72 Lysnar Road, Upper Orewa, Auckland

Technical Assessment of Environmental Effects of Treated Wastewater Discharge – Milldale WWTP Project

for: Apex Water Ltd

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1 INTRODUCTION

1.1 Background

Apex Water Limited (Apex Water) engaged Babbage Consultants (Babbage) to carry out ecological and environmental baseline investigations at Waterloo Creek and Orewa River. These baseline investigations, conducted in October and November 2024, and January 2025, form the basis of this technical assessment of environmental effects to support a resource consent application for the discharge of treated wastewater from a proposed wastewater treatment plant (WWTP) associated with a residential development at Lysnar Road, Upper Orewa, Auckland.

The proposed residential development involves the capacity for 1,250 houses, with wastewater treated by a WWTP that proposes to discharge to water at Waterloo Creek. However, for the scope of this report and assessment, the proposed wastewater treatment plant (WWTP) is the main focus, and the plant related area is referred to as the 'Site'.

This technical assessment of environmental effects focuses on potential scenarios of treated wastewater discharges, where different conditions and rates are discharged to Waterloo Creek, potentially affecting the current environmental conditions to some degree.

Babbage has conducted baseline biological and environmental monitoring and prepared this report to outline the biological and water quality characteristics of Waterloo Creek and the Orewa River estuary, as well as to assess the potential effects of the WWTP on the receiving environment.

1.2 Purpose and Scope

This technical report has been prepared to support the resource consent application prepared by Woods-Fulton Hogan Land Development, on behalf of Apex Water, for the proposed WWTP discharge in the Waterloo Creek. It is structured as follows:

- Section 2 describes the Site and surrounding environment including the Waterloo Creek, and the adjacent Orewa River estuary.
- Section 3 provides the baseline biological and water quality monitoring results along with the data quality assessment that supports the proposed discharge.
- Section 4 provides an overview of the proposed development, including the characteristics of the proposed discharge.
- Section 5 provides the outcome of the surface water quality modelling with proposed method and assumptions, and modelled results.
- Section 6 presents a technical assessment of the effects of the discharge on receiving water quality and outcomes associated with the discharge on both receiving waters and ecological values.

- Section 7 outlines proposed consent conditions which shall support the management of the proposed development.
- Section 8 presents a summary and concludes on the findings of the assessment of effects.

2 SITE AND SURROUNDING ENVIRONMENT

2.1 Site Location and Surrounding Land Use

The proposed Site is a section of the property located on the northern side of Lysnar Road and adjacent to Waterloo Creek to the east within a rural/residential area (Refer to Figure 1) north of Milldale and west of Silverdale in the North Shore of Auckland.

Table 1. Site identification.

Address	Legal description	Area in hectares (ha)
Lot 4 DP 353309, Wainui Road Upper Orewa 0992	Lot 4 DP 353309	10.4451

Note: Source – Auckland Regional Council GeoMaps website[1].

State Highway 1 is located approximately 800 m to the east, and the Northridge Golf Resort approximately 700 m to the north of the Site. A new residential development is under construction to the south of the Site.

The surrounding area is relatively flat sloping down approximately 8 m across the site towards Waterloo Creek to the east.

2.2 Geology and Hydrogeology

Published geological information from the 1:250k GNS[2] geological map shows the Site to be underlain by late Pleistocene alluvium/colluvium and fan deposits (lQa) of Tauranga Group. The alluvium/colluvium youngest deposits typically consist of organic silts and clays and is found bordering watercourses and gullies. These sediments are also present in hillslope and low-lying coastal areas that interfinger with volcanic fields.

The bore logs from hand augers carried out on-site and nearby by CMW Geosciences in October 2020 (obtained from the NZGD website) confirmed the presence of alluvial soil. At the site, the water level was measured at RL 4.3 m from a ground elevation of RL 7 m, indicating a likely connection between the groundwater and surface water from Waterloo Creek (RL 3 m based on Auckland Geomaps).

According to Geomaps, the Site is underlain by the Orewa Waitemata aquifer, which is not considered to be a high-use or quality-sensitive aquifer in this area.

[1] Auckland Council GeoMaps 14 January 2025. Retrieved from https://geomapspublic.aucklandcouncil.govt.nz/viewer/index.html

[2] GNS Science 14 January 2025. Retrieved from https://data.gns.cri.nz/geology/

2.3 Hydrology

Auckland Council Geomaps shows that a series of overland flow paths are present within and adjacent to the Site with an overland flow path present running west to east across the central section of the Site and flow paths running west to east along both the northern and southern boundaries of the Site, flowing into Waterloo Creek. Flood plains are also indicated at the Site and at property boundaries with the majority of them following the overland flow paths directions. Geomaps also shows that the residential development directly to the south of the Site is overlayed by stormwater management plan (SMP), which indicates that Auckland Council Healthy Waters holds a consent for diversion and discharge of stormwater based on SMP criteria.

The Waterloo Creek discharges into the Orewa River to the north of the Site, which discharges to Orewa Beach and Puawai Bay. As Waterloo Creek is a permanent watercourse, it would be expected to constantly discharge into the Orewa River and maintain a flow through the year.

A series of overland flow paths are shown to be present within and adjacent to the Site with an overland flow path present running west to east across the central section of the site and flow paths running west to east along both the northern and southern boundaries of the site, flowing into Waterloo Creek.

2.4 Other Significant Features

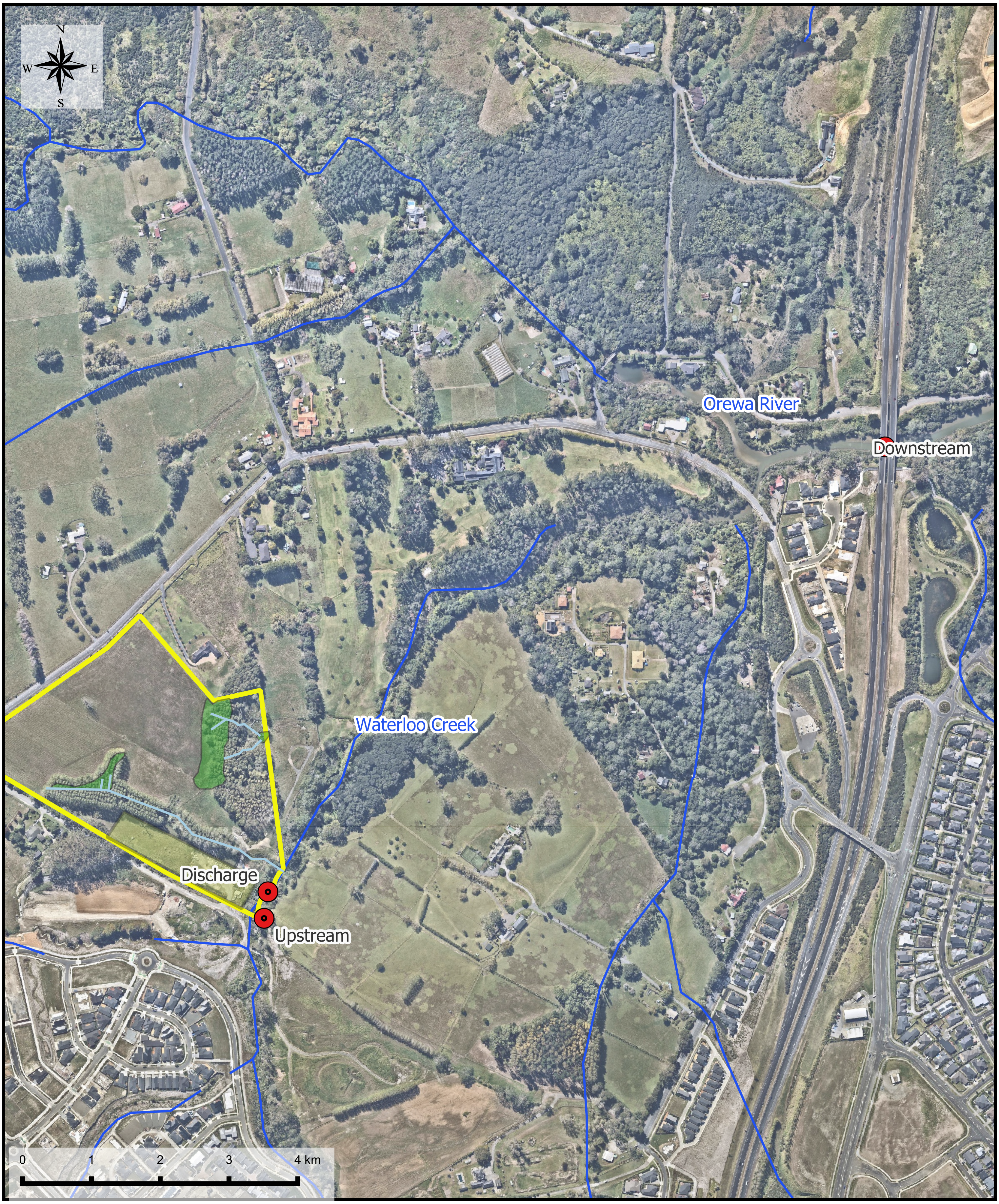
The following additional environmental features are described around the Site based on the ecological assessment completed by RMA Ecology[3].

The intermittent stream north of the Site is described as having abundant bank erosion and sediment deposition and is indicated to be of poor quality.

Vegetation surrounding the stream area at the Site is described to comprise of Tasmanian Blackwood with dense gorse/ young brush wattle and blackberry. The vegetation is described as not qualifying as indigenous vegetation.

Maps from Viridis and Woods provided to Babbage (Refer to Figure 1 for wetland locations) show three areas of wetland within the property to the north and west of the Site. No descriptions of these wetland areas were available at the time of reporting.

[3] RMA Ecology 2019, Milldale Wastewater Transmission Line: Wainui to Lysnar Road: Ecological Effects Assessment created for Fulton Hogan Land Development Ltd. Job 1811.100.



67717 **Figure 1** **v1** Apex Water Ltd

Site Map with Proposed WWTP Area and Environmental Features

SCALE **@ A4 1:7,200**

Milldale Wastewater Discharge

5 February 2025 ARB

Aerial image from Nearmap.com

SOURCES

Road and Legal data: QuickMap v7.5.185

Aerial Photography: LINZ Online Database

Legend

- Site Layout
- Sampling Locations
- Intermittent Streams
- Wetland
- Property Boundary

Babbage®

DISCLAIMER:
This map/plan is not an engineering draft.
This map/plan is illustrative only and all information should be independently verified on site before taking any action.

3 BASELINE ASSESSMENTS

3.1 Environmental Assessments Methodologies

The environmental assessment methodology focusses on the investigation of the Waterloo Creek (at two sites) and the downstream receiving Orewa River's current conditions (baseline) to support the assessment of environmental effects related to the proposed treated discharges to these watercourses. It involves field assessments associated with biological components, hydrology and water quality during three sampling rounds undertaken in October and November 2024 and January 2025. Refer to Figure 2 for sampling locations.

The reports with details of methodologies and results for each of sampling rounds are included in the **Appendix A**.

3.1.1 Biological Assessment

Biological and visual monitoring was conducted at both an upstream control site and a downstream impact site in Waterloo Creek (freshwater sites), along with one site in the Orewa River (estuarine site). The aim was to collect baseline data for the watercourses prior to any potential effects from future discharges. This monitoring included:

- Visual estimates of in-stream and riparian habitat;
- Visual and qualitative assessment of periphyton coverage and composition;
- Benthic macroinvertebrate sample collection and identification; and
- General observations of surface water appearance and sampling conditions.

In the absence of specific consent limits, biomonitoring results were compared against relevant standards and guidelines to assess general stream health. Full details of the biomonitoring methodology can be found in Appendix A.

3.1.2 Biological Assessment Sites

Visual and biological assessments were undertaken on the Waterloo Creek (upstream and impact sites) which is considered a freshwater stream. An assessment was also undertaken on the Orewa River (downstream site), which is classified as an estuarine system. A description of the sites is provided in Table 2 and displayed in Figure 2.

Waterloo Creek discharges into the Orewa River, which then flows to the sea. The upstream site (WUp) represents baseline and control conditions upstream of the discharge point, including contributions from an unnamed tributary flowing from the west side of the proposed WWTP position. The downstream location (Wimp) represents the baseline conditions directly downstream of proposed discharge point. The downstream site (ODown) is on the Orewa River, influenced by the estuary (seawater) and contributions from the upstream Orewa River catchment.

Figure 2: Overview of the biomonitoring locations along the Waterloo Creek and Orewa River, relative to the proposed discharge outlet.

Table 2. Locations for each watercourse monitoring site.

Watercourse name	Site name	Watercourse Type	Sampling date	Site type	Coordinates	
					Southing	Easting
Waterloo Creek	WUp	Freshwater	17 October 2024	Control	1747790	5947683
Waterloo Creek	WImp	Freshwater	17 October 2024	Impact	1747803	5947733
Orewa River	ODown	Marine	23 October 2024	Impact	1748703	5948381

3.1.3 Biological Assessment Aspects

3.1.3.1 Habitat Characteristics

General aquatic and riparian habitat characteristics were assessed at each monitoring site and included estimates of stream width, depth, streambed substrate, habitat type (i.e. run, riffle and pool), erosion, shading, riparian characteristics, periphyton cover and aquatic plant cover.

3.1.3.2 Stream Physiochemistry

Water temperature, conductivity, dissolved oxygen (DO) concentration and pH were measured by Babbage during the water quality and biological surveys. The results were compared to relevant water quality guidelines, as discussed in the Section 3.2.3.

Australian & New Zealand Guidelines for fresh & marine water quality default guideline values (ANZG, 2018), which succeeded ANZECC (2000), provides generic default guideline values (DGV) (as 80th percentiles) for chemical and physical stressors that indicate marginal water quality for supporting ecosystem health.

3.1.3.3 Macroinvertebrates

3.1.3.3.1 Freshwater macroinvertebrate sampling

Macroinvertebrates were sampled from instream habitats to obtain semi-quantitative data in accordance with the Ministry for the Environment's current "Protocols for Sampling Macroinvertebrates in Wadeable Streams" (Stark *et al.* 2001). Sampling was undertaken using protocol 'C2: soft-bottomed, semi-quantitative' as the sites were predominantly soft bottomed (WUp and WImp). The Macroinvertebrate sample was preserved in 70% ethyl alcohol (ethanol), returned to the laboratory and sorted (using protocol 'P3: full count with sub-sampling option' (Stark *et al.* 2001)). Macroinvertebrates were then identified to the lowest practicable level and counted to enable biotic indices to be calculated.

Benthic macroinvertebrates were identified and counted to a level suitable for calculating taxa richness, abundance, EPT taxa richness and % EPT, macroinvertebrate community index (MCI) and quantitative MCI (QMCI) following protocols outlined in Stark *et al.* (2001). EPT refers to taxa that belong to the Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies) taxonomic groups.

Taxa richness is a measure of the number of invertebrate taxa in a sample. In general, streams supporting a high number of invertebrate taxa are more likely to be of a higher environmental quality than streams with few taxa present. However, interpretation of taxa number data as an environmental indicator is dependent on the pollution sensitivity or tolerance of taxa present.

Abundance is a measure of the total number of invertebrates in a sample. Invertebrate abundance tends to increase in the presence of organic or nutrient enrichment and decreases in the presence of toxic contaminants. Abundance can be a useful measure for comparison between sites but can be highly variable.

EPT taxa are generally sensitive to changes in water and habitat quality. Percent EPT (%EPT) is a measure of the proportion of EPT taxa making up the community. EPT and % EPT values[4] can provide a good

[4] The caddisflies *Oxyethira* and *Paroxyethira* are not sensitive to nutrient enrichment so are excluded from EPT calculations.

indication of stream health, with high values indicating good water/habitat quality and low values indicating poor water/habitat quality.

The MCI and QMCI (Stark & Maxted 2007) are biological indices that are based on indicator scores between 1 and 10, which are assigned to each taxon based on their sensitivity to organic enrichment. Although developed to assess nutrient enrichment, these scores are now used to assess the general health of New Zealand streams. MCI scores are based on presence/absence data, while the QMCI also uses abundance data. Higher MCI and QMCI indicate better habitat quality (and as such better water quality) with scores interpreted using the thresholds and classes provided in Table 3 (Stark & Maxted 2007).

Table 3. Estimates of stream health using MCI and QMCI indices (Stark & Maxted 2007).

Quality class	MCI	QMCI
Excellent	>119	>5.99
Good	100-119	5.00-5.99
Fair	80-99	4.00-4.99
Poor	<80	<4.00

The Auckland Unitary Plan (AUP), Chapter E1.3, provides additional MCI values criteria, AUP Table E1.3.10, for freshwater ecosystem health associated with various land uses within catchments (Table 4). Policy E1.3(2) mandates the management of discharges that could potentially impact freshwater systems to maintain or improve water quality, flow rates, stream channels, margins, and other freshwater values. This policy applies when the current condition is either above (for maintenance) or below (for enhancement) the National Policy Statement for Freshwater Management (NPS-FM) National Bottom Lines and the relevant MCI guidelines.

Table 4. MCI guideline for Auckland rivers and streams as per AUP Policy E1.3(2)

Land use	MCI guideline
Native forest	123
Exotic forest	111
Rural areas	94
*Urban areas	68

*MCI guideline applicable to the Milldale catchment

3.1.3.3.2 Marine macroinvertebrate sampling

In New Zealand's marine environment, macroinvertebrate sampling protocols are tailored to assess benthic (seafloor) communities, which are essential indicators of ecosystem health. Sampling position at the site is chosen based on habitat type (e.g., intertidal, subtidal) and exposure levels. Representative sampling across different substrate types, such as sandy or muddy areas, is prioritized to capture diversity.

Core sampling was employed as the primary method, utilizing cylindrical cores inserted into the sediment to a standard depth (typically 10–15 cm). This approach captures macroinvertebrates along with the substrate for subsequent analysis. In the field, sediment samples were sieved through a 0.5 mm mesh using seawater, separating invertebrates from the sediment matrix. Retained material was transferred to zip-lock bags and preserved using a solution of 5% glyoxal, 70% ethanol, and seawater to fix the animal tissues effectively. Each sample bag was placed into an additional zip-lock bag and stored in a plastic container to prevent leakage during transport.

In the laboratory, samples were rinsed thoroughly after a minimum of one week of fixation in glyoxal. Biota were then carefully sorted and identified by an experienced benthic taxonomist (Rod Asher, Biolive, Nelson), to the lowest practicable taxonomic level (typically species or genus). Individuals were enumerated to provide quantitative data. Abundance, diversity, and community composition were analysed to assess the ecological health of the benthic environment.

3.1.4 Water Quality Assessment Aspects

3.1.4.1 Sampling locations

Water quality monitoring was conducted at three locations established to assess the water quality of Waterloo Creek as baseline assessment and to assess potential condition of treated wastewater discharge. The three sampling locations were the same used for the biological assessment as shown in Figure 2 to associate the water quality and biological results. Based on this, water samples were collected from Waterloo Creek upstream (sample labelled as "Upstream"), at proposed discharge point (labelled as "Discharge") and downstream at Orewa River/estuary (labelled as "Downstream"). Water sampling was conducted in 17 October, 21 November 2024 and 21 January 2025.

3.1.4.2 Sampling methodology, analytical parameters, and conditions

Water analytes were selected to evaluate the current water quality conditions in response to external anthropogenic discharges associated with agricultural activities, residential stormwater and wastewater, which include the following parameters: nitrate, nitrite, total Kjeldahl nitrogen (TKN), nitrogen ammoniacal, total nitrogen (TN), dissolved reactive phosphorus (DRP), total phosphorus (TP), soluble carbonaceous biochemical oxygen demand (cBOD5), faecal coliforms, E. coli, enterococci, total suspended solids (TSS), turbidity and pH.

Surface water samples were collected directly into laboratory-prepared bottles using a mighty-gripper. Field parameters, including water temperature, pH, dissolved oxygen (DO), oxidation-reduction potential

(ORP), specific conductance (electrical conductivity (EC) at 25 °C) were measured on-site for each sample location.

Surface water samples were kept on ice and sent to Analytica Laboratories in Hamilton with a chain of custody documentation.

3.1.5 Hydrology Assessment Aspects

As part of this methodology, changes in water depth and water temperature were monitored using a Solinst Levelogger 5 (levelogger) instrument placed at the Discharge location (refer to Figure 1). This assessment can indicate the variation range of water depth and the influence of rainfall and dry periods on stream hydrology. All results have been interpreted by a suitably qualified and experienced professional.

This instrument also measures water temperature, which is an important parameter for discharges. The temperature of the receiving water body must not change by more than 3°C when mixed with the discharge to avoid potentially affecting the natural environment.

During the water quality monitoring, flow rate measurement using flow tracker 2 instrument at the Discharge location were included in the hydrology work to verify field data against the modelling data available on the NZ River Maps – NIWA website[5].

3.2 Baseline Assessments Results

3.2.1 Habitat Characteristics – Freshwater Sites

3.2.1.1 Waterloo Creek – Upstream site (WUp)

The Waterloo Creek upstream site (WUp), situated upstream of the proposed discharge point, exhibits a relatively uniform habitat dominated by run-type flow (85%), with a short chute comprising the remaining 15%. The streambed primarily consists of silt and sand, categorizing this as a soft-bottomed stream. Average water depth during the survey was 0.5 m, and the wetted width was 2.6 m.

Riparian vegetation includes exotic *Elaeagnus x reflexa*, rank grasses, and tree privet (*Ligustrum lucidum*), with scattered native vegetation such as cabbage trees (*Cordyline australis*) and tree ferns. A single crack willow (*Salix fragilis × S. euxina*) partially shades the channel. While minor bank erosion was noted, the banks were predominantly stable. Macrophyte coverage within the channel was limited (<3%), with sparse patches of water starwort (*Callitriche stagnalis*) and water purslane (*Ludwigia palustris*). No periphyton was observed, likely due to type of river substrate (sand and silt stream bed) and shaded areas not allowing the presence of algae communities.

[5] Niwa 2022. NZ River Maps retrieved from: https://shiny.niwa.co.nz/nzrivermaps/.

Figure 3. Overview of the downstream reach of the WUp site, looking upstream (left) and downstream (right).

Figure 4. Overview of the upstream reach of the WUp site, looking upstream (left) and downstream (right).

3.2.1.2 Waterloo Creek – Impact site (WImp)

The impact site (WImp), located downstream of the proposed discharge point, exhibits a run habitat with slightly more substrate variability compared to WUp. The streambed is primarily composed of silt and sand with some gravel. When disturbed, silt plumes were visible, reinforcing the soft-bottomed classification. Average water depth was 0.2 m, and the wetted width was 2.3 m.

Riparian vegetation at this site features a mix of exotic species, dominated by tree privet. A fallen pine tree spans the stream, with minor bank erosion and flood debris observed on the true left bank. Macrophyte coverage remained sparse (<5%), with water starwort, water purslane, water celery (*Helosciadium nodiflorum*), and water forget-me-not (*Myosotis laxa*) recorded. Minimal periphyton (<0.5%) was present as green filaments along a single transect (less than 0.5% cover).

Figure 5. Overview of the downstream reach of the WImp site, looking downstream (left) and upstream (right).

Figure 6. Overview of the upstream reach of the WImp site, looking upstream (left) and downstream (right).

3.2.1.3 Benthic invertebrates

A summary of the benthic macroinvertebrate data is presented in Table 5, and the raw data are presented in **Appendix B**.

In both Waterloo Creek sites, macroinvertebrate communities were overwhelmingly dominated by *Potamopyrgus antipodarum* (New Zealand mud snail), with this species comprising 94% of the community at the upstream site (WUp) and 98% at the impact site (WImp). Other taxa made up only 6% and 2% of the communities at WUp and WImp, respectively. Notably, no pollution-sensitive taxa (from the Ephemeroptera, Plecoptera, and Trichoptera (EPT) groups) were recorded at either site. This absence of EPT taxa, which are indicators of good water quality, highlights the degraded ecological condition of the creek.

The Macroinvertebrate Community Index (MCI) scores at both freshwater sites were classified as 'Poor,' with values of 46 at WUp and 54 at WImp. The slightly higher score at WImp may reflect the marginally greater taxonomic richness observed at this site (9 taxa compared to 7 at WUp), though this increase was not sufficient to improve the classification.

Similarly, the Quantitative Macroinvertebrate Community Index (QMCI) scores, which consider the abundance of taxa, were also classified as 'Poor' at both sites (2.03 at WUp and 2.06 at WImp), further reflecting the dominance of pollutant-tolerant species *Potamopyrgus*.

Potamopyrgus thrives in disturbed environments with elevated nutrient levels and thicker algal growth (albeit absent from the Waterloo Creek sites), conditions often associated with increased light penetration and nutrient inputs from surrounding land use. The near-monoculture of this species suggests that the creek lack habitat complexity or suitable conditions to support a more diverse and sensitive invertebrate community.

The difference in community composition between WUp and WImp are negligible, and could reflect subtle differences in habitat or water quality, potentially influenced by localized inputs or flow conditions. However, both sites indicate a highly degraded system overall, with limited ecological functionality.

These results highlight the potential vulnerability of the creek to further degradation. The lack of pollution-sensitive taxa and the dominance of a single, tolerant species suggest that the creek is already under stress, likely from land use activities in the catchment, such as agricultural runoff or urban inputs.

In summary, macroinvertebrate communities at Waterloo Creek reflect a waterbody in poor ecological health, as indicated by low MCI and QMCI scores, absence of EPT taxa, and high dominance of freshwater mud snails.

3.2.1.3.1 MCI Guidelines in the AUP(OP) and NPS-FM

The MCI score at both sites is also below the guideline value (MCI = 68) for Auckland rivers and streams in urban areas as per AUP Policy E1.3(2).

Chapter E1 of the AUP(OP) identifies, that where freshwater quality is degraded, that it be maintained or enhanced over time and that the MCI score be used as a 'guideline' or indicator of freshwater ecosystem health. Policy E1.3.(2) presents MCI guidelines in Table E1.3.1 for streams draining various land uses (Table 4). The NPS-FM has a 'national bottom line' MCI score of 90 in wadeable streams to protect ecosystem health. Policy E1.3 requires the maintenance or enhancement of water quality, flows, stream channels and their margins and other freshwater values where the current condition is above NPS-FM bottom line (MCI = 90) and the relevant MCI guideline in the AUP(OP) (based on land use) or enhance if it is below the NPS-FM or the relevant AUP guideline. The MCI scores for the Waterloo Creek does not currently meet the AUP(OP) guideline for urban land use or the NPS-FM bottom line of > 90. Water quality, flow, stream channel and margins and other freshwater values are required to be enhanced to achieve the NPS-FM bottom line value of MCI >90.

3.2.1.4 Summary of freshwater site characteristics

A summary of the physical characteristics is provided in the Table 5 below.

Table 5. Summary of the physical characteristics and biological survey results of the Waterloo Creek

Site	Upstream / WUp	Impact /WImp
Survey date	17 Oct 2024	17 Oct 2024
Habitat		
Average Width (m)	2.6	2.3
Average Depth (m)	0.5	0.2
Dominant substrate	Silt & sand	Silt & sand, gravels
Macrophytes and Algae		
No. of Taxa	2	2
Average % Cover	Less than 3%	Less than 5%
Species Recorded	Water starwort and water purslane	Water starwort and water purslane
Benthic macroinvertebrates		
Number of taxa	7	9
Number of EPT taxa	0	0
Number of individuals	1694	2112
% Dominance of *Potamopyrgus antipodarum*	94	98
MCI	46	54
	Poor	Poor
SQMCI	2.03	2.06
	Poor	Poor

3.2.2 Habitat Characteristics – Marine Site

3.2.2.1 Orewa River – Downstream site (ODown)

Approximately 1.3 km downstream of WImp, this site lies within a tidally influenced section of the Orewa River. The channel width measures ~26 m, with depths varying throughout the tidal cycle. The low-tide channel is positioned centrally to the side embankments.

A site assessment of the intertidal area was conducted at low tide on 23 October 2024. The vegetation along the true right bank (above the high-water mark) is dominated by mangroves (*Avicennia marina* subsp. *australasica*). On the true left bank, mangroves are also present above the high-water mark, alongside a range of planted native species, including māhoe (*Melicytus ramiflorus* subsp. *ramiflorus*), mānuka (*Leptospermum scoparium var. scoparium*), and red māpou (*Myrsine australis*). Intertidal areas, exposed at low tide, are characterized by mangrove pneumatophores and prevalent tunnelling mud crab (*Austrohelice crassa*) holes. No vegetation was observed in submerged areas below the high-water level.

Figure 7. Overview of the ODown site on the Orewa River, looking upstream (left) and downstream (right).

Figure 8. Overview of the vegetation of the Orewa River site along its true left bank, comprising planted natives; mature pine trees are along both embankments.

3.2.2.2 Benthic macroinvertebrates

The benthic biota composition sampled along the Orewa River is summarized in Table 6, highlighting the primary taxa. The samples were taken along the stream channel (5 core samples) and within the intertidal zone (5 core samples). From the benthic samples, a total of 13 taxa were identified, comprising 115 invertebrate individuals. Polychaetes represented the dominant group, accounting for 52% of all individuals recorded in the core samples. Within this group, juvenile Nereidae (31%) and *Perinereis vallata* (14%) were the most abundant taxa.

Another significant taxon was the endemic tunnelling mud crab, *Austrohelice crassa*, contributing 36% of the total abundance. The relatively high densities of these species suggest elevated organic material inputs, likely stemming from natural detritus, runoff, or mild anthropogenic sources, which support scavengers and deposit feeders. The dominance of opportunistic species, such as juvenile Nereidae, indicates potential disturbance, such as sediment turnover or moderate pollution. However, the concurrent abundance of more sensitive taxa like *Perinereis vallata* suggests that these disturbances are not severe.

Sediment conditions in the area appear to be predominantly muddy or fine-grained, creating a suitable habitat for burrowing species such as the tunnelling mud crab. While the presence of opportunistic taxa signals possible enrichment or disturbance, this requires ongoing monitoring to better understand and manage site conditions.

The diversity across the samples was generally low, with Shannon-Wiener diversity indices ranging from 0.69 to 1.43 and species richness varying between 2 and 5 taxa per sample. This low diversity is likely influenced by substantial freshwater discharge from multiple streams in the area (such as the Waterloo Creek). While several of the identified taxa are endemic to New Zealand, they are commonly distributed across the country.

Table 6. Summary of the macrofauna identified at Orewa River site (ODown).

Phylum	Taxa	Name	All samples	
			Total No.	**% Total**
Annelida	Polychaeta: Nereididae	*Ceratonereis* sp.	1	0.87
		Nereidae (juvenile)	36	31.30
		*Perinereis vallata**	17	14.78
	Polychaeta: Spionidae	*Boccardia* sp.	1	0.87
		*Scolecolepides benhami**	5	4.35
Arthropoda	Amphipoda	Corophiidae	8	6.96
		Phoxocephalidae	1	0.87
		Amphipoda Unid.	1	0.87
	Decapoda	*Austrohelice crassa**	41	35.65
		Palaemon affinis	1	0.87
	Insecta	Dolichopodidae larvae	1	0.87
Mollusca	Gastropoda	*Amphibola crenata**	1	0.87
	Bivalvia	*Xenostrobus neozelanicus**	1	0.87

*Denotes endemic taxa to New Zealand.

3.2.3 Water Quality Results – Freshwater and Marine Sites

The analytical results of water samples for three sampling rounds and their respective trigger levels are provided in Table 7 below (laboratory analytical reports are included in **Appendix C**). Guidelines used in Table 7 are set by:

- Australian and New Zealand guidelines for fresh and marine water quality (ANZG 2018) default guideline values (DGV) for lowland river in a warm-wet climate (such as the Waterloo Creek). Classifications were obtained from the New Zealand River Environmental Classification (REC) database (NIWA 2004).
- Australian and New Zealand guidelines for fresh and marine water quality (ANZECC 2000)- Table 3.3.2 for Estuaries Default Trigger Values.
- National Policy Statement for Freshwater Management (NPSFM 2020) – National Bottom Line (NBL).
- Water Quality Guidelines No. 1: Guidelines for the Control of Undesirable Biological Growths in Water (MfE 1992) specifically for $cBOD_5$.

The key findings are described as follows:

3.2.3.1 Physiochemistry Results

Freshwater Sites (Discharge and Upstream locations at Waterloo Creek):

- The pH of the Discharge site (7.46-7.66) was within the ANZG DGV (7.3-7.7) for all three sampling rounds, whereas the Upstream results (7.08-7.75) were slightly outside the ANZG DGV range during the first and second rounds. The pH from both sites was generally circumneutral (around a pH of 7) with minimal difference between them, suggesting stable conditions along the stream.
- The specific conductivity values at both sites on Waterloo Creek exceeded the ANZG guideline value of 115 µS/cm for all sampling rounds. These relatively high conductivity values (above 500 µS/cm) for freshwater may reflect seawater influence due to the proximity to the estuary but can also be associated with dissolved ions originating from catchment area runoff.
- The dissolved oxygen (DO) measured values ranged from 91% to 108% throughout the sampling rounds, with higher values recorded at the Upstream site, likely due to aeration caused by the junction with an unnamed tributary that runs beside Lysnar Road. Despite all Upstream DO results being outside the ANZG DGV range (92-103%), and also the last from the Discharge point, both sites are considered within attribute state A according to the NPSFM (≥ 8 mg/L). This indicates a sufficient amount of oxygen dissolved in the water for aquatic organisms to assist in breakdown nutrients and harmful gases like ammonia.

Marine Site (Downstream location at Orewa River/Estuary):

- The pH of Downstream site ranged from 7.39 and 7.64, which indicates low variation and within the ANZECC guidelines values (7-8.5). These pH results were also within the range of freshwater results, the main source of discharges, and generally circumneutral (about a pH of 7) indicating stable pH conditions along the stream and estuary.
- The specific conductivity at the Downstream site was representative of estuarine environmental, with high levels due to seawater inflow.
- The DO levels ranged from 76% to 93%, which were below the measured levels at upstream sites but within the ANZECC range (80%-110%), except on the first sampling round. This difference between both environments is due to higher temperature and salinity at Downstream site (DO solubility decrease as temperature and salinity increase). Saltwater holds about 20% less dissolved oxygen than freshwater at same pressure and temperature conditions.

3.2.3.2 Clarity Results

Freshwater Sites (Discharge and Upstream locations at Waterloo Creek):

Turbidity quantifies the extent to which water loses its transparency due to the presence of suspended particulates. Total suspended solids (TSS) provide a quantitative measure of these particulates. Together, these parameters offer a technical assessment of water clarity, indicating the concentration of particulate matter that can affect light penetration and overall water quality.

Despite the Waterloo Creek soft-bottom stream, with natural levels of fine sediment in the substrate, the turbidity was generally elevated, ranging from 11 to 26 NTU, and above the ANZG DGV (5.2 NTU). This was particularly evident in the third sampling round, which was conducted during heavy rain, leading to increased runoff inflows and likely sediment discharges. TSS results followed a similar pattern, exceeding the ANZG (2018) DGV of 8.8 g/m^3, with higher values recorded in the third sampling round.

Marine Site (Downstream location at Orewa River/Estuary):

The turbidity at the downstream site was usually lower than at the freshwater sites, except for an unusual high result in the second sampling round. Despite the generally lower values compared to the upstream sites, the downstream site exceeded the water quality index (WQI) of 10 NTU (Ingley 2020) used by Auckland Council during the rainy sampling rounds (second and third rounds).

3.2.3.3 Nutrients Results

Freshwater Sites (Discharge and Upstream locations at Waterloo Creek):

Nitrogen and phosphorus are essential nutrients for aquatic ecosystems, supporting plant and algae growth. However, excess levels can be harmful, with ammoniacal nitrogen being particularly toxic to aquatic life. High nutrient levels can lead to eutrophication, causing oxygen depletion and harmful algal blooms.

The guidelines values for nutrients are presented in Table 7. The NPSFM NBL values for ammoniacal and nitrate nitrogen protect freshwater biota from toxicity. In contrast, the ANZG DGV values for these and other nutrients prevent excessive algal growth, which can deplete oxygen and harm aquatic life and plant.

The key findings from the freshwater nutrients results were:

- Nitrate concentrations ranged from 0.188 g/m^3 to 0.416 g/m^3 throughout the sampling rounds, with all monitored sites falling within Attribute State A. This means that it is *"...Unlikely to be effects even on sensitive species*". Nonetheless, the results of monitored locations exceeded the ANZG guidelines of 0.065 g/m^3 (80th percentile) for WWLE river.
- Total nitrogen (TN) ranged from 0.81 g/m^3 to 1 g/m^3 and also exceed ANZG guidelines from all sampling rounds. Higher Total Kjeldahl Nitrogen (TKN) suggests that most of the nitrogen is in the form of organic nitrogen compounds, such as proteins and amino acids (i.e. plant and animal debris, agricultural runoff), rather than inorganic forms like nitrate.
- Ammoniacal nitrogen was not detected throughout the sampling rounds indicating that ammonium/ammonia is quickly being converted to nitrite and nitrate through the process of nitrification.
- Total phosphorus (TP) concentrations ranged from 0.037 g/m^3 to 0.13 g/m^3, exceeding ANZG guidelines in all sampling rounds. However, the low concentrations of dissolved reactive phosphorus (DRP), ranging from 0.005 g/m^3 to 0.009 g/m^3, were below the ANZG guideline values (0.014 g/m^3) and within the NPS-FM attribute state A (95% percentile below 0.021 g/m^3). This suggests that the TP exceedances are more likely associated with natural sources (e.g: erosion) rather than anthropogenic (e.g.: fertilizer use), as evidenced by the last sampling round where TP levels were highest due to increased rainfall runoff, but DRP levels remained low.

In summary, some degree of chemical stress was identified in Waterloo Creek due to nutrient and sediment discharges associated with its catchment. Despite this, the results remain well below the NBL, with nutrient levels still within the attribute State A of the NPSFM indicating relatively healthy condition.

Marine Site (Downstream location at Orewa River/Estuary):

The key findings from the marine nutrients results were:

- Nitrate concentrations ranged from 0.005 g/m^3 to 0.251 g/m^3 throughout the sampling rounds. These results were well below the freshwater levels and likely due to denitrification process.
- Ammoniacal nitrogen was detected in all sampling round (ranging from 0.005 to 0.009 g/m^3), however with concentrations below the ANZECC guideline (0.015 g/m^3).

- TN concentrations, ranging from 0.42 g/m³ to 0.94 g/m³, exceeded the ANZECC guidelines (0.3 g/m³). This was particularly evident during the last sampling round, where increased rainfall runoff led to higher nutrient discharge at the Downstream site.
- TP results ranged from 0.025 g/m³ to 0.074 g/m³ with the last two sampling rounds exceeding the ANZG guidelines (0.03 g/m³). DRP (ranging from 0.003 g/m³ to 0.004 g/m³) remained below the ANZECC guidelines (0.005 g/m³) and relatively stabilised.

At the Downstream site, some degree level of chemical stress was also identified due to nutrient and sediment discharges from the upstream stream. However, this stress was less intense compared to the freshwater sites.

3.2.3.4 Microbiology

Freshwater Sites (Discharge and Upstream locations at Waterloo Creek):

- E. coli is a bacterial indicator used to detect faecal contamination and evaluate the risk of waterborne diseases. Results from the freshwater sampling locations indicated that E. coli levels (ranging from 1100 cfu/100mL to 4000 cfu/100mL) fall between Attribute State D or E (NPS-FM), meaning that the predicted average infection risk is above >3% and >7%, respectively. The results were also above the NPSFM NBL (540 cfu/100mL) if considered primary contact rivers during the bathing season.

Marine Site (Downstream location at Orewa River/Estuary):

- E. coli is results at Dowstream site were significantly lower than upstream sites and were below 670 cfu/100mL.

3.2.3.5 Oxygen Demand

Freshwater Sites (Discharge and Upstream locations at Waterloo Creek):

- Soluble Carbonaceous Bioavailable Oxygen Demand (Soluble cBOD5) is a measure of the amount of dissolved oxygen required biologically to remove waste organic matter from water. It measures the degradation of organic compounds in water over a five-day period. High cBOD5 values indicate significant organic pollution, leading to oxygen depletion and potential harm to aquatic life. Results of soluble cBOD5 were below the detection limit throughout the sampling rounds, except at the upstream site during the first sampling round, where the concentrations (3.29 g/m³) exceeded the MfE (1992) guideline value of 2 g/m³.

Marine Site (Downstream location at Orewa River/Estuary):

- At Downstream site, all results of Soluble $cBOD_5$ were below the laboratory detection limit

Table 7. Summary of water quality results for Waterloo Creek and Orewa River.

	Round 1 - Sampling date - 17/10/2024			Round 2 - Sampling date - 21/11/2024			Round 3 - Sampling date - 21/01/2025			Freshwater guidelines		Estuarine guidelines
Parameter	Waterloo Creek - Discharge	Waterloo Creek - Upstream	Orewa River - Downstream - (Estuarine water)	Waterloo Creek - Discharge	Waterloo Creek - Upstream	Orewa River - Downstream - (Estuarine water)	Waterloo Creek - Discharge	Waterloo Creek - Upstream	Orewa River - Downstream - (Estuarine water)	ANZG DGV	NPSFM NBL	ANZECC TV
Collection Time	9:45	10:00	10:30	15:15	14:20	15:55	15:00	15:15	17:00	-	-	-
Precipitation in 24 h (mm/day)	0			3.2			6.8					
Conductivity (uS/cm)[A]	534	524	18730	800	806	43092	397	377.9	9133	115	-	-
Dissolved Oxygen (g O_2/m^3)	10.1	11.14	9.17	9.66	10.33	6.98	8.37	8.39	8.28	-	<4*	-
Dissolved Oxygen (%)	98%	108%	93%	101%	107%	76%	91%	91%	92%	92-103	-	80-110
pH (unitless)[A]	7.66	7.75	7.58	7.52	7.08	7.64	7.46	7.5	7.39	7.3 - 7.7##	-	7-8.5
Temperature (C)[A]	14.2	14.3	15.9	17.2	17.4	19.5	19.6	19.6	20.6	-	-	-
Total suspended Solids	22	10	12	14	18	56	30	33	21	8.8	-	-
Turbidity (NTU)	20	12	7.5	11	14	26	22	26	14	5.2	-	10###
Ammoniacal nitrogen	<0.005	<0.005	0.009	<0.005	<0.005	0.005	<0.005	<0.005	0.005	0.01	0.4**	0.015
Nitrite nitrogen	0.0018	0.0019	<0.0010	0.00526	0.00506	<0.0010	0.00575	0.00535	0.0014	-	-	-
Nitrate nitrogen	0.188	0.206	0.0588	0.416	0.415	0.005	0.279	0.322	0.251	0.065	3.5**	-
Total Kjeldahl nitrogen	0.62	0.63	0.36	0.56	0.58	0.62	0.75	0.71	0.69	-	-	-
Total nitrogen	0.81	0.84	0.42	0.98	1	0.62	1	1	0.94	0.292	-	0.3
Dissolved reactive phosphorus	0.006	0.005	0.003	0.009	0.008	0.004	0.009	0.008	0.004	0.014	0.021 ***	0.005
Total phosphorus	0.044	0.037	0.025	0.037	0.042	0.064	0.12	0.13	0.074	0.024	-	0.03
Soluble $cBOD_5$ (g O2/m3)	<1.00	3.29	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	2#	-	-
Faecal coliforms (cfu/100mL)	1900	1200	670	2800	4000	15	-	-	-	-	-	-
Escherichia coli (cfu/100mL)	1900	1100	670	2800	4000	15	-	-	-	-	540	-
Enterocci (cfu/100mL)	60	30	90	100	220	46	-	-	-	-	-	-

Note: All units g/m3 unless stated; DGV = default guideline value, 80th percentile; NBL = national bottom line, *= 1-day minimum, ** as an annual 95th percentile. ***= Attribute state A as 95th percentile. #this limit is set specifically to prevent the growth of sewage fungus (MfE 1992).## DGV = default guideline value, 20th percentile - 80th percentile. A- Field dta. ### Auckland Council reference level - WQI

(grey)	Exceedance to NPSFM NBL criteria
(peach)	Exceedance to ANZG DGV criteria
(light blue)	Exceedance to Both (ANZG and NPSFM)
(pink)	Exceedance to ANZECC TV criteria

3.2.3.6 Summary of Water Quality and Biological Results for Freshwater.

Based on the results of water quality and biological monitoring undertaken by Babbage, the key observations for the freshwater environment include:

- The physiochemistry measurements of the stream indicated the stream presented DO concentrations within NPSFM attribute state A and unlikely cause stress to aquatic organisms. The pH of the watercourse was generally circumneutral, however specific conductivity exceeded the ANZG guideline value indicating potential natural seawater salinity or anthropogenic sources from catchment runoff.
- Turbidity and TSS results, indicators of stream clarity, were above the ANZG guidelines. This suggest that even for a soft-bottom stream where more turbidity is expected, these results can affect the light penetration and hinder photosynthesis in aquatic plants and algae, particularly for the existing shading areas.
- Biochemical oxygen demand was very low, indicating low levels of organic pollution.
- Concentrations of nitrogen and phosphorus species were generally elevated above the relevant ANZG guideline value, however nitrate, ammonia and DRP fall within in attribute state A of NPSFM indicating that there is some level of nutrient stress affecting the stream, but it remains healthy.
- E.Coli concentrations indicate relative “poor” condition for bathing due to likely discharges from pastoral land or wastewater.
- Despite the relative healthy condition observed by water quality results (particularly in relation to nutrients), the biological assessment indicate high level of ecology degradation, where the macroinvertebrate communities at Waterloo Creek reflect a waterbody in poor ecological health, as indicated by low MCI and QMCI scores, absence of EPT taxa, dominance of tolerant species and high dominance of mud snails.

In summary, the association of water quality and biological results with stream features, such as soft bottom substrate and high shading areas, indicates that water clarity, influenced by suspended sediments, turbidity, and stream features, plays a more critical role in the current level of stream degradation than nutrient levels. This conclusion is supported by the observed low concentrations of harmful nutrient derivatives, such as ammonia and nitrates, which, if present in excess, could contribute to degradation. Additionally, the absence of algae growth further supports this assumption, as algae typically thrive in nutrient-rich environments.

However, the recent and ongoing change in catchment land use from pastoral land to residential areas may have masked the contribution of nutrient degradation from the past, which still remains.

3.2.3.7 Summary of Water Quality and Biological Results for Estuarine Environment.

Based on the results of water quality and biological monitoring undertaken by Babbage, the key observations for the estuarine environment include:

- The physiochemistry measurements indicated that DO results fall within ANZECC range (except on the first round) with pH generally circumneutral and within the ANZECC range.
- The turbidity and suspended solids were usually below the levels of upstream freshwater results. However, exceeded the used guideline value of 10 NTU except on the first sampling round (dry sampling round).
- Oxygen demand was low, indicating low levels of organic pollution in the estuary.
- Similar pattern to upstream sites, the concentrations of nitrogen and phosphorus species were generally elevated above the relevant ANZECC guideline value. However, ammonia and DRP fall below the ANZECC guideline value.
- E. coli is results at the estuarine site was significantly lower than upstream sites
- The biological assessment at the estuarine site identified moderate level of degradation with also generally low diversity of species, which is likely associated with upstream freshwater discharges (such as the Waterloo Creek).

In summary, the association of water quality and biological results for estuarine environment indicates some degree of environmental stress due to sediments and nutrients discharges. However, this stress was less intense compared to the freshwater sites.

3.2.4 Hydrology results

The hydrology data collected by the logger at the Discharge site was used along with NIWA atmospheric pressure data from a nearby weather station (Whangaparaoa weather station, approximately 15 km away from the Site, data obtained from National Climate Database website[6]) to compensate the variation of atmosphere pressure and calculate the water depth in the stream. The same weather station was used to determine the rainfall precipitation. The level-logger was retrieved after collecting data every hour from 17 October to 21 November 2024.

Figure 9 illustrates the water depth data at the Discharge site (Waterloo creek) for the mentioned period. Four notable peaks (0.65 m in 26/10, 0.62 m in 30/10, 0.54 m in 10/11 and 0.86 m in 15/11) are evident in the figure, indicating the impact of precipitation on water depth at this site, which present during this period the median depth value of 0.43 m.

The water temperature, as measured by the levelogger, fluctuated between 12°C and 20°C during the period as shown in the Figure 10. Daily and nightly temperature variations are observed in the graph.

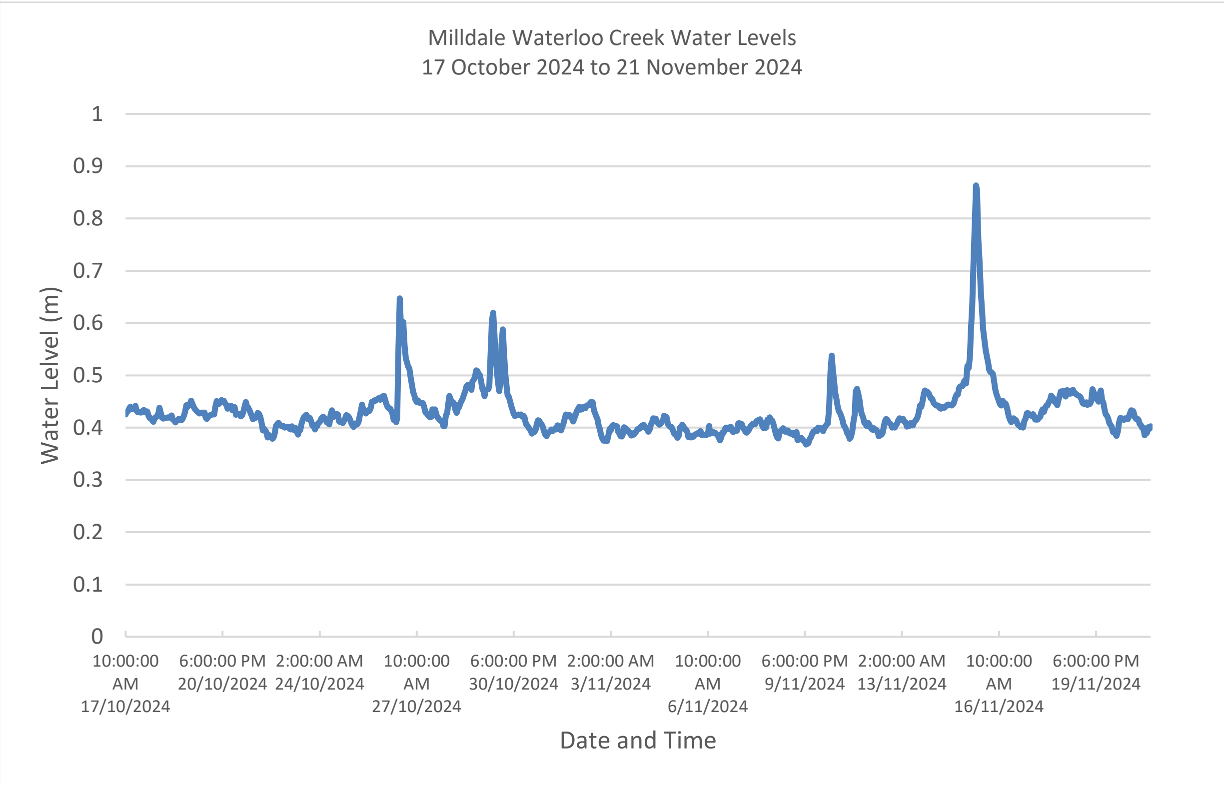


Figure 9. Water depth at Discharge site (Waterloo Creek).

[6] The National Climate Database 2024. Niwa DataHub website, retrieved on 20 January 2025 from: https://data.niwa.co.nz/.

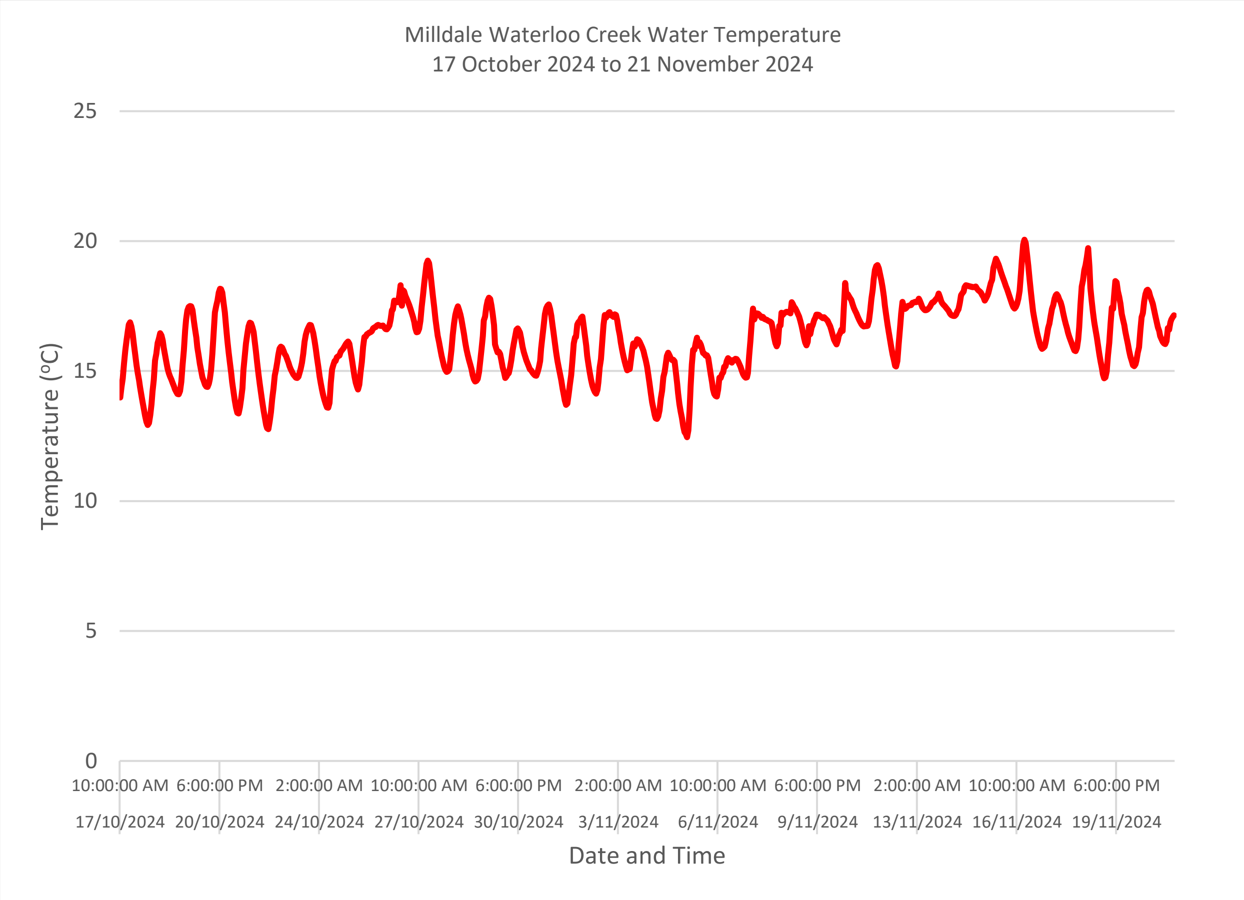


Figure 10. Water temperature at Discharge site (Waterloo Creek).

Flow rate measurement using the Flow Tracker 2 instrument was conducted on 21 January 2025 at the discharge site. During the fieldwork, the water level reached a depth of 0.67 m due to rainfall precipitation (6.8 mm/day), and the total river discharge was measured at 0.088 m^3/s (refer to field notes in **Appendix D**).

3.3 Baseline data quality assessment

As described previously, the water quality results were assessed over three sampling rounds (October and November 2024 and January 2025), covering the spring and summer season only. Water quality results are usually influenced by seasonal variations. Historical precipitation data indicates that the precipitation during the spring and summer period in 2024/2025 as well as the whole year was typical, following the range of historical data from 2014 to 2023. The 2024 precipitation data and median of historical results are represented by a red and black dashed line, respectively, as shown in **Figure 11** below.

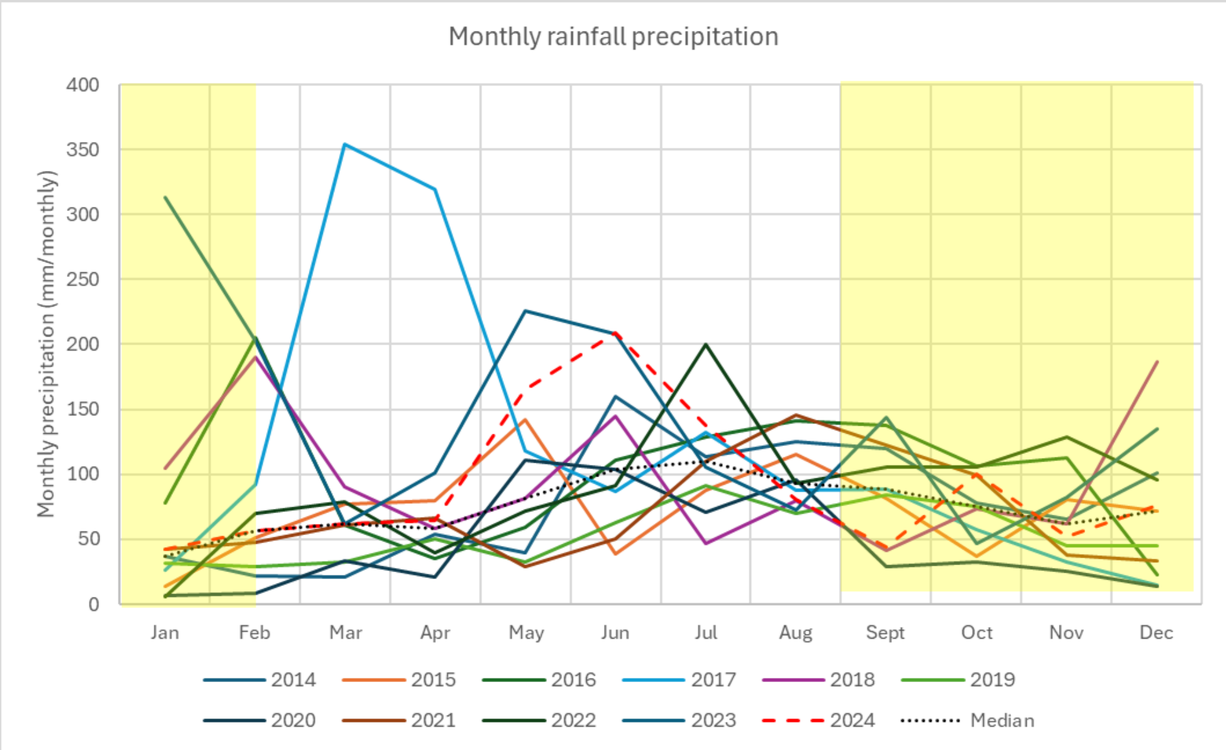


Figure 11. Monthly precipitation from 2014 to 2024 (Data source: Niwa weather station: Whangaparaoa, retrieved from: https://cliflo.niwa.co.nz/)

Based on this observation, it is expected that pollutant concentrations detected during the sampling undertaken will be representative of a typical dry season. This period is characterised by reduced runoff and associated contamination from the catchment.

For the wet season, no sampling was carried out at Waterloo Creek. In the absence of wet season results, assessing historical data from a nearby similar catchment is a useful approach to identify the level of increment between seasons. Accordingly, historical results from the LAWA website (https://www.lawa.org.nz/) for the sampling location at Okura Creek at Awanohi Road, approximately 10 km from Waterloo Creek, from the period of 2013 to 2022, were applied.

This monitoring site (Okura Creek) has the same River Environment Classification (REC) – warm wet low elevation – and an upstream catchment that is predominantly residential, rural agricultural, and near the coast. It shares the same attribute states for ammoniacal nitrogen and nitrate (both state A) as Waterloo Creek.

Historical annual results by year of Okura Creek for total nitrogen (TN) and total phosphorus (TP) are plotted below (Figures 12 and 13) with the median of results during the dry and wet period.

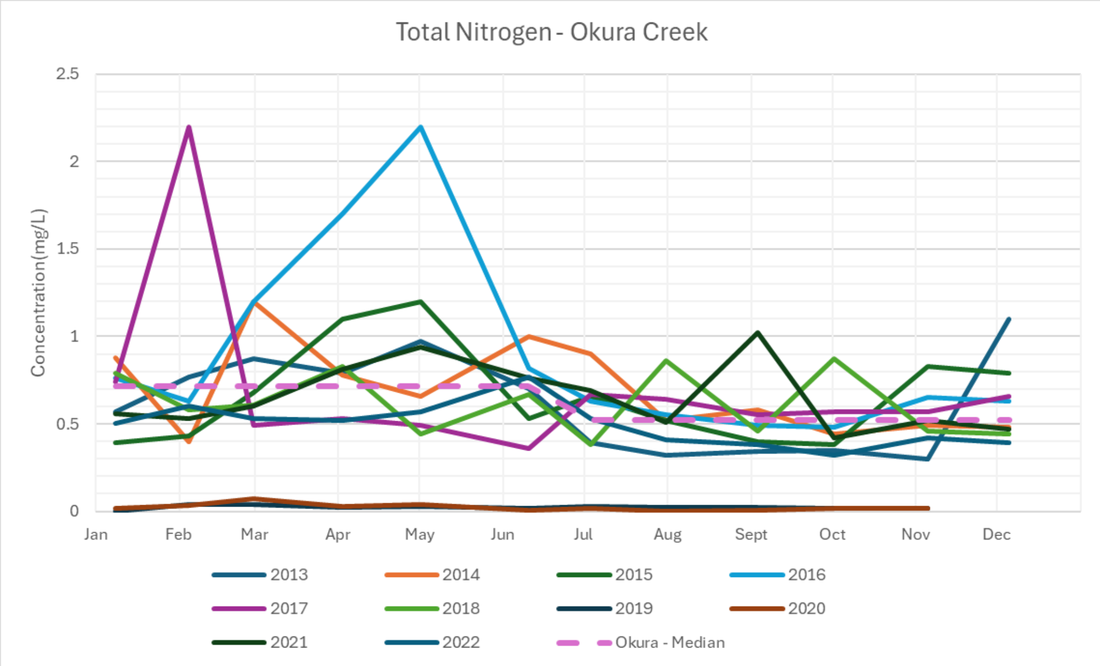


Figure 12. Total nitrogen and median historical results of Okura Creek. (Data source https://www.lawa.org.nz/)

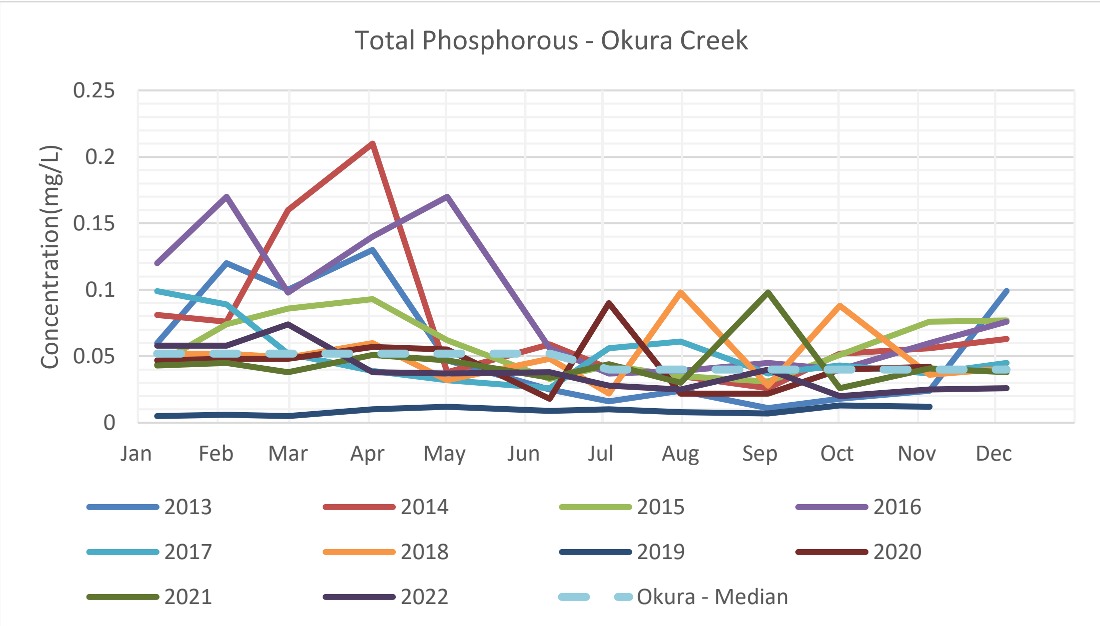


Figure 13. Total phosphorous and median historical results of Okura Creek. (Data source https://www.lawa.org.nz/)

The comparison of the median historical results from the wet and dry seasons for Okura Creek is presented in Table 8 below. This table indicates an increase of 37% for TN and 30% for TP between dry and wet seasons.

Table 8. Median historical results – Okura Creek.

Parameters	Dry season – Median results	Wet season – Median results	Variation between seasons (%)
TN (g/m3)	0.52	0.71	**37%**
TP(g/m3)	0.04	0.05	**30%**

Therefore, based on the historical results of Okura Creek presented in Table 8, a similar increase of 30% in concentrations between the dry and wet seasons is expected for Waterloo Creek.

Table 9 below shows the comparison of NIWA-modelled results (available on the NIWA River Maps website) with the average of current results and the proposed wet season concentration (30% increase) for Waterloo Creek for TN and TP.

Table 9. Comparison between median Niwa modelled results and proposed wet season concentrations (30% increase of dry season results) – Waterloo Creek.

Parameters	Median Niwa (modelled)	Average of 3 sampling rounds – dry season	Proposed wet concentrations – Wet season (increase of 30%)
TN (g/m3)	1.2	0.9	1.2
TP(g/m3)	0.05	0.07	0.09

4 PROPOSED TREATED WASTEWATER DISCHARGE

4.1 Process Overview

Woods-Fulton Hogan Land Development is preparing a resource consent application for discharges from a proposed private wastewater treatment plant to the Waterloo Creek. Apex Water Limited have been engaged to provide design for consent for the proposed wastewater treatment plant (WWTP).

The WWTP has two proposed set flowrates for dry and wet weather conditions, which will be triggered by high rainfall events monitored by the WWTP.

The proposed treatment plant will employ a hybrid biological nutrient removal system, featuring a 4-stage Bardenpho activated sludge treatment process, a Membrane Aerated Biofilm Reactor (MABR), and Ultra-filtration membranes to produce high-quality permeate. This system is designed to treat wastewater to such an extent that it is suitable for domestic garden use and unrestricted municipal irrigation. Refer to WWTP layout in **Appendix E**.

MABR is considered a modified activated sludge process, where nitrification (the conversion of ammonia in raw wastewater to nitrate) is carried out in a very quick and efficient manner. A MABR is characterised by submerged gas transfer membranes which provide air pumped through them directly to a biofilm attached to the surface of the membrane. The gas transfer membrane allows for efficient oxygen transfers, applied directly to the biofilm carrying out the nitrification reaction. For the same nitrification rate, an MABR treatment process requires a smaller footprint (ie, smaller tanks) and uses less aeration energy which often comprises the largest operational expense, alongside chemicals and labour.

Raw wastewater shall be screened before flowing into the biological process which consists of pre-anoxic, aerobic and post anoxic zones to provide the required level of nutrient removal. The wastewater is then passed through a membrane to separate bulk solids, bacteria and other pathogens before being passed through UV reactors for tertiary disinfection. The treated wastewater is stored for re-use on site where suitable, or discharged into a land contact bed prior to entering the receiving environment at the Waterloo creek.

4.2 Estimated WWTP Discharge Flows

As previously described, the proposed WWTP plant will have two set flowrates for dry and wet weather conditions, these will be 675.12 and 829.2 m^3/day, respectively, considering the plant will operate 24/7. The plant will monitor for rainfall and upon registering an event of a certain intensity and duration, the plant will switch from the dry-weather to the wet-weather flowrate before changing back to the dry-weather flowrate after an agreed duration has expired.

Based on this, it was identified three scenarios of discharge with two set of flow rates that may occur when the project is completed that may influence the amount of wastewater that is required to be discharged to river. The three scenarios, and the respective discharge flows, are presented in Table 10.

Table 10. Estimated WWTP discharge volumes scenarios.

Scenario	Description	Discharge flow (m^3/day)
1	Dry weather discharge (minimum discharge)	675
2	Average weather discharge (minimum discharge)	675
3	Peak wet weather discharge (maximum discharge)	829

4.3 Proposed Discharge Quality Targets

Apex has identified the proposed discharge quality targets for the treated wastewater. The discharge quality targets are reproduced in Table 11 and apply to each scenario identified in Section 4.2. These values reflect the quality of effluent exiting the wastewater treatment systems at the Discharge site and do not take into consideration further dilution that occurs along the Waterloo Creek and Orewa River.

Table 11. Proposed treated discharge water quality targets.

Parameter	Proposed discharge quality
Soluble five-day carbonaceous biochemical oxygen demand (g O_2/m^3)	0.5
Total suspended solids	4
Ammoniacal nitrogen	0.3
Total nitrogen	1
Nitrate	0.5
Total phosphorus	0.1
Escherichia coli (cfu/100mL)*	4

Notes: All units g/m^3 unless stated; and data provided by Apex; and *reported as <4 MPN/100 mL by Apex.

5 SURFACE WATER QUALITY MODELLING

5.1 Overview

The proposed discharge has the potential to impact the water quality and flows of Waterloo Creek. To assess the effects of the proposed discharges on the receiving environment, three scenarios were identified and modelled. These scenarios consider discharge flows at Waterloo Creek and potential receiving water flow conditions when receive the additional discharge from the WWTP. They reflect environmental seasonality (dry, wet, and average conditions), which may vary throughout the year.

The Waterloo Creek flow rates were provided by in situ measurements using level loggers for water depth readings and a flow tracker for flow rates. The flow rate is directly related to water depth, and based on the in-situ measurements, the following ratio was observed at the Discharge site:

$$Flow\ rate\ \left(\frac{m3}{s}\right) = \ 0.1313x\ Water\ Depth\ (m)$$

Following this direct relationship, three flow rates of Waterloo Creek were assumed:

- Dry scenario, water depth equal to 0.35 m, flow rate equal to 0.046 m^3/s (3,974 m^3/d)
- Average scenario, water depth equal to 0.43 m, flow rate equal to 0.0565 m^3/s (4,882m^3/d)
- Wet scenario, flow rate equal to 0.85 m, flow rate equal to 0.11 m^3/s (9,504m^3/d)

Table 12 presents the conditions modelled for each scenario. The potential receiving water flow condition represents more realistic conditions than the modelled results from NIWA River Maps (https://shiny.niwa.co.nz/nzrivermaps/), which indicate a wetted width at median flow of 0.5 m for Waterloo Creek, whereas it was observed to be 2-2.6 m during the site visits (spring and summer periods).

Table 12. Scenarios for assessment of effects.

Scenario	Description of stream flow rate condition*	Treated wastewater flow rate
1	Dry weather (3,974 m^3/day)	675 m^3/day
2	Average weather discharge (4,882 m^3/day)	675 m^3/day
3	Peak wet weather discharge (9,504 m^3/day)	829 m^3/day

5.2 Method and Assumptions

Using a mass balance approach, the water quality (WQ) in the receiving waters of Waterloo Creek is influenced by the inlet discharges originating at Waterloo Creek at the Discharge site and the treated wastewater discharged from the WWTP.

The combined effect of these inlet discharges on Waterloo Creek WQ for each discharge scenario can be estimated using the following expression:

$$Waterloo\ Creek\ combined\ WQ = \frac{(Waterloo\ flow\ \times Waterloo\ \ WQ) + (WWTP\ flow\ \times WWTP\ WQ)}{Waterloo\ flow + WWTP\ flow}$$

The following assumptions have been made:

- Background stream flows under Scenarios 1, 2 and 3 were estimated based on field measurements and assumptions as described in Section 5.1.
- WWTP flow rates were specified by Apex, which considered two sets of flow rates.
- Water quality in the Waterloo Creek Discharge site was provided by the three sampling rounds conducted by Babbage in 2024 and 2025. Specifically:
    - Scenario 1 (Dry season) is a conservative representation of summer. As such, the water quality was calculated from the average data obtained from the three sampling rounds undertaken between October and January.
    - Scenario 2 (Average weather) is representative of the average. As such, is was considered the water quality calculated from the average data obtained from the three sampling rounds undertaken between October and January (same as Scenario 1).
    - Scenario 3 (Wet weather) is a conservative representation of the winter season and was considered the increase of 30% in relation to average and dry seasons (Refer to Section 3.3 for more details).

5.3 Results

5.3.1 Introduction

The results of the mass balance calculations, including the resultant flows and concentrations of soluble $cBOD_5$, Total suspend solids (TSS), Total nitrogen (TN), nitrate, ammoniacal nitrogen (AMN), total phosphorus (TP) and E.coli, and the inputs used (i.e., discharge volumes and concentrations) are presented in Table 13.

5.3.2 Waterloo Creek

The key observations from the modelling results, as shown in Table 13, with respect to the water quality of the Waterloo Creek discharge are summarised below.

In all scenarios, the water quality at Waterloo Creek is expected to improve, with concentrations projected to be below or equal to the current Waterloo Discharge site levels or to remain in the same attribute state as before (e.g., for ammonia and nitrate attribute states). Note that modelled TSS and E. coli concentrations decreased, while nitrate, TN, TP, and cBOD5 remain stable. Although AMN increases in the discharge under this scenario, it remains within the same attribute state A. Additionally, these modelling results do not take into consideration the high concentrations of dissolved oxygen in the creek, which will stimulate the nitrification process and removal of ammonia from the water.

Table 13. Input data and results of modelled water quality for discharge scenarios.

Parameters	Scenario 1 (Dry season)			Scenario 2 (Average)			Scenario 3 (Wet season)			Guidelines	Guidelines – Reference
	WWTP Discharge	Waterloo Creek – Low Flow		WWTP Discharge	Waterloo Creek – Median Flow		WWTP Discharge	Waterloo Creek – Wet Peak Flow			
		No discharge* (Discharge site WQ)	With WWTP discharge**		No discharge* (Discharge site WQ)	With WWTP discharge**		No discharge* (Discharge site WQ)	With WWTP discharge**		
Flow (m^3/day)	**675**	3,974	4,650	**675**	4,882	5,557	**829**	9,504	10,333	-	-
Soluble cBOD$_5$ (g O_2/m^3)	**0.5**	0.5	**0.5**	**0.5**	0.5	**0.5**	**0.5**	0.7	**0.7**	**2**	**Mfe**
Total suspended solids	**4**	22	**19**	**4**	22	**20**	**4**	29	**27**	**8.8**	**ANZG**
Total nitrogen	**1**	0.9	**0.9**	**1**	0.9	**0.9**	**1**	1.2	**1.2**	**0.292**	**ANZG**
Nitrate	**0.5**	0.3	**0.3**	**0.5**	0.3	**0.3**	**0.5**	0.4	**0.4**	**1.5**	**NPSFM – State A**
Ammoniacal nitrogen	**0.3**	0.003	**0.05**	**0.3**	0.003	**0.04**	**0.3**	0.003	**0.03**	**0.05**	**NPSFM – State A**
Total phosphorus	**0.1**	0.07	**0.07**	**0.1**	0.07	**0.07**	**0.1**	0.09	**0.09**	**0.024**	**ANZG**
E.Coli (cfu/100mL)*	**4**	2,350	**2,009**	**4**	2,350	**2,065**	**4**	3,055	**2,810**	**540**	**NPSFM - NBL**

Notes: All units g/m^3 unless stated; WD means Water Depth . *measured at Waterloo Creek (sampling location Discharge);. Green text indicates the discharge results in no change or a decrease in concentrations compared to the environment without the discharge or that it remains in the same attribute state.; water quality data are presented to the same number of significant figures as the projected WWTP discharge water quality; ** Calculated based on mass balance approach. cBOD5 = carbonaceous biochemical oxygen demand;

6 ASSESSMENT OF EFFECTS

6.1 Effects on Waterloo Creek

6.1.1 Water quality

As demonstrated in the technical assessment (Section 5.3), the proposed development is not expected to have a significant effect on Waterloo Creek, with the concentrations of all assessed parameters under the modelled scenarios either remaining unchanged, decreasing, or staying within the same attribute level (NPS-FM criteria).

A conservative approach was assumed for the proposed treatment capacity of the WWTP. The combination of a MABR system and ultrafiltration membranes is designed to achieve a high level of treatment and is suitable even for reuse on site.

Furthermore, the results in Table 13 were conservatively modelled and do not account for higher attenuation levels of the creek due to the change of land use from pastoral land to residential use, which may further decrease nutrient levels and runoff of agricultural soils. Based on the current water quality results, nutrients do not represent the main cause of the degradation observed in the biological assessment.

Sediments from erosion of stream banks and rainfall runoff are associated with decreased water clarity, which can hinder photosynthesis in aquatic plants, reduce habitat quality, and lower biodiversity.

The results indicated in Table 13 show that TSS will decrease with the proposed discharge, which should have a positive effect on the receiving environment.

It is proposed that the development will use devices or construction techniques to control the velocity of discharges to avoid water turbulence in the river and the increase in turbidity. The details of the proposed discharge device into the waterloo creek can be found in the Apex Water wastewater report supporting the overall application.

6.1.2 Water temperature

Based on the proposed treatment technology, no temperature fluctuation will occur during the wastewater discharge. Therefore, it is expected that the temperature difference between the proposed discharge and Waterloo Creek will be less than the required 3°C, minimizing adverse thermal effects on the stream.

6.1.3 Overflow risk

The proposed flow rates of the WWTP (675 m^3/day and 829 m^3/day) are well below the river's capacity, and no noticeable effect in terms of overflow risks is expected due to this additional discharge.

6.2 Effects on Ecology

6.2.1 Introduction

As discussed in the summary of water quality and biological results in the Section 3.2.3, the potential adverse effects that may arise as result of the development's proposed discharges include:

- Reduction of aquatic habitat quality due to water quality
- Reduction of aquatic habitat quality due to water temperature
- Reduction of aquatic habitat quality due to additional flow rate
- Erosion of stream banks

The proposed development is also expected to give rise to some positive effects, such as the reduction of sediment discharge that can improve fauna habitat quality. These positive effects are expected to be associated with the following actions:

- Stream works and controlled release of discharges
- Riparian vegetation planting

The likelihood and severity of both adverse and positive effects are discussed below.

6.2.2 Reduction of aquatic habitat quality due to water quality

As demonstrated in the discharge assessment (Section 5.3), all scenarios predict improved or relatively unchanged freshwater quality. The proposed discharge will not change the current attribute state of Waterloo Creek. For this reason, the proposed development discharges are not expected to reduce the aquatic habitat quality of this environment or downstream at Orewa River.

6.2.3 Reduction of aquatic habitat quality due to temperature

As discussed in the assessment of effects on water temperature (Section 6.1.2), the proposed treatment system will discharge the treated wastewater at a similar temperature to Waterloo Creek. The absence of a temperature difference will ensure that there is no direct impact on thermally sensitive organisms, nor will it alter key physical-chemical parameters like pH and oxygen saturation or increase ammonia concentrations.

6.2.4 Reduction of aquatic habitat quality due to additional flow rate

The proposed development could potentially increase the flow rate during the dry season., however it is not expected significant amount considering that the proposed discharge (675 m^3/day) would be approximately 17% of estimated stream flow rate. Additionally, the indication of flood plains along this creek suggests that the existing habitat is already accustomed to significant fluctuations in flow rate, and the proposed discharge is unlikely to alter water levels substantially.

6.2.5 Erosion of stream banks

As a result of the proposed development, the wastewater and stormwater discharges represent potential additional flows to the freshwater environment, which may erode stream banks over time. However, the potential for erosion of the banks can be mitigated through soft engineering techniques. For example, planting of the stream bank and riparian area can improve bank stability and provide stream ecosystem services.

6.2.6 Stream works and controlled release of discharges

Stream works, or the strategic placement of boulders, can armour stream corners, dissipate energy and provide hydrologic variation.

In addition to soft engineering techniques, the stormwater management to be implemented on site will intended to ensure the controlled release of stormwater flows.

Due to the proposed mitigation measures, it is considered the risk of stream bank erosion is properly managed. Stream works and riparian planting is likely to influence the freshwater environment by reducing potential increases in fine sediment and providing hard variable substrate for invertebrates to colonise.

6.2.7 Riparian planting

Riparian planting is recommended along the margins and banks at the Waterloo Creek discharge point. If managed appropriately, riparian buffer strips offer multiple functions related to improving water quality, biodiversity, and climate adaptation. When mature, the planting can increase shading that is expected to limit in-stream plant growth, regulate instream temperature, limit soil erosion, and maintain instream biodiversity.

The treatment performance of riparian buffers can range depending on factors such as buffer width, maturity, and type (grassy or woody). For example, grass buffers can intercept sediments and sediment-bound pollutants such as phosphorus, while woody vegetation is effective in subsurface and ground-water nutrient removal due to their deep-rooted systems. The riparian planting on Site shall contain a mixture of grassy and woody vegetation, intended to achieve optimum nutrient removal.

The overhanging branches, roots, and woody debris from well-developed riparian buffers can provide enhanced habitat diversity and spawning grounds for aquatic fauna (Parkyn 2004). Furthermore, established riparian buffers also provide increased shading, which can reduce conditions necessary for excessive instream macrophyte growth (such as high temperature and light levels). Collier et al. (1995) reports that a single line of fully-grown trees can provide about 80% shade to streams, giving rise to better aquatic habitat conditions.

Provided the recommended riparian planting is implemented, the development is expected to provide an increase in stream vegetation abundance and diversity. The additional vegetation can provide filtration of sediment and contaminants, improving water quality for the Waterloo Creek, which in turn can positively influence the quality of the Orewa River estuary.

7 RECOMMENDATIONS

7.1 Introduction

The adverse effects of the proposed discharge on the receiving environment have been assessed to be less than minor. However, Babbage recommends that the following consent conditions and measures are implemented to aid the avoidance, remediation, or mitigation of any adverse effects.

7.2 Monitoring

7.2.1 Water quality

For a period of at least 12 months prior to the first discharge from the WWTP, the proposed development shall take surface water quality samples on a quarterly basis at two locations, one upstream and another downstream of Waterloo Discharge site and one ay Orewa River estuary.

Following the first discharge from the WWTP, the proposed development shall obtain surface water quality samples on a quarterly basis at the same locations within the Waterloo Creek. Once the development has been fully utilised and at design capacity for a minimum period of 2 years the in-stream monitoring frequency may be reduced to every 3 years, provided that results indicate no significant change in surface water quality has resulted from the discharge. Water quality monitoring shall be undertaken by a suitably qualified and experienced person, who shall provide advice if results indicate the water quality has deteriorated because of the WWTP discharge.

All surface water quality samples shall be tested for the following parameters:

- Temperature
- Dissolved oxygen
- pH
- Total suspended solids
- Total ammoniacal nitrogen
- Nitrate nitrogen
- Nitrite nitrogen
- Total nitrogen
- Dissolved reactive phosphorus
- Total phosphorus
- Soluble $cBOD_5$

All sample analyses shall be undertaken by an IANZ accredited or equivalent laboratory. All methods shall be appropriate for the sample analyses undertaken.

7.2.2 Ecology

Prior to the first discharge from the WWTP, the proposed development shall undertake a surface water ecology survey at two locations within the Waterloo Creek and one at Orewa River estuary.

Following the first discharges from the WWTP, ecology surveys should be conducted each Autumn at two locations within the Waterloo Creek present on Site. Once the development has been fully utilised and at design capacity for a minimum period of 2 years, the in-stream monitoring frequency may be reduced to once every three years if results indicate the ecological community has been unaffected by the discharge. Ecological monitoring shall be undertaken by a suitably qualified and experienced person, who shall provide advice if results indicate the aquatic habitat has deteriorated because of the WWTP discharge.

All surface water ecology surveys shall, as a minimum, meet the following requirements:

- Provide an assessment of fish and macroinvertebrate communities, physical habitat quality, macrophytes and periphyton
- Shall be undertaken by person(s) suitably qualified in freshwater ecology
- Shall not be undertaken within two weeks of a flood event
- Shall report on any significant trends observed over time.

7.3 Discharge Monitoring

The proposed development shall implement and maintain as a minimum, a type of supervisory control and data acquisition (SCADA) electronic recording system that shall continuously monitor wastewater discharge flow, volume and temperature. The purpose of the system is to collate monitoring information that may be used to assist with decision making, including managing incidents that may trigger alarms and non-compliance. In addition, samples of the discharge shall be collected each month and analysed for the following:

- Temperature
- pH
- Total suspended solids
- Total ammoniacal nitrogen
- Nitrate nitrogen
- Nitrite nitrogen
- Total nitrogen
- Dissolved reactive phosphorus
- Total phosphorus
- *Escherichia coli*
- Soluble $cBOD_5$

7.4 Riparian Planting

It is proposed that native planting is undertaken along the length of the Waterloo Creek on Site. A minimum buffer distance of between 5 m and 10 m either side of the watercourse is recommended. The purpose of the planting is to provide additional shading of the stream to help reduce macrophyte growth and water temperatures.

Species planted will include a mix of lower-lying sedges and grasses such as pukio (*Carex secta*), cutty grass (*Carex geminata*) and toetoe (*Austroderia fulvida*), as well as taller trees to provide shading such as cabbage trees (*Cordyline australis*), black matipo (*Pittosporum tenuifolium*), and manuka (*Leptospermum scoparium*). In addition, a grass strip at least one metre wide should be left between all fences and riparian buffers to aid in sediment filtration. It is recommended that plants in the riparian buffer strip are native and eco-sourced when applicable.

It is expected that the riparian planting will only provide all of the proposed functions, namely shading, once the plantings have reached a certain level of maturity e.g., 5-10 years.

8 CONCLUSIONS

The discharge of water from the WWTP is proposed to interact with Waterloo Creek and Orewa River estuary. Based on monitoring results, water quality modelling, and an assessment of effects, the following conclusions have been drawn:

- The degraded freshwater environment observed in the biological assessment is likely due to the historical pastoral land uses on the associated catchment and surrounding areas. The historical land use activities are reflected in the monitoring results in the Waterloo Creek and with less intensity in Orewa River estuary. These water bodies indicated elevated sediment discharges and some degree of nutrient concentrations that affect the freshwater environment. It is expected that the effects associated with nutrients will be reduced with the change of land use from pastoral to residential, as is currently on going.
- The proposed discharge is expected to increase stream flows under all scenarios and improve the concentrations of measured parameters (TSS, turbidity, E. Coli) within the Waterloo Creek. Despite the mass balance indicating increases in ammonia, it is expected that it will be within attribute state A or concentrations will be reduced, due to the significant concentration of DO and nitrification capacity.
- Potential adverse effects on ecology, such as erosion or habitat degradation, can be managed through controlled discharge, stream works (by strategic placement of boulders), riparian planting, and stormwater management.
- Proposed consent conditions, such as water quality or ecological monitoring, will ensure the adverse effects of the proposed discharge will be properly identified and managed.

Overall, it has been concluded that the proposed discharges associated with the proposed development, should have a minor impact on the Site's receiving waters and ecological values. Freshwater within the area is proposed to be managed in a way that gives effect to Te Mana o te Wai, a tenet detailed in the NPS-FM that frameworks the importance of maintaining or providing for the health and well-being of water, the health needs of people, and the ability of people and communities to provide for their social, economic and cultural well-being. The proposed development is consistent with the provisions of the NPS-FM and Te Mana o te Wai. It is expected that due the recommended consent conditions and proposed discharge management, the adverse effects of the development will be less than minor.

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MfE 2020 National Policy Statement for Freshwater Management. Ministry for the Environment. Wellington, New Zealand.

NIWA 2004. New Zealand River Environment Classification User Guide. A report prepared by NIWA for Ministry for the Environment.

NZWERF 2004. On-Site Stormwater Management Guideline. A report prepared by New Zealand Water Environment Research Foundation for Ministry for the Environment.

APPLICABILITY AND LIMITATIONS

Restrictions of Intended Purpose

This report has been prepared solely for the benefit of Apex Water Ltd as our client with respect to the brief. The reliance by other parties on the information or opinions contained in the report shall, without our prior review and agreement in writing, be at such party's sole risk.

Legal Interpretation

Opinions and judgements expressed herein are based on our understanding and interpretation of current regulatory standards, and should not be construed as legal opinions. Where opinions or judgements are to be relied on they should be independently verified with appropriate legal advice.

Maps and Images

All maps, plans, and figures included in this report are indicative only and are not to be used or interpreted as engineering drafts. Do not scale any of the maps, plans or figures in this report. Any information shown here on maps, plans and figures should be independently verified on site before taking any action. Sources for map and plan compositions include LINZ Data and Map Services and local council GIS services. For further details regarding any maps, plans or figures in this report, please contact Babbage Consultants Limited.

Reliability of Investigation

Babbage has performed the services for this project in accordance with the standard agreement for consulting services and current professional standards for environmental site assessment. No guarantees are either expressed or implied.

Recommendations and opinions in this report are based on discrete sampling data. The nature and continuity of matrix sampled away from the sampling points are inferred and it must be appreciated that actual conditions could vary from the assumed model.

There is no investigation that is thorough enough to preclude the presence of materials at the Site that presently, or in the future, may be considered hazardous. Because regulatory evaluation criteria are constantly changing, concentrations of contaminants present and considered to be acceptable may in the future become subject to different regulatory standards, which cause them to become unacceptable and require further remediation for this site to be suitable for the existing or proposed land use activities.

Appendix A

Baseline Assessment Reports

2 December 2024 Job No: 67717 eTrack No: 200048997

Jack Taylor
Apex Water Limited

MILLDALE WWTP PROJECT – BIO-ENVIRONMENTAL BASELINE SURVEY REPORT – ROUND 2

Dear Jack

Please, find below the round 2 of biological inspection and environmental baseline survey report for the Milldale Wastewater Treatment Plant Project. The bio-environmental works were conducted by Babbage Consultants Limited (Babbage) in 21 of November 2024.

These works are part of baseline bio-environmental monitoring approved on 8 October 2024 (Proposal Etrack no. 200048486) to assess potential effects associated with proposed development of a Wastewater Treatment Plant (WWTP) and its discharge into Waterloo Creek.

Details of ecology and environmental works undertaken are described below.

Surface Water Sampling Methodology and Conditions

Surface water samples were collected from three locations, two along the Waterloo Creek (Discharge point and Upstream) and one in the Orewa River-Estuary (Downstream). Refer to **Figure 1** for sampling locations.

Waterloo Creek discharges into the Orewa River, which then flows to the estuary and into the Hauraki Gulf. The upstream location represents baseline conditions upstream of the discharge point, including contributions from an unnamed tributary flowing from the west side of the WWTP site. The downstream location is in the Orewa River, influenced by the estuary (seawater influence) and baseline contributions from the Orewa River (northwestern branch) and an unnamed stream that flows parallel to State Highway 1.

The sampling was conducted on 21 November 2024. Samples were collected directly into laboratory-prepared bottles using a mighty gripper. Field parameters, including water temperature, pH, dissolved oxygen (DO), oxidation-reduction potential (ORP) and specific conductance (electrical conductivity (EC) at 25 °C) were measured on-site for each sample using a multiparameter instrument (see **Appendix A** for field sheet and calibration certificates).

Surface water samples were kept on ice and sent to Analytica Laboratories with a chain of custody documentation. Surface water samples were analysed for typical parameters related to water quality and domestic wastewater discharge, including nitrate, nitrite, total Kjeldahl nitrogen (TKN), ammonia, total nitrogen (TN), dissolved reactive phosphorus (DRP), total phosphorus (TP), soluble carbonaceous biochemical oxygen demand ($cBOD_5$), faecal coliforms, E. coli, enterococci, total suspended solids (TSS), turbidity and pH.

The sampling activities were conducted on a rainy day, with 3.2 mm of rainfall recorded on the sampling day and 0.8 mm recorded the day before[1]. Given the site's proximity to the sea, samples were collected at mid-ebb (midway through the falling tide), with high tide recorded at 12:20 pm.

Analytical Results – Surface Water

The analytical results of the samples and their respective trigger levels are provided in **Table 1** below (laboratory analytical report attached – **Appendix B**). Guidelines used in Table 1 are set by:

- Australian and New Zealand guidelines for fresh and marine water quality (ANZG 2018) default guideline values (DGV) for warm wet low elevation (WWLE) stream according to river environmental classification - REC presented in Niwa NZ River maps.
- Australian and New Zealand guidelines for fresh and marine water quality (ANZECC 2000)- Table 3.3.2 for Estuaries Default Trigger Values.
- National Policy Statement for Freshwater Management (NPSFM 2020) – National Bottom Line (NBL).
- Water Quality Guidelines No. 1: Guidelines for the Control of Undesirable Biological Growths in Water (MfE 1992) specifically for $cBOD_5$.

In summary, results from the second sampling event indicated exceedances relative to the proposed guidelines for electrical conductivity, pH, TSS, turbidity, nitrate nitrogen, total nitrogen, total phosphorus, and *E. coli*. However, only *E. coli* exceeded the NPSFM National Bottom Line (NBL) for freshwater samples. These results were consistent with the first sampling round in terms of the parameters that exceeded guideline values and their concentrations, except for pH, which exceeded guideline values only in the second round, and BOD, which exceeded guideline values only in the first round.

[1] Rainfall data retrieved on 2/12/2024 from: https://www.metservice.com/towns-cities/regions/auckland/locations/orewa/past-weather. Metservice Observations recorded at Whangaparaoa (AWS-93103).

In comparing results from the Discharge Point and Upstream locations against the ANZG freshwater guideline values, conductivity, TSS, turbidity, nitrate, TN, and TP were found to exceed their respective recommended values at both monitoring locations. The concentrations levels were similar, as expected, given the proximity of sampling points. The pH at the Upstream location exceeded the guideline value but remains within the acceptable range for aquatic organisms (pH of 6.5 to 8.0, as per Davies-Colley *et al.* (2013)).

For the Downstream sampling location (Orewa river/estuary), which can be considered estuarine water based on specific conductivity results, a comparison with the guidelines values in ANZECC 2000 indicates exceedance related to nutrients TN and TP. The TP result at the Downstream location was higher than at the Upstream and Discharge points, likely reflecting contributions from other streams and the broader catchment area.

As observed in the first sampling round, the current freshwater results from the Discharge and Upstream locations indicate some level of chemical stress due to nutrients and sediments, likely from stormwater runoff within the Waterloo Creek catchment or from the riverbank. This catchment receives inputs from pasture and agricultural land, residential areas, and possibly earthworks from land development. Riverbank erosions were also observed in several points during the site visit. The relatively high conductivity (above 500 µS/cm) for freshwater may also reflect seawater influence due to the proximity to the estuary.

Despite the exceedances to ANZECC guideline values observed at both sampling points, the results—except for *E. coli*—remain well below the NBL. For nutrients, which are the main potential pollutants, the attribute remains in State A, indicating it is “unlikely to have effects even on sensitive species” (NPS-FM 2020).

Biological Inspection

Visual biological inspections were conducted at the upstream control site and downstream impact site on the Waterloo Creek (freshwater sites), along with one site in the Orewa River (estuarine site). These inspections were carried out on the same day as the surface water sampling, aiming to confirm, as expected, that no significant changes had occurred since the baseline data collection in October's monitoring occasion.

Based on the photos collected during this November inspection (refer to **Appendix C**), no notable visual changes were observed compared to the October monitoring. Signs of scour and erosion remain present, with limited vegetation and reduced habitat complexity at the proposed discharge point.

Conclusions and Recommendations:

Based on the observations and analytical results from the second sampling round, which was similar to the first round undertaken in October, some degree of chemical stress was identified in Waterloo Creek due to nutrient and sediment discharges associated with its catchment. Despite this, the results remain well below the NBL, with nutrient levels still within the attribute State A of the NPS-FM, indicating that Waterloo Creek, as well as the Orewa River-Estuary, are in relatively healthy condition.

Surface water quality results can vary temporally and seasonally; therefore, assessing historical data from nearby areas or those with similar environmental characteristics is recommended to enhance and validate the understanding of water quality at the discharge point and its associated implications for the proposed development.

Additionally, no significant changes were observed during the biological inspection in comparison to that observed in October. It is still recommended that biomonitoring be conducted again in the autumn (March). This additional monitoring will provide comparative seasonal data, offering insights into potential variations in water quality and habitat conditions.

Yours sincerely

Tiago Teixeira — Environmental Engineer

Christel du Preez — Senior Freshwater Ecologist

Babbage Consultants Ltd

Attachments: Figure 1– Sampling Location Plan

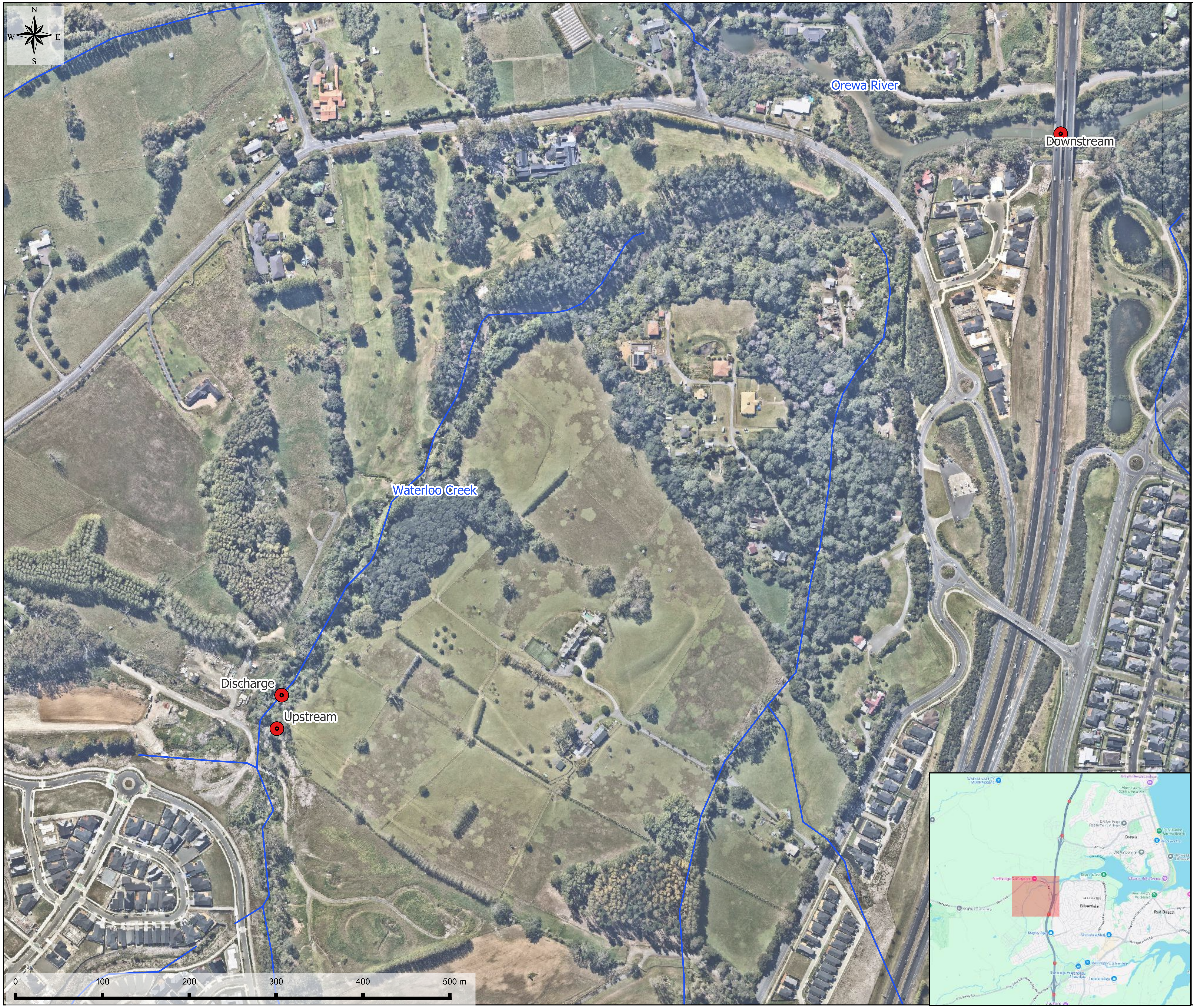
Table 1 – Surface water analytical results – Milldale Project.

Applicability and limitations

Appendix A –Field Sheets and Calibration Certificate

Appendix B –Laboratory Reports

Appendix C –Biological Inspection – 21/11/24



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CLIENT / PROJECT

APEX WATER LIMITED

MILLDALE WWTP PROJECT

MAP TITLE

BASELINE SAMPLING PLAN

MAP REVISIONS

07/1/2024 Initial version by TT.

Legend

Sampling Locations

Stream

NOTES
Aerial Images: LINZ Basemap
Rivers and Streams: LINZ Database

DISCLAIMER:
This map/plan is not an engineering draft.
This map/plan is illustrative only and all information should be independently verified on site before taking any action.

SCALE

1:4,000 @ A3

MAP NO.

67717-01#ESE

Table 1 -Surface water analytical results - Milldale Project

Parameter	Round 1 - Sampling date - 17/10/2024			Round 2 - Sampling date - 21/11/2024			Freshwater guidelines		Estuarine guidelines
	Discharge	Upstream	Downstream - Estuarine water	Discharge	Upstream	Downstream - Estuarine water	ANZG DGV	NPSFM NBL	ANZECC TV
Collection Time	9:45	10:00	10:30	15:15	14:20	15:55	-	-	-
Conductivity (uS/cm)[A]	534	524	18730	800	806	43092	115	-	-
Dissolved Oxygen (g O_2/m^3)	10.1	11.14	9.17	9.66	10.33	6.98	-	<4*	-
pH (unitless)[A]	7.66	7.75	7.58	7.52	7.08	7.64	7.3 - 7.7[##]	-	7-8.5
Temperature (C)[A]	14.2	14.3	15.9	17.2	17.4	19.5	-	-	-
Total suspended Solids	22	10	12	14	18	56	8.8	-	-
Turbidity (NTU)	20	12	7.5	11	14	26	5.2	-	-
Ammonia nitrogen	<0.005	<0.005	0.009	<0.005	<0.005	0.005	0.01	0.4**	0.015
Nitrite nitrogen	0.0018	0.0019	<0.0010	0.00526	0.00506	<0.0010	-	-	-
Nitrate nitrogen	0.188	0.206	0.0588	0.416	0.415	0.005	0.065	3.5**	-
Total Kjeldahl nitrogen	0.62	0.63	0.36	0.56	0.58	0.62	-	-	-
Total nitrogen	0.81	0.84	0.42	0.98	1	0.62	0.292	-	0.3
Dissolved reactive phosphorus	0.006	0.005	0.003	0.009	0.008	0.004	0.014	0.021 ***	0.005
Total phosphorus	0.044	0.037	0.025	0.037	0.042	0.064	0.024	-	0.03
Soluble $cBOD_5$ (g O2/m3)	<1.00	3.29	<1.00	<1.00	<1.00	<1.00	2[#]	-	-
Faecal coliforms (cfu/100mL)	1900	1200	670	2800	4000	15	-	-	-
Escherichia coli (cfu/100mL)	1900	1100	670	2800	4000	15	-	540	-
Enterocci (cfu/100mL)	60	30	90	100	220	46	-	-	-

Note: All units g/m3 unless stated; DGV = default guideline value, 80^{th} percentile; NBL = national bottom line, *= 1-day minimum, ** as an annual 95th percentile. ***= Attribute state A as 95^{th} percentile. [#]this limit is set specifically to prevent the growth of sewage fungus (MfE 1992).## DGV = default guideline value, 20th percentile - 80th percentile. A- Field dta

Exceedance to NPSFM NBL criteria

Exceedance to ANZG DGV criteria

Exceedance to Both (ANZG and NPSFM)

Exceedance to ANZECC TV criteria

APPLICABILITY AND LIMITATIONS

Restrictions of Intended Purpose

This report has been prepared solely for the benefit of Apex Water as our client with respect to the brief. The reliance by other parties on the information or opinions contained in the report shall, without our prior review and agreement in writing, be at such party's sole risk.

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Maps and Images

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Recommendations and opinions in this report are based on discrete sampling data. The nature and continuity of matrix sampled away from the sampling points are inferred and it must be appreciated that actual conditions could vary from the assumed model.

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APPENDIX A – Field Sheet and Calibration Certificate

FIELD SHEET

WATER QUALITY SAMPLING

Babbage®

SITE: Milldale

Job No: 67717

SAMPLING STAFF: MS

Sample date	21/11/24
Tide condition	High tide 12:20PM
Weather	Light rain, windy
Preceding rainfall (mm)	—

Location	Time	Temp (°C)	pH	Cond. (µS/cm)	ORP (mV)	DO (mg/L)
Upstream	2:30	17.4	7.08	806	-166.6	10.33
Discharge	3:15	17.2	7.52	800	-151.1	9.66
Dowstream	3:55	19.5	7.64	43092	-141.6	6.98

Notes (i.e., species observed, ground/sea conditions, access, bank vegetation, etc):

Observations (e.g., species observed, ground/sea conditions, access, bank vegetation)

RETURN ADDRESS

Please ship to:

ENVCO
438B Rosebank Road

Avondale
Auckland 1026

The Environmental Collective Ltd
438B Rosebank Road, Avondale, Auckland 1026, New Zealand
www.envcoglobal.com | info@envcoglobal.com | Phone NZ 0800 623 336 or +64 (09) 307 3285 | Fax +64 (09) 307 3287

CERTIFICATE OF CALIBRATION AND COMPLIANCE

Customer:	Matthew Smith - Babbage
Instrument:	YSI ProQuatro
Serial No:	22B104368
Date Checked:	Wednesday, November 13, 2024
Calibrated by:	Shannon Dias (Rental Manager)

Envco certifies that the above instrument has been calibrated and/or assessed in accordance with the manufacturers' specifications.

PARAMETER	BUFFER SOLUTION	CERTIFIED	LOT#	CALIBRATION RESULT
Temperature 19.2 °C	-	-	-	-
pH 4	pH4	NIST	A0058	4.00 pH
pH 7	pH7	NIST	A0059	7.00 pH
pH10	pH10	NIST	A9239	10.00 pH
ORP	263mV	NIST	309/09	263.0 mV
Conductivity	1413 µs.cm	NIST	14051	1413 µs.cm
Dissolved Oxygen	Zero in water	-	18003260126	0.0 %
	100% in Air	-	-	100.0 %

Comments:
Please store probe inside clear storage cup – ensure cup is moist (few droplets of water).
Please wipe equipment down before returning. Cleaning fee will apply if returned in unsuitable condition.

Rental Checklist:
Please check that all items are received, and all returned. Please clean equipment before returning. A charge may apply to any unclean items. Any damaged or lost items are the liability of the renter.

Sent		Returned
☒	Handheld	☐
☒	Cable and sensors, 4 m	☐
☒	Black sensor guard	☐
☒	Clear calibration cup	☐
☒	Flow-through Cell (only on request)	☐
☒	Quick reference guide	☐
☒	Envco storage/troubleshooting guide	☐
☒	Spare batteries ($8.65 + GST if used)	☐
☒	Case	☐

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www.envcoglobal.com | info@envcoglobal.com | Phone NZ 0800 623 336 or +64 (09) 307 3285 | Fax +64 (09) 307 3287

APPENDIX B – Laboratory Reports

ALS Food & Environmental NZ
Ruakura Research Centre
10 Bisley Road, Hamilton 3214, New Zealand
T: +64 7 974 4740
E: ALSEnviro.Hamilton@alsglobal.com

CERTIFICATE OF ANALYSIS

Babbage Consultants
Level 4, 68 Beach Road
Auckland 1010

Attention: Tiago Teixeira
Phone: 027 414 5454
Email: matthew.smith@babbage.co.nz

Lab Reference: 24-35980
Submitted by: Mathew Smith
Date Received: 22/11/2024
Testing Initiated: 22/11/2024
Date Completed: 27/11/2024
Order Number: 67717#ESE01
Reference: Milldale

Sampling Site: Milldale

Report Comments

Samples were collected by yourselves (or your agent) and analysed as received at ALS NZ (or at the subcontracted laboratories, when applicable). Samples were in acceptable condition unless otherwise noted on this report.
Specific testing dates are available on request.

Solids in Water

		Client Sample ID	Upstream	Discharge	Downstream
		Date Sampled	21/11/2024	21/11/2024	21/11/2024
Analyte	Unit	*Reporting Limit*	24-35980-1	24-35980-2	24-35980-3
Total Suspended Solids	g/m^3	*3*	18	14	56

Turbidity

		Client Sample ID	Upstream	Discharge	Downstream
		Date Sampled	21/11/2024	21/11/2024	21/11/2024
Analyte	Unit	*Reporting Limit*	24-35980-1	24-35980-2	24-35980-3
Turbidity	NTU	*0.05*	14	11	26

Inorganic Nutrients and Nutrient Species in Water

		Client Sample ID	Upstream	Discharge	Downstream
		Date Sampled	21/11/2024	21/11/2024	21/11/2024
Analyte	Unit	*Reporting Limit*	24-35980-1	24-35980-2	24-35980-3
Nitrate-N	g/m^3	*0.002*	0.415	0.416	0.0050
Nitrite-N	g/m^3	*0.001*	0.00506	0.00526	<0.0010
Ammoniacal-N	g/m^3	*0.005*	<0.005	<0.005	0.005
Dissolved Reactive Phosphorus (FIA)	g/m^3	*0.002*	0.008	0.009	0.004

Total Nitrogen / Kjeldahl Nitrogen in Water

		Client Sample ID	Upstream	Discharge	Downstream
		Date Sampled	21/11/2024	21/11/2024	21/11/2024
Analyte	Unit	*Reporting Limit*	24-35980-1	24-35980-2	24-35980-3
Total Kjeldahl Nitrogen	g/m^3	*0.1*	0.58	0.56	0.62
Total Nitrogen	g/m^3	*0.1*	1.0	0.98	0.62

Total Phosphorus in Water

		Client Sample ID	Upstream	Discharge	Downstream
		Date Sampled	21/11/2024	21/11/2024	21/11/2024
Analyte	Unit	*Reporting Limit*	24-35980-1	24-35980-2	24-35980-3
Total Phosphorus	g/m^3	*0.005*	0.042	0.037	0.064

Biochemical Oxygen Demand

		Client Sample ID	Upstream	Discharge	Downstream
		Date Sampled	21/11/2024	21/11/2024	21/11/2024
Analyte	Unit	*Reporting Limit*	24-35980-1	24-35980-2	24-35980-3
Sol Carbonaceous Biochem. Oxygen Demand*	g/m^3	*1*	<1.00	<1.00	<1.00

Receiving Water Microbiology

		Client Sample ID	Upstream	Discharge	Downstream
		Date Sampled	21/11/2024	21/11/2024	21/11/2024
Analyte	Unit	*Reporting Limit*	24-35980-1	24-35980-2	24-35980-3
Faecal Coliforms Count	cfu/100mL	*1*	4,000	2,800	15
Enterococci Count	cfu/100mL	*1*	220	100	46
E.Coli Count	cfu/100mL	*1*	4,000	2,800	15

Temperature on Arrival

		Client Sample ID	Upstream	Discharge	Downstream
		Date Sampled	21/11/2024	21/11/2024	21/11/2024
Analyte	Unit	*Reporting Limit*	24-35980-1	24-35980-2	24-35980-3
Temp on Arrival*	°C	*0*	3.30	3.30	3.30

Method Summary

Total Suspended Solids	Measured gravimetrically following filtration through glass micro-fibre filters. (APHA 2540 D - Modified - Online edition).
Turbidity	Samples analysed as received using a conventional turbidimeter. (APHA 2130 B Online edition - Modified).
NO3-N	Calculated from oxidised nitrogen and Nitrite-N, measured colourimetrically by flow injection analysis. (APHA NO_{3-} I. Online edition)
NO2-N	Samples analysed colourimetrically by flow injection analysis following filtration. (APHA 4500-NO_3 I. Online edition).

Method Summary

Ammoniacal-N	Samples are filtered and measured colourimetrically by flow injection analysis. Results represent total ammonical nitrogen (APHA 4500-NH_3 H - Modified - Online edition).
Dissolved Reactive Phosphorus	Samples filtered and measured colourimetrically by flow injection analysis. (APHA 4500-P G - Modified - Online edition)
TKN	Samples analysed colourimetrically following an acid digestion. (APHA 4500-N_{Org} D - Modified - Discrete Analyser - Online edition).
TN	Sum of Total Kjeldahl Nitrogen (APHA 4500 N_{org} - Modified - Online edition), Nitrate-N and Nitrite-N (APHA 4500 NO_3 I - Online edition). (APHA 4500-N A - Online Edition).
Total Phosphorus	Samples analysed colourimetrically following an acid digestion. (APHA 4500 P H - Modified - Discrete Analyser - Online edition)
cBOD	Following lab filtration, dissolved oxygen measured using a dissolved oxygen electrode after addition of the nitrification inhibitior ATU and a 5 day incubation period. (APHA 5210 B - Online edition).
Total Faecal Coliform Count	Samples analysed by Thermotolerant (Fecal) Coliform Membrane Filter Procedure using mFC medium. Incubated at 44.5°C for 24hours. APHA 9222 D Online Edition.
Enterococcus Count	Samples analysed by Enterococci Membrane Filter Procedure using mEnterococcus medium. Incubated at 36°C for 48 hours. AS/NZS 4276.9:2007
E.coli Count	Samples analysed by E.coli Membrane Filter Procedure using mFC medium. Incubated at 44.5°C for 24hours. APHA 9222 D Online Edition.
Temp on Arrival	Measured on arrival by a digital infra-red laser thermometer.

Louise Coombridge, B.Sc.
Chemist

Rowin Angkico, B.Sc.
Laboratory Technician

Matthew Counsell, B.Sc.
Environmental Lab Manager

Dona Mathew, B.Sc. Microbiology
Laboratory Technician

Deanna Rhind
Technician

APPENDIX C – Biological Inspection – 21/11/24

Waterloo Creek - Upstream




Waterloo Creek - Discharge

Orewa River – Downstream

8 November 2024 Job No: 67717#ESE01 eTrack No: 200048873

Jack Taylor
Apex Water Limited

MILLDALE WWTP PROJECT – ENVIRONMENTAL BASELINE SAMPLING REPORT – ROUND 1

Dear Jack

Please, find below the round 1 environmental baseline sampling report for the Milldale Wastewater Treatment Plant Project. The water quality sampling was conducted by Babbage Consultants Limited (Babbage) in October 2024.

This surface water sampling is part of baseline environmental monitoring approved on 8 October 2024 (Proposal Etrack no. 200048486) to assess potential effects associated with proposed development of a Wastewater Treatment Plant (WWTP) and its discharge into Waterloo Creek.

Surface Water Sampling Methodology and Conditions

Surface water samples were collected from three locations, two along the Waterloo Creek (Discharge point and Upstream) and one in the Orewa River-Estuary (Downstream). Refer to **Figure 1** for sampling locations.

Waterloo Creek discharges into the Orewa River, which then flows to the estuary and sea. The upstream location represents baseline conditions upstream of the discharge point, including contributions from an unnamed tributary flowing from the west side of the WWTP site. The downstream location is in the Orewa River, influenced by the estuary (seawater influence) and baseline contributions from the Orewa River (northwestern branch) and an unnamed stream that flows parallel to State Highway 1.

The sampling was conducted on 17 October 2024. Samples were collected directly into laboratory-prepared bottles using a mighty gripper. Field parameters, including water temperature, pH, dissolved oxygen (DO), oxidation-reduction potential (ORP) and specific conductance (electrical conductivity (EC) at 25 °C) were measured on-site for each sample using a multiparameter instrument (see **Appendix A** for field sheet and calibration certificates).

Babbage Consultants Limited
Level 4, 68 Beach Road, Auckland 1010
PO Box 2027, Shortland Street,
Auckland 1140, New Zealand
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E admin@babbage.co.nz www.babbage.co.nz

Surface water samples were kept on ice and sent to Analytica Laboratories with a chain of custody documentation. Surface water samples were analysed for typical parameters related to water quality and domestic wastewater discharge, including nitrate, nitrite, total Kjeldahl nitrogen (TKN), ammonia, total nitrogen (TN), dissolved reactive phosphorus (DRP), total phosphorus (TP), soluble carbonaceous biochemical oxygen demand ($cBOD_5$), faecal coliforms, E. coli, enterococci, total suspended solids (TSS), turbidity and pH).

Sampling was conducted during dry weather, with only a light rainfall recorded on 15 October (0.4 mm/day). Given the site's proximity to the sea, samples were collected at mid-ebb (midway through the falling tide).

During the site visit, a level logger was installed near the proposed WWTP discharge point to monitor stream water depth to support future hydrology assessment. Refer to photos in **Appendix B**.

Analytical Results

The analytical results of the samples and their respective trigger levels are provided in **Table 1** below (laboratory analytical report attached – **Appendix C**). Guidelines used in Table 2 are set by:

- Australian and New Zealand guidelines for fresh and marine water quality (ANZG 2018) default guideline values (DGV) for warm wet low elevation (WWLE) stream according to river environmental classification - REC presented in Niwa NZ River maps.
- Australian and New Zealand guidelines for fresh and marine water quality (ANZECC 2000)- Table 3.3.2 for Estuaries Default trigger values.
- National Policy Statement for Freshwater Management (NPSFM 2020) – National Bottom Line (NBL).
- Water Quality Guidelines No. 1: Guidelines for the Control of Undesirable Biological Growths in Water (MfE 1992) specifically for $cBOD_5$.

In summary, results from this first sampling event yielded exceedances in relation to proposed guidelines for TSS, turbidity, nitrate nitrogen, total nitrogen, total phosphorus, E.Coli and soluble $cBOD_5$. However, just *E. coli* exceeded the NPSFM national bottom line (NBL) for freshwater samples.

In comparing results from the Discharge Point and Upstream locations against the ANZG freshwater limits, conductivity, TSS, turbidity, nitrate, TN, and TP were found to exceed their respective limits at each monitoring location. Additionally, $cBOD_5$ exceeded the MfE (1992) limit at the Upstream location.

For the Downstream sampling location (Orewa river/estuary), which can be considered estuarine water based on specific conductivity results, comparison with the limits in ANZECC 2000 indicates an exceedance for TN only. This is an indicative of relatively healthy state.

The freshwater results from the Discharge and Upstream locations indicate some level of chemical stress due to nutrients and sediments, likely from stormwater runoff within the Waterloo Creek catchment or from the riverbank. This catchment receives inputs from pasture and agricultural land, residential areas, and possibly earthworks from land development. Riverbank erosions were also observed in several points during the site visit. The relatively high conductivity (around 500 µS/cm) for freshwater may also reflect seawater influence due to the proximity to the estuary. Despite the exceedances observed at both sampling points, the results—except for *E. coli*—remain well below the NBL. For nutrients, which are the main pollutants, the attribute remains in State A, indicating it is "unlikely to have effects even on sensitive species" (NPS-FM 2020).

Conclusions and Recommendations:

Based on the observations and analytical results from this initial sampling round, some degree of chemical stress was identified in Waterloo Creek due to nutrient and sediment discharges associated with its catchment. Despite this, the results remain well below the NBL, with nutrient levels still within the attribute State A of the NPS-FM, indicating that Waterloo Creek, as well as the Orewa River-Estuary, are in healthy condition.

We recommend conducting a second water quality sampling round (second fortnight of November) to compare with these current results and to gather additional data to support the assessments of the effects of the proposed development.

Yours sincerely

Tiago Teixeira

Environmental Engineer

Babbage Consultants Ltd

Attachments: Figure 1– Sampling Location Plan

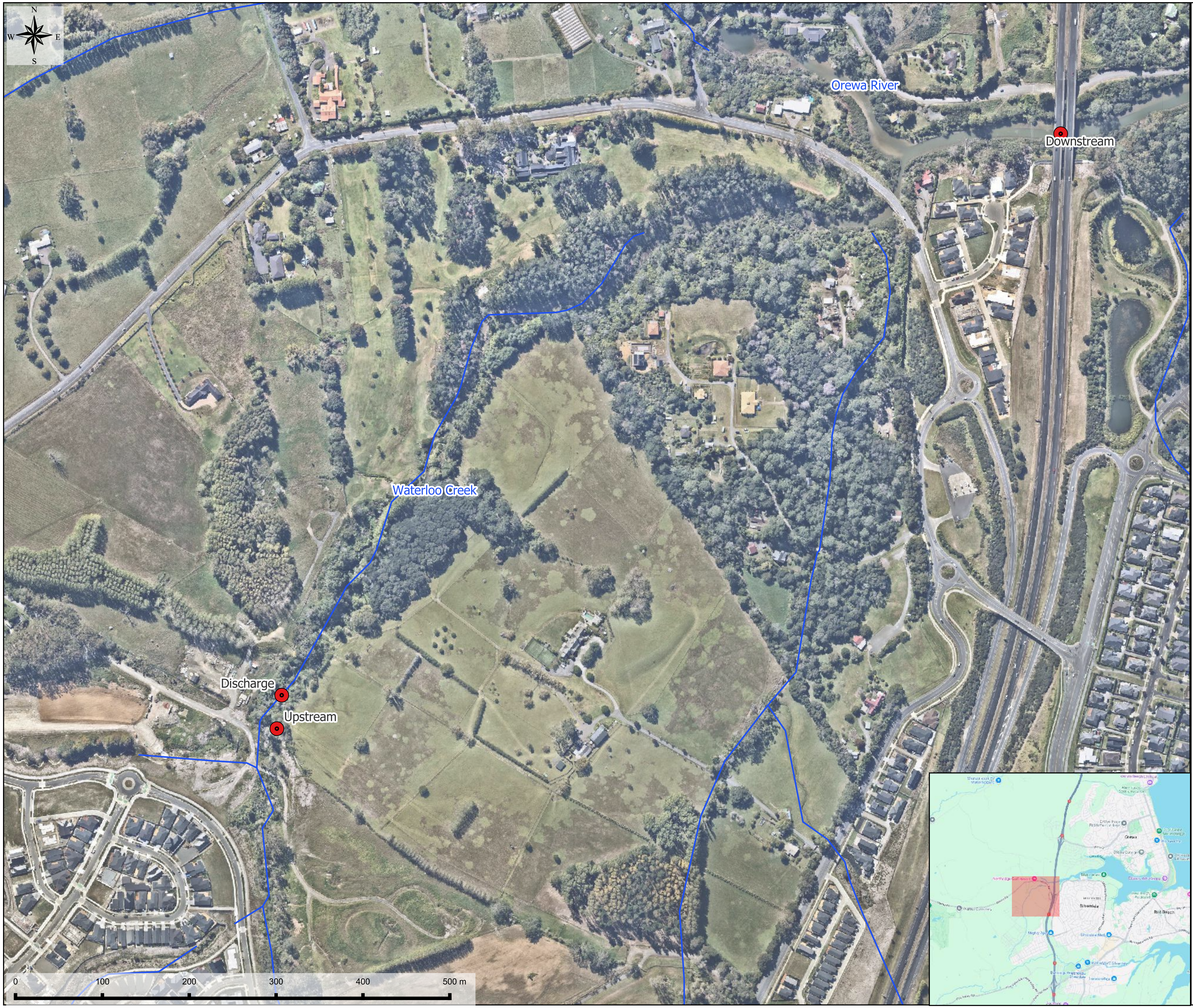
Table 1 – Surface water analytical results – Round 1.

Applicability and limitations

Appendix A –Field Sheets and Calibration Certificate

Appendix B –Photos site visit – 17/10/24

Appendix C –Laboratory Reports



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CLIENT / PROJECT

APEX WATER LIMITED

MILLDALE WWTP PROJECT

MAP TITLE

BASELINE SAMPLING PLAN

MAP REVISIONS

07/1/2024 Initial version by TT.

Legend

Sampling Locations

Stream

NOTES
Aerial Images: LINZ Basemap
Rivers and Streams: LINZ Database

DISCLAIMER:
This map/plan is not an engineering draft.
This map/plan is illustrative only and all information should be independently verified on site before taking any action.

SCALE

1:4,000 **@ A3**

MAP NO.

67717-01#ESE

Table 1 -Surface water analytical results - Milldale Project

Parameter	Sampling date - 17/10/2024			Freshwater guidelines		Estuarine guidelines
	Discharge	Upstream	Downstream - Estuarine water	ANZG DGV	NPSFM NBL	ANZECC TV
Collection Time	9:45	10:00	10:30	-	-	-
Conductivity (uS/cm)	534	524	18730	115	-	-
Dissolved Oxygen (g O_2/m^3)	10.1	11.14	9.17	-	<4*	-
pH (unitless)	7.66	7.75	7.58	7.3 - 7.7##	-	7-8.5
Temperature (C)	14.2	14.3	15.9	-	-	-
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Turbidity (NTU)	20	12	7.5	5.2	-	-
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Nitrate nitrogen	0.188	0.206	0.0588	0.065	3.5**	-
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Total nitrogen	0.81	0.84	0.42	0.292	-	0.3
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APPENDIX A – Field Sheet and Calibration Certificate

FIELD SHEET

WATER QUALITY SAMPLING

Babbage

SITE: Millwaterdale

Job No:

SAMPLING STAFF: MS, TT

Sample date	17/10/24						
Tide condition	High Tide 7:30AM						
Weather	90% CC						
Preceding rainfall (mm)	–						
Location	**Time**	**Temp (°C)**	**pH**	**Cond. (µS/cm)**	**ORP (mV)**	**Turbidity (NTU)**	**DO (mg/L)**
Discharge	9:45	14.2	7.66	534	-47.6		10.1
Upstream	10:00	14.3	7.75	524	-53		11.14
Downstream	10:30	15.9	7.58	18730	-43.7		9.17

Notes (i.e., species observed, ground/sea conditions, access, bank vegetation, etc):

Observations (e.g., species observed, ground/sea conditions, access, bank vegetation)

RETURN ADDRESS

Please ship to:

ENVCO
438B Rosebank Road

Avondale
Auckland 1026

CERTIFICATE OF CALIBRATION AND COMPLIANCE

Customer:	Tiago Teixeira - Babbage
Instrument:	YSI ProQuatro
Serial No:	22B104368
Date Checked:	Tuesday, October 15, 2024
Calibrated by:	Shannon Dias (Rental Manager)

Envco certifies that the above instrument has been calibrated and/or assessed in accordance with the manufacturers' specifications.

PARAMETER	BUFFER SOLUTION	CERTIFIED	LOT#	CALIBRATION RESULT
Temperature 15.2 °C	-	-	-	-
pH 4	pH4	NIST	A0058	4.00 pH
pH 7	pH7	NIST	A0059	7.00 pH
pH10	pH10	NIST	A9239	10.00 pH
ORP	263mV	NIST	309/09	263.0 mV
Conductivity	1413 µs.cm	NIST	14051	1413 µs.cm
Dissolved Oxygen	Zero in water	-	18003260126	0.0 %
	100% in Air	-	-	100.0 %

Comments:
Please store probe inside clear storage cup – ensure cup is moist (few droplets of water).
Please wipe equipment down before returning. Cleaning fee will apply if returned in unsuitable condition.

Rental Checklist:
Please check that all items are received, and all returned. Please clean equipment before returning. A charge may apply to any unclean items. Any damaged or lost items are the liability of the renter.

Sent		Returned
☒	Handheld	☐
☒	Cable and sensors, 4 m	☐
☒	Black sensor guard	☐
☒	Clear calibration cup	☐
☐	Flow-through Cell (only on request)	☐
☒	Quick reference guide	☐
☒	Envco storage/troubleshooting guide	☐
☒	Spare batteries ($8.65 + GST if used)	☐
☒	Case	☐

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APPENDIX B – Photos site visit – 17/10/24

Photo 1. Upstream sampling point.

Photo 2. Discharge sampling point. The red arrow indicates the location of level logger installation.

Photo 3. Downstream sampling point.

APPENDIX C – Laboratory Reports

ALS Food & Environmental NZ
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CERTIFICATE OF ANALYSIS

Babbage Consultants
Level 4, 68 Beach Road
Auckland 1010

Attention: Tiago Teixeira
Phone: 020 414 36031
Email: tiago.teixeira@babbage.co.nz

Sampling Site: Milldale

Lab Reference: 24-32242
Submitted by: Tiago Teixeiro and Mathew Smith
Date Received: 17/10/2024
Testing Initiated: 17/10/2024
Date Completed: 24/10/2024
Order Number:
Reference: Milldale

Report Comments

Samples were collected by yourselves (or your agent) and analysed as received at ALS NZ (or at the subcontracted laboratories, when applicable). Samples were in acceptable condition unless otherwise noted on this report.
Specific testing dates are available on request.

Solids in Water

		Client Sample ID	Discharge	Upstream	Downstream
		Date Sampled	17/10/2024	17/10/2024	17/10/2024
Analyte	Unit	*Reporting Limit*	24-32242-1	24-32242-2	24-32242-3
Total Suspended Solids	g/m^3	*3*	22	10	12

Turbidity

		Client Sample ID	Discharge	Upstream	Downstream
		Date Sampled	17/10/2024	17/10/2024	17/10/2024
Analyte	Unit	*Reporting Limit*	24-32242-1	24-32242-2	24-32242-3
Turbidity	NTU	*0.05*	20	12	7.5

Inorganic Nutrients and Nutrient Species in Water

		Client Sample ID	Discharge	Upstream	Downstream
		Date Sampled	17/10/2024	17/10/2024	17/10/2024
Analyte	Unit	*Reporting Limit*	24-32242-1	24-32242-2	24-32242-3
Ammonia as N	g/m^3	*0.005*	<0.005	<0.005	0.009
Nitrate-N	g/m^3	*0.002*	0.188	0.206	0.0588
Nitrite-N	g/m^3	*0.001*	0.0018	0.0019	<0.0010
Dissolved Reactive Phosphorus (FIA)	g/m^3	*0.002*	0.006	0.005	0.003

Total Nitrogen / Kjeldahl Nitrogen in Water

	Client Sample ID		Discharge	Upstream	Downstream
	Date Sampled		17/10/2024	17/10/2024	17/10/2024
Analyte	Unit	*Reporting Limit*	24-32242-1	24-32242-2	24-32242-3
Total Kjeldahl Nitrogen	g/m^3	*0.1*	0.62	0.63	0.36
Total Nitrogen	g/m^3	*0.1*	0.81	0.84	0.42

Biochemical Oxygen Demand

	Client Sample ID		Discharge	Upstream	Downstream
	Date Sampled		17/10/2024	17/10/2024	17/10/2024
Analyte	Unit	*Reporting Limit*	24-32242-1	24-32242-2	24-32242-3
Sol Carbonaceous Biochem. Oxygen Demand*	g/m^3	*1*	<1.00	3.29	<1.00

Total Phosphorus in Water

	Client Sample ID		Discharge	Upstream	Downstream
	Date Sampled		17/10/2024	17/10/2024	17/10/2024
Analyte	Unit	*Reporting Limit*	24-32242-1	24-32242-2	24-32242-3
Total Phosphorus	g/m^3	*0.005*	0.044	0.037	0.025

Receiving Water Microbiology

	Client Sample ID		Discharge	Upstream	Downstream
	Date Sampled		17/10/2024	17/10/2024	17/10/2024
Analyte	Unit	*Reporting Limit*	24-32242-1	24-32242-2	24-32242-3
Faecal Coliforms Count	cfu/100mL	*1*	1,900	1,200	670
Enterococci Count	cfu/100mL	*1*	60	30	90
E.Coli Count	cfu/100mL	*1*	1,900	1,100	670

Temperature on Arrival

	Client Sample ID		Discharge	Upstream	Downstream
	Date Sampled		17/10/2024	17/10/2024	17/10/2024
Analyte	Unit	*Reporting Limit*	24-32242-1	24-32242-2	24-32242-3
Temp on Arrival*	°C	*0*	3.30	3.30	3.30

Method Summary

Total Suspended Solids	Measured gravimetrically following filtration through glass micro-fibre filters. (APHA 2540 D - Modified - Online edition).
Turbidity	Samples analysed as received using a conventional turbidimeter. (APHA 2130 B Online edition - Modified).
Ammonia-N	Samples filtered and measured colourimetrically by flow injection analysis. (APHA 4500-NH_3 H - Modified - Online edition).
NO3-N	Calculated from oxidised nitrogen and Nitrite-N, measured colourimetrically by flow injection analysis. (APHA NO_{3-} I. Online edition)

Method Summary

NO2-N	Samples analysed colourimetrically by flow injection analysis following filtration. (APHA 4500-NO_3 I. Online edition).
Dissolved Reactive Phosphorus	Samples filtered and measured colourimetrically by flow injection analysis. (APHA 4500-P G - Modified - Online edition)
TKN	Samples analysed colourimetrically following an acid digestion. (APHA 4500-N_{Org} D - Modified - Discrete Analyser - Online edition).
TN	Sum of Total Kjeldahl Nitrogen (APHA 4500 N_{org} - Modified - Online edition), Nitrate-N and Nitrite-N (APHA 4500 NO_3 I - Online edition). (APHA 4500-N A - Online Edition).
cBOD	Following lab filtration, dissolved oxygen measured using a dissolved oxygen electrode after addition of the nitrification inhibitior ATU and a 5 day incubation period. (APHA 5210 B - Online edition).
Total Phosphorus	Samples analysed colourimetrically following an acid digestion. (APHA 4500 P H - Modified - Discrete Analyser - Online edition)
Total Faecal Coliform Count	Samples analysed by Thermotolerant (Fecal) Coliform Membrane Filter Procedure using mFC medium. Incubated at 44.5°C for 24hours. APHA 9222 D Online Edition.
Enterococcus Count	Samples analysed by Enterococci Membrane Filter Procedure using mEnterococcus medium. Incubated at 36°C for 48 hours. AS/NZS 4276.9:2007
E.coli Count	Samples analysed by E.coli Membrane Filter Procedure using mFC medium. Incubated at 44.5°C for 24hours. APHA 9222 D Online Edition.
Temp on Arrival	Measured on arrival by a digital infra-red laser thermometer.

Prianshu Chawla, B.Sc.
Chemist

Louise Coombridge, B.Sc.
Chemist

Rowin Angkico, B.Sc.
Laboratory Technician

Matthew Counsell, B.Sc.
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Dona Mathew, B.Sc. Microbiology
Laboratory Technician

Deanna Rhind
Technician

8 November 2024

Job No: 67717

Jack Taylor & Matt Savage

Apex Water Limited

BASELINE BIOMONITORING REPORT TO PROVIDE INPUT TO THE ASSESSMENT OF EFFECTS TO SUPPORT TREATED WASTEWATER DISCHARGE AT MILLDALE

Dear Jack and Matt

Please find below the baseline biomonitoring report for the proposed Milldale Wastewater Treatment Plant (WWTP) Project. The sampling was conducted by Babbage Consultants Limited (Babbage) in October 2024. This study forms part of the baseline ecological monitoring program to assess potential effects associated with the proposed construction of a WWTP and the subsequent discharge to Waterloo Creek.

Biomonitoring requirements

Biological and visual monitoring was conducted at both an upstream control site and a downstream impact site in Waterloo Creek (freshwater sites), along with one site in the Orewa River (estuarine site). The aim was to collect baseline data for the watercourses prior to any potential effects from future discharges. This monitoring included:

- Visual estimates of in-stream and riparian habitat;
- Visual and qualitative assessment of periphyton coverage and composition;
- Benthic macroinvertebrate sample collection and identification; and
- General observations of surface water appearance and sampling conditions.

In the absence of specific consent limits, biomonitoring results were compared against relevant standards and guidelines to assess general stream health. Full details of the biomonitoring methodology can be found in Appendix A. Refer to the baseline sampling report, for details pertaining to the surface water quality.

Note that at the time of report compilation, the macroinvertebrate identification results are yet to be produced.

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Sites

Visual and biological assessments were undertaken on the Waterloo Creek (upstream and impact sites) which is considered a freshwater stream. An assessment was also undertaken on the Orewa River(downstream site), which is classified as an estuarine system. A description of the sites is provided in Table 1 and displayed in Figure 1.

Waterloo Creek discharges into the Orewa River, which then flows to the sea. The upstream site (WUp) represents baseline and control conditions upstream of the discharge point, including contributions from an unnamed tributary flowing from the west side of the proposed WWTP position. The downstream site (ODown) is on the Orewa River, influenced by the estuary (seawater) and contributions from the upstream Orewa River catchment.

Figure 1: Overview of the biomonitoring locations along the Waterloo Creek and Orewa River, relative to the proposed discharge outlet.

Table 1. Locations for each watercourse monitoring site.

Watercourse name	Site name	Watercourse Type	Sampling date	Site type	Coordinates	
					Southing	Easting
Waterloo Creek	WUp	Freshwater	17 October 2024	Control	1747790	5947683
Waterloo Creek	WImp	Freshwater	17 October 2024	Impact	1747803	5947733
Orewa River	ODown	Marine	23 October 2024	Impact	1748703	5948381

Habitat characteristics – freshwater sites

Waterloo Creek – Upstream site (WUp)

Located upstream of the proposed discharge point, the Waterloo Creek upstream site (WUp) exhibited a fairly uniform habitat, predominantly run-type (85%) with a short chute (15%) within the assessed reach. The average water depth during the field survey was 0.5 m, with an average wetted width of 2.6 m. The streambed substrate, primarily silt and sand, classifies this as a soft-bottomed stream site.

Riparian vegetation on both banks is dominated by *Elaeagnus x reflexa*, an exotic dense shrub, along with various rank grasses and tree privet (*Ligustrum lucidum*). Cabbage trees (*Cordyline australis*) and scattered tree ferns line the embankments, with a crack willow (*Salix fragilis × S. euxina*) overhanging part of the reach. This vegetation provides partial channel shading. While some bank erosion was observed, the banks remain mostly stable.

Macrophyte cover within the channel was limited to sparse patches of water starwort (*Callitriche stagnalis*) and water purslane (*Ludwigia palustris*), covering less than 3 % of the area. No periphyton was observed in the assessed reach.

Waterloo Creek – Impact site (WImp)

Situated directly downstream of the proposed discharge point, the impact site (WImp) displayed a run habitat with a more variable substrate than the upstream site. The average water depth was 0.2 m, and the average wetted width was 2.3 m. The streambed contained some gravel but was mainly composed of silt and sand, with silt plumes visible when the bed was disturbed (thus classified as a soft bottom site).

The stream banks at this site are well-vegetated with a mix of native and exotic species, predominantly tree privet. A pine tree lies across the stream at this location, and minor bank erosion was noted during the survey, with flood debris present along the true left bank. Macrophyte cover was limited to sparse patches (5 % or less) of water starwort and water purslane, while water celery (*Helosciadium nodiflorum*) and water forget-me-not (*Myosotis laxa*) were found along the banks. Periphyton cover was minimal, observed as green filaments along a single transect (less than 0.5% cover).

Physiochemistry of the Waterloo Creek

The results of monitoring during the spring 2024 survey are presented in Table 2 together with relevant water quality guidelines. The key findings from these data are:

- The pH of the upstream site is within the Australian & New Zealand Guidelines for fresh & marine water quality default guideline values (ANZG DGV) (WUP = 7.66), whereas that of the impact site just about exceeded the DGV (WImp = 7.75). The pH difference between the upstream and impact sites is minimal, suggesting stable conditions between the two sites.
- The conductivity values at both the upstream (534 µS/cm) and downstream (524 µS/cm) sites on Waterloo Creek significantly exceed the ANZG default guideline value (DGV) of 115 µS/cm. This exceedance suggests that the system receives runoff which might be contaminated from either agricultural or urban areas. Given that conductivity remains high across both sites, the source of elevated ions may be originating from the catchment area, affecting water quality and potentially stressing aquatic ecosystems that prefer lower conductivity levels.

Summary of freshwater site characteristics

A summary of the physical characteristics is provided in the table below.

Table 2. Summary of the physical characteristics and biological survey results of the Waterloo Creek

Site	Upstream / WUp	Impact / WImp
Date	17 Oct 2024	17 Oct 2024
Habitat		
Average Width (m)	2.6	2.3
Average Depth (m)	0.5	0.2
Dominant substrate	Silt & sand	Silt & sand, gravels
Macrophytes and Algae		
No. of Taxa	2	2
Average % Cover	Less than 3%	Less than 5%
Species Recorded	Water starwort and water purslane	Water starwort and water purslane
Stream Physiochemistry		
Temperature (°C)	14.2	14.3
pH (unitless)	7.66	7.75
Conductivity (µS/cm)	534	524
Dissolved oxygen (mg/L)	10.1	11.14

<u>Orewa River – Downstream site (ODown)</u>

Located approximately 1.3 km downstream of the Waterloo Creek impact site (WImp), this site lies within the Orewa River, best characterized as a shallow estuary. The stream width at the assessment point measures around 26 m. The site is tidally influenced, resulting in variable active channel depths throughout the day. The low-tide channel is positioned centrally to the side embankments.

A site assessment of the intertidal area was conducted at low tide on 23 October 2024. The vegetation along the true right bank (above the high-water mark) is dominated by mangroves (*Avicennia marina subsp. australasica*). On the true left bank, mangroves are also present above the high-water mark, alongside a range of planted native species, including māhoe (*Melicytus ramiflorus subsp. ramiflorus*), mānuka (*Leptospermum scoparium var. scoparium*), and red mapou (*Myrsine australis*). Below the high-water level, the intertidal zone become exposed at low tide, revealing mangrove pneumatophores with no additional vegetation in the submerged area. Crab holes were prevalent within the intertidal zone.

Conclusion & Recommendations

The Waterloo Creek has a uniform environment, as both the upstream and impact sites noted the same soft bottom substrate and fairly similar habitat conditions. Signs of scour and erosion were noted at both the upstream and impact sites during the spring survey. Macrophyte cover was minimal (less than 5%) at each site, which can be attributed to the partial shading the riparian vegetation provides to the stream. Similarly, periphyton cover was largely absent at both sites. Soft-bottomed streams are not typically a good habitat for periphyton because of the instability of the substrate, which makes it difficult for periphyton to attach. Historically influenced by agricultural runoff and, more recently, by increased urbanization, the Waterloo Creek appears to be a degraded watercourse. This suggest that it is already under ecological stress, as observed by erosion, limited vegetation, and reduced habitat complexity. The combined pressures from point-source inputs, such as stormwater discharges and from overland runoff currently contributes to the degraded state of the creek.

The physiochemistry of the Waterloo Creek indicate some level of chemical stress due to nutrients and sediments, likely from stormwater runoff within the catchment. This catchment receives inputs from pasture and agricultural land, residential areas, and possibly earthworks from land development.

The Orewa River downstream site lies within a shallow estuarine environment, experiencing tidal influences and receiving upstream inputs from Waterloo Creek and other tributaries. Riparian vegetation was typical of estuarine systems—such as mangroves above the high-water mark—typically capturing accumulating sediment and prevent coastal erosion. Given the estuary's position in the catchment, it is likely impacted by cumulative anthropogenic stressors from upstream land use, including nutrients, sediments, and potential pollutants.

Based on biological sampling and observations made during this monitoring round, and pending the results of the macroinvertebrate data, it is evident that the assessed watercourses are impacted by surrounding land uses. Despite these pressures, they continue to provide essential habitat for a variety of native fauna and hold significant ecological value within the landscape. These watercourses contribute to regional biodiversity and support ecological functions that are valuable in maintaining the health of downstream ecosystems, including estuarine and coastal areas.

To build a more comprehensive understanding of the ecological dynamics, it is recommended that biomonitoring be conducted again in the autumn (March). This additional monitoring will provide comparative seasonal data, offering insights into potential variations in water quality and habitat conditions. Understanding these seasonal shifts will enhance the accuracy of predictions on how the WWTP discharge may interact with the natural fluctuations of these watercourses, thereby supporting more informed management decisions.

Yours sincerely

Christel du Preez

Senior Freshwater Ecologist

Babbage Consultants Ltd

APPLICABILITY AND LIMITATIONS

Restrictions of Intended Purpose

This report has been prepared solely for the benefit of Apex Water as our client with respect to the brief. The reliance by other parties on the information or opinions contained in the report shall, without our prior review and agreement in writing, be at such party's sole risk.

Legal Interpretation

Opinions and judgements expressed herein are based on our understanding and interpretation of current regulatory standards, and should not be construed as legal opinions. Where opinions or judgements are to be relied on they should be independently verified with appropriate legal advice.

Maps and Images

All maps, plans, and figures included in this report are indicative only and are not to be used or interpreted as engineering drafts. Do not scale any of the maps, plans or figures in this report. Any information shown here on maps, plans and figures should be independently verified on site before taking any action. Sources for map and plan compositions include LINZ Data and Map Services and local council GIS services. For further details regarding any maps, plans or figures in this report, please contact Babbage Consultants Limited.

Reliability of Investigation

Babbage has performed the services for this project in accordance with the standard agreement for consulting services and current professional standards for environmental site assessment. No guarantees are either expressed or implied.

Recommendations and opinions in this report are based on discrete sampling data. The nature and continuity of matrix sampled away from the sampling points are inferred and it must be appreciated that actual conditions could vary from the assumed model.

There is no investigation that is thorough enough to preclude the presence of materials at the site that presently, or in the future, may be considered hazardous. Because regulatory evaluation criteria are constantly changing, concentrations of contaminants present and considered to be acceptable may in the future become subject to different regulatory standards, which cause them to become unacceptable and require further remediation for this site to be suitable for the existing or proposed land use activities.

APPENDIX A – Biomonitoring methodology

Habitat Characteristics

General aquatic and riparian habitat characteristics were assessed at each monitoring site and included estimates of stream width, depth, streambed substrate, habitat type (i.e. run, riffle and pool), erosion, shading, riparian characteristics, periphyton cover and aquatic plant cover.

Stream Physiochemistry

Water temperature, conductivity, dissolved oxygen (DO) concentration and pH were measured by Babbage during the biological surveys. The results were compared to relevant water quality guidelines, as discussed below.

Australian & New Zealand Guidelines for fresh & marine water quality default guideline values (ANZG, 2018), which succeeded ANZECC (2000), provides generic default guideline values (DGV) (as 80th percentiles) for chemical and physical stressors that indicate marginal water quality for supporting ecosystem health. If the median value of a variable for a particular site exceeds the ANZG (2018) DGV, then it is intended to trigger a management response.

Water physiochemistry has been compared with the ANZG (2018) DGV for either lowland river in a warm-wet climate (such as the Waterloo Creek) (Table 3). Classifications were obtained from the New Zealand River Environmental Classification (REC) database (NIWA 2004).

Table 3. ANZG (2018) default guideline values.

Parameter	Default guideline value
River environmental classification	**Warm-wet climate low elevation**
Temperature (°C)	-
pH (unitless)	7.26-7.7
Conductivity (µS/cm)	115
Dissolved oxygen (%)	92-103

Macroinvertebrates

Freshwater macroinvertebrate sampling

Macroinvertebrates were sampled from instream habitats to obtain semi-quantitative data in accordance with the Ministry for the Environment's current "Protocols for Sampling Macroinvertebrates in Wadeable Streams" (Stark *et al.* 2001). Sampling was undertaken using protocol 'C2: soft-bottomed, semi-quantitative' as the sites were predominantly soft bottomed (WUp and WImp). The Macroinvertebrate sample was preserved in 70% ethyl alcohol (ethanol), returned to the laboratory and sorted (using protocol 'P3: full count with sub-sampling option' (Stark *et al.* 2001)). Macroinvertebrates were then identified to the lowest practicable level and counted to enable biotic indices to be calculated.

Benthic macroinvertebrates were identified and counted to a level suitable for calculating taxa richness, abundance, EPT taxa richness and % EPT, macroinvertebrate community index (MCI) and quantitative MCI (QMCI) following protocols outlined in Stark *et al.* (2001). EPT refers to taxa that belong to the Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies) taxonomic groups.

Taxa richness is a measure of the number of invertebrate taxa in a sample. In general, streams supporting a high number of invertebrate taxa are more likely to be of a higher environmental quality than streams with few taxa present. However, interpretation of taxa number data as an environmental indicator is dependent on the pollution sensitivity or tolerance of taxa present.

Abundance is a measure of the total number of invertebrates in a sample. Invertebrate abundance tends to increase in the presence of organic or nutrient enrichment and decreases in the presence of toxic contaminants. Abundance can be a useful measure for comparison between sites but can be highly variable.

EPT taxa are generally sensitive to changes in water and habitat quality. Percent EPT (%EPT) is a measure of the proportion of EPT taxa making up the community. EPT and % EPT values[1] can provide a good indication of stream health, with high values indicating good water/habitat quality and low values indicating poor water/habitat quality.

The MCI and QMCI (Stark & Maxted 2007) are biological indices that are based on indicator scores between 1 and 10, which are assigned to each taxon based on their sensitivity to organic enrichment. Although developed to assess nutrient enrichment, these scores are now used to assess the general health of New Zealand streams. MCI scores are based on presence/absence data, while the QMCI uses abundance data. Higher MCI and QMCI indicate better habitat quality (and as such better water quality) with scores interpreted using the thresholds and classes provided in Table 4 (Stark & Maxted 2007).

[1] The caddisflies *Oxyethira* and *Paroxyethira* are not sensitive to nutrient enrichment so are excluded from EPT calculations.

Table 4. Estimates of stream health using MCI and QMCI indices (Stark & Maxted 2007).

Quality class	MCI	QMCI
Excellent	>119	>5.99
Good	100-119	5.00-5.99
Fair	80-99	4.00-4.99
Poor	<80	<4.00

The Auckland Unitary Plan (AUP), Chapter E1.3, provides additional MCI values criteria, AUP Table E1.3.10, for freshwater ecosystem health associated with various land uses within catchments (Table 5). Policy E1.3(2) mandates the management of discharges that could potentially impact freshwater systems to maintain or improve water quality, flow rates, stream channels, margins, and other freshwater values. This policy applies when the current condition is either above (for maintenance) or below (for enhancement) the National Policy Statement for Freshwater Management (NPS-FM) National Bottom Lines and the relevant MCI guidelines.

Table 5. MCI guideline for Auckland rivers and streams as per AUP Policy E1.3(2)

Land use	MCI guideline
Native forest	123
Exotic forest	111
Rural areas	94
*Urban areas	68

*MCI guideline applicable to the Milldale catchment

<u>Marine macroinvertebrate sampling</u>

In New Zealand's marine environment, macroinvertebrate sampling protocols are tailored to assess benthic (seafloor) communities, which are essential indicators of ecosystem health. Sampling position at the site is chosen based on habitat type (e.g., intertidal, subtidal) and exposure levels. Representative sampling across different substrate types, such as sandy or muddy areas, is prioritized to capture diversity.

Core Sampling was undertaken, whereby a cylindrical core is inserted into the sediment to a standard depth (typically 10-15 cm), capturing macroinvertebrates and substrate for analysis. Samples are sieved through a mesh (often 0.5-1 mm) to separate invertebrates from sediment. Collected organisms are preserved in ethanol for transport to the lab. Macroinvertebrates are identified to the lowest practical taxonomic level (usually species or genus). Abundance, diversity, and composition are analyzed to assess ecological health.

APPENDIX B – Site photographs

Waterloo Creek – Upstream (WUp)




Waterloo Creek – Impact (WImp)




Orewa River – Downstream (ODown)




Appendix B

Biological Assessment Raw Data

Waterloo Creek: Freshwater Macroinvertebrate Results

PHYLUM	CLASS: Order	Family	Taxa	Taxa MCI sb	Upstream	Impact
MOLLUSCA	**GASTROPODA**	Hydrobiidae	*Potamopyrgus antipodarum*	2.1	1596	2060
		Physidae	*Physella fontinalis*	0.1	52	8
ARTHROPODA	**CRUSTACEA: Decapoda**		*Paratya curvirostris*	3.6	5	3
	INSECTA: Odonata	Zygoptera	*Xanthocnemis zealandica*	1.2	27	31
	Hemiptera	Veliidae	*Microvelia* sp.	4.6	12	2
		Corixidae	*Sigara* sp.	2.4	1	3
			Anisops sp.	2.2	1	
	Diptera	Simuliidae	*Austrosimulium australense* gp	3.9		1
		Chironomidae	*Chironomus*	3.4		2
			Orthcladiinae	3.2		2
		TOTALS:	**NO. TAXA**		7	9
			NO. EPT TAXA		0	0
			NO. INDIVIDUALS		1694	2112

Orewa River: Marine Macroinvertebrate Results

General Group	Taxa	Common Name	Bank-01	Bank-02	Bank-03	Bank-04	Bank-05	Channel-01	Channel-02	Channel-03	Channel-04	Channel-05
Gastropoda	*Amphibola crenata*	Mud Snail					1					
Bivalvia	*Xenostrobus neozelanicus*	Little Black Mussel						1				
Polychaeta: Nereididae	*Ceratonereis* sp.	Rag worm			1							
Polychaeta: Spionidae	*Boccardia* sp.	Polychaete worm									1	
Polychaeta: Spionidae	*Scolecolepides benhami*	Polychaete worm	2	1		1	1					
Polychaeta: Nereidae	Nereidae (juvenile)	Rag worms	1	2	5	1	1	4	7	2	5	8
Polychaeta: Nereidae	*Perinereis vallata*	Rag worm		2			1	2	5	2	2	3
Amphipoda	Corophiidae	Amphipod (family)				2	4	1			1	
Amphipoda	Phoxocephalidae	Amphipod (family)				1						
Amphipoda	Amphipoda Unid.	Amphipod							1			
Decapoda	*Austrohelice crassa*	Tunnelling Mud Crab	2	3	6	4		6	5		8	7
Decapoda	*Palaemon affinis*	Estuarine Prawn			1							
Insecta	Dolichopodidae larvae	small fly larvae	1									
	Count: No of Individuals		**6**	**8**	**13**	**9**	**8**	**14**	**18**	**4**	**17**	**18**
	Count: No of Taxa		**4**	**4**	**4**	**5**	**5**	**5**	**4**	**2**	**5**	**3**
	SW_Diversity		**1.3297**	**1.3209**	**1.119**	**1.4270999**	**1.3863**	**1.3761**	**1.2395**	**0.6931**	**1.2997**	**1.0263**
	SW_Evenness		**0.9591**	**0.9528**	**0.8072**	**0.8867**	**0.8614**	**0.8550**	**0.8941**	**1.0000**	**0.8076**	**0.9342**

Appendix C

Laboratory Report

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CERTIFICATE OF ANALYSIS

Babbage Consultants
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Sampling Site: Milldale

Lab Reference: 24-32242
Submitted by: Tiago Teixeiro and Mathew Smith
Date Received: 17/10/2024
Testing Initiated: 17/10/2024
Date Completed: 24/10/2024
Order Number:
Reference: Milldale

Report Comments

Samples were collected by yourselves (or your agent) and analysed as received at ALS NZ (or at the subcontracted laboratories, when applicable). Samples were in acceptable condition unless otherwise noted on this report.
Specific testing dates are available on request.

Solids in Water

		Client Sample ID	Discharge	Upstream	Downstream
		Date Sampled	17/10/2024	17/10/2024	17/10/2024
Analyte	Unit	*Reporting Limit*	24-32242-1	24-32242-2	24-32242-3
Total Suspended Solids	g/m^3	*3*	22	10	12

Turbidity

		Client Sample ID	Discharge	Upstream	Downstream
		Date Sampled	17/10/2024	17/10/2024	17/10/2024
Analyte	Unit	*Reporting Limit*	24-32242-1	24-32242-2	24-32242-3
Turbidity	NTU	*0.05*	20	12	7.5

Inorganic Nutrients and Nutrient Species in Water

		Client Sample ID	Discharge	Upstream	Downstream
		Date Sampled	17/10/2024	17/10/2024	17/10/2024
Analyte	Unit	*Reporting Limit*	24-32242-1	24-32242-2	24-32242-3
Ammonia as N	g/m^3	*0.005*	<0.005	<0.005	0.009
Nitrate-N	g/m^3	*0.002*	0.188	0.206	0.0588
Nitrite-N	g/m^3	*0.001*	0.0018	0.0019	<0.0010
Dissolved Reactive Phosphorus (FIA)	g/m^3	*0.002*	0.006	0.005	0.003

Total Nitrogen / Kjeldahl Nitrogen in Water

	Client Sample ID		Discharge	Upstream	Downstream
	Date Sampled		17/10/2024	17/10/2024	17/10/2024
Analyte	Unit	*Reporting Limit*	24-32242-1	24-32242-2	24-32242-3
Total Kjeldahl Nitrogen	g/m^3	*0.1*	0.62	0.63	0.36
Total Nitrogen	g/m^3	*0.1*	0.81	0.84	0.42

Biochemical Oxygen Demand

	Client Sample ID		Discharge	Upstream	Downstream
	Date Sampled		17/10/2024	17/10/2024	17/10/2024
Analyte	Unit	*Reporting Limit*	24-32242-1	24-32242-2	24-32242-3
Sol Carbonaceous Biochem. Oxygen Demand*	g/m^3	*1*	<1.00	3.29	<1.00

Total Phosphorus in Water

	Client Sample ID		Discharge	Upstream	Downstream
	Date Sampled		17/10/2024	17/10/2024	17/10/2024
Analyte	Unit	*Reporting Limit*	24-32242-1	24-32242-2	24-32242-3
Total Phosphorus	g/m^3	*0.005*	0.044	0.037	0.025

Receiving Water Microbiology

	Client Sample ID		Discharge	Upstream	Downstream
	Date Sampled		17/10/2024	17/10/2024	17/10/2024
Analyte	Unit	*Reporting Limit*	24-32242-1	24-32242-2	24-32242-3
Faecal Coliforms Count	cfu/100mL	*1*	1,900	1,200	670
Enterococci Count	cfu/100mL	*1*	60	30	90
E.Coli Count	cfu/100mL	*1*	1,900	1,100	670

Temperature on Arrival

	Client Sample ID		Discharge	Upstream	Downstream
	Date Sampled		17/10/2024	17/10/2024	17/10/2024
Analyte	Unit	*Reporting Limit*	24-32242-1	24-32242-2	24-32242-3
Temp on Arrival*	°C	*0*	3.30	3.30	3.30

Method Summary

Total Suspended Solids — Measured gravimetrically following filtration through glass micro-fibre filters. (APHA 2540 D - Modified - Online edition).

Turbidity — Samples analysed as received using a conventional turbidimeter. (APHA 2130 B Online edition - Modified).

Ammonia-N — Samples filtered and measured colourimetrically by flow injection analysis. (APHA 4500-NH_3 H - Modified - Online edition).

NO3-N — Calculated from oxidised nitrogen and Nitrite-N, measured colourimetrically by flow injection analysis. (APHA NO_{3-} I. Online edition)

Method Summary

NO2-N	Samples analysed colourimetrically by flow injection analysis following filtration. (APHA 4500-NO_3 I. Online edition).
Dissolved Reactive Phosphorus	Samples filtered and measured colourimetrically by flow injection analysis. (APHA 4500-P G - Modified - Online edition)
TKN	Samples analysed colourimetrically following an acid digestion. (APHA 4500-N_{Org} D - Modified - Discrete Analyser - Online edition).
TN	Sum of Total Kjeldahl Nitrogen (APHA 4500 N_{org} - Modified - Online edition), Nitrate-N and Nitrite-N (APHA 4500 NO_3 I - Online edition). (APHA 4500-N A - Online Edition).
cBOD	Following lab filtration, dissolved oxygen measured using a dissolved oxygen electrode after addition of the nitrification inhibitior ATU and a 5 day incubation period. (APHA 5210 B - Online edition).
Total Phosphorus	Samples analysed colourimetrically following an acid digestion. (APHA 4500 P H - Modified - Discrete Analyser - Online edition)
Total Faecal Coliform Count	Samples analysed by Thermotolerant (Fecal) Coliform Membrane Filter Procedure using mFC medium. Incubated at 44.5°C for 24hours. APHA 9222 D Online Edition.
Enterococcus Count	Samples analysed by Enterococci Membrane Filter Procedure using mEnterococcus medium. Incubated at 36°C for 48 hours. AS/NZS 4276.9:2007
E.coli Count	Samples analysed by E.coli Membrane Filter Procedure using mFC medium. Incubated at 44.5°C for 24hours. APHA 9222 D Online Edition.
Temp on Arrival	Measured on arrival by a digital infra-red laser thermometer.

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Matthew Counsell, B.Sc.
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CERTIFICATE OF ANALYSIS

Babbage Consultants
Level 4, 68 Beach Road
Auckland 1010

Attention: Tiago Teixeira
Phone: 027 414 5454
Email: matthew.smith@babbage.co.nz

Sampling Site: Milldale

Lab Reference: 24-35980
Submitted by: Mathew Smith
Date Received: 22/11/2024
Testing Initiated: 22/11/2024
Date Completed: 27/11/2024
Order Number: 67717#ESE01
Reference: Milldale

Report Comments

Samples were collected by yourselves (or your agent) and analysed as received at ALS NZ (or at the subcontracted laboratories, when applicable). Samples were in acceptable condition unless otherwise noted on this report.
Specific testing dates are available on request.

Solids in Water

		Client Sample ID	Upstream	Discharge	Downstream
		Date Sampled	21/11/2024	21/11/2024	21/11/2024
Analyte	Unit	*Reporting Limit*	24-35980-1	24-35980-2	24-35980-3
Total Suspended Solids	g/m^3	*3*	18	14	56

Turbidity

		Client Sample ID	Upstream	Discharge	Downstream
		Date Sampled	21/11/2024	21/11/2024	21/11/2024
Analyte	Unit	*Reporting Limit*	24-35980-1	24-35980-2	24-35980-3
Turbidity	NTU	*0.05*	14	11	26

Inorganic Nutrients and Nutrient Species in Water

		Client Sample ID	Upstream	Discharge	Downstream
		Date Sampled	21/11/2024	21/11/2024	21/11/2024
Analyte	Unit	*Reporting Limit*	24-35980-1	24-35980-2	24-35980-3
Nitrate-N	g/m^3	*0.002*	0.415	0.416	0.0050
Nitrite-N	g/m^3	*0.001*	0.00506	0.00526	<0.0010
Ammoniacal-N	g/m^3	*0.005*	<0.005	<0.005	0.005
Dissolved Reactive Phosphorus (FIA)	g/m^3	*0.002*	0.008	0.009	0.004

Total Nitrogen / Kjeldahl Nitrogen in Water

		Client Sample ID	Upstream	Discharge	Downstream
		Date Sampled	21/11/2024	21/11/2024	21/11/2024
Analyte	Unit	*Reporting Limit*	24-35980-1	24-35980-2	24-35980-3
Total Kjeldahl Nitrogen	g/m^3	*0.1*	0.58	0.56	0.62
Total Nitrogen	g/m^3	*0.1*	1.0	0.98	0.62

Total Phosphorus in Water

		Client Sample ID	Upstream	Discharge	Downstream
		Date Sampled	21/11/2024	21/11/2024	21/11/2024
Analyte	Unit	*Reporting Limit*	24-35980-1	24-35980-2	24-35980-3
Total Phosphorus	g/m^3	*0.005*	0.042	0.037	0.064

Biochemical Oxygen Demand

		Client Sample ID	Upstream	Discharge	Downstream
		Date Sampled	21/11/2024	21/11/2024	21/11/2024
Analyte	Unit	*Reporting Limit*	24-35980-1	24-35980-2	24-35980-3
Sol Carbonaceous Biochem. Oxygen Demand*	g/m^3	*1*	<1.00	<1.00	<1.00

Receiving Water Microbiology

		Client Sample ID	Upstream	Discharge	Downstream
		Date Sampled	21/11/2024	21/11/2024	21/11/2024
Analyte	Unit	*Reporting Limit*	24-35980-1	24-35980-2	24-35980-3
Faecal Coliforms Count	cfu/100mL	*1*	4,000	2,800	15
Enterococci Count	cfu/100mL	*1*	220	100	46
E.Coli Count	cfu/100mL	*1*	4,000	2,800	15

Temperature on Arrival

		Client Sample ID	Upstream	Discharge	Downstream
		Date Sampled	21/11/2024	21/11/2024	21/11/2024
Analyte	Unit	*Reporting Limit*	24-35980-1	24-35980-2	24-35980-3
Temp on Arrival*	°C	*0*	3.30	3.30	3.30

Method Summary

Total Suspended Solids	Measured gravimetrically following filtration through glass micro-fibre filters. (APHA 2540 D - Modified - Online edition).
Turbidity	Samples analysed as received using a conventional turbidimeter. (APHA 2130 B Online edition - Modified).
NO3-N	Calculated from oxidised nitrogen and Nitrite-N, measured colourimetrically by flow injection analysis. (APHA NO_{3-} I. Online edition)
NO2-N	Samples analysed colourimetrically by flow injection analysis following filtration. (APHA 4500-NO_3 I. Online edition).

Method Summary

Ammoniacal-N	Samples are filtered and measured colourimetrically by flow injection analysis. Results represent total ammonical nitrogen (APHA 4500-NH_3 H - Modified - Online edition).
Dissolved Reactive Phosphorus	Samples filtered and measured colourimetrically by flow injection analysis. (APHA 4500-P G - Modified - Online edition)
TKN	Samples analysed colourimetrically following an acid digestion. (APHA 4500-N_{Org} D - Modified - Discrete Analyser - Online edition).
TN	Sum of Total Kjeldahl Nitrogen (APHA 4500 N_{org} - Modified - Online edition), Nitrate-N and Nitrite-N (APHA 4500 NO_3 I - Online edition). (APHA 4500-N A - Online Edition).
Total Phosphorus	Samples analysed colourimetrically following an acid digestion. (APHA 4500 P H - Modified - Discrete Analyser - Online edition)
cBOD	Following lab filtration, dissolved oxygen measured using a dissolved oxygen electrode after addition of the nitrification inhibitior ATU and a 5 day incubation period. (APHA 5210 B - Online edition).
Total Faecal Coliform Count	Samples analysed by Thermotolerant (Fecal) Coliform Membrane Filter Procedure using mFC medium. Incubated at 44.5°C for 24hours. APHA 9222 D Online Edition.
Enterococcus Count	Samples analysed by Enterococci Membrane Filter Procedure using mEnterococcus medium. Incubated at 36°C for 48 hours. AS/NZS 4276.9:2007
E.coli Count	Samples analysed by E.coli Membrane Filter Procedure using mFC medium. Incubated at 44.5°C for 24hours. APHA 9222 D Online Edition.
Temp on Arrival	Measured on arrival by a digital infra-red laser thermometer.

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CERTIFICATE OF ANALYSIS

Babbage Consultants
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Attention: Tiago Teixeira
Phone: 021 41436031
Email: tiago.teixeira@babbage.co.nz

Lab Reference: 25-01975
Submitted by: Tiago Teixeira
Date Received: 23/01/2025
Testing Initiated: 23/01/2025
Date Completed: 29/01/2025
Order Number: 67717#ESE01
Reference: Milldale

Sampling Site: Milldale

Report Comments

Samples were collected by yourselves (or your agent) and analysed as received at ALS NZ (or at the subcontracted laboratories, when applicable). Samples were in acceptable condition unless otherwise noted on this report.
Specific testing dates are available on request.

Inorganic Nutrients and Nutrient Species in Water

		Client Sample ID	Upstream (River)	Discharge (River)	Downstream (estuary)
		Date Sampled	21/01/2025	21/11/2024	21/11/2024
Analyte	Unit	*Reporting Limit*	25-01975-1	25-01975-2	25-01975-3
Ammoniacal-N	g/m^3	*0.005*	<0.005	<0.005	0.005
Nitrate-N	g/m^3	*0.002*	0.322	0.279	0.251
Nitrite-N	g/m^3	*0.001*	0.00535	0.00575	0.0014

Solids in Water

		Client Sample ID	Upstream (River)	Discharge (River)	Downstream (estuary)
		Date Sampled	21/01/2025	21/11/2024	21/11/2024
Analyte	Unit	*Reporting Limit*	25-01975-1	25-01975-2	25-01975-3
Total Suspended Solids	g/m^3	*3*	33	30	21

Total Nitrogen / Kjeldahl Nitrogen in Water

		Client Sample ID	Upstream (River)	Discharge (River)	Downstream (estuary)
		Date Sampled	21/01/2025	21/11/2024	21/11/2024
Analyte	Unit	*Reporting Limit*	25-01975-1	25-01975-2	25-01975-3
Total Kjeldahl Nitrogen	g/m^3	*0.1*	0.71	0.75	0.69
Total Nitrogen	g/m^3	*0.1*	1.0	1.0	0.94

Total Phosphorus in Water

		Client Sample ID	Upstream (River)	Discharge (River)	Downstream (estuary)
		Date Sampled	21/01/2025	21/11/2024	21/11/2024
Analyte	Unit	*Reporting Limit*	25-01975-1	25-01975-2	25-01975-3
Total Phosphorus	g/m^3	*0.005*	0.13	0.12	0.074

Biochemical Oxygen Demand

		Client Sample ID	Upstream (River)	Discharge (River)	Downstream (estuary)
		Date Sampled	21/01/2025	21/11/2024	21/11/2024
Analyte	Unit	*Reporting Limit*	25-01975-1	25-01975-2	25-01975-3
Sol Carbonaceous Biochem. Oxygen Demand*	g/m^3	*1*	<1.00	<1.00	<1.00

Turbidity

		Client Sample ID	Upstream (River)	Discharge (River)	Downstream (estuary)
		Date Sampled	21/01/2025	21/11/2024	21/11/2024
Analyte	Unit	*Reporting Limit*	25-01975-1	25-01975-2	25-01975-3
Turbidity	NTU	*0.05*	26	22	14

Method Summary

Ammoniacal-N Samples are filtered and measured colourimetrically by flow injection analysis. Results represent total ammonical nitrogen (APHA 4500-NH_3 H - Modified - Online edition).

NO3-N Calculated from oxidised nitrogen and Nitrite-N, measured colourimetrically by flow injection analysis. (APHA NO_{3-} I. Online edition)

NO2-N Samples analysed colourimetrically by flow injection analysis following filtration. (APHA 4500-NO_3 I. Online edition).

Total Suspended Solids Measured gravimetrically following filtration through glass micro-fibre filters. (APHA 2540 D - Modified - Online edition).

TKN Samples analysed colourimetrically following an acid digestion. (APHA 4500-N_{Org} D - Modified - Discrete Analyser - Online edition).

TN Sum of Total Kjeldahl Nitrogen (APHA 4500 N_{org} - Modified - Online edition), Nitrate-N and Nitrite-N (APHA 4500 NO_3 I - Online edition). (APHA 4500-N A - Online Edition).

Total Phosphorus Samples analysed colourimetrically following an acid digestion. (APHA 4500 P H - Modified - Discrete Analyser - Online edition)

cBOD Following lab filtration, dissolved oxygen measured using a dissolved oxygen electrode after addition of the nitrification inhibitior ATU and a 5 day incubation period. (APHA 5210 B - Online edition).

Turbidity Samples analysed as received using a conventional turbidimeter. (APHA 2130 B Online edition - Modified).

Rowin Angkico, B.Sc.
Laboratory Technician

Matthew Counsell, B.Sc.
Environmental Lab Manager

Deanna Rhind
Technician

Appendix D

Flow Tracker 2 Report

Discharge Measurement Summary

Site name	Water2
Site number	
Operator(s)	Tt
File name	20250121_---_2.ft
Comment	

Start time	21/01/2025 2:30 PM
End time	21/01/2025 3:36 PM
Start location latitude	-
Start location longitude	-
Calculations engine	FlowTracker2

Sensor type	Top Setting
Handheld serial number	FT2H2107038
Probe serial number	FT2P2107021
Probe firmware	1.30
Handheld software	1.9

# Stations	Avg interval (s)	Total discharge (m³/s)
16	40	0.088

Total width (m)	Total area (m²)	Wetted Perimeter (m)
3.000	1.362	3.258

Mean SNR (dB)	Mean depth (m)	Mean velocity (m/s)
33.986	0.454	0.064

Mean temp (°C)	Max depth (m)	Max velocity (m/s)
19.667	0.670	0.098

Discharge Uncertainty

Category	ISO	IVE
Accuracy	1.0%	
Depth	0.2%	
Velocity	0.3%	
Width	0.1%	
Method	1.4%	
# Stations	3.1%	
Overall	**3.6%**	

Discharge equation	Mean Section
Discharge uncertainty	IVE
Discharge reference	Rated

Data Collection Settings

Salinity	0.000 PSS-78
Temperature	-
Sound speed	-
Mounting correction	0.000 %

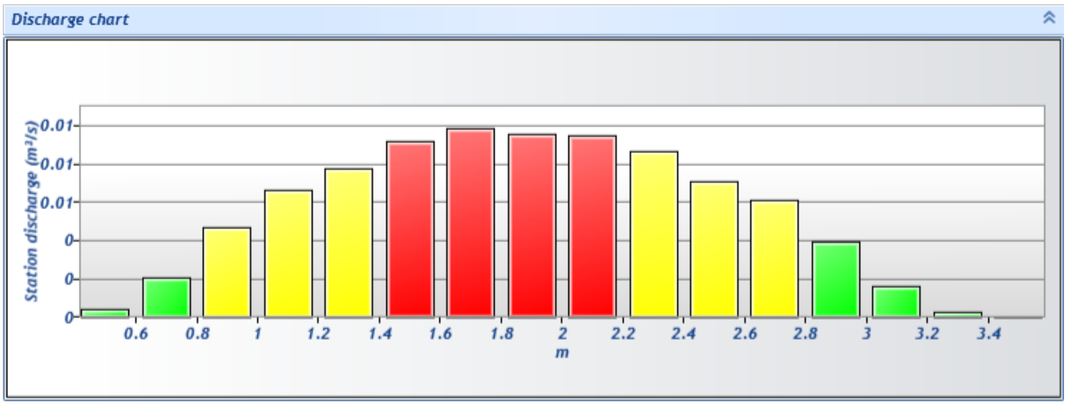
Summary overview

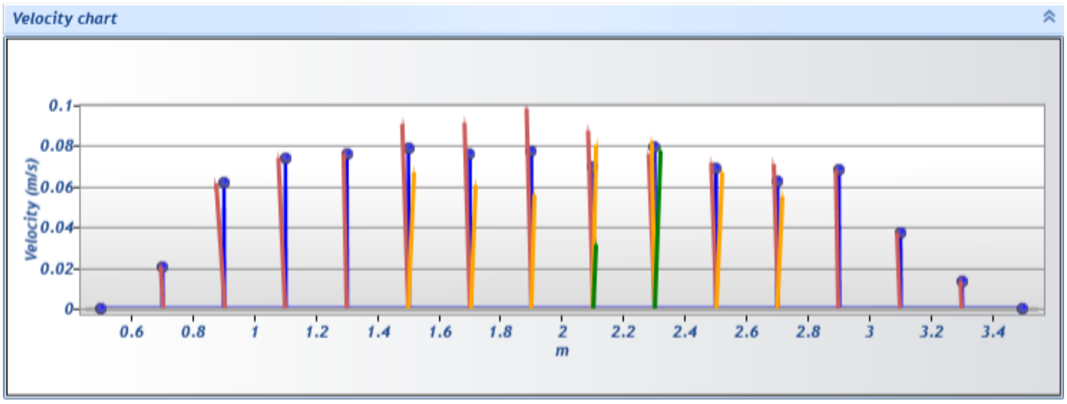
No changes were made to this file
Quality control warnings

Discharge Measurement Summary

Site name	Water2
Site number	
Operator(s)	Tt
File name	20250121_---_2.ft
Comment	

Station Warning Settings		
Station discharge OK	Station discharge < 5.000%	
Station discharge caution	5.000% >= Station discharge < 10.000%	
Station discharge warning	Station discharge >= 10.000%	





22/01/2025 8:55:57 AM

Discharge Measurement Summary

Site name	Water2
Site number	
Operator(s)	Tt
File name	20250121_---_2.ft
Comment	

Measurement results

St#	Time	Location (m)	Method	Depth (m)	%Depth	Measured Depth (m)	Samples	Velocity (m/s)	Correction	Mean Velocity (m/s)	Area (m²)	Flow (m³/s)	%Q	
0	2:30 PM	0.500	None	0.210	0.000	0.000	0	0.000		0.010	0.044	0.000	0.513	✓
1	2:30 PM	0.700	0.6	0.230	0.600	0.138	80	0.020	1.000	0.041	0.051	0.002	2.381	✓
2	2:43 PM	0.900	0.6	0.280	0.600	0.168	80	0.062	1.000	0.068	0.070	0.005	5.397	✓
3	2:46 PM	1.100	0.6	0.420	0.600	0.252	80	0.074	1.000	0.075	0.089	0.007	7.591	✓
4	2:50 PM	1.300	0.6	0.470	0.600	0.282	80	0.076	1.000	0.077	0.101	0.008	8.892	✓
5	2:54 PM	1.500	0.2/0.8	0.540	0.200	0.108	80	0.091	1.000	0.077	0.119	0.009	10.473	✓
5	2:54 PM	1.500	0.2/0.8	0.540	0.800	0.432	80	0.067	1.000	0.077	0.119	0.009	10.473	✓
6	2:58 PM	1.700	0.2/0.8	0.650	0.200	0.130	80	0.091	1.000	0.076	0.129	0.010	11.224	✓
6	2:58 PM	1.700	0.2/0.8	0.650	0.800	0.520	80	0.061	1.000	0.076	0.129	0.010	11.224	✓
7	3:04 PM	1.900	0.2/0.8	0.640	0.200	0.128	80	0.098	1.000	0.073	0.131	0.010	10.949	✓
7	3:04 PM	1.900	0.2/0.8	0.640	0.800	0.512	80	0.056	1.000	0.073	0.131	0.010	10.949	✓
8	3:09 PM	2.100	0.2/0.6/0.8	0.670	0.200	0.134	80	0.087	1.000	0.075	0.128	0.010	10.861	✓
8	3:09 PM	2.100	0.2/0.6/0.8	0.670	0.600	0.402	80	0.080	1.000	0.075	0.128	0.010	10.861	✓
8	3:09 PM	2.100	0.2/0.6/0.8	0.670	0.800	0.536	80	0.031	1.000	0.075	0.128	0.010	10.861	✓
9	3:15 PM	2.300	0.2/0.6/0.8	0.610	0.200	0.122	80	0.076	1.000	0.074	0.117	0.009	9.883	✓
9	3:15 PM	2.300	0.2/0.6/0.8	0.610	0.600	0.366	80	0.082	1.000	0.074	0.117	0.009	9.883	✓
9	3:15 PM	2.300	0.2/0.6/0.8	0.610	0.800	0.488	80	0.078	1.000	0.074	0.117	0.009	9.883	✓
10	3:20 PM	2.500	0.2/0.8	0.560	0.200	0.112	80	0.072	1.000	0.066	0.108	0.007	8.122	✓
10	3:20 PM	2.500	0.2/0.8	0.560	0.800	0.448	80	0.067	1.000	0.066	0.108	0.007	8.122	✓
11	3:24 PM	2.700	0.2/0.8	0.520	0.200	0.104	80	0.071	1.000	0.065	0.094	0.006	6.999	✓
11	3:24 PM	2.700	0.2/0.8	0.520	0.800	0.416	80	0.055	1.000	0.065	0.094	0.006	6.999	✓
12	3:28 PM	2.900	0.6	0.420	0.600	0.252	80	0.068	1.000	0.052	0.076	0.004	4.543	✓
13	3:31 PM	3.100	0.6	0.340	0.600	0.204	80	0.037	1.000	0.025	0.065	0.002	1.867	✓
14	3:33 PM	3.300	0.6	0.310	0.600	0.186	80	0.013	1.000	0.007	0.040	0.000	0.304	✓
15	3:36 PM	3.500	None	0.090	0.000	0.000	0	0.000		0.000	0.000	0.000	0.000	✓

Discharge Measurement Summary

Site name	Water2
Site number	
Operator(s)	Tt
File name	20250121_---_2.ft
Comment	

Quality Control Settings	
Maximum depth change	50.000%
Maximum spacing change	100.000%
SNR threshold	10.000 dB
Standard error threshold	0.010 m/s
Spike threshold	10.000%
Maximum velocity angle	20.000 deg
Maximum tilt angle	5.000 deg

Quality control warnings

St#	Time	Location (m)	Method	Depth (m)	%Depth	Measured Depth (m)	Warnings
1	2:30 PM	0.700	0.6	0.230	0.600	0.138	Velocity Angle > QC
2	2:43 PM	0.900	0.6	0.280	0.600	0.168	Velocity Angle > QC
5	2:54 PM	1.500	0.2/0.8	0.540	0.200	0.108	High Stn % Discharge
5	2:54 PM	1.500	0.2/0.8	0.540	0.800	0.432	High Stn % Discharge
6	2:58 PM	1.700	0.2/0.8	0.650	0.200	0.130	High Stn % Discharge
6	2:58 PM	1.700	0.2/0.8	0.650	0.800	0.520	High Stn % Discharge
7	3:04 PM	1.900	0.2/0.8	0.640	0.200	0.128	High Stn % Discharge
7	3:04 PM	1.900	0.2/0.8	0.640	0.800	0.512	High Stn % Discharge
8	3:09 PM	2.100	0.2/0.6/0.8	0.670	0.200	0.134	High Stn % Discharge
8	3:09 PM	2.100	0.2/0.6/0.8	0.670	0.600	0.402	High Stn % Discharge
8	3:09 PM	2.100	0.2/0.6/0.8	0.670	0.800	0.536	High Stn % Discharge
15	3:36 PM	3.500	None	0.090	0.000	0.000	Water Depth > QC

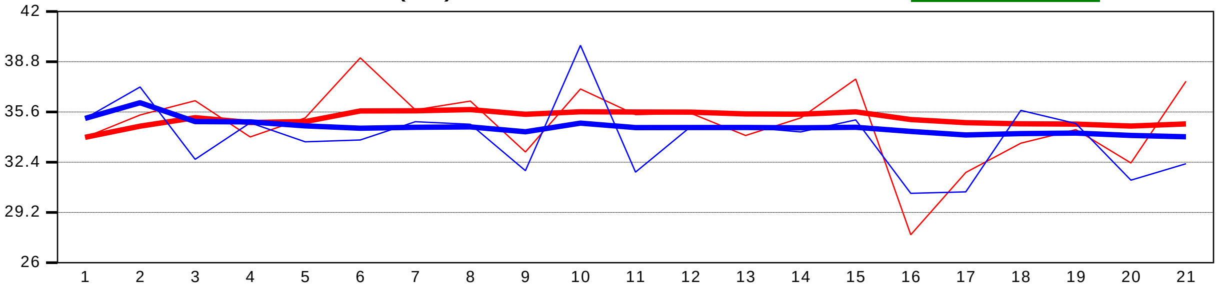
Discharge Measurement Summary

Site name	Water2
Site number	
Operator(s)	Tt
File name	20250121_---_2.ft
Comment	

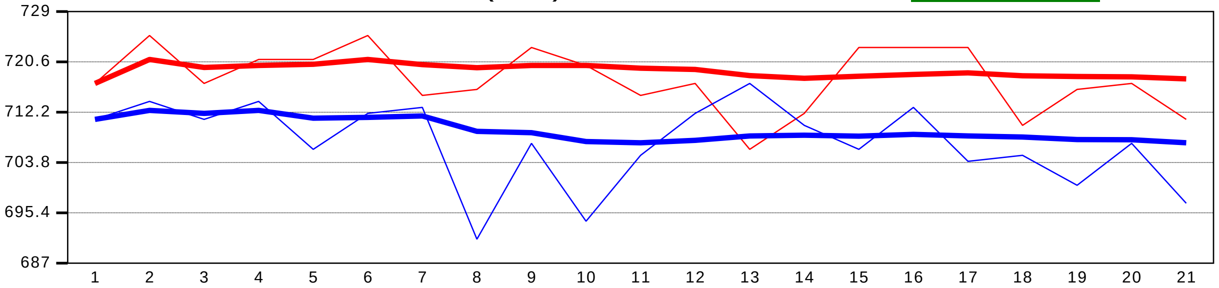
Beam 1	
Beam 2	

Automated beam check Start time 21/01/2025 2:30:03 PM

Automated beam check SNR(dB) PASS



Automated beam check Noise level(cnts) PASS



Automated beam check Quality control warnings
No quality control warnings

22/01/2025 8:55:57 AM

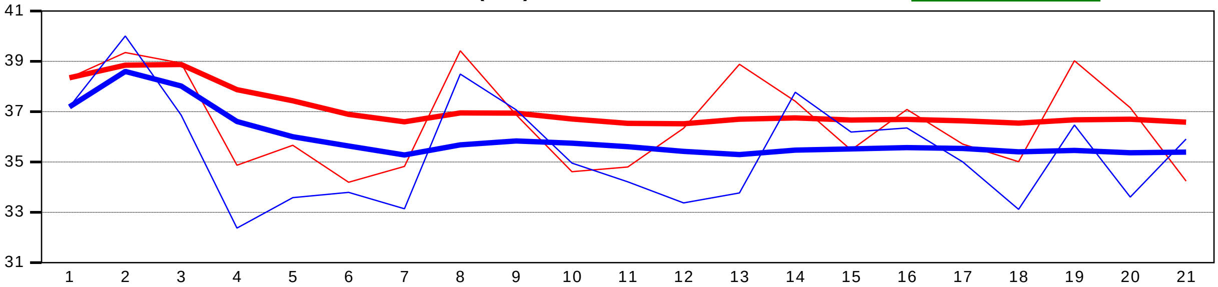
Discharge Measurement Summary

Site name	Water2
Site number	
Operator(s)	Tt
File name	20250121_---_2.ft
Comment	

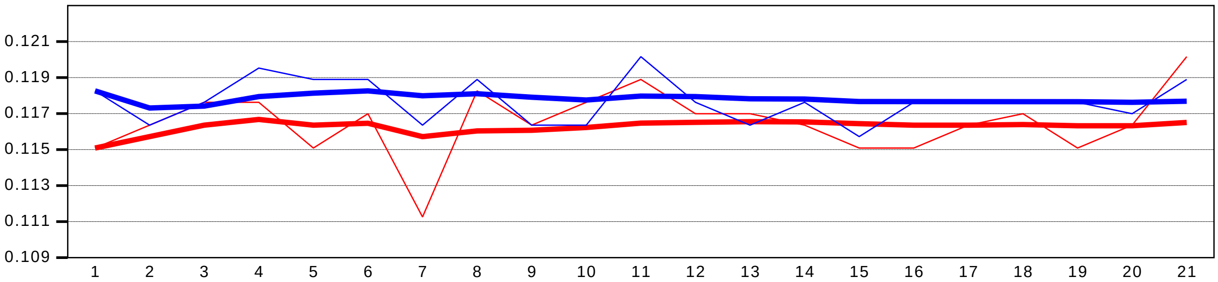
Beam 1	(red)
Beam 2	(blue)

Automated beam check Start time 21/01/2025 2:30:03 PM

Automated beam check Peak level(dB) PASS



Automated beam check Peak position(m) PASS

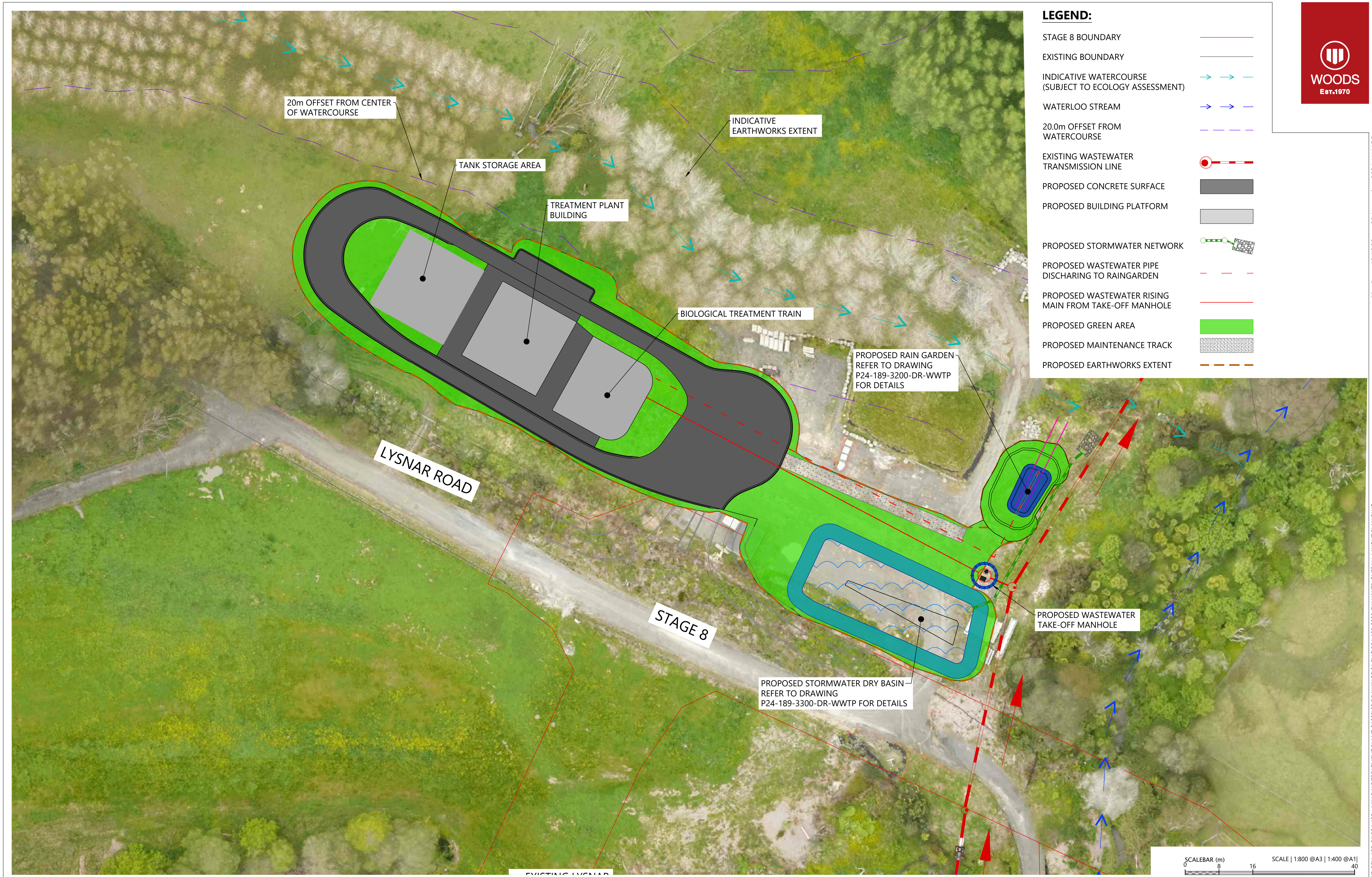


Automated beam check Quality control warnings
No quality control warnings

22/01/2025 8:55:57 AM

Appendix E

WWTP Lay Out



LEGEND:

- STAGE 8 BOUNDARY
- EXISTING BOUNDARY
- INDICATIVE WATERCOURSE (SUBJECT TO ECOLOGY ASSESSMENT)
- WATERLOO STREAM
- 20.0m OFFSET FROM WATERCOURSE
- EXISTING WASTEWATER TRANSMISSION LINE
- PROPOSED CONCRETE SURFACE
- PROPOSED BUILDING PLATFORM
- PROPOSED STORMWATER NETWORK
- PROPOSED WASTEWATER PIPE DISCHARGING TO RAINGARDEN
- PROPOSED WASTEWATER RISING MAIN FROM TAKE-OFF MANHOLE
- PROPOSED GREEN AREA
- PROPOSED MAINTENANCE TRACK
- PROPOSED EARTHWORKS EXTENT

WOODS EST.1970

Plot Date: 10:46:22 pm,28 November 2024, YANGC

REVISION DETAILS		INT	DATE	SURVEYED	WOODS
1	ISSUED FOR INFORMATION	YC	29/11/2024	DESIGNED	YC
				DRAWN	YC
				CHECKED	TR
				APPROVED	TR

BUILDING B, LEVEL 1
8 NUGENT ST, GRAFTON,
AUCKLAND 1023
+64 9 308 9229
WOODS.CO.NZ

MILLDALE WASTEWATER TREATMENT PLANT

OVERALL LAYOUT PLAN

N

STATUS	ISSUED FOR INFORMATION	REV
SCALE	1:800 @ A3	1
COUNCIL	AUCKLAND COUNCIL	
DWG NO	P24-189-2000-EW-WWTP	

File: C:\12DSYNERGY\DATA\WP-PEN-APP-01\P24-189 - MILLDALE TREATMENT PLANT_21668\02 DRAWINGS\01 ENG\P24-189-2000-EW-WWTP-OVERALL LAYOUT PLAN.DWG

Appendix F

Statement of Qualification and Experience

24 February 2025 eTrack No: 200049338

STATEMENT OF QUALIFICATIONS AND EXPERIENCE

This statement refers to the report "Technical Assessment of Environmental Effects of Treated Wastewater Discharge – Milldale WWTP Project" prepared by Babbage Consultants Limited, for Apex Water Limited, dated 25 February 2025, eTrack no 200049338.

I am Luiz Lobo Coutinho, Senior Environmental Engineer, and the Environmental Science and Engineering Team Lead at Babbage Consultants Limited (Babbage).

Babbage is a New Zealand staff-owned multi-disciplinary consultancy business specialising in ecology, geotech, planning, engineering (environmental, process, civil, infrastructure, structure, fire), project management, architecture, and land surveying. I have been employed at Babbage since February, 2015.

I hold a BE (Environmental) by the Pontificia Universidade Catolica do Rio de Janeiro (PUC-Rio, Brazil) and a MSc in Hydrogeology, Engineering Geology and Environmental Management by the Technische Universität Darmstadt (TU Darmstard, Germany). These qualifications have been reviewed by Engineering New Zealand and the New Zealand Qualifications Authority (NZQA) and accepted as a Washington Accord equivalent. I am also a registered Chartered Professional Engineer (Environmental).

I have over 15 years of professional experience in the Environmental Engineering and Consultancy sectors, including roles such as Technical Lead for the assessment of effects of various proposed discharges to the environment (land and water). My experience includes coordinating experts of different disciplines to assess the effects of proposed treated wastewater discharges in support of resource consent applications, coordinating experts of different disciplines to develop concept designs of treatment and discharge options to reduce the effects to the environment and risks to the consenting process, assessing effects of discharges to land and water, and monitoring and reporting on the effects of discharges to land and water for compliance with resource consents.

Some examples of projects that I have been part of are:

> Designing and preparing technical assessments to support a resource consent application for a treated dairy wastewater discharge in the Waikato Region in 2020. The work included preliminary design of the system, assessment of environmental effects, and stakeholder engagement. The design included a retention pond with floating wetlands, a series of subsurface flow and surface flow wetlands with recirculation and discharge to streams through naturalized catchment flow and to agricultural land via spray irrigation.

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Coordinating a team of experts and preparing assessment of effects to support a resource consent application for a treated council wastewater discharge to a golf course in the Auckland Region in 2022. The work was part of a pilot project on water recycling to reduce pressure on drinking water supply. The project aimed to evaluate the viability of treated wastewater reuse for irrigation, assess potential environmental effects on soil, ecology, and freshwater resources (both groundwater and surface water), and included a comprehensive assessment of effects and recommendations.

Designing and assessing the environmental effects of treated domestic wastewater discharge to soil and surface water from a proposed wastewater treatment plant for a planned residential subdivision in 2021. This project involved carrying out baseline surveys, assessing the effects, and providing preliminary design and recommendations for discharge of treated wastewater from the Karaka North Village Wastewater Treatment Plant which treats the wastewater from a 1200 house subdivision in the Auckland Region.

Providing expert advice and presenting evidence on the proposed wetland system for reducing nitrogen concentrations from treated effluent from the on-site wastewater treatment plant (WWTP) proposed as part of Plan Change 93 (Private): Warkworth South to the Auckland Unitary Plan (Operative in part) (AUP(OP)) (the Development or PC93).

I confirm that, in my capacity as reviewer of this report, I have read and abide by the Environment Court of New Zealand's Code of Conduct for Expert Witnesses Practice Note 2023.

Yours sincerely

Lobo, Luiz Coutinho
Environmental Science and Engineering Lead

Babbage Consultants Limited

24 February 2025 eTrack No: 200049338

STATEMENT OF QUALIFICATIONS AND EXPERIENCE

This statement refers to the report "Technical Assessment of Environmental Effects of Treated Wastewater Discharge – Milldale WWTP Project" prepared by Babbage Consultants Limited, for Apex Water Limited, dated 25 February 2025, eTrack no 200049338.

I am the Technical Director of Freshwater and a Senior Coastal and Freshwater Ecologist at Bioresearches, Consulting Biologists in Auckland which is a subsidiary of Babbage Consultants.

Babbage is a New Zealand staff-owned multi-disciplinary consultancy business specialising in ecology, geotech, planning, engineering (environmental, process, civil, infrastructure, structure, fire), project management, architecture, and land surveying. I have been employed at Babbage since 2011.

I have a Bachelor of Science (1983) and Master of Science (Hons) (1985) from the University of Auckland. I am a member of the New Zealand Freshwater Sciences Society, the Ornithological Society of New Zealand, and the Environment Institute of Australia and New Zealand (EIANZ).

I have practised as a consultant ecologist for the past 30 years. I specialise in freshwater and coastal ecology and I have been responsible for undertaking and coordinating numerous assessments of rivers, streams, wetlands, estuaries and coastal environments throughout New Zealand.

Examples of my experience relevant to this project are:

Land development at McLaughlin Road; Karaka North Village; Kapiti Road, Kapiti; Shelly Bay, Wellington; West Hoe Heights, Orewa; Pak'nSave Warkworth; and the expansion of Belmont, Brookby, Drury and Smythes Quarries.

Private Plan Changes for Halls Farm "Ara Hills"; Stubbs Farm, Warkworth; Ardmore "Sunfield"; Plan Change 43, McLaughlins Quarry; Plan Change 42 Te Tuhi Point, Taupō; and Plan Change 90 Highbrook.

Freshwater and coastal ecological lead for Papakura to Bombay, State Highway 1 (SH1) improvements; Northland Bridges Project, Kaeo Bridge; Mangawhai Shared Path; Auckland International Airport developments for Taxiway Mike and remote stands.

I have been engaged by KA Waimanawa Limited Partnership and Stepping Towards Far Limited (the Applicants) since October 2020 to provide expert advice on freshwater ecology in relation to Plan Change 93 (Private): Warkworth South to the Auckland Unitary Plan (Operative in part) (AUP(OP)) (the Development or PC93).

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I have undertaken freshwater ecological assessments, including classifications, ecological values and assessments of effects on those values, and I have provided evidence before an Independent Hearing Panel in the matter of Notices of Requirement on behalf of the Applicants in relation to Te Tupu Ngātahi Supporting Growth Programme.

I confirm that, in my capacity as reviewer of this report, I have read and abide by the Environment Court of New Zealand's Code of Conduct for Expert Witnesses Practice Note 2023.

Yours sincerely

Treffery Jean Barnett
Technical Director of Freshwater

Babbage Consultants Limited

24 February 2025 eTrack No: 200049338

STATEMENT OF QUALIFICATIONS AND EXPERIENCE

This statement refers to the report "Technical Assessment of Environmental Effects of Treated Wastewater Discharge – Milldale WWTP Project" prepared by Babbage Consultants Limited, for Apex Water Limited, dated 25 February 2025, eTrack no 200049338.

I am a Senior Freshwater Ecologist at Bioresearches, Consulting Biologists in Auckland which is a subsidiary of Babbage Consultants.

Babbage is a New Zealand staff-owned multi-disciplinary consultancy business specialising in ecology, geotech, planning, engineering (environmental, process, civil, infrastructure, structure, fire), project management, architecture, and land surveying. I have been employed at Babbage since July 2022.

I have a Bachelor of Science (2011), and Master of Science (Hons) (2017) from the Northwest University in South Africa. I am a member of the New Zealand Freshwater Sciences Society and the Environment Institute of Australia and New Zealand (**EIANZ**).

I have over 14 years of freshwater ecological experience and have practised as a consultant ecologist for the past 9 years. I specialise in freshwater ecology, and I have been responsible for undertaking and coordinating numerous assessments of rivers, streams and wetlands throughout New Zealand, but more specifically in the Auckland region.

My experience includes undertaking freshwater ecological assessments, including classifications, ecological values and assessments of effects on those values, biological monitoring of freshwater ecosystems, and providing specialist input to development infrastructure on how to avoid/minimise ecological effects.

Some examples of projects that I have been part of are:

Preparing technical assessments, predominantly focussing on freshwater ecological value and effects assessments, to support resource consent applications for a various development spheres: this includes assessment of various properties across Auckland, most notably along Fred Taylor Drive, Don Buck Road, West Hoe Heights, Karaka Road in Drury, and Ngatea South in Paroa.

Biological monitoring of watercourses receiving discharges from industrial/mining developments. Project examples that involved ongoing yearly (and in some cases bi-annual) monitoring to ensure compliance with existing consent conditions, includes monitoring at OceanaGold Waihi Gold mine,

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Watercare Beachlands wastewater treatment plant, Hauraki District Council wastewater treatment plant in Waihi, and land development at 4 Scott Road in Auckland.

I confirm that, in my capacity as reviewer of this report, I have read and abide by the Environment Court of New Zealand's Code of Conduct for Expert Witnesses Practice Note 2023.

Yours sincerely

Christel du Preez
Senior Freshwater Ecologist

Babbage Consultants Limited

24 February 2025 eTrack No: 200049338

STATEMENT OF QUALIFICATIONS AND EXPERIENCE

This statement refers to the report "Technical Assessment of Environmental Effects of Treated Wastewater Discharge – Milldale WWTP Project" prepared by Babbage Consultants Limited, for Apex Water Limited, dated 25 February 2025, eTrack no 200049338.

I am Tiago Marques Araujo Teixeira, an Environmental Engineer at Babbage Consultants Limited (Babbage).

Babbage is a New Zealand staff-owned, multi-disciplinary consultancy specializing in ecology, geotechnical engineering, planning, environmental engineering, process engineering, civil engineering, infrastructure, structural engineering, fire engineering, project management, architecture, and land surveying. I have been employed at Babbage since August 2018.

I hold a BE in Chemical Engineering and an MSc in Environmental Geotechnics from the Federal University of Bahia (UFBA, Brazil). These qualifications have been reviewed by Engineering New Zealand and the New Zealand Qualifications Authority (NZQA) and accepted as Washington Accord equivalents. I am also a registered Member of Engineering New Zealand and the Australasian Land and Groundwater Association (ALGA).

I have over 20 years of professional experience in the Environmental Engineering and Consultancy sectors, specializing in contaminated land investigations, water and wastewater quality, and monitoring for compliance and remediation. I have experience in the design, construction, and operation of remediation systems for the treatment of soil and groundwater contaminated with hydrocarbons and metals in Brazil for public and private organizations. My experience in New Zealand includes groundwater and water quality monitoring, modelling contamination discharges on receiving environments for residential, commercial, and industrial developments, assessing the effects of discharges to land and water, and reporting on the effects of discharges for compliance with resource consents, proposing mitigation actions, and engineering controls. I also have experience in the contaminated land industry, preparing detailed site investigations, remedial action plans, site management plans, and validation reports to support resource consents (e.g., Kāinga Ora, NZ Bus, Greenstone Group, Williams Corporation, Foodstuffs supermarkets, and others in Auckland).

Some examples of New Zealand projects that I have been part of are:

- **Assessment of stormwater discharges from the New Zealand Defence Force (NZDF)**: Recommended stormwater treatment options to improve the quality of stormwater discharge

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from the NZDF site. This project included reviewing current stormwater treatments, analyzing historical stormwater quality data with statistical and trend analysis, and evaluating alternative options based on treatment capability, associated costs (including CAPEX and OPEX), sustainability, and maintenance.

- **Assessment of environmental effects associated with discharges from Oceana Gold mine in Otago:** Conducted for the purpose of discharge consent renewal. This assessment included evaluating the effects on surface water from sediment pond discharges used to control sediment associated with surface water runoff from land disturbed by mining operations, post-mining rehabilitation, and waste rock stacks (WRS). The assessment involved modelling the effects of contaminant discharge using a mass balance approach to assess metal and metalloid contaminant discharges as well as flow rate effects.
- **Assessment of environmental effects from the Karaka North Village Wastewater Treatment Plant (WWTP):** This plant treats wastewater from a 1200-house subdivision in the Auckland Region. The assessment included modelling the effects of contaminant discharge using a mass balance approach to evaluate discharges of nutrients, sediments, and bacteria from the proposed WWTP to the environment, and proposing recommendations to control and mitigate adverse effects.

I confirm that, in my capacity as author of this report, I have read and abide by the Environment Court of New Zealand’s Code of Conduct for Expert Witnesses Practice Note 2023.

Yours sincerely

Tiago Teixeira
Environmental Engineer

Babbage Consultants Limited

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