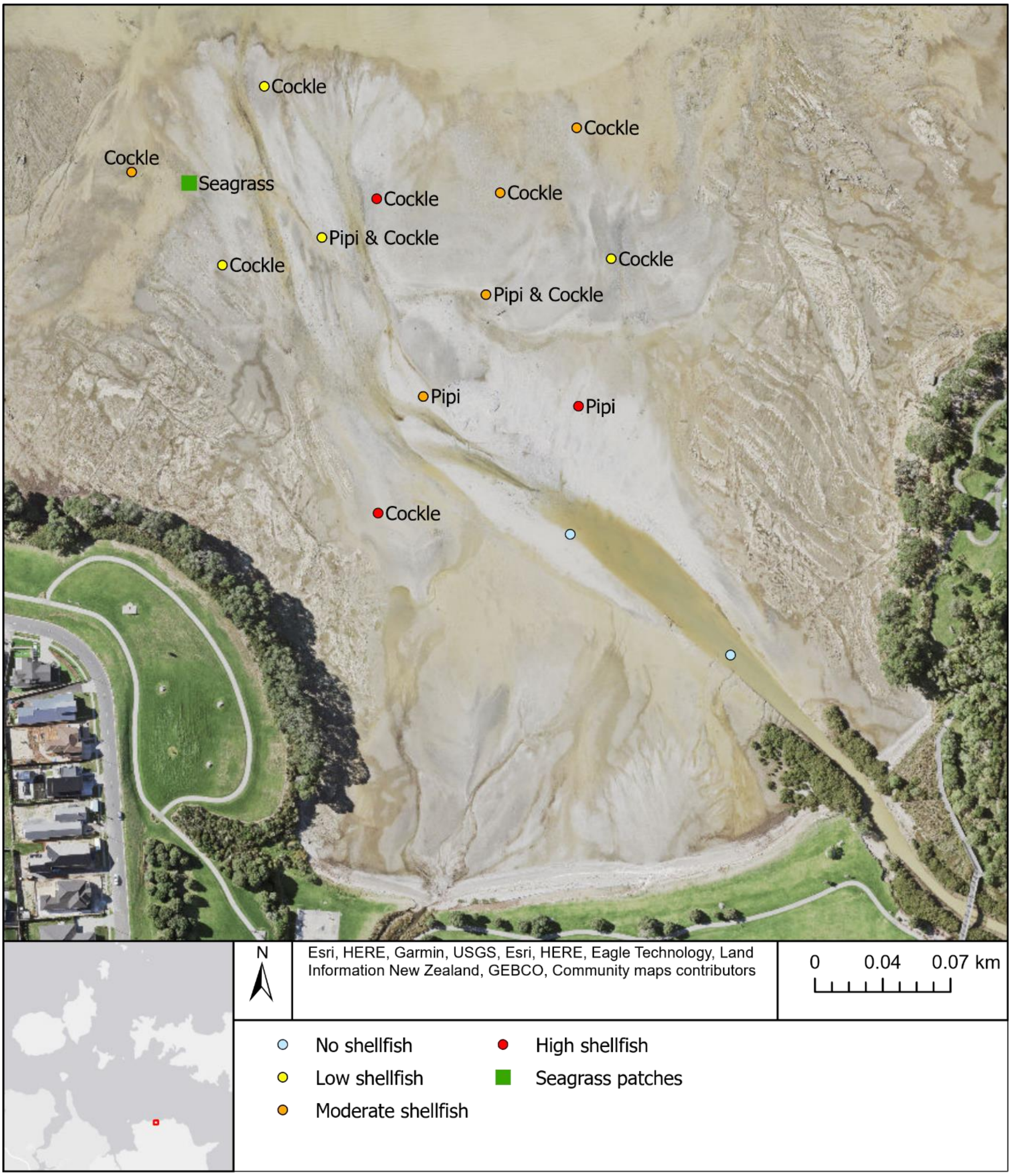

Figure 38. Abundance of shellfish at the inspection stations around Kelly's Beach. No seagrass was found within any of the inspection stations, but small patches of moderately dense seagrass were observed at the location shown.

Figure 39. Examples of the substrate and shellfish found at inspection stations: A. Soft mud with burrows. B. Sandy mud with shells. C. Sand interspersed with dense shell and rock. D. Sand. E. Juvenile cockles found at one inspection station. F. Juvenile pipis found at one inspection station.

Figure 40. The sandstone reef on the eastern side of Kelly's Beach: A. Rocks covered with Pacific oysters and Neptune's necklace. B. A dense patch of Neptune's necklace. C. *Codium fragile* subsp. *novae-zelandiae*. D. *Scytothamnus australis*. E. Mud whelks, Pacific oysters, and modest barnacles. F. A clump of small blue mussels.

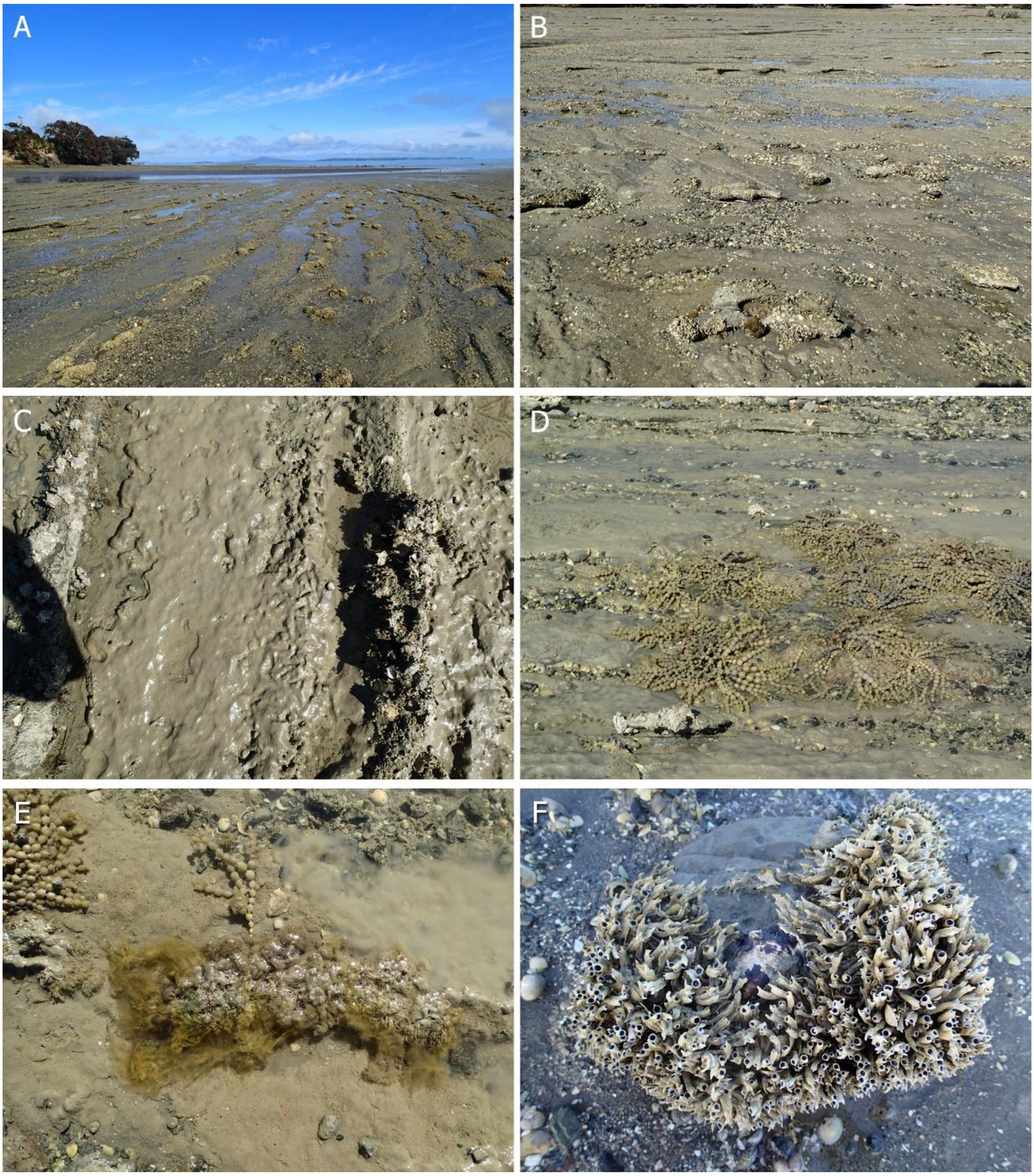

Figure 41. The sandstone reef on the western side of Kelly's Beach: A–B. Low-lying sandstone reefs. C. A layer of mud covering the sandstone. D. Clumps of Neptune's necklace. E. Brown filamentous algae. F. The blue tube worm.

4.7.2 Beachlands & Maraetai

The area between west Beachlands and Motukaraka/Flat Island (**Figure 36** (SEA-M1-43b)) is designated as a SEA-Marine 1 due to the presence of large shellbanks that are used as high tide roosts by wading and coastal birds. The substrate is sandy, becoming coarser towards Motukaraka (Chiaroni et al., 2010). Seagrass beds have developed over this area over the last decade or so and the substrates around the seagrass beds are softer due to the accumulation of fine sediment

(Jackson et al., 2022). No seagrass was recorded in Whitford embayment, including around Motukaraka, by Chiaroni et al. (2010), however, large patches of seagrass are visible in Google Earth satellite imagery from around 2014 onwards, and extensive areas of seagrass are now present south of Motukaraka (**Figure 42**) and further west on the intertidal flats between Turanga and Waikopua Creeks. Jackson et al. (2022) found that the most common species present within the seagrass beds were crabs (*Austrohelice crassa, Hemigrapsus crenulatus, Macrophthalmus hirtipes*), shrimps, gastropods, including bubble shells (*Haminoea zelandiae*), wedge shells and cockles.

Most of Whitford embayment, including the area around Motukaraka is designated as a SEA-Marine 2 (**Figure 36,** (SEA-M2-43a)) due to the presence of large areas of intertidal mud, sand and shellflats that provide a habitat for a wide range of marine species. The intertidal flats also provide feeding and roosting areas for a variety of coastal and wading birds. Intertidal macrofauna samples taken between Pine Harbour and the entrance to Waikopua Creek found that the macrofaunal community was typical of sheltered northern estuaries, mainly comprising polychaetes, bivalves and amphipods. Species richness (6–23 taxa/core) and abundance (24–340/core) were moderate (Jackson et al., 2022).

Sunkist Bay, west of Te Maraetai/Kellys Beach, grades from sand at the high tide mark to shell and bedrock on the lower intertidal area. Chiaroni et al. (2010) found shellfish (cockles, pipis and wedge shells (*Macomona liliana*)) abundances in this bay were low. Omana Beach, east of Te Maraetai/Kellys Beach, is a sandy/shelly beach. Chiaroni et al. (2010) did not find any visible biological features or adult shellfish beds in this bay.

Maraetai Beach is a popular recreational beach that is designated as a SEA-Marine 2 and Marine 2w (**Figure 36,** (SEA-M2-169)) due to the long sandy beach that provides extensive feeding areas for wading and coasting birds. Further east around the coast is Umupuia Beach where cockles have been monitored by the Ministry for Primary Industries for over twenty years. Harvesting of cockles from Umupuia has been prohibited since 2008, and subsequently, the number of harvestable-sized cockles has increased from around 5.0 million to around 23.4 million (**Figure 43**; (Berkenbusch et al., 2023)).

Occasional blooms of the nuisance cyanobacteria *Okeania* spp. (previously called *Lyngbya majuscula*) have been reported from the Beachlands-Maraetai coastline. In the late 1970s *Okeania* spp. were reported as seasonally dominant species around Motukaraka, and throughout the 2000's there were regular occurrences of the *Okeania* spp. blooms around the Beachlands and Omana area. No *Okeania* spp. blooms were observed in Te Maraetai/Kellys Beach during the intertidal survey. Little is known about the drivers and impacts of cyanobacterial blooms (Auckland Council, 2024).

Figure 42. Seagrass beds covering the intertidal area south of Motukaraka/Flat Island (photo: J. McMeeking, Feb 2024).

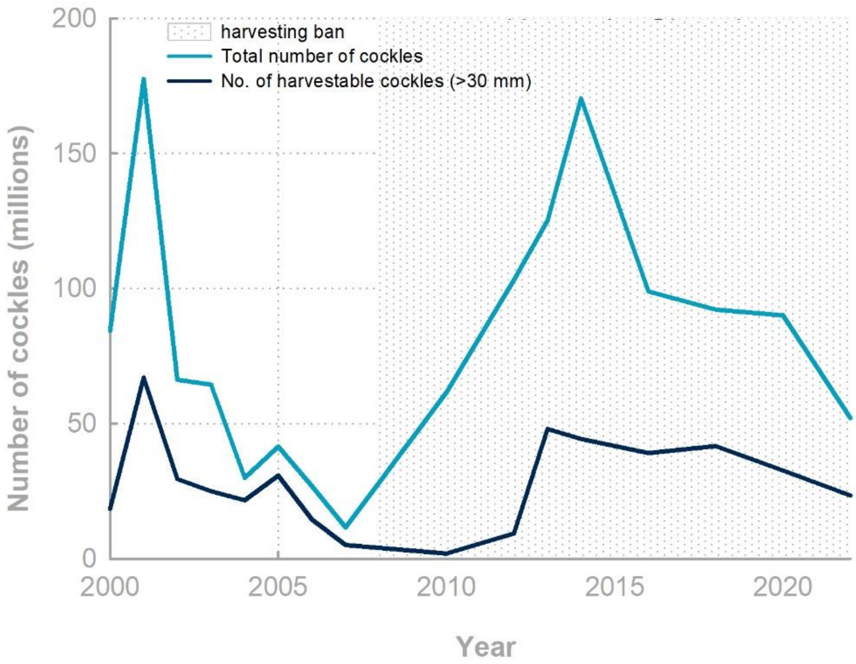

Figure 43. Estimated number of cockles present in the survey area of Umupuia Beach between 2000 and 2022. Data from Berkenbusch et al. (2023).

4.7.3 Tamaki Strait

Tidal currents directly offshore of the Beachlands-Maraetai coastline are moderate (<0.25 cm/s) and substrates are predominantly muddy sand, though large patches of shell hash occur in places (Chiaroni et al., 2010). An underwater video survey was conducted approximately 3 km offshore of Te Maraetai/Kellys Beach on 6th November 2023. The survey found that that habitat throughout the region was sandy-mud to muddy-sand interspersed with patches of dense shell (**Figure 44**). The Mediterranean fan worm (*Sabella spallanzanii*), an unwanted organism, was the only common epifaunal species observed. Other species that were occasionally observed included sponges, hydroids, bryozoans, horse mussels (*Atrina zelandica*), 11-armed starfish (*Coscinasterias muricata*) and sea cucumbers (*Australostichopus mollis*) (**Figure 45**). No rocky reefs, living biogenic habitats, or regionally significant benthic species were observed in the survey (Kelly and Alder, 2023).

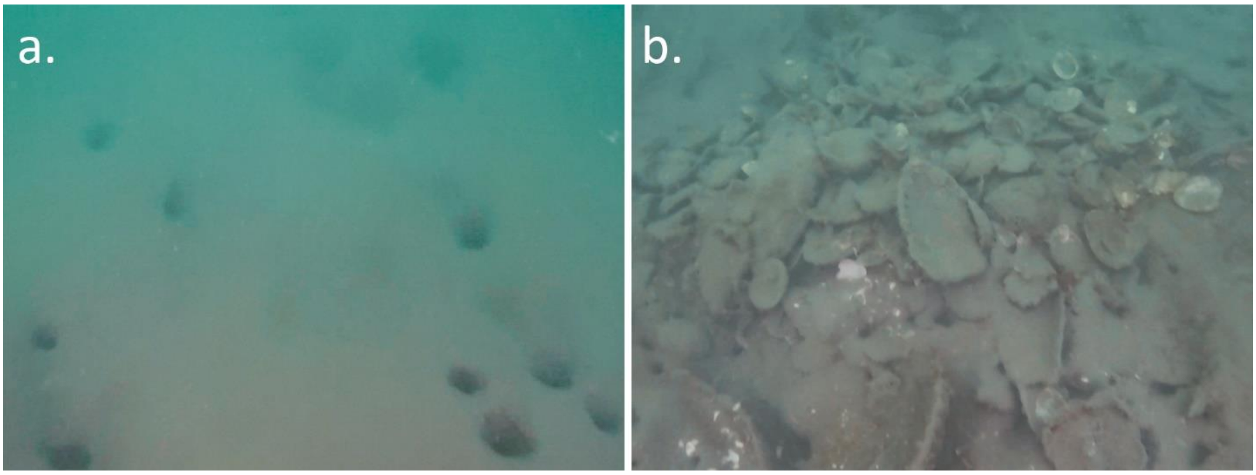

Figure 44. Habitat characteristics in the survey area: a) uniform sandy-mud/muddy-sand with burrows, and b) dense shell (including mussel shell) covered by a thin sediment layer.

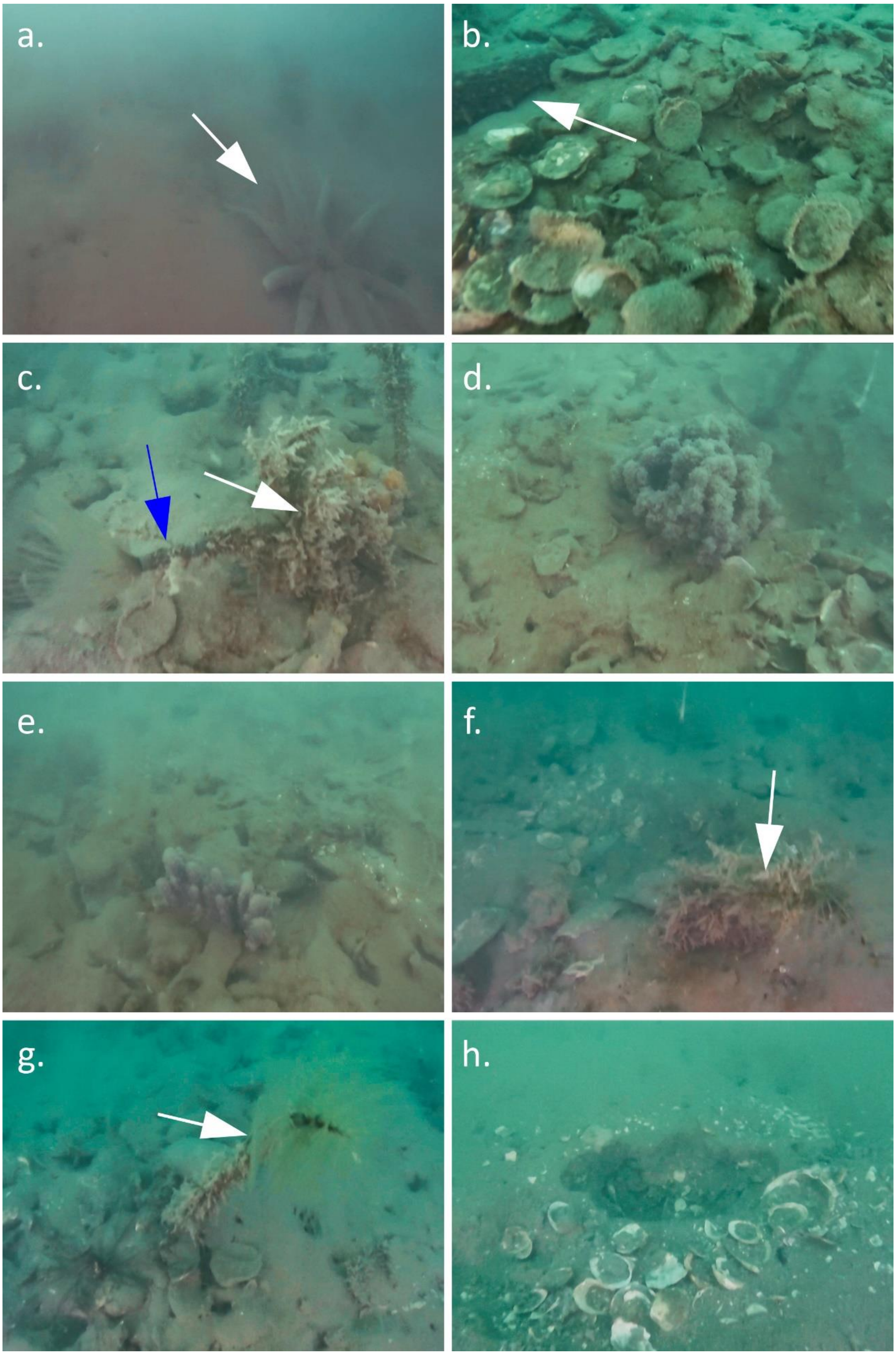

Figure 45. Examples of biota observed along video transects, including a) 11-armed starfish, b) sea cucumber, c) what appears to be a heavily fouled horse mussel (white arrow) with Mediterranean fan worm (blue arrow), d) and e) unidentified sponges, f) what appears to be a heavily fouled horse mussel with hydroids and Mediterranean fan worm, g) Mediterranean fan worm on shell, h) ray feeding pit? Note that images have been enhanced for colour and clarity.

4.8 Summary of the current environment

For the existing freshwater environment (upstream sites regarded as the "existing environment" i.e. without the WWTP):

- The catchment is low relief, rural pasture with areas of exotic forestry and regenerating native bush in stream gullies.
- There is a clear demarcation of freshwater and saline environments below the Quarry site.
- The flows in the Te Puru Stream network appear to be highly dependent on rainfall.
- PDP derived theoretical stream flows from water level sensor and stream gauging to inform to inform the potential for erosion during a 3-fold increase in wastewater flows.
- Water is generally well oxygenated, with DO similar upstream and downstream of the WWTP discharge.
- $cBOD_5$ is at low concentrations and similar upstream and downstream of the WWTP discharge.
- Water temperature is slightly elevated at sites downstream relative to sites upstream of the WWTP discharge.
- Low pH appears to be more an issue than high pH in the receiving environment and appears to be driven by the upstream farm pond site, not the WWTP discharge.
- Conductivity at all sites is above ANZG DGV but there is a clear influence of the WWTP discharge on conductivity in sites downstream.
- There is evidence of minor salinity ingress into the WWTP (influent maximum 2.4 ppt and discharge maximum 1.4 ppt) and environment sites upstream (maximum salinity 1.4 ppt) of Te Puru Park which has a known saline influence (maximum salinity 32.4 ppt). There is a clear linear relationship between salinity and conductivity so elevated conductivity observed is likely to be due to saline water intrusion into Beachlands WWTP.
- TSS and turbidity are low and at similar concentrations in receiving environment sites upstream of the Quarry site and unrelated to the WWTP discharge.
- Nitrogen concentrations are elevated at sites downstream of the WWTP relative to concentrations observed upstream. Ammoniacal-N and nitrate-N concentrations at the potential mixing zone – Bridge site (15) – place them in NPS-FM attribute band B for toxicity. Dissolved inorganic nitrogen (DIN) at the same site is at a level considered to be degraded and likely to contribute to eutrophication.
- Phosphorus shows a similar pattern to nitrogen with concentrations downstream markedly higher than concentrations upstream of the WWTP discharge.
- Chlorophyll *a* is not measured in the influent or discharge. Concentrations are slightly elevated at the farm pond and the next downstream site, but back to upstream levels by the Bridge site.
- Bacteria – *E. coli*, FC, and enterococci – concentrations are higher upstream of the WWTP, suggesting catchment sources dominate.
- All metal concentrations measured were below the applicable ANZG 95% DGV.
- Pharmaceutical and personal care products (PPCPs) measured show an average attenuation of 2.9-fold from the WWTP outlet to the Bridge site (15).

- Sediment phosphorus appears to be higher at the Bridge site than the farm pond. However, other studies show that sediment P appears to be relatively static over decadal timeframes.
- Temporal trend analysis was undertaken on water quality data collected from the upstream farm pond (A) and farm pond (B) sites from February 2020 to March 2023. Only nitrate in the farm pond showed a meaningful (>1% annual change) and significant ($p<0.05$) trend.
- Stream ecology surveys were undertaken in 2016, 2019, 2022, and 2024. Sites were grouped into 'reference' sites (above the WWTP discharge) and 'effect' sites (below the WWTP discharge) For the most recent survey:
    - Macrophyte diversity and the percentage of macrophyte and algae cover generally increased downstream of the discharge.
    - Higher numbers of macroinvertebrate species were noted at the reference sites. Species numbers in the effects sites increased with distance from the WWTP discharge. Bioresearches noted that the poor macroinvertebrate scores downstream of the discharge are likely due to a combination of stressors, including the decreased riparian vegetation and hard substrate at downstream sites.
    - The percentage of sensitive species (%EPT) ranged from 22-30% at the reference sites, with either no EPT taxa recorded or virtually 0% EPT at effect sites.
    - The Macroinvertebrate Community Index (MCI) indices placed reference sites on the border between 'good' and 'fair' (and above the AUP minimum of 94 for rural areas) with effect sites in 'fair' and 'poor' categories (and below the AUP minimum of 94 for rural areas).
    - The Semi-Quantitative Macroinvertebrate Community Index (SQMCI) showed similar results to MCI with reference sites in the 'fair' or 'excellent' category (and above the NPS-FM NBL of 4.5) and effect sites in the 'poor' or 'fair' category (with only site F below the NPS-FM NBL of 4.5).
    - Native fish species abundance and diversity were higher at reference sites than effect sites.
    - A Fish Index of Biotic Integrity (IBI) allows comparison with other Auckland streams and rated reference sites in 'poor' or 'fair' categories and effect sites in 'very poor' or 'poor' categories.
    - For trends from 2016-2024:
        - For most sites the number of macrophyte and algae taxa appear to be stable or increasing since 2016, with generally more taxa recorded at downstream sites. A similar trend is noted for percentage macrophyte/algae cover.
        - For macroinvertebrates the number of taxa appear to be stable or declining at the reference sites and generally lower but stable or increasing at the effect sites.
        - %EPT has remained very low and between 0% and 3% for effect sites.
        - MCI scores for reference sites have been relatively consistent and mostly above the AUP minimum for rural areas of 94.
        - In contrast to the reference sites, all but one MCI value has been below the AUP minimum for rural areas of 94. Sites F and G have shown signs of improvement since 2016, with site G a general decline.
        - As for MCI there is a general increasing trend in the SQMCI scores for the effect sites.

        - Numbers of native fish species were generally low (1-5) for reference sites and 0-4 for effect sites with no apparent temporal trends were observed.
        - The number of native fish at reference site H was declining from 2016 (38) to 2022 (14) but returned to near 2016 numbers in 2024 (36). Reference sites E and A showed a general increase in the number of native fish. Site F had consistently very low numbers of native fish with the other effect sites variable.
        - Fish IBI appears to be reducing as reference site H, but stable or increasing at reference sites E and A. For effect sites, site F has either no fish or a very low Fish IBI, while sites S2 and G appear to be generally improving.
    - The improvement in MCI and SQMCI scores at site F (closest to the WWTP discharge) is promising, however improved water quality in the future WWTP discharge (primarily lower concentrations of toxic nitrate and ammonia, and conductivity) is required to contribute to further improve the macroinvertebrate communities downstream.
    - Macroinvertebrate and native fish communities did not appear to fully recover at the most downstream sites and lacked more sensitive taxa. The overall magnitude of effect of all activities on the tributary and stream environment can be classified as moderate.

For the existing marine coastal environment:

- The lower, estuarine reaches of Te Puru Stream are strongly influenced by seawater inflow during high tide, with salinities of 20–35 ppt at high tide but decreasing to 5–15 ppt during low tide.
- The entrance to Te Puru Stream is designated as a Significant Ecological Area–Marine 1 due to the variety of saline vegetation and coastal vegetation present and the intact ecological sequence from estuarine to freshwater wetlands.
- Te Maraetai/Kellys Beach and the surrounding coastal area is designated as a Significant Ecological Area–Marine 2 due to the variety of intertidal habitats present that provide a habitat for a wide variety of marine organisms. An intertidal survey of Te Maraetai/Kellys Beach found that:
    - The upper shore is very muddy with abundant crustacean burrows. Mangroves line the stream bank around the entrance to Te Puru Stream.
    - The mid to lower shore is sandy with scattered shell/rock. Low lying shell banks are present in some areas.
    - Juvenile cockles and pipi were present in low to high densities across the mid to lower sandflats, but no shellfish were found that were near harvestable size.
    - Three small patches (each 2 m × 1 m) of moderately dense seagrass were observed near the low tide mark.
    - Intertidal sandstone reef platforms are present on either side of the bay that provide a habitat for a range of common intertidal species.
    - In summary, the intertidal marine community at Kelly’s Beach is typical of sheltered beaches around the Auckland region. The only threatened marine species (excluding birds) observed during the survey was seagrass, which was present in three small patches on the lower shore. The area of seagrass cover is much too small to meet the criteria of biogenic habitat.

- The area between west Beachlands and Motukaraka/Flat is designated as a Significant Ecological Area-Marine 1 due to the presence of large shellbanks that are used as high tide roosts by wading and coastal birds. Extensive seagrass beds have developed over this area over the last decade.
- Most of Whitford embayment, including the area around Motukaraka is designated as a Significant Ecological Area-Marine 2 due to the presence of large areas of intertidal flats that provide a habitat for a wide range of marine species. The intertidal flats also provide feeding and roosting areas for a variety of coastal and wading birds. The intertidal macrofaunal community is typical of sheltered northern estuaries.
- Sunkist Bay, west of Te Maraetai/Kellys Beach, grades from sand at the high tide mark to shell and bedrock on the lower intertidal area. Shellfish (cockles, pipis and wedge shells) abundances in this bay were low.
- Omana Beach, east of Te Maraetai/Kellys Beach, is a sandy/shelly beach with no shellfish beds.
- Maraetai Beach is a popular recreational beach that is designated as a Significant Ecological Area-Marine 2 due to the long sandy beach that provides extensive feeding areas for wading and coasting birds.
- Subtidal areas approximately 3 km offshore of Te Maraetai/Kellys Beach were surveyed by underwater video. Substrates comprised sandy-mud to muddy-sand, interspersed with patches of dense shell. The Mediterranean fan worm, an unwanted organism, was the only common epifaunal species observed. Other species that were occasionally observed included sponges, hydroids, bryozoans, horse mussels, 11-armed starfish, and sea cucumbers. No rocky reefs, living biogenic habitats, or regionally significant benthic species were observed in the survey.

5. Assessment of environmental effects

5.1 Introduction

The matters associated with the proposed discharge of treated wastewater reaching the receiving environments that require assessment include:

- Deteriorating water quality and general health through increases in nutrients, metal and organic toxicants, and microbial contaminants.
- Effects of the proposed discharge on stream ecology and the marine receiving environment.
- Potential for nuisance plant growths, including macroalgae and phytoplankton.
- Changes to benthic fauna and indirectly the food web leading to fish and birds.
- Increased risk of microbial contaminations for shellfish gathering (including aquaculture) and for recreation.

We now address the actual and potential effects of the proposed discharge on the receiving environment by comparing water quality and ecological values from sites upstream of the influence of the WWTP discharge with sites downstream of the influence of the WWTP. The environment at the reference sites upstream is considered the “existing state” i.e. without the WWTP contaminants noting that the habitat can change downstream. We then assess the actual and potential effects of the proposed discharge from the expanded and upgraded WWTP and whether they will improve the health of the receiving environment downstream.

For the avoidance of doubt, for the purposes of this assessment we have excluded the current discharge from the WWTP from the existing “environment” for the purposes of section 104(1)(a) of the Resource Management Act 1991 (**RMA**).

Whether the effects of the proposed discharge are the same, better or worse than those of the current discharge has also been noted in our assessment. For the purposes of section 104(1)(b) of the RMA, the NPS-FM and AUP require that effects from the discharge are managed to either maintain, or maintain and enhance, the existing environment (see later in this section); and in the context of that assessment a comparison between the effects of the proposed discharge and those of the existing discharge can be made.

We identify separate freshwater and marine sections in the receiving environment to assess the actual and potential effects of the proposed discharge from the expanded and upgraded WWTP.

For an observed effect, we have determined if discharged wastewater will satisfy the objective of negligible, very low or low level of effects in the receiving environment, broadly following the framework described in the Ecological Impact Assessment (EcIA) EIANZ guidelines (**Table 11**) (Roper-Lindsay et al., 2018).

Table 11. Criteria for describing magnitude of effect (from Roper-Lindsay et al. 2018)

Magnitude	Description
Negligible	Very slight change from the existing baseline condition. Change barely distinguishable, approximating to the 'no change' situation; AND/OR Having negligible effect on the known population or range of the element/feature.
Low	Minor shift away from existing baseline conditions. Change arising from the loss/alteration will be discernible, but underlying character, composition and/or attributes of the existing baseline condition will be similar to pre-development circumstances or patterns; AND/OR Having a minor effect on the known population or range of the element/feature.
Moderate	Loss or alteration to one or more key elements/features of the existing baseline conditions, such that the post-development character, composition and/or attributes will be partially changed; AND/OR Loss of a moderate proportion of the known population or range of the element/feature.
High	Major loss or major alteration to key elements/features of the existing baseline conditions such that the post-development character, composition and/or attributes will be fundamentally changed; AND/OR Loss of a high proportion of the known population or range of the element/feature.
Very high	Total loss of, or very major alteration to, key elements/features/ of the existing baseline conditions, such that the post-development character, composition and/or attributes will be fundamentally changed and may be lost from the site altogether; AND/OR Loss of a very high proportion of the known population or range of the element/feature.

The objectives and policies provided within the AUP are clear around water quality and integrated management, specifically that it needs to be either maintained at current levels or enhanced (if above NBLs) or improved (if below NBLs). Applicable parts of the AUP are summarised below.

E1.2. Objectives [rp/rcp]

1. Freshwater and sediment quality is maintained where it is excellent or good and progressively improved over time in degraded areas.
2. The mauri of freshwater is maintained or progressively improved over time to enable traditional and cultural use of this resource by Mana Whenua.
3. Stormwater and wastewater networks are managed to protect public health and safety and to prevent or minimise adverse effects of contaminants on freshwater and coastal water quality.

E1.3. Policies [rp/rcp/dp]

Freshwater quality and ecosystem health interim guidelines

1. Manage discharges, until such time as objectives and limits are established in accordance with Policy E1.3(7), having regard to:
    a. the National Policy Statement for Freshwater Management National Bottom Lines;
    b. the Macroinvertebrate Community Index as a guideline for freshwater ecosystem health associated with different land uses within catchments in accordance with Policy E1.3(2); or
    c. other indicators of water quality and ecosystem health.
2. Manage discharges, subdivision, use, and development that affect freshwater systems to:
    a. <u>maintain or enhance</u> water quality, flows, stream channels and their margins and other freshwater values, where the current condition is <u>above</u> National Policy

Statement for Freshwater Management National Bottom Lines and the relevant Macroinvertebrate Community Index guideline **Table 12**); or

b. enhance water quality, flows, stream channels and their margins and other freshwater values where the current condition is below national bottom lines or the relevant Macroinvertebrate Community Index guideline (**Table 12**).

3. Require freshwater systems (3) to be enhanced unless existing intensive land use and development has irreversibly modified them such that it practicably precludes enhancement.

Table 12. Macroinvertebrate Community Index guideline for Auckland rivers and streams (AUP Table E1.3.1).

Land use	Macroinvertebrate Community Index guideline
Native forest	123
Exotic forest	111
Rural areas	94
Urban areas	68

By synthesising the intention of the above policies a summary of whether upstream sites – upstream farm pond (A) and tributary upstream (E) (reference or "existing" environment sites without the WWTP influence) – are degraded is provided in **Table 13**. All nutrient concentrations at these sites are at concentrations below the NPS-FM NBL or expert conference accepted threshold for degradation. *E. coli* concentrations are contributing to a degraded environment at these sites with concentrations that exceed the NPS-FM NBL. MCI indices at the tributary upstream site (93) and upstream farm pond (108) are below and above the AUP value of 94, respectively. Fish IBI indices are well above those specified by Joy and Death (2004).

Table 13. Summary of degraded nature of two upstream sites against relevant guidelines specified in AUP. Thresholds exceeded are bolded red. Note the upstream sites provide an indication of the "existing environment" without the WWTP.

Attribute	Statistic	Numeric threshold	Source	Upstream Farm Pond (A)	Tributary upstream (E)	Degraded?
DIN	Median	1.0	SRC 2019	0.05	0.14	No
DRP	Median	0.018	NPS-FM NBL	0.014	0.014	No
DRP	95th %ile	0.054	NPS-FM NBL	0.026	0.026	No
NH_4-N	Median	0.24	NPS-FM NBL	0.027	0.020	No
NH_4-N	95th %ile	0.4	NPS-FM NBL	0.047	0.032	No
NO_3-N	Median	2.4	NPS-FM NBL	0.02	0.11	No
NO_3-N	95th %ile	3.5	NPS-FM NBL	0.13	0.15	No
E. coli	Median	130	NPS-FM NBL	**1,250**	**930**	Yes
E. coli	95th %ile	1,200	NPS-FM NBL	**4,815**	**3,780**	Yes
Macroinvertebrates (MCI)	Median (last 4 surveys)	94	AUP	108	**93**	Yes (E only)
Fish (IBI)	Average (last 3 surveys)	23	Joy and Death (2004)	33	30	No

5.2 Hydrology

Increased flow rates under the proposed discharge may lead to physical effects, such as erosion of stream channels, or resuspension and transport of sediment from stream beds further downstream. Higher discharge volumes may lead to improvements during dry conditions but ultimately lead to greater dilution of saltwater in marine environments, leading to potential adverse effects on marine species.

Bioresearches undertook a site assessment to identify the potential effects of the proposed discharge of up to 6,000 m^3/day (Bioresearches, 2024b). Sites assessed where those monitored in the stream assessment (Section 4.6), namely six 'effect' sites (F, 15, S2, G, S3 and C) and one control site (E). During the site assessment, stream characteristics were recorded, including water quality, width, depth, flow velocity, instream macrophytes and periphyton. General notes regarding substrates, deposited sediments, stream bank condition riparian yard condition and were taken.

Both the control site (E) and effect sites have similar width (average 2.16m for both, but effect sides ranging from 1.82-2.69m) and depth (0.23m for E and 0.25m (range 0.12-0.51m) for effect sites). Stream substrates are also similar with silt and cobble at site E and silt, cobble, and gravel at effect sites, with the silt reducing with distance from the discharge. Riparian vegetation was poor at site E and variable at effect sites. Importantly, it was noted that the lower reaches contained no significant riparian yard and evidence of bank erosion.

Using bully as a reference fish as they have the lowest tolerance to increases velocities (so worst-case), Bioresearches concluded that the increase in depths and stream velocities from the proposed discharge is unlikely to result in flow velocities throughout the tributary being permanently affected and result in a reduction of native fish habitat.

They concluded that the most significant effect of the proposed discharge volume on the Te Puru Tributary is the potential for increases in erosion and scour, particularly during flood and storm events and recommended to minimise erosion and scour that infill riparian planting with deep rooting vegetation is undertaken throughout the Te Puru Stream Tributary, particularly where erosion and scour is evident. This would also benefit invertebrate and fish habitats downstream through shading and reducing runoff effects.

As part of a stream hydraulic assessment, PDP (2024b) assessed current stream bank and bed erosion through site visits on 6th September 2023, 27th October 2023, and 18th January 2024. They noted that there is evidence of current stream bank erosion between the farm pond and bridge site, and near the confluence with Te Puru Stream, but minimal erosion at the Quarry site. Erosion was likely caused by storm events. They modelled estimated velocities for the current and added future increase in discharge volume and found that during high flow events (90th percentile flows) there was minimal increase in flows from the future discharge (0.3 m/s) and no effect at higher flows. They concluded that any increase in erosive potential due to the proposed discharge is expected to be minor resulting in a low effect on stream bank erosion. This suggests that riparian planting suggested by Bioresearches may not be required to mitigate erosion through increased flows.

In terms of the marine environment, the estimated dry weather stream discharge will increase from ~2200 m^3/day to ~6000 m^3/day (DHI, 2024), which corresponds to a 23 L/s and 69 L/s, respectively. Most intertidal species, particularly those living near estuary mouths, are highly tolerant of low salinity, and river flows onto nearby intertidal areas can be much higher than the predicted flows from Te Puru Stream. By comparison, the 5-year, 7-day mean annual low flow rates for the nearby Wairoa River is 415 L/s, respectively (Johnson, 2021). Therefore, the increase flow rate from the proposed discharge is considered to be negligible.

5.3 Potential effects on Te Puru Stream water quality

5.3.1 Physical stressors

DO and $cBOD_5$

DO is critical to supporting healthy aquatic ecosystems and the NPS-FM specifies a summer daily minimum NBL of >4 mg/L for rivers below point sources.

High BOD can result in low DO concentrations as oxygen is consumed during organic matter decomposition, which in turn can impact on aquatic biota, as well as result in the proliferation of bacterial and fungal growths. The general MfE guideline to protect against nuisance bacterial or fungal growths is <2 mg/L (soluble) however where the discharge is predominantly treated sewage then the BOD limit of 5 mg/L is adequate (Ministry for the Environment, 1992).

Based on the recent extensive water quality monitoring, the existing Beachlands WWTP discharge has at times a low minimum DO (noting that measurements are spot measurements and not diurnal). However, based on monitoring at receiving environment sites this does not appear to be impacting on DO in the pond or further downstream, and this is not expected to change for any future stages of the updated WWTP. Accordingly, there are no DO standards included as part of the proposed discharge from the new MBR WWTP.

Between 2018 and 2023 the median $cBOD_5$ in the Beachlands WWTP discharge has been <2 mg/L (**Table 2**) and declining at 1.6% per annum (**Table 3**). The recent elevated $cBOD_5$ in the Beachlands WWTP discharge in 2023/24 (median 5.7 mg/L) does not appear to be impacting on $cBOD_5$ (nor DO) in the pond or further downstream. All receiving environment sites are well below the MfE guideline of <2 mg/L. The proposed median operational limit for the Current Short-Term Stage discharge is 7 mg/L, which is marginally higher than the WWTP discharge in 2023/24 (median 5.7 mg/L). This potential increase (noting the operational limit is a maximum concentration) is not expected to impact significantly on $cBOD_5$ or DO in the pond or further downstream during the Short-Term Stage. The proposed median operational limit for the new MBR WWTP (Long-Term Stage 1 and Long-Term Stage 2) are an approximate 1.4-fold and 1.14-fold decrease in $cBOD_5$ from the Short-Term Stage and 2023/24 levels, respectively. Therefore, $cBOD_5$ in the proposed discharge for the new MBR WWTP (both stages) is expected to continue to have a negligible effect on the environment. The reduction in $cBOD_5$ in the future MBR stages will contribute to improved water quality downstream of the discharge compared to the present discharge.

Water temperature

Water temperature is not measured routinely as part of the existing Beachlands WWTP discharge. Recent extensive monitoring of the discharge and receiving environment sites show that

Beachlands WWTP appears to be impacting on temperature in the pond and downstream as far as the Bridge site. The 5-year data provided by Watercare for the upstream of the farm pond (A) and farm pond (B) sites showed maximum water temperature over the summer months of between 20.6-22.7°C upstream of the farm pond (A) and between 21.0-23.1°C at the farm pond (B).

For both sites water temperatures are high in summer and well above the AC guideline of 17.7°C. The 2013 National Objective Framework provides attribute states for temperatures to protect ecosystem health with <18°C being attribute state A (where no thermal stress occurs), and attribute state B <20°C (minor stress). River water temperatures greater than 24°C have been shown to be stressful to a range of invertebrate taxa and fish species and temperatures around 24–27°C potentially result in some sensitive invertebrates, particularly some insects, being severely stressed and some fish eliminated, if such temperatures persist. Occasionally the pond outlet (Site B) and Farm Pond downstream (Site F) are above 24°C but only for very short periods. The sites further downstream do not reach this critical temperature.

These data show that during times of heat stress there is very little difference between water temperatures in the upstream and downstream sites suggesting the existing Beachlands WWTP is showing minimal impacts on water temperature in the farm pond. There are no water temperature standards proposed for the new MBR WWTP, but temperature at all 4 discharge stages of the WWTP is not expected to change from existing, resulting in low changes in temperature at downstream sites compared with upstream sites.

pH

Low pH appears to be more an issue than high pH in the receiving environment, with most sites showing a 20th percentile pH below the ANZG DGV of 7.26. The existing Beachlands WWTP discharge appears to be contributing negligible impacts on pH at the farm pond and sites further downstream. There are no pH standards proposed for the new MBR WWTP, but pH at all 4 discharge stages of the WWTP is not expected to change from existing, resulting in negligible changes in pH at downstream sites.

Conductivity and salinity

Conductivity increases with water temperature. This is clear from the recent extensive water quality monitoring data, which shows a general increase in conductivity and water temperature across all sites from September to January. A potential effect of high conductivity is reduced DO, but as shown above, effects on DO are not apparent downstream of the existing Beachlands WWTP discharge.

All receiving environment sites monitored between September 2023 and January 2024 had 80th percentile concentrations above the ANZG 80th percentile DGV (155 µS/cm). However, sites upstream of the discharge only marginally exceed this DGV and there is a clear influence of the existing Beachlands WWTP discharge on conductivity downstream. By the confluence (the Bridge site) the 80th percentile conductivity value (965 mg/L) exceeds the ANZG 80%ile DGV of 115 mg/L by 8.4-fold.

The DGV indicates that there is a 'potential risk' of adverse effects at a site, when the value is exceeded (McDowell et al., 2013). In terms of effects on aquatic life, the Stream Health Monitoring and Assessment Kit (SHMAK) report (NIWA, 2019) states that "the dissolved salts measured by conductivity usually do not have a direct effect on stream life until they reach levels found in brackish water or seawater (greater than about 5,000 µS/cm).” Conductivity at all receiving environment sites receiving the wastewater discharge are well below 5,000 µS/cm, suggesting that any effects would be indirect.

There was evidence of minor salinity ingress into the WWTP (influent maximum 2.4 ppt (7% salinity) and discharge maximum 1.4 ppt (4% salinity), and environment sites upstream (maximum salinity 1.4 ppt) of Te Puru Park which has a known saline influence (maximum salinity 32.4 ppt). There is a clear linear relationship between salinity and conductivity[19]. Therefore, elevated conductivity observed is likely to be due to saline water intrusion into Beachlands WWTP.

There are no discharge standards for conductivity and salinity proposed for the new MBR WWTP. Water-tight connections associated with new connections (and population growth) will reduce saltwater intrusion into the new MBR WWTP, diluting the saline influence (and elevated conductivity) in the future. We also recommend a trigger for conductivity which would result in an assessment of the cause and if any mitigation is appropriate.

TSS and turbidity

TSS levels can have an impact on receiving environments and communities by directly affecting physiological processes of invertebrates and fish and availability of light for photosynthesizing plants (algae, periphyton, macrophytes). There are also impacts on aesthetics and recreation through changes in water clarity and colour. 80^{th} percentile TSS concentrations above 8.8 mg/L exceed the ANZG DGV.

The existing Beachlands WWTP discharge has consistently low TSS (median 7.8 mg/L and 80^{th} percentile 10.2 mg/L). There appears to be little difference in TSS for the receiving environment sites upstream and downstream of the wastewater influence, until a large increase at the Quarry and Te Puru Park sites, which is likely due the quarry activity and tidal influence, respectively. The Current and Short-Term Stages of the WWTP upgrade have a proposed operation median TSS concentration limit of <7mg/L, which is a decrease of 1.1-fold from the existing discharge concentration (7.8 mg/L).

The proposed operational median TSS concentration limit of <7mg/L from the new MBR WWTP discharge (Long-Term Stages 1 and 2) should see an approximate 1.4-fold decrease in TSS from the existing levels (**Table 6**). TSS from the discharge of all stages of the proposed upgrade of the WWTP will continue to result in a negligible effect on the environment. Overall, the reduction in TSS in the future (at all stages) will contribute to improved water quality downstream of the discharge, compared to at present.

5.3.2 Nutrient concentrations

A major concern with discharges from a WWTP and other industries is the potential for acute and chronic ammoniacal-N toxicity. Ammoniacal-N toxicity will depend on both pH and temperature

[19] The extensive water quality monitoring data shows a strong linear relationship between salinity and conductivity particularly when salinity is consistently above 0.5 ppt (R^2 = 0.95, 0.93, 0.95 for Beachlands WWTP inlet, outlet and Te Puru Park, respectively.

of the receiving waters. The NPS-FM sets a NBL for ammonia toxicity based on an annual median (0.24 mg/L) and annual 95th percentile (0.40 mg/L), based on a pH dependent correction factor applied to standardise the ammoniacal-N concentration to pH 8 (Ministry for the Environment, 2018). As stated in Section 4.4.1.2, the existing Beachlands WWTP discharge has very low ammoniacal-N concentrations (and ca. 0.5% of TN being discharged from the WWTP) and is unlikely to be significantly contributing to ammoniacal-N concentrations downstream.

Median and 95th percentile concentrations are proposed for ammoniacal-N as part of the application for discharge consent. The concentrations are not expected to increase significantly in the future and will be very low in the discharge, and not contributing significantly to elevated nitrogen downstream. Processes in the pond will continue to increase ammoniacal-N levels downstream (see **Table 8**) but would be expected to meet the NBL for ammoniacal-N toxicity and be unlikely to impact on species found downstream. We note that for these reasons we have not estimated ammoniacal-N concentrations downstream.

At high concentrations nitrate-N can be toxic to aquatic fauna and humans while considerably lower concentrations are also a concern as they can lead to increased risk of nuisance plant growth (algae, macrophytes). The NPS-FM sets a NBL for nitrate toxicity based on an annual median (2.4 mg/L) and annual 95th percentile (3.5 mg/L).

In some cases plant growth can be limited by both N and P. The ANZG DGV to avoid increased risk of eutrophication is 0.024 mg/L for TP. For DRP, the NPS-FM has attribute states for DRP in rivers to protect ecosystem health. There is no NBL for DRP in the NPS-FM but attribute state B (median >0.006 and ≤0.010 mg/L; 95th percentile >0.021 and ≤0.030 mg/L) corresponds to ecological communities being slightly impacted by minor DRP elevation above natural reference conditions, attribute state C (median >0.010 and ≤0.018 mg/L; 95th percentile >0.030 and ≤0.054 mg/L) corresponds to ecological communities being slightly impacted by moderate DRP elevation above natural reference conditions. Attribute states A and D bookmark lower and higher concentrations and correspond to similar natural reference conditions and substantial DRP elevation above natural reference conditions, respectively.

To assess the actual and potential effects of the key nutrients nitrate-N and DRP in the proposed discharge on Te Puru Stream, estimation of concentrations for median WWTP discharge data were calculated based on the assumption that the expanded overland flow system (and a pond/wetland area) would provide the same level of attenuation that is achieved with the current system. The expanded overland flow system has not yet been designed and the plan will be developed with input from iwi. However, PDP (2024c) noted that the overland flow system could be designed to mimic the existing system.

5.3.2.1 Median data

The current measured median water quality concentrations and NPS-FM attribute bands for nitrate-N, ammoniacal-N, and DRP for receiving environment sites are summarised in **Table 14**. For nitrate-N, based on median concentrations, the Bridge site (potential mixing zone) is in attribute state B, whereas the Quarry site and both upstream sites are in attribute state A. For ammoniacal-N the Bridge site (potential mixing zone) and the Quarry sites are in attribute state A band the same state as both upstream sites. For DRP, All sites influenced by the existing WWTP discharge are in attribute state D with upstream sites in attribute state C.

Attenuation of nitrate-N and DRP from the WWTP discharge to the quarry site based on median concentrations is summarised in **Table 15**. Based on current median data, nitrate-N and DRP concentrations would be 32% (3.2-fold reduction), and 25% (4.0-fold reduction) of the WWTP discharge concentration at the Bridge site (potential mixing zone), respectively.

Table 14. Summary of current measured water quality median concentrations and NPS-FM attribute bands for nitrate-N, ammoniacal-N, and DRP at receiving environment sites with median WWTP outlet concentrations. The Bridge site (potential mixing zone) is highlighted grey.

Parameter (mg/L)	WWTP Outlet (Median)	Farm Pond (B)	Farm Pond downstream (F)	Bridge (15)	Quarry	Upstream Farm Pond (A)	Tributary upstream (E)
Nitrate-N (Attribute Band)	5.1	2.8	3.2	1.6	0.6	0.02	0.11
	NA	(C)	(C)	(B)	(A)	(A)	(A)
Ammoniacal-N	0.04	0.29	0.21	0.07	0.04	0.03	0.02
Ammoniacal-N @pH8 (Attribute Band)	0.02	0.14	0.13	0.03	0.02	0.01	0.01
	NA	(B)	(B)	(A)	(A)	(A)	(A)
DRP (Attribute Band)	0.726	0.374	0.370	0.182	0.034	0.014	0.014
	NA	(D)	(D)	(D)	(D)	(C)	(C)

Table 15. Percentage of median nitrate-N and DRP WWTP outlet concentrations at receiving environment sites based on current median water quality data. The Bridge site (potential mixing zone) is highlighted grey.

Parameter (mg/L)	WWTP Outlet	Farm Pond (B)	Farm Pond downstream (F)	Bridge (15)	Quarry
Nitrate-N	100	55%	63%	32%	12%
DRP	100	52%	51%	25%	5%

Based on attenuation calculated in **Table 15**, potential water quality concentrations were calculated at receiving environment sites (**Table 16**).

With the marked reduction in median nitrate-N operational limit from the Current and Short-Term stages to the Long-Term Stages 1 and 2 of the proposed WWTP upgrade (see **Table 6**), the median concentration at the Bridge site (potential mixing zone) would be 1.1 mg/L (NPS-FM attribute band B), and 0.6 mg/L (NPS-FM attribute band A), respectively. Quarry sites would be 0.4 mg/L, and 0.2 mg/L, for Current and Short-Term and Long-Term Stages 1 and 2 respectively, placing them both in NPS-FM attribute band A (**Table 16**).

For the Current and Short-Term Stages operational limits for DRP will be <1.000 mg/L, with a median DRP concentration at the Bridge site (potential mixing zone) of 0.251 mg/L, placing it in NPS-FM attribute band D (**Table 16**). After the new MBR WWTP is installed (Long-Term Stages 1 and 2) operational maximum median DRP concentration will reduce to <0.500 mg/L, with a median DRP concentration at the Bridge site of 0.125 mg/L, placing it in NPS-FM attribute band D (**Table 16**). There would be an approximate 1.4-fold increase in DRP for the Current and Short-Term Stages and an approximate 1.5-fold decrease in DRP for the new MBR WWTP from DRP currently measured in the WWTP discharge. There would be no change to the attribute band (D) for any of the four Stages from that currently observed (**Table 14**). It is not feasible to reduce DRP in the discharge to a level that would improve the attribute band from D to C (**Table 16**) as upstream sites are very close to the attribute band D threshold of 0.018 mg/L, however the improvement on the current median concentration of ca. 0.73 mg/L to 0.50 mg/L (**Table 16**) proposed from the new MBR WWTP will contribute to improved water quality downstream, satisfying the intent of the AUP.

Table 16. Summary of potential water quality median concentrations and NPS-FM attribute bands for nitrate-N and DRP at receiving environment sites with median operational limits for WWTP outlet concentrations for existing (Current and Short-Term) and new (Long-Term Stage 1 and Stage 2) WWTP stages (see Table 6). The Bridge site (potential mixing zone) is highlighted grey.

Parameter /Stage	WWTP Outlet	Farm Pond (B)	Farm Pond downstream (F)	Bridge (15)	Quarry	Upstream Farm Pond (A)	Tributary upstream (E)
Nitrate-N Existing Current (Attribute Band)	3.5	1.9	2.2	1.1	0.4	0.02	0.1
	NA	(B)	(B)	(B)	(A)	(A)	(A)
Nitrate-N Existing Short-Term (Attribute Band)	3.5	1.9	2.2	1.1	0.4	0.02	0.1
	NA	(B)	(B)	(B)	(A)	(A)	(A)
Nitrate-N New (MBR) Long-Term Stage 1 (Attribute Band)	2.0	1.1	1.3	0.6	0.2	0.02	0.1
	NA	(B)	(B)	(A)	(A)	(A)	(A)
Nitrate-N New (MBR) Long-Term Stage 2 (Attribute Band)	2.0	1.1	1.3	0.6	0.2	0.02	0.1
	NA	(B)	(B)	(A)	(A)	(A)	(A)
DRP Existing Current (Attribute Band)	1.000	0.515	0.510	0.251	0.046	0.014	0.014
	NA	(D)	(D)	(D)	(D)	(C)	(C)
DRP Existing Short-Term (Attribute Band)	1.000	0.515	0.510	0.251	0.046	0.014	0.014
	NA	(D)	(D)	(D)	(D)	(C)	(C)
DRP New (MBR) Long-Term Stage 1 (Attribute Band)	0.500	0.258	0.255	0.125	0.023	0.014	0.014
	NA	(D)	(D)	(D)	(D)	(C)	(C)
DRP New (MBR) Long-Term Stage 2 (Attribute Band)	0.500	0.258	0.255	0.125	0.023	0.014	0.014
	NA	(D)	(D)	(D)	(D)	(C)	(C)

5.3.2.2 95th percentile data

We have not assessed the 95th percentiles and changes downstream as a result of improved levels in the proposed discharge as there will be considerable mixing of water and the peaks will be attenuated and unlikely to be manifest below the pond. As for the median assessment above attenuation of ammoniacal-N is not included as any peaks will also be attenuated in the pond and downstream and levels are very low in the discharge and changes downstream are due to pond processes.

5.3.2.3 DIN

As stated earlier, DIN is calculated from the sum of ammoniacal-N, nitrate-N, and nitrite-N, with generally >90% of DIN in the discharge and receiving environment consisting of nitrate-N.

Conversely, nitrite-N is negligible and around 0.1% of DIN for most receiving environment sites and as stated earlier ammoniacal-N in the discharge has little effect on the downstream concentrations.

Therefore, assuming the same attenuation for DIN as for nitrate-N, potential water quality concentrations of DIN were calculated at receiving environment sites (**Table 17**). The currently measured median DIN concentration in the WWTP discharge and the Bridge Site is 5.5 mg/L and 1.7 mg/L, respectively. The Bridge Site concentration is well above the accepted threshold for a degraded water body and eutrophication (1 mg/L). The proposed operational maximum DIN in the WWTP discharge during all stages of the upgrade: 4.1 mg/L for the Existing and Short-Term Stages and 2.5 mg/L for the new MBR Long-Term Stage 1 and 2 Stages, will be a reduction on what is presently in the WWTP discharge (5.5 mg/L). This will result in a mean DIN concentration at the Bridge site from the proposed discharge of 1.3 mg/L for the Current and Short-Term Stages and 0.8 mg/L for the new MBR WWTP (Long-Term Stages 1 and 2), respectively (**Table 17**). We note that these proposed operational medians will require an improvement on the present DIN WWTP concentration of 5.5 mg/L. DIN would still be above the accepted threshold for a degraded water body and eutrophication for the Current and Short-Term Stages (but an improvement on current state) but below the same threshold for the new MBR WWTP (Long-Term Stages 1 and 2).

Table 17. Summary of potential water quality median concentrations for DIN at receiving environment sites with median WWTP outlet concentrations for existing (Current and Short-term) and new (Long-term Stage 1 and Stage 2) WWTP stages (see Table 6). The Bridge site (potential mixing zone) is highlighted grey.

Parameter/Stage	WWTP Outlet	Farm Pond (B)	Farm Pond downstream (F)	Bridge (15)	Quarry	Upstream Farm Pond (A)	Tributary upstream (E)
DIN Existing Current	4.1	2.3	2.6	1.3	0.5	0.1	0.1
DIN Existing Short-Term	4.1	2.3	2.6	1.3	0.5	0.1	0.1
DIN New (MBR) Long-Term Stage 1	2.5	1.4	1.6	0.8	0.3	0.1	0.1
DIN New (MBR) Long-Term Stage 2	2.5	1.4	1.6	0.8	0.3	0.1	0.1

5.3.2.4 Discussion

Nitrogen (predominantly nitrate-N and ammoniacal-N) in Beachlands WWTP discharge is having a clear impact on downstream sites, with catchment influence low, as evidenced by low nitrate-N in upstream sites.

For the existing WWTP (Current and Short-Term) predictions are that the operational limits will result in the following:

- Median nitrate-N concentrations (3.5 mg/L) will likely result in an NPS-FM attribute band B for toxicity at the Bridge site (1.1 mg/L). This is the same attribute band as the current WWTP.

- For DIN – and assuming the same attenuation as for nitrate-N – a median concentration of 4.1 mg/L would mean a DIN concentration at the Bridge site of 1.3 mg/L, above the accepted threshold for eutrophication but an improvement on DIN concentration from the current WWTP (1.7 mg/L). This will require an improvement on the present DIN WWTP concentration of 5.5 mg/L.
- For DRP, the median concentration of 1.0 mg/L would mean a DRP concentration at the Bridge site of 0.25 mg/L, resulting in an NPS-FM attribute band D and potentially an increase of DRP concentration at this site compared to the current WWTP (0.18 mg/L: also NPS-FM attribute band D).

For the New MBR WWTP (Long-Term Stages 1 and 2) significant reduction in future proposed median nitrate-N concentrations (2.0 mg/L) in the discharge from current (5.1 mg/L), and assuming the expanded overland flow system will attenuate nitrate-N to the same level as current, will likely result in nitrate-N concentrations at the potential mixing zone (the Bridge site) of around 0.6 mg/L, leading to a change in the NPS-FM attribute band for toxicity from B (current) to A (future). This would satisfy the requirement for an improvement under the NPS-FM.

Between 2018 and 2023 ammoniacal-N has been consistently around 0.40 mg/L in Beachlands WWTP, reflected by equal median and 95th percentile concentrations of 0.40 mg/L. However, recent measurements with a more sensitive detection limit show that the median is more like 0.04 mg/L in the existing discharge.

The NPS-FM attribute states for ammoniacal-N are based on pH 8 and a temperature of 20°C, with the NBL of 0.40 mg/L (as a 95th percentile). Hickey (2002, 2001) derived site specific ammoniacal-N guidelines for Te Puru Stream of 4.12 mg/L (based on pH 7.5 and 80% species protection) and the farm pond of <0.6 mg/L (based on pH >9.0 and acute protection of species).

High pH (maximum pH 9.26 and average pH 8.12) was noted in the farm pond during diurnal monitoring over 4 days in late February 2002 (Nagels and Maunder, 2002) with maximum and average values at a site (named site S2, just downstream of the Bridge site) of pH 7.46, and 7.38, respectively. Current monitoring has not captured the high pH in the farm pond with 80th percentile and maximum pH of 7.5 and 7.9, respectively. Current pH at the Bridge site is similar to Nagels and Maunder (2002) and the farm pond with maximum and average pH of 7.7 and 7.3, respectively.

The potential mixing zone (the Bridge site) pH values are well below pH 8, and adjustments for pH (as required under the NPS-FM) provides more conservatism to the results.

For ammoniacal-N higher concentrations are proposed as operational limits for the existing and new WWTP upgrades than the WWTP is currently discharging. However, as stated above, processes in the farm pond are primarily determining ammoniacal-N concentrations downstream.

For DIN, there will be a significant reduction in median DIN in the WWTP discharge from 5.5 mg/L (currently measured) to 4.1 mg/L and 2.5 mg/L for the Current and Short-Term stages, and new MBR WWTP (Long-Term Stage 1 and 2), respectively stage. This would translate to a concentration of around 1.3 mg/L and 0.8 mg/L at the potential mixing zone (the Bridge site), for the Current and Short-Term, and Long-term Stage 1 and 2 and even lower concentrations further downstream. With the Current and Short-Term Stages, the DIN concentrations in the discharge would still result in levels generally considered degraded but will be an improvement on current state. With the new MBR WWTP (Long-term Stage 1 and 2) Stages the DIN concentrations in the discharge would be unlikely to result in levels generally considered degraded. In summary, all four stages of the WWTP upgrade will lead to a reduction in DIN (and hence an improvement) from that currently measured.

Phosphorus (both total and dissolved) in Beachlands WWTP is having a clear impact on downstream sites, with catchment influence low, as evidenced by lower TP and DRP concentrations in upstream sites compared with downstream sites. The downstream ecological communities are currently potentially impacted by elevated phosphorus concentrations, however this is only one component among other drivers contributing to ecological stress such as shade (or lack of), the width of stream, and the stream substrate. The potential mixing zone (the Bridge site) has 80^{th} percentile TP concentrations 12-fold higher than the ANZG DGV, while DRP is in the NPS-FM attribute band D, below the NBL, for the median concentrations.

Between 2018 and 2023 DRP has been increasing in the existing Beachlands WWTP discharge by 24% per annum. TP measurement in the WWTP is not required under existing consent conditions. Median concentrations from the 2023/24 extensive monitoring are 0.7 mg/L. The proposed median DRP operational limit concentration is 1.0 mg/L for the Current and Short-Term stages of the WWTP upgrade, and 0.5 mg/L for the new MBR WWTP (Long-Term Stages 1 and 2) (TP has the same limits). This would lead to an approximate 1.4-fold <u>increase</u> in DRP for the Current and Short-Term Stages and an approximate 1.5-fold <u>decrease</u> in DRP for the new WWTP (Long-Term Stages 1 and 2) from currently measured DRP at the potential mixing zone (the Bridge site). Notwithstanding other contributors to ecological stress, it is expected that elevated phosphorus concentrations would be expected to potentially continue to contribute to a high level of effect on the environment compared with upstream. As stated above, the NPS-FM attribute band will not change as a result of the proposed discharge as D is the lowest band and upstream sites have DRP concentration near this threshold.

The requirement to improve water quality where it is contributing to degradation would be satisfied by decreases in the proposed DRP concentrations <u>from the MBR WWTP (Long-Term Stages 1 and 2) Stage of the upgrade</u>.

5.3.3 Bacteria

E. coli, FC, and enterococci are at extremely low concentrations (median 2 cfu/100 mL for all three) in the existing Beachlands WWTP discharge. For the receiving environment sites, bacteria concentrations are highly variable and higher upstream of the WWTP, suggesting catchment sources dominate. Based on median and 95th percentile concentrations, *E. coli* is in NPS-FM attribute band E (Red) for all sites, which corresponds to an average infection risk (from Campylobacter) of >7%.

With respect to the effects of the proposed discharge, FC and *E. coli* concentrations will also remain unchanged throughout all four stages of the WWTP upgrade. Therefore, risks from bacteria are negligible compared to catchment sources now and with all four stages of the future upgrades.

5.3.4 Metals

Total and dissolved metal concentrations were measured in the existing WWTP discharge and at the upstream farm pond (site A), farm pond (site B), and Bridge (site 15) on 10th and 11th December 2023. For the WWTP outlet, exceedance of the ANZG 95% DGV was only observed for total copper (1.4-fold), and total zinc (3.5-fold) and dissolved zinc (2-fold). Of note, chromium (total only), copper (total and dissolved) and zinc (total and dissolved) concentrations at the farm pond (B) site were more than 50% of the ANZG 95% DGV, but all had reduced to 50% or below by the Bridge (15) site.

Surficial sediments were measured for metals at the upstream farm pond (A), farm pond (B), and Bridge (15) sites on 10th November 2023. All sediment metal concentrations were below the ANZG DGV, with only zinc reported at concentrations that were increased downstream of the influence of Beachlands WWTP relative to upstream.

There are no discharge concentrations for metals currently proposed as part of the proposed discharge consent for the upgraded Beachlands WWTP. Concentrations of metals in the discharge at all future stages of the WWTP upgrade are not expected to increase, however with the proposed increase in discharge volume proposed, then assuming concentrations are static, loads will increase proportionally.

Although based on only two monitoring events, zinc, copper, and chromium appear to be increasing at the farm pond site (and to a lesser extent at the Bridge site) to near ecological guideline values as a result of the influence of Beachlands WWTP discharge. Further monitoring, through consent conditions is considered warranted to ensure metals are not increasing to above DGVs downstream as a result of the WWTP.

5.3.5 EOCs

To estimate the ecological risk of EOCs in the proposed Beachlands WWTP discharge to the receiving environment, hazard risk quotients (RQs) were calculated. The RQ was calculated as EOC concentration/ predicted no-effect concentration (PNEC), with a value >1 indicating a potential ecological effect.

Generally, for many EOCs, a PNEC – or no observed effect concentration (NOEC) – is extracted from literature reports. To our knowledge, the most complete database for ecotoxicity of EOCs is the NORMAN[20] Ecotoxicology Database, where lowest freshwater and marine PNECs for many EOCs are provided. PNECs are updated periodically, so most recent PNECs were used for this assessment.[21]

Freshwater RQs for PPCPs measured by Watercare at Beachlands WWTP outlet and receiving environment sites are summarised in **Table 18**. RQs were only summarised for PPCPs reported above detection limit from at least one site. As shown in **Table 18**, the only RQ >1 in the outlet is venlafaxine with an RQ of 1.7. Interestingly the RQ for venlafaxine in the farm pond is 23.1, but at

[20] NORMAN is a network of reference laboratories, research centres and related organisations for monitoring of emerging environmental substances. NORMAN has a membership of more than 70 leading laboratories and authorities across Europe and North America.

[21] https://www.norman-network.com/nds/ecotox/lowestPnecsIndex.php accessed 22-02-24.

the Bridge site it is 0.34 (**Table 18**). There is large variation in the two venlafaxine measurements (600 ng/L on 10th November and 40,000 ng/L on 11th November), with the latter value driving the high RQ at this site. This is likely an anomaly as there is a general significant attenuation between the farm pond discharge point and the Bridge site for PPCPs with an average of 2.9-fold reduction (see Section 4.4.1.5).

Table 18. Risk quotients for PPCPs measured by Watercare at Beachlands WWTP outlet and receiving environment sites based on freshwater PNEC. Blanks denote PPCP was below detection limit. RQ>1 are bolded red.

Analyte	FW PNEC (ng/)	RQ Outlet	RQ Upstream Farm Pond (A)	RQ Farm Pond (B)	RQ Bridge (15)
Bupropion	1110	0.04		0.03	0.01
Caffeine	1200	0.03	0.04	0.06	0.03
Carbamazepine	2000	0.10		0.08	0.04
Cotinine	10000	0.00			
Diclofenac	50	1.00			
Diltiazem	230	0.13		0.09	
Fluoxetine	100	0.10			
Gabapentin	1000000	<0.001		<0.001	<0.001
Lamotrigine	8000	0.25	0.001	0.19	0.09
Metoprolol	8600	0.06		0.03	0.01
Paracetamol	46000			0.002	
Sucralose	29700	0.34	0.003	0.84	0.25
Sulfamethoxazole	600	0.25		0.25	0.09
Triclosan	110	0.09	0.09	0.59	
Trimethoprim	120000	<0.001		<0.001	
Venlafaxine	880	**1.70**		**23.1**	0.34

As stated above the RQ in **Table 18** were calculated using PNECs derived for freshwater species. RQ calculated using PNECs derived for marine species are also necessary as the ultimate receiving environment is the coastal marine environment. Marine RQ calculated from Beachlands WWTP outlet and receiving environment sites are summarised in (**Table 19**). At the Bridge site, only sucralose (RQ 2.5) and venlafaxine (RQ 3.4) present with minor potential for ecological risk. However, as noted above, attenuation from the farm pond to the Bridge site (approximately 350m) is 2.9-fold, so significantly higher attenuation is expected between the Bridge site and Quarry site (a distance of around 2.5km), likely reducing the RQ to well below 1 at the Quarry site, and not requiring further dilution to reduce the ecological risk to marine species.

For EOC WWTP data supplemented from literature (see Section 3.1.7.2), freshwater and marine RQs were calculated based on literature wastewater discharge concentrations and freshwater and marine PNEC, respectively. Results (**Table 20**) suggest that most EOCs are present in treated wastewater at concentrations below effects concentrations for freshwater and marine species. RQ>1 were noted for diclofenac (RQ=1.19 for freshwater and RQ=12.0 for marine), ibuprofen (RQ=10.0 for marine), MEHP (RQ=1.7 for marine), and PFOS (RQ=12 for freshwater and RQ=61 for marine) (**Table 20**).

Table 19. Risk quotients for PPCPs measured by Watercare at Beachlands WWTP outlet and receiving environment sites based on marine PNEC. Blanks denote PPCP was below detection limit. RQ>1 are bolded red.

Analyte	Marine PNEC (ng/L)	RQ Outlet	RQ Upstream Farm Pond (A)	RQ Farm Pond (B)	RQ Bridge (15)
Bupropion	110	0.4		0.3	0.14
Caffeine	8700	<0.001	0.01	0.01	0.005
Carbamazepine	200	1.0		0.8	0.35
Cotinine	1000	0.01			
Diclofenac	5	**10.0**			
Diltiazem	23	**1.3**		0.9	
Fluoxetine	10	1.0			
Gabapentin	100000	<0.001		0.001	0.001
Lamotrigine	800	**2.5**	0.01	**1.9**	0.9
Metoprolol	860	0.6		0.3	0.11
Sucralose	2970	**3.4**	0.03	**8.4**	**2.5**
Sulfamethoxazole	60	**2.5**		**2.5**	0.9
Triclosan	6.9	**1.4**	**1.5**	**9.4**	
Trimethoprim	12000	<0.001			
Venlafaxine	88	**17.0**		**231**	**3.4**

We reiterate that these RQ are based on discharge concentrations from literature for WWTPs. For the PPCPs measured, significant attenuation (2.9-fold) is observed in the freshwater environment from the Farm Pond site to the Bridge site, and likely much higher attenuation to the Quarry site. It is likely that the same degradation/immobilisation processes contributing to the observed attenuation of PPCPs is occurring for most of the literature EOCs, with the notable exception of PFOS, which is highly resistant to degradation. We recommended that a monitoring programme for EOCs is included as a consent condition to better understand the risks of EOCs.

In summary, the majority of EOCs will result in negligible ecological effects based on measured and literature treated WWTP discharge concentrations. Most of the few that will be present in the proposed WWTP discharge at concentrations above ecological effects concentrations will likely be significantly attenuated and/or diluted in the freshwater and marine environments and present with low risk of adverse effects. Accordingly, overall, the effects on the environment from EOCs present in the discharge at all future stages of the proposed WWTP upgrade are likely to be between negligible and low. However, we recommended that a monitoring programme for EOCs is included as a consent condition to better understand the risks of EOCs.

Table 20. Freshwater and marine risk quotients calculated for literature EOCs in treated wastewater (from Table 5). RQ>1 are bolded red.

Class	Analyte[1]	FW PNEC (ng/)	Marine PNEC (ng/L)	FW RQ	Marine RQ
Akylphosphate flame retardant	TBEP	24000	2400	0.003	0.033
	TBP	37000	35000	0.001	0.001
	TCEP	65000	6500	0.001	0.010
	TCPP	260000	64000	0.003	0.014
	TDCP	1100	1000	0.049	0.053
	TiBP	11000	1100	0.002	0.018
	TPP	170	370	0.014	0.006
Alkylphenol	Tech-NP-equivalents	300	300	0.360	0.360
Antimicrobial	Chlorophene	540	54	0.007	0.067
	Chloroxylenol	7050	700	0.001	0.010
Insecticide	DEET	88000	8800	0.001	0.006
Nitro and polycyclic musk fragrance	Cashmeran	850	400	0.016	0.034
	Galaxolide	7000	440	0.039	0.628
	Tonalide	23	220	0.634	0.066
Pharmaceutical	Acetaminophen	46000	13400	<0.001	0.001
	Carbamazepine	2000	200	0.081	0.813
	Diclofenac	50	5.0	**1.19**	**12**
	Ibuprofen	11	1.1	0.98	**10**
	Naproxen	1700	170	0.044	0.443
	Salicylic acid	18000	20000	0.002	0.002
Plasticiser	BBP	5200	750	0.001	0.005
	Bisphenol A	240	16000	0.067	0.001
	DBP	10000	1000	0.002	0.016
	DEHP	1300	1300	0.023	0.023
	DEP	73000	1200	<0.001	0.008
	DMP	192000	19200	<0.001	<0.001
Plasticiser metabolite	MBP	2310	230	0.006	0.062
	MEHP	190	19	0.170	**1.7**
	MMP	14700	1470	<0.001	0.003
PFAS	PFOS	0.65	0.13	**12**	**61**
	PFHxA	140000	14000	<0.001	0.001
	PFHpA	500	50	0.006	0.064
	PFOA	180	18	0.037	0.369
	PFNA	1000	100	0.002	0.019
	PFDA	170	17	0.009	0.094

[1] TBEP = Tris-(2-butoxyethyl) phosphate; TBP = Tributyl-phosphate; TCEP= Tris(2-chloroethyl) phosphate; TCPP = Tris (1-chloro-2-propyl) phosphate; TDCP = Tris[2-chloro-1-(chloromethyl)ethyl] phosphate; TiBP = Tri-isobutyl-phosphate; TPP = Triphenylphosphate; Tech-NP-equivalents = Technical nonylphenol equivalents; DEET = N, N-Diethyl-meta-toluamide; BBP = Butylbenzylphthalate; DBP = Di-n-butylphthalate; DEHP = Diethylphthalate; DEP = Diethylphthalate; DMP = Dimethylphthalate; MBP = Monobutyl-phthalate acid ester; MEHP = Monoethylhexyl phthalate acid ester; MMP = Monomethyl phthalate acid ester; PFOS = Perfluorooctanesulfonic acid; PFHxA = Perfluorohexanoic acid; PFHpA = Perfluoroheptanoic acid; PFOA = perfluorooctanoic acid; PFNA = Perfluorononanoic acid; PFDA = Perfluorodecananoic acid.

5.3.6 Viruses (QMRA)

5.3.6.1 Methodology

The QMRA used norovirus as a reference pathogen for human health risks from human sources (i.e. wastewater) citing previous epidemiological evidence (Landrigan et al., 2020; Sinclair et al., 2009) and evidence from previous QMRAs (Soller et al., 2010; Stott and Wood, 2022). Importantly, norovirus was not considered in the 2004 QMRA for Beachlands (Stott and McBride, 2004) due to no published dose-response model at that time. Therefore, the current QMRA provides a more robust assessment of human health risks than in 2004.

As stated in Section 3.1.8, viruses have not been measured in Beachlands WWTP. Therefore, and consistent with many of the more recent New Zealand QMRAs (Cressy, 2021; Dada, 2021; Stott et al., 2023; Wood and Hudson, 2023), a distribution of standard factors of norovirus influent concentrations of minimum, median, and maximum values of $1x10^3$, $1x10^5$, and $1x10^7$ genome copies/L, respectively were used.

Simulations of 10-fold, 100-fold, 1,000-fold and 10,000-fold, 100,000-fold, 1,000,000-fold and 10,000,000-fold reductions (or 1, 2, 3, 4, 5, 6, and 7 log reduction value: LRV) of norovirus by Beachlands WWTP were used. It was noted that in 2004, log reductions for Beachlands WWTP ranged from 4.3-6.0 for adenovirus and rotavirus.

Exposure sites for the QMRA are shown in **Figure 46** and **Figure 47**. Marine exposure sites (for primary contact recreation, or swimming) were Magazine Bay, Shelly Bay, Pohutukawa Bay, Omana, Umupuia (Inner), Sunkist Bay, Te Puru stream mouth (**Figure 46**) and Kelly's Beach mid beach. It was noted that Kelly's mid beach is covered by part of the day so transects were chosen along the water edge (**Figure 47**).

Freshwater sites – Bridge, C and Quarry sites – were consistent with water quality monitoring sites (**Figure 46**) and included contact recreation and watercress consumption exposure risks. It was noted that it is unlikely that the Te Puru stream will be used for recreational activities but that watercress was noted at several sites along the stream including site F (upstream of bridge site), site C and sites G and C (Bioresearches, 2024a). Watercress consumption risks were based on raw harvested watercress with large (250g) and small (40g) meal sizes approximated. It was noted that due to uncertainties with norovirus internalisation on watercress the health risks are precautionary.

Shellfish exposure was assessed at three sites, Wairoa West Bay, Clevedon, and Umupuia (Outer) (**Figure 46**) Shellfish risks were not assessed for Kelly's Beach as they are likely too small to harvest (see Section 4.7.1.1).

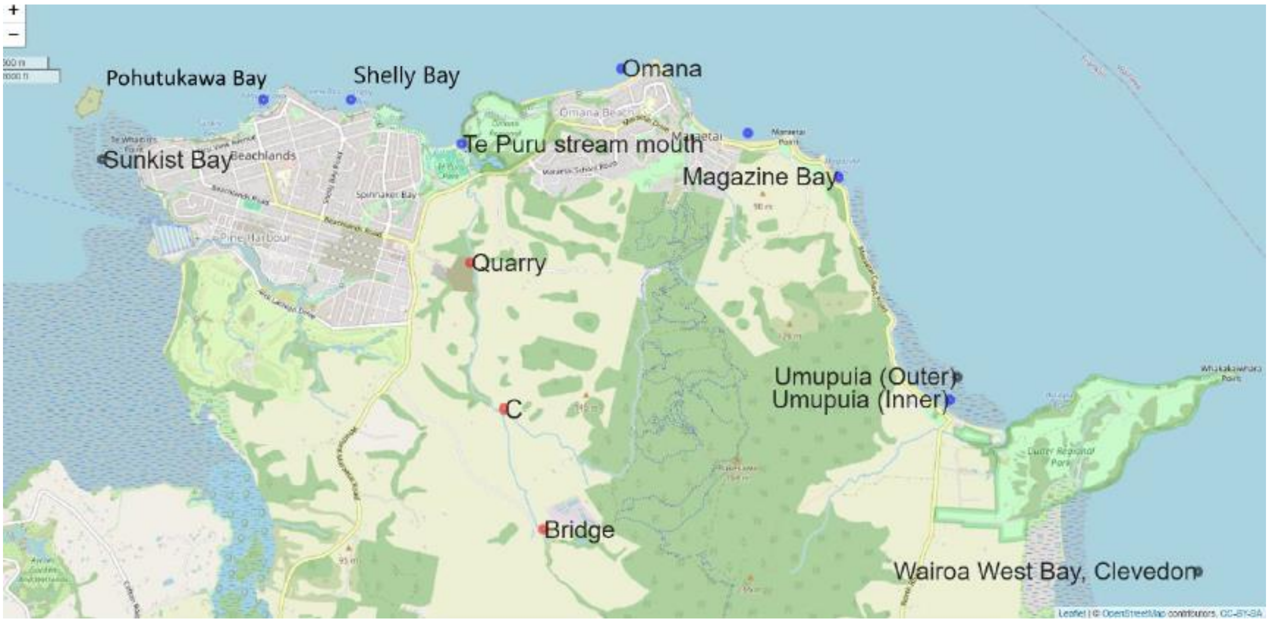

Figure 46. Location of QMRA assessment sites. Red = River sites, Blue = Marine (swim), Black = Marine (shellfish) (Wood and Stott, 2024).

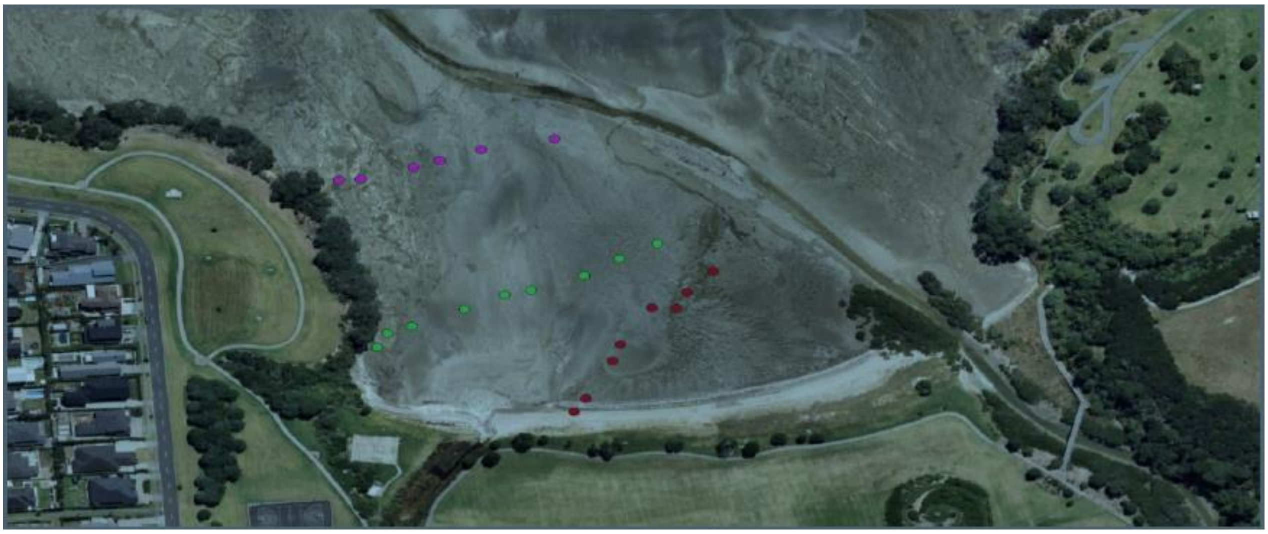

Figure 47. Location of QMRA assessment sites on Kelly's Beach. Pink - Northern, green – Mid, dark red - Eastern transect (Wood and Stott, 2024).

Dilutions of treated wastewater were informed by estimated flows in Te Puru Stream (PDP, 2024b) and hydrodynamic modelling of the discharge in the wider marine environment (DHI, 2024). Current, interim, and Stage 2 discharge volumes (see **Table 6**, Section 3.2) were modelled.

Infection risks were calculated as individual infection risks (IInfR) for each exposure event: swimming or consumption of shellfish or watercress. The QMRA used Monte Carlo statistical modelling to allow for ranges of likely conditions including infrequent but highly influential elevated virus concentrations.

5.3.6.2 Health risks due to consumption of watercress

Health risks from consumption of raw (uncooked) watercress at the Bridge, C, and Quarry sites are summarised in **Figure 48**, considering the different discharge stages[22], the range of log reduction values (LRV) for norovirus, and the large meal size. There was little difference in risk between the current, interim/Short-Term, and Long-Term Stage 2 discharge stages (**Figure 48**). The Bridge site exhibited the highest risk, with an LRV of 5 required to reduce the risk of infection to <1%. The large meal size was considered appropriate for the assessment, and it was noted that reducing the meal size to 40g does not result in a linear reduction of risk.

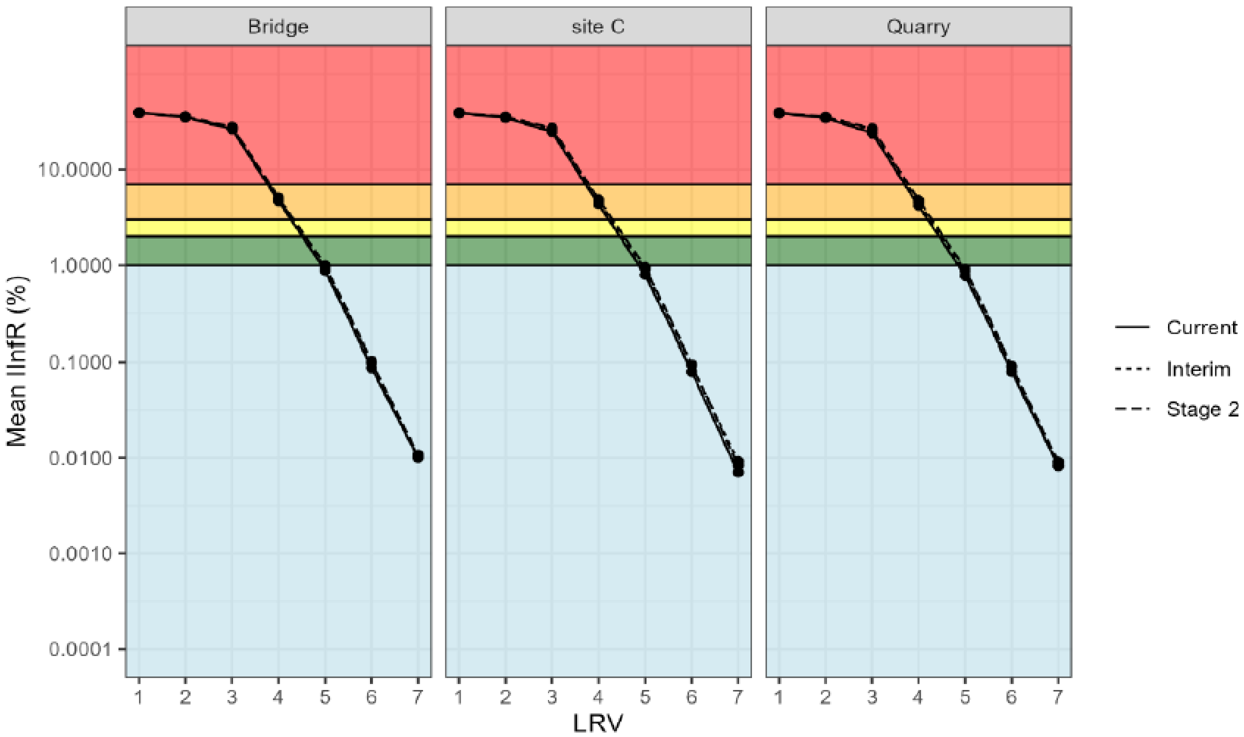

Figure 48. Mean infection risk (IInfR) from consumption of watercress harvested at three sites in the Te Puru stream assuming a meal size of 250 g. The colours relate to the NPS-FM categories: blue IInfR < 1% per event, green 1 -2%, yellow 2-3%, orange 3-7% and red >7% (Wood and Stott, 2024).

5.3.6.3 Health risks due to swimming

Health risks due to swimming were summarised for the three riverine sites (Bridge, Quarry and Te Puru stream mouth) and nine marine sites (**Figure 49**). Swimming risks were highest at the Bridge and Quarry sites with an LRV >4 required to reduce risks to below 1%. It was noted that the discharge stages had little effect on the Bridge and Quarry sites (nor site C, not shown in

[22] We note that at the time the QMRA was undertaken there were 3 discharge stages proposed for the WWTP upgrade. There was no Long-Term Stage 1 stage. Further, the interim stage was subsequently updated to Short-Term stage. No QMRA modelling has been undertaken for the Long-Term Stage 1 stage with risks, due to the installation of the MBR at Long-Term Stage 1, similar but lower than the Long-Term Stage 2 stage.

Figure 49), but did have an effect on the marine swimming sites (**Figure 49**). As noted earlier, swimming at the Bridge, Quarry and C sites is unlikely.

Swimming health risks at the marine sites were low, due to the high dilution, with an LRV of at 2-3 required for Te Puru Stream Kelly's Beach transect sites (depending on discharge stage), but less than 1 for those further out in the bay and for all discharge stages (**Figure 49**).

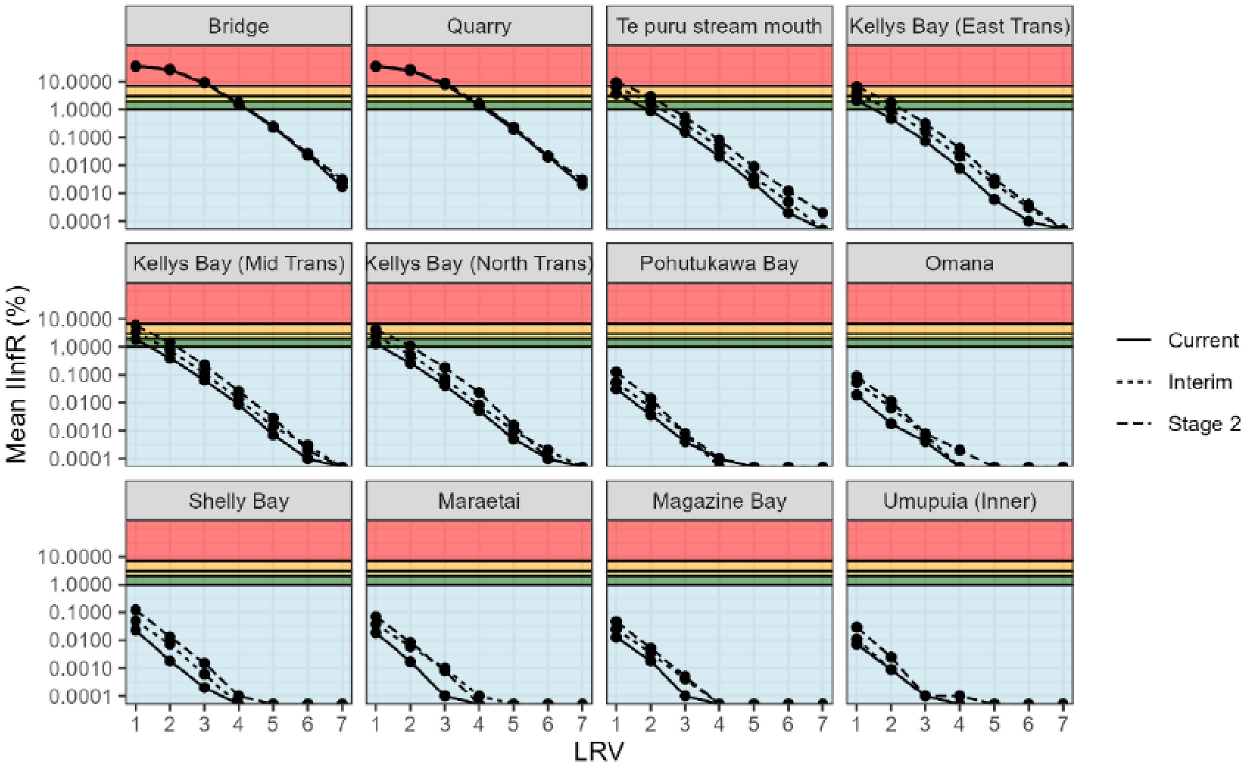

Figure 49. Mean infection risk (IInfR) from swimming at 12 sites (3 river and 9 marine). The colours relate to the NPS-FM categories: blue IInfR < 1% per event, green 1 -2%, yellow 2-3%, orange 3-7% and red >7% (Wood and Stott, 2024).

5.3.6.4 Health risks due to shellfish consumption

Shellfish consumption risks (mean IInfR) for shellfish harvested from Sunkist Bay, Umupuia (Outer) and Wairoa West Bay and for current, Short-Term, and Long-Term Stage 2 discharge stages are summarised in **Figure 50**. Under the current discharge stage, an LRV of 1 is sufficient to provide a risk of <1%, while this increases but is below 2 for Short-Term and Long-Term Stage 2 discharge stages.

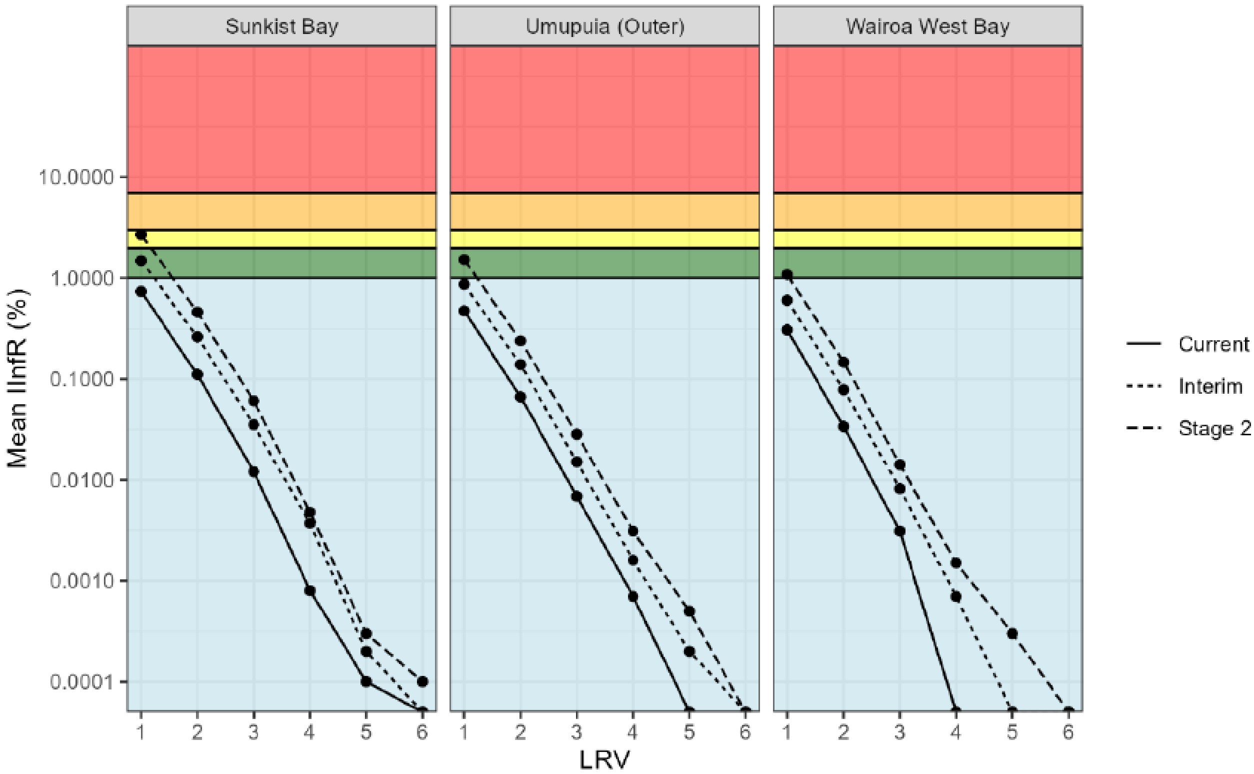

Figure 50. Mean infection risk (IInfR) from shellfish consumption from three sites. The colours relate to the NPS-FM categories: blue IInfR < 1% per event, green 1 -2%, yellow 2-3%, orange 3-7% and red >7% (Wood and Stott, 2024).

5.3.6.5 Summary of human health risks from viruses

The QMRA provided mean infection risks summarised as:

- For watercress consumption, a log reduction of 5 is required to reduce the risk of infection to <1% at the Te Puru stream sites.
- For swimming, a log reduction of >4 required to reduce risks to below 1% at Te Puru stream sites, while it was noted that swimming is unlikely at these sites. For marine sites log reductions ranged from 2-3 Kelly's Beach transect sites (depending on discharge stage), but less than 1 for those further out in the bay and for all discharge stages.
- For shellfish consumption, an LRV of 1 is sufficient to provide a risk of <1% for the current discharge stage at all marine sites, while this increases but is below 2 for interim and Stage 2 discharge stages.

We note that the QMRA looks at the added risk from the proposed discharge from the WWTP, there is still existing risks from other sources but these are not part of QMRA.

5.4 Potential effects on aquatic ecology of Te Puru Stream and tributaries

Bioresearches summarised in their 2024 report (Bioresearches, 2024a) that the effects of the discharge from Beachlands WWTP in the upper Te Puru Tributary were varied, however predominantly limited to a short length of stream of at least 200m downstream of the discharge pond (Site F), with conductivity and nutrients affected for a greater distance.

Water quality parameters, such as temperature, conductivity, and nutrients (nitrogen and phosphorus), that increased immediately downstream of the discharge pond, appeared to correspond with a localised decrease in the presence of native fish and pollutant sensitive macroinvertebrates. This has been an ongoing trend since 2002.

Nuisance aquatic plant growth coincided with increased conductivity and bioavailable nutrient concentrations (DIN and DRP) below the farm pond. It was noted that this could also be attributed in part to the lack of shading at downstream sites, substrate, and the ongoing observed level of stock access to streams.

Macroinvertebrate and native fish communities did not appear to fully recover at the most downstream sites and lacked more sensitive taxa. The proposed MBR WWTP will result in an improvement in water quality compared to the current water quality results and is highly likely to result in an improvement in the overall macroinvertebrate and fish community downstream compared to the most recent survey results. The overall magnitude of this effect will likely continue to be moderate but the effect from the WWTP cannot be easily separated from other variables (i.e. higher quality riparian vegetation and shading upstream) and stressors (sedimentation and nutrient input from adjacent farmland and side tributaries). Riparian planting would also help improve the tributary and stream habitat.

5.5 Potential effects on coastal water quality

5.5.1 Water quality

Nitrogen, and to a lesser extent, phosphorus, are the two primary limiting nutrients of concern in coastal waters. Small increases in these nutrients can lead to increased productivity, but excessive concentrations can result in nuisance phytoplankton and macroalgal booms, increased turbidity, and reduced dissolved oxygen near the seabed.

Median concentrations proposed in treated wastewater discharge following the MBR upgrade are 5 mg/L TN, 0.5 mg/L for TP/DRP (**Table 6**). Concentrations of nitrogen (TN and nitrate-N) and phosphorus (TP and DRP) show a clear decrease in concentration down Te Puru stream with increasing distance from the WWTP due to dilution (See Section 4.4.1.2). Concentrations will be further decreased by rapid mixing with coastal waters. The levels of dilution in coastal surface waters predicted by DHI for the current WWTP discharge and proposed for the upgraded Short-Term, Long-Term Stage 1 and Long-Term Stage 2 are shown in **Table 21.**

At the existing Short-Term Stage, the 50th percentile dilution factor at Te Puru stream mouth is 1,352×, which increases to 13,302× midway down Te Maraetai/Kellys Beach (northern transect), and to over 675,000× by the neighbouring bays (Shelly Bay, Pohutukawa Bay, and Omana Beach).

Given a median discharge concentration of 7 mg/L for TN in the treated wastewater, concentrations due to the WWTP will be approximately 0.005 mg/L at Te Puru stream mouth, 0.0005 mg/L at the northern transect on Te Maraetai/Kellys Beach, and 0.00001 mg/L in the neighbouring bays. Similarly, the concentration of TP will be diluted from 1.0 mg/L in the treated discharge to approximately 0.0007 mg/L at the Te Puru stream mouth, 0.00008 mg/L at the northern transect on Te Maraetai/Kellys Beach, and <0.000001 mg/L in the neighbouring bays.

At Long-Term Stage 1, the 50th percentile dilution factor at Te Puru stream mouth is 831×, which increases to 7,928× midway down Te Maraetai/Kellys Beach (northern transect), and to over 427,000× by the neighbouring bays (Shelly Bay, Pohutukawa Bay, and Omana Beach). Given a median discharge concentration of 5 mg/L for TN in the MBR treated wastewater, concentrations will be approximately 0.006 mg/L at Te Puru stream mouth, 0.001 mg/L at the northern transect on Te Maraetai/Kellys Beach, and 0.00001 mg/L in the neighbouring bays. Similarly, the concentration of TP will be diluted from 0.5 mg/L in the treated discharge to approximately 0.0006 mg/L at the Te Puru stream mouth, 0.00006 mg/L at the northern transect on Te Maraetai/Kellys Beach, and 0.000001 mg/L in the neighbouring bays.

At Long-Term Stage 2, the 50th percentile dilution factor at Te Puru stream mouth is 309×, which increases to 2554× midway down Te Maraetai/Kellys Beach (northern transect), and to over 180,000× by the neighbouring bays (Shelly Bay, Pohutukawa Bay, and Omana Beach). Given a median discharge concentration of 5 mg/L for TN in the treated wastewater, concentrations will be approximately 0.016 mg/L at Te Puru stream mouth, 0.002 mg/L at the northern transect on Te Maraetai/Kellys Beach, and 0.000028 mg/L in the neighbouring bays. Similarly, the concentration of TP will be diluted from 0.5 mg/L in the treated discharge to approximately 0.0015 mg/L at the Te Puru stream mouth, 0.00019 mg/L at the northern transect on Te Maraetai/Kellys Beach, and 0.000003 mg/L in the neighbouring bays.

Background concentrations of TN and TP are not available for Te Maraetai/Kellys Beach, but long-term Auckland Council monitoring data are available for Wairoa Estuary, Clevedon, which has a ‘good’ water quality index rating. Five-year (2018–2022) median concentration of TN and TP are 0.179 mg/L and 0.024 mg/L, respectively (Kelly and Kamke, 2023). Thus, TN and TP concentrations in the proposed discharged for all stages assessed would be diluted to below background levels of coastal waters before it reaches the Te Puru stream mouth. Given the rapid dilution rate, and the reduction of TN concentration in the proposed discharge from the expanded and upgraded MBR WWTP, no increase in nutrient concentrations in coastal waters, or related adverse effects from increased nutrients, are likely to occur as a result of the proposed discharge. Other minor contaminants that are present in the treated wastewater at low concentrations will be diluted at a similar rate to TN and TP.

Table 21. Modelled percentile dilution estimates in surface waters at various coastal locations in the Current, Short-term, Long-Term Stage 1, and Long-Term Stage 2 stages.

	Percentiles	Wairoa West Bay, Clevedon	Umupuia	Maraetai	Magazine Bay	Shelly Bay	Pohutukawa Bay	Omana	Umupuia	Sunkist Bay	Northern Transect	Mid Transect	Eastern Transect	Te Puru stream mouth
Current	1	87,460	28,893	9,418	15,687	8,430	4,917	6,568	30,707	16,841	20	20	18	10
	2	102,886	40,684	13,051	20,692	14,796	8,858	11,539	43,850	22,124	51	37	26	12
	5	169,673	60,176	25,919	41,002	30,195	20,487	25,043	61,614	53,019	166	102	61	25
	10	404,592	126,271	92,283	101,842	67,523	73,432	77,840	121,590	90,970	471	284	231	75
	20	796,418	878,355	404,477	653,117	314,554	308,489	343,279	811,851	627,861	2,779	1,099	985	177
	30	1,529,184	1,414,678	894,811	1,068,633	745,212	874,640	822,967	1,406,233	1,349,843	9,755	3,090	2,729	483
	50	7,648,008	6,274,904	2,330,568	3,039,283	3,020,719	3,075,059	2,558,304	6,181,807	4,128,785	109,282	35,287	25,395	13,018
Short-Term	1	40,061	16,070	5,124	8,144	3,327	2,133	3,005	16,447	7,056	9	10	9	5
	2	47,019	19,505	6,256	10,497	5,278	3,414	5,470	18,748	9,395	22	16	12	6
	5	77,641	28,399	12,404	19,304	11,187	8,532	11,519	29,520	22,525	62	41	25	10
	10	182,109	57,839	38,287	45,850	23,501	26,320	33,232	55,930	38,069	141	92	73	28
	20	353,346	326,394	126,483	236,530	91,293	82,324	111,794	331,880	187,430	579	283	241	61
	30	619,869	537,466	340,083	390,367	228,630	224,694	309,756	528,949	365,840	1,878	600	532	123
	50	2,383,171	1,635,168	628,247	1,027,488	714,192	675,055	695,563	1,677,036	1,031,517	13,302	3,680	2,782	1,352
Long-Term Stage 1	1	29,673	12,238	4,084	6,355	2,426	1,596	2,396	12,315	5,363	7	8	7	4
	2	35,055	14,455	4,947	8,316	3,845	2,508	4,324	14,108	7,114	15	12	10	5
	5	58,087	21,827	9,720	14,862	8,226	6,213	8,876	22,794	16,546	46	30	19	7
	10	129,378	44,161	28,589	34,503	17,030	18,796	24,588	42,911	28,115	102	65	51	21
	20	261,576	240,155	88,229	161,604	60,625	54,660	78,947	244,033	130,672	376	192	161	46
	30	448,658	389,890	239,422	281,846	153,505	143,205	219,627	384,435	246,851	1,173	389	346	88
	50	1,650,209	1,149,961	451,795	702,428	463,334	427,695	479,722	1,164,964	665,243	7,928	2,163	1,657	831

	Percentiles	Wairoa West Bay, Clevedon	Umupuia	Maraetai	Magazine Bay	Shelly Bay	Pohutukawa Bay	Omana	Umupuia	Sunkist Bay	Northern Transect	Mid Transect	Eastern Transect	Te Puru stream mouth
Long-Term Stage 2	1	19,284	8,406	3,044	4,566	1,526	1,060	1,786	8,183	3,670	6	6	5	3
	2	23,092	9,405	3,638	6,136	2,413	1,601	3,178	9,467	4,833	9	8	7	4
	5	38,533	15,254	7,037	10,420	5,266	3,894	6,233	16,068	10,566	29	19	12	5
	10	76,648	30,483	18,891	23,155	10,560	11,273	15,944	29,893	18,160	62	38	28	14
	20	169,805	153,917	49,975	86,679	29,958	26,995	46,099	156,186	73,913	174	100	82	31
	30	277,446	242,315	138,760	173,324	78,380	61,716	129,498	239,920	127,862	468	179	159	53
	50	917,246	664,754	275,343	377,368	212,476	180,334	263,880	652,891	298,970	2,554	646	532	309

5.5.2 Nutrient loads

Mean annual attenuated TN and TP loads from the current WWTP are estimated to be 1,979 kg/year and 233 kg/year, respectively (DHI, 2024). With respect to the proposed discharge:

- By the Short-Term Stage, mean annual attenuated TN loads are estimated to increase 1.6-fold from current to 3,239 kg/year, and mean annual attenuated TP loads are estimated to increase 1.6-fold from current to 382 kg/year.
- By Long-Term Stage 1, mean annual attenuated TN loads are estimated to increase 1.6-fold from current to 3,085 kg/year, and mean annual attenuated TP loads are estimated to increase 1.1-fold from current to 255 kg/year.
- By Long-Term Stage 2, mean annual attenuated TN loads are estimated to increase 1.9-fold from current to 3,856 kg/year, and mean annual attenuated TP loads are estimated to increase 1.4-fold from current to 318 kg/year.

While these increases in loads represent a large percentage increase, the absolute values need to be considered in context with other nutrient inputs into the inner Hauraki Gulf and Firth of Thames. TN loads for the Tamaki River, Wairoa River, Piako River, and Waihou River are around 60,000, 160,000, 1,415,000 and 2,168,000 kg/year, respectively, while TP loads for the Piako River, and Waihou River are 74,000 and 121,000 kg/year, respectively (DHI, 2024; Vant, 2022).[23] Given that the estimated loads from the proposed discharge from the expanded and upgraded WWTP represent a very small percentage of the TN and TP loads entering the inner Hauraki Gulf and Firth of Thames, the effects of the increased loads from the proposed discharge for all stages assessed are expected to be less than minor.

5.6 Summary of the ecological effects of proposed discharge

5.6.1 Effects of Discharges during the Current Stage

The actual and potential ecological effects of the proposed discharge on the freshwater and marine receiving environment during the Current Stage can be summarised as follows:

- The proposed annual average discharge volume is 2,200 m^3/day at this stage, which is a slight increase, but comparable, to the existing annual median for 2022 (1,947 m^3/day) and 2023 (2,038 m^3/day). A discharge at this slightly increased flow is likely to result in a <u>low effect</u> on stream bank erosion, and <u>negligible</u> effects on the coastal marine environment.
- Based on monitoring at receiving environment sites occasional low DO in the current discharge does not appear to be impacting on DO in the pond or further downstream. $cBOD_5$ in the current WWTP discharge does not appear to be impacting on receiving environment sites. A proposed maximum operational discharge limit of 7 mg/L is marginally higher than the WWTP discharge in 2023/24 (median 5.7 mg/L). A discharge with this potential increase in $cBOD_5$ (noting the operational limit is a maximum concentration) is not expected to impact significantly on $cBOD_5$ (or DO) in the pond or further downstream.

[23] Loads for the Piako and Waihou Rivers are an annual mean value for 2011–2020.

- The current Beachlands WWTP discharge is showing minimal effects on water temperature in the farm pond. There are no water temperature standards proposed for the upgraded WWTP discharge, but the proposed discharge is expected to result in low impacts on temperature at downstream sites compared with upstream sites.
- Low pH appears to be more an issue than high pH in the receiving environment. The current Beachlands WWTP discharge appears to be having negligible impacts on pH at sites downstream and this is expected to remain the same for the proposed discharge during the Current stage.
- There is a clear influence of the current Beachlands WWTP discharge on conductivity downstream, with all sites showing conductivity manyfold above the ANZG DGV, indicating a 'potential risk' of adverse effects. The NIWA Stream Health Monitoring and Assessment Kit (**SHMAK**) report suggests that direct effects from conductivity on stream life does not occur until conductivity reaches levels found in brackish water or seawater, well above conductivity at these sites. Further, elevated conductivity may lead to reduced DO, but there are no apparent effects on DO downstream attributable to the current WWTP discharge. As stated earlier there was evidence of minor salinity in the current WWTP discharge. There are no proposed new discharge standards for conductivity and salinity but concentrations of salts are not expected to increase as a result of the proposed discharge. Accordingly, it is expected that conductivity in the proposed discharge will contribute to low/moderate effects on stream ecology downstream compared with upstream. Riparian planting and installation of new pipes for the network along with a trigger for further work on causes should also reduce the effects of conductivity.
- The current Beachlands WWTP discharge has consistently low TSS (mean from 2018-2023 of 7.4 mg/L) and there appears to be little difference in TSS for the receiving environment sites upstream and downstream of the wastewater discharge. The discharge concentration limits under the Current Stage (7 mg/L) should see a decrease in TSS of approximately 1.06-fold compared to the current discharge and contribute to improved water quality downstream of the discharge.
- Between 2018 and 2023 ammoniacal-N has been consistently around 0.40 mg/L in discharges from the Beachlands WWTP, reflected by equal median and 95th percentile concentrations of 0.40 mg/L. However, recent measurements with a more sensitive detection limit show that the median is more like 0.04 mg/L in the discharge.
    - Ammoniacal-N makes up around 0.5% of TN being discharged from the WWTP and is unlikely to be significantly contributing to ammoniacal-N concentrations downstream.
    - Processes in the pond will continue to increase ammoniacal-N levels downstream but would be expected to meet the NBL for ammoniacal-N toxicity and be unlikely to impact on species found downstream.
    - For these reasons we have not estimated ammoniacal-N concentrations downstream for any of the proposed discharge stages.
- A maximum operational median nitrate-N concentration (3.5 mg/L) will likely result in an NPS-FM attribute band B for toxicity at the Bridge site (1.1 mg/L). This is the same attribute band as the Bridge site currently.
- For DIN – and assuming the same attenuation as for nitrate-N – a maximum operational median concentration of 4.1 mg/L would mean a DIN concentration at the Bridge site of 1.3 mg/L, above the accepted threshold for eutrophication.

- For DRP, a maximum operational median concentration of 1.000 mg/L would mean a DRP concentration at the Bridge site of 0.251 mg/L, resulting in an NPS-FM attribute band D and potentially an increase of DRP concentration at Bridge site currently (0.182 mg/L: also NPS-FM attribute band D). Note that 1.0 mg/L is an operational limit and we would not expect concentrations to get this high in the discharge and change from the existing levels.
- After attenuation through the overland and stream system, TN and TP loads will contribute 34% and 46% of total load from the catchment to the marine coastal environment.
- Risks from bacteria are negligible compared to catchment sources.
- Although based on only two monitoring events water metal concentrations are currently at 50% or below the ANZG DGV at the Bridge site and would be expected to be the same during the Current Stage. Zinc, copper and chromium appear to be increasing at the farm pond site (and to a lesser extent at the Bridge site) to near ecological guideline values as a result of the influence of Beachlands WWTP discharge.
- All sediment metal concentrations were below the ANZG DGV, with only zinc reported at concentrations that were increased downstream of the influence of Beachlands WWTP relative to upstream.
- Further monitoring, through consent conditions is warranted to ensure metals are not increasing to above DGVs downstream.
- The majority of EOCs will present negligible ecological effects based on measured and literature treated WWTP discharge concentrations. Most of the few EOCs that are present in concentrations above ecological effects concentrations will likely be significantly attenuated and/or diluted in the freshwater and marine environments and present with low risk of adverse effects. Concentrations of EOCs, and hence risks, are not expected to increase during the Current Stage. Further monitoring, through consent conditions is warranted to better understand the risks of EOCs.
- A QMRA assessed mean infection risks, which are summarised as:
    - For watercress consumption, a log reduction of 5 (100,000-fold reduction) is required to reduce the current risk of infection to <1% at the Te Puru stream sites.
    - For swimming, a log reduction of >4 (<10,000-fold) is required to reduce risks to below 1% at Te Puru stream sites. It was noted that swimming is unlikely at these sites.
    - For marine sites, swimming health risks were currently low with a log reduction of <2 (<100-fold) required at Kelly's Beach transect sites, and <1 (<10-fold) for those further out in the bay.
    - For shellfish consumption, a log reduction of 1 (10-fold) is sufficient to provide a risk of <1% currently at all marine sites.
    - We note that the QMRA looks at the added risk from the WWTP, there is still existing risks from other sources but these are not part of QMRA.

5.6.2 Effects of Discharges during the Short-Term Stage

The actual and potential ecological effects of the proposed discharge on the freshwater and marine receiving environment during the Short-Term Stage can be summarised as follows:

- The proposed annual average discharge volume is 3,600 m^3/day at this stage, compared to the existing annual median for 2023 of 2,038 m^3/day. A discharge at this increased annual average discharge volume is likely to result in a low effect on stream bank erosion, and negligible effects on the coastal marine environment.
- Based on monitoring at receiving environment sites occasional low DO in the current discharge does not appear to be impacting on DO in the pond or further downstream. $cBOD_5$ in the current WWTP discharge does not appear to be impacting on receiving environment sites. A proposed maximum operational discharge limit of 7 mg/L during the Short-Term Stage is marginally higher than the WWTP discharge in 2023/24 (median 5.7 mg/L). A discharge with this potential increase in concentration (noting the operational limit is a maximum concentration) is not expected to impact significantly on $cBOD_5$ (or DO) in the pond or further downstream.
- The current Beachlands WWTP discharge is showing minimal effects on water temperature in the farm pond. There are no water temperature standards proposed for the upgraded WWTP discharge, but the proposed discharge during the Short-Term Stage is expected to continue to result in low impacts on temperature at downstream sites compared with upstream sites.
- Low pH appears to be more an issue than high pH in the receiving environment. The current Beachlands WWTP discharge appears to be having negligible impacts on pH at sites downstream and this is expected to remain the same for the proposed discharge during the Short-Term Stage.
- There is a clear influence of the current Beachlands WWTP discharge on conductivity downstream, with all sites showing conductivity manyfold above the ANZG DGV, indicating a 'potential risk' of adverse effects. Implications of increased conductivity are discussed in relation to the Current stage and not repeated here. It is expected that conductivity in the proposed discharge during the Short-Term Stage will contribute to low/moderate effects on stream ecology downstream compared with upstream. Riparian planting and installation of new pipes for the network along with a trigger for further work on causes should reduce the effects of conductivity.
- The current Beachlands WWTP discharge has consistently low TSS (mean from 2018-2023 of 7.4 mg/L) and there appears to be little difference in TSS for the receiving environment sites upstream and downstream of the wastewater discharge. The maximum operational discharge concentrations under the Short-Term Stage (7 mg/L) should see a decrease in TSS of approximately1.06-fold compared to the current discharge and contribute to improved water quality downstream of the discharge.
- For ammoniacal-N – and the reasons discussed in relation to the Current stage – we have not estimated ammoniacal-N concentrations downstream
- A maximum operational median nitrate-N concentration (3.5 mg/L) for the Short-Term Stage will likely result in an NPS-FM attribute band B for toxicity at the Bridge site (1.1 mg/L). This is the same attribute band as the Bridge site currently.
- For DIN – and assuming the same attenuation as for nitrate-N – a maximum operational median concentration of 4.1 mg/L for the Short-Term Stage would mean a DIN concentration at the Bridge site of 1.3 mg/L, above the accepted threshold for eutrophication.
- For DRP, a maximum operational median concentration of 1.000 mg/L for the Short-Term Stage would mean a DRP concentration at the Bridge site of 0.251 mg/L, resulting in an

NPS-FM attribute band D and potentially an increase of DRP concentration at Bridge site currently (0.182 mg/L: also NPS-FM attribute band D). Note that 1.0 mg/L is an operational limit and we would not expect concentrations to get this high in the discharge and change from the existing levels.

- After attenuation through the overland and stream system, TN and TP loads will contribute 46% and 59% of total load from the catchment to the marine coastal environment.
- Risks from bacteria are negligible compared to catchment sources now and with future upgrades.
- Although based on only two monitoring events water metal concentrations are currently at 50% or below the ANZG DGV at the Bridge site and would be expected to be the same for the Short-Term Stage. Zinc, copper and chromium appear to be increasing at the farm pond site (and to a lesser extent at the Bridge site) to near ecological guideline values as a result of the influence of Beachlands WWTP discharge.
- All sediment metal concentrations were, and will continue to be for the Short-Term Stage, below the ANZG DGV, with only zinc reported at concentrations that were increased downstream of the influence of Beachlands WWTP relative to upstream.
- Further monitoring, through consent conditions is warranted to ensure metals are not increasing to above DGVs downstream for each stage of the proposed future discharge.
- The majority of EOCs will present negligible ecological effects based on measured and literature treated WWTP discharge concentrations. Most of the few EOCs that are present in concentrations above ecological effects concentrations will likely be significantly attenuated and/or diluted in the freshwater and marine environments and present with low risk of adverse effects. Concentrations of EOCs, and hence risks, are not expected to increase for the Short-Term Stage. Further monitoring, through consent conditions is warranted to better understand the risks of EOCs.
- A QMRA assessed mean infection risks, which are summarised as:
  - For watercress consumption, a log reduction of 5 (100,000-fold reduction) is required to reduce the risk of infection to <1% at the Te Puru stream sites. There was little difference in risk between the discharge stages.
  - For swimming, a log reduction of >4 (<10,000-fold) is required to reduce risks to below 1% at Te Puru stream sites. There was little difference in risk between the discharge stages and it was noted that swimming is unlikely at these sites. For marine sites, swimming health risks were low with a log reduction of <2 (<100-fold) required at Kelly's Beach transect sites, and <1 (<10-fold) for those further out in the bay.
  - For shellfish consumption, a log reduction of 1-2 (10-fold to 100-fold) is sufficient to provide a risk of <1% at all marine sites.
  - We note that the QMRA looks at the added risk from the WWTP, there is still existing risks from other sources but these are not part of QMRA.

5.6.3 Effects of Discharges during Long-Term Stage 1

The actual and potential ecological effects of the proposed discharge on the freshwater and marine receiving environment during Long-Term Stage 1 Stage can be summarised as follows:

- The proposed annual average discharge volume limit is 4,800 m^3/day at this stage, compared to the existing annual median for 2023 of 2,038 m^3/day. With this increase in annual average discharge volume the discharge is still likely to result in a low effect on stream bank erosion, and negligible effects on the coastal marine environment.
- Based on monitoring at receiving environment sites occasional low DO in the current discharge does not appear to be impacting on DO in the pond or further downstream. $cBOD_5$ in the current WWTP discharge does not appear to be impacting on receiving environment sites. A maximum proposed operational discharge limit of 5 mg/L for Long-Term Stage 1 is marginally lower than the WWTP discharge in 2023/24 (median 5.7 mg/L). This potential decrease (noting the operational limit is a maximum concentration) is not expected to change the impact significantly on $cBOD_5$ (or DO) in the pond or further downstream.
- The current WWTP discharge is showing minimal effects on water temperature in the farm pond. There are no water temperature standards proposed for the upgraded WWTP discharge, but the proposed discharge during Long-Term Stage 1 is expected to continue to result in low impacts on temperature at downstream sites compared with upstream sites.
- Low pH appears to be more an issue than high pH in the receiving environment. The current WWTP discharge appears to be having negligible impacts on pH at sites downstream and this is expected to remain the same for the proposed discharge during Long-Term Stage 1.
- There is a clear influence of the current Beachlands WWTP discharge on conductivity downstream, with all sites showing conductivity manyfold above the ANZG DGV, indicating a 'potential risk' of adverse effects. Implications of increased conductivity are discussed in for the Current stage and not repeated here. It is expected that conductivity in the proposed discharge will have to low/moderate effects on stream ecology downstream compared with upstream during Long-Term Stage 1. Riparian planting and installation of new pipes for the network along with a trigger for further work on causes should reduce the effects of conductivity.
- The current Beachlands WWTP discharge has consistently low TSS (median 7.8 mg/L) and there appears to be little difference in TSS for the receiving environment sites upstream and downstream of the wastewater discharge. The discharge concentrations under Long-Term Stage 1 (5 mg/L) should see a decrease in TSS of approximate 1.6-fold compared to the existing discharge and contribute to improved water quality downstream of the discharge.
- For ammoniacal-N – and the reasons discussed in relation to the Current stage – we have not estimated ammoniacal-N concentrations downstream under any stage of the proposed WWTP upgrade.
- A maximum operational median limit of nitrate-N concentrations (2.0 mg/L) for Long-Term Stage 1 will likely result in an NPS-FM attribute band A for toxicity at the Bridge site. This is an improvement on the attribute band (B) for the Bridge site currently and would satisfy the requirement for an improvement under the NPS-FM.
- For DIN – and assuming the same attenuation as for nitrate-N – a maximum operational median of 2.5 mg/L for Long-Term Stage 1 would mean a DIN concentration at the Bridge site from the proposed discharge of around 0.8 mg/L, below the accepted threshold for eutrophication and a major improvement on DIN for the Bridge site currently (1.7 mg/L).

- For DRP, a maximum operational median concentration of 0.500 mg/L for Long-Term Stage 1 would mean a DRP concentration at the Bridge site of 0.125 mg/L, resulting in an NPS-FM attribute band D but a decrease of DRP concentration at this site compared to the Bridge site currently (0.182 mg/L (also NPS-FM attribute band D). The proposed median DRP concentrations during Long-Term Stage 1 will contribute to improved water quality downstream compared with the current WWTP discharge, satisfying the intent of the NPS-FM.
- After attenuation through the proposed expanded overland and stream system, TN and TP loads will contribute 45% and 49% of total load from the catchment to the marine coastal environment.
- Risks from bacteria are negligible compared to catchment sources currently and with the future upgrades.
- Although based on only two monitoring events water metal concentrations are currently at 50% or below the ANZG DGV at the Bridge site and would be expected to be the same, or reduced, during Long-Term Stage 1, with the MBR upgrade.
- All sediment metal concentrations are currently and will be expected to be for Long-Term Stage 1, below the ANZG DGV.
- Further monitoring, through consent conditions is warranted to ensure metals are not increasing to above DGVs downstream as a result of the proposed discharge.
- The majority of EOCs will present negligible ecological effects based on measured and literature treated WWTP discharge concentrations. Most of the few EOCs that are present in concentrations above ecological effects concentrations will likely be significantly attenuated and/or diluted in the freshwater and marine environments and present with low risk of adverse effects. Concentrations of EOCs, and hence risks, are not expected to increase for Long-Term Stage 1, and with the MBR upgrade there may be a reduction in concentrations. Further monitoring, through consent conditions is warranted to better understand the risks of EOCs.
- A QMRA for Long-Term Stage 1 upgrade was not undertaken. At the time the QMRA was undertaken there were 3 discharge stages proposed for the WWTP upgrade, with no Long-Term Stage 1 stage. Further, the interim stage (in the QMRA report) terminology was subsequently updated to Short-Term stage. No QMRA modelling has been undertaken for the Long-Term Stage 1 stage with risks, due to the installation of the MBR at Long-Term Stage 1, similar but lower than the Long-Term Stage 2 stage.

5.6.4 Effects of discharges during Long-Term Stage 2

The actual and potential ecological effects of the proposed discharge on the freshwater and marine receiving environment during Long-Term Stage 2 can be summarised as follows:

- The proposed annual average discharge volume is 6,000 m^3/day at this stage, compared to the existing annual median for 2023 of 2,038 m^3/day. With this increase in annual average discharge volume the discharge is still likely to result in a low effect on stream bank erosion, and negligible effects on the coastal marine environment.
- Based on monitoring at receiving environment sites occasional low DO in the current discharge does not appear to be impacting on DO in the pond or further downstream. $cBOD_5$ in the current WWTP discharge also does not appear to be impacting on receiving environment sites. A proposed maximum operational discharge limit of 5 mg/L for Long-

Term Stage 2 is marginally lower than the WWTP discharge in 2023/24 (median 5.7 mg/L). This potential decrease (noting the operational limit is a maximum concentration) is not expected to change significantly on $cBOD_5$ (or DO) in the pond or further downstream.

- The current Beachlands WWTP discharge is showing minimal effects on water temperature in the farm pond. There are no water temperature standards proposed for the upgraded WWTP discharge, but the proposed discharge is expected to result in <u>low</u> impacts on temperature at downstream sites compared with upstream sites.
- Low pH appears to be more an issue than high pH in the receiving environment. The current Beachlands WWTP discharge appears to be having <u>negligible</u> impacts on pH at sites downstream and this is expected to remain the same for the proposed discharge during Long-Term Stage 2.
- There is a clear influence of the current Beachlands WWTP discharge on conductivity downstream, with all sites showing conductivity manyfold above the ANZG DGV, indicating a 'potential risk' of adverse effects. Implications of increased conductivity are discussed in relation to the Current stage and not repeated here. It is expected that conductivity in the proposed discharge will continue to contribute to <u>low/moderate</u> effects on stream ecology downstream compared with upstream during Long-Term Stage 2. Riparian planting and installation of new pipes for the network along with a trigger for further work on causes should also reduce the effects of conductivity.
- The current WWTP discharge has consistently low TSS (median 7.8 mg/L) and there appears to be little difference in TSS for the receiving environment sites upstream and downstream of the wastewater discharge. The discharge concentrations during Long-Term Stage 2 (5 mg/L) should see a decrease in TSS of approximate 1.6-fold compared to the existing discharge and contribute to <u>improved</u> water quality downstream of the discharge.
- For ammoniacal-N – and the reasons discussed in the Current stage – we have not estimated ammoniacal-N concentrations downstream under any stage of the proposed WWTP upgrade.
- A maximum operational median nitrate-N concentration (2.0 mg/L) during Long-Term Stage 2 will likely result in an NPS-FM attribute band A for toxicity at the Bridge site. This is an improvement on the attribute band (B) for the Bridge site currently and would satisfy the requirement for an improvement under the NPS-FM.
- For DIN – and assuming the same attenuation as for nitrate-N – a maximum operational median of 2.5 mg/L during Long-Term Stage 2 would mean a DIN concentration at the Bridge site from the proposed discharge of around 0.8 mg/L, below the accepted threshold for eutrophication and a major improvement on DIN for the Bridge site currently (1.7 mg/L).
- For DRP, a maximum operational median concentration of 0.500 mg/L during Long Term Stage 2 would mean a DRP concentration at the Bridge site of 0.125 mg/L, resulting in an NPS-FM attribute band D but a decrease of DRP concentration at this site compared to the Bridge site currently (0.182 mg/L: also NPS-FM attribute band D). The proposed median DRP concentrations under the Long-Term Stage 2 WWTP upgrade will contribute to improved water quality downstream compared with the current WWTP, satisfying the intent of the NPS-FM.

- After attenuation through the proposed expanded overland and stream system, TN and TP loads will contribute 50% and 54% of total load from the catchment to the marine coastal environment.
- Risks from bacteria are negligible compared to catchment sources currently and with the future upgrades.
- Although based on only two monitoring events water metal concentrations are currently at 50% or below the ANZG DGV at the Bridge site and would be expected to be the same, or reduced, for Long-Term Stage 2, with the MBR upgrade.
- All sediment metal concentrations are currently and will be expected to be for Long-Term Stage 2, below the ANZG DGV.
- Further monitoring, through consent conditions is warranted to ensure metals are not increasing to above DGVs downstream as a result of the proposed discharge.
- The majority of EOCs will present negligible ecological effects based on measured and literature treated WWTP discharge concentrations. Most of the few EOCs that are present in concentrations above ecological effects concentrations will likely be significantly attenuated and/or diluted in the freshwater and marine environments and present with low risk of adverse effects. Concentrations of EOCs, and hence risks, are not expected to increase for Long-Term Stage 2, and with the MBR upgrade there may be a reduction in concentrations. Further monitoring, through consent conditions is warranted to better understand the risks of EOCs.
- A QMRA assessed mean infection risks, which are summarised as:
    - For watercress consumption, a log reduction of 5 (100,000-fold reduction) is required to reduce the risk of infection to <1% at the Te Puru stream sites. There was little difference in risk between the discharge stages.
    - For swimming, a log reduction of >4 (<10,000-fold) is required to reduce risks to below 1% at Te Puru stream sites. There was little difference in risk between the discharge stages and it was noted that swimming is unlikely at these sites. For marine sites, swimming health risks were low with a log reduction of <3 (<1000-fold) required at Kelly's Beach transect sites, and <1 (<10-fold) for those further out in the bay.
    - For shellfish consumption, a log reduction of <2 (<10-fold) is sufficient to provide a risk of <1% at all marine sites.
    - We note that the QMRA looks at the added risk from the WWTP, there is still existing risks from other sources but these are not part of QMRA.

5.6.5 Overall summary and conclusions

- The reference sites upstream provide a basis for considering the existing environment without the input of the WWTP noting that there can be changes in habitat as one moves downstream. The reference sites would be currently classified as degraded based on microbial contaminants and DRP is close to band D. With the WWTP contaminants added downstream the stream would be considered to be degraded on the basis of microbial contaminants, TN, nitrate-N, DIN, DRP and macroinvertebrate indices.
- The intertidal marine community at Kelly's Beach is typical of sheltered beaches around the Auckland region. The only threatened marine species (excluding birds) observed during the survey was seagrass, which was present in three very small patches on the lower shore. The area of seagrass cover is too small to meet the criteria of biogenic habitat.

- Overall, the potential ecological effects of the discharge on the freshwater ecological communities under the four proposed stages can be summarised as follows:
    - The proposed discharge operational limits for the Current and Short-Term Stages will likely result in similar water quality compared to the current water quality results and is highly likely to result in no significant change in the overall macroinvertebrate and fish community downstream compared to the most recent survey results.
    - The proposed discharge operational limits for Long-Term Stages 1 and 2, following the MBR upgrade, will result in an improvement in water quality compared to the current water quality results and is highly likely to result in an improvement in the overall macroinvertebrate and fish community downstream compared to the most recent survey results although the improvements may not be measurable. The overall magnitude of this effect will likely continue to be moderate but the effect from the WWTP cannot be easily separated from other variables (i.e. higher quality riparian vegetation and shading upstream) and stressors (sedimentation and nutrient input from adjacent farmland and side tributaries).
- Overall, the potential ecological effects of the discharge on the coastal marine environment under the 4 Stages covered by the consent application can be summarised as follows:
    - The proposed discharge rates under all four stages will have negligible effects on the salinity and the marine communities of Te Maraetai/Kellys Beach due to the relatively low discharge rates compared to other nearby streams and rivers, the rapid dilution, and the tolerance of intertidal biota to low salinities. There will effectively be no change in salinity under any of the four stages from the existing WWTP.
    - Nitrogen, and to a lesser extent, phosphorus, are the two primary limiting nutrients of concern in coastal waters. Proposed median TN and TP discharge concentrations will be 7 mg/L and 1.0 mg/L for the Current and Short-Term Stages, and 5 mg/L and 0.5 mg/L for Long-Term Stages 1 and 2. The WWTP discharge flow will increase over the term of the consent, therefore concentrations of these nutrients will be diluted (50% percentile) by 13,018× (Current), 1,352× (Short-Term), 831× (Long-Term Stage 1), and 309× (Long-Term stage 2) by the time they reach the Te Puru Stream mouth. This will result in nutrient concentrations being well below background concentrations in coastal waters under all four stages. Given the rapid dilution rate under all four stages, no increase in nutrient concentrations in coastal waters, or related adverse effects from increased nutrients, are likely to occur. Other minor contaminants that are present in the treated wastewater at low concentrations will be diluted at a similar rate to TN and TP. There will effectively be no change from the current WWTP.
    - Potential effects on SEA-M1 site at Te Puru Stream estuary and SEA-M2 site at Te Maraetai/Kellys Beach are anticipated to be low given the level of influence the treated wastewater discharge under all four stages will have on nutrient concentrations and salinity in coastal waters. There will effectively be no change from the existing WWTP.
    - Mean annual attenuated TN and TP loads from the existing WWTP by the time they reach the mouth of the Te Puru Stream are currently 1,979 kg/year and 233 kg/year, respectively. With respect to the proposed discharge:

- For the Short-Term Stage, mean annual attenuated TN loads are estimated to increase 1.6-fold from current to 3,239 kg/year, and mean annual attenuated TP loads are estimated to increase 1.6-fold from current to 382 kg/year.
- For Long-Term Stage 1, mean annual attenuated TN loads are estimated to increase 1.6-fold from current to 3,085 kg/year, and mean annual attenuated TP loads are estimated to increase 1.1-fold from current to 255 kg/year.
- For Long-Term Stage 2, mean annual attenuated TN loads are estimated to increase 1.9-fold from current to 3,856 kg/year, and mean annual attenuated TP loads are estimated to increase 1.4-fold from current to 318 kg/year.

- In comparison, TN loads for the Tamaki River, Wairoa River, Piako River, and Waihou River are around 60,000, 160,000, 1,415,000 and 2,168,000 kg/year, respectively, while TP loads for the Piako River, and Waihou River are 74,000 and 121,000 kg/year, respectively. Given that the estimated loads from the proposed discharge from the expanded and upgraded WWTP represent a very small percentage of the TN and TP loads entering the inner Hauraki Gulf and Firth of Thames, the effects of the increased loads from the proposed discharge for all stages assessed are expected to be less than minor.

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Appendix 1. Summary of analysis of trends between 2018 and 2023 for Beachlands WWTP discharge quality

Meaningful increasing trend = statistically significant AND >1% annual change

Meaningful decreasing trend = statistically significant AND >1% annual change

Parameter	Unit	Method	Seasonal variation	Mean	Max	Min	Median	Kendall statistic	P	Median annual slope	Percent annual change	Likelihood	Trend direction and confidence
Discharge	m^3/day	Seasonal Kendall	0.000	1854	3515	0	1843	-4	0.894	-3.50	-0.2	0.578	Trend unlikely
BOD	mg/L	Seasonal Kendall	0.000	1.6	5.9	0.5	1.3	-10	0.626	-0.02	-1.6	0.687	Decreasing trend about as likely as not
Conductivity	**µS/cm**	**Seasonal Kendall**	**0.000**	**359**	**941**	**64**	**320**	**-77**	**0.000**	**-52.58**	**-16.4**	**1.000**	**Decreasing trend virtually certain**
TSS	**mg/L**	**Mann-Kendall**	**0.254**	**7.5**	**17.0**	**2.5**	**6.9**	**-520**	**0.012**	**-0.51**	**-7.4**	**0.994**	**Decreasing trend very likely**
pH		Seasonal Kendall	0.000	7.0	7.3	6.7	7.0	-75	0.000	-0.03	-0.5	1.000	Decreasing trend virtually certain
DRP	**mg/L**	**Seasonal Kendall**	**0.000**	**0.35**	**0.97**	**0.03**	**0.28**	**84**	**0.000**	**0.07**	**23.5**	**1.000**	**Increasing trend virtually certain**
NO_3-N	**mg/L**	**Mann-Kendall**	**0.058**	**2.09**	**7.10**	**0.02**	**1.18**	**1101**	**0.000**	**0.91**	**77.4**	**1.000**	**Increasing trend virtually certain**
NO_2-N	mg/L	Mann-Kendall	0.089	0.09	1.70	0.02	0.02	188	0.199	0.00	0.0	0.900	Increasing trend possible
NNN	**mg/L**	**Mann-Kendall**	**0.054**	**2.19**	**7.20**	**0.02**	**1.19**	**1090**	**0.000**	**0.92**	**77.9**	**1.000**	**Increasing trend virtually certain**
NH_4-N	mg/L	Seasonal Kendall	0.004	0.54	2.60	0.04	0.40	-53	0.001	0.00	0.0	1.000	Decreasing trend virtually certain
Faecal Coliforms	cfu/100mL	Mann-Kendall	0.281	3	10	2	2	-370	0.025	0.00	0	0.988	Decreasing trend very likely
E. coli	cfu/100mL	Mann-Kendall	0.794	2	5	2	2	-81	0.503	0.00	0	0.754	Decreasing trend about as likely as not

Appendix 2. Summary of analysis of trends for selected parameters between 2020 and 2023 for upstream farm pond and farm pond sites

Site	Parameter	Unit	Method	Seasonal variation	Mean	Max	Min	Median	Kendall statistic	P	Median annual slope	Percent annual change	Likelihood	Trend direction and confidence
Upstream	Temperature	°C	Seasonal Kendall	0.000	17.3	22.7	12.9	16.9	0	1.000	0.033	0.2	0.500	No detectable trend
Upstream	NH_4-N	mg/L	Mann-Kendall	0.633	0.40	0.40	0.40	0.40	0	1.000	0.000	0.0	0.500	No detectable trend
Upstream	NO_3-N	mg/L	Seasonal Kendall	0.014	0.04	0.16	0.02	0.02	-1	1.000	0.000	0.0	0.876	Trend exceptionally unlikely
Upstream	TP	mg/L	Mann-Kendall	0.124	0.09	0.18	0.02	0.07	5	0.856	0.000	0.0	0.572	Trend unlikely
Upstream	DRP	mg/L	Mann-Kendall	0.075	0.025	0.050	0.010	0.023	-3	0.927	0.000	0.0	0.573	Trend extremely unlikely
Downstream	Temperature	°C	Seasonal Kendall	0.000	18.2	23.1	12.6	18.3	0	1.000	0.054	0.3	0.500	No detectable trend
Downstream	NH_4-N	mg/L	Seasonal Kendall	0.032	0.40	0.43	0.40	0.40	1	1.000	0.000	0.0	0.500	Trend exceptionally unlikely
Downstream	NO_3-N	mg/L	Mann-Kendall	0.918	1.57	3.12	0.02	1.68	70	0.002	0.716	42.7	0.999	Increasing trend virtually certain
Downstream	TP	mg/L	Seasonal Kendall	0.010	0.33	0.56	0.10	0.35	1	1.000	0.082	23.3	0.549	Trend exceptionally unlikely
Downstream	DRP	mg/L	Seasonal Kendall	0.006	0.201	0.330	0.030	0.228	3	0.371	0.049	21.6	0.831	Increasing trend about as likely as not