Beachlands Wastewater Treatment Plant

2024-2025 Annual Report

Final - September 2025

Watercare

QUALITY INFORMATION

Document	Annual Report
Date	30 September 2025
Name and position of originator	Emma Baker, Environmental Scientist
Report directory	\\water.internal\ORG\Ops\Wastewater Operations\Regional Plants\Sth Region\03 Asset Ops_Sth\DTBEA\03_Plant_Ops\03-Resource Consents\03-Administration and Monitoring\02-Reporting\2025-2025 Annual Report

REVISION HISTORY

Rev	Revision Date	Name	Position	Signature
1	24/09/2025	Michiel Jonker	Environmental Care Manager	
2	26/09/2025	Iris Tscharntke	Operations Controller	
3	29/09/2025	Jonathan Piggot	Head of Wastewater	

APPROVED

Date	Name	Position	Signature
29/09/2025	Michiel Jonker	Environmental Care Manager	

CONSENT CHANGE AND MONITORING HISTORY

Change type	Description	Effective date	Reference / condition	Reporting / monitoring implications
Management plan	Environmental Monitoring Plan written.	July 2006	14	N/A
Consent variation	A variation of consent 26875 and other associated consents changed the quarterly reporting periods to align with financial quarters.	6 December 2013	22	Quarterly reports submitted within 20 working days of the specified quarters.
Monitoring location moved	Reference site A for the 3-yearly Te Puru Stream assessments relocated 10 m upstream from previous monitoring assessments	January 2024		Trend analysis must include this consideration where applicable.
Management plan update	Updated the original (2009) Operations Management Plan to reflect current operations.	May 2024	14	N/A

EXECUTIVE SUMMARY

The 2024-2025 annual report for the Beachlands Wastewater Treatment Plant (WWTP) provides an overview of the plant's performance, environmental monitoring, and compliance with resource consents. Covering the period from 1 July 2024 to 30 June 2025, the report highlights key operational changes, compliance results, and monitoring data, fulfilling regulatory reporting obligations.

Key points include:

- Effluent Discharge: The average daily effluent discharge for the year was 2,006 m^3/day, below the consented limit of 2,800 m^3/day. However, during large weather events, the plant exceeded the discharge limit on 32 days due to high inflow and infiltration caused by rainfall. Despite these exceedances, no significant environmental impact was recorded.
- Water Quality: The WWTP consistently met water quality consent conditions for all parameters such as 5-day carbonaceous biochemical oxygen demand ($cBOD_5$), total suspended solids (TSS), ammoniacal nitrogen and bacteria. Additional sampling during high flow events showed no breaches in limits.
- Environmental Monitoring: Monitoring of the receiving environment (Te Puru Stream) revealed that the effluent had some local impacts on water quality, such as increased nutrients downstream, however there was no significant bacterial contamination compared to reference sites. Long-term monitoring indicated similar conditions compared to previous years, though some effects on aquatic life were noted.
- Compliance: The WWTP achieved a high level of compliance across both water and air discharge consents, exceeding only the discharge volumetric limits throughout the reporting period.

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ABBREVIATIONS

For ease of reading, this report uses abbreviations for some technical terms. Table 0-1 lists these abbreviations.

Table 0-1: Abbreviations

Abbreviation	Description
$cBOD_5$	5-day carbonaceous biochemical oxygen demand
BNR	Biological nutrient removal
DO	Dissolved oxygen
E. coli	*Escherichia coli*
NH_x-N	Ammonia and ammonium, reported in milligrams nitrogen
NO_3-N	Nitrate as measured in units of nitrogen
TN	Total nitrogen
DRP	Dissolved reactive phosphorus
TSS	Total suspended solids
Watercare	Watercare Services Limited
WWTP	Wastewater treatment plant

1 INTRODUCTION

This annual report presents the compliance monitoring results for the Beachlands Wastewater Treatment Plant (WWTP) from 1 July 2024 to 30 June 2025. The report includes:

- Description of the WWTP
- Relevant consents and management plans
- Plant performance
- Summary of compliance
- Tables of monitoring data form appendices to the main body of the report.

Table 1-1 lists the active resource consents for the WWTP. Watercare made no changes to these consents in 2024-2025 and is progressing with the application for new discharge permits.

Table 1-1: Beachlands WWTP resource consents

Consent type	Consent number	Council number	Expiration date
Wastewater discharge permit	26875	DIS60263339	31/12/2025
Air discharge permit	26876	DIS60263339	31/12/2026
Stormwater discharge permit	33614	DIS60266874	31/12/2041

2 TREATMENT PLANT

2.1 Current operation

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

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

The treated effluent discharges via ground soakage to the farm pond along the receiving tributary. The farm pond tributary meets another arm to form Te Puru Stream.

All dried biosolids go to a permitted solid waste landfill at Hampton Downs.

2.2 Changes in 2024-2025

No changes to the operations of the WWTP occurred in 2024-2025.

2.3 Future changes

Watercare is not intending to make changes to the WWTP in 2025-2026. Work will progress on the re-consenting process for the discharge permit, which will facilitate planning for upgrades required.

3 COMPLIANCE

The assessment of the WWTP performance considers:

- Results of compliance monitoring
- Recorded incidents and complaints.

Watercare assesses compliance with the consent using the same compliance rating system utilised by Auckland Council (Table 3-1).

Table 3-1: Compliance assessment criteria

Rating	Detail
Category 1	Watercare has complied with the consent condition. Where a resource consent condition refers to a provision in a Management Plan, then the plan has been referred to in assessing consent compliance.
Category 2	Watercare has not complied with the consent condition. Watercare has assessed the non-compliance as technical or having no more than minor adverse effect.
Category 3	Watercare has not complied with the consent condition. Watercare has assessed the non-compliance having the potential to result in more than minor adverse effects on the environment. Alternatively, since the last audit, there is evidence of repeat Category 2 non-compliance.
Category 4	Watercare has not complied with the consent condition. Watercare has assessed the non-compliance as having the potential to cause significant adverse effects on the environment. Alternatively, since the last audit, there is evidence of repeat Category 3 non-compliance.

3.1 Plant performance

3.1.1 Method statement

The following monitoring was included:

- Effluent flow was continuously measured by a calibrated flow meter at the WWTP outlet, with daily totals recorded and aggregated to monthly and annual values.
- Effluent quality was monitored twice monthly at the UV discharge point, with additional samples collected during discharge volume exceedances. Analyses were undertaken by Watercare laboratory (IANZ-accredited).
- The receiving environment monitoring included weekly upstream and downstream sampling, and a full ecological survey undertaken every three years (most recently March–April 2025). Results were compared with reference sites and long-term trends.
- Air quality monitoring comprised weekly biofilter pH and moisture checks, and daily odour inspections at the site boundary.
- Complaints and incidents were logged in accordance with consent requirements.

Data handling and analysis:

- All raw monitoring data were collated Watercare Pi Historian and XX- data tags and IDs are detailed in Appendix C.
- Data were summarised using consent-specified statistics (rolling medians, 90th and 95th percentiles, daily maxima).

3.1.2 Effluent volumes

Figure 3-1 shows daily effluent volumes for July 2024 to June 2025 (results and rainfall are in appendix A). The daily discharge limit is 2,800 m^3/day. The average daily effluent discharge during the reporting period was 2,006 m^3/day, higher than the 1,906 m^3/day average for 2024-2025. The annual total was 732,091 m^3, also higher than the previous reporting period, due to an increase in periods where the discharge limit was exceeded. The discharge volumes in 2024-2025 are more comparable to 2022-2023, which had elevated inflow and infiltration associated with rainfall and a number of discharge volume exceedances.

Daily discharge volumes exceeded the consented limit on 32 days throughout the period: 12 of these days in July to October 2024, and 20 days in May to June 2025. On these occasions, high rainfall increased the inflow and infiltration in the wastewater network significantly and subsequently the flow into the plant. It was not possible to store all the incoming flows in the storm buffer and post-treatment ponds; the discharge was increased to treat as much of the raw wastewater as the processes allowed. The alternative to exceeding the discharge consent limit would be to allow wastewater to back up into the network, causing overflows of untreated wastewater.

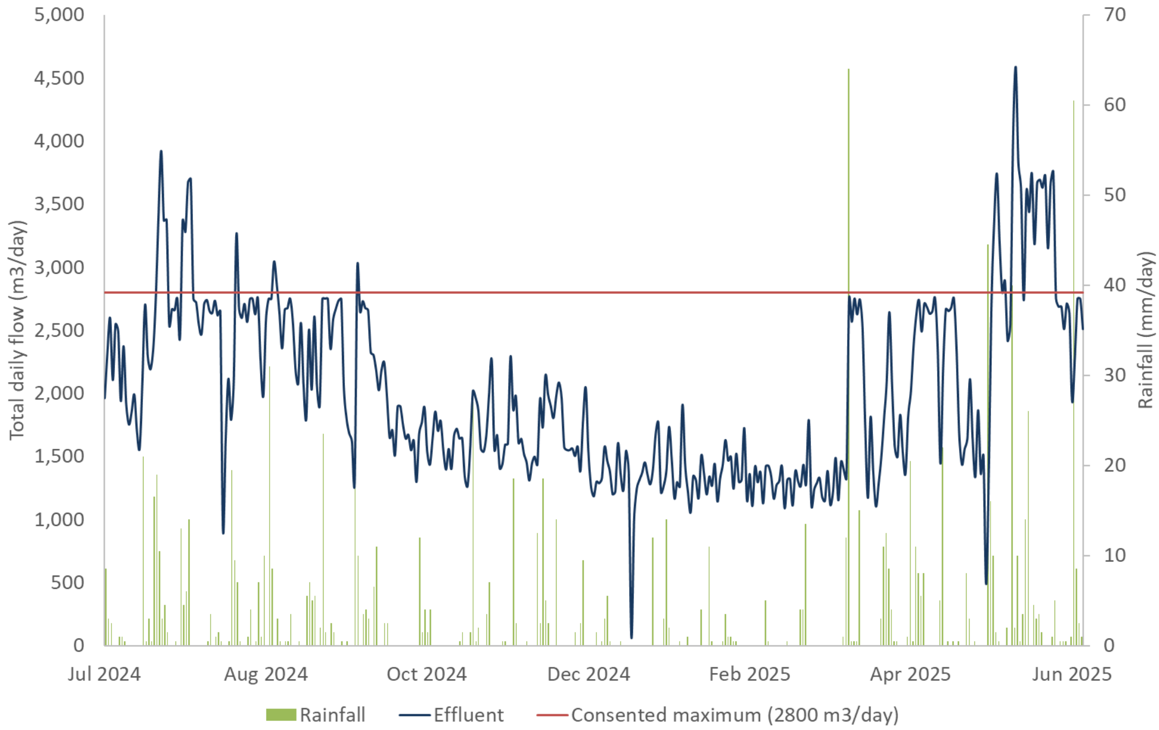

Figure 3-1: Beachlands WWTP effluent discharge volumes (July 2024 - June 2025).

3.1.3 Effluent quality

The WWTP met its compliance criteria for water quality across the reporting period. Table 3-2 summarises water quality and the relevant calculations with consent limits, and appendix A contains the raw data.

Extra samples were taken in addition to the routine samples (when applicable) during events when the volume of the discharge exceeded the daily limit (Section 3.1.2). The results for these extra samples indicated the effluent quality did not breach the consent limits during the increased flows.

The results of these extra samples are included with the reporting of the routine samples in this report.

3.2 Receiving environment monitoring

Watercare monitors the water quality upstream and downstream of the farm pond weekly (appendix A). More intensive receiving environment monitoring is carried out every three years, as agreed with Auckland Council in 2016. The most recent monitoring required by the current consent was undertaken in March and April 2025 by Bioresearches (appendix B).

The report’s key findings include:

- Overall water quality and biological health were poor in both reference and impact sites
- Electrical conductivity was consistently very high at all sites below the discharge, and reference sites were elevated compared to the 2024 survey
- Dissolved oxygen, pH and $cBOD_5$ did not appear to be influenced by the discharge
- Nitrogen and phosphorus increased below the discharge, with total nitrogen higher than usual at several downstream sites. Phosphorus exceeded guidelines at almost all sites, including reference
- High bacterial levels throughout the catchment, indicating widespread contamination is not exclusively caused by the farm pond effluent discharge
- Localised indication of adverse effects in macroinvertebrate communities near the discharge site, although the influence of habitat structure (substrate) on macroinvertebrate communities are not accounted for. Reference sites generally had higher macroinvertebrate communities
- Fish communities appeared to be influenced by the discharge, with reductions in native species numbers and abundance observed immediately downstream of the discharge pond. Further downstream, survey results were comparable to reference sites
- Comparisons to previous surveys since 2002 found water quality and ecological conditions in the upper Te Puru Stream tributaries were generally similar over time
- The survey results indicate the discharge from the WWTP influences the quality of the habitat of the Te Puru Stream tributary for at least 200 m downstream of the pond, with some water quality parameters (i.e. conductivity, bioavailable nutrients) affected for a greater distance. Fish populations, sensitive macroinvertebrates and filamentous algae also appeared to be affected for some distance downstream of the discharge.

Overall, monitoring shows ecological health in the receiving environment remains generally poor, with localised effects from the WWTP discharge evident immediately downstream, although wider catchment contamination indicates multiple sources. While the plant has complied with concentration limits, the findings highlight that the receiving environment is degraded, and the results will be important for the upcoming re-consenting process to inform any future treatment or network improvements.

Table 3-2: Summary of effluent monitoring for Beachlands WWTP (2024-2025). Colours indicate compliance limits and status.

Parameter	Units	n	Minimum	Average	Maximum	Consented Maximum	Median	Consented Median	90th Percentile	Consented 90th Percentile	Compliant
Discharge Volume	m^3/day	365	65	2,006	4,588	2,800	1,806	-	-	-	No
Escherichia coli	cfu/100mL	62	1.6	2.4	11.0	-	1.6	-	-	-	-
Faecal Coliforms	cfu/100mL	62	1.6	3.3	23.0	-	1.6	≤14	-	-	Yes
$cBOD_5$	mg/L O	60	0.5	1.2	2.9	-	1.2	-	1.7	≤15	Yes
Nitrate	mg N/L	60	1.7	6.0	8.6	-	6.0	-	6.9	≤15	Yes
Ammoniacal Nitrogen*	mg N/L	60	0.02	0.20	8.80	-	0.03	-	0.07 0.60	≤4 (Nov-Apr) * ≤5 (May-Oct) *	Yes
Soluble Reactive Phosphorus	mg P/L	60	0.07	0.30	1.30	-	0.30	-	0.60	≤5	Yes
pH	No units	60	6.5	6.9	7.7	-	6.8	-	-	-	-
Total Suspended Solids	mg/L	60	1.0	5.0	12.0	-	4.6	-	8.6	≤15	Yes

Note: Quarterly reports submitted to Auckland Council provide compliance assessments based on ten samples (rolling).

*95th percentile

3.3 Air quality

Routine odour inspections are carried out by the operator and detailed in log sheets. No operator recorded any odours at the boundary during the inspections.

3.3.1 Biofilter monitoring

Figure 3-2 shows results for weekly biofilter pH and moisture-content monitoring. Biofilter moisture content averaged at 64.4% during the monitoring period, in accordance with the maintenance requirements outlined in the air quality management plan (approximately 60%). The pH of the biofilter was typically near neutral but had some more acidic periods in summer and autumn. This has minimal impact on the performance of the biofilter and is adjusted with lime shells as needed.

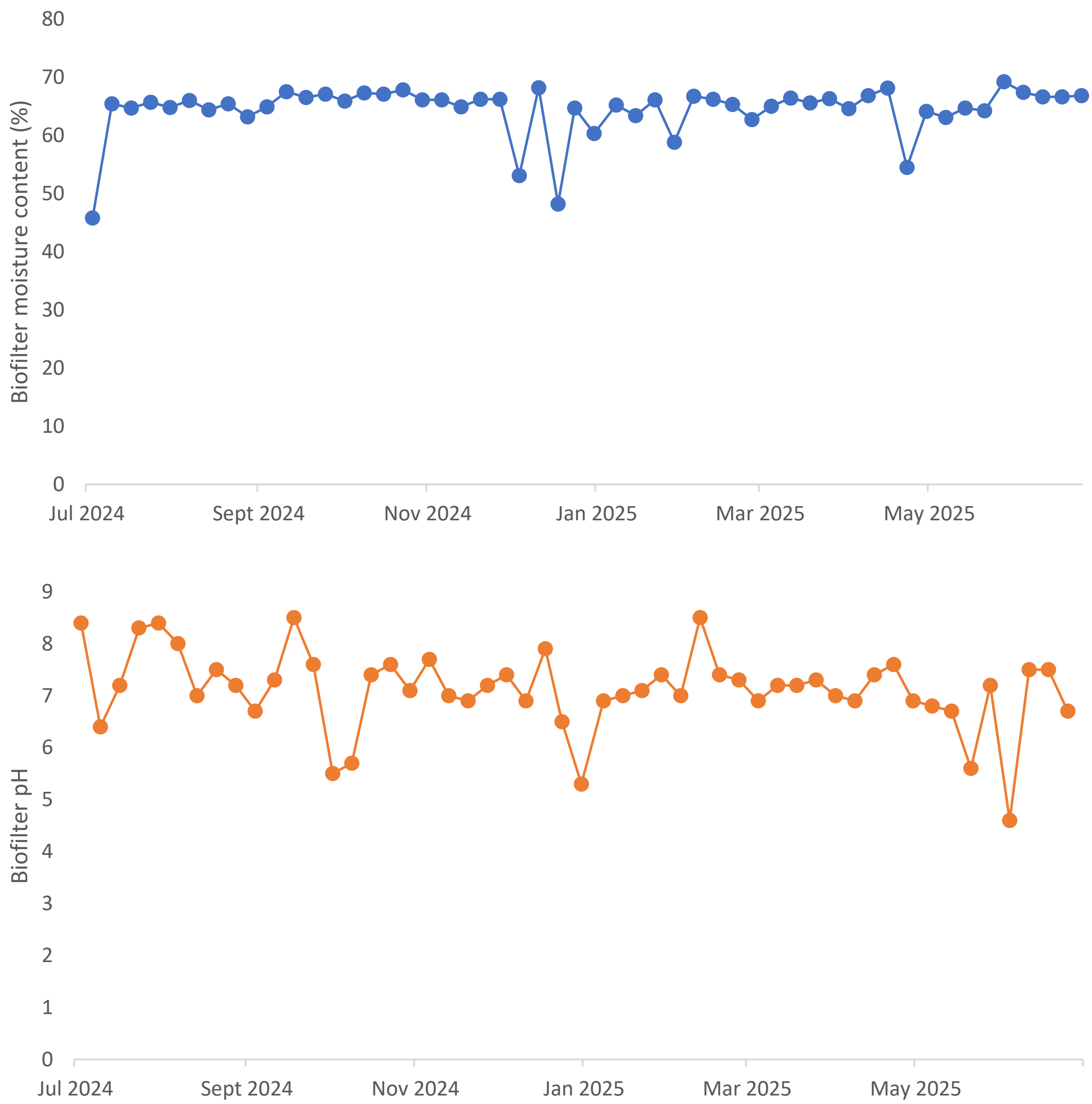

Figure 3-2: Biofilter monitoring results (2024-2025).

3.4 Complaints and incidents

The Beachlands WWTP did not receive any complaints or have any incidents in 2024-2025.

4 CONCLUSION

The 2024-2025 annual report for the Beachlands WWTP reflects a year of steady operational performance and consistent compliance with resource consent conditions. Challenges to meet the effluent volume limit continue, due to high inflow and infiltration, which led to discharge volume exceedances on 32 days. Additional water quality testing conducted during these events showed that the effluent remained within concentration limits.

Environmental monitoring indicated localised impacts, particularly an increase in nutrients downstream of the discharge. However, long-term monitoring showed no significant deterioration in water quality or ecological conditions in the Te Puru Stream.

An assessment of compliance with each consent is in Table 4-1 and Table 4-2.

Table 4-1: Compliance assessment with consent 26875 (water)

Condition Number	Consent Condition Beachlands Discharge to Stream (#26875)	Compliance Rating	Comments
01	ARC agents may access the property at reasonable times to carry out inspections, surveys, tests, or measurements, or to take samples.	1	Compliant.
02	Consent Holder shall operate the plant and associated processes in accordance with the documentation submitted to the ARC as part of application number 26875 and with the conditions of this consent. No alterations shall be made to the plant or processes that do not, or are not likely to, comply with the provisions of this consent, a regional rule, or regulations under the RMA 1991.	1	Compliant.
03	Within 3 years of the granting of this consent, an upgrade to the wastewater treatment and disposal system shall be designed, constructed, installed and operated as an activated sludge process with clarifier and phosphorus removal facility, sand filtration or equivalent and UV disinfection.	1	Completed in Dec 2008 and performance tested in July 2009.
04	Consent Holder shall engage an Engineer experienced in wastewater treatment and disposal systems to certify in writing to the Manager, within 3 months of granting of this consent, that all existing system components have been inspected and are considered to be in sound condition for continued use in accordance with this consent, and within 3 months of commissioning of any new key system component, that the new component has been inspected and installed in accordance with standard engineering practice and with the specifications and conditions of this consent.	1	Completed by Fulton Hogan and Opus as consultant.
05	"As-built" plans for the wastewater treatment system shall be forwarded to the Manager within 3 months of commissioning of any new key component of the system.	1	Acknowledgement letter from Council on 30 Nov 2009 and O&M manual on 20 Oct 2009 from Manukau Water.
06	No trade, non-domestic or other strong (non-domestic) wastes shall be permitted to be connected to the wastewater system serviced by the Treatment Plant without the Manager's written approval. When seeking Manager approval for a proposed new trade, non-domestic or other strong (non-domestic type) waste connection, the Consent Holder shall verify to the Manager's satisfaction that the proposed waste contribution will not change the performance of the treatment system or result in any significant decrease in wastewater quality discharged from the Plant. In this consent, "trade wastes" refers to anything which is discharged from trade premises as defined in s 489 of the LGA 1974. Industrial waste shall not be permitted to be connected to the wastewater system serviced by the Treatment Plant.	1	Compliant and covered by Trade Waste Bylaw.
07	The population serviced by the plant shall not exceed 10,000.	1	
08	Consent Holder shall ensure that for the duration of this consent the plant is maintained and operated by a suitably qualified and experienced wastewater treatment plant operator. This operator shall perform the operational and maintenance responsibilities specified in the Management Plan to comply with the conditions of this consent.	1	Compliant.

Condition Number	Consent Condition Beachlands Discharge to Stream (#26875)	Compliance Rating	Comments
09	Consent Holder shall maintain the system in an efficient and professional manner, in accordance with the Management Plan required by Condition 14 and the other conditions of this permit, to ensure that it functions efficiently such that any impact on the receiving environment is minimised.	1	Ongoing.
10	Consent Holder shall desludge the plant as required and the sludge shall be dewatered according to the standard in the Management Plan approved by the Manager. Waste sludge shall be disposed of off-site to an appropriate licensed waste disposal facility, in a manner that ensures that the sludge or runoff from the sludge does not enter any natural waters.	1	Ongoing. Desludging is usually three times per year and the sludge is disposed at the landfill.
11	Consent Holder shall log all complaints received and system malfunctions regarding the wastewater.	1	Ongoing.
12	Consent Holder shall ensure that appropriate personnel are available to respond to any alarm sounding or complaint arising from a wastewater treatment plant emergency, on a 24/7 basis. The Consent Holder shall ensure that emergency situations are responded to as soon as practicable upon receipt of indication. Complaints regarding odour from the treatment works shall be handled in accordance with Condition 24 of Permit No. 26876.	1	Ongoing.
13	In the event that any incident with the wastewater treatment plant and/or discharge results in more than 2 complaints being received within 48 hours, then the Consent Holder shall report the incident and the complaints to the Manager as soon as practicable.	1	Did not occur during this reporting year.
14	Consent Holder shall prepare a Management Plan for the wastewater treatment and disposal system to enable compliance with the conditions of this consent and as necessary to ensure that any adverse effects on the environment are minimised. The Plan shall be in accordance with the conditions of this consent and shall cover the following: a) inspection and maintenance; b) monitoring and reporting; c) contingency plans; d) desludging of waste activated sludge. See consent condition for further detail.	1	Management Plan and O&M were submitted to Council on 16 Nov 2009. An updated management plan was submitted in May 2024.
15	Consent Holder shall continuously measure and record effluent discharge flow volume from the treatment plant. The flow measuring device shall be capable of providing cumulative measurements to an accuracy of plus or minus 5% and shall be maintained in accordance with the manufacturer's specifications at all times. Where pump hours are used to meter flows, the pump flow time shall be regularly calibrated to consistently ensure an accuracy of plus or minus 5% is achieved. The flow measuring device shall be respectively read at the same time each day. These readings shall be recorded in a logbook and copies of the flow data for the prior 3 months shall be reported to the Manager in the quarterly monitoring report, as per Condition 22.	1	Ongoing.

Condition Number	Consent Condition Beachlands Discharge to Stream (#26875)	Compliance Rating	Comments
16	Consent Holder shall collect samples weekly from the discharge point of the UV sterilisation unit prior to discharge into the irrigation trenches connected to the riparian wetland and analyse the samples for the following parameters: BOD, total suspended solids, total oxidised nitrogen, ammonia nitrogen, dissolved reactive phosphorus, faecal coliforms, e. coli, pH.	1	As per condition 16 (see the full requirement in the consent document), the monitoring shall be reduced to fortnightly for such time as full compliance continues to be achieved. Our consent sampling is not scheduled fortnightly instead consent sampling is scheduled for every 2nd and 4th Wednesday in a month.
17	All sample analyses shall be undertaken to the detection limits identified and the results reported in the units specified in the appended table (Appendix 1).	1	Ongoing.
18	All samples collected as per Conditions 16 and 17 shall be collected and analysed in accordance with the latest edition of "Standard Methods for the Examination of Water and Wastewater", APHA, AWWA, WPCE or equivalent approved in writing by the Manager.	1	Ongoing.
19	The effluent quality as determined by the results of the analyses required by Conditions 16, 17 and 18 shall comply with the following standards: BOD - better than 15g/m3 at the 90% percentile; suspended solids - better than 15g/m3 at the 90% percentile; ammonia nitrogen (summer, i.e. November to April inclusive) - better than 4gN/m3 at the 95th percentile; ammonia nitrogen (winter) - better than 5gN/m3 at the 95th percentile; nitrate nitrogen - better than 15gN/m3 at the 90th percentile; nitrate nitrogen (for the transition phase) - better than 25gN/m3 at the 90th percentile; dissolved reactive phosphorus - better than 5g/m3 at the 90th percentile; dissolved reactive phosphorus (for the transition phase) - better than 12g/m3 at the 90th percentile; faecal coliforms - better than a median of 14 cfu/100ml. See consent condition for further details.	1	Compliant.
20	Following full commissioning of the upgraded system, samples shall be collected from the discharge point of the UV sterilisation unit prior to discharge into the irrigation trenches connected to the riparian wetland with the purpose of confirming the efficacy of the upgraded system at removing hormonally active compounds.	1	Ongoing.
21	Consent Holder shall design an Impact Assessment Monitoring Program for the ongoing assessment of any effects of the discharge on the receiving environment. The Program shall include provision to monitor the following effects on the receiving waters of Te Puru stream: water quality effects; sediment quality effects; ecological effects; birth defects amongst animals that obtain drinking water downstream of the discharge, provided that in absence of scientific evidence to the contrary, the presence of any birth defects in the vicinity shall not be inferred to have been caused by the discharge. See consent condition for further detail.	1	Earth Consult completed IAMP on 29 Nov 2005 and Pond Sediment sampling report in May 2014. The last Te Puru water quality monitoring assessment by Bioresearches was completed in March and April 2025.

Condition Number	Consent Condition Beachlands Discharge to Stream (#26875)	Compliance Rating	Comments
22	That the results of the monitoring undertaken in accordance with Conditions 15, 16, 17 and 18 shall be reported to the Manager - Change to condition - please refer to condition 22a	1	Ongoing.
22a	That the results of the monitoring undertaken in accordance with Conditions 15, 16, 17 and 18 shall be reported to the Manager quarterly within 20 working days of the period ending 30 September, 31 December, 31 March and 30 June each year. The quarterly monitoring report shall identify any exceedences of the discharge standard limits specified in Condition 19 with an explanation for the exceedences. The report shall also include comment on general plant performance and any trends in changes in the discharge volume and/or the discharge quality standards over time. The report shall generally comply with the Monitoring and Reporting details defined by the Management Plan as required by Condition 14.	1	Ongoing.
23	Consent Holder shall consult with representatives of the local community, including any appropriate local community groups and neighbours to facilitate the establishment and maintenance of a Community Liaison Group (CLG). See consent condition for further detail.	1	Ongoing.
24	Within one year of the granting of this consent, riparian planting in accordance with ARC Technical Publication 148 and fencing of the entire length of the stream within the Consent Holder's property shall be completed.	1	Completed in Feb 2007.
25	Conditions of this consent may be reviewed by the Manager pursuant to Section 128 of the RMA 1991, by the giving of notice pursuant to Section 129, in the month of June of the year following that in which the consent is granted, and annually thereafter in order to do things listed in i) to vi) in the consent condition.	1	Compliant.
0	The consent holder shall that the maximum discharge does not exceed 2,800 m^3 per day.	2	Daily discharges from the Beachlands were above consented maximum on 32 days in the reporting period.

Table 4-2: Compliance assessment for consent 26876 (air)

Condition Number	Consent Condition Beachlands Discharge to Air (#26876)	Compliance Rating	Comments
01	ARC agents may access the property at reasonable times to carry out inspections, surveys, tests, or measurements, or to take samples.	1	Compliant.
02	Consent Holder shall operate the plant and associated processes in accordance with the documentation submitted to the Council as part of application number 26876, where not amended by the conditions of this consent. No alterations shall be made to the plant or processes that do not, or are not likely to, comply with the provisions of this consent, a regional rule, or regulations under the RMA 1991.	1	Compliant.
03	The construction of the additional system components permitted under the Works Condition shall be carried out under the supervision of an Engineer experienced in wastewater treatment and disposal systems. The supervising Engineer shall certify in writing to the Manager, within 3 months of the commissioning of any new key component of the system, that this has been designed, inspected and installed in accordance with standard engineering practice and with the specifications and conditions of this consent.	1	Completed.
04	Consent Holder shall submit "As-Built" plans and detail information for the wastewater treatment system to the Manager within 3 months of commissioning any new key component of the system, including any biofilter or other odour control equipment. Such detail information shall include, but not be limited to, the items listed in a) to e) of the consent condition.	1	Completed and submitted to Council by OPUS in 2008.
05	Any biofilter or other odour control equipment shall be designed, installed and maintained to provide effective odour control in accordance with the requirements of that version of TP152 that is current 3 months prior to the installation of that equipment.	1	Completed and submitted to Council by OPUS in 2008.
06	Consent Holder shall provide details of the designs of any biofilter(s) or other odour control equipment to the Manager for review prior to installation. The Manager shall advise the Consent Holder in writing if there are any matters associated with the biofilter design that are considered to be inconsistent with the conditions of this consent.	1	Completed and submitted to Council by OPUS in 2008.
07	From the date of the commissioning of the second clarifier, the inlet step screen works and screenings collection area shall be enclosed to prevent fugitive discharges to atmosphere, and any contaminated or odorous gases shall be extracted to a biofilter or other odour control equipment prior to discharge to atmosphere.	N/A	Presently operating with only one clarifier, inlet works are enclosed, and odorous gases treated in the biofilter.
08	Any belt press for dewatering of sewage sludge shall be enclosed within a building to prevent fugitive discharges to atmosphere and any contaminated or odorous gases shall be extracted to a biofilter or other odour control equipment prior to discharge to atmosphere.	N/A	Presently the plant does not use belt press for dewatering.
09	Consent Holder shall at all times operate, maintain, supervise, monitor and control all processes on site so that emissions authorised by this consent are maintained at the minimum practicable level.	1	Compliant.

Condition Number	Consent Condition Beachlands Discharge to Air (#26876)	Compliance Rating	Comments
10	Beyond the boundary of the site there shall be no odour, dust, particulate, smoke, ash or fume caused by discharges from the site which, in the opinion of an enforcement officer, is noxious, dangerous, offensive or objectionable.	1	None reported during the year.
11	No discharges from any activity on site shall give rise to visible emissions, other than water vapour and steam, to an extent which, in the opinion of an enforcement officer, is noxious, dangerous, offensive, or objectionable.	1	None reported during the year.
12	Beyond the boundary of the site there shall be no hazardous air pollutant caused by discharges from the site, which is present at a concentration that is, or is likely to be, detrimental to human health or the environment.	1	None reported during the year.
13	No part of the process shall be operated without the emissions control equipment being fully operational and functioning correctly.	1	Compliant.
14	All ducting and emissions control equipment shall be maintained in good condition and be free from leaks in order to prevent fugitive discharges to atmosphere.	1	Compliant.
15	All relevant fans and ducting to air emission control equipment shall draw sufficient negative pressure to ensure that fugitive emissions are kept to a practicable minimum.	1	Compliant.
16	All sludge, biosolids and screenings shall be disposed of off site to an appropriately authorised facility unless alternative disposal methods are agreed to in writing by the Manager.	1	Compliant.
17	No solid or liquid waste materials shall be disposed of on the site by open burning.	1	Compliant.
18	Consent Holder shall give consideration to wind direction and the proximity of neighbouring properties prior to undertaking any potentially odorous activities on the site.	1	Ongoing.
19	All sludge removal from the sludge accumulation lagoons and subsequent de-watering and disposal shall be carried out in a manner that minimises odour.	1	Ongoing. Sludge disposed offsite.
20	A walkover inspection of the site shall be undertaken at least once every working day to identify any odours that may be originating from the site. Any evidence of significant odour shall be recorded and investigated. Where necessary, remedial actions shall be undertaken as soon as practicable to reduce odour discharges. The procedures for the walkover, recording of the results and any remedial actions taken shall be as specified in the Air Quality Management Plan.	1	Ongoing.
21	From the date of commissioning of any biofilters, the Consent Holder shall record, as part of the Air Quality Management Plan, a log of all relevant information regarding the condition of the biofilters, including items listed in in a) to f) of the consent condition.	1	Ongoing.

Condition Number	Consent Condition Beachlands Discharge to Air (#26876)	Compliance Rating	Comments
22	All records, monitoring and test results that are required by the conditions of this consent shall be made available on request, during operating hours, to an enforcement officer and shall be kept for a minimum period of 12 months from the date of each entry.	1	Compliant.
23	Consent Holder shall notify an enforcement officer as soon as practicable in the event of any significant increase in the discharge of contaminants to air, which may result in adverse effects on the environment. In the event of an incident, shall provide a written report to the Manager within 10 working days of the occurrence. The report shall give reasons for the incident, any remedial actions taken and any mitigation measures taken to prevent its reoccurrence.	1	No significant increase in the discharge of odour to air during the reporting year.
24	Consent Holder shall log all air quality complaints received. The complaint details shall include: a) date, time, position and nature of complaint; b) weather conditions at the time of the complaint; c) name, phone number and address of the complainant, unless not supplied; d) any remedial actions undertaken. Details of any complaints received shall be provided to the Manager within 7 days of receipt of the complaint/s.	1	Ongoing.
25	Consent Holder shall prepare an Air Quality Management Plan, which specifies all management and operation procedures necessary to comply with the conditions of this consent. This plan may be a section of the Operations Management Plan. The plan shall include but not be limited to details listed in a) to i) in the consent condition.	1	Air Quality Management Plan (AQMP) completed in Nov 2009 and O&M in June 2009 by OPUS. An updated AQMP was included in the May 2024 revision of the O&M plan.
26	Consent Holder shall submit the Air Quality Management Plan to the Manager for review within 3 months of commencement of this consent. Any subsequent changes to the Management Plan shall be made and submitted to the Manager within one month. The Manager will advise the Consent Holder in writing if any aspects of the Management Plan are considered to be inconsistent with achieving the conditions of this consent.	1	First AQMP submitted to Council on 16 Nov 2009. An updated AQMP was prepared, submitted to and approved by Auckland Council in May 2024.
27	A compliance report summarising the plant performance and all information relevant to complying with this consent and with the Air Quality Management Plan shall be submitted to the Manager every 6 months.	1	Ongoing. Report submitted annually.
28	Within 3 months of commissioning any subsequent alterations to the treatment system, the Air Quality Management Plan shall be amended, to the satisfaction of the Manager, to reflect any changes in the management and operation procedures necessary to comply with the conditions of this consent.	1	No alterations required.
29	Conditions of this consent may be reviewed by the Manager pursuant to Section 128 of the RMA 1991, by the giving of notice pursuant to Section 129, in the month of June of the year following that in which the consent is granted, and annually thereafter in order to do things listed in a) to e) of the consent condition.	1	Compliant.

Appendix A. Supplementary data

Discharge volumes

Date	Effluent volume (m^3)	Rainfall (mm/day)	Date (continued)	Effluent volume (m^3)	Rainfall (mm/day)
1-Jul-24	1963	8.5	1-Jan-25	1289	0
2-Jul-24	2326	3	2-Jan-25	1327	0.5
3-Jul-24	2597	2.5	3-Jan-25	1578	3
4-Jul-24	2107	0	4-Jan-25	1466	5.5
5-Jul-24	2548	0	5-Jan-25	1380	0.5
6-Jul-24	2494	1	6-Jan-25	1201	0
7-Jul-24	1940	1	7-Jan-25	1223	0
8-Jul-24	2374	0.5	8-Jan-25	1606	0
9-Jul-24	1913	0	9-Jan-25	1357	0.5
10-Jul-24	1754	0	10-Jan-25	1233	0
11-Jul-24	1853	0	11-Jan-25	1546	0
12-Jul-24	1990	0	12-Jan-25	1376	0
13-Jul-24	1695	0	13-Jan-25	65	0
14-Jul-24	1567	0	14-Jan-25	1001	0
15-Jul-24	2086	21	15-Jan-25	1248	0
16-Jul-24	2703	0.5	16-Jan-25	1316	0
17-Jul-24	2295	3	17-Jan-25	1373	0
18-Jul-24	2191	0.5	18-Jan-25	1454	0
19-Jul-24	2343	16.5	19-Jan-25	1355	0
20-Jul-24	2751	19	20-Jan-25	1280	0
21-Jul-24	3399	10.5	21-Jan-25	1399	12
22-Jul-24	3922	3	22-Jan-25	1677	0
23-Jul-24	3370	4.5	23-Jan-25	1767	0
24-Jul-24	3377	1.5	24-Jan-25	1217	0
25-Jul-24	2542	0	25-Jan-25	1268	3
26-Jul-24	2667	0	26-Jan-25	1388	14
27-Jul-24	2660	0.5	27-Jan-25	1735	2
28-Jul-24	2751	0	28-Jan-25	1473	0
29-Jul-24	2443	13	29-Jan-25	1169	0
30-Jul-24	3370	4.5	30-Jan-25	1298	0
31-Jul-24	3280	6	31-Jan-25	1262	0.5
1-Aug-24	3674	14	1-Feb-25	1910	0
2-Aug-24	3700	0	2-Feb-25	1431	0

Date	Effluent volume (m³)	Rainfall (mm/day)	Date (continued)	Effluent volume (m³)	Rainfall (mm/day)
3-Aug-24	2751	0	3-Feb-25	1225	1
4-Aug-24	2723	0	4-Feb-25	1056	0
5-Aug-24	2546	0	5-Feb-25	1344	0
6-Aug-24	2470	0	6-Feb-25	1314	0
7-Aug-24	2709	0	7-Feb-25	1171	0
8-Aug-24	2741	0.5	8-Feb-25	1509	4
9-Aug-24	2654	3.5	9-Feb-25	1366	0
10-Aug-24	2637	0	10-Feb-25	1200	0
11-Aug-24	2735	1	11-Feb-25	1342	11
12-Aug-24	2618	1.5	12-Feb-25	1269	0.5
13-Aug-24	2653	0.5	13-Feb-25	1442	0
14-Aug-24	918	0	14-Feb-25	1145	0
15-Aug-24	1626	0	15-Feb-25	1328	0
16-Aug-24	2116	0.5	16-Feb-25	1438	0.5
17-Aug-24	1791	19.5	17-Feb-25	1631	3.5
18-Aug-24	2094	9.5	18-Feb-25	1468	1
19-Aug-24	3260	7	19-Feb-25	1499	1
20-Aug-24	2667	0.5	20-Feb-25	1245	0.5
21-Aug-24	2598	0	21-Feb-25	1523	0.5
22-Aug-24	2710	0	22-Feb-25	1298	0
23-Aug-24	2567	1	23-Feb-25	1316	0
24-Aug-24	2747	4	24-Feb-25	1725	0
25-Aug-24	2751	0	25-Feb-25	1153	0
26-Aug-24	2628	0.5	26-Feb-25	1362	0
27-Aug-24	2751	7	27-Feb-25	1108	0
28-Aug-24	2258	1	28-Feb-25	1422	0
29-Aug-24	1980	10	1-Mar-25	1297	0
30-Aug-24	2586	0	2-Mar-25	1377	0
31-Aug-24	2751	31	3-Mar-25	1129	0
1-Sept-24	2751	8.5	4-Mar-25	1423	5
2-Sept-24	3045	0	5-Mar-25	1427	0.5
3-Sept-24	2866	3	6-Mar-25	1343	0
4-Sept-24	2637	0.5	7-Mar-25	1166	0
5-Sept-24	2358	0	8-Mar-25	1274	0

Date	Effluent volume (m^3)	Rainfall (mm/day)	Date (continued)	Effluent volume (m^3)	Rainfall (mm/day)
6-Sept-24	2664	0.5	9-Mar-25	1306	0
7-Sept-24	2675	0.5	10-Mar-25	1424	0
8-Sept-24	2751	3.5	11-Mar-25	1091	0
9-Sept-24	2565	0	12-Mar-25	1315	0.5
10-Sept-24	2187	0	13-Mar-25	1323	0
11-Sept-24	2081	0.5	14-Mar-25	1112	0
12-Sept-24	2559	0	15-Mar-25	1385	0
13-Sept-24	2061	0	16-Mar-25	1305	0
14-Sept-24	1800	5.5	17-Mar-25	1266	4
15-Sept-24	2504	7	18-Mar-25	1435	4
16-Sept-24	2030	5	19-Mar-25	1282	13.5
17-Sept-24	2610	5.5	20-Mar-25	1789	0
18-Sept-24	2051	0	21-Mar-25	1110	0
19-Sept-24	1909	2	22-Mar-25	1238	0
20-Sept-24	2751	23.5	23-Mar-25	1290	0
21-Sept-24	2751	1.5	24-Mar-25	1329	0
22-Sept-24	2751	0	25-Mar-25	1178	0
23-Sept-24	2354	2.5	26-Mar-25	1150	0
24-Sept-24	2587	1.5	27-Mar-25	1386	0
25-Sept-24	2671	0	28-Mar-25	1118	0
26-Sept-24	2735	0	29-Mar-25	1220	0
27-Sept-24	2749	0.5	30-Mar-25	1489	0
28-Sept-24	2038	0	31-Mar-25	1154	0
29-Sept-24	1798	0.5	1-Apr-25	1457	0
30-Sept-24	1682	0	2-Apr-25	1397	1
1-Oct-24	1619	0	3-Apr-25	1327	12
2-Oct-24	1289	22	4-Apr-25	2751	64
3-Oct-24	2997	10	5-Apr-25	2569	0.5
4-Oct-24	2651	0	6-Apr-25	2752	0.5
5-Oct-24	2731	3.5	7-Apr-25	2627	0.5
6-Oct-24	2675	4	8-Apr-25	2745	15
7-Oct-24	2660	3	9-Apr-25	2521	0
8-Oct-24	2325	0	10-Apr-25	1741	0
9-Oct-24	2306	6.5	11-Apr-25	1173	0

Date	Effluent volume (m^3)	Rainfall (mm/day)	Date (continued)	Effluent volume (m^3)	Rainfall (mm/day)
10-Oct-24	2183	11	12-Apr-25	1814	0
11-Oct-24	2026	0	13-Apr-25	1374	0
12-Oct-24	2186	0	14-Apr-25	1105	0
13-Oct-24	2246	2.5	15-Apr-25	1287	0
14-Oct-24	1981	2.5	16-Apr-25	1501	3
15-Oct-24	1652	0	17-Apr-25	1801	11
16-Oct-24	1710	0	18-Apr-25	2102	12.5
17-Oct-24	1510	0	19-Apr-25	2644	8.5
18-Oct-24	1898	0	20-Apr-25	2065	4
19-Oct-24	1898	0	21-Apr-25	1576	0.5
20-Oct-24	1751	0	22-Apr-25	1497	0.5
21-Oct-24	1642	0	23-Apr-25	1831	0
22-Oct-24	1672	0	24-Apr-25	1524	0
23-Oct-24	1550	0	25-Apr-25	1365	0
24-Oct-24	1624	0	26-Apr-25	1821	1
25-Oct-24	1299	0	27-Apr-25	2016	20.5
26-Oct-24	1681	12	28-Apr-25	2381	0.5
27-Oct-24	1769	1.5	29-Apr-25	2622	11
28-Oct-24	1888	4	30-Apr-25	2739	8
29-Oct-24	1537	1.5	1-May-25	2491	5.5
30-Oct-24	1436	4	2-May-25	2712	8
31-Oct-24	1642	0	3-May-25	2683	0
1-Nov-24	1856	0	4-May-25	2632	0
2-Nov-24	1704	0	5-May-25	2652	0
3-Nov-24	1782	0	6-May-25	2752	0
4-Nov-24	1547	0	7-May-25	2341	0
5-Nov-24	1397	0	8-May-25	1444	5
6-Nov-24	1560	0	9-May-25	2198	22
7-Nov-24	1402	0	10-May-25	2668	0
8-Nov-24	1668	0	11-May-25	2653	0.5
9-Nov-24	1720	0	12-May-25	2681	0
10-Nov-24	1642	0.5	13-May-25	2752	0.5
11-Nov-24	1646	1.5	14-May-25	2343	0
12-Nov-24	1337	0	15-May-25	1673	0.5

Date	Effluent volume (m^3)	Rainfall (mm/day)	Date (continued)	Effluent volume (m^3)	Rainfall (mm/day)
13-Nov-24	1264	0	16-May-25	1436	0
14-Nov-24	1567	1.5	17-May-25	1561	0
15-Nov-24	2018	27	18-May-25	1640	8
16-Nov-24	1967	0.5	19-May-25	2113	3
17-Nov-24	1868	2	20-May-25	1629	0
18-Nov-24	1561	0	21-May-25	1341	0.5
19-Nov-24	1538	0	22-May-25	1867	0
20-Nov-24	1670	3.5	23-May-25	1364	0
21-Nov-24	1990	7	24-May-25	1503	0
22-Nov-24	2266	0	25-May-25	490	0
23-Nov-24	1556	0	26-May-25	1388	44.5
24-Nov-24	1671	0	27-May-25	2717	16
25-Nov-24	1407	0	28-May-25	3363	10
26-Nov-24	1442	0.5	29-May-25	3741	1.5
27-Nov-24	1595	0.5	30-May-25	3197	0.5
28-Nov-24	1601	0	31-May-25	2801	0
29-Nov-24	2293	0	1-Jun-25	2890	0
30-Nov-24	1874	18.5	2-Jun-25	2416	2
1-Dec-24	1978	2.5	3-Jun-25	2547	0
2-Dec-24	1608	0	4-Jun-25	3991	40
3-Dec-24	1641	0	5-Jun-25	4588	2
4-Dec-24	1521	0	6-Jun-25	3830	10
5-Dec-24	1451	0.5	7-Jun-25	3612	0.5
6-Dec-24	1311	0	8-Jun-25	2739	3.5
7-Dec-24	1446	0	9-Jun-25	3605	14
8-Dec-24	1499	0	10-Jun-25	3438	26
9-Dec-24	1438	12.5	11-Jun-25	3744	0
10-Dec-24	1959	2.5	12-Jun-25	3183	4.5
11-Dec-24	1732	18.5	13-Jun-25	3671	3
12-Dec-24	2143	5	14-Jun-25	3694	3.5
13-Dec-24	1989	2.5	15-Jun-25	3631	1.5
14-Dec-24	1899	0	16-Jun-25	3722	0
15-Dec-24	1806	0	17-Jun-25	3150	0
16-Dec-24	1976	14	18-Jun-25	3666	0

Date	Effluent volume (m³)	Rainfall (mm/day)	Date (continued)	Effluent volume (m³)	Rainfall (mm/day)
17-Dec-24	2087	0	19-Jun-25	3753	1
18-Dec-24	1969	0	20-Jun-25	2752	5
19-Dec-24	1574	0	21-Jun-25	2687	0
20-Dec-24	1552	0	22-Jun-25	2687	0.5
21-Dec-24	1551	0	23-Jun-25	2510	0.5
22-Dec-24	1564	0	24-Jun-25	2713	0.5
23-Dec-24	1505	1.5	25-Jun-25	2635	0
24-Dec-24	1578	0	26-Jun-25	1938	1
25-Dec-24	1385	2.5	27-Jun-25	2279	60.5
26-Dec-24	1787	9.5	28-Jun-25	2751	8.5
27-Dec-24	2045	0	29-Jun-25	2751	2.5
28-Dec-24	1530	0	30-Jun-25	2510	1
29-Dec-24	1255	0			
30-Dec-24	1185	0			
31-Dec-24	1300	1.5			

WWTP effluent monitoring

Date	E. coli	F. coliforms	cBOD	NO_3-N	NO_x-N	DRP	pH	NH_3-N	TSS
	cfu/100mL	cfu/100mL	mg O_2/L	mg/L	mg/L	mg/L		mg/L N	mg/L
3-Jul-24	3.3	1.6	0.89	5.73	5.90	0.108	6.70	0.03	4.40
10-Jul-24	1.6	1.6	1.20	5.85	5.80	0.073	6.70	0.03	8.40
17-Jul-24	1.6	1.6	1.30	5.40	5.40	0.075	6.70	0.03	1.40
24-Jul-24	1.6	3.3	1.40	5.20	5.40	0.207	6.90	0.02	4.80
30-Jul-24	6.6	8.2	2.10	5.10	5.40	0.142	6.70	0.05	11.00
31-Jul-24	1.6	4.9	1.30	5.50	5.50	0.090	6.70	0.02	7.00
7-Aug-24	1.6	1.6	1.50	5.80	5.80	0.139	6.70	0.03	10.00
16-Aug-24	1.6	1.6	2.90	4.50	4.60	1.320	7.70	8.83	11.00
21-Aug-24	1.7	1.7	1.20	5.70	5.70	0.153	6.60	0.03	8.20
28-Aug-24	1.6	1.6	1.20	5.40	5.40	0.142	6.70	0.03	5.60
2-Sept-24	1.6	1.6	1.70	5.30	5.60	0.666	6.70	0.23	4.80
4-Sept-24	1.6	1.6	0.73	5.70	5.70	0.451	6.70	0.03	5.20
11-Sept-24	1.6	1.6	0.97	5.50	5.60	0.218	6.80	0.88	1.40
18-Sept-24	1.6	1.6	1.70	6.00	6.00	0.274	6.60	0.03	8.20
25-Sept-24	1.7	1.7	1.30	5.40	5.40	0.190	6.70	0.03	2.40
2-Oct-24	1.6	1.6	1.30	4.50	4.50	0.083	6.80	0.03	3.00
9-Oct-24	1.6	1.6	0.82	4.40	4.40	0.187	6.80	0.02	1.60
16-Oct-24	1.6	1.6	1.00	4.80	4.80	0.202	6.80	0.03	3.60
23-Oct-24	1.6	1.6	1.30	6.40	6.40	0.408	6.70	0.03	6.00
30-Oct-24	1.6	1.6	1.60	6.30	6.30	0.697	7.00	0.03	3.80
6-Nov-24	1.7	3.3	1.80	6.50	6.50	0.495	6.90	0.03	3.40
13-Nov-24	1.6	1.6	1.40	6.50	6.50	0.586	7.00	0.03	5.40
20-Nov-24	1.6	1.6	1.00	1.66	1.70	0.451	7.00	0.02	2.20
27-Nov-24	1.6	1.6	0.73	5.90	5.90	0.432	6.90	0.02	1.00
4-Dec-24	1.6	1.6	0.97	6.02	6.00	0.639	6.80	0.03	1.20
11-Dec-24	3.3	6.6	2.60	5.73	5.80	0.391	6.90	0.03	3.20
18-Dec-24	1.6	1.6	1.40	6.01	6.10	0.354	6.80	0.03	1.00
24-Dec-24	1.6	1.6	0.85	6.16	6.20	0.136	7.10	0.03	3.60
31-Dec-24	1.6	1.6	1.30	6.20	6.20	0.860	7.30	0.04	4.20
8-Jan-25	1.60	3.30	1.40	5.87	5.90	0.667	7.00	0.05	7.20
15-Jan-25	4.90	6.60	0.92	6.83	6.80	0.619	7.00	0.03	8.20
22-Jan-25	1.60	6.60	1.00	6.56	6.70	0.539	6.90	0.03	12.00
29-Jan-25	1.60	1.60	0.52	6.38	6.40	0.134	7.00	0.03	1.00
5-Feb-25	4.90	1.60	0.77	6.39	6.60	0.244	6.90	0.04	7.20
12-Feb-25	8.20	18.00	0.91	5.80	6.60	0.587	7.00	0.08	7.00

19-Feb-25	1.60	1.60	-	5.52	-	0.484	6.90	0.07	7.40
26-Feb-25	3.30	6.60	0.85	5.79	6.20	0.569	6.90	0.06	4.40
5-Mar-25	11.00	23.00	1.60	5.67	5.70	0.440	7.00	0.05	5.80
6-Mar-25	4.90	4.90	0.62	5.43	5.40	0.564	7.20	0.06	3.60
12-Mar-25	4.90	1.60	0.79	6.92	6.90	0.397	6.80	0.04	7.60
19-Mar-25	1.60	3.30	1.30	6.92	7.30	0.428	7.10	0.05	5.60
26-Mar-25	1.60	8.20	0.68	7.07	7.20	0.259	7.00	0.04	3.20
2-Apr-25	1.60	1.60	0.65	8.57	8.60	0.242	7.00	0.05	1.10
9-Apr-25	1.60	1.60	1.10	6.23	7.20	0.410	6.90	0.05	3.10
16-Apr-25	3.30	4.90	1.50	6.73	6.80	0.111	7.00	0.03	11.00
23-Apr-25	1.60	4.90	0.61	6.47	6.90	0.158	6.90	0.05	1.00
30-Apr-25	1.60	1.60	0.95	3.62	6.10	0.781	7.20	0.05	6.80
7-May-25	1.60	1.60	1.00	5.98	6.60	0.101	6.60	0.03	3.80
14-May-25	6.60	8.20	0.99	6.93	6.90	0.080	6.50	0.02	5.60
21-May-25	1.70	1.70	1.00	5.40	7.00	0.122	6.80	0.10	1.40
28-May-25	1.6	1.6	-	5.71	-	0.131	6.70	0.16	6.40
30-May-25	1.6	1.6	1.60	6.08	6.10	0.083	6.60	0.14	12.00
1-Jun-25	1.6	1.6	1.50	5.53	5.70	0.139	6.80	0.08	6.90
4-Jun-25	1.6	1.6	1.40	4.99	5.90	0.093	6.80	0.12	5.60
5-Jun-25	1.7	1.70	1.40	5.12	5.80	0.287	6.70	0.18	5.80
6-Jun-25	1.6	6.60	1.30	5.52	6.30	0.316	6.60	0.09	2.60
11-Jun-25	1.6	3.3	1.00	5.41	6.10	0.201	6.60	0.07	2.20
14-Jun-25	1.6	1.6	-	-	-	-	-	-	-
15-Jun-25	1.6	1.6	1.20	5.37	5.90	0.390	7.00	0.42	1.00
17-Jun-25	1.7	1.6	-	-	-	-	-	-	-
18-Jun-25	1.6	1.6	0.70	5.11	5.60	0.186	6.80	0.18	2.80
25-Jun-25	1.6	1.6	1.90	5.05	5.70	0.178	6.70	0.23	1.00

Farm pond monitoring

Date	NO_2-N mg/L	NO_3-N mg/L N	NO_X-N mg/L	DRP mg/L	TKN mg/L N	NH_3-N mg/L	Tot-P mg/L	TSS mg/L
2-Jul-24	-	-	-	0.155	-	0.095	0.194	8.4
3-Jul-24	0.02	4.18	4.2	0.15	0.947	0.112	0.212	3.8
7-Jul-24	-	-	-	0.015	-	0.079	0.22	5.6
8-Jul-24	-	-	-	0.174	-	0.15	0.252	5.6
10-Jul-24	0.02	4.19	4.2	0.144	0.955	0.4	0.196	3.6
13-Jul-24	-	-	-	0.132	-	0.084	0.203	4
15-Jul-24	-	-	-	0.097	-	0.065	0.202	7.8
17-Jul-24	0.02	3.6	3.6	0.147	1.49	0.4	0.268	4.6
21-Jul-24	-	-	-	0.191	-	0.091	0.368	20
22-Jul-24	-	-	-	0.205	-	0.088	0.334	14
24-Jul-24	0.08	3.9	4	0.208	0.976	0.4	0.341	8
27-Jul-24	-	-	-	0.171	-	0.143	0.273	3.4
29-Jul-24	-	-	-	0.137	-	0.12	0.268	6.4
31-Jul-24	0.04	3.8	3.9	0.169	1.03	0.098	0.347	12
4-Aug-24	-	-	-	0.194	-	0.195	0.321	6.4
5-Aug-24	-	-	-	0.169	-	0.226	0.292	11
7-Aug-24	0.02	4.1	4.1	0.147	1.08	0.141	0.432	15
10-Aug-24	-	-	-	0.131	-	0.123	0.215	5.8
12-Aug-24	-	-	-	0.176	-	0.109	0.291	13
14-Aug-24	0.02	3.9	3.9	0.157	0.997	0.129	0.265	7
18-Aug-24	-	-	-	0.26	-	0.938	0.424	15
19-Aug-24	-	-	-	0.259	-	0.387	0.426	9.7
21-Aug-24	0.04	3.6	3.7	0.335	1.11	0.244	0.471	3.4
24-Aug-24	-	-	-	0.231	-	0.166	0.345	9
26-Aug-24	-	-	-	0.211	-	0.19	0.39	19
28-Aug-24	0.02	3.9	3.9	0.178	1.41	0.4	0.331	14
1-Sept-24	-	-	-	0.198	-	0.18	0.356	69
2-Sept-24	-	-	-	0.227	-	0.21	0.398	33
4-Sept-24	0.04	3.4	3.4	0.328	1.15	0.24	0.409	11
7-Sept-24	-	-	-	0.218	-	0.16	0.339	7.6
9-Sept-24	-	-	-	0.202	-	0.29	0.346	7.4
11-Sept-24	0.02	3.7	3.7	0.231	1.01	0.17	0.387	7.8
15-Sept-24	-	-	-	0.199	-	0.19	0.302	9.6
16-Sept-24	-	-	-	0.221	-	0.17	0.343	2.4
18-Sept-24	0.02	3.6	3.6	0.229	1.18	0.16	0.328	4.6
21-Sept-24	-	-	-	0.275	-	0.14	0.393	12
23-Sept-24	-	-	-	0.25	-	0.17	0.608	160
25-Sept-24	0.02	3.7	3.7	0.22	0.954	0.14	0.284	4.4
29-Sept-24	-	-	-	0.177	-	0.12	0.544	4.4
30-Sept-24	-	-	-	0.137	-	0.13	-	9
1-Oct-24	-	-	-	0.137	-	0.13	0.264	9

Date	NO_2-N mg/L	NO_3-N mg/L N	NO_X-N mg/L	DRP mg/L	TKN mg/L N	NH_3-N mg/L	Tot-P mg/L	TSS mg/L
2-Oct-24	0.02	3.2	3.2	0.135	0.978	0.13	0.246	12
5-Oct-24	-	-	-	0.144	-	0.16	0.217	7.2
7-Oct-24	-	-	-	0.166	-	0.12	0.234	6.4
9-Oct-24	0.02	2.9	2.9	0.161	0.861	0.12	0.216	4
13-Oct-24	-	-	-	0.143	-	0.091	0.233	5
16-Oct-24	0.02	2.7	2.7	0.164	0.885	0.1	0.25	4.6
19-Oct-24	-	-	-	0.158	-	0.083	0.23	7.2
23-Oct-24	0.02	3.8	3.8	0.165	0.943	0.1	0.238	6
27-Oct-24	-	-	-	0.25	-	0.092	0.326	4.2
30-Oct-24	0.02	3.6	3.6	0.305	0.929	0.12	0.37	6
2-Nov-24	-	-	-	0.322	-	0.1	0.536	4.8
6-Nov-24	0.02	3.5	3.5	0.271	0.98	0.09	0.378	10
10-Nov-24	-	-	-	0.486	-	0.092	0.667	1.6
13-Nov-24	0.02	3.2	3.2	0.449	0.965	0.09	0.541	10
16-Nov-24	-	-	-	0.456	-	0.25	0.549	5.4
20-Nov-24	0.02	3.27	3.3	0.324	0.916	0.087	0.45	46
24-Nov-24	-	-	-	0.294	-	0.051	0.327	5.6
27-Nov-24	0.02	3.16	3.2	0.289	0.859	0.094	0.409	12
30-Nov-24	-	-	-	0.524	-	0.1	0.599	5.8
4-Dec-24	0.12	2.9	3	0.619	1.36	0.22	0.846	12
8-Dec-24	-	-	-	0.461	-	0.17	0.526	24.6
11-Dec-24	0.02	2.33	2.4	0.392	1.31	0.26	0.464	4.8
14-Dec-24	-	-	-	0.38	-	0.19	0.462	7
18-Dec-24	0.02	2.84	2.8	0.346	1	0.29	0.491	1.8
22-Dec-24	-	-	-	0.229	-	0.069	0.293	11
24-Dec-24	0.02	3.18	3.2	0.201	0.729	0.087	0.265	6.6
28-Dec-24	-	-	-	0.235	-	0.36	0.39	8.2
31-Dec-24	0.02	3.45	3.5	0.251	1.1	0.17	0.356	2.4
5-Jan-25	-	-	-	0.502	-	0.23	0.605	11
8-Jan-25	0.02	2.95	2.9	0.448	1.16	0.22	0.486	9.2
11-Jan-25	-	-	-	0.422	-	0.43	0.522	9.2
15-Jan-25	0.02	3.3	3.3	0.428	1.03	0.14	0.512	5.6
19-Jan-25	-	-	-	0.381	-	0.14	0.54	6.4
22-Jan-25	0.02	3.03	3	0.28	0.887	0.17	0.385	13
25-Jan-25	-	-	-	0.255	-	0.099	0.379	14
29-Jan-25	0.04	3.57	3.6	0.268	1.06	0.089	0.385	4.2
2-Feb-25	-	-	-	0.29	-	0.069	0.329	4.4
5-Feb-25	0.02	3.15	3.1	0.249	1.03	0.12	0.393	8.8
8-Feb-25	-	-	-	0.258	-	0.072	0.377	11
12-Feb-25	0.02	4	4	0.316	0.866	0.079	0.38	9
16-Feb-25	-	-	-	0.472	-	0.1	0.51	5
19-Feb-25	0.03	4.2	4.2	0.496	1.03	0.12	0.58	14

Date	NO_2-N mg/L	NO_3-N mg/L N	NO_X-N mg/L	DRP mg/L	TKN mg/L N	NH_3-N mg/L	Tot-P mg/L	TSS mg/L
22-Feb-25	-	-	-	0.47	-	0.076	0.634	17
26-Feb-25	0.02	3.01	3	0.418	2.07	0.046	0.744	30.8
2-Mar-25	-	-	-	0.464	-	0.03	0.644	27
5-Mar-25	0.02	2.81	2.8	0.502	1.5	0.42	0.642	13
8-Mar-25	-	-	-	0.477	-	0.16	0.55	8.8
12-Mar-25	0.02	4.47	4.5	0.348	1.15	0.12	0.51	19
16-Mar-25	-	-	-	0.322	-	0.027	0.436	20.6
19-Mar-25	0.02	3.75	3.8	0.336	1.66	0.042	0.575	23.2
22-Mar-25	-	-	-	0.386	-	0.025	0.543	16
26-Mar-25	0.02	3.7	3.7	0.276	1.48	0.028	0.423	18
30-Mar-25	-	-	-	0.42	-	0.19	0.528	10
2-Apr-25	0.02	4.49	4.5	0.375	1.16	0.12	0.513	8.8
9-Apr-25	0.09	4.8	4.9	0.565	1.25	0.3	0.626	5.2
16-Apr-25	0.02	5.69	5.7	0.316	1.37	0.097	0.423	9.2
23-Apr-25	0.02	4.35	4.3	0.276	0.917	0.086	0.373	3.6
30-Apr-25	0.04	4.43	4.5	0.347	1.1	0.11	0.429	5
7-May-25	0.1	4.95	5	0.283	0.874	0.049	0.355	3.8
14-May-25	0.02	4.67	4.7	0.195	0.9	0.059	0.328	6.8
21-May-25	0.02	4.42	4.4	0.194	0.76	0.045	0.261	1
28-May-25	0.13	2.06	2.2	0.178	1.3	0.23	0.316	23.8
4-Jun-25	0.12	4.4	4.5	0.194	0.71	0.094	0.31	6.8
11-Jun-25	0.11	2.38	2.5	0.14	1	0.094	0.257	32.6
18-Jun-25	0.08	4.14	4.2	0.232	0.76	0.13	0.279	5.2
25-Jun-25	0.05	4.04	4.1	0.199	0.84	0.066	0.24	3.8
22-Apr-24	-	-	-	0.433	-	0.146	0.472	9
24-Apr-24	0.3	2.75	3.1	0.368	1.12	0.4	0.457	14
28-Apr-24	-	-	-	0.37	-	0.099	0.409	2.8
29-Apr-24	-	-	-	0.282	-	0.083	0.373	7.6
1-May-24	0.02	2.47	2.5	0.208	0.759	0.089	0.288	3.6
4-May-24	-	-	-	0.157	-	0.096	0.215	10
6-May-24	-	-	-	0.135	-	0.075	0.296	12.4
8-May-24	0.02	2.03	2	0.164	0.844	0.099	0.27	8
12-May-24	-	-	-	0.095	-	0.081	0.153	10
13-May-24	-	-	-	0.091	-	0.064	0.176	9.2
15-May-24	0.02	2.02	2	0.093	0.915	0.101	0.217	13
18-May-24	-	-	-	0.138	-	0.115	0.19	1
20-May-24	-	-	-	0.131	-	0.105	0.217	6.4
22-May-24	0.02	2.88	2.9	0.162	0.969	0.4	0.289	7.6
26-May-24	-	-	-	0.214	-	0.144	0.285	3.2
27-May-24	-	-	-	0.168	-	0.124	0.226	6.4
29-May-24	0.02	2.28	2.3	0.168	0.771	0.131	0.238	5.6
1-Jun-24	-	-	-	0.364	-	0.099	0.502	4

Date	NO_2-N mg/L	NO_3-N mg/L N	NO_X-N mg/L	DRP mg/L	TKN mg/L N	NH_3-N mg/L	Tot-P mg/L	TSS mg/L
4-Jun-24	-	-	-	0.18	-	0.125	0.24	5
5-Jun-24	0.02	2.65	2.7	0.156	0.859	0.4	0.239	7.2
9-Jun-24	-	-	-	0.135	-	0.162	0.222	8
10-Jun-24	-	-	-	0.211	-	0.123	0.304	9.8
12-Jun-24	0.02	3.36	3.4	0.193	1.1	0.216	0.273	6.2
15-Jun-24	-	-	-	0.259	-	0.138	0.361	11
17-Jun-24	-	-	-	0.238	-	0.103	0.366	27.6
19-Jun-24	0.45	3.91	4.4	0.309	0.962	0.4	0.443	6.6
23-Jun-24	-	-	-	0.165	-	0.072	0.261	26
24-Jun-24	-	-	-	0.177	-	0.086	0.312	11
26-Jun-24	0.04	4.36	4.4	0.184	1.65	0.4	0.29	8.4
29-Jun-24	-	-	-	0.164	-	0.1	0.221	4.4

Appendix B. Receiving environment monitoring report

Bioresearches
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Water Quality and Biological Assessment, Te Puru Stream Tributary, Beachlands
August 2025

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Water Quality and Biological Assessment, Te Puru Stream Tributary, Beachlands August 2025

DOCUMENT APPROVAL

Document title:	Water Quality and Biological Assessment, Te Puru Stream Tributary, Beachlands
Prepared for:	Watercare Services Limited
Version:	V2
Date:	26 August 2025
Document name:	68084 Te Puru Tributary Monitoring 250825

Authors:	Christel du Preez M.Sc. (Hons) Freshwater Ecologist
Reviewer	Treffery Barnett M.Sc. (Hons), MEIANZ Technical Director, Freshwater Senior Coastal & Freshwater Ecologist

Reference: Bioresearches (2025). Water Quality and Biological Assessment, Te Puru Stream Tributary, Beachlands. Report for Watercare Services Limited. pp 91

Cover Illustration: Site C, Farm Pond Tributary of the Te Puru Stream, Beachlands (31 January 2024)

CONTENTS

EXECUTIVE SUMMARY

A survey of the upper Te Puru Stream catchment was undertaken on behalf of Watercare Services Limited (Watercare) to provide a comparative study of water quality and biological condition upstream and downstream of the Beachlands wastewater treatment plant (WWTP) discharge point. This report presents the results of the water quality and biological survey undertaken at ten sites over the period 31st of March, and 1st and 2nd of April 2025, to determine the effects of the existing discharge of highly treated effluent from the treatment facility on the water quality and biology of the receiving waters.

Overall, the water quality and biological health of the Te Puru Stream tributaries were generally indicative of poor freshwater conditions, a status partly attributed to the pastoral land use dominating the surrounding catchment. Consistent trends observed across multiple monitoring surveys show that water quality and biological parameters were often at their poorest at sites immediately downstream of the discharge pond.

In terms of water quality:

- Conductivity levels were consistently very high at all effect sites, indicating a very high concentration of dissolved ions downstream of the WWTP. Even a reference site showed a substantial increase in conductivity between 2024 and 2025, suggesting background enrichment. All sites generally exceeded guideline values.
- pH values across all sites remained within guideline ranges, indicating circum-neutral conditions that are not a stressor to aquatic biota.
- Carbonaceous biochemical oxygen demand ($cBOD_5$) was consistently low across all sites, often below detection limits, indicating an absence of significant organic pollution and a low risk of sewage fungus proliferation.
- Total Suspended Solids (TSS) varied considerably, with the highest concentration recorded at a reference site during 2025, indicating a likely localised disturbance or runoff. Most sites, except those with undetectable TSS, exceeded guidelines.
- Bioavailable nutrients, including nitrogen and phosphorus compounds, were notably elevated below the discharge point.
- Total nitrogen concentrations at effect sites consistently exceeded the site-specific guideline, remaining substantially higher than reference sites, and this marks the first time that sites further downstream also exceeded this guideline.
- Similarly, total phosphorus and dissolved reactive phosphorus (DRP) levels consistently exceeded guidelines at almost all sites, including reference sites, and all effect sites surpassed the national bottom line threshold.
- Ammonia concentrations, while elevated below the discharge, remained consistently below site-specific toxicity guidelines for the Te Puru Stream during all monitoring events, showing a low risk of toxicity from ammoniacal nitrogen.
- Dissolved oxygen concentrations were generally within 'good' stream health categories, with all sites exceeding the national bottom line.

High bacterial indicator levels (faecal coliforms and enterococci) were found both above and below the discharge pond. All sites exceeded guidelines. This lack of a clear spatial trend suggests that the source of contamination is not limited to the farm pond discharge, but rather from widespread faecal inputs from livestock grazing and water birds within the pastoral catchment.

Macroinvertebrate communities were generally indicative of fair/good quality habitat at reference sites and poor/fair quality habitat across effect sites. The site closest to the discharge recorded the lowest scores for all indices since 2019, ranking as 'poor' for both MCI and SQMCI. Sensitive macroinvertebrate taxa tended to be absent from effect sites immediately downstream, though some improvements were observed at the most downstream sites, indicating localised adverse effects from the discharge on macroinvertebrate communities.

Fish communities appeared to be influenced by the discharge, with reduced native species diversity and abundance observed immediately downstream of the discharge pond. However, further downstream, fish diversity and IBI scores were comparable to reference sites, achieving 'Very Good' ratings. Juvenile eels and banded kōkopu were recorded in the upstream reference site, confirming their ability to migrate upstream past the discharge point.

Macrophytes and algae generally increased in cover and diversity downstream of the discharge, dominated by Nitella and filamentous algae. This increase reflects both reduced riparian vegetation and shading, as well as higher levels of bioavailable nutrients at the effect sites.

Overall, comparison with the results of previous surveys since 2002 shows that water quality and ecological conditions in the upper Te Puru Stream tributaries were broadly similar to past findings. While some parameters showed recovery with increasing distance downstream, others, such as conductivity and nutrients, remained elevated even at the lowest monitoring sites. The survey results indicate that the wastewater treatment plant discharge influences the quality of the habitat of the Te Puru Stream Tributary for a distance of at least 200 m downstream of the farm pond, with some water quality parameters such as conductivity and bioavailable nutrients affected for a greater distance. Fish populations, sensitive macroinvertebrates, and filamentous algae also appeared to be affected for some distance downstream of the discharge, although eels and banded kōkopu were able to migrate upstream past the discharge.

1. INTRODUCTION

Watercare operates the wastewater treatment plant (WWTP) at Beachlands, Auckland, and regular monitoring of the effects of the discharge on water quality and stream biology is required. The WWTP discharges highly treated effluent through pipes and then through a trickle system through a vegetated area, then into a large farm pond, which discharges to a tributary of the Te Puru Stream in Beachlands.

This water quality and biological assessment of selected Te Puru Stream tributaries is a repeat of the water quality and biological surveys carried out for Manukau Water in 1997, 1999, 2002 and 2010, and for Watercare in 2016, 2019, 2022 and 2024[1] (Bioresearches 1997, 1999, 2002, 2010, 2016, 2019, 2022 and 2024).

The Te Puru Stream is located in the Beachlands area, near the east coast, south of Auckland. The stream is approximately four kilometres long and flows through moderately steep pastoral land before discharging into the ocean at Kelly's Beach. The highly treated effluent from the WWTP is discharged into a farm pond on a tributary of the Te Puru Stream located approximately 4.5 km inland from the stream mouth.

Analysing water and sediment quality can give an indication of the presence and extent of nutrient enrichment/contaminants from influences such as wastewater discharges, urban areas and pastoral land use. Parameters such as nitrogen and phosphorous compounds and bacteria are often measured when analysing water and sediment quality. The biological characteristics of stream ecosystems can give indications of stream health and the effects that factors such as a wastewater discharge may have on freshwater communities.

Sampling was undertaken in two main tributaries adjacent to Okaroro Road, referred to as the Reference Tributary and Te Puru Stream Tributary. A side tributary of the main tributary, which included the farm pond into which the treated wastewater is held for final polishing, was referred to as the Farm Pond Tributary (Figure 1).

Water quality samples were taken at seven sites from the two tributaries, including three reference sites, and sediment quality samples were taken at four sites. Biological samples included fish and macroinvertebrates, taken from six sites, and macrophytes, which were evaluated at eight sites. Site names and locations correspond to those used in previous Te Puru Stream monitoring surveys (Bioresearches 1997, 1999, 2002, 2010, 2016, 2019, 2022 and 2024). This report presents the results of the water quality and biological assessments carried out on the 31st of March, 1st and 2nd of April 2025.

[1] The 2024 monitoring occasion was an exception to the regular monitoring programme as it was carried out only two years after the 2022 monitoring to inform Watercare's application to Auckland Council to renew its current discharge consent.

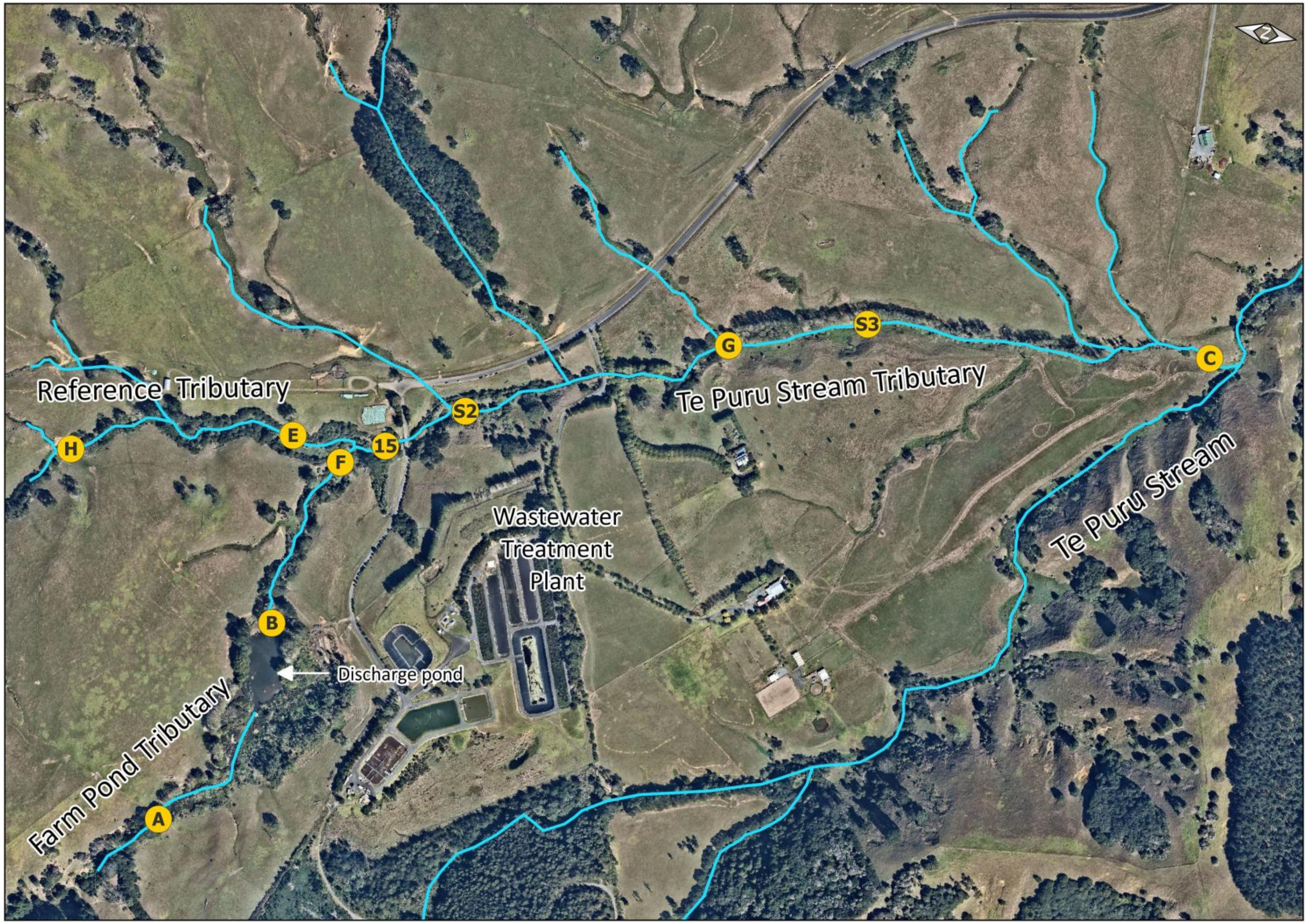

Figure 1. Sampling site locations in Te Puru Stream tributaries, with blue lines indicating the Reference Tributary, Farm Pond Tributary, and Te Puru Stream Tributary, and yellow circles showing site locations, alongside the wastewater treatment plant.

2. METHODOLOGY

2.1 Site Locations

Locations of sampling sites for the water quality and biological surveys were the same as in the previous monitoring surveys (Table 1 and Table 2).

Table 1. Sampling site locations.

Site	Description	Tributary	Location (NZTM)
A	Reference site, upstream of the farm pond.	Farm Pond Tributary	E1781181.11 N5912504.77
B	Effect site, immediately downstream of the farm pond discharge.	Farm Pond Tributary	E1780823.81 N5912650.06
F	Effect site, approximately 200m downstream of the farm pond and immediately upstream of the Te Puru Stream Tributary confluence.	Farm Pond Tributary	E1780640.75 N5912676.69
H	Reference site, upstream of E in the headwaters of the Reference Tributary	Reference Tributary	E1780642.45 N5912324.68
E	Reference site, downstream of H and just upstream of the confluence with the Farm Pond Tributary, Te Puru Stream Tributary	Reference Tributary	E1780549.89 N5912604.50
15	Effect site, immediately downstream of the confluence of the of the Farm Pond Tributary and the Reference Tributary	Te Puru Stream Tributary	E1780548.57 N5912764.51
S2	Effect site, approximately 200m downstream of the Farm Pond Tributary and Reference Tributary confluence, within replanted area.	Te Puru Stream Tributary	E1780445.25 N5912920.30
G	Effect site, approximately 600m downstream of the Farm Pond Tributary and Reference Tributary confluence.	Te Puru Stream Tributary	E1780300.63 N5913226.02
S3	Effect site, approximately 800m downstream of the Farm Pond Tributary and Reference Tributary confluence.	Te Puru Stream Tributary	E1780236.26 N5913406.90
C	Effect site, approximately 100m upstream of the confluence with the mainstem Te Puru Stream	Te Puru Stream Tributary	E1780186.32 N5913871.81

Table 2. Sample types taken at each site.

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

2.2 Water and Sediment Quality

Water quality sampling was undertaken on the 31st of March 2025, after a period of settled weather and under late summer low-flow conditions. Water samples were collected from Sites A, B, C, E, F, G & 15 (Figure 1). The water samples were chilled and delivered to the laboratory (Hills Laboratories, Hamilton) within 24-29 hours of collection. These samples were analysed for the following parameters:

- Conductivity – the total ionic strength of the water and an indication of nutrient enrichment;
- pH – the concentration of hydrogen ions in the water showing the strength of acid present;
- Total Suspended Solids – suspended particles that are not dissolved in the water;
- Carbonaceous Biochemical Oxygen Demand ($CBOD_5$) – the oxygen used by bacteria for the biochemical degradation of organic matter;
- Chlorophyll-α – a measure of the phytoplankton biomass;
- Total Ammoniacal Nitrogen (NH_4-N) – an indicator of nutrient enrichment, often from point source discharges such as sewage or dairy effluent;
- Total Nitrogen – the sum of all organic and inorganic forms of nitrogen, an indicator of nutrient enrichment;
- Nitrate Nitrogen (NO_3-N) – a common nutrient in urban and rural areas and an indicator of nutrient enrichment;
- Nitrite Nitrogen (NO_2-N) – a less common form of nitrogen and an indicator of nutrient enrichment;
- Total Kjeldahl Nitrogen (TKN) – a measure of nitrogen in the trivalent state (NH_4-N, protein N and non-protein-N), an indicator of nutrient enrichment;
- Dissolved Inorganic Nitrogen (DIN) – a measure of nitrite, nitrate and ammonium, an indicator of nutrient enrichment;
- Total Phosphorus – all phosphorus concentrations (dissolved, solid or bound to sediment), an indicator of nutrient enrichment;
- Dissolved Reactive Phosphorus (DRP) – a measure of the dissolved phosphorus compounds that are readily available for use by plants and algae, an indicator of a waterbody's ability to support algae/plant growth;
- Faecal Coliform Bacteria – predominantly found in the gut of humans and animals, an indicator of faecal contamination; and
- Enterococci – a faecal coliform bacteria species that naturally occurs in the gut of humans and animals (including birds, fish and reptiles), an indicator of faecal contamination.

Spot measurements of basic water quality parameters (temperature, dissolved oxygen and conductivity) were also taken using a Yellow Springs Instrument (YSI) Professional Series meter and water clarity was measured using a turbidity tube at each site.

Water quality results were compared to the Australia and New Zealand Guidelines for Freshwater and Marine Water Quality (ANZECC Guidelines – ANZG 2018, ANZECC and ARMCANZ 2000); the New Zealand National Policy Statement for Freshwater Management (NPS-FM) criteria for protecting aquatic ecosystems, (Ministry for the Environment (MfE) 2020); habitat indicators of stream health from the National Institute of Water and Atmosphere (NIWA) (Hickey 2001, 2014 and Biggs *et al*. 2002); and sewage fungus growth (Quinn 2009). The raw water quality data are presented in Appendix 1.

Composite sediment samples were collected at Sites C, E, F and G on the 31st of March 2025. Six sediment cores (80mm x 100mm) were collected from each site (two from true left bank, two from true right bank, two from centre of tributary) and combined. A representative sub-sample was taken from this composite sample and sent to Hills Laboratories, Hamilton for analyses of the following parameters:

- % Dry Weight – the amount of organic matter in a sample;
- Total Phosphorus – an indicator of nutrient enrichment;
- Total Nitrogen – an indicator of nutrient enrichment and of sources of organic matter input;
- Total Carbon – an indicator of sources of organic matter input;
- Carbon: Nitrogen Ratio – an indicator of the relative sources of organic matter; and
- Ammonium-Nitrogen – an indicator of nutrient enrichment.

Stream velocity measurements were undertaken on the 31st of March and 1st of April 2025 at sites within all three tributaries. The width of the stream was measured, and depth and velocity readings were taken at proportional intervals across a transect – at 10%, 30% 50%, 70% and 90% of the stream width. This enabled flow to be calculated. While a pygmy flow meter was the preferred instrument to take the stream velocity measurements, the high electrical conductivity in the water meant the instrument was unable to perform as required. As such, stream velocity was recorded by measuring the amount of time it took for an object to travel a certain distance. Other limitations with once-off flow measurements include:

- A Lack of temporal variability: A single flow measurement may not capture the temporal variability in flow patterns, which can affect habitat conditions and the distribution of aquatic organisms over time;
- Inadequate representation: Flow measurements taken at a single point at the various sites in time may not adequately represent the range of flow conditions experienced by aquatic organisms throughout different seasons or hydrological events (high flows, low flows etc.);
- Inaccuracy in habitat assessment: Flow data collected at a single time point may not accurately reflect the range of habitats available to aquatic organisms, particularly if flow conditions vary significantly over the various seasons;
- Without multiple flow measurements over time and during various flow conditions, it is challenging to assess long-term trends in flow patterns and its effects on aquatic ecosystems;
- Without repeated flow measurements, it is difficult to develop a comprehensive understanding of the relationships between flow dynamics and ecological responses in the Te Puru stream and tributaries; and
- Limited ability to evaluate management interventions: Single flow measurements may not provide sufficient data to evaluate the effectiveness of management interventions aimed at mitigating the impacts of altered flow regimes on aquatic ecosystems.

2.3 Biological Surveys

Biological assessments were undertaken on the 31st of March, and 1st and 2nd of April 2025. Six sites were sampled for macroinvertebrates and fish, and macrophytes were sampled at eight sites (Figure 1 and Table 2).

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 'C1: hard-bottomed, semi-quantitative' where the majority of the substrate was hard bottomed (Sites H and E), and protocol 'C2: soft-bottomed, semi-quantitative' where the site was predominantly soft bottomed (Sites A, F, G and C). 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.

Several biotic indices were calculated, namely the number of taxa, the number and percentage of Ephemeroptera (mayflies); Plecoptera (stoneflies) and Trichoptera (caddisflies) recorded in a sample (%EPT), the Macroinvertebrate Community Index (MCI) and the Semi-Quantitative Macroinvertebrate Community Index (SQMCI) (Stark & Maxted, 2007a). EPT are three orders of insects that are generally sensitive to organic or nutrient enrichment but exclude *Oxyethira* and *Paroxyethira* as these taxa are not sensitive and can proliferate in degraded habitats. The MCI and SQMCI are based on the average sensitivity score for individual taxa recorded within a sample; although the SQMCI is calculated using coded abundances instead of actual scores. The raw macroinvertebrate data are presented in Appendix 2. For the MCI and SQMCI, respectively, scores of:

- ≥ 120 and ≥ 6.0 are indicative of excellent habitat quality,
- 100 – 119 and 5.0 – 5.9 are indicative of good habitat quality,
- 80 – 99 and 4.0 – 4.9 are indicative of fair habitat quality and
- < 80 and < 4.0 are indicative of poor habitat quality (Stark & Maxted, 2007b).

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 3). 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 3. 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 Te Puru catchment

Fish communities can be good indicators of stream ecosystem health. Freshwater fish were sampled in line with the New Zealand Freshwater Fish Sampling Protocols (Joy *et al.* 2013) using one fyke net and two Gee's minnow traps (all unbaited) every 25 m over the sample reach[2], which were deployed overnight at each site. Electric fishing was also intended to be carried out at each site using an electric fishing machine (EFM) 300 backpack. Electric fishing was only effective at Site A and H as the high conductivity at sites downstream of the pond prevented effective operation of the machine. The electric fishing machine temporarily stuns the fish, allowing them to be captured. All fish captured were identified and counted, and their size estimated before being returned to their habitats. A Fish Index of Biotic Integrity (IBI) for the Auckland Region was calculated for each site based on fish species present, altitude and distance inland (Joy and Henderson 2004). New Zealand Freshwater Fish Database (NZFFD, NIWA) forms were completed for each site. The raw freshwater fish data are presented in Appendix 3.

At each site the percentage cover (proportion of the total line width impinged) of algae and/or macrophytes was recorded along twelve random replicate transects which ran from bank to bank. Transect locations were determined using a random number table. From the centre of the site, six transects were completed in an upstream direction at random intervals in metres determined by the table, followed by six transects returning in a downstream direction. At each transect the stream width, and the length of the transect impinged by the plant taxa were recorded and converted to percentage plant cover. Incidental species present at the site but not recorded along the transects were also noted. The raw macrophyte survey results are present in Appendix 5.

2.4 Results Comparison

All results were compared to guideline values, where applicable. Guideline values for water quality can give an indication as to the relevant concentrations of nutrients and toxicants above or below which possible adverse effects are known to occur.

Results from 2025 were also compared to the most recent survey (Bioresearches, 2024). Any large deviations in results from what was found in 2019 and 2022 was also reported.

[2] A total of three fyke nets and six Gee Minnow traps were set overnight at each site.

3. RESULTS

3.1 Physical Characteristics

The physical characteristics of Te Puru Stream tributary sites are summarised in Table 4 and photographs of each site are shown in Photos 1 to 10.

The average width at each stream site varied between 1.48 m (Site H) to 2.69 m (Site G) wide, and the average stream width across all sites was 2.06 m. Average depth at most sites was relatively shallow and ranged between 0.08 m (Site A) and 0.29 m (Site G).

Substrate was predominantly made up of silt, with the exception of Sites H and S2, where bedrock and cobbles were dominant. Cobble and gravels were also common at all sites. Fish habitat/cover types observed during the survey comprised macrophytes, instream debris (e.g. wood), undercut banks and bankside vegetation.

Stream flow varied across the sites. Flow was highest at Site G (54.82 L/s) and lowest at Site E (10.13 L/s), and generally increased with distance downstream.

Since 2024, monitoring of reference Site A was shifted 10 m upstream from previous monitoring assessments due to the abundant growth of wetland plants within the previous monitoring site. This is further discussed in Section 4.1.1

Table 4. Summary of the physical characteristics and biological survey results of the Te Puru Stream sites, 31st of March to the 2nd of April 2025

	Reference Tributary		Farm Pond Tributary		Te Puru Stream Tributary			
Site	**H**	**E**	**A**	**F**	**S2**	**G**	**S3**	**C**
Date	31 Mar 2025	31 Mar 2025	31 Mar 2025	31 Mar 2025	31 Mar 2025	31 Mar 2025	31 Mar 2025	31 Mar 2025
Habitat								
Average Width (m)	1.53	2.39	1.61	1.85	1.96	2.69	2.68	1.82
Average Depth (m)	0.17	0.23	0.08	0.18	0.22	0.29	0.11	0.24
Flow (L/s)	Not assessed	10.13	Not assessed	25.7	42.67	54.82	52.58	39.44
Dominant substrate	Bedrock with small cobble	Silt and cobble	Small gravel on top of soft sediments	Thick layer of fine organic material and silt, cobble	Bedrock, cobble	Silt, cobble and gravel	Silt, cobble and gravel	Silt, cobble and gravel
Fish Cover	Instream debris, Undercut banks	Macrophytes, instream debris, undercut banks, bank vegetation	Macrophytes, instream debris, undercut banks, bank vegetation	Macrophytes, instream debris, bank vegetation	Instream debris, bank vegetation	Macrophytes, instream debris, bank vegetation	Instream debris, bank vegetation, undercut banks	Macrophytes, instream debris, undercut banks, bank vegetation
Macrophytes and Algae								
No. of Taxa	4	7	4	7	7	6	7	9
Average % cover	12	66	9	23	62	99	99	101
Species Recorded	Watercress, duckweed, watercelery & green mat	Willow weed, starwort, water celery, buttercup, red ludwigia, nitella & green mat	Starwort, red ludwidgia, green filament & brown filament	Willow weed, watercress, duckweed, liverwort, nitella, green filament, brown mat & brown filament	Duckweed, starwort, curly pondweed, nitella, green filament, brown mat & brown filament	Willow weed, watercress, duckweed, starwort, water celery and nitella	Willow weed, watercress, duckweed, water celery, nitella, green mat & brown mat	Willow weed, watercress, duckweed, cape pondweed, starwort, water celery, buttercup, nitella and green filament

Site	H	E	A	F	S2	G	S3	C
Macroinvertebrates								
No. of Taxa	18	17	18	5	Not assessed	13	Not assessed	12
Dominant taxon	*Triplectides obsoleta*	*Potymopyrgus*	*Paracalliope fluviatilis*	*Potymopyrgus*		*Potymopyrgus*		*Potymopyrgus*
No. EPT	3	3	3	0		2		2
%EPT	42	6	8	0		0		0
MCI	92 - Fair	90.6 Fair	111.8 - Good	67.6 - Poor		75.4 Poor		83.8 - Fair
SQMCI	4.5 - Fair	4.2 - Fair	5.9 - Good	2.3 - Poor		4.5 - Fair		3.8 - Poor
Large invertebrates	*Paratya* shrimp, koura	*Paratya* shrimp, koura	koura	-		-		*Paratya* shrimp, koura
Fish								
No. of species	4	4	3	1	Not assessed	4	Not assessed	5
No. of fish	20	22	23	1		13		28
Fish IBI	42 - Very Good	34 - Fair	32 - Fair	14 - Very Poor		42 - Very Good		44 - Very Good
Species recorded	Banded kokopu, common bully, redfin bully & koura	Longfin eel, banded kokopu, common bully & koura	Shortfin eel, banded kokopu and koura	Shortfin eel		Shortfin eel, longfin eel, banded kokopu & common bully		Longfin eel, banded kokopu, common bully, redfin bully & koura

*HB = hard-bottomed, SB = soft-bottomed

Photo 1. Site A – reference site, Farm Pond Tributary.

Photo 2. Site H – reference site, Reference Tributary.

Photo 3. Site E – reference site, Reference Tributary.

Photo 4. Site B – effect site, Farm Pond Tributary.

Photo 5. *Site F – effect site, Farm Pond Tributary.*

Photo 6. *Site 15 – effect site, Te Puru Stream Tributary*

Photo 7. Site S2 – effect site, Te Puru Stream Tributary

Photo 8. Site S3 – effect site, Te Puru Stream Tributary

Photo 9. Site G – effect site, Te Puru Stream Tributary

Photo 10. Site C – effect site, Te Puru Stream Tributary

3.2 Water Quality

Water quality results are presented in Table 5 and Figures 2 to 6.

Small amounts of nutrients such as nitrogen and phosphorus in freshwater are important for plant growth, however excess concentrations can lead to nuisance aquatic plant growth, algal blooms, eutrophication of freshwater ecosystems and some compounds are toxic to aquatic life at high concentrations. Faecal bacteria associated with wastewater discharges can indicate a risk to human health.

Water quality results were compared to freshwater guideline values for the protection of aquatic ecosystems, where values for the water quality component were available and relevant. Guideline values used were all New Zealand based data (ANZG 2018; ANZECC and ARMCANZ 2000; Ministry for the Environment 2020; Quinn 2009; Biggs *et al.* 2002, Hickey 2014) and NIWA site specific data (Hickey 2001). These guidelines give the concentrations of nutrients and toxicants above or below which possible adverse effects are known to occur.

The ANZG (2018), which succeeded ANZECC (2000), provides Default Guideline Values (DGVs) for toxicants and physical and chemical stressors in waterways. DGVs are the recommended concentrations (numeric values) for toxicants or stressors in water bodies that aim to protect aquatic ecosystems (used when local / site specific guideline values are not available). Physical and chemical DGVs are available for both high and low values:

- High indicates the stressor is harmful at high values (80^{th} percentile); and
- Low indicates the stressor is harmful at low values (20^{th} percentile).

DGVs for physical and chemical stressors were derived for a low elevation river in a warm-wet climate, based on the River Environmental Classification (REC) of Te Puru stream and tributaries (NIWA 2004)[3].

Guidelines from the National Policy Statement for Freshwater Management (NPS-FM – Ministry for the Environment 2020) include several attribute states, the lowest being Attribute State D (significant, persistent stress on aquatic organisms, high risk of local extinctions of keystone species and loss of ecological integrity) to the highest of Attribute State A (no stress caused by the indicator on 99% aquatic organisms at pristine (reference) sites). Attribute State B refers to lakes and rivers impacted by land use practices and/or provides for 95% species protection level (i.e. starting to impact occasionally on the 5% most sensitive species). As the surrounding catchment has been cleared and the dominant land use is farming this report mainly refers to the Attribute State B guideline values.

Habitat indicators of stream health from Biggs *et al*. (2002) do not provide specific guideline values, however, they do provide ranges of some water quality components that would indicate ‘poor’, ‘fair’, ‘good’ and ‘excellent’ stream health and these ranges were used where appropriate.

[3] Since 2019, the monitoring report used DGVs for a REC of low elevation river in a warm-wet climate. This change in classification does not impact on the outcome of this study, as the updated classification refers to specific guidelines to which the most recent water quality analysis is compared to.

Specific guideline values for carbonaceous biochemical oxygen demand ($cBOD_5$) were not available for New Zealand river systems. Evidence presented by Quinn (2009) at a hearing relating to water quality in the Horizons region presents professional opinion regarding the concentration of BOD to protect river systems from sewage fungus. This evidence has been cited and utilised as a guideline value when reporting on water quality previously (Mott MacDonald 2017). Chlorophyll α concentrations in lake ecosystems from the NPS-FM (MfE 2020) were used as guideline values in this report, however, should be reviewed with some caution due to the differing ecosystem types.

Table 5. Water quality results for the Te Puru Stream sites, sampled March/April 2025. Bold text corresponds to values not meeting the guideline.

	Reference Tributary	Farm Pond Tributary			Te Puru Stream Tributary			Guideline	
	E	**A**	**B**	**F**	**15**	**G**	**C**	**Low/High***	**Value**
Time (hrs, NZDST)	14:15	12:20	12:40	13:00	13:20	11:00	9:30		
Temperature (°C)	16.4	17.3	**20.7**	**20.5**	19.5	18	17.2	H	20 [5]
Dissolved Oxygen (mg/L)	6.54	**7.55**	**9.95**	**8.88**	7.38	**10.91**	**9.06**	L	5.0 - 7.5 [4]
Oxygen Saturation (%)	**73.8**	**78.8**	**111.7**	89.4	80.5	116	94.9	L and H	82 - 100 [1]
Conductivity (µS/cm)	**1124**	**199**	**1671**	**1664**	**1364**	**1368**	**1320**	H	86 [1]
Conductivity (mS/m)	112.4	19.9	167.1	166.4	136.4	136.8	132	H	
Visual Clarity (m)	**0.59**	**0.31**	**0.33**	**0.55**	0.74	**0.69**	0.83	L	0.7 [1]
pH (pH unit)	7.3	7.4	7.5	7.6	7.7	7.7	7.3	L and H	7.27 - 7.8 [1]
Total Suspended Solids (g/m^3)	**7**	**81**	**9**	**5**	**5**	< 3	< 3	H	4.6 [1]
Carbonaceous Biochemical Oxygen Demand (g O_2/m^3)	< 2	< 2	< 2	< 2	< 2	< 2	< 2	H	2 [3]
Chlorophyll α (g/m^3)	< 0.003	< 0.003	0.006	< 0.003	< 0.003	< 0.003	< 0.003	H	0.05 - 0.12 [4]
Total Ammoniacal Nitrogen (g/m^3)	< 0.010	0.043	0.154	0.113	0.039	< 0.010	< 0.010	H	3 [6]
Total Nitrogen (g/m^3)	0.32	0.42	**5.7**	**5.5**	**4.3**	**4.3**	**3.8**	H	3 [6]
Nitrate-N (g/m^3)	0.108	0.146	**4.4**	**4.3**	**3.3**	**3.4**	**3.1**	H	0.195 [1]
Nitrite-N (g/m^3)	0.003	0.006	0.141	0.083	0.04	0.012	0.014	H	0.444 [2]
Nitrate-N + Nitrite-N (g/m^3)	0.111	0.151	4.5	4.4	3.4	3.4	3.1	-	
Total Kjeldahl Nitrogen (g/m^3)	0.21	0.27	1.18	1.02	0.88	0.91	0.75	-	
Dissolved Inorganic Nitrogen (g/m^3)	0.112	0.195	4.7	4.5	3.4	3.4	3.1	-	
Total Phosphorous (g/m^3)	**0.047**	**0.091**	**0.55**	**0.53**	**0.42**	**0.36**	**0.25**	H	0.023 [1]
Dissolved Reactive Phosphorous (g/m^3)	**0.019**	**0.012**	**0.4**	**0.42**	**0.32**	**0.28**	**0.199**	H	0.007 [1]
Faecal Coliforms (cfu / 100mL)	**690** [#3]	**2,700** [#2]	**2,000** [#2]	**1,200** [#3]	**800** [#3]	**1,900** [#3]	**1,600** [#3]	H	150 [2]
Enterococci (MPN / 100mL)	488 [#1]	461 [#1]	411 [#1]	517 [#1]	435 [#1]	**816** [#1]	**770** [#1]	H	700 [2]

*L = harmful at low values; H = harmful at high values, [1] ANZG (2018), [2] ANZECC (2000), [3] Quinn (2009), [4]Ministry for the Environment (2020), [5] Biggs *et al.* (2002), [6]Hickey 2011, 2014) specific guideline for Te Puru derived from ANZECC (2000); Ammoniacal nitrogen guideline used as Total N is the sum of nitrate, nitrite, organic nitrogen and ammonia.

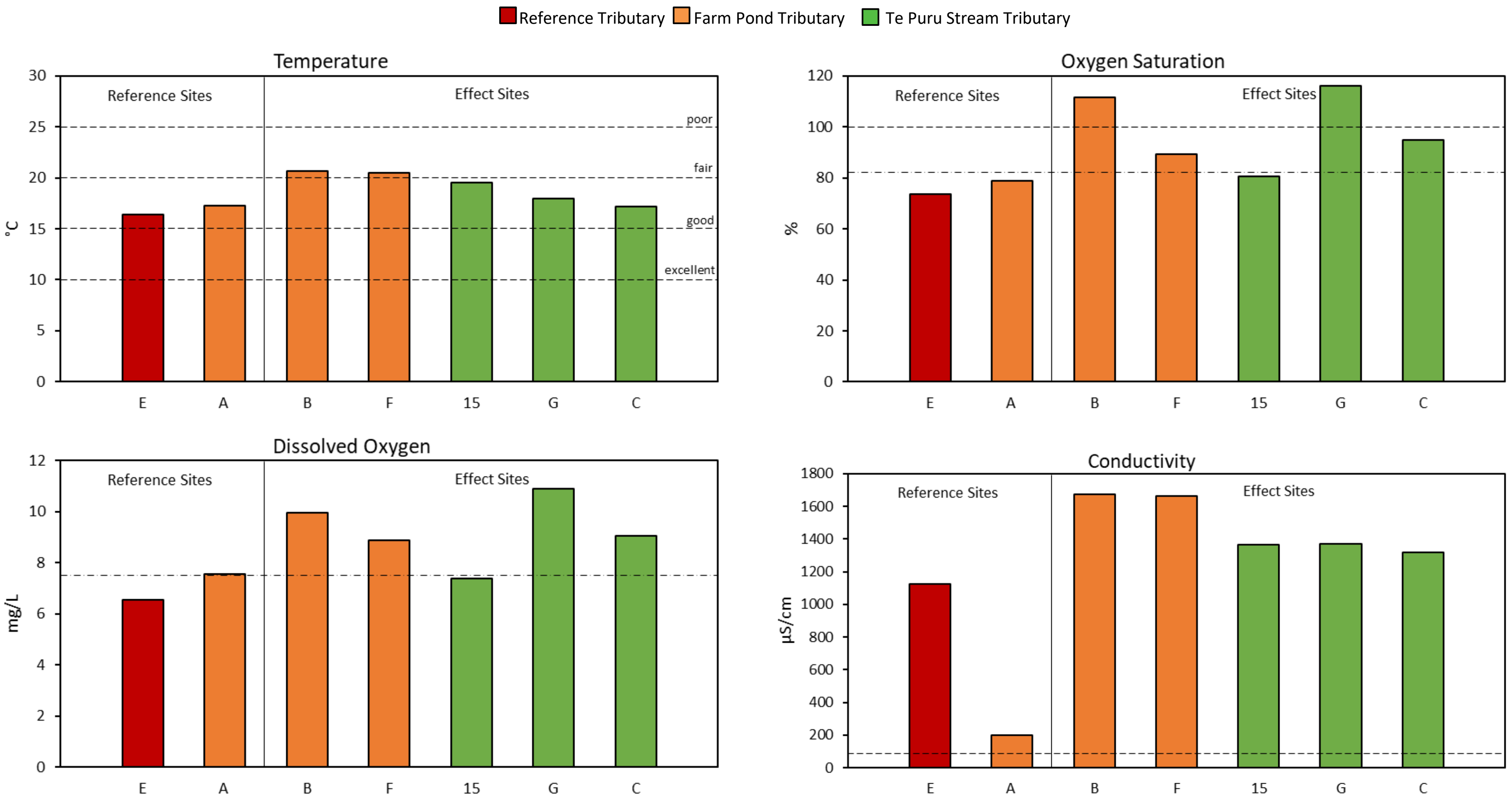

Figure 2. ***Water quality results for temperature, oxygen saturation, dissolved oxygen and conductivity for the Te Puru Stream tributaries. Dashed lines represent upper guideline values and dot-dashed lines represent lower guideline values.***

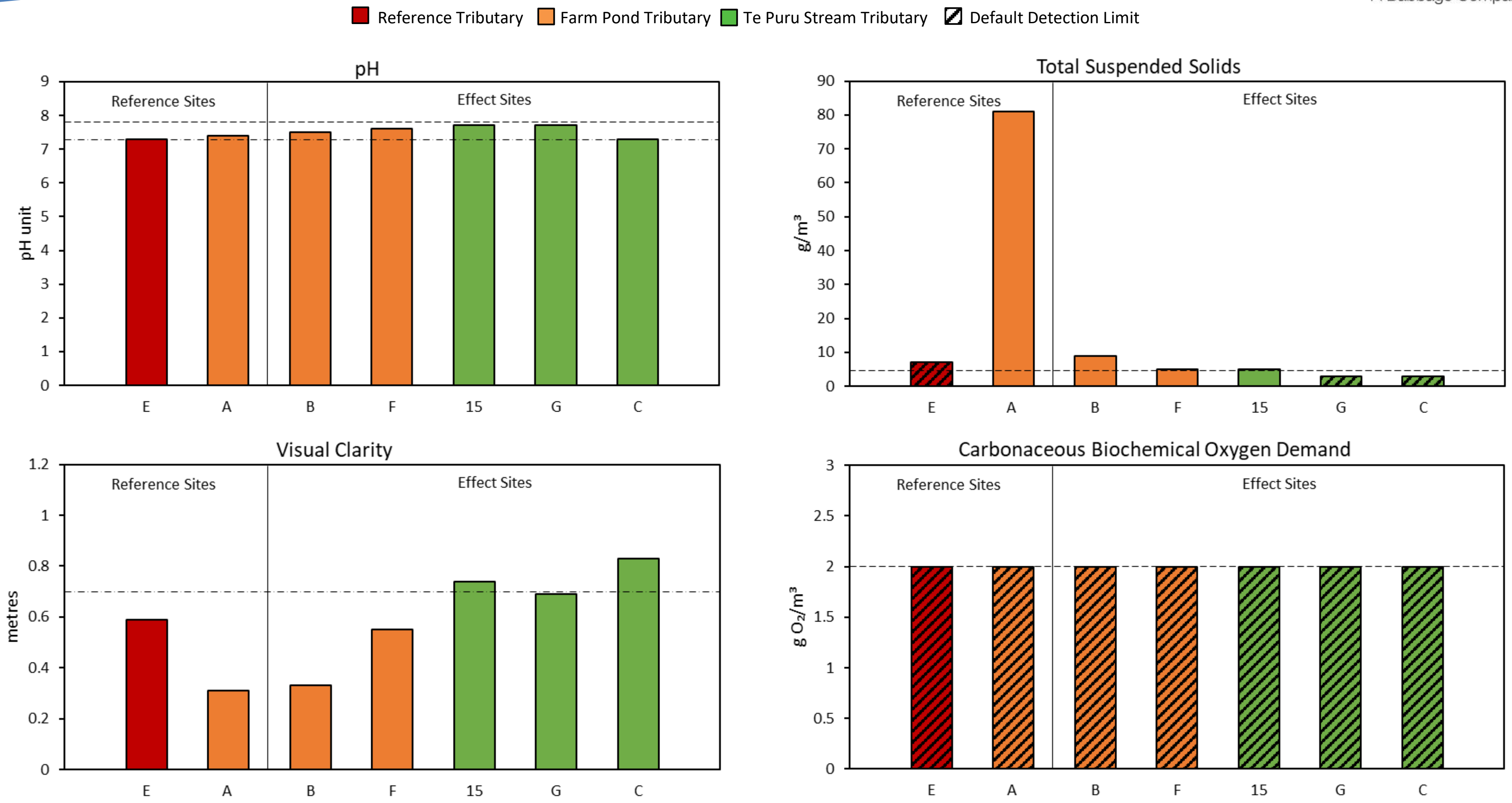

Figure 3. ***Water quality results for pH, total suspended solids, visual clarity and carbonaceous biochemical oxygen demand for the Te Puru Stream tributaries. Dashed lines represent upper guideline values and dot-dashed lines represent lower guideline values. Hashed fill represents values below the detection limit[4].***

[4] A detection limit range indicates the lowest and highest detection limits in the associated suite of analytes.

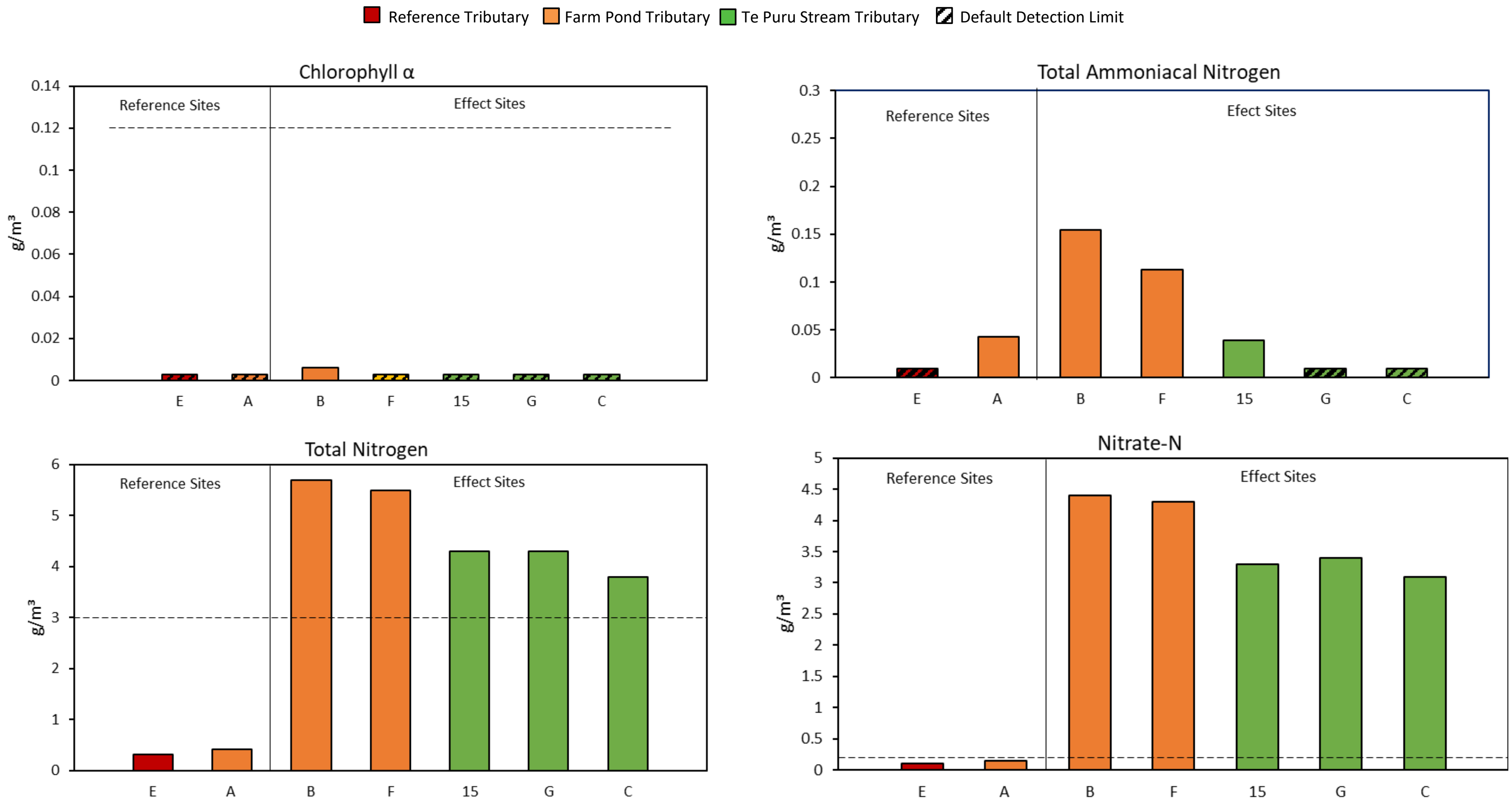

Figure 4. Water quality results for chlorophyll α, total ammoniacal nitrogen, total nitrogen and nitrate nitrogen for the Te Puru Stream tributaries. Dashed lines represent upper guideline values. Note that the guideline value of Total Ammoniacal Nitrogen is set at 3 g/m3, which far exceeds the measured concentrations, and thus also the scale of the graph.

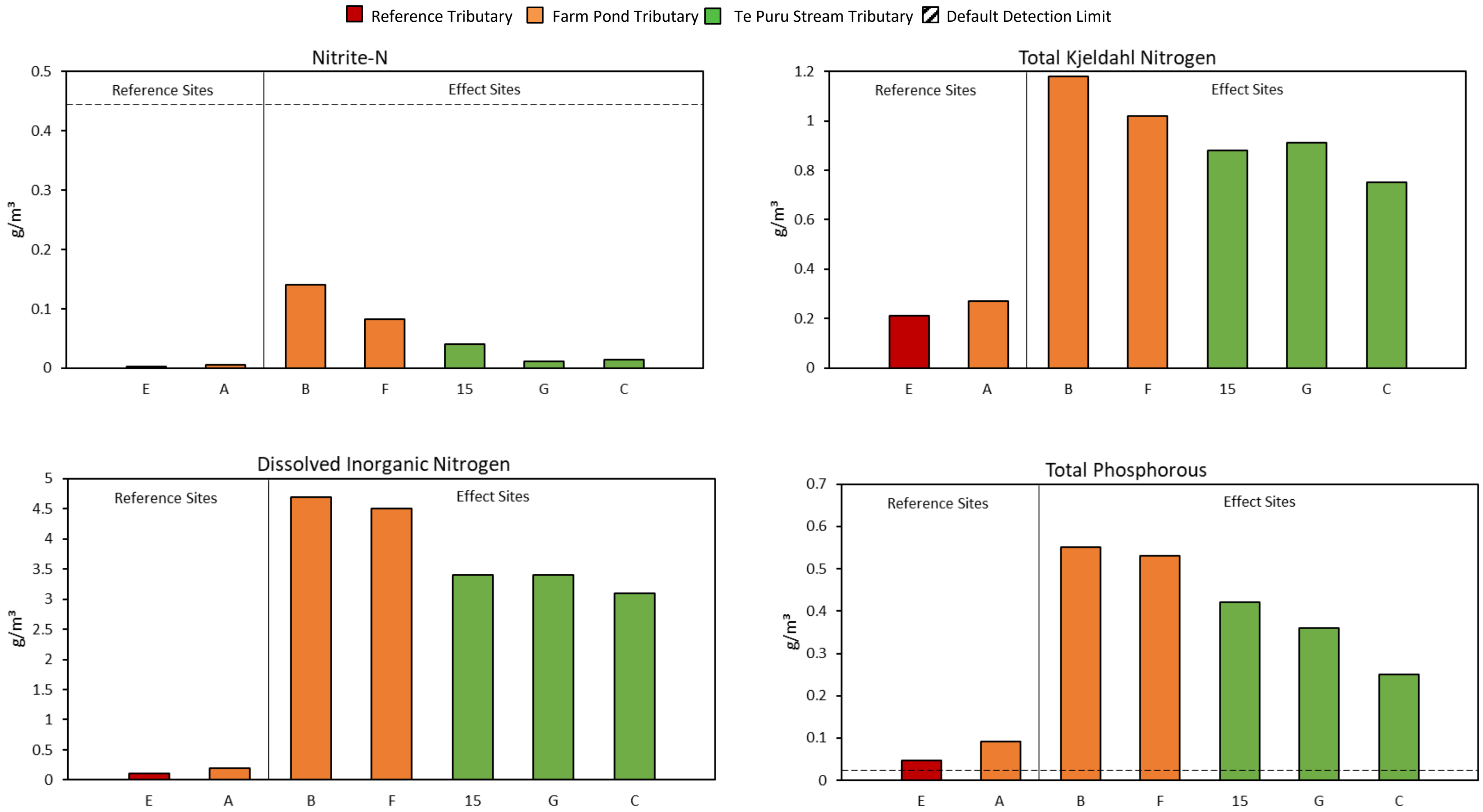

Figure 5. ***Water quality results for nitrite nitrogen, total Kjeldahl nitrogen, dissolved inorganic nitrogen and total phosphorus for the Te Puru Stream tributaries. Dashed lines represent upper guideline values. Note that Total Kjeldahl Nitrogen and Dissolved Inorganic Nitrogen does not have set guideline values.***

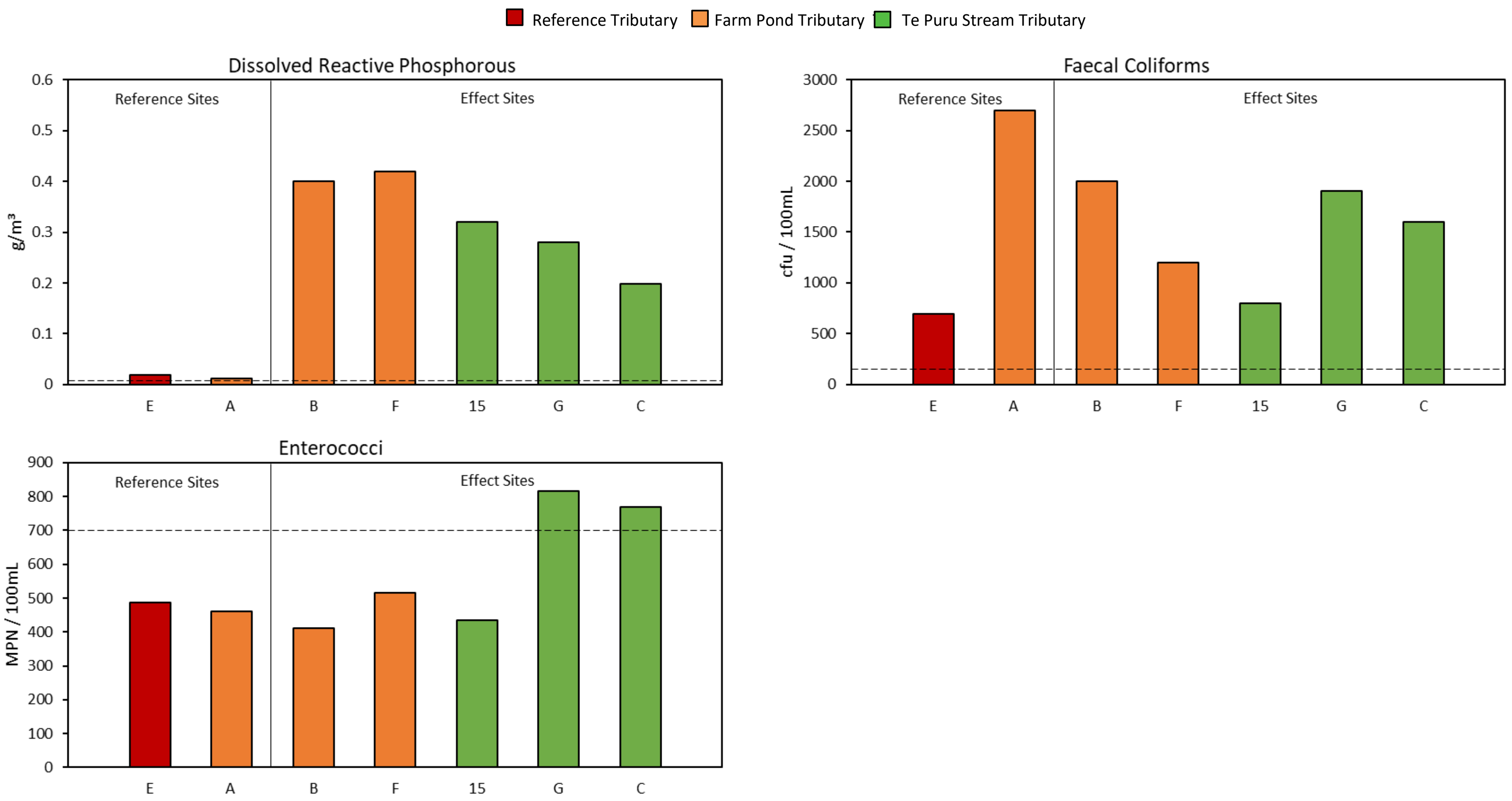

Figure 6. ***Water quality results for dissolved reactive phosphorus, faecal coliforms and enterococci for the Te Puru Stream tributaries. Dashed lines represent upper guideline values.***

3.2.1 Temperature

Elevated water temperatures can adversely affect the physiological processes of aquatic fauna, particularly more sensitive species. Water temperatures are heavily influenced by the shading provided by riparian vegetation both at the monitoring sites along the stream and more importantly the catchment upstream of the site.

In 2025, temperature ranged between 16.4 °C (Site E) and 20.7 °C (Site B). The lowest temperatures were recorded at the reference site upstream of the farm pond, peaking immediately downstream of it, and gradually decreasing further downstream (Figure 2). The higher temperature recorded at Site B, the discharge point from the farm pond, was not unexpected during summer as the pond is large and mostly unshaded, and ponds such as this develop thermoclines in summer with a layer of much warmer surface water overlying the deeper cooler water. This would have influenced the temperature of the impact sites, particularly the upper impact sites. While all impact sites were warmer than the reference sites, Site C (downstream) closely matched upstream Site A at ~17 °C.

According to Biggs et al. (2002), reference sites (E and A) and downstream sites (C and G) fell within the "good" stream health range (15–19.9 °C), though nearing levels that can stress some invertebrates (e.g., stoneflies). In contrast, the upper impact sites (B and F) exceeded 20 °C, placing them in the "fair" range (20–24.9 °C).

3.2.2 Dissolved Oxygen

Dissolved oxygen is required by aquatic fauna for respiration. Low dissolved oxygen can be a stressor, providing insufficient oxygen to maintain stream health, however high levels of dissolved oxygen can also indicate excess plant/algal growth, which can lead to super-saturation with associated lethal and sub-lethal effects on fish.

In 2025, both dissolved oxygen saturation (%) and concentration (mg/L) were measured at all water quality sites (Figure 2). Dissolved oxygen concentrations ranged from 6.54 mg/L (Site E) to 10.91 mg/L (Site G). All sites exceeded the national bottom line of 5.0 mg/L, with Sites A, B, F, G, and C above 7.5 mg/L, thus falling within attribute band B, and higher of the NPS-FM for dissolved oxygen. Saturation levels ranged from 73.8 % to 116 %, with Sites B and G exceeding the upper DGV of 100 %, suggesting algal photosynthesis may be influencing oxygen levels (Site G had a relatively high coverage of algae and macrophytes - Figure 12). Site E, A, and 15 were below the 82 % lower guideline.

The results mirrored stream flow conditions, with higher DO and saturation at sites with more flow or oxygen exchange (e.g., B and G), and lower DO at slower flowing or more pooled sites (e.g., E). Dissolved oxygen concentrations at Sites B, F, G and C were classified under Attribute State A (≥8 mg/L), while sites A and 15 were classified under Attribute State B (≥7 and <8 mg/L). Site E was the only site which fell under prescribed Attribute State C (≥5 and <7 mg/L), yet all remained above the National bottom line (MfE, 2020).

3.2.3 Conductivity

Conductivity is a measure of the free ions in the water and indicates the amount of mineral salts in the water, which is often an indicator of the presence of dissolved nutrients, salt water or pollution.

There was a very large difference in conductivity between reference and effect sites in 2025. Site A had the lowest reading (199 µS/cm), while Site B (the pond discharge site) recorded the highest (1671 µS/cm) (Figure 2). Conductivity remained elevated downstream of the discharge point at all effect sites (over 1300 µS/cm) (Figure 2). All sites exceeded the ANZG (2018) guideline value of 86 µS/cm, including reference site E (1124 µS/cm), suggesting background enrichment.

Site A was close to the 'good' range threshold (Biggs *et al.,* 2002), while Site E was within the 'fair' range. All effect sites were in the 'poor' range, indicative of highly enriched or contaminated waters, likely reflecting elevated nutrient or salt concentrations from the discharge.

3.2.4 pH

pH is a measure of the acidity or alkalinity of water (and hence the strength of acid present), with neutral pH at 7. With increasingly acidic waters, the numbers of species and individuals of aquatic organisms decrease (Biggs *et al*., 2002). Water that is too acidic or too alkaline can negatively affect aquatic life, especially sensitive macroinvertebrates and fish.

In 2025, pH values ranged from 7.3 (Sites E and C) to 7.7 (Sites F and G), with most effect sites recording values between 7.5 and 7.6 (Figure 3). All values were within the ANZG (2018) guideline range of 7.27 to 7.8 (Figure 3), which defines acceptable bounds for aquatic ecosystem health.

The pH values observed indicate circum-neutral conditions across the catchment. This range is typical for New Zealand streams (LAWA, 2024) and suggests that acidity or alkalinity is not posing a stressor to aquatic biota at any of the sampled sites. While the pH at Site A was close to the lower guideline limit, it remained within acceptable ecological bounds, and the slight variability observed between sites is unlikely to result in adverse biological effects.

3.2.5 Total Suspended Solids

Total Suspended Solids (TSS) refer to the solid particles (typically less than 2 microns) found suspended in water. These include materials such as silt, organic matter, algae, and other particulates. Elevated TSS can have adverse effects on aquatic ecosystems by reducing light penetration, smothering habitat, clogging fish gills, and impairing the feeding and reproduction of aquatic invertebrates.

In 2025, TSS values varied considerably across the Te Puru Stream sites (Figure 3). TSS was below the detectable limit (< 3 g/m^3) at the downstream effects sites, G and C. The highest TSS concentration was recorded at Site A (81 g/m^3), which is unusually high for a reference site and likely reflects recent disturbance or runoff upstream of the sampling point. Effect Site B, located immediately downstream of the farm pond, showed a moderate increase (9 g/m^3); while Site F had a reduced concentration of 5 g/m^3. Site 15 displayed elevated TSS levels (5 g/m^3), but concentrations dropped again to below detection at Sites G and C, which are further downstream.

The ANZG (2018) guideline value for TSS is 4.6 g/m³. All sites, except for those with undetectable TSS levels, exceeded this guideline, indicating potential for ecological impacts due to sedimentation or suspended particulate matter. The unexpected elevation at reference Site A suggests a localised input or land-use effect not associated with the farm pond discharge.

The general spatial pattern shows elevated TSS at certain upstream and mid-reach locations, with dilution or settling likely accounting for the reduced concentrations downstream. This pattern supports the importance of bank stabilisation and riparian vegetation in mitigating sediment input to streams.

3.2.6 Visual Clarity

Water clarity refers to the degree of transparency or how clear the water appears, indicating how far light can penetrate through it. It is often inversely related to Total Suspended Solids (TSS), with low clarity typically associated with high TSS levels. Reduced clarity can inhibit photosynthesis, limit visual feeding for aquatic fauna, and indicate sediment-related stressors.

In 2025, visual clarity ranged from 0.31 m at reference Site A to 0.83 m at the downstream effect Site C (Figure 3). Effects sites 15 and C were the only sites with clarity values above the guideline value (0.7 m) (Figure 3).

Interestingly, some effect sites exhibited higher visual clarity than the reference sites, despite higher TSS readings. For example, Site 15 showed visual clarity of 0.74 m despite a TSS level of 5 g/m³—above the guideline. This disparity may reflect differences in particle type or size, as not all suspended solids equally affect light transmission.

The ANZG (2018) guideline value for visual clarity is 0.7 m. Both reference sites (E and A), as well as three effects sites, including Site B (immediately downstream of the farm pond) fell below this threshold. This result indicates wider catchment level disturbance or bank erosion at Site A and E, and by particle composition or settling patterns downstream of the pond discharge.

Overall, while TSS and clarity are generally expected to trend inversely, the 2025 results suggest that localised conditions and sediment characteristics also play a role. Most effect sites demonstrated acceptable visual clarity from an ecological perspective.

3.2.7 Carbonaceous Biochemical Oxygen Demand

Carbonaceous biochemical oxygen demand ($cBOD_5$) measures the amount of oxygen consumed by microorganisms during the decomposition of organic matter in the water. High cBOD values may indicate the presence of organic pollution, often associated with wastewater or nutrient-rich runoff, and can lead to oxygen depletion, negatively affecting aquatic life. Prolonged low-oxygen conditions can favour the growth of undesirable species such as sewage fungus.

In 2025, all sites recorded $cBOD_5$ values below the laboratory detection limit of 2 g O_2/m³ (Figure 3). This detection limit also corresponds to the guideline value proposed by Quinn (2009), which has been used in previous reporting to assess the risk of sewage fungus proliferation in New Zealand rivers.

The consistent non-detectable $cBOD_5$ values across all reference and effect sites indicate an absence of significant organic pollution or oxygen-demanding waste material. This suggests that the discharge and surrounding land use did not contribute to elevated organic loads in the stream system at the time of sampling.

Therefore, the risk of impacts related to excessive organic enrichment—such as reduced oxygen availability or microbial blooms—appears low throughout the assessed reaches of the streams.

3.2.8 Chlorophyll α

Chlorophyll α is a pigment found in all photosynthetic algae and is commonly used as an indicator of algal biomass in aquatic ecosystems. Elevated chlorophyll α concentrations can suggest nutrient enrichment and are often associated with eutrophication, reduced oxygen levels, and declines in aquatic habitat quality. In stream systems, chlorophyll α can be influenced by light availability, temperature, flow velocity, and nutrient concentrations—especially nitrogen and phosphorus.

In 2025, chlorophyll α was below the laboratory detection limit (<0.003 g/m^3) at all sites except Site B, located directly downstream of the farm pond, where it was measured at 0.006 g/m^3 (Figure 4). Although this was the highest recorded value, it remains below the NPS-FM (2020) guideline range of 0.05–0.12 g/m^3 used to assess the risk of algal proliferation in lake ecosystems. While that guideline is not directly intended for streams, it serves as a conservative benchmark.

The elevated chlorophyll α at Site B corresponds with elevated nutrient levels (e.g., nitrogen and phosphorus), warm temperatures, and increased light availability immediately below the pond—conditions favourable for periphyton and algal growth. However, the low concentrations elsewhere suggest minimal risk of nuisance algal blooms throughout the wider stream system at the time of sampling.

Overall, chlorophyll α concentrations in 2025 suggest that while localised algal growth may occur downstream of the pond outflow, it is not at levels indicative of ecological concern.

3.2.9 Total Ammoniacal Nitrogen

In freshwater systems, ammoniacal nitrogen exists in equilibrium between un-ionised ammonia (NH_3) and the ammonium ion (NH_4^+). Un-ionised ammonia is significantly more toxic to aquatic life than ammonium, and the proportion of each form depends on temperature and pH. Elevated concentrations of ammoniacal nitrogen, particularly in the un-ionised form, can adversely affect fish and macroinvertebrates.

In 2025, the highest total ammoniacal nitrogen concentration was observed at Site B (0.154 g/m^3), immediately downstream of the farm pond (Figure 4). Elevated concentrations were also recorded at Site F (0.113 g/m^3) and Site 15 (0.039 g/m^3), but reference site A had almost similar elevated concentrations (Site A: 0.043 g/m^3) (Figure 4). All other sites, including reference site E, recorded concentrations below the detection limit (<0.010 g/m^3).

As in previous years, these concentrations were assessed against site-specific guidelines developed by Hickey (2001), which are more appropriate than national default values due to their derivation for the Te Puru Stream. The acute threshold for protection of aquatic life is 3.0 g/m³, and the chronic threshold for sensitive species such as banded kōkopu is 2.46 g/m³. All measured concentrations in 2025 were well below both thresholds, indicating a low risk of toxicity from ammoniacal nitrogen.

Although elevated concentrations immediately below the farm pond suggest that the discharge contributes to localised enrichment, the values rapidly decline with distance downstream. The very low levels at downstream sites (G and C) and at reference site E further affirm that ammoniacal nitrogen is not a widespread stressor in the stream system under current conditions.

3.2.10 Total Nitrogen

Total nitrogen (TN) in freshwater is a combined measure of all nitrogen forms present, including nitrate (NO_3^-), nitrite (NO_2^-), ammoniacal nitrogen (NH_4^+/NH_3), and organic nitrogen (typically expressed as Total Kjeldahl Nitrogen). Elevated total nitrogen concentrations can drive periphyton and algal growth, increase biological oxygen demand, and contribute to eutrophication, particularly in slow-moving or low-light environments.

In 2025, total nitrogen concentrations were lowest at the reference sites—0.32 g/m³ at Site E and 0.42 g/m³ at Site A (Figure 4). In contrast, concentrations were markedly higher at all effect sites, ranging from 3.8 g/m³ (Site C) to 5.7 g/m³ (Site B) (Figure 4). Sites B and F, located directly below and shortly downstream of the farm pond, had the highest concentrations, indicating a strong influence from the pond discharge.

These effect site values exceed the NIWA site-specific guideline for the Te Puru Stream tributary (3.0 g/m³; Hickey, 2001), indicating potential risk to aquatic health due to excessive nitrogen enrichment.

The pattern observed—a sharp increase in total nitrogen immediately downstream of the farm pond, followed by a gradual decrease at downstream sites—mirrors previous monitoring years and is consistent with dilution, assimilation, or settling processes. Despite this attenuation, total nitrogen values at even the most downstream effect site (Site C) remained substantially higher than at the reference sites, suggesting that the system remains under nutrient stress for a considerable distance downstream of the discharge.

3.2.11 Nitrate-Nitrogen

Nitrate (NO_3^-) is the most oxidised form of nitrogen and typically originates from nitrogen-fixing plants, fertiliser runoff, animal waste, and the nitrification of ammonium. It is highly mobile in water and commonly found in agricultural catchments. While it is an important nutrient for plant growth, elevated nitrate concentrations can be harmful to aquatic ecosystems and are toxic to fish and invertebrates at high levels.

In 2025, nitrate-nitrogen concentrations were lowest at the reference sites—0.108 g/m³ (Site E) and 0.146 g/m³ (Site A). These concentrations were well below the ANZG (2018) guideline value of 0.195 g/m³ for ecosystem protection. In contrast, all effect sites recorded significantly elevated concentrations, exceeding the ANZG (2018) guideline value: Site B had the highest at 4.4 g/m³, closely followed by Site F (4.3 g/m³). Downstream effect sites also remained high, with values of 3.3–3.1 g/m³ at Sites 15, G, and C (Figure 4).

All effect site concentrations were more than 15 times the guideline threshold, indicating strong nutrient enrichment downstream of the pond discharge. The elevated nitrate at Site B corresponds with the high total nitrogen observed there and reflects a dominant contribution of oxidised nitrogen forms from the pond system.

Although concentrations decline downstream, they remain above ecological thresholds at all measured distances. These findings support the classification of all effect sites as nutrient-enriched and highlight the potential for ecological stress, such as periphyton proliferation (refer to Section 3.4.3) or reductions in invertebrate diversity (refer to Section 3.4.1).

3.2.12 Nitrite-Nitrogen

Nitrite (NO_2^-) is an intermediate compound in the nitrogen cycle, formed during the microbial oxidation of ammonium and converted rapidly to nitrate under oxygenated conditions. Though typically present in much lower concentrations than nitrate, nitrite is more toxic to aquatic organisms, particularly fish, as it interferes with oxygen transport in the bloodstream.

In 2025, nitrite-nitrogen concentrations were lowest at the reference sites: 0.003 g/m³ at Site E and 0.006 g/m³ at Site A. Effect site concentrations peaked at Site B (0.141 g/m³), with values gradually declining downstream to 0.014 g/m³ at Site C (Figure 5). Site F recorded 0.083 g/m³, while Site 15 and Site G showed intermediate values of 0.04 and 0.012 g/m³, respectively.

All values were below the ANZECC (2000) guideline of 0.444 g/m³ for aquatic ecosystem protection, indicating that nitrite concentrations in the stream do not pose a toxicity risk based on current sampling.

Despite the elevated levels at effect sites relative to the reference sites, the observed concentrations fall within expected ranges for streams affected by pastoral land use and wastewater inputs. The decline in nitrite levels downstream suggests active nitrification processes and dilution, supporting the resilience of the system to convert reactive nitrogen species into less harmful forms.

3.2.13 Total Kjeldahl Nitrogen

Total Kjeldahl Nitrogen (TKN) is a measure of the sum of organic nitrogen and ammoniacal nitrogen (NH_3/NH_4^+). It provides an estimate of the biologically available and particulate-bound nitrogen in water. Elevated TKN levels can indicate pollution from agricultural runoff, wastewater discharge, or decomposition of organic matter, contributing to eutrophication and oxygen demand.

In 2025, TKN concentrations were lowest at the two reference sites: 0.21 g/m³ (Site E) and 0.27 g/m³ (Site A). Levels increased markedly at all effect sites, peaking at 1.18 g/m³ at Site B (immediately downstream of the farm pond), with a gradual decline at sites further downstream (Figure 5).

Although there are no specific guideline values for TKN in New Zealand, the elevated concentrations observed at the effect sites are consistent with other nutrient indicators and suggest increased organic nitrogen input associated with the pond discharge. The spatial pattern mirrors trends in total nitrogen and ammoniacal nitrogen, confirming that both dissolved and particulate organic nitrogen are contributing to the overall nitrogen load.

3.2.14 Dissolved Inorganic Nitrogen

Dissolved Inorganic Nitrogen (DIN) includes the bioavailable forms of nitrogen—namely nitrate (NO_3^-), nitrite (NO_2^-), and ammoniacal nitrogen (NH_4^+/NH_3). These forms are readily assimilated by aquatic plants and algae, fuelling primary productivity and periphyton growth. Elevated DIN is closely associated with eutrophication and excessive algal biomass, particularly in streams with high light availability and stable flows.

In 2025, DIN concentrations ranged from 0.112 g/m³ at the upstream reference site (Site E) to 4.7 g/m³ at the impact site directly downstream of the farm pond (Site B) (Figure 5). Elevated concentrations were also recorded at Site F (4.5 g/m³), Site 15 (3.4 g/m³), and Site G (3.4 g/m³), with levels tapering to 3.1 g/m³ at the most downstream effect site, Site C (Figure 5). Reference Site A recorded a moderately elevated DIN of 0.195 g/m³, reflecting slight background enrichment relative to Site E. There are no specific guidelines for concentrations of DIN.

3.2.15 Total Phosphorus

Total phosphorus represents the sum of all forms of phosphorus in the water column, including both particulate-bound and dissolved fractions. As a key nutrient, phosphorus is often the limiting factor for algal and periphyton growth in freshwater systems. However, excessive concentrations can lead to eutrophication, harmful algal blooms, and degradation of aquatic habitats. Phosphorus can enter waterways via wastewater discharges, fertiliser runoff, animal waste, and eroded soil.

In 2025, total phosphorus concentrations followed a similar spatial pattern to nitrogen-related parameters. The lowest concentrations were recorded at the two reference sites: 0.047 g/m³ (Site E) and 0.091 g/m³ (Site A) (Figure 5). All effect sites had substantially higher values. The highest total phosphorus was at Site B (0.55 g/m³), just downstream of the farm pond discharge sites (Figure 5). Levels gradually decreased downstream, but remained elevated—0.53 g/m³ at Site F, 0.42 g/m³ at Site 15, 0.36 g/m³ at Site G, and 0.25 g/m³ at the most downstream site (Site C) (Figure 5).

All sites exceeded the ANZG (2018) guideline value of 0.023 g/m³, including the reference sites. Furthermore, all effect sites surpassed the National Policy Statement for Freshwater Management (NPS-FM) Attribute D threshold (>0.05 g/m³), which represents the national bottom line. These concentrations indicate persistent and significant phosphorus enrichment throughout the catchment, particularly in areas downstream of the discharge.

The dominance of particulate-bound phosphorus, inferred from the corresponding DRP results (Section 3.2.16), suggests erosion, sediment mobilisation, or particulate discharge from the pond may be contributing to the total phosphorus load. Elevated phosphorus supports nuisance periphyton growth (as observed at effect Sites G and C - Figure 12) and may exacerbate dissolved oxygen fluctuations, particularly during warmer months.

3.2.16 Dissolved Reactive Phosphorous

Dissolved Reactive Phosphorus (DRP) is the form of phosphorus most readily available for uptake by aquatic plants and algae. Unlike total phosphorus, DRP is immediately bioavailable and is therefore a strong indicator of the potential for periphyton growth and eutrophication. Elevated DRP concentrations, even in small quantities, can lead to significant ecological responses, particularly in low-gradient or stable-flow streams.

In 2025, DRP was lowest at the reference sites: 0.019 g/m³ (Site E) and 0.012 g/m³ (Site A) (Figure 6). These values are elevated relative to the ANZG (2018) guideline of 0.007 g/m³ but are significantly lower than those at the effect sites (Figure 6). The highest DRP concentrations were recorded at Site B (0.4 g/m³) and Site F (0.42 g/m³), both downstream of the farm pond. Further downstream, DRP declined gradually to 0.199 g/m³ at Site C (Figure 6) yet remained markedly higher than reference levels.

All effect sites in 2025 exceeded the NPS-FM Attribute D threshold for DRP (>0.018 g/m³), which defines the national bottom line for riverine phosphorus concentrations. The concentrations at Sites B and F were more than 50 times the guideline threshold, indicating an extreme level of phosphorus enrichment from the discharge.

The strong spatial gradient observed—high concentrations just below the pond and progressive decline downstream—points to the pond as the primary source. However, elevated DRP at downstream sites suggests limited assimilation or retention, allowing bioavailable phosphorus to remain active through the lower reach.

3.2.17 Faecal Coliforms

Faecal coliforms are a group of bacteria commonly found in the intestines of warm-blooded animals, including livestock, wildlife, and humans. Their presence in freshwater is an indicator of faecal contamination and potential health risks for contact recreation. Faecal coliforms, particularly Escherichia coli, are used as proxies for the presence of pathogenic microorganisms that can cause gastrointestinal illness.

In 2025, faecal coliform concentrations were elevated at all sites, ranging from 690 cfu/100 mL (reference Site E) to 2,700 cfu/100 mL (reference Site A) (Figure 6). All concentrations far exceed the ANZECC (2000) guideline of 150 cfu/100 mL for freshwater environments.

The lack of a clear spatial trend and the elevated levels at reference sites suggest that the source of contamination is not limited to the farm pond discharge. Instead, widespread faecal inputs are likely entering the stream from livestock grazing and access to waterways throughout the catchment. Stock was observed during the site visit, and there is minimal fencing along some stream margins.

It is important to note that the faecal coliform results must be interpreted with caution. Laboratory reports indicated that samples were received at temperatures exceeding 10°C and was analysed more than 24 hours after collection, which may result in bacterial regrowth during transit and artificially elevated counts.

3.2.18 Enterococci

Enterococci are bacteria commonly found in the gastrointestinal tracts of warm-blooded animals. Like faecal coliforms, their presence in freshwater is an indicator of faecal contamination. Enterococci are considered more robust and reliable indicators of water quality for recreational purposes, especially in marine and mixed saline environments, but are also relevant in freshwater. High levels can suggest the presence of pathogenic microorganisms and an elevated risk of illness from water contact.

In 2025, enterococci concentrations ranged from 411 MPN/100 mL (effect Site B) to 816 MPN/100 mL (effect Site G) (Figure 6). Both reference sites recorded high values as well—488 MPN/100 mL (Site E) and 461 MPN/100 mL (Site A). Other effect site results included 517 MPN/100 mL (Site F) and 770 MPN/100 mL (Site C) (Figure 6).

All sites exceeded the ANZECC (2000) guideline of 100 MPN/100 mL for primary contact recreation (i.e. full-body immersion activities such as swimming). Moreover, Sites C and G also exceeded the upper threshold for secondary contact (450–700 MPN/100 mL), suggesting that even wading or other incidental contact could pose health risks at these locations.

As with faecal coliforms, these results show no clear spatial trend and suggest multiple diffuse sources of faecal input across the catchment. The fact that the most elevated result (816 MPN/100 mL) occurred at an effect site, while a similarly high result (488 MPN/100 mL) was recorded at a reference site, underscores the complexity of land use impacts and potential wildlife or livestock access across the system.

Again, these results must be interpreted with some caution due to laboratory receipt temperatures exceeding 10°C and analysis thereof more than 24 hours after collection, which may result in bacterial regrowth in samples prior to analysis.

3.3 Sediment Quality

Sediment quality results are presented in Table 6 and Figure 7 and Figure 8. Components of sediment quality were tested at one reference site (Site E) and three effect sites (Sites F, G and C).

Sediment characteristics such as organic matter and relevant carbon/nutrient compositions can give an indication as to the sources of organic matter input the stream receives. Factors such as carbon and nitrogen can affect the primary production and eutrophication status of aquatic ecosystems.

Table 6. Sediment quality results summary for the Te Puru Stream tributaries. Site E is a reference site and sites F, G and C are effect sites.

	Reference Tributary	Farm Pond Tributary	Te Puru Stream Tributary	
	E	F	G	C
Dry Matter (% of sample)	49	40	68	55
Total Carbon (g/100g dry weight)	2.8	2.6	1.2	3.6
Total Nitrogen (g/100g dry weight)	0.17	0.2	0.09	0.24
C : N ratio	16	13	13	15
Ammonium-N (mg/kg dry weight)	8	13	6	13

Total Recoverable Phosphorous (mg/kg dry weight)	490	1,810	560	1,110

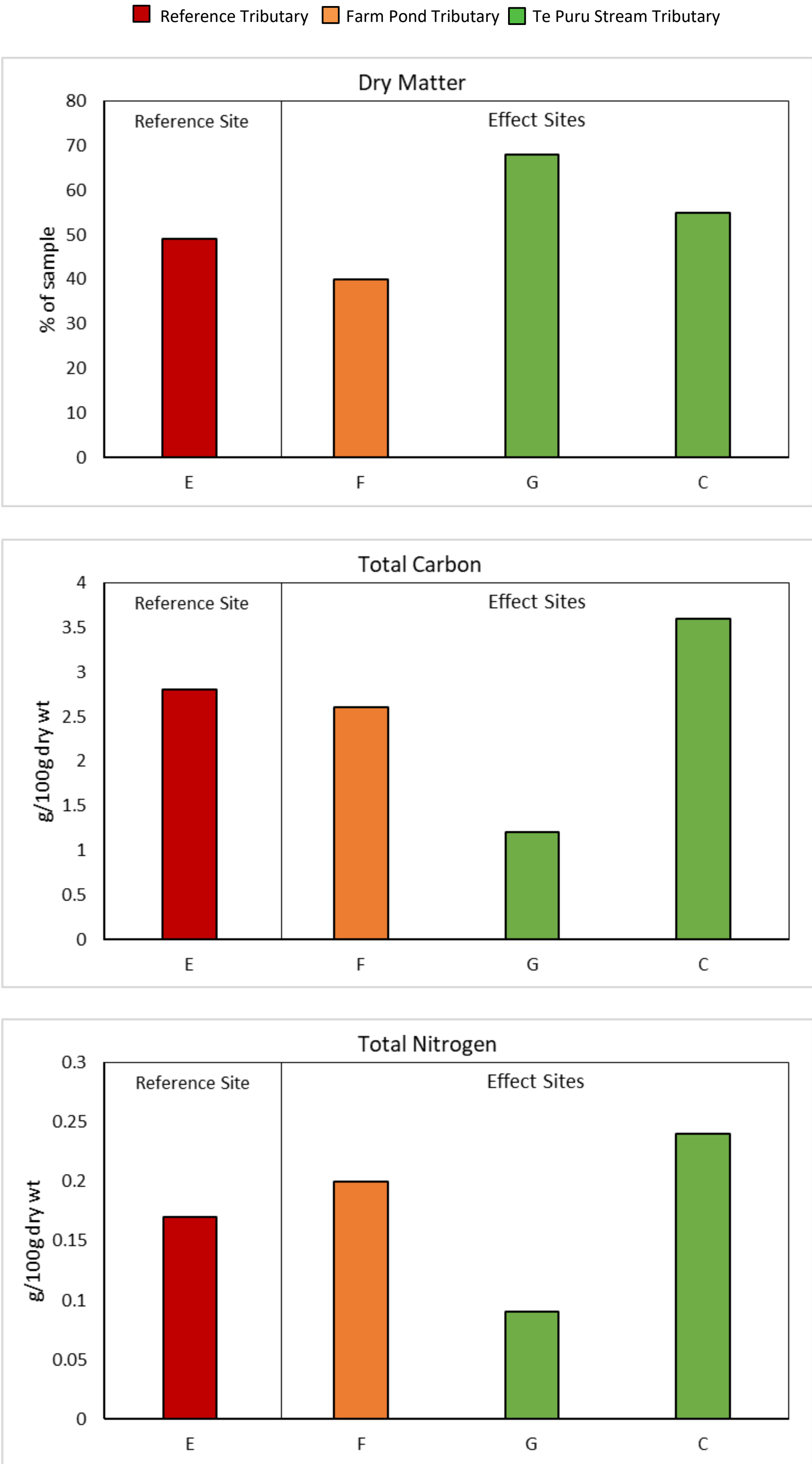

Figure 7. Sediment quality results for dry matter, total carbon and total nitrogen.

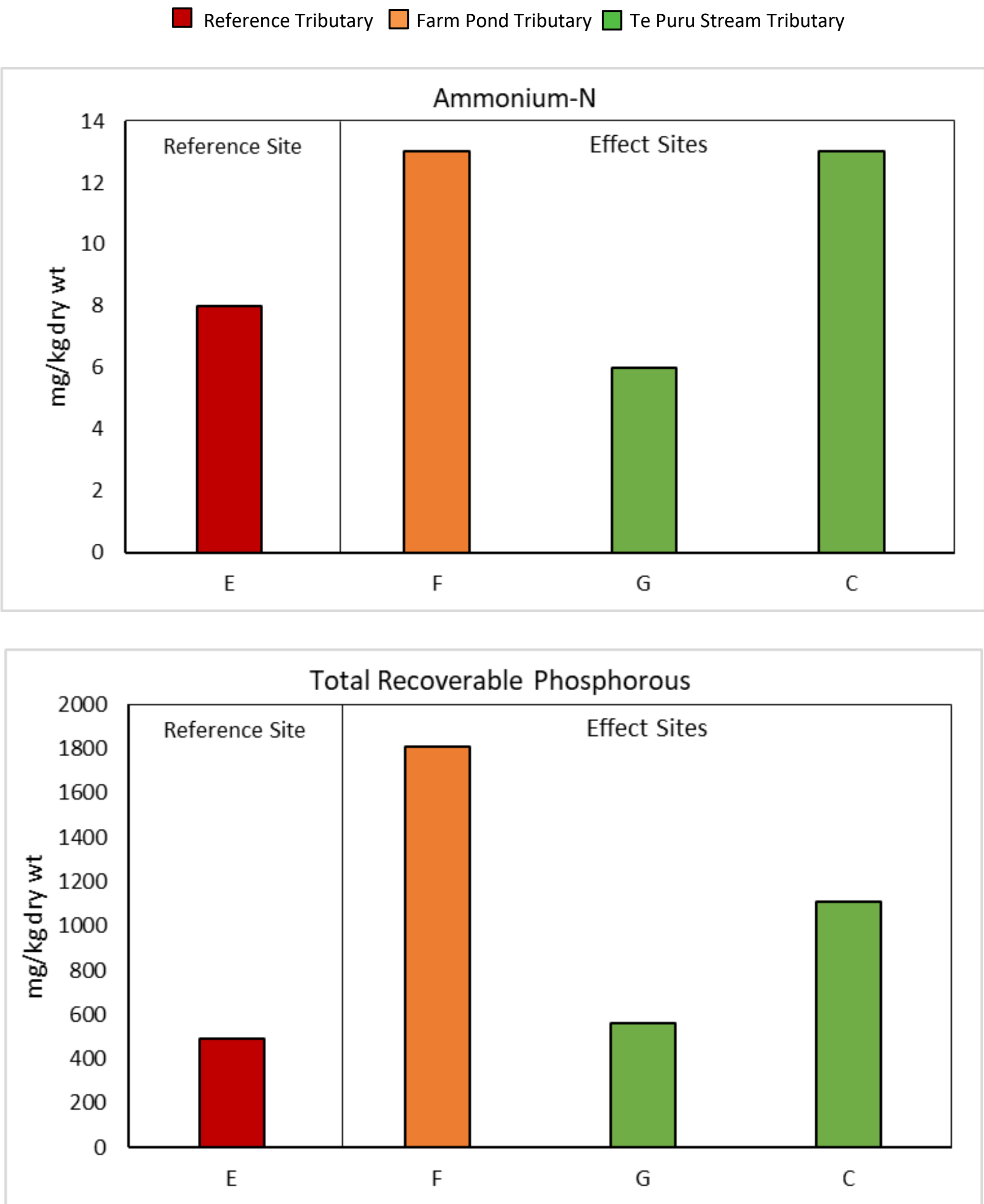

Figure 8. Sediment quality results for Ammonium – N and total recoverable phosphorous.

3.3.1 Dry Matter

Dry matter content, representing the proportion of the sediment sample not made up of water, is a general indicator of sediment composition, including the proportion of organic and inorganic material. High dry matter percentages can reflect well-drained or more mineral-rich sediments, whereas lower values may indicate organic enrichment or poorly consolidated material.

In 2025, the highest dry matter percentage was recorded at the midstream effect site G (68 %), followed by the downstream effect site C (55 %). Reference Site E had a dry matter content of 49 %, while the lowest was at Site F (40 %), located immediately downstream of the farm pond discharge. This pattern indicates a notable reduction in dry matter at Site F, likely reflecting finer, more organic-rich sediment accumulation downstream of the discharge, with coarser or more mineral-rich sediments occurring further downstream.

3.3.2 Total Carbon and Total Nitrogen

Total carbon and total nitrogen in sediments are indicators of organic matter content and nutrient loading. Elevated levels typically signal enrichment from organic inputs such as wastewater, plant material, or faecal matter.

The highest total carbon concentration was recorded at the most downstream site, Site C (3.6 g/100g dry weight), followed by the reference site E (2.8 g/100g), Site F (2.6 g/100g), and the lowest at Site G (1.2 g/100g). For total nitrogen, Site C again showed the highest concentration (0.24 g/100g), followed by Site F (0.2 g/100g), Site E (0.17 g/100g), and Site G (0.09 g/100g).

3.3.3 Carbon to Nitrogen Ratio

The carbon-to-nitrogen (C:N) ratio helps characterise the type of organic matter present in sediments. Higher ratios suggest more refractory, plant-derived organic matter, while lower ratios may indicate fresher, nitrogen-rich inputs such as faecal material or algae.

In 2025, the highest C:N ratio was again observed at the reference Site E (16), suggesting natural plant-based organic material dominates. Sites F and G both recorded a C:N ratio of 13, while Site C had a slightly higher ratio of 15. The lower C:N values at the effect sites, especially F and G, suggest fresher organic matter inputs consistent with pond discharge influence or faecal enrichment. The slightly elevated ratio at Site C may reflect a shift toward more plant-derived material further downstream.

3.3.4 Ammonium - Nitrogen

Ammonium-N in sediments indicates recent nitrogen input and the early stages of organic matter decomposition. High concentrations can result from nutrient-rich discharges and anaerobic conditions.

The highest concentrations were recorded at effect Sites F and C (13 mg/kg dry weight), followed by the reference Site E (8 mg/kg). Site G recorded the lowest value (6 mg/kg).

The elevated ammonium at both F and C indicates that organic enrichment from the discharge continues to influence nitrogen dynamics downstream. The relatively low value at Site G again highlights site-specific variation, possibly due to flushing, lower sedimentation rates, or better oxygenation.

3.3.5 Total Recoverable Phosphorous

Total Recoverable Phosphorus (TRP) in sediments reflects long-term phosphorus accumulation and can act as a reservoir for future phosphorus release under anoxic conditions. High TRP is a legacy indicator of enrichment and eutrophication risk.

In 2025, TRP was lowest at the reference Site E (490 mg/kg dry weight). Substantially elevated concentrations were recorded at all effect sites, with the highest at Site F (1,810 mg/kg), followed by Site C (1,110 mg/kg) and Site G (560 mg/kg). This spatial trend reflects a strong influence of the farm pond discharge, with phosphorus inputs settling near the outfall (Site F) and gradually declining downstream.

3.4 Biological Survey

3.4.1 Macroinvertebrates

Macroinvertebrate results are presented in Table 4 and Figure 9 and Figure 10.

Macroinvertebrate diversity (taxa richness) varied considerably. The highest richness (18 taxa) occurred at headwater reference sites A and H, while the lowest (5 taxa) was recorded at Site F, immediately downstream of the discharge pond. Richness increased downstream in the Te Puru Stream tributary, reaching 13 taxa at Site G and 12 taxa at Site C.

With the exception of reference sites, communities were dominated by the freshwater snail *Potamopyrgus antipodarum*, comprising 43 % at Site E, 94 % at Site F, 61 % at Site G, and 59 % at Site C. In contrast, Site A was dominated by the freshwater amphipod *Paracalliope fluviatilis* (78 %), while Site H was dominated by the caddis fly *Triplectides obsoleta* (41 %).

Total abundance was highest at the lower tributary sites (12,022 individuals at Site G; 10,294 at Site C), again dominated by snails and amphipods. The lowest abundance occurred at Site H.

With the exception of Site H, where EPT taxa comprised 42% of the macroinvertebrate population, the percentage of EPT was very low at all other sites, each recording less than 10%. No EPT taxa were noted at Site F (effect site downstream of the farm pond). At effect Sites G and C, located further downstream, EPT taxa were present but their contribution was negligible (0% or near 0%).

MCI scores were highest at reference site A indicating 'Good' quality habitat (Stark & Maxted, 2007b), with reference sites H and E falling within 'Fair' quality habitat. The MCI score dropped to 67.6 at effect Site F ('Poor' habitat quality) and increased at Site G (75.4) but remained in 'Poor' habitat quality. The MCI score increased at the most downstream effect site (Site C) to be in the 'Fair' habitat quality band. The 'fair' habitat quality scores on the reference tributary may have been influenced by low water levels and potentially a lack of aquatic habitat during the driest summer months, or the agricultural catchment inputs as observed in the other biomonitoring metrices (as described above). Only the MCI score of the most upstream reference site (Site A, located immediately downstream of a forested catchment) is above the AUP guideline value (94).

The Scores Quality Macroinvertebrate Community Index (SQMCI), which considers the relative abundance of taxa as well as the MCI score, was highest at the most upstream reference site on the farm pond tributary (Site A – 5.9) which falls in the 'Good' habitat quality band. Reference sites H and E on the reference tributary, as well as effect site G all had an SCMCI that fell in the 'Fair' habitat quality band. Effect Site F, the first effect site below the farm pond, had the lowest SQMCI score, falling in the 'Poor' habitat quality band, however the lowest effect site, Site C, also fell in the 'Poor' habitat quality band, due to the dominance of low scoring snails.

The presence of large macroinvertebrates, kōura (freshwater crayfish) and kākahi (freshwater mussels) were recorded. Kōura were recorded as present at reference Sites A, H and E, plus effect site C, and are therefore likely to be present in low numbers through the entire tributary. No live kākahi were recorded but shells were observed at Sites H and E (Photo 11 and Photo 12).

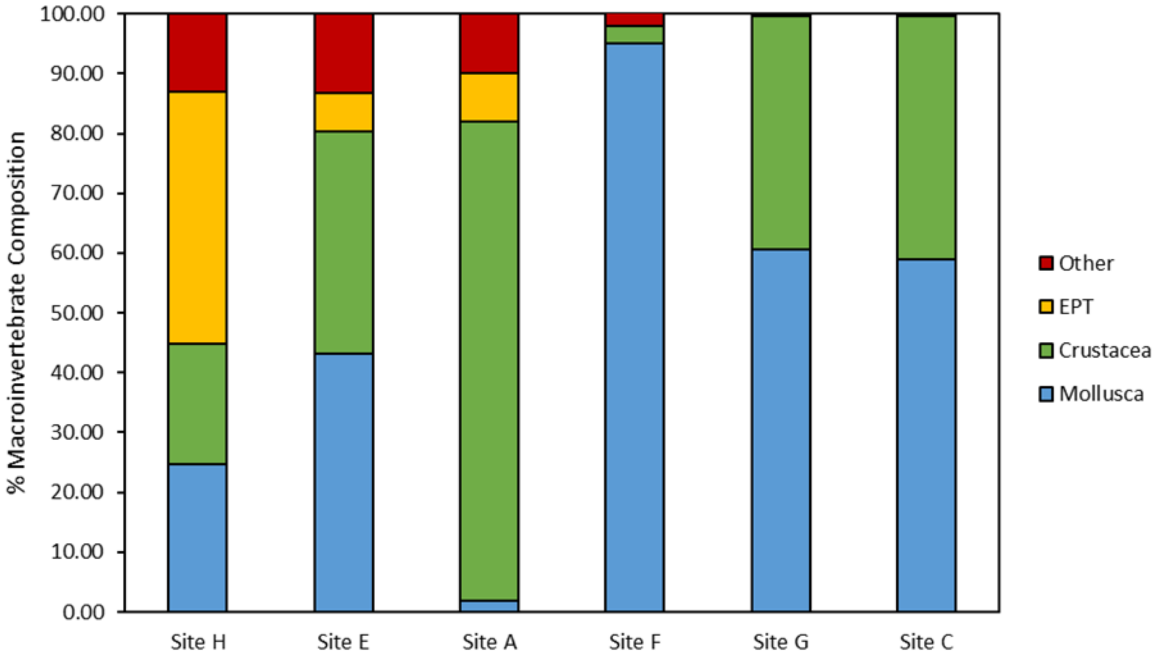

Figure 9. The percent composition of macroinvertebrate taxa at each Te Puru site.

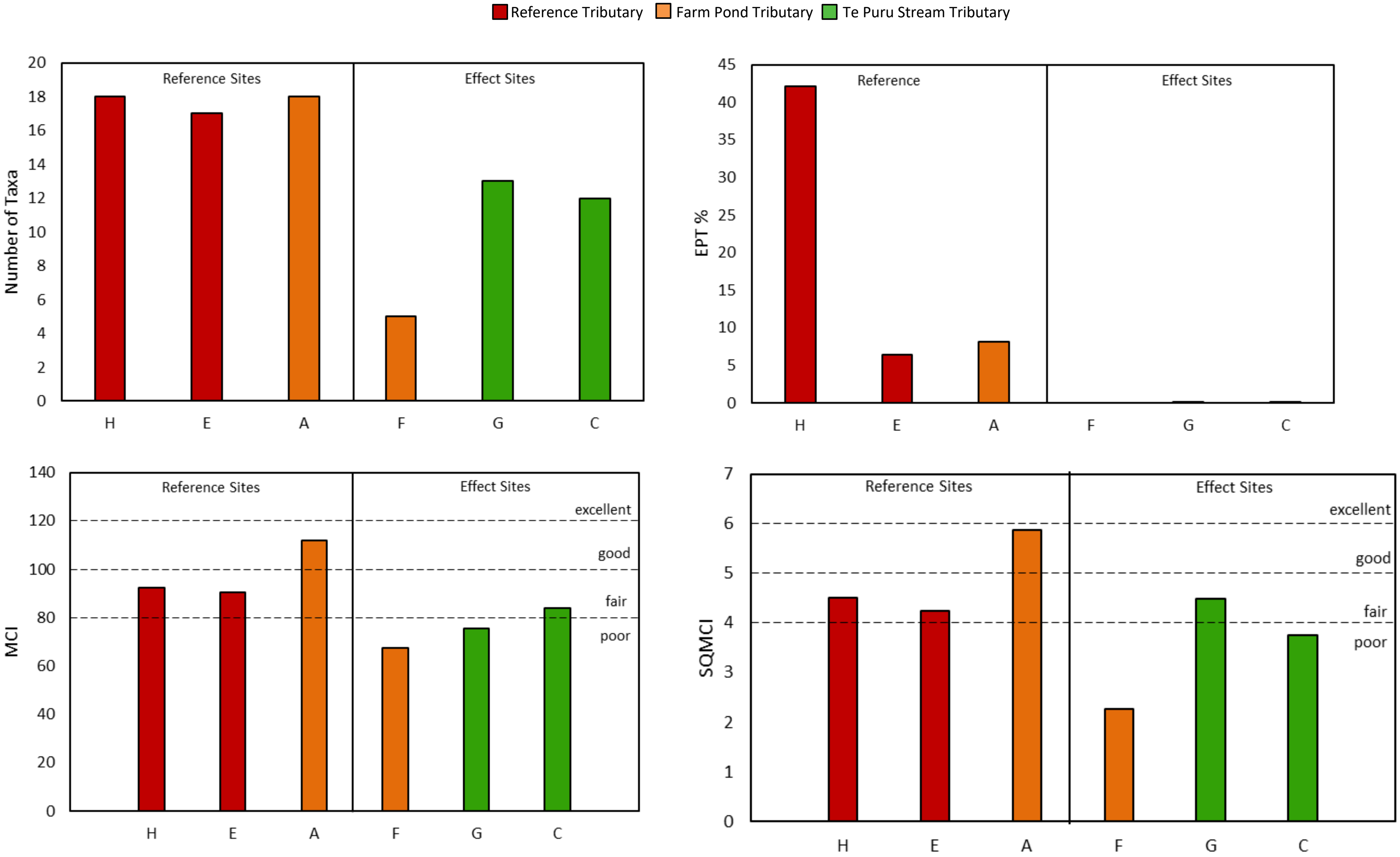

Figure 10. Macroinvertebrate community results – number of taxa, EPT%, MCI and SQMCI.

3.4.2 Freshwater Fish

Fish species were sampled using electric fishing and Gee minnow traps at the three reference sites (Sites H, E, and A). Native fish species diversity and abundance were relatively high across these sites, with Site A recording the highest number of individuals (23), followed by Site E (22) and Site H (20). Four native species were recorded at Site E and H, with three native species recorded at Site A.

At Site H, the community was dominated by banded kōkopu (*Galaxias fasciatus*, 14 individuals), along with common bully (*Gobiomorphus cotidianus*, 3), redfin bully (*Gobiomorphus huttoni*, 2), and kōura (*Paranephrops planifrons*, 1). Site E had a high number of common bully (16), along with longfin eel (*Anguilla dieffenbachii*, 3), banded kōkopu (1), and kōura (2). Site A was characterised by high numbers of banded kōkopu (12) and kōura (10), with single individuals of shortfin eel (*Anguilla australis*) also recorded.

Electric fishing could not be undertaken at reference site E, and at sites downstream of the farm pond (Sites F, G, and C) due to elevated electrical conductivity; therefore, fyke nets and Gee minnow traps, and a hand netting were used. Site F had the lowest diversity and abundance, with only one shortfin eel recorded. Site G had three native species: banded kōkopu (10), shortfin eel (1), and longfin eel (1), totalling 13 individuals. Site C had the highest number of individuals across all sites (28) and the greatest diversity, with five native species present: longfin eel (3), banded kōkopu (6), common bully (17), redfin bully (1), and kōura (1).

Fish IBI scores reflected patterns in species richness and composition. Sites H, G, and C received scores of 42, 42, and 44, respectively, corresponding to a 'Very Good' rating (Joy & Henderson, 2004). Sites E and A scored 34 and 32, both rated as 'Fair'. Site F, with just a single individual recorded, had an IBI score of 14, rated as 'Very Poor'.

These results highlight strong native fish communities at reference sites and at downstream Site C, with reduced diversity and abundance immediately below the pond (Site F), likely reflecting habitat or water quality constraints.

Table 7. Fish previously recorded in the Te Puru Stream catchment, from the New Zealand Freshwater Fish Database (NIWA, sourced February 2025).

Genus	Scientific name	Common name	Number of Records	Year sampled*:
Galaxias	*fasciatus*	Banded kokopu	38	1997, 1998, 2001, 2002, 2005, 2010, 2016, 2022, 2024
Galaxias	*maculatus*	īnanga	4	2001, 2005
Gobiomorphus	*cotidianus*	Common bully	45	1991, 1997, 1998, 1999, 2001, 2002, 2005, 2010, 2016, 2019, 2022, 2024
Gobiomorphus	*basalis*	Crans bully	1	1991
Gobiomorphus	*huttoni*	Redfin bully	6	1998, 2005, 2016, 2019
Anguilla	*unidentified*	unidentified eel	17	19971999, 2002, 2005, 2010, 2022
Anguilla	*australis*	shortfin eel	43	1991, 1997, 1998, 1999, 2002, 2005, 2010, 2019, 2022, 2024

Genus	Scientific name	Common name	Number of Records	Year sampled*:
Anguilla	*dieffenbachii*	longfin eel	18	1991, 1997, 1998, 1999, 2002, 2005, 2010, 2016, 2022, 2024
Echydridella	*spp.*	freshwater mussel	5	2005, 2016
Paranephrops	*spp.*	kōura	30	1997, 1998, 1999, 2002, 2005, 2010, 2016, 2022, 2024
Paratya	*curvirostris*	Freshwater Shrimp	11	1991, 2002, 2005, 2016

*This column provides the listed years in which the corosponding species were sampled based on the recorded data available from NIWA. Those higlighted in red, have not since the listed date been recorded.

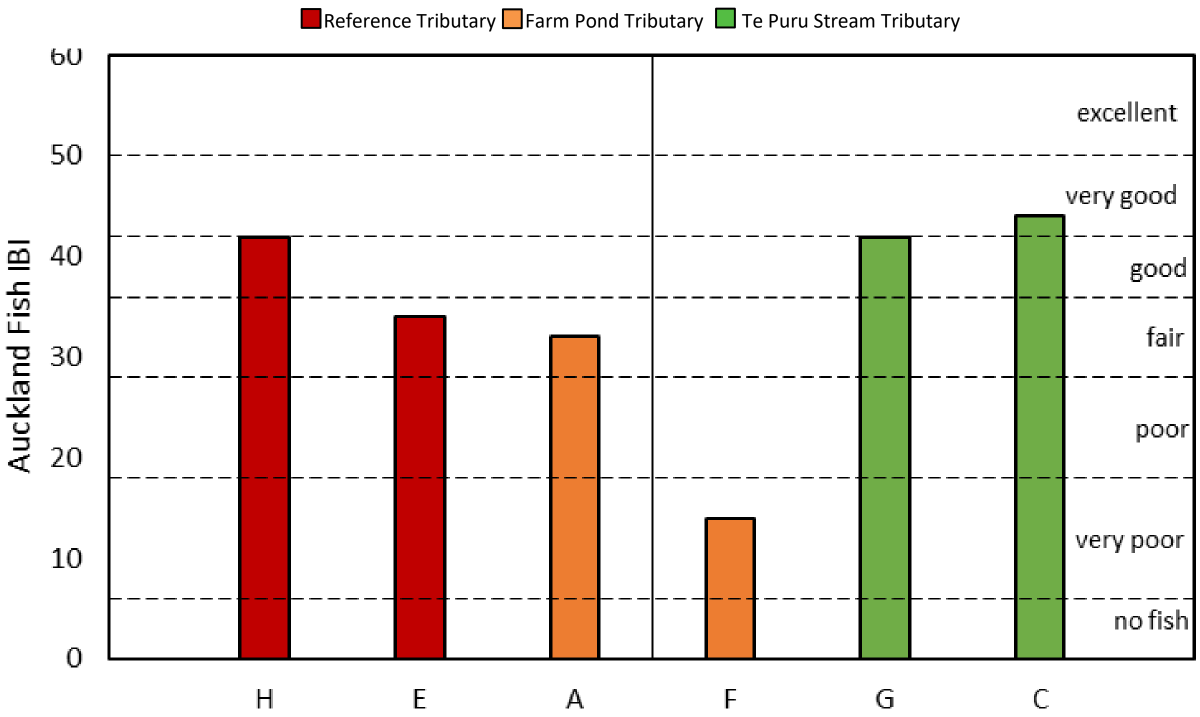

Figure 11. Auckland Fish IBI scores for sites on the Te Puru Stream Tributaries.

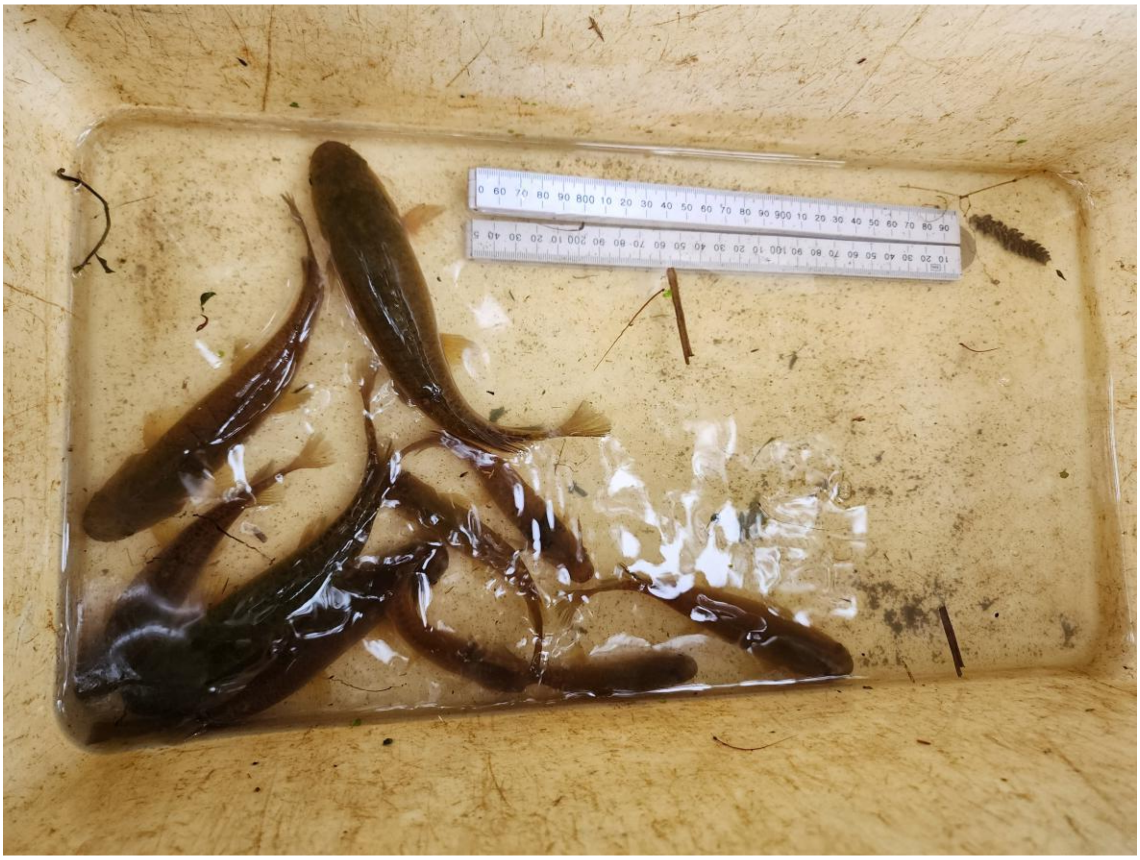

Photo 11. Various large banded kōkopu captured at Site A

Photo 12. Longfin eel captured at Site E

3.4.3 Macrophytes

Macrophyte diversity and cover generally increased with distance downstream. Reference sites (Sites H and A) exhibited the lowest percentage cover, with total macrophytes comprising just 1.33 % and 5.63 % of surveyed habitat, respectively. Both these sites only hosted two or three species of macrophytes (such as watercress, duckweed and/or water celery). The highest macrophyte cover was observed at Site C (55.25 %, attributed to the presence of water celery), followed closely by Sites S3 (31.08 %) and G (28.93 %), both can be attributed to the coverage of duckweed, all situated downstream of the discharge point.

Filamentous algae were also widespread, with the highest coverage recorded at Site G (70.83 %) and Site S3 (68.33 %), both attributed due to the high coverage of Nitella. Site E (a reference site) displayed notably high algal cover as well (63.75 %, Nitella). In contrast, reference Site A had the lowest algal cover (3.33 %), and Site H recorded 10.83 %. At sites G, S3 and C, the algae was present on the macrophytes, hence the overall high coverage at these sites.

This distribution suggests that macrophyte and algal proliferation increases in downstream reaches (Table 8), likely due to a combination of reduced shading, elevated nutrient concentrations, and slower water velocities. The sites downstream of the farm pond (F, S2, G, S3, and C) generally showed much greater vegetative cover than the reference sites, with three of those sites (G, S3, and C) recording macrophyte and algae cover exceeding 75 %. Site C had the highest combined vegetative cover. Nitella accounted for the highest percent cover among plant species, followed by duckweed and water celery (Figure 12).

Table 8. Average percent cover (n=12) and standard error (S.E.) at each site of macrophytes, algae and bare substrate.

Site	Total Macrophytes (%)		Total Algae / Iron Floc (%)		Bare Substrate (%)	
	Mean (n = 12)	S.E.	Mean (n = 12)	S.E.	Mean (n = 12)	S.E.
H	1.33	± 1.33	10.83	± 3.68	87.83	± 3.57
E	2.63	± 1.27	63.75	± 11.58	33.63	± 12.1
A	5.63	± 3.14	3.33	± 2.49	91.04	± 3.55
F	5.33	± 2.68	17.92	± 3.75	76.75	± 5.6
S2	6.96	± 2.25	55.00	± 11.5	38.04	± 13.15
G	28.93	± 9.33	70.83	± 8.46	0.24	± 7.14
S3	31.08	± 9.21	68.33	± 12.53	0.58	± 10.26
C	55.25	± 11.12	46.08	± 13.04	8.04	± 6.56

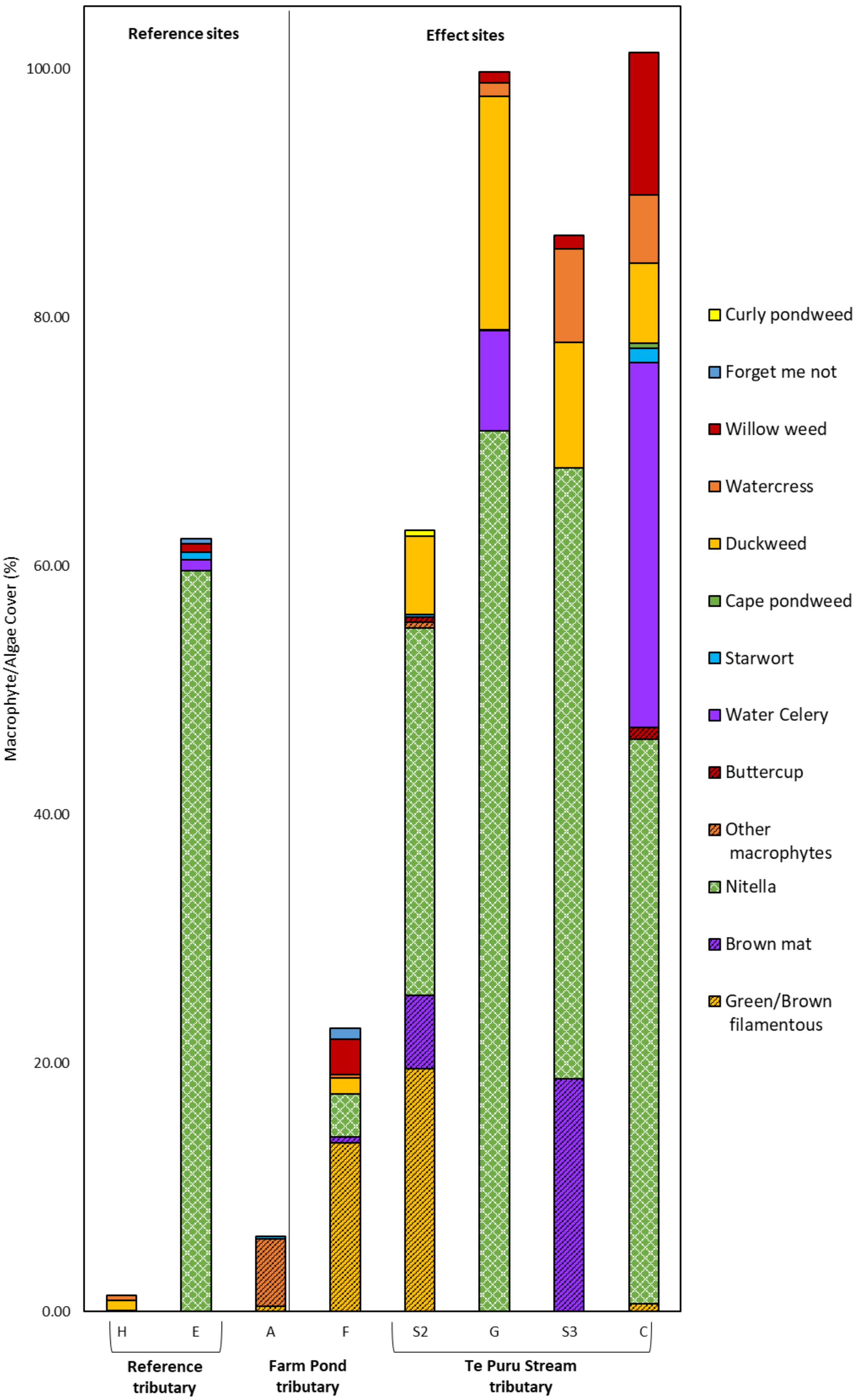

Figure 12. Macrophyte and algae % cover by species for the Te Puru Stream Tributaries

3.5 Comparison with 2024 Survey

The results of the 2025 study at Te Puru were compared to the same study carried out in 2024 (Bioresearches 2024). Results that appeared to deviate substantially from the 2024 survey or results that changed in regard to the current guideline value are summarised below. All 2025 data are visually compared to the 2024 data in Appendix 6.

3.5.1 Water Quality:

- Dissolved Oxygen (DO): DO concentrations increased markedly at most sites. The largest increases occurred at Sites F (+4.28 mg/L), G (+3.91 mg/L) and C (+3.76 mg/L), indicating enhanced oxygen availability downstream. All sites exceeded the 5.0 mg/L guideline, with Sites B, G, and C exceeding 9.0 mg/L, suggesting improved aeration or reduced organic loading.
- Oxygen Saturation: Oxygen saturation levels improved at all sites except Site E (−2.2 %). The most significant increases were at Sites B (+17.7 %) and G (+35 %). These rises may indicate increased photosynthetic activity or better re-aeration, although values above the 100 % threshold (Sites B and G) suggest possible algal activity.
- Conductivity: Conductivity trends between 2024 and 2025 displayed a mixed pattern across the Te Puru catchment. Most notably, reference Site E increased substantially, from 162 to 1124 µS/cm — a 594 % rise. In contrast, the other reference site (Site A) experienced a minor decrease (−9 %), maintaining relatively low conductivity. Effect sites immediately downstream of the discharge (Sites B and F) exhibited moderate decreases in conductivity (−13 to −14 %). However, conductivity increased again at downstream effect sites (Sites G and C), indicating potential downstream accumulation or additional inputs. These changes suggest spatially variable shifts in water chemistry.
- pH: Minor changes in pH were noted across sites, all remaining close to or within guideline ranges. Site A increased slightly from 7.1 to 7.4, while other sites varied by minor decimal values, maintaining circumneutral conditions throughout.
- Total Suspended Solids (TSS): TSS levels increased sharply at Site A (from 6 to 81 g/m³), suggesting possible localised erosion, disturbance or agricultural inputs. Effect Site B increased slightly (+2 g/m³), while Sites F and 15 saw reductions. Downstream Sites G and C remained below detection limits, indicating improved settling or reduced inputs.
- Total Ammoniacal Nitrogen (TAN): Total ammoniacal nitrogen levels showed moderate changes across the catchment from 2024 to 2025. At the reference sites, Site E remained low and stable, while Site A increased by nearly 50 % from 2024 to 2025. Effect sites showed a mixed response. Site B — directly below the discharge pond — showed a slight reduction (−8 %) but remained the highest overall. However, Site F exhibited a substantial increase (+98 %) from 2024 to 2025, and Site 15 also rose significantly (+77 %), suggesting enhanced nutrient input or reduced attenuation in midstream areas. By contrast, Sites G and C remained stable and low, indicating that nitrogen enrichment is largely confined to the upper to midstream effect sites, with effective dilution or assimilation occurring further downstream.
- Total Nitrogen: Total nitrogen concentrations in 2025 were substantially higher than in 2024 across all sites, including both reference and effect locations. Reference sites increased by 39 to 68 %, while effect sites experienced rises of 57 to 115 %. In 2025, similar to 2024, the highest concentrations were observed at Sites B (5.7 g/m³) and F (5.5 g/m³), consistent with their proximity to the farm pond discharge. Downstream, levels remained elevated at Sites 15, G, and C - indicating that nitrogen enrichment extends throughout the system.

- Nitrate and Nitrite: In 2025, the combined nitrate and nitrite nitrogen concentrations rose sharply across all effect sites compared to 2024, mostly attributable to the Nitrate-N concentrations. The most dramatic increases occurred at Sites G and C, while upstream effect Sites B and F also showed marked rises. Nitrite concentrations remained well below toxicity thresholds but increased slightly in 2025 compared to 2024 at downstream sites (e.g. Site 15 and C), with small declines at Sites B, F and G. Notably, Site A, a reference site, recorded a significant increase in nitrite-N in 2025 compared to 2024.
- Total Kjeldahl Nitrogen (TKN): TKN increased at all sites in 2025 compared to 2024, particularly at effects Sites 15 and G, reflecting elevated organic nitrogen and ammonium.
- Dissolved Inorganic Nitrogen (DIN): DIN concentrations were consistently higher in 2025, at all sites except for Site E. Site B had the highest increase in 2025, followed by Site F reinforcing the pattern of increased bioavailable nitrogen downstream of the discharge pond.
- Total Phosphorus: In 2025, total phosphorus concentrations decreased at most effect sites compared to 2024, particularly at Sites B (−20%) and F (−13%). At the reference sites, Site A experienced a large increase (+214%) in total phosphorus, from 0.029 to 0.091 g/m³ — the most pronounced change across the dataset.
- Dissolved Reactive Phosphorus (DRP): DRP remained elevated at effect sites in 2025, though some reductions were observed in comparison to 2024: Site B dropped the most, from 0.51 to 0.4 g/m³. DRP increased minimally at both reference sites in 2025 compared to 2024.
- Faecal Coliforms: In 2025, faecal coliform concentrations increased across all monitoring sites, with the largest rise observed at reference Site A (a 382% increase from 2024 to 2025), followed by effect Site B (a 270% increase from 2024 to 2025).
- Enterococci concentrations in 2025 showed a mixed response across the various sites. A substantial reduction was recorded at reference Site E, which decreased by 75 % in 2025 compared to 2024. Site A remained unchanged. Among the effect sites, Site B experienced a 148 % increase in 2025. Downstream, trends were variable: Sites F, 15, and G saw decreases, while Site C increased sharply (+67%).

3.5.2 Sediment Quality:

- Dry matter increased at all sites from 2024 to 2025 (between 1% to 25 %)
- Total carbon concentrations in sediments varied between 2024 and 2025. The reference site (E) showed an increase of 27 %. In contrast, the effect sites F and G both recorded significant reductions (−33 % and −59 %, respectively) in 2025 compared to 2024, while a significant increase was noted at Site C (+ 122 %) in 2025.
- Total Nitrogen: Reference Site E increased by 42 % in 2025, while effect Sites F and G saw reductions of 23 % and 55 %, respectively. However, the most downstream site, Site C, recorded a 100 % increase in comparison to 2024.
- The C:N ratio generally declined between 2024 and 2025, with reductions at Sites E (−10 %), F (−13 %), and G (−8 %). In contrast, Site C saw an increase from 13.5 to 15.0 (+ 11 %).
- Ammonium-N decreased across all sites in 2025 compared to 2024, with the most significant drop recorded at Site F, which fell by 91 %. Reference Site E also declined markedly (− 67 %) in 2025. Downstream effect sites G and C saw more moderate reductions.
- Total Recoverable Phosphorus (TRP): TRP decreased significantly at Site F (from 2,000 to 1,810 mg/kg) and Site G (from 1,210 to 560 mg/kg) but increased at Site C (from 800 to 1,110 mg/kg). These trends support ongoing phosphorus accumulation in the lower catchment.

- Total recoverable phosphorus (TRP) concentrations in sediments showed mixed changes from 2024 to 2025. The reference site E increased by 29 %. Among the effect sites, Site F (closest to the farm pond) decreased slightly (−10 %), while Site G showed the largest reduction (−54 %). In contrast, the downstream site C recorded a substantial increase (+39 %).

3.5.3 Biological Surveys:

- Changes in macrophyte diversity between 2024 and 2025 were mixed across sites. In 2025, diversity increased at reference Site H (+2 species), and at two effect sites: Site S2 (+3 species), and Site C (+2 species), but macrophyte diversity was unchanged at Sites A and F. Declines were recorded at reference Site E (−2 species), and at two effect sites: Site G (−3 species), and Site S3 (−1 species). Overall, the monitoring sites across the Te Puru Stream tributaries shows a small net gain of one species across all sites from 2024 to 2025.
- Macrophyte coverage generally increased across most sites between 2024 and 2025. Substantial increases were observed at effect Site S2 (+615%), reference Site E (+484 %), and reference Site H (+139 %). In contrast, effects Site F was the only location to show a decline in macrophyte coverage, decreasing by 45 % compared to 2024. These results indicate a widespread upward trend in coverage across the monitoring sites of the Te Puru Stream tributaries, with only one site (Site F) experiencing a reduction.
- Fish diversity generally increased across most sites between 2024 and 2025. The largest increase was observed at the lowest effect site, Site C (+4 species), followed by increases at Sites E and G (+3 species each), and Sites F and H (+2 species each). Site A (reference site on the pond tributary) was the only site to record a decline, with diversity decreasing by 1 species compared to 2024. Overall, the results indicate a positive trend in fish diversity across the majority of sites in 2025.
- Between 2024 and 2025, the MCI scores varied. In 2025 three sites improved: Site A (+7.1), remaining in the good habitat quality band; Site F (+4.27), remained in the poor habitat quality band; and Site C (+16.5), lifting from the poor habitat quality band to the fair habitat quality band. The other three sites declined (Site H (−9.11), dropping from the good to fair habitat quality band; E (−7.59), staying in the fair habitat quality band; and Site G (−6.28), sliding from the fair to poor habitat quality band). SQMCI patterns were similar but with smaller changes overall. Slight decreases were recorded at most sites, except for Site F. The SQMCI at Site A decreased from the excellent habitat quality band (6.01) to good (5.87). F showed a small improvement (+0.12) but remained in the poor habitat quality band, while C experienced the largest decline (−1.09), falling from the fair habitat quality band (4.83) to poor (3.74). Using Stark & Maxted (2007b) thresholds, these results suggest a slight overall decline in habitat quality between 2024 and 2025, with notable category changes for Sites H, G, and C in MCI, and a drop for Site C in SQMCI.

4. DISCUSSION

4.1 Summary

This survey of the upper Te Puru Stream catchment, undertaken on behalf of Watercare Services Limited, provides a comparative study of water quality and biological conditions both upstream and downstream of the Beachlands wastewater treatment plant (WWTP) discharge point. This report presents the findings from the April 2025 monitoring period, analysing the effects of the highly treated effluent discharge on the water quality and biology of the receiving waters, a tributary of the Te Puru Stream. Overall, the water quality and biological health of the Te Puru Stream tributaries were generally indicative of poor freshwater conditions, which is partly attributed to the pastoral land use dominating the surrounding catchment.

Consistent trends were observed across multiple monitoring surveys, showing that water quality and biological parameters were often at their poorest at sites immediately downstream of the discharge pond. While some parameters showed recovery with increasing distance downstream, others, such as conductivity and nutrients, remained elevated even at the lowest surveyed sites

4.1.1 Physical characteristics

The diversity of substrate types was highest at reference Site H, which consistently exhibited bedrock as dominant, with cobbles and gravels also common, and some silt loading present. In contrast, silt was recorded as the only substrate type at effect sites close to the discharge pond. An increase in gravel abundance was evident at sites further from the discharge. Observed at all sites in 2025 were sediment plumes in the water whenever the stream bed was disturbed. The silt dominance at both reference and effect sites reflects the pastoral catchment. The increase in soft substrate downstream of the discharge is likely the result of fine material, algae, and sediment being retained in the farm pond and released during high flow to settle at nearby sites.

The width and depth of the stream varied between each site, with the stream generally flowing in incised, vertical banks with good access to the floodplain. Notably, no significant changes to the embankment structure/condition at the various sites were observed and the incision noted is considered normal in comparison to previous monitoring occasions. Since the previous monitoring occasion in 2024, Site A currently reflects a predominantly wetland habitat, with the stream transitioning into small and shallow braided channels over the floodplain at the sampling site.

Instream flow rates varied at the reference sites, with Site E having a relatively slow rate in comparison to the downstream sites (G, S3, and C). The volume of water discharged from the farm pond forms a significant proportion of the stream flow. Riparian vegetation extent and shading also varied between sites. Reference sites typically had riparian vegetation dominated by native trees and shrubs, resulting in higher shading in the upper stream. Downstream, vegetation and shading generally decreased as the Te Puru Stream Tributary flowed through pasture.

4.1.2 Water quality

All reference sites had temperatures indicative of ‘good’ stream health (15°C to 19.9°C) (Biggs *et al.* 2002), with the effects sites all having temperatures indicative of ‘good’ and ‘fair’ stream health (20 to 24.9°C). A marginal increase in temperature was noted at the sites directly downstream of the discharge across all previous surveys, attributed to the low shading and summer heating of the water in the farm pond. The temperature of the most downstream site (Site C) in 2010, 2016, and 2019 was similar to that of the reference tributary site (Site E) or upper reference sites. In 2024 and 2025, Site C temperatures were still lower than the immediate effect sites, but generally higher than Site E. The 2024 survey noted that water temperatures were taken during the peak of summer (25-29°C ambient), while previous monitoring was often in cooler autumn months, which likely influenced the higher overall temperatures recorded.

Conductivity levels have consistently been very high at all effect sites across all surveys. They have consistently exceeded ANZECC (2000) or ANZG (2018) guideline values, even at reference sites, suggesting wider catchment enrichment, as well as saline inputs from the discharge. The levels recorded in 2016, 2019, 2022, and 2024 at effect sites were at least 1000 µS/cm higher than the highest conductivity recorded in 2002 or 2010. This indicates a very high concentration of dissolved ions downstream of the WWTP. However, at Site E in 2025, a reference site, also showed a substantial increase from 162 µS/cm in 2024 to 1124 µS/cm. Following the 2016 survey, investigations were recommended to determine the source of these elevated levels, and network repairs near the coastal management area resulted in a decrease in conductivity in 2019. However, increases in conductivity were again recorded in 2019, 2022, and 2024, indicating likely infiltration through the network. Further repairs were conducted to remove saltwater intrusion, resulting in a decrease in conductivity in 2024. Despite this, conductivity at effect sites in 2025 remained high. The noted enrichment at the reference sites is likely attributed to nutrient runoff from the surrounding pastoral landscape.

Dissolved oxygen concentration and saturation has always varied between the sites, with no clear trend emerging when compared between the various monitoring periods. Both reference sites and effect Site 15, failed to meet the stringent ANZECC 2018 oxygen saturation (%) guidelines. Reference Sites A and E last met the guideline value in 2019. In comparison, most sites have historically almost all met the national bottom line value of 5 mg/L (NPS-FM), with the exception of Sites B and F in 2002, and Site F again in 2024. In general, the dissolved oxygen concentration of most sites is within attribute bands B and C of the NPS-FM.

Over the collective monitoring series, chlorophyll α was predominantly measured below the lower detection limit (< 0.003 g/m^3) at most sites. The recent exception to this is the site directly downstream of the discharge pond (Site B) during both 2024 and 2025. The concentration of chlorophyll α of all sites has always been below the lower guideline value (MfE, 2020). The higher levels of chlorophyll-α at Site B in 2024 and 2025, in comparison to all other sites, were attributed to the influence of photosynthetic activity in the pond itself, with large amounts of algae observed. These findings were similar to those from the previous surveys (Bioresearches, 2002, 2010, 2016, 2019, 2022, and 2024).

Total suspended solids (TSS) has always been typically low, generally varying between 3 g/m^3 to 7 g/m^3, with higher levels (between 9 and 20 g/m^3) recorded at selective sites, with no obvious or consistent patterns noted, with the exception of Site B, which tend to generally have a higher TSS than the other sites (attributed to turbidity from the pond), but an immediate reduction in TSS is always noted at Site F, located below the discharge. Over the last three monitoring periods (2022, 2024, and 2025), reference Site A has also been indicating elevated TSS, with the highest TSS on record in 2025.

Visual clarity at all sites had worsened since 2016, with some improvement noted since then (especially at Site C), however has not been able to reach the same clarity levels as at 2016. Visual clarity levels are similar to that of 2019 and 2022 where only one or two sites met the ANZECC DGV. As TSS affects visual clarity, the relatively high TSS at some sites relates to poor visual clarity. It's unclear why the TSS varied; however, it may potentially be prescribed to the ongoing land use changes (specifically noting the change at the upstream reference site), potentially due to erosion (increased stock rates) within the larger catchment.

Levels of pH fell within the ANZECC (ANZG, 2018) values at all sites and fell within the 'excellent' to 'fair' range for New Zealand stream health monitoring (Biggs *et al*. 2002) that would maintain stream life.

Carbonaceous biochemical oxygen demand (BOD^5/$cBOD^5$) levels were consistently low across all surveys, often below detection limits at both reference and effect sites, indicating an absence of significant organic pollution and a low risk of sewage fungus proliferation

High bacterial indicators were found both above and below the discharge pond, but tend to vary at each site, with no obvious trends emerging. These bacteria are found in the gut of warm-blooded animals and are indicators of faecal contamination. High bacteria levels both above and below the discharge pond likely reflect the pastoral catchment, where stock come in close proximity to water bodies, and the large population of water birds present in the discharge pond. The treatment plant discharge was not considered to be having any major effect on bacterial contamination of the Te Puru Stream (considering similarly high amounts upstream and downstream of the discharge).

Although the faecal coliforms at all sites in 2025 increased, when compared to 2024, it is still lower than the peaks recorded in 2019 and 2022, with the exception of Site A, which recorded the highest concentrations from any of the biomonitoring surveys in 2025. The overall high concentrations of faecal coliforms may be attributed to farming practices and the number of livestock within the catchment at the time of monitoring. The bacterial contamination could be bovine (from the stock) and/or avian (from the significant number of birds on the pond).

All nitrogen components (total ammoniacal nitrogen, total nitrogen, nitrate, nitrite, total Kjeldahl nitrogen, and dissolved inorganic nitrogen (DIN)) typically followed a consistent pattern: levels were low at reference sites, elevated immediately downstream of the farm pond, and then generally decreased with increasing distance downstream.

Total ammoniacal nitrogen (Ammonia) levels, a toxic pollutant often found in waste products such as sewage and dairy effluent, while elevated below the discharge, consistently remained below site-specific toxicity guidelines derived for the Te Puru Stream by Hickey (2001) during all monitoring events. Ammonia levels were significantly lower in 2016 compared to previous surveys (1998, 2002, 2010). However, in 2019, they showed substantial increases at effect sites compared to 2016, returning to levels comparable to 2010. In 2022, ammonia levels increased again at reference sites and Site B, but decreased at downstream effect sites, while in 2024, they significantly decreased at all sites compared to 2022, reaching their lowest levels since 2002 at some sites (E, F, S15). Despite fluctuations, all sites in 2025 remained within MfE (2020) 95% species protection guidelines for ammoniacal nitrogen. As concluded in the previous monitoring surveys, the elevated nitrate levels were likely to have influenced the similarly elevated total nitrogen levels downstream of the discharge, as well as the high dissolved inorganic nitrogen, which are readily bioavailable. Elevated nitrogen values at both reference and effect sites indicate some influence from land use practices; however, the very high levels seen downstream of the farm pond indicate amplified nutrient enrichment caused by the wastewater discharge. Nonetheless, all levels were lower than the site-specific banded kōkopu protection guideline values (Hickey, 2001).

Over the last three monitoring occasions (2022, 2024 and 2025), the total nitrogen at the effect Sites B, F and 15 exceeded site-specific toxicity guidelines derived for the Te Puru Stream by Hickey (2001), but in 2025, it was also the first time that the other two effects sites (Site G and C) also exceeded this level. However, the total nitrogen levels have always remained fairly stable at reference sites, except for Site A in 2002.

Dissolved inorganic nitrogen (DIN), considered to be one of the key nutrients promoting periphyton growth, has consistently been substantially higher at effect sites than reference sites, indicating its readily bioavailable nature. While DIN levels immediately below the farm pond were much lower in 2016 and 2019 compared to 2002 and 2010, they were, however, elevated again in 2022 and 2024, and notably higher in 2025. Elevated nitrogen levels at both reference and effect sites generally indicate an influence from land use practices, which is amplified downstream of the farm pond discharge.

Phosphorus (both total and dissolved reactive) consistently showed a pattern of elevation below the discharge, and despite decreasing concentrations with distance downstream, levels did not return to concentrations comparable to reference sites. Across all surveys, total phosphorus and dissolved reactive phosphorus (DRP) levels consistently exceeded ANZECC (2000) or ANZG (2018) guidelines at almost all sites, including reference sites. In 2016, phosphorus results were much lower than the previous 2010 survey (which was similar to 2002), but still showed the same pattern of elevated levels below discharge. In 2019, total phosphorus decreased by approximately half at all effect sites compared to 2016, and DRP also decreased significantly. However, in 2022, total phosphorus increased again at all effect sites (29-71% higher than 2019), and DRP was slightly elevated compared to 2019. In 2024, phosphorus levels were similar to slightly elevated compared to 2022 but substantially less than 2002 and 2010. Approximately 50-60% (2019), 67-77% (2022), and 73-78% (2024, 2025) of the total phosphorus recorded at effect sites comprised DRP, indicating the high bioavailable form. All effect sites have consistently exceeded the NPS-FM attribute D (national bottom line) for total phosphorus and DRP over all monitoring periods.

4.1.3 Sediment quality

Sediment quality results showed the concentration of carbon, nitrogen (total nitrogen and ammonium), and phosphorus were elevated below the farm pond when compared to reference sites, then decreased at downstream sites, a general trend throughout all surveys (2002 - 2025). Total carbon, total nitrogen, and the C:N ratio at Site G decreased to concentrations similar to or slightly higher than the reference site, and were comparable for the phosphorus parameters. These parameters are similar or slightly higher/lower at Site C (the most downstream site), indicating further nutrient input from the surrounding pasture near the most downstream site.

Carbon to nitrogen ratios (C : N) can give an indication of whether the source of organic matter input is from vascular land plants or non-vascular (e.g., algae) plant material. Algae typically have atomic C : N ratios between 4 and 10, whereas vascular land plants have C : N ratios of 20 or more (Premuzic *et al*. 1982; Jasper and Gagosian 1990). The C : N ratios were highest at Site E in 2024 and 2025 and decreased with distance downstream, indicating more organic material came from algal sources than land sources downstream of the reference site. Apart from the markedly high C:N ratio at Site C in 2022, and the lowest ratio recorded in 2010 (at Site E – 7.7), all other ratios are within the measured range between 2002 and 2025.

4.1.4 Biological aspects

Macrophyte and algal cover differed between reference and effect sites. Downstream of the farm pond, percent cover of macrophytes and algae increased, accompanied by greater aquatic plant diversity—a general trend observed since 2002. This increase in abundance and diversity reflects both reduced riparian vegetation and shading, as well as higher levels of bioavailable nutrients (dissolved inorganic nitrogen and dissolved reactive phosphorus) at the effect sites. Species composition also differed: Nitella algae were present at most effect sites, often forming the largest proportion of cover. In addition, filamentous algae were more prominent in 2024 and 2025 than in 2022.

Macroinvertebrate communities displayed consistent patterns across the survey sites. Biotic indices — including number of taxa, %EPT, MCI, and SQMCI — were consistently lower at effect sites than at reference sites. Site F, immediately downstream of the discharge, recorded the lowest scores for all indices since 2019 and was classified as ‘poor’ for both MCI and SQMCI. At Sites G and C further downstream, the number of taxa, MCI, and SQMCI values improved relative to Site F, but they remained below those recorded at the reference sites. EPT taxa were scarce across all sites, with the exception of Reference Site H where values were higher. At the other reference sites, %EPT was typically less than 20% at Site A and less than 7% at Site E. At all effect sites downstream of the discharge, %EPT has remained below 0.5% since 2016.

Dominant macroinvertebrate taxa were typically species associated with slow-flowing or poor-quality habitats, such as the freshwater snail *Potamopyrgus antipodarum*—a trend continuing since 2022. Interestingly, in 2024 similar dominance by snails and amphipods was also observed at some reference sites.

Between 2002 and 2024, native fish diversity generally declined with increasing distance downstream. However, in 2025, Sites G and C supported fish diversity comparable to reference Sites H and E. Fish IBI scores at reference sites typically ranged from ‘fair’ to ‘very good,’ with some exceptions (e.g., Site E in 2016 and 2024). At effect sites, scores were usually ‘poor’ to ‘very poor,’ though in 2025 both Sites G and C achieved ‘very good’ ratings. Electric fishing of the Te Puru Tributary and lower Farm Pond Tributary could not be carried out as the conductivity of the water was too high to carry the charge from the electric fishing machine. As such, netting and trapping was carried out (in line with the NZ native fish sampling protocols) at all sites and the species diversity of these sites may have therefore been under-represented.

The presence of juvenile eels and juvenile banded kōkopu at reference sites confirms successful upstream migration past the discharge point in recent years. This aligns with findings from earlier surveys (Bioresearches 2002, 2010, 2016, 2019, 2022, and 2024), which also recorded both adult and juvenile banded kōkopu and eels at upstream reference sites.

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6. APPENDICES

Appendix 1. Laboratory Water and Sediment Quality Results

R J Hill Laboratories Limited
28 Duke Street Frankton 3204
Private Bag 3205
Hamilton 3240 New Zealand

0508 HILL LAB (44 555 22)
+64 7 858 2000
mail@hill-labs.co.nz
www.hill-labs.co.nz

Certificate of Analysis

Page 1 of 3

Client:	Bioresearches	**Lab No:**	3843177 SPv1
Contact:	Treff Barnett C/- Bioresearches PO Box 2828 Auckland 1140	**Date Received:**	03-Apr-2025
		Date Reported:	14-Apr-2025
		Quote No:	74278
		Order No:	
		Client Reference:	
		Submitted By:	Treff Barnett

Sample Type: Sediment

Sample Name:		F [Sediment] 31-Mar-2025 1:00 pm	E [Sediment] 31-Mar-2025 2:40 pm	G [Sediment] 31-Mar-2025 11:00 am	C [Sediment] 31-Mar-2025 9:30 am
Lab Number:		3843177.8	3843177.9	3843177.10	3843177.11
Individual Tests					
Dry Matter	g/100g as rcvd	40	49	68	55
Total Recoverable Phosphorus	mg/kg dry wt	1,810	490	560	1,110
Total Nitrogen*	g/100g dry wt	0.20	0.17	0.09	0.24
Ammonium-N*	mg/kg dry wt	13	8	6	13
Total Carbon*	g/100g dry wt	2.6	2.8	1.20	3.6

Sample Type: Aqueous

Sample Name:		A 31-Mar-2025 12:20 pm	B 31-Mar-2025 12:40 pm	C 31-Mar-2025 9:30 am	E 31-Mar-2025 2:15 pm	F 31-Mar-2025 1:00 pm
Lab Number:		3843177.1	3843177.2	3843177.3	3843177.4	3843177.5
Individual Tests						
pH	pH Units	7.4	7.5	7.3	7.3	7.6
Electrical Conductivity (EC)	mS/m	26.6	183.1	155.2	21.6	182.7
Total Suspended Solids	g/m^3	81	9	< 3	7	5
Dissolved Inorganic Nitrogen*	g/m^3	0.195	4.7	3.1	0.112	4.5
Total Nitrogen	g/m^3	0.42	5.7	3.8	0.32	5.5
Total Kjeldahl Nitrogen (TKN)	g/m^3	0.27	1.18	0.75	0.21	1.02
Total Phosphorus	g/m^3	0.091	0.55	0.25	0.047	0.53
Carbonaceous Biochemical Oxygen Demand ($cBOD_5$)	$g O_2/m^3$	< 2	< 2	< 2	< 2	< 2
Faecal Coliforms	cfu / 100mL	2,700 #2	2,000 #2	1,600 #3	690 #3	1,200 #3
Enterococci	MPN / 100mL	461 #1	411 #1	770 #1	488 #1	517 #1
Chlorophyll a	g/m^3	< 0.003	0.006	< 0.003	< 0.003	< 0.003
Nutrient Profile						
Total Ammoniacal-N	g/m^3	0.043	0.154	< 0.010	< 0.010	0.113
Nitrite-N	g/m^3	0.006	0.141	0.014	0.003	0.083
Nitrate-N	g/m^3	0.146	4.4	3.1	0.108	4.3
Nitrate-N + Nitrite-N	g/m^3	0.151	4.5	3.1	0.111	4.4
Dissolved Reactive Phosphorus	g/m^3	0.012	0.40	0.199	0.019	0.42

Sample Name:		G 31-Mar-2025 11:00 am	15 31-Mar-2025 1:40 pm
Lab Number:		3843177.6	3843177.7
Individual Tests			
pH	pH Units	7.7	7.7
Electrical Conductivity (EC)	mS/m	160.5	153.9
Total Suspended Solids	g/m^3	< 3	5
Dissolved Inorganic Nitrogen*	g/m^3	3.4	3.4
Total Nitrogen	g/m^3	4.3	4.3
Total Kjeldahl Nitrogen (TKN)	g/m^3	0.91	0.88

This Laboratory is accredited by International Accreditation New Zealand (IANZ), which represents New Zealand in the International Laboratory Accreditation Cooperation (ILAC). Through the ILAC Mutual Recognition Arrangement (ILAC-MRA) this accreditation is internationally recognised.
The tests reported herein have been performed in accordance with the terms of accreditation, with the exception of tests marked * or any comments and interpretations, which are not accredited.

Sample Type: Aqueous			
	Sample Name:	G 31-Mar-2025 11:00 am	15 31-Mar-2025 1:40 pm
	Lab Number:	3843177.6	3843177.7
Individual Tests			
Total Phosphorus	g/m^3	0.36	0.42
Carbonaceous Biochemical Oxygen Demand ($cBOD_5$)	$g\ O_2/m^3$	< 2	< 2
Faecal Coliforms	cfu / 100mL	1,900 #3	800 #3
Enterococci	MPN / 100mL	816 #1	435 #1
Chlorophyll a	g/m^3	< 0.003	< 0.003
Nutrient Profile			
Total Ammoniacal-N	g/m^3	< 0.010	0.039
Nitrite-N	g/m^3	0.012	0.040
Nitrate-N	g/m^3	3.4	3.3
Nitrate-N + Nitrite-N	g/m^3	3.4	3.4
Dissolved Reactive Phosphorus	g/m^3	0.28	0.32

Analyst's Comments

Due to unexpected sample numbers and limited resources, we were unable to commence the carbonaceous Biochemical oxygen demand (cBOD5) analyses on the day that they arrived at the laboratory. The analyses were performed, as soon as possible, on the frozen samples.

#1 Please interpret this microbiological result with caution as the sample was >24 hours old on receipt at the lab. The sample is required to reach the laboratory with sufficient time to allow testing to commence within 24 hours of sampling.

#2 Please interpret this microbiological result with caution as the sample was > 24 hours old at the time of testing in the laboratory. The sample is required to reach the laboratory with sufficient time to allow testing to commence within 24 hours of sampling.

#3 Statistically estimated count based on the theoretical countable range for the stated method.
Please interpret this microbiological result with caution as the sample was > 24 hours old at the time of testing in the laboratory. The sample is required to reach the laboratory with sufficient time to allow testing to commence within 24 hours of sampling.

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively simple matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis. A detection limit range indicates the lowest and highest detection limits in the associated suite of analytes. A full listing of compounds and detection limits are available from the laboratory upon request.
Unless otherwise indicated, analyses were performed at Hill Labs, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Sediment

Test	Method Description	Default Detection Limit	Sample No
Environmental Solids Sample Drying*	Air dried at 35°C Used for sample preparation. May contain a residual moisture content of 2-5%. (Free water removed before analysis, non-soil objects such as sticks, leaves, grass and stones also removed).	-	8-11
Environmental Solids Sample Drying*	Air dried at 35°C Used for sample preparation. May contain a residual moisture content of 2-5%.	-	8-11
Environmental Solids Sample Preparation	Air dried at 35°C and sieved, <2mm fraction. Used for sample preparation May contain a residual moisture content of 2-5%. (Free water removed before analysis, non-soil objects such as sticks, leaves, grass and stones also removed).	-	8-11
Soil Prep Dry & Sieve for Agriculture	Air dried at 35°C and sieved, <2mm fraction.	-	8-11
Dry Matter	Dried at 103°C for 4-22hr (removes 3-5% more water than air dry) , gravimetry. (Free water removed before analysis, non-soil objects such as sticks, leaves, grass and stones also removed). US EPA 3550.	0.10 g/100g as rcvd	8-11
2M KCl Extraction*	2M potassium chloride extraction of as received fraction for analysis of NH4N, NO2N and NO3N. Analyst, 109, 549, (1984).	-	8-11
Total Recoverable digestion	Nitric / hydrochloric acid digestion. US EPA 200.2 (modified).	-	8-11
Total Recoverable Phosphorus	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, screen level. US EPA 200.2 (modified).	40 mg/kg dry wt	8-11
Total Nitrogen*	Catalytic Combustion (900°C, O2), separation, Thermal Conductivity Detector [Elementar Analyser].	0.05 g/100g dry wt	8-11

Sample Type: Sediment			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Ammonium-N*	2M potassium chloride extraction on as received fraction. Phenol/hypochlorite colorimetry. Flow Injection Analyser. APHA 4500-NH_3 H (modified) : Online Edition.	5 mg/kg dry wt	8-11
Total Carbon*	Catalytic Combustion (900°C, O_2), separation, Thermal Conductivity Detector [Elementar Analyser].	0.05 g/100g dry wt	8-11

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Nutrient Profile		0.0010 - 0.010 g/m³	1-7
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1-7
pH	pH meter. APHA 4500-H^+ B (modified) : Online Edition. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field. Samples and Standards are analysed at an equivalent laboratory temperature (typically 18 to 22 °C). Temperature compensation is used.	0.1 pH Units	1-7
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B : Online Edition.	0.1 mS/m	1-7
Total Suspended Solids	Filtration using Whatman 934 AH, Advantec GC-50 or equivalent filters (nominal pore size 1.2 - 1.5µm), gravimetric determination. APHA 2540 D (modified) : Online Edition.	3 g/m³	1-7
Dissolved Inorganic Nitrogen*	Calculation: NH_4-N + NO_3-N + NO_2-N. In-house calculation.	0.005 g/m³	1-7
Total Nitrogen	Calculation: TKN + Nitrate-N + Nitrite-N. Please note: The Default Detection Limit of 0.05 g/m³ is only attainable when the TKN has been determined using a trace method utilising duplicate analyses. In cases where the Detection Limit for TKN is 0.10 g/m³, the Default Detection Limit for Total Nitrogen will be 0.11 g/m³. In-house calculation.	0.05 g/m³	1-7
Total Ammoniacal-N	Phenol/hypochlorite colourimetry. Flow injection analyser. (NH_4-N = NH_4^+-N + NH_3-N). APHA 4500-NH_3 H (modified) : Online Edition.	0.010 g/m³	1-7
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I (modified) : Online Edition.	0.002 g/m³	1-7
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - Nitrite-N. In-House.	0.0010 g/m³	1-7
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I (modified) : Online Edition.	0.002 g/m³	1-7
Total Kjeldahl Nitrogen (TKN)	Total Kjeldahl digestion, phenol/hypochlorite colorimetry. Discrete Analyser. APHA 4500-N_{org} D (modified) 4500 NH_3 F (modified) : Online Edition.	0.10 g/m³	1-7
Dissolved Reactive Phosphorus	Filtered sample. Molybdenum blue colourimetry. Flow injection analyser. APHA 4500-P G (modified) : Online Edition.	0.004 g/m³	1-7
Total Phosphorus	Total phosphorus digestion, automated ascorbic acid colorimetry. Flow Injection Analyser. APHA 4500-P H (modified) : Online Edition.	0.002 g/m³	1-7
Carbonaceous Biochemical Oxygen Demand ($cBOD_5$)	Incubation 5 days, DO meter, nitrification inhibitor added, seeded. APHA 5210 B (modified) : Online Edition.	2 g O_2/m³	1-7
Faecal Coliforms	Membrane Filtration, Count on CCA agar, Incubated at 44.5°C for 21-24 hours. APHA 9222 D (modified) : Online Edition.	1 cfu / 100mL	1-7
Enterococci	MPN count using Enterolert, Incubated at 41°C for 24 hours. MIMM 12.4, APHA 9230 D : Online Edition.	1 MPN / 100mL	1-7
Chlorophyll a	Acetone extraction. Spectroscopy. APHA 10150 B (modified) : Online Edition.	0.003 g/m³	1-7

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Testing was completed between 04-Apr-2025 and 14-Apr-2025. For completion dates of individual analyses please contact the laboratory.

Samples are held at the laboratory after reporting for a length of time based on the stability of the samples and analytes being tested (considering any preservation used), and the storage space available. Once the storage period is completed, the samples are discarded unless otherwise agreed with the customer. Extended storage times may incur additional charges.

This certificate of analysis must not be reproduced, except in full, without the written consent of the signatory.

Ara Heron BSc (Tech)
Client Services Manager - Environmental

Appendix 2. Raw Macroinvertebrate Data

						Reference Sites			Effect sites		
						SB	HB	HB	SB	HB	SB
PHYLUM	CLASS: Order	Family	Taxa	Taxa MCI hb	Taxa MCI sb	Site A	Site H	Site E	Site F	Site G	Site C
ANNELIDA	OLIGOCHAETA		Oligochaeta	1	3.8	1	1	1		1	1
	HIRUDINEA		*Glossiphonia* sp.	3	1.2		8	24	16	8	24
MOLLUSCA	GASTROPODA	Hydrobiidae	*Potamopyrgus antipodarum*	4	2.1		152	536	1080	7288	6056
		Physidae	*Physella fontinalis*	3	0.1				8	2	
		Lymneaidae	*Lymnaea columella*	3	1.2		1				
		Ancylidae	*Gundlachia* sp.	3	2.4					1	
	BIVALVIA	Sphaeriidae	*Pisidium hodgkini*	3	2.9	40	2			1	8
ARTHROPODA	ARACHNIDA: Acari (mites)		Acari	5	5.2	16		8		8	
	Araneae		*Dolomedes* sp.	5	6.2		8	1			1
	CRUSTACEA: Ostracoda		Ostracoda	3	1.9	32	32				
	Amphipoda		*Paracalliope fluviatilis*	5	5.5	1616	88	456	32	4696	4176
	Decapoda		*Paranephrops planifrons*	5	8.4	2		2			1
			Paratya curvirostris	5	3.6		8	1			7
	INSECTA: Megaloptera	Corydalidae	*Archichauliodes diversus*	7	7.3		2				
	Odonata	Zygoptera	*Xanthocnemis zealandica*	5	1.2	32	24	8		8	1
		Anisoptera	*Antipodochlora braueri*	6	6.3	1					
			Hemicordulia australiae	5	0.4					1	
	Ephemeroptera	Leptophlebiidae	*Zephlebia* spp	7	8.8	32					
			Neozephlebia scita	7	7.6	32					
	Trichoptera	Hydropsychidae	*Orthopsyche fimbriata*	9	7.5		8				
		Hydroptilidae	*Oxyethira albiceps*	2	1.2					6	16
		Hydrobiosidae	*Psilochorema* sp.	8	7.8			8			
		Polycentropodidae	*Polyplectropus puerilis*	8	8.1	104		16			
		Leptoceridae	*Triplectides obsoleta*	5	5.7		256	56		1	2
		Conoesucidae	*Pycnocentrodes* sp.	5	3.8		1				
	Hemiptera	Veliidae	*Microvelia* sp.	5	4.6			8			
		Corixidae	*Sigara* sp.	5	2.4			96			
	Coleoptera	Ptilodactylidae	Ptilodactylidae	8	7.1	1	1				
	Diptera	Hexatomini	*Paralimnophila skusei*	6	7.4	1					
		Chironomidae	*Chironomus*	1	3.4	1		1			
			Maoridiamesa sp.	3		3					
			Polypedilum	3	8	40	2	16	8		
			Tanypodinae	5	6.5	104	14				
		Dixidae	*Paradixa* sp.	4	8.5	4	22	1			1
		Stratiomyidae	Stratiomyidae	5	4.2					1	
		TOTALS:	**NO. TAXA**			18	18	17	5	13	12
			NO. EPT TAXA			3	3	3	0	2	2
			NO. INDIVIDUALS			2062	630	1239	1144	12022	10294

Appendix 3. New Zealand Freshwater Fish Database Forms

FRESHWATER FISH DATABASE FORM					1
Date	03/04/2025	River/Lake system	Tributary to Te Puru Stream	Catchment number	084.00
Time		Sampling locality	C: Lower		
Observer	ld	Access		Altitude (m)	15
Organisation	bior	NZMS 260 Map no.	Coord.	Distance inland (km)	3.6
Fishing method	gmt	Area fished (m2) or no. nets used	Number of electric fishing passes	Tidal water	n

HABITAT DATA

Water	Colour		Clarity		Temp.	pH
	Average width (m)	Average depth (m)	Maximum depth (m)		Conductivity	
Habitat type (%)	Still	Back-water	Pool	Run	Riffle	Rapid	Casc.
Substrate type (%)	Mud	Sand	Fine gravel	Coarse gravel	Cobble	Boulder	Bed-rock
Fish cover (y/n)	Macrophyte	Instream debris	Undercut bank	Bank veg.			
Catchment vegetation(%)	Native forest	Exotic forest	Farm	Urban zone	Scrub	Swamp land	Other
Riparian vegetation(%)	Native forest	Exotic forest	Grass tussock	Exposed bed	Scrub willow	Raupo flax	Other
Type of river/stream/lake							
Water level			Downstream barrier			Pollution	
Large invertebrate fauna		Koura		Paratya		Freshwater mussel	
Bottom fauna abundance			Predominant species group			Permanent water	

FISH DATA

Species		Abundance	Length	Habitat/Comments
Anguilla dieffenbachii	**Longfin eel**	**3**		
Galaxias fasciatus	**Banded kokopu**	**6**		
Gobiomorphus cotidianus	**Common bully**	**17**		
Gobiomorphus huttoni	**Redfin bully**	**1**		
Paranephrops	**Koura**	**1**		

Comments

FRESHWATER FISH DATABASE FORM							2
Date **03/04/2025**		River/Lake system **Tributary to Te Puru Stream**				Catchment number **084.00**	
Time		Sampling locality **H: Farmstop**					
Observer **ld**		Access				Altitude (m) **31**	
Organisation **bior**		NZMS 260 Map no. **s11**		Coord.		Distance inland (km) **5.5**	
Fishing method **gmt**		Area fished (m2) or no. nets used		Number of electric fishing passes		Tidal water **n**	

HABITAT DATA

Water	Colour			Clarity		Temp.	pH
	Average width (m)		Average depth (m)	Maximum depth (m)		Conductivity	
Habitat type (%)	Still	Back-water	Pool	Run	Riffle	Rapid	Casc.
Substrate type (%)	Mud	Sand	Fine gravel	Coarse gravel	Cobble	Boulder	Bed-rock
Fish cover (y/n)	Macrophyte	Instream debris	Undercut bank	Bank veg.			
Catchment vegetation(%)	Native forest	Exotic forest	Farm	Urban zone	Scrub	Swamp land	Other
Riparian vegetation(%)	Native forest	Exotic forest	Grass tussock	Exposed bed	Scrub willow	Raupo flax	Other
Type of river/stream/lake							
Water level			Downstream barrier			Pollution	
Large invertebrate fauna		Koura		Paratya		Freshwater mussel	
Bottom fauna abundance			Predominant species group			Permanent water	

FISH DATA

Species		Abundance	Length	Habitat/Comments
Galaxias fasciatus	**Banded kokopu**	**14**		
Gobiomorphus cotidianus	**Common bully**	**3**		
Gobiomorphus huttoni	**Redfin bully**	**2**		
Paranephrops	**Koura**	**1**		

Comments

FRESHWATER FISH DATABASE FORM			3
Date **03/04/2025**	River/Lake system **Tributary to Te Puru Stream**		Catchment number **084.00**
Time	Sampling locality **E: farm access**		
Observer **ld**	Access		Altitude (m) **24**
Organisation **bior**	NZMS 260 Map no. **s11**	Coord.	Distance inland (km) **5.1**
Fishing method **gmt**	Area fished (m2) or no. nets used	Number of electric fishing passes	Tidal water **n**

HABITAT DATA

Water	Colour			Clarity		Temp.	pH
	Average width (m)		Average depth (m)	Maximum depth (m)		Conductivity	
Habitat type (%)	Still	Back-water	Pool	Run	Riffle	Rapid	Casc.
Substrate type (%)	Mud	Sand	Fine gravel	Coarse gravel	Cobble	Boulder	Bed-rock
Fish cover (y/n)	Macrophyte	Instream debris	Undercut bank	Bank veg.			
Catchment vegetation(%)	Native forest	Exotic forest	Farm	Urban zone	Scrub	Swamp land	Other
Riparian vegetation(%)	Native forest	Exotic forest	Grass tussock	Exposed bed	Scrub willow	Raupo flax	Other
Type of river/stream/lake							
Water level			Downstream barrier			Pollution	
Large invertebrate fauna		Koura		Paratya		Freshwater mussel	
Bottom fauna abundance			Predominant species group			Permanent water	

FISH DATA

Species		Abundance	Length	Habitat/Comments
Anguilla dieffenbachii	**Longfin eel**	**3**		
Galaxias fasciatus	**Banded kokopu**	**1**		
Gobiomorphus cotidianus	**Common bully**	**16**		
Paranephrops	**Koura**	**2**		

Comments

FRESHWATER FISH DATABASE FORM

FRESHWATER FISH DATABASE FORM				4
Date **02/04/2025**	River/Lake system **Tributary to Te Puru Stream**		Catchment number **084.00**	
Time	Sampling locality **A: Upper pond trib**			
Observer **ld**	Access		Altitude (m) **40**	
Organisation **bior**	NZMS 260 Map no. **s11**	Coord.	Distance inland (km) **5.8**	
Fishing method **gmt**	Area fished (m2) or no. nets used	Number of electric fishing passes	Tidal water **n**	

HABITAT DATA

Water	Colour			Clarity		Temp.	pH
	Average width (m)		Average depth (m)	Maximum depth (m)		Conductivity	
Habitat type (%)	Still	Back-water	Pool	Run	Riffle	Rapid	Casc.
Substrate type (%)	Mud	Sand	Fine gravel	Coarse gravel	Cobble	Boulder	Bed-rock
Fish cover (y/n)	Macrophyte	Instream debris	Undercut bank	Bank veg.			
Catchment vegetation(%)	Native forest	Exotic forest	Farm	Urban zone	Scrub	Swamp land	Other
Riparian vegetation(%)	Native forest	Exotic forest	Grass tussock	Exposed bed	Scrub willow	Raupo flax	Other
Type of river/stream/lake							
Water level			Downstream barrier			Pollution	
Large invertebrate fauna		Koura		Paratya		Freshwater mussel	
Bottom fauna abundance			Predominant species group			Permanent water	

FISH DATA

Species		Abundance	Length	Habitat/Comments
Anguilla australis	**Shortfin eel**	**1**		
Galaxias fasciatus	**Banded kokopu**	**12**		
Paranephrops	**Koura**	**10**		

Comments

FRESHWATER FISH DATABASE FORM

FRESHWATER FISH DATABASE FORM					5
Date	02/04/2025	River/Lake system	Tributary to Te Puru Stream	Catchment number	084.00
Time		Sampling locality	G: Mid down trib		
Observer	ld	Access		Altitude (m)	18
Organisation	bior	NZMS 260 Map no. s11	Coord.	Distance inland (km)	4.4
Fishing method	gmt	Area fished (m2) or no. nets used	Number of electric fishing passes	Tidal water	n

HABITAT DATA

Water	Colour			Clarity	Temp.	pH
	Average width (m)	Average depth (m)		Maximum depth (m)	Conductivity	
Habitat type (%)	Still	Back-water	Pool	Run	Riffle	Rapid	Casc.
Substrate type (%)	Mud	Sand	Fine gravel	Coarse gravel	Cobble	Boulder	Bed-rock
Fish cover (y/n)	Macrophyte	Instream debris	Undercut bank	Bank veg.			
Catchment vegetation(%)	Native forest	Exotic forest	Farm	Urban zone	Scrub	Swamp land	Other
Riparian vegetation(%)	Native forest	Exotic forest	Grass tussock	Exposed bed	Scrub willow	Raupo flax	Other
Type of river/stream/lake							
Water level			Downstream barrier		Pollution		
Large invertebrate fauna		Koura		Paratya	Freshwater mussel		
Bottom fauna abundance			Predominant species group		Permanent water		

FISH DATA

Species		Abundance	Length	Habitat/Comments
Anguilla australis	**Shortfin eel**	**1**		
Anguilla dieffenbachii	**Longfin eel**	**1**		
Galaxias fasciatus	**Banded kokopu**	**10**		
Gobiomorphus cotidianus	**Common bully**	**1**		

Comments

FRESHWATER FISH DATABASE FORM							6
Date **02/04/2025**		River/Lake system **Tributary to Te Puru Stream**				Catchment number **084.00**	
Time		Sampling locality **F: Below pond**					
Observer **ld**		Access				Altitude (m) **25**	
Organisation **bior**		NZMS 260 Map no. **s11**		Coord.		Distance inland (km) **5**	
Fishing method **gmt**		Area fished (m2) or no. nets used		Number of electric fishing passes		Tidal water **n**	
HABITAT DATA							
Water	Colour			Clarity		Temp.	pH
	Average width (m)		Average depth (m)	Maximum depth (m)		Conductivity	
Habitat type (%)	Still	Back-water	Pool	Run	Riffle	Rapid	Casc.
Substrate type (%)	Mud	Sand	Fine gravel	Coarse gravel	Cobble	Boulder	Bed-rock
Fish cover (y/n)	Macrophyte	Instream debris	Undercut bank	Bank veg.			
Catchment vegetation(%)	Native forest	Exotic forest	Farm	Urban zone	Scrub	Swamp land	Other
Riparian vegetation(%)	Native forest	Exotic forest	Grass tussock	Exposed bed	Scrub willow	Raupo flax	Other
Type of river/stream/lake							
Water level			Downstream barrier			Pollution	
Large invertebrate fauna		Koura		Paratya		Freshwater mussel	
Bottom fauna abundance			Predominant species group			Permanent water	

FISH DATA

Species		Abundance	Length	Habitat/Comments
Anguilla australis	**Shortfin eel**			

Comments

Appendix 4. Auckland Fish Index of Biotic Integrity (IBI)

Index of Biological Integrity - Auckland Region : Fish

Centre for Freshwater Ecosystem Modelling and Management, Massey University

Site	IBI score	Rating
H	42	Very Good
E	34	Fair
A	32	Fair
F	14	Very Poor
G	42	Very Good
C	44	Very Good

Report printed 13/05/2025 11:39:39 AM

Appendix 5. Macrophyte Survey Results

Site A															
Transect		1	2	3	4	5	6	7	8	9	10	11	12	**Mean**	**S.E**
Width (m)		1.04	0.98	1.14	1.17	0.97	0.85	0.99	1.03	0.68	1.22	0.78	0.57		
Macrophytes (%)															
Willow weed	*Persicaria sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Watercress	*Nasturtium officinale*	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Duckweed	*Lemna minor*	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cape pondweed	*Aponogeton distachyus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Starwort	*Callitriche stagnalis*	0	0	0	0	0	0	0	0	0	0	0.5	2	0.208333	0.168081
Water Celery	*Apium nodiflorum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oxygen weed	*Elodea canadensis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Curly pondweed	*Potamogeton crispus*	0	0	0	0	0	0	0	0	0	0	0	0	0	
Buttercup	*Ranunculus repens*	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other macrophytes	*Forget-me-knot*	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Red ludwigia	15	15	0	0	0	0	0	0	35	0	0	0	5.416667	3.165769
Iron flocc		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitella	*Nitella hookeri*	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Green mat		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Green filamentous		0	0	0	5	0	0	0	0	0	0	0	0	0.416667	0.416667
Brown mat		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Brown filamentous		0	0	0	0	0	0	0	5	0	30	0	0	2.916667	2.496841
Total Macrophytes (%)		15	15	0	0	0	0	0	0	35	0	0.5	2	5.63	3.14
Total Algae (%)		0	0	0	5	0	0	0	5	0	30	0	0	3.33	2.49
Bare Substrate (%)		85	85	100	95	100	100	100	95	65	70	99.5	98	91.04	3.55

Site H															
Transect		1	2	3	4	5	6	7	8	9	10	11	12	**Mean**	**S.E**
Width (m)		1.09	2.21	1.48	1.09	0.98	1.42	1.29	2.38	2.48	1.61	0.96	1.38		
Macrophytes (%)															
Willow weed	*Persicaria sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Watercress	*Nasturtium officinale*	0	0	0	0	0	0	0	0	0	0	0	5	0.42	0.42
Duckweed	*Lemna minor*	0	0	0	0	0	0	0	0	0	0	0	10	0.83	0.83
Cape pondweed	*Aponogeton distachyus*	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Starwort	*Callitriche stagnalis*	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Water Celery	*Apium nodiflorum*	0	0	0	0	0	0	0	0	0	0	0	1	0.08	0.08
Oxygen weed	*Elodea canadensis*	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Curly pondweed	*Potamogeton crispus*	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Buttercup	*Ranunculus repens*	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Other macrophytes	*Forget-me-knot*	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Iron flocc		0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Nitella	*Nitella hookeri*	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Green mat		0	0	0	30	25	10	5	30	25	0	5	0	10.83	3.68
Green filamentous		0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Brown mat		0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Brown filamentous		0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Total Macrophytes (%)		0	0	0	0	0	0	0	0	0	0	0	16	1.33	1.33
Total Algae (%)		0	0	0	30	25	10	5	30	25	0	5	0	10.83	3.68
Bare Substrate (%)		100	100	100	70	75	90	95	70	75	100	95	84	87.83	3.57

Site E															
Transect		1	2	3	4	5	6	7	8	9	10	11	12	**Mean**	**S.E**
Width (m)		1.77	1.73	2.86	2.77	2.56	2.41	2.12	1.71	2.12	1.94	2.07	1.89		
Macrophytes (%)															
Willow weed	*Persicaria sp.*	0	0	1	0	5	1	0	0	0.5	0	0	0	0.63	0.41
Watercress	*Nasturtium officinale*	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Duckweed	*Lemna minor*	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Cape pondweed	*Aponogeton distachyus*	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Starwort	*Callitriche stagnalis*	0	0	0	0	0	5	0	0	0	0.5	0	2	0.63	0.43
Water Celery	*Apium nodiflorum*	0	0	1	0	10	0	0	0	0	0	0	0	0.92	0.83
Oxygen weed	*Elodea canadensis*	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Curly pondweed	*Potamogeton crispus*	0	0	0	0	0	0	0	0	0	0	0	0	0.00	
Buttercup	*Ranunculus repens*	0	0	0	0.5	0	0	0	0	0	0	0	0	0.04	0.04
Other macrophytes	*Forget-me-knot*	5	0	0	0	0	0	0	0	0	0	0	0	0.42	0.42
Iron flocc		0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Nitella	*Nitella hookeri*	95	90	95	85	90	90	30	0	65	15	60	0	59.58	10.98
Green mat		0	5	30	0	0	0	0	0	0	10	0	5	4.17	2.53
Green filamentous		0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Brown mat		0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Brown filamentous		0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Total Macrophytes (%)		5	0	2	0.5	15	6	0	0	0.5	0.5	0	2	2.63	1.27
Total Algae (%)		95	95	125	85	90	90	30	0	65	25	60	5	63.75	11.58
Bare Substrate (%)		0	5	-27	14.5	-5	4	70	100	34.5	74.5	40	93	33.63	12.10

Site F															
Transect		1	2	3	4	5	6	7	8	9	10	11	12	**Mean**	**S.E**
Width (m)		2.41	1.95	3.2	1.73	1.65	1.3	1.2	1.12	1.43	1.1	1.26	1.28		
Macrophytes (%)															
Willow weed	*Persicaria sp.*	1	30	0	0	0	0	2	1	0	0	0	0	2.83	2.48
Watercress	*Nasturtium officinale*	2	1	0	0	0	0	0	0	0	0	0	0	0.25	0.18
Duckweed	*Lemna minor*	1	0	0	0	0	0	0	0	5	0	10	0	1.33	0.89
Cape pondweed	*Aponogeton distachyus*	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Starwort	*Callitriche stagnalis*	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Water Celery	*Apium nodiflorum*	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Oxygen weed	*Elodea canadensis*	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Curly pondweed	*Potamogeton crispus*	0	0	0	0	0	0	0	0	0	0	0	0	0.00	
Buttercup	*Ranunculus repens*	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Other macrophytes	*Forget-me-knot*	0	1	0	0	0	0	0	10	0	0	0	0	0.92	0.83
Iron flocc		0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Nitella	*Nitella hookeri*	0	20	10	3	3	5	0	0	0	0	0	0	3.42	1.75
Green mat		0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Green filamentous		5	0	0	0	0	0	0	0	0	0	0	0	0.42	0.42
Brown mat		0	0	0	0	0	0	1	5	0	0	0	0	0.50	0.42
Brown filamentous		10	20	10	3	0	0	20	0	15	40	30	15	13.58	3.64
Total Macrophytes (%)		4	32	0	0	0	0	2	11	5	0	10	0	5.33	2.68
Total Algae (%)		15	40	20	6	3	5	21	5	15	40	30	15	17.92	3.75
Bare Substrate (%)		81	28	80	94	97	95	77	84	80	60	60	85	76.75	5.60

Site S2															
Transect		1	2	3	4	5	6	7	8	9	10	11	12	**Mean**	**S.E**
Width (m)		2.56	2.12	1.59	1.27	1.46	1.31	1.38	2.46	1.72	2.38	1.75	1.57		
Macrophytes (%)															
Willow weed	*Persicaria sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Watercress	*Nasturtium officinale*	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Duckweed	*Lemna minor*	3	1	5	25	7	5	0	5	7	5	10	3	6.33	1.87
Cape pondweed	*Aponogeton distachyus*	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Starwort	*Callitriche stagnalis*	0	0	2	0	0	0	0	0	0	0	0	0	0.17	0.17
Water Celery	*Apium nodiflorum*	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Oxygen weed	*Elodea canadensis*	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Curly pondweed	*Potamogeton crispus*	0	0	0.5	5	0	0	0	0	0	0	0	0	0.46	0.41
Buttercup	*Ranunculus repens*	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Other macrophytes	*Forget-me-knot*	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Iron flocc		0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Nitella	*Nitella hookeri*	80	30	80	90	20	25	0	30	0	0	0	0	29.58	10.01
Green mat		0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Green filamentous		0	0	0	5	0	15	0	0	0	0	0	0	1.67	1.28
Brown mat		0	0	30	40	0	0	0	0	0	0	0	0	5.83	3.98
Brown filamentous		0	0	0	0	30	0	30	0	15	80	60	0	17.92	7.87
Total Macrophytes (%)		3	1	7.5	30	7	5	0	5	7	5	10	3	6.96	2.25
Total Algae (%)		80	30	110	135	50	40	30	30	15	80	60	0	55.00	11.50
Bare Substrate (%)		17	69	-17.5	-65	43	55	70	65	78	15	30	97	38.04	13.15

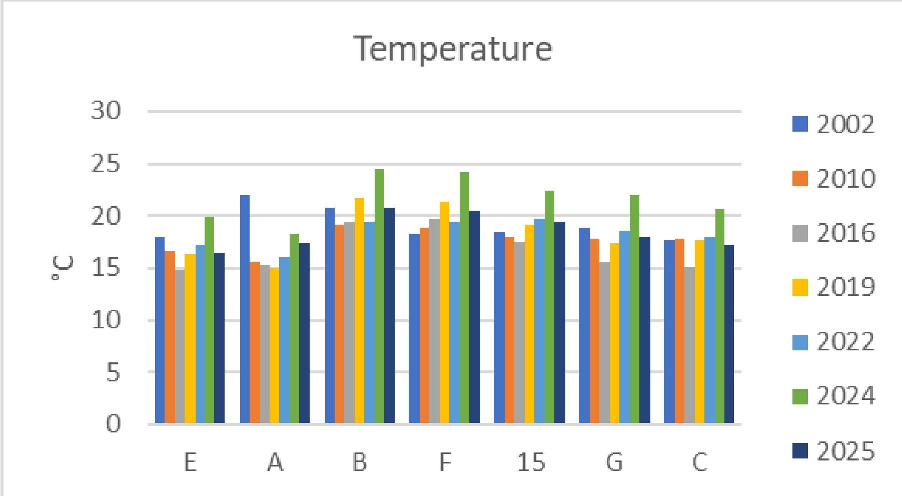
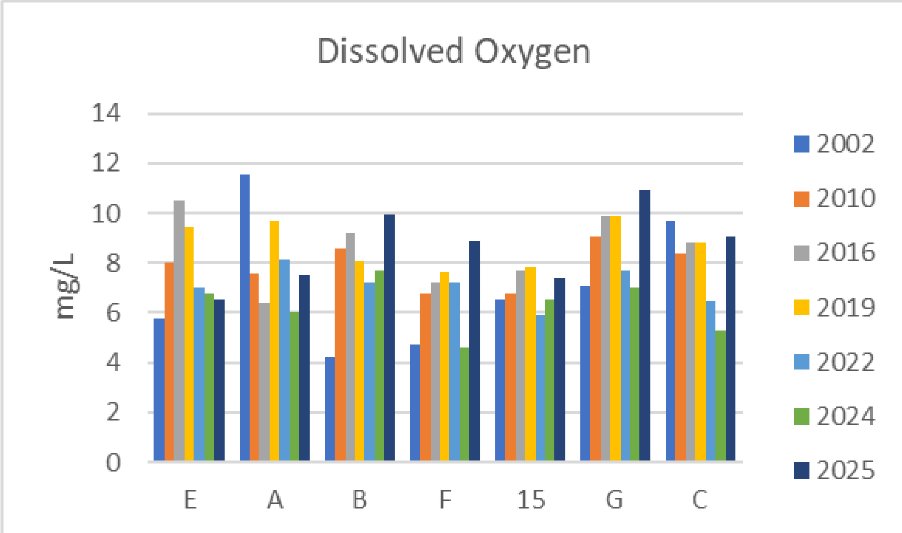
Site G															
Transect		1	2	3	4	5	6	7	8	9	10	11	12	**Mean**	**S.E**
Width (m)		1.93	2.5	2.4	3.9	2.5	2.4	2.9	3.8	1.41	3.1	2.4	3.1		
Macrophytes (%)															
Willow weed	*Persicaria sp.*	5	2	0	0	0	0	0	2	0	2	0	0	0.92	0.45
Watercress	*Nasturtium officinale*	0	0	0	5	0	7.5	0	0	0	0	0	0	1.04	0.72
Duckweed	*Lemna minor*	20	15	10	10	5	1	20	10	0	5	30	100	18.83	7.79
Cape pondweed	*Aponogeton distachyus*	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Starwort	*Callitriche stagnalis*	0	0	0.5	0	0	0	0	0	0	0	0	0	0.04	0.04
Water Celery	*Apium nodiflorum*	10	3	0.5	0	0.1	7.5	25	2	5	4	20	20	8.09	2.54
Oxygen weed	*Elodea canadensis*	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Curly pondweed	*Potamogeton crispus*	0	0	0	0	0	0	0	0	0	0	0	0	0.00	
Buttercup	*Ranunculus repens*	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Other macrophytes	*Forget-me-knot*	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Iron flocc		0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Nitella	*Nitella hookeri*	70	90	95	95	70	80	60	100	30	80	80	0	70.83	8.46
Green mat		0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Green filamentous		0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Brown mat		0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Brown filamentous		0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Total Macrophytes (%)		35	20	11	15	5.1	16	45	14	5	11	50	120	28.93	9.33
Total Algae (%)		70	90	95	95	70	80	60	100	30	80	80	0	70.83	8.46
Bare Substrate (%)		-5	-10	-6	-10	24.9	4	-5	-14	65	9	-30	-20	0.24	7.14

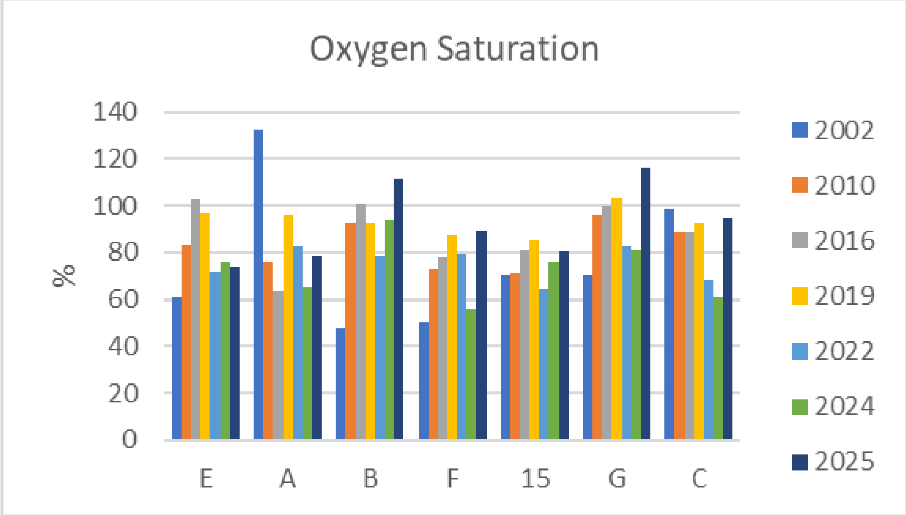
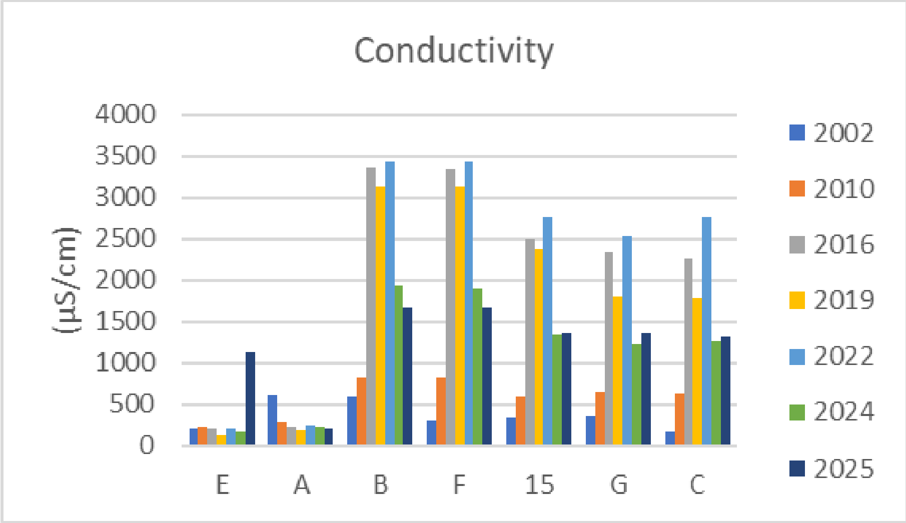
Site S3															
Transect		1	2	3	4	5	6	7	8	9	10	11	12	**Mean**	**S.E**
Width (m)		1.4	1.47	1.44	2.12	1.53	1.75	2.5	1.5	2.8	2.1	1.55	2.3		
Macrophytes (%)															
Willow weed	*Persicaria sp.*	0	0	0	0	0	3	0	0	0	10	0	0	1.08	0.85
Watercress	*Nasturtium officinale*	10	0	0	10	5	5	0	0	30	30	0	0	7.50	3.23
Duckweed	*Lemna minor*	0	20	20	10	10	1	0	5	50	0	0	5	10.08	4.20
Cape pondweed	*Aponogeton distachyus*	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Starwort	*Callitriche stagnalis*	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Water Celery	*Apium nodiflorum*	2	5	5	5	0	0	0	2	0	30	10	90	12.42	7.45
Oxygen weed	*Elodea canadensis*	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Curly pondweed	*Potamogeton crispus*	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Buttercup	*Ranunculus repens*	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Other macrophytes	*Forget-me-knot*	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Iron flocc		0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Nitella	*Nitella hookeri*	80	50	50	30	30	80	90	30	30	10	60	50	49.17	7.12
Green mat		0	0	0	0	0	0	0	0	0	5	0	0	0.42	0.42
Green filamentous		0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Brown mat		0	30	10	5	20	50	80	30	0	0	0	0	18.75	7.29
Brown filamentous		0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Total Macrophytes (%)		12	25	25	25	15	9	0	7	80	70	10	95	31.08	9.21
Total Algae (%)		80	80	60	35	50	130	170	60	30	15	60	50	68.33	12.53
Bare Substrate (%)		8	-5	15	40	35	-39	-70	33	-10	15	30	-45	0.58	10.26

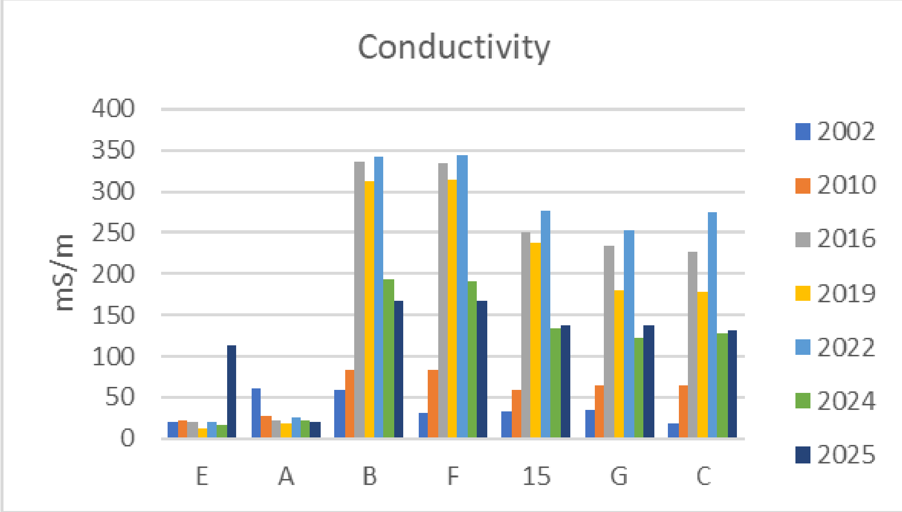
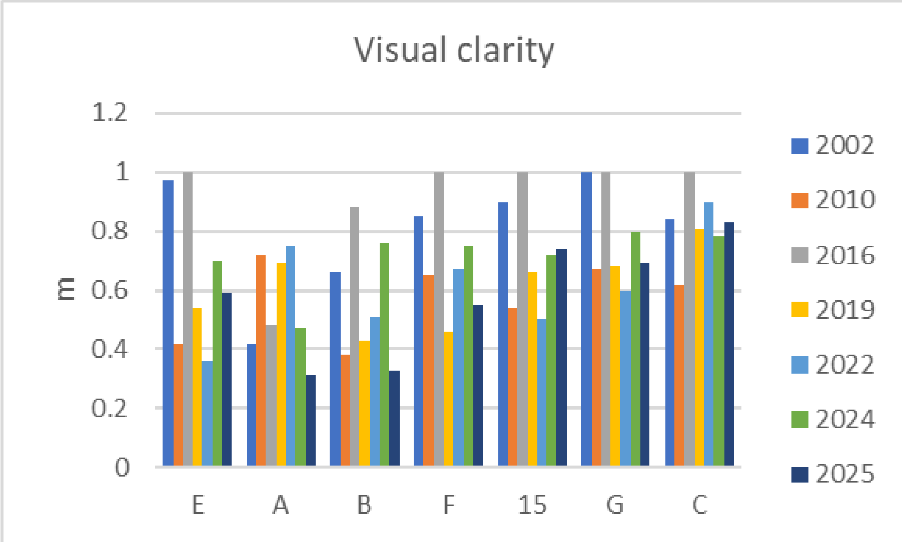
Site C															
Transect		1	2	3	4	5	6	7	8	9	10	11	12	**Mean**	**S.E**
Width (m)		1.27	2.42	1.32	1.46	1.73	2.23	1.84	1.3	1.39	2.33	2.24	1.29		
Macrophytes (%)															
Willow weed	*Persicaria sp.*	1	60	0	2	2	70	0	0	0	0	3	0	11.50	7.25
Watercress	*Nasturtium officinale*	20	3	0	0	30	5	0	0	0	3	0	5	5.50	2.76
Duckweed	*Lemna minor*	0	0	5	3	40	3	5	10	0	0	1	10	6.42	3.23
Cape pondweed	*Aponogeton distachyus*	0	0	5	0	0	0	0	0	0	0	0	0	0.42	0.42
Starwort	*Callitriche stagnalis*	0	5	0	0	0	0	0	0	0.5	3	0	5	1.13	0.58
Water Celery	*Apium nodiflorum*	0.5	10	80	20	0	25	95	90	15	2	5	10	29.38	10.53
Oxygen weed	*Elodea canadensis*	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Curly pondweed	*Potamogeton crispus*	0	0	0	0	0	0	0	0	0	0	0	0	0.00	
Buttercup	*Ranunculus repens*	0	0	0	10	0	0	0	0	0	1	0	0	0.92	0.83
Other macrophytes	*Forget-me-knot*	0	0	0	0	0	0	0	0			0	0	0.00	0.00
Iron flocc		0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Nitella	*Nitella hookeri*	0	5	10	85	100	0	0	0	90	95	90	70	45.42	13.12
Green mat		0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Green filamentous		0	0	0	0	0	0	5	0	0	0	0	3	0.67	0.47
Brown mat		0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Brown filamentous		0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Total Macrophytes (%)		21.5	78	90	35	72	103	100	100	15.5	9	9	30	55.25	11.12
Total Algae (%)		0	5	10	85	100	0	5	0	90	95	90	73	46.08	13.04
Bare Substrate (%)		78.5	17	0	0	0	0	0	0	0	0	1	0	8.04	6.56

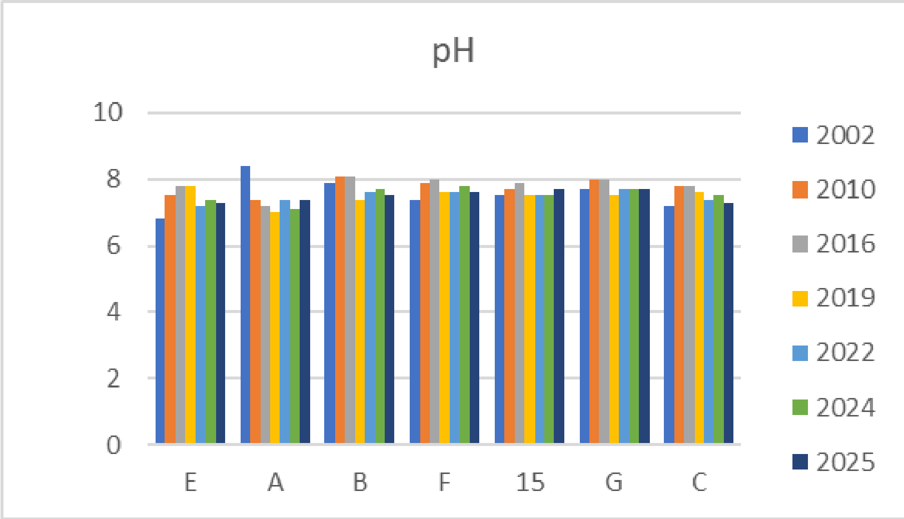
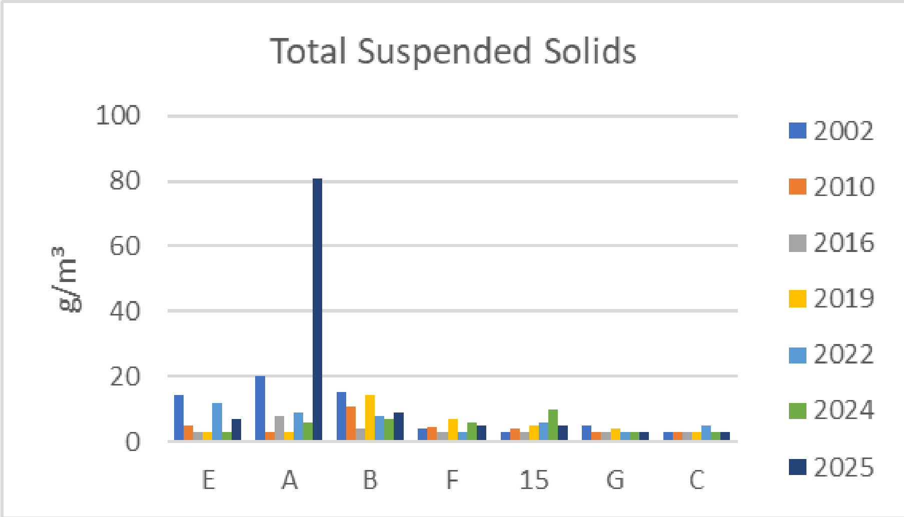
Appendix 6. Historical water quality, sediment quality and biological data (2002 – 2025)

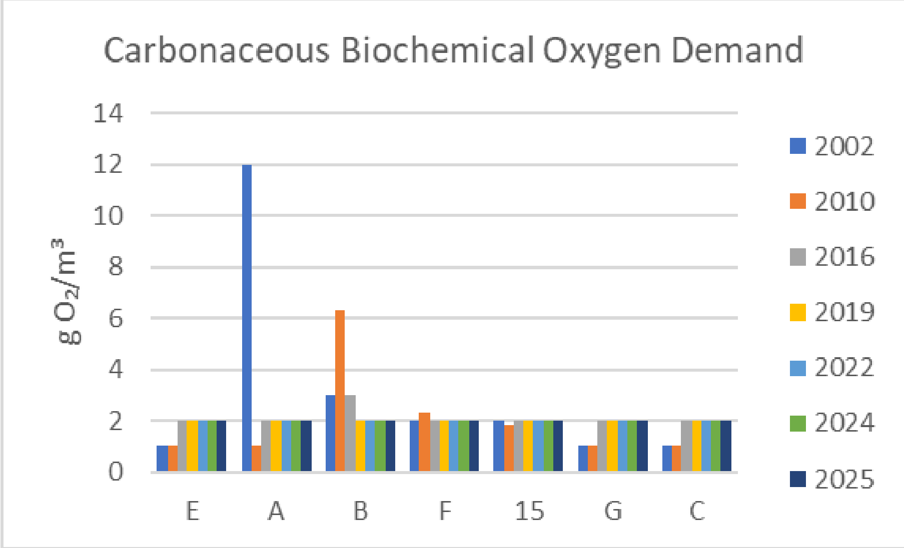
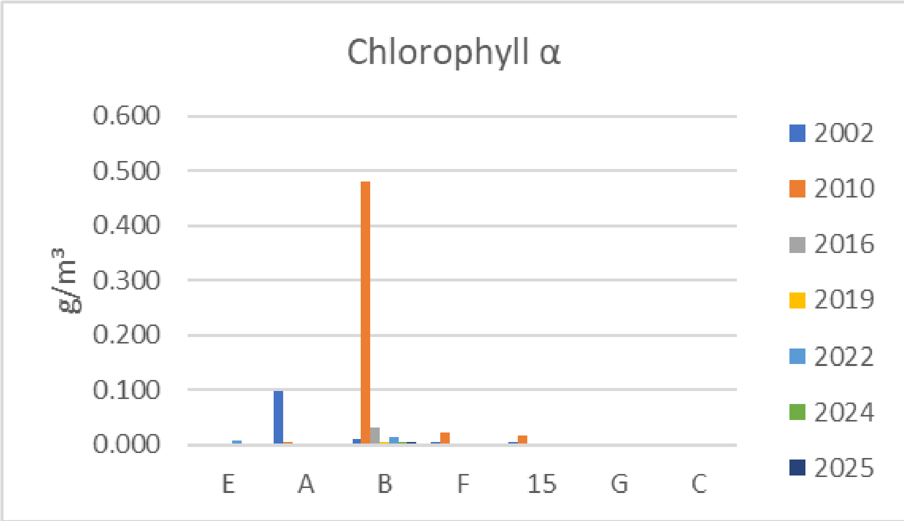
6.1 Water Quality

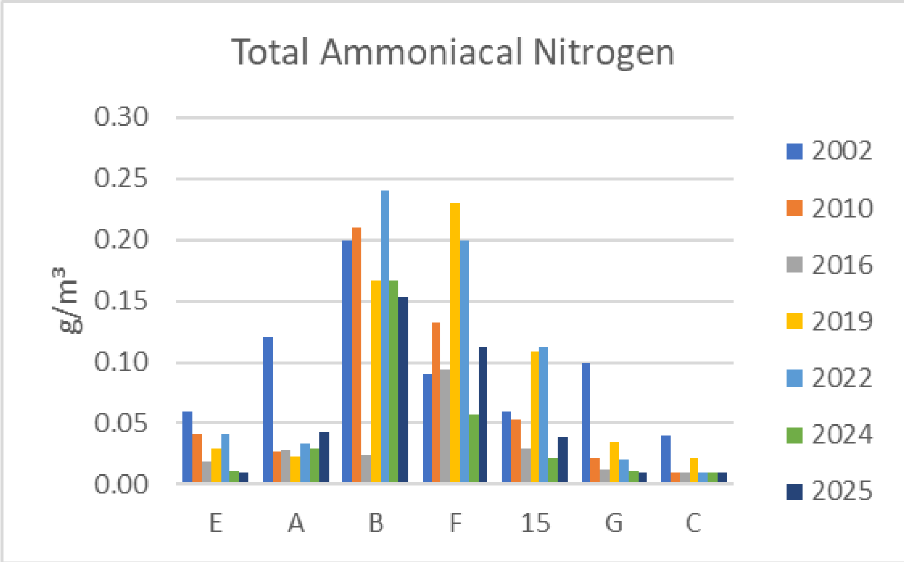
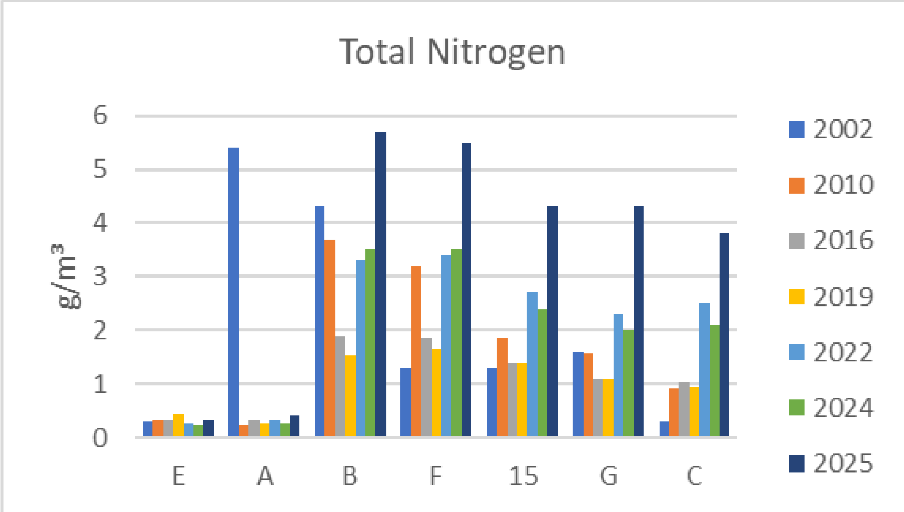
		E	A	B	F	15	G	C	Corresponding graph
Temperature (°C)	2002	17.9	22	20.7	18.3	18.4	18.9	17.6	
	2010	16.6	15.6	19.2	18.9	17.9	17.8	17.8	
	2016	14.8	15.3	19.5	19.7	17.5	15.6	15.2	
	2019	16.3	15	21.7	21.4	19.1	17.4	17.6	
	2022	17.2	16.0	19.5	19.5	19.7	18.6	17.9	
	2024	19.9	18.2	24.5	24.2	22.4	22	20.6	
	2025	16.4	17.3	20.7	20.5	19.5	18	17.2	
Dissolved Oxygen (mg/L)	2002	5.79	11.55	4.25	4.73	6.51	7.07	9.67	
	2010	8	7.6	8.6	6.8	6.8	9.1	8.4	
	2016	10.5	6.4	9.2	7.2	7.7	9.9	8.8	
	2019	9.44	9.71	8.05	7.66	7.83	9.9	8.83	
	2022	7	8.12	7.18	7.22	5.88	7.70	6.47	
	2024	6.8	6	7.7	4.6	6.5	7.00	5.3	
	2025	6.54	7.55	9.95	8.88	7.38	10.91	9.06	

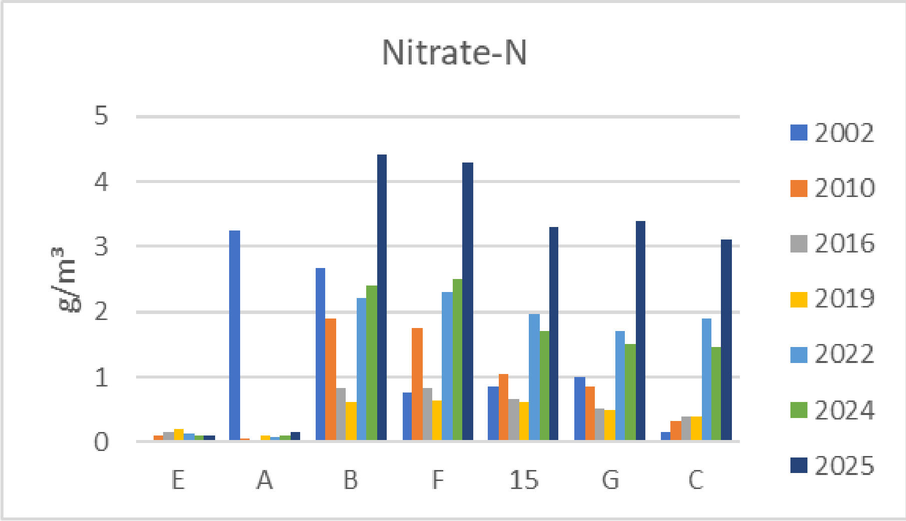
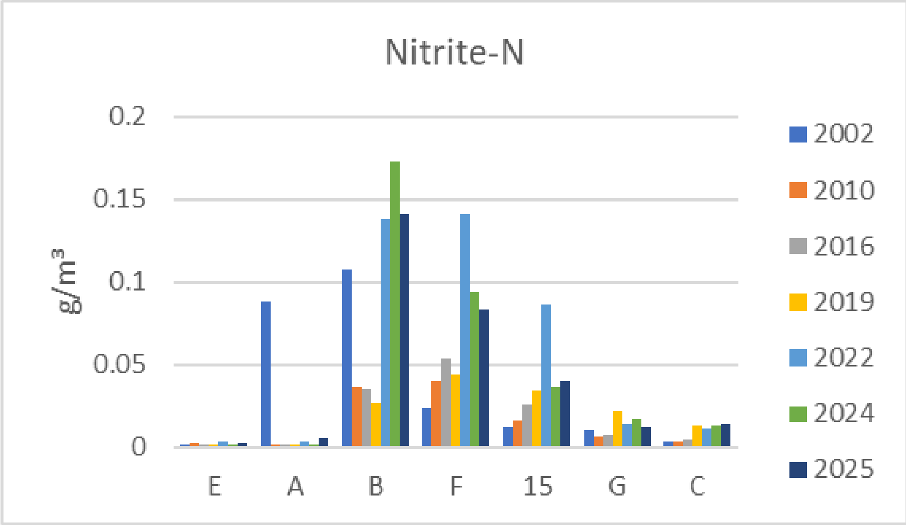
		E	A	B	F	15	G	C	Corresponding graph
Oxygen Saturation (%)	2002	61	132.4	47.5	50.4	70.2	70.2	98.5	
	2010	83	76	93	73	71	96	89	
	2016	103	64	101	78	81	100	89	
	2019	96.5	96.1	92.6	87	85.5	103.4	92.6	
	2022	71.9	82.8	78.4	79.5	64.5	82.3	68.5	
	2024	76	65	94	56.0	76	81	61	
	2025	73.8	78.8	111.7	89.4	80.5	116	94.9	
Conductivity (µS/cm)	2002	202	610	598	307	334	358	176	
	2010	218	279	828	828	597	649	639	
	2016	199	228	3360	3340	2500	2350	2270	
	2019	134.7	184.1	3126	3139	2377	1800	1782	
	2022	203	256	3430	3440	2770	2530	2760	
	2024	162	219	1936	1908	1345	1218	1275	
	2025	1124	199	1671	1664	1364	1368	1320	

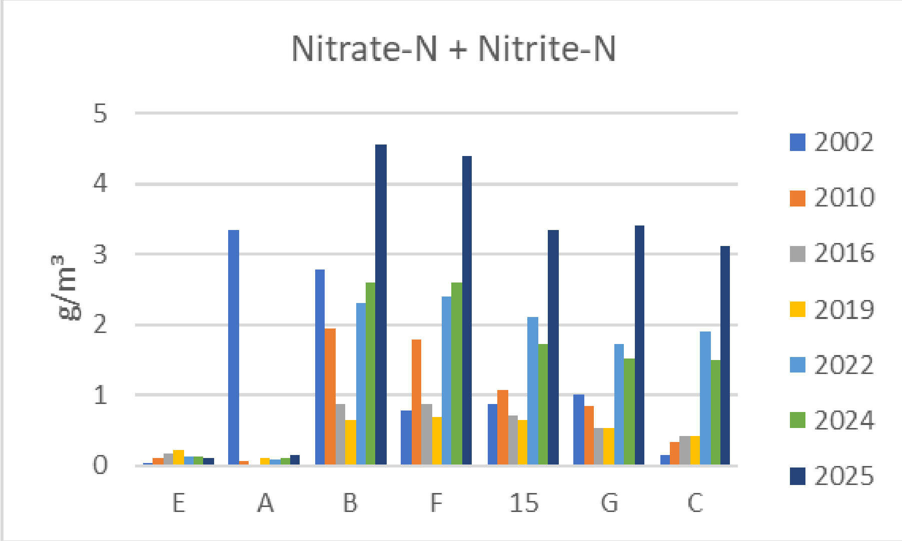
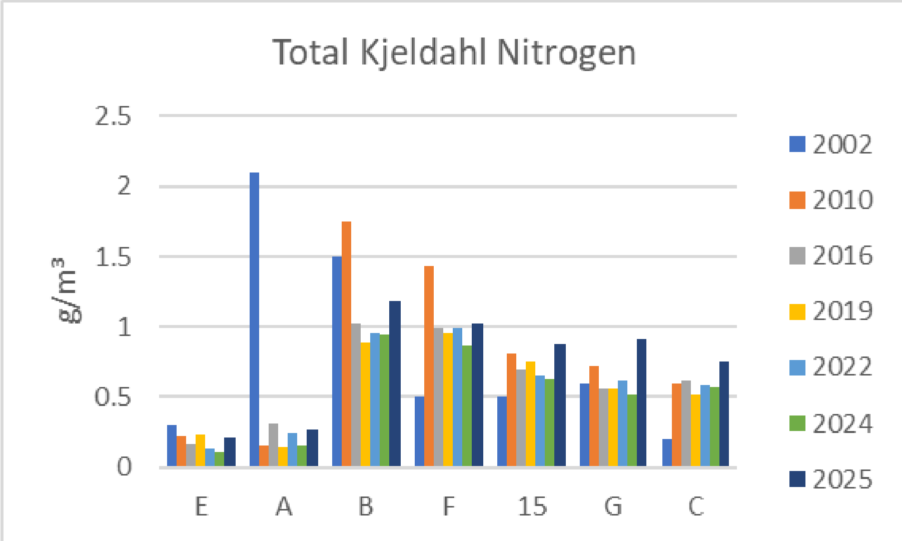
		E	A	B	F	15	G	C	Corresponding graph
Conductivity (mS/m)	2002	20.2	61	59.8	30.7	33.4	35.8	17.6	
	2010	21.8	27.9	82.8	82.8	59.7	64.9	63.9	
	2016	19.9	22.8	336	334	250	235	227	
	2019	13.47	18.41	312.6	313.9	237.7	180	178.2	
	2022	20.3	25.6	343	344	277	253	276	
	2024	16.2	21.9	193.6	190.8	134.5	121.8	127.5	
	2025	112.4	19.9	167.1	166.4	136.4	136.8	132	
Visual Clarity (m)	2002	0.97	0.42	0.66	0.85	0.9	1	0.84	
	2010	0.42	0.72	0.38	0.65	0.54	0.67	0.62	
	2016	1	0.48	0.88	1	1	1	1	
	2019	0.54	0.69	0.43	0.46	0.66	0.68	0.81	
	2022	0.36	0.75	0.51	0.67	0.5	0.6	0.9	
	2024	0.7	0.47	0.76	0.75	0.72	0.8	0.78	
	2025	0.59	0.31	0.33	0.55	0.74	0.69	0.83	

		E	A	B	F	15	G	C	Corresponding graph
pH (pH unit)	2002	6.8	8.4	7.9	7.4	7.5	7.7	7.2	
	2010	7.5	7.4	8.1	7.9	7.7	8	7.8	
	2016	7.8	7.2	8.1	8	7.9	8	7.8	
	2019	7.8	7	7.4	7.6	7.5	7.5	7.6	
	2022	7.2	7.4	7.6	7.6	7.5	7.7	7.4	
	2024	7.4	7.1	7.7	7.8	7.5	7.7	7.5	
	2025	7.3	7.4	7.5	7.6	7.7	7.7	7.3	
Total Suspended Solids (g/m³)	2002	14	20	15	4	3	5	3	
	2010	4.7	3	10.6	4.3	3.7	3	3	
	2016	3	8	4	3	3	3	3	
	2019	3	3	14	7	5	4	3	
	2022	12	9	8	3	6	3	5	
	2024	3	6	7	6	10	3	3	
	2025	7	81	9	5	5	3	3	

		E	A	B	F	15	G	C	Corresponding graph
Carbonaceous Biochemical Oxygen Demand (g O_2/m^3)	2002	1	12	3	2	2	1	1	
	2010	1	1	6.3	2.3	1.8	1	1	
	2016	2	2	3	2	2	2	2	
	2019	2	2	2	2	2	2	2	
	2022	2	2	2	2	2	2	2	
	2024	2	2	2	2	2	2	2	
	2025	2	2	2	2	2	2	2	
Chlorophyll α (g/m³)	2002	0.003	0.097	0.011	0.005	0.005	0.003	0.003	
	2010	0.003	0.004	0.480	0.023	0.016	0.003	0.003	
	2016	0.003	0.003	0.031	0.003	0.003	0.003	0.003	
	2019	0.003	0.003	0.006	0.003	0.003	0.003	0.003	
	2022	0.008	0.003	0.013	0.003	0.003	0.003	0.003	
	2024	0.003	0.003	0.006	0.003	0.003	0.003	0.003	
	2025	0.003	0.003	0.006	0.003	0.003	0.003	0.003	

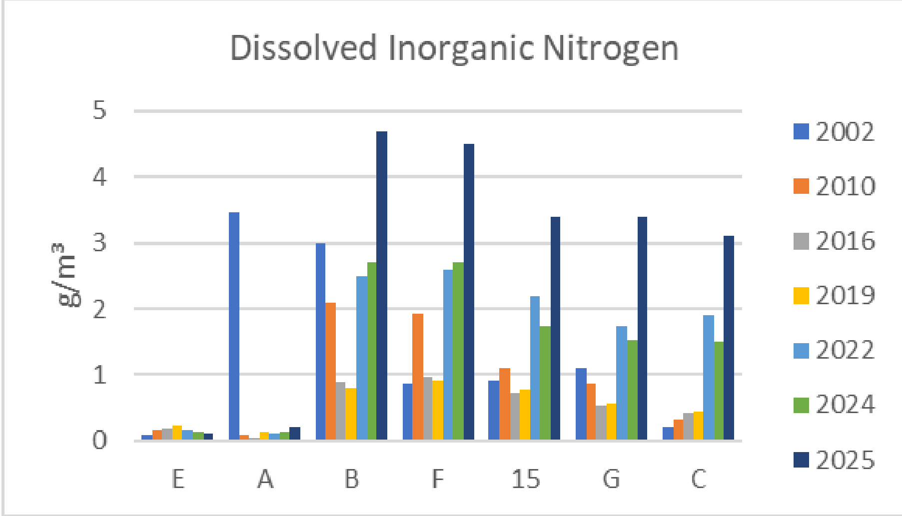
		E	A	B	F	15	G	C	Corresponding graph
Total Ammoniacal Nitrogen (g/m³)	2002	0.06	0.12	0.20	0.09	0.06	0.10	0.04	
	2010	0.04	0.03	0.21	0.13	0.05	0.02	0.01	
	2016	0.02	0.03	0.02	0.09	0.03	0.01	0.01	
	2019	0.03	0.02	0.17	0.23	0.11	0.04	0.02	
	2022	0.04	0.03	0.24	0.20	0.11	0.02	0.01	
	2024	0.01	0.03	0.17	0.06	0.02	0.01	0.01	
	2025	0.01	0.04	0.15	0.11	0.04	0.01	0.01	
Total Nitrogen (g/m³)	2002	0.3	5.4	4.3	1.3	1.3	1.6	0.3	
	2010	0.32	0.22	3.7	3.2	1.86	1.57	0.91	
	2016	0.33	0.32	1.89	1.86	1.4	1.08	1.03	
	2019	0.44	0.25	1.53	1.65	1.4	1.08	0.94	
	2022	0.25	0.33	3.3	3.4	2.7	2.3	2.5	
	2024	0.23	0.25	3.5	3.5	2.4	2	2.1	
	2025	0.32	0.42	5.7	5.5	4.3	4.3	3.8	

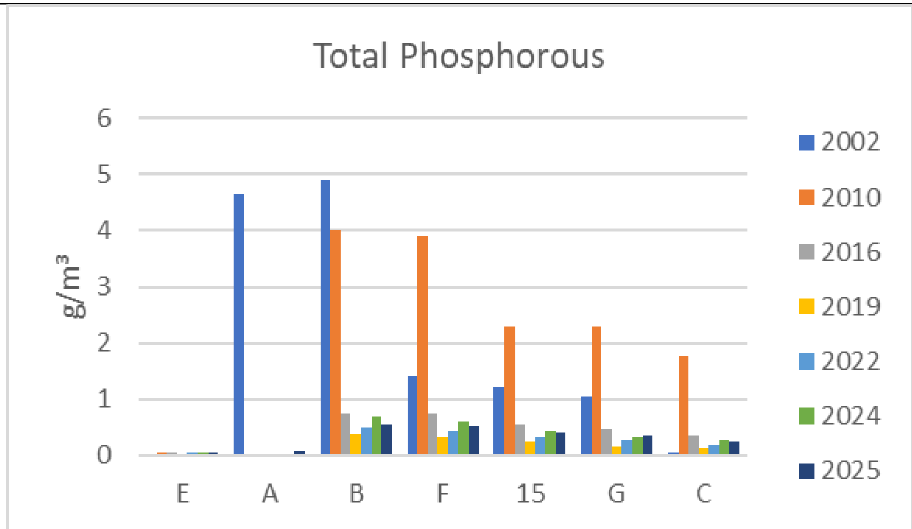
		E	A	B	F	15	G	C	Corresponding graph
Nitrate-N (g/m³)	2002	0.032	3.26	2.68	0.761	0.844	0.992	0.152	
	2010	0.103	0.058	1.9	1.74	1.04	0.85	0.31	
	2016	0.157	0.015	0.82	0.82	0.67	0.51	0.4	
	2019	0.2	0.11	0.61	0.64	0.62	0.49	0.4	
	2022	0.116	0.082	2.2	2.3	1.97	1.7	1.89	
	2024	0.115	0.099	2.4	2.5	1.69	1.51	1.47	
	2025	0.108	0.146	4.4	4.3	3.3	3.4	3.1	
Nitrite-N (g/m³)	2002	0.002	0.088	0.107	0.024	0.012	0.01	0.004	
	2010	0.0032	0.002	0.036	0.04	0.0158	0.007	0.0034	
	2016	0.002	0.002	0.035	0.054	0.026	0.008	0.005	
	2019	0.002	0.002	0.027	0.044	0.034	0.022	0.013	
	2022	0.004	0.004	0.138	0.141	0.086	0.014	0.011	
	2024	0.002	0.002	0.173	0.094	0.036	0.017	0.013	
	2025	0.003	0.006	0.141	0.083	0.04	0.012	0.014	

		E	A	B	F	15	G	C	Corresponding graph
Nitrate-N + Nitrite-N (g/m³)	2002	0.034	3.348	2.787	0.785	0.856	1.002	0.156	
	2010	0.106	0.06	1.94	1.78	1.06	0.85	0.32	
	2016	0.159	0.017	0.86	0.87	0.7	0.52	0.41	
	2019	0.21	0.11	0.64	0.68	0.65	0.52	0.41	
	2022	0.12	0.086	2.3	2.4	2.1	1.71	1.9	
	2024	0.117	0.101	2.6	2.6	1.73	1.52	1.49	
	2025	0.1	0.2	4.5	4.4	3.3	3.4	3.1	
Total Kjeldahl Nitrogen (g/m³)	2002	0.3	2.1	1.5	0.5	0.5	0.6	0.2	
	2010	0.22	0.155	1.75	1.43	0.81	0.72	0.6	
	2016	0.17	0.31	1.03	0.99	0.7	0.56	0.62	
	2019	0.23	0.14	0.89	0.96	0.75	0.56	0.52	
	2022	0.13	0.25	0.96	0.99	0.65	0.62	0.58	
	2024	0.11	0.15	0.95	0.87	0.63	0.52	0.57	
	2025	0.21	0.27	1.18	1.02	0.88	0.91	0.75	

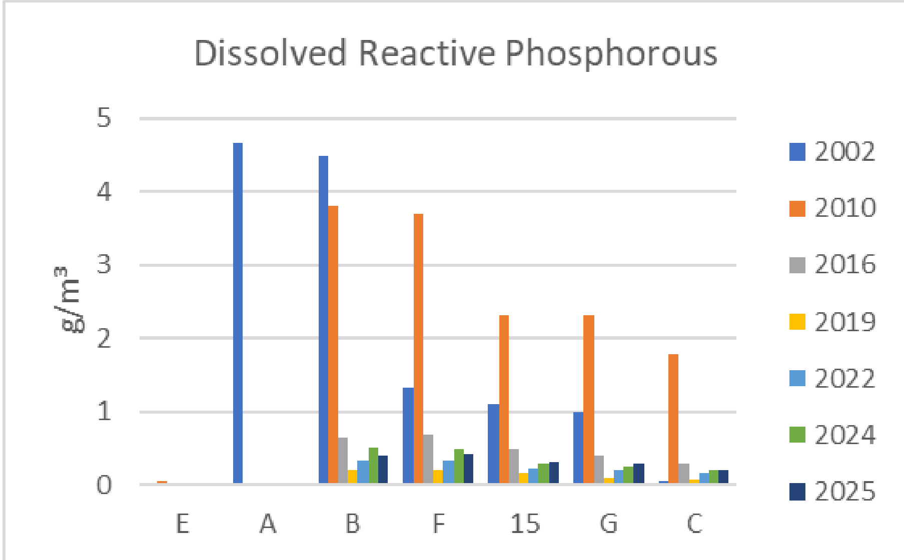
		E	A	B	F	15	G	C
Dissolved Inorganic Nitrogen (g/m³)	2002	0.09	3.47	2.98	0.87	0.91	1.1	0.2
	2010	0.148	0.086	2.1	1.92	1.11	0.87	0.32
	2016	0.179	0.044	0.88	0.96	0.73	0.53	0.41
	2019	0.24	0.133	0.8	0.92	0.76	0.55	0.43
	2022	0.161	0.119	2.5	2.6	2.2	1.73	1.91
	2024	0.128	0.13	2.7	2.7	1.75	1.53	1.5
	2025	0.112	0.195	4.7	4.5	3.4	3.4	3.1
Total Phosphorous (g/m³)	2002	0.019	4.66	4.89	1.41	1.22	1.04	0.051
	2010	0.058	0.025	4	3.9	2.3	2.3	1.77
	2016	0.04	0.037	0.74	0.74	0.55	0.46	0.35
	2019	0.036	0.026	0.38	0.34	0.24	0.164	0.144
	2022	0.041	0.031	0.49	0.44	0.33	0.28	0.2
	2024	0.04	0.029	0.69	0.61	0.45	0.32	0.28
	2025	0.047	0.091	0.55	0.53	0.42	0.36	0.25

Corresponding graph

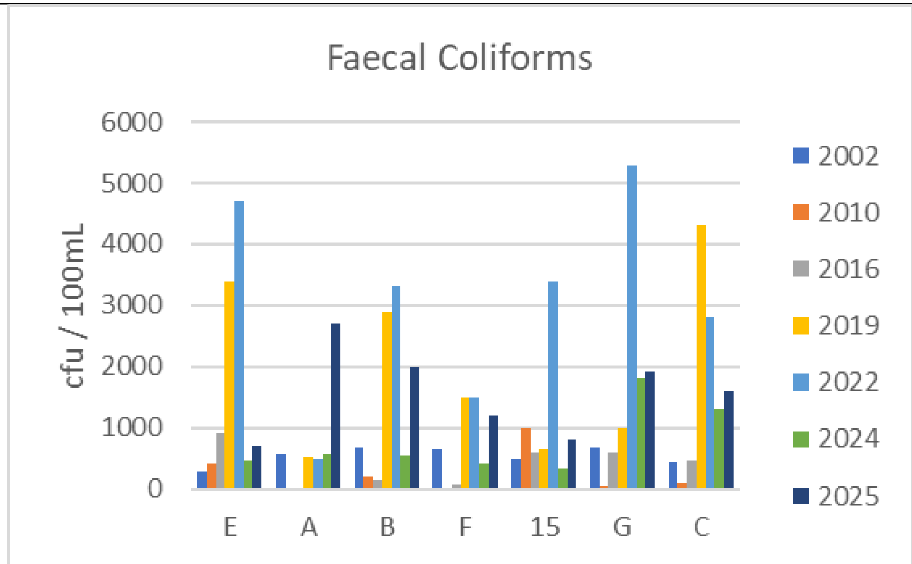


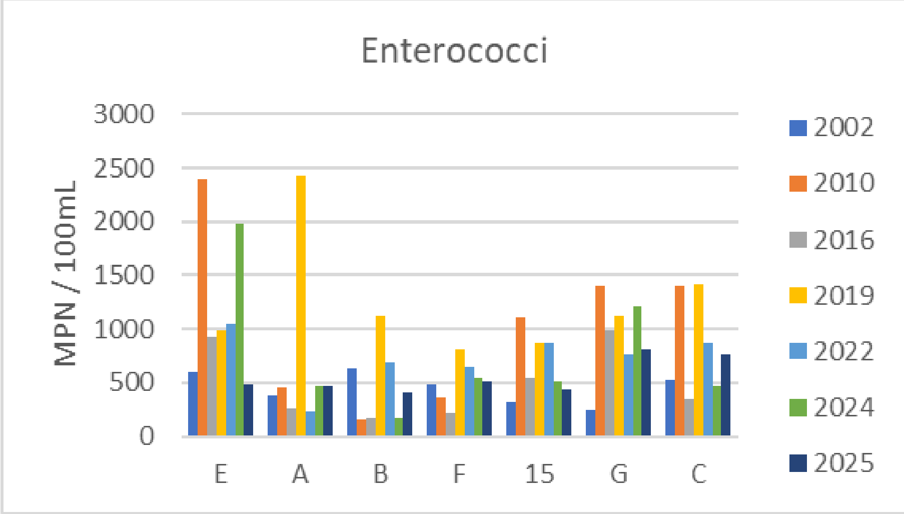


		E	A	B	F	15	G	C	Corresponding graph
Dissolved Reactive Phosphorous (g/m³)	2002	0.017	4.67	4.48	1.32	1.1	0.992	0.039	
	2010	0.04	0.013	3.8	3.7	2.3	2.3	1.79	
	2016	0.029	0.008	0.64	0.68	0.48	0.4	0.28	
	2019	0.008	0.007	0.192	0.21	0.149	0.091	0.077	
	2022	0.02	0.013	0.33	0.34	0.23	0.21	0.146	
	2024	0.015	0.005	0.51	0.48	0.29	0.24	0.2	
	2025	0.019	0.012	0.4	0.42	0.32	0.28	0.199	

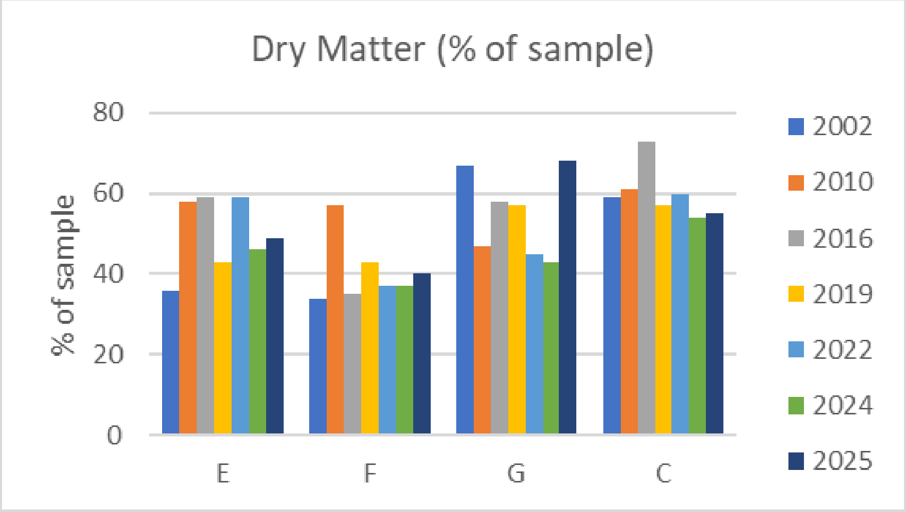
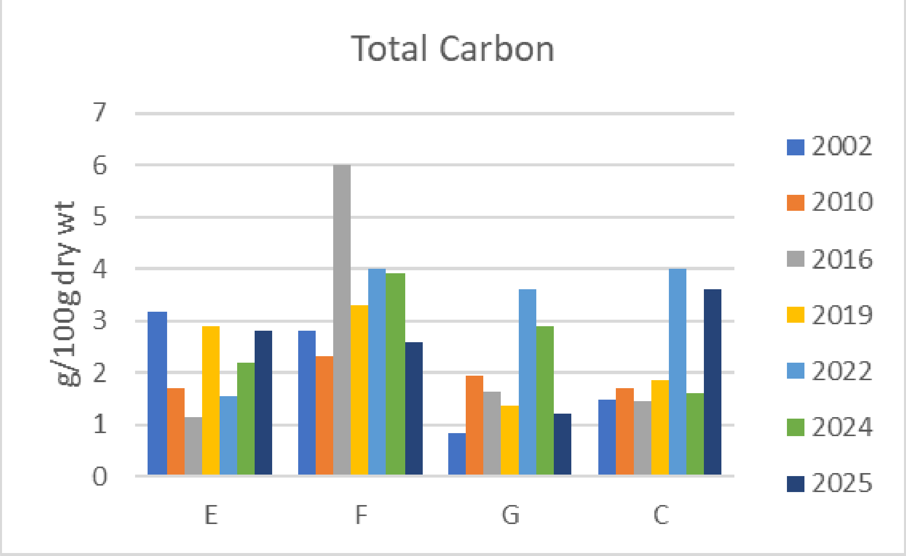


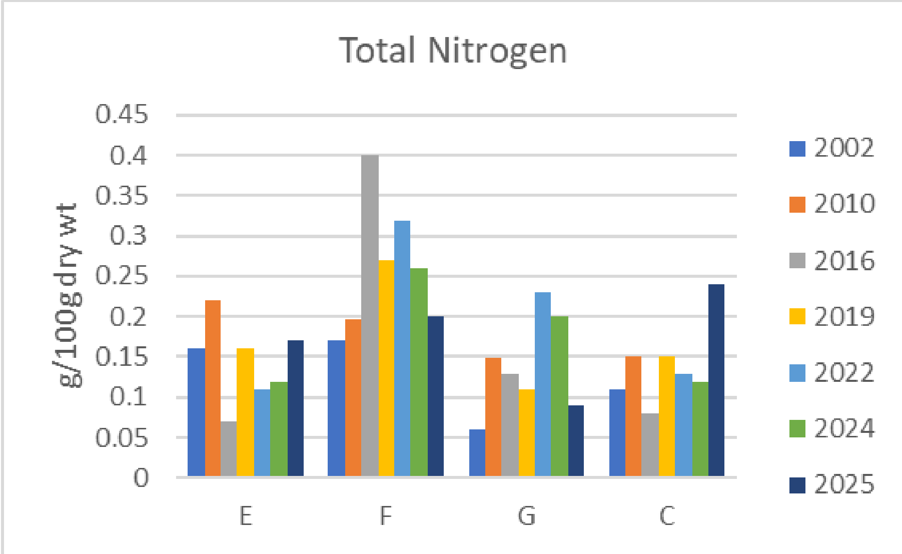
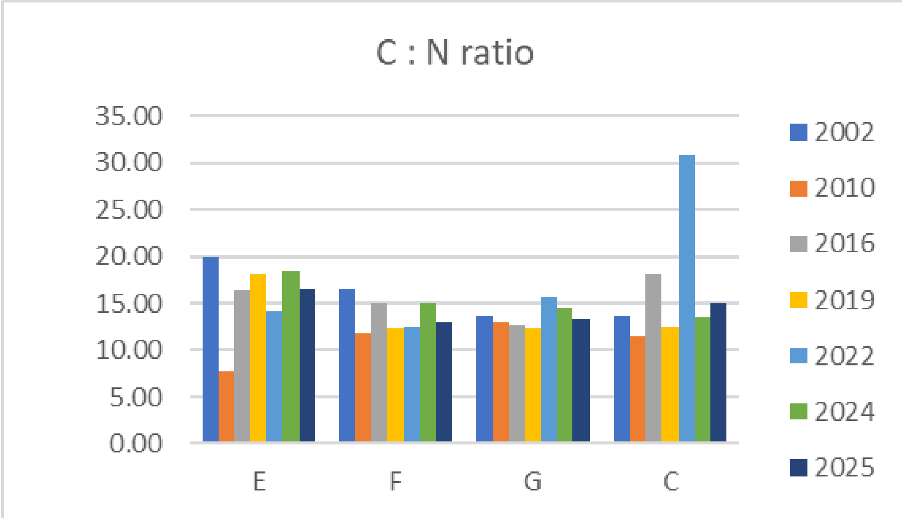
		E	A	B	F	15	G	C	Corresponding graph
Faecal Coliforms (cfu / 100mL)	2002	280	570	670	650	480	680	430	
	2010	410	12	210	24	1000	39	100	
	2016	900	22	150	70	600	590	470	
	2019	3,400	510	2,900	1,500	660	1,000	4,300	
	2022	4,700	490	3,300	1,500	3,400	5,300	2,800	
	2024	460	560	540	410	340	1,800	1,300	
	2025	690	2700	2000	1200	800	1,900	1,600	

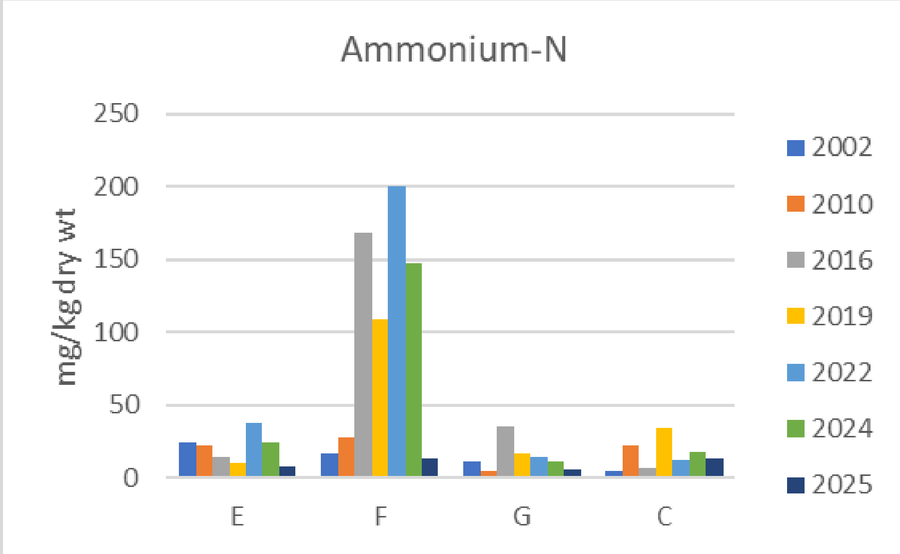
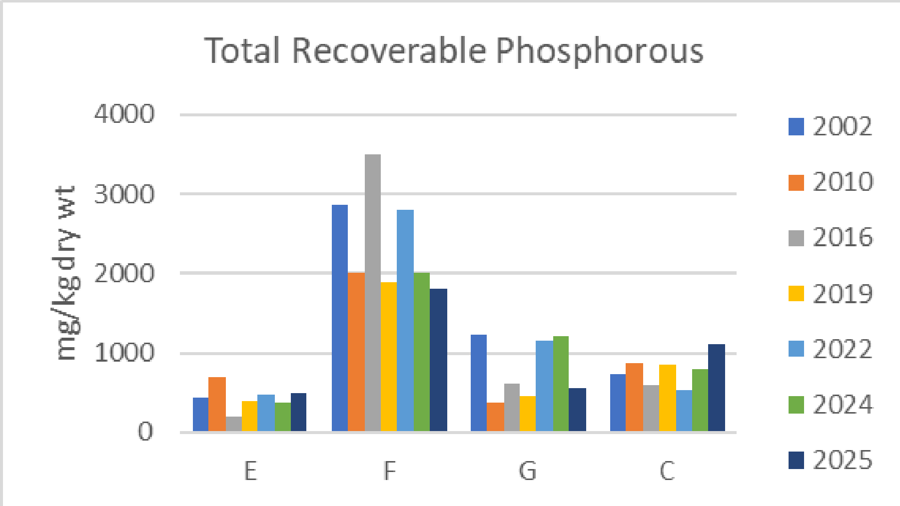


Enterococci (MPN / 100mL)		E	A	B	F	15	G	C	Corresponding graph
	2002	600	380	630	480	320	240	520	
	2010	2400	460	150	370	1100	1400	1400	
	2016	921	260	172	214	548	980	345	
	2019	985	2,420	1,120	816	866	1,120	1,414	
	2022	1,046	236	687	649	866	770	866	
	2024	1,986	461	166	549	517	1,203	461	
	2025	488	461	411	517	435	816	770	

6.2 Sediment Quality

		E	F	G	C	Corresponding graph
Dry Matter (% of sample)	**2002**	35.9	33.9	66.9	59.1	
	2010	58	57	47	61	
	2016	59	35	58	73	
	2019	43	43	57	57	
	2022	59	37	45	60	
	2024	46	37	43	54	
	2025	49	40	68	55	
Total Carbon (g/100g dry wt)	**2002**	3.184	2.805	0.822	1.496	
	2010	1.71	2.3	1.93	1.71	
	2016	1.14	6	1.65	1.44	
	2019	2.9	3.3	1.36	1.86	
	2022	1.56	4	3.6	4	
	2024	2.2	3.9	2.9	1.62	
	2025	2.8	2.6	1.2	3.6	

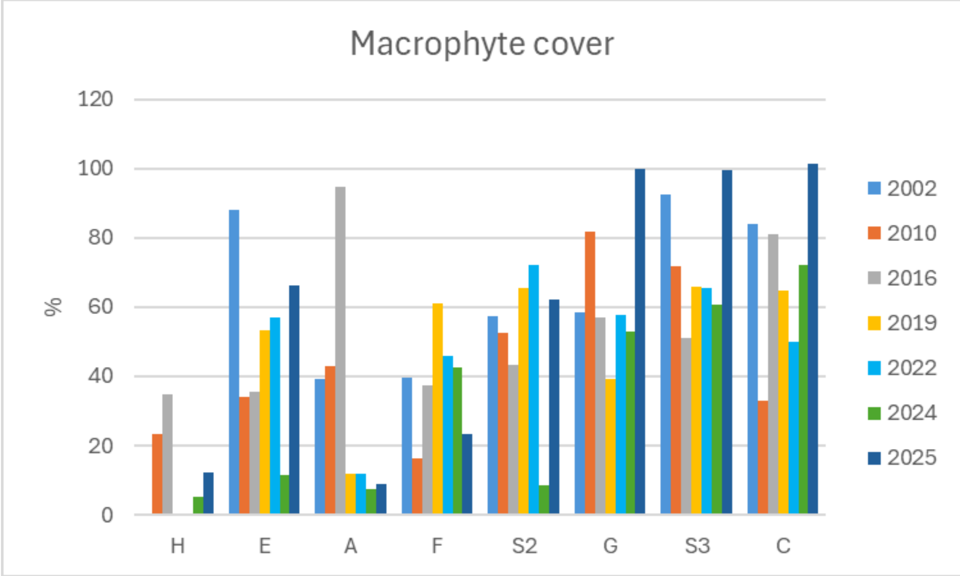
		E	F	G	C	Corresponding graph
Total Nitrogen (g/100g dry wt)	2002	0.16	0.17	0.06	0.11	
	2010	0.22	0.196	0.149	0.15	
	2016	0.07	0.4	0.13	0.08	
	2019	0.16	0.27	0.11	0.15	
	2022	0.11	0.32	0.23	0.13	
	2024	0.12	0.26	0.2	0.12	
	2025	0.17	0.2	0.09	0.24	
C : N ratio	2002	19.90	16.50	13.70	13.60	
	2010	7.77	11.73	12.95	11.40	
	2016	16.29	15.00	12.69	18.00	
	2019	18.13	12.22	12.36	12.40	
	2022	14.18	12.50	15.65	30.77	
	2024	18.33	15.00	14.50	13.50	
	2025	16.47	13.00	13.33	15.00	

		E	F	G	C	Corresponding graph
Ammonium-N (mg/kg dry wt)	**2002**	25	17	11	5	
	2010	22	28	5	22	
	2016	15	168	35	7	
	2019	10	109	17	34	
	2022	38	200	15	12	
	2024	24	148	11	18	
	2025	8	13	6	13	
Total Recoverable Phosphorous (mg/kg dry wt)	**2002**	440	2860	1230	730	
	2010	700	2000	370	880	
	2016	194	3500	620	590	
	2019	400	1890	450	850	
	2022	480	2800	1150	540	
	2024	380	2000	1210	800	
	2025	490	1810	560	1110	

6.3 Macrophyte cover

		H	E	A	F	S2	G	S3	C
Macrophyte cover	2002		87.9	39.1	39.8	57.3	58.3	92.5	84.0
	2010	23.3	34.0	43.1	16.3	52.5	81.7	71.9	32.9
	2016	34.6	35.4	94.7	37.5	43.3	57.1	50.9	81.0
	2019	0.0	53.4	11.7	60.9	65.4	39.3	66.0	64.9
	2022	0.0	57.1	12.0	46.0	72.1	57.7	65.3	50.0
	2024	5.1	11.4	7.4	42.6	8.7	52.8	60.7	72.0
	2025	12.2	66.4	9.0	23.3	62.0	99.8	99.4	101.3

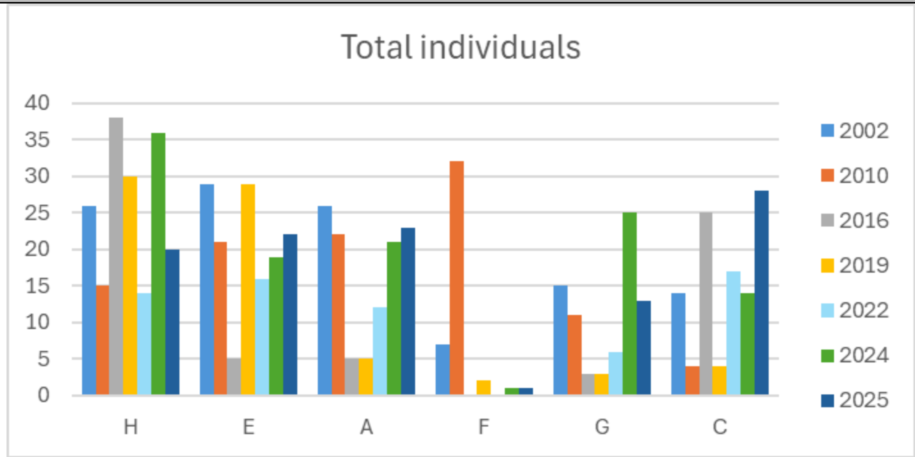
Corresponding graph

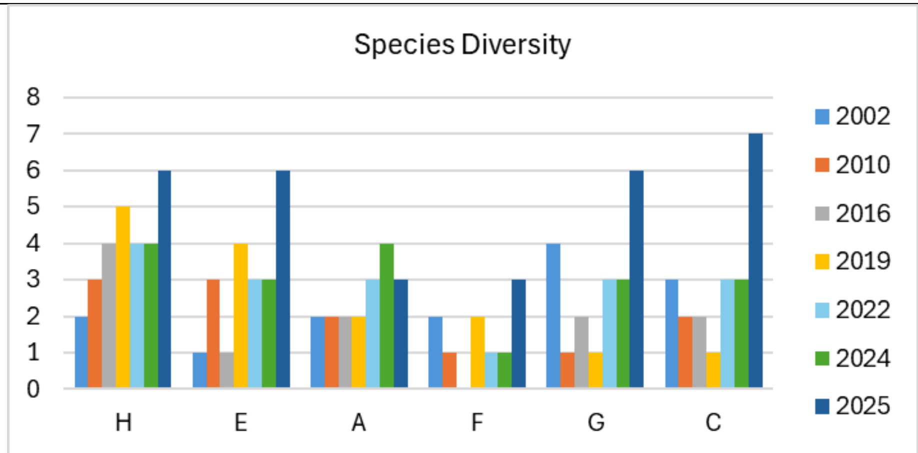


6.4 Freshwater Fish

		H	E	A	F	G	C
TOTAL INDIVIDUALS	2002	26	29	26	7	15	14
	2010	15	21	22	32	11	4
	2016	38	5	5	0	3	25
	2019	30	29	5	2	3	4
	2022	14	16	12	0	6	17
	2024	36	19	21	1	25	14
	2025	20	22	23	1	13	28
FISH DIVERSITY	2002	2	1	2	2	4	3
	2010	3	3	2	1	1	2
	2016	4	1	2	0	2	2
	2019	5	4	2	2	1	1
	2022	4	3	3	1	3	3
	2024	4	3	4	1	3	3
	2025	6	6	3	3	6	7

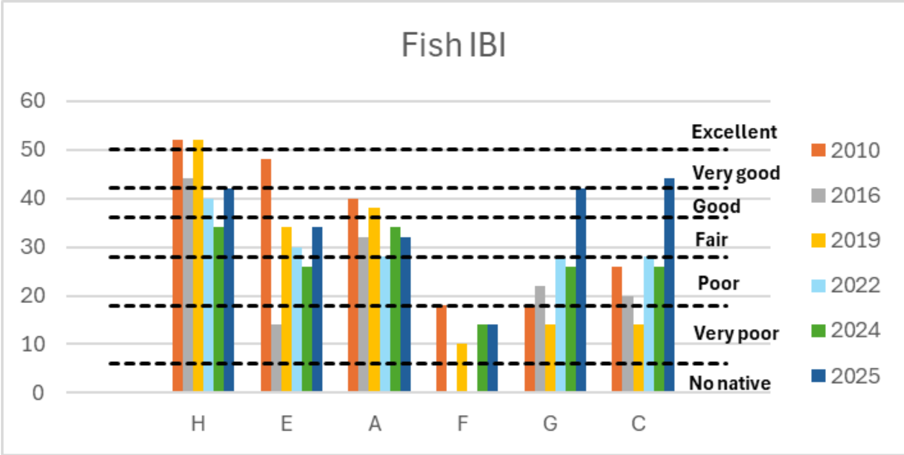
Corresponding Grah





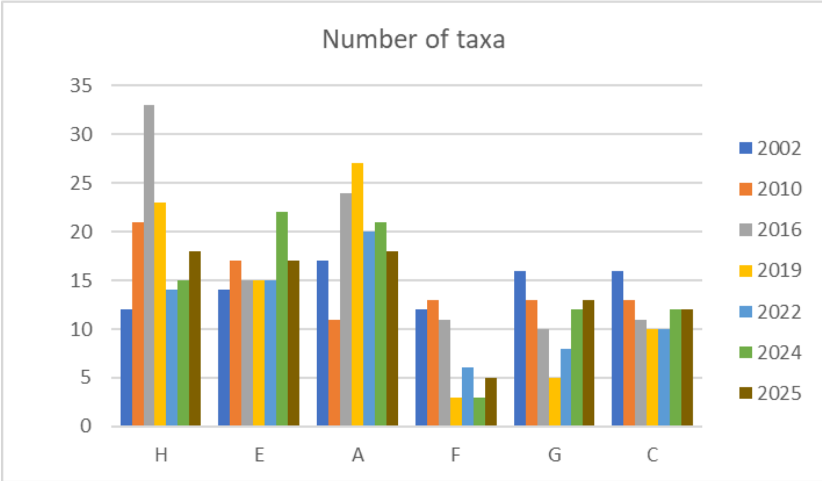
FISH IBI		H	E	A	F	G	C
	2002	52	48	40	18	18	26
	2010	44	14	32	0	22	20
	2016	52	34	38	10	14	14
	2019	40	30	28	0	28	28
	2022	34	26	34	14	26	26
	2024	42	34	32	14	42	44
	2025	52	48	40	18	18	26

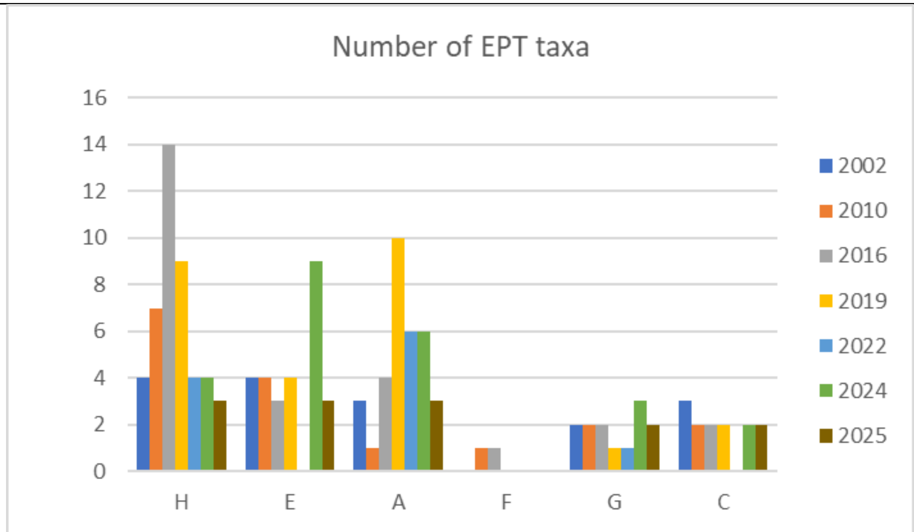
Corresponding Grah



6.5 Macroinvertebrates

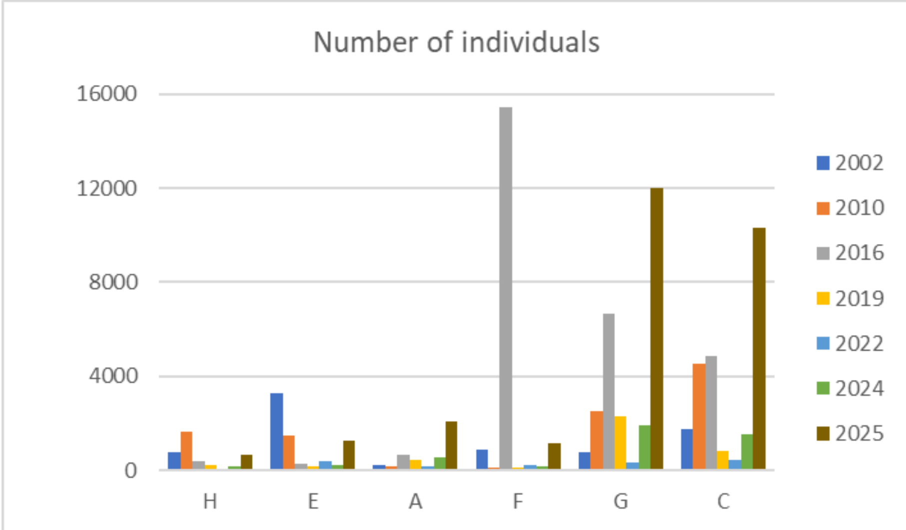
		H	E	A	F	G	C	Corresponding Grah
NO. TAXA	2002	12	14	17	12	16	16	
	2010	21	17	11	13	13	13	
	2016	33	15	24	11	10	11	
	2019	23	15	27	3	5	10	
	2022	14	15	20	6	8	10	
	2024	15	22	21	3	12	12	
	2025	18	17	18	5	13	12	
NO. EPT TAXA	2002	4	4	3	0	2	3	
	2010	7	4	1	1	2	2	
	2016	14	3	4	1	2	2	
	2019	9	4	10	0	1	2	
	2022	4	0	6	0	1	0	
	2024	4	9	6	0	3	2	
	2025	3	3	3	0	2	2	

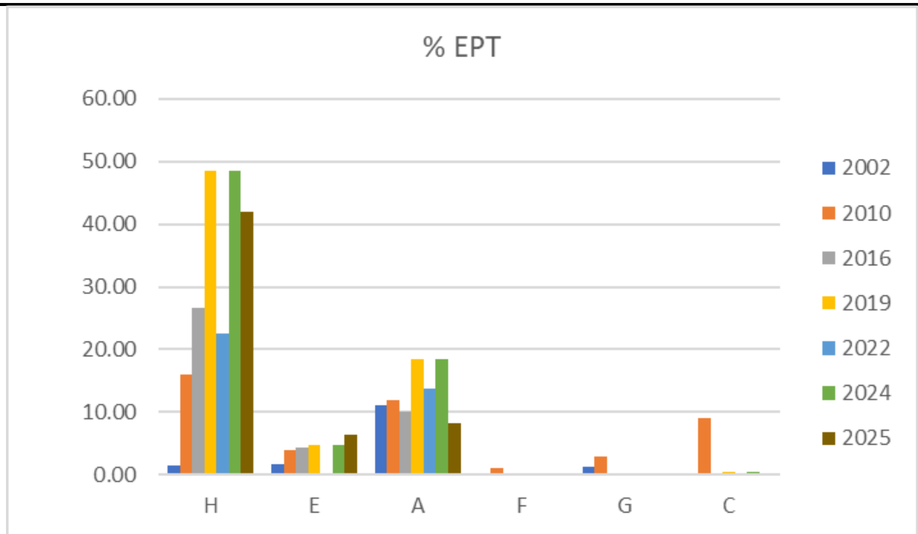


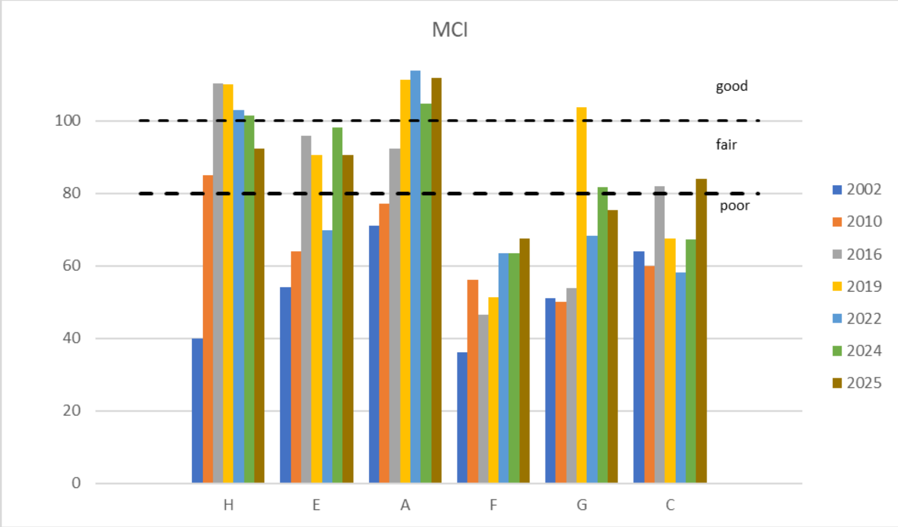
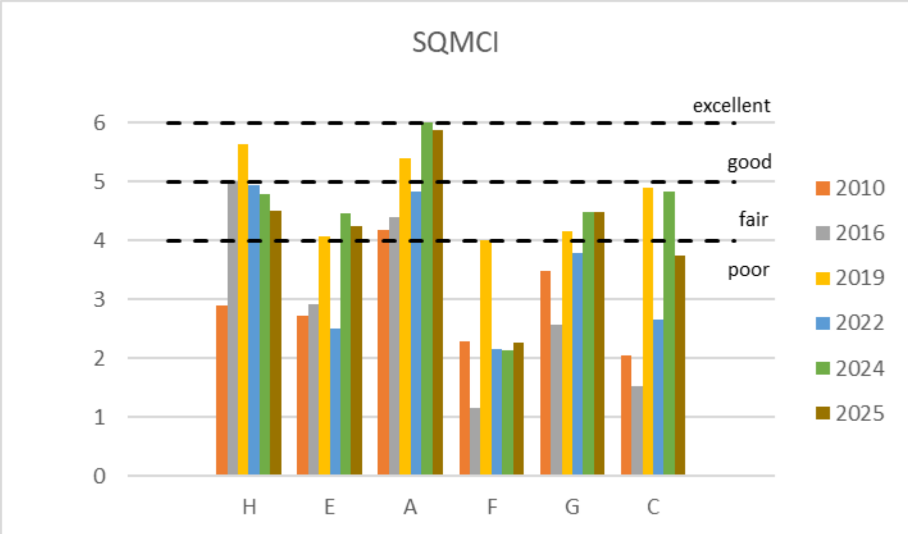


		H	E	A	F	G	C
NO. INDIVIDUALS	**2002**	748	3256	217	876	745	1747
	2010	1636	1460	180	129	2500	4508
	2016	384	294	669	15418	6675	4869
	2019	192	147	412	103	2265	832
	2022	49	360	181	199	316	451
	2024	149	225	525	183	1911	1534
	2025	630	1239	2062	1144	12022	10294
% EPT	**2002**	1.50	1.70	11.10	0.00	1.30	0.02
	2010	16.00	4.00	12.00	1.00	3.00	9.00
	2016	26.56	4.42	10.16	0.00	0.00	0.02
	2019	48.44	4.76	18.45	0.00	0.04	0.36
	2022	22.45	0.00	13.81	0.00	0.32	0.00
	2024	48.44	4.76	18.45	0.00	0.04	0.36
	2025	42.06	6.46	8.15	0.00	0.01	0.02

Corresponding Grah





		H	E	A	F	G	C	Corresponding Grah
MCI	2002	40.00	54.00	71.00	36.00	51.00	64.00	
	2010	85.00	64.00	77.00	56.00	50.00	60.00	
	2016	110.30	95.73	92.42	46.36	53.80	81.82	
	2019	110.00	90.53	111.19	51.33	103.60	67.40	
	2022	102.86	69.73	113.90	63.33	68.25	58.20	
	2024	101.33	98.18	104.67	63.33	81.67	67.33	
	2025	92.22	90.59	111.78	67.60	75.38	83.83	
SQMCI	2010	2.89	2.71	4.18	2.29	3.48	2.04	
	2016	5.00	2.91	4.40	1.15	2.57	1.52	
	2019	5.64	4.06	5.39	4.00	4.17	4.89	
	2022	4.93	2.51	4.83	2.16	3.78	2.65	
	2024	4.78	4.46	6.01	2.13	4.49	4.83	
	2025	4.50	4.24	5.87	2.26	4.48	3.74	

Appendix C. Data sources

Table 4-3: Download location of environmental monitoring data used in this report

Category	Parameter	Source platform	Tag/ID
Effluent volume	N/A	Pi	DTBEA_48_FQ_001_VOLUMEDAY
Rainfall	N/A	Hydrotel	DTBEA – Beachlands WWTP RG; 09_RG_01_RainGauge
Effluent quality	*Escherichia coli*	Pi	DTBEA_48_13_UV_ECOLMTEC
Effluent quality	Faecal Coliforms	Pi	DTBEA_48_13_UV_FC
Effluent quality	cBOD5	Pi	DTBEA_48_13_UVE_BOD
Effluent quality	Nitrate	Pi	DTBEA_48_13_UVE_NO3
Effluent quality	Ammoniacal Nitrogen	Pi	DTBEA_48_13_UVE_TNH3N
Effluent quality	Soluble Reactive Phosphorus	Pi	DTBEA_48_13_UVE_P
Effluent quality	pH	Pi	DTBEA_48_13_UVE_pH
Effluent quality	Total Suspended Solids	Pi	DTBEA_48_13_UVE_TSS
Biofilter	Moisture	Pi	DTBEA_35_BIOFILTER_moisture
Biofilter	pH	Pi	DTBEA_35_BIOFILTER_pH