Christchurch Aquatic Ecology Monitoring 2024

Including the Ōtākaro–Avon River, Wilsons Drain, Cashmere Stream, and Balguerie Stream

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EXECUTIVE SUMMARY

This report presents results of the 2024 round of aquatic ecology monitoring for Christchurch City Council (CCC), undertaken as a requirement of its Comprehensive Stormwater Network Discharge Consent. This report includes five-yearly monitoring data collected from the Ōtākaro – Avon River catchment and annual monitoring data from Wilsons Drain, Cashmere Stream, and Balguerie Stream.

Habitat quality is in a poor state in the Ōtākaro catchment, compared to less urbanised waterways in the district. Key issues are lack of sufficient native riparian vegetation to shade and buffer waterways, and high bed cover with deposited fine sediment. This observation is unchanged from the last round of monitoring in 2019. However, there are indications of slowly improving habitat quality at some locations, based on long term annual monitoring data from Environment Canterbury (ECan).

Sediment concentrations of common stormwater contaminants exceeded consent Attribute Target Levels for at least some parameters at most sites in 2024, but there were no indications of increasing or decreasing trends. As with previous years, zinc concentrations were elevated at most locations, and targeted removal of contaminated sediments should be trialled.

Annual invertebrate monitoring data were compared against attribute bands in the National Policy Statement for Freshwater Management. For the Quantitative Macroinvertebrate Community Index (QMCI), scores were in the D band (the lowest) for five sites, in the C band for two sites, and in the A band for one site. Consistent with previous years, monitoring sites in the city were in a more degraded state compared to Banks Peninsula waterways, where urban impacts are less. Seven of the eight annual monitoring sites showed improving trends in QMCI scores, although the rate of improvement is slow for most sites. Regression analysis indicates that physical habitat – particularly fine sediment deposition – better explained invertebrate community health than measures of water or sediment quality.

Recent searches have revealed that At Risk kākahi (freshwater mussels) are widespread in the lower Ōtākaro river. Kākahi monitoring in non-wadeable river reaches could be used to complement conventional sampling of invertebrates in wadeable river sections.

The Ōtākaro fish community is similar to that of other Christchurch waterways, with shortfin eels and upland bullies the most common and widespread species. However, the presence of At Risk longfin eel, inanga, bluegill bully, giant bully, and torrentfish, and Threatened lamprey is notable, given the modified urban setting. There were no marked changes in the fish community compared to previous years, although more inanga and bluegill bullies were caught at some locations than previously.

Key recommendations include: increase the rate of habitat restoration and protection (this is the highest priority); undertake fine sediment removal trials (high priority); monitor At Risk kākahi populations; undertake surveys for Threatened lamprey; shift from five-yearly to annual ecology monitoring, to better detect trends (underway from 2025); use new annual monitoring data from across the district to assess the relative impact of habitat, water and sediment quality on waterway ecology.

1. INTRODUCTION

The discharge of stormwater from Christchurch city and settlements in the district is authorised by a Comprehensive Stormwater Network Discharge Consent (CSNDC), issued by Environment Canterbury (ECan[1]). Attached to the CSNDC is an Environmental Monitoring Programme (EMP). Consent condition 49 of the CSNDC states that the purpose of the EMP is to monitor whether the consent's Receiving Environment Objectives and Attribute Target Levels are being met. These objectives and levels are stipulated in Schedule 7 of the consent, and include a range of biotic, abiotic, and cultural parameters. Included in the EMP are requirements to undertake ecological monitoring at specified sites across the district on a five-yearly basis, focusing on one catchment per year[2]. Annual ecology monitoring is also undertaken at several sites, with a focus on catchments where there is more rapid urban development occurring.

This report presents results of the 2024 round of five-yearly ecology monitoring for Christchurch City Council (CCC) in the Ōtākaro – Avon River catchment and annual monitoring in Wilsons Drain, Cashmere Stream, and Balguerie Stream.

2. METHODS

2.1. Monitoring Sites

Instream sampled the following sites in February and March 2024:

- 17 five-yearly ecology sites in the Ōtākaro – Avon River catchment.
- 4 annual ecology sites, including 2 in Wilsons Drain and 2 in Cashmere Stream.
- 14 five-yearly instream sediment quality sites in the Ōtākaro catchment.

In addition, this report includes a desktop review of macroinvertebrate data collected annually by ECan from four sites in the Ōtākaro catchment and two sites on Balguerie Stream. The CSNDC only requires one of the Balguerie Stream sites (at Settlers Hill Road) to be reported on, but the additional upstream site (at Stony Bay Road) is included here to provide context. Similarly, the annual monitoring data for the four Ōtākaro sites is used to complement the EMP sites. Annual ECan monitoring data was available from both Balguerie Stream sites from November 2005 to November 2023 and from the four Ōtākaro sites from summer 1999/2000 to 2023/2024.

Sampling site locations for ecology and sediment quality are shown in Figure 1 to Figure 4 and summarised in Table 1 and Table 2. Note that EMP site codes have changed over time, so site codes used in previous rounds of monitoring have been updated to align with the new codes.

The Ōtākaro is a spring-fed river that flows through the centre of urban Christchurch. Adjacent landuse varies amongst the sampling sites, and comprises a mix of residential and commercial properties, and urban parkland. Water quality, hydrology, and habitat are all affected by the urban landuse.

Cashmere Stream is a spring-fed tributary of the Ōpāwaho – Heathcote River, located to the southwest of the centre of Christchurch city. Its headwaters arise as springs near Sutherlands

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[1] ECan consent number CRC252424

[2] EMP methods have since been updated to annual ecology monitoring at all sites, from summer 2025.

Road, and it passes through a rapidly urbanising catchment, before discharging into the Ōpāwaho at Cashmere Road. Water quality is affected by the adjacent rural and residential land, as well as sediment-laden runoff from the Port Hills following rainfall. The two annual monitoring sites are located along Cashmere Road, upstream and downstream of a stormwater outlet.

Ōtukaikino Creek is a medium-sized spring-fed river north of the city that drains an urban and rural catchment and flows into the Waimakariri River near State Highway 1. The two sites sampled for this report fall within the Wilsons Drain sub-catchment. Wilsons Drain is spring-fed and there is a mix of rural and urban (including industrial) landuse in the catchment, with further urban development planned. Wilsons Drain flows through Ōtūkaikino Reserve and is then piped under State Highway 1, before discharging into Ōtūkaikino Creek.

Balguerie Stream is a small, hill-fed stream that drains the flanks of Stony Bay Peak and flows into Akaroa Harbour after passing through the town of Akaroa. The mid to upper reaches of the catchment include a mix of native bush and pasture, while the lower reaches include a mix of native bush and urban landuse. The Stony Bay Road monitoring site is located within native bush in the upper catchment, while the Balguerie Road site is located adjacent to residential properties and native bush in the lower catchment.

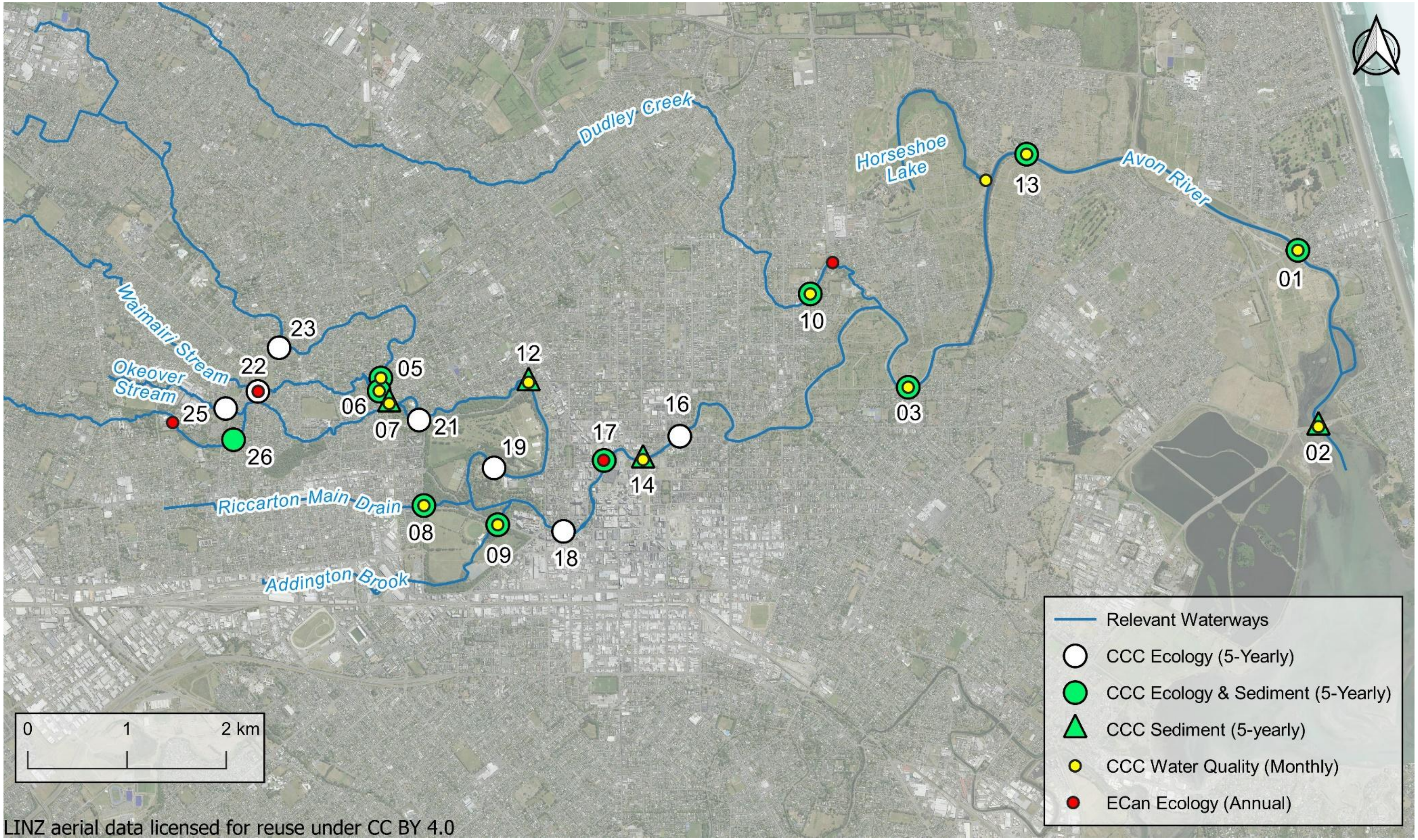

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Figure 1: Ōtākaro – Avon River catchment five-yearly and annual monitoring sites. The site code AVON prefix has been omitted for clarity.

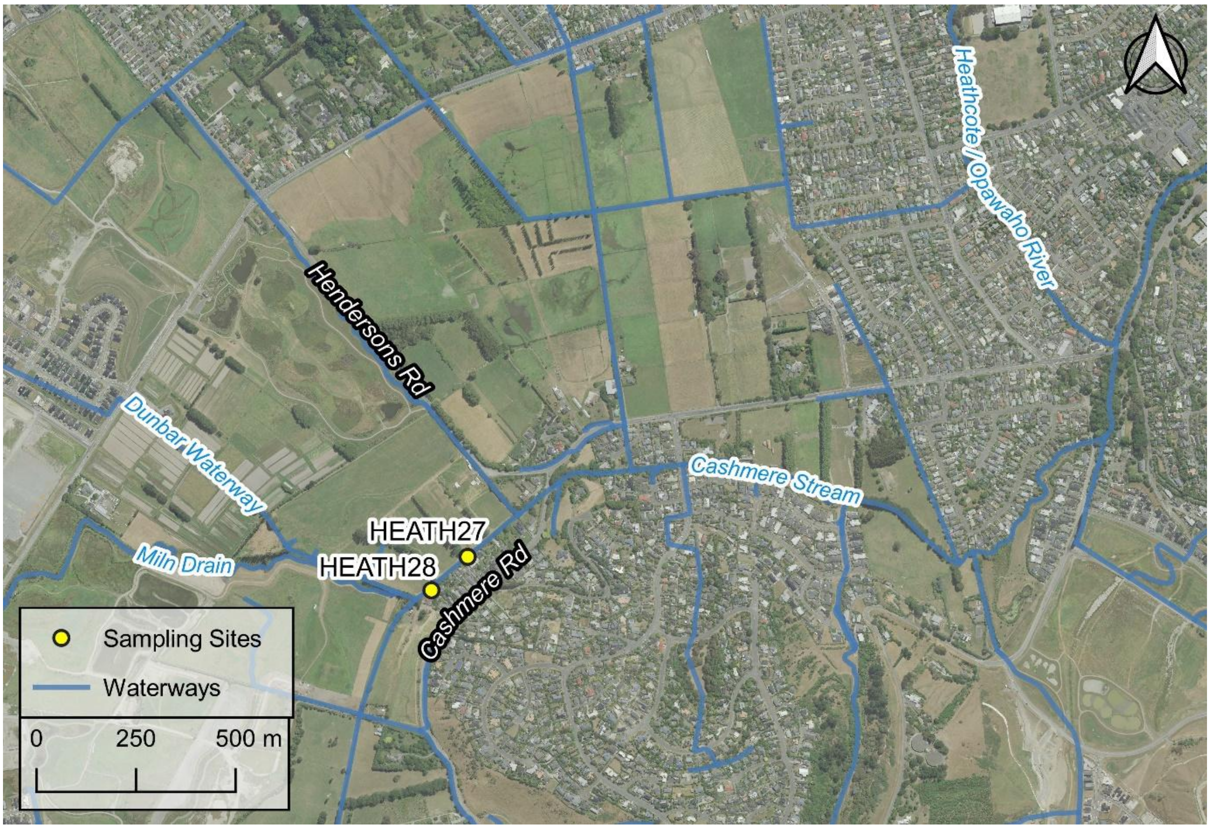

Figure 2: Cashmere Stream annual ecology monitoring sites.

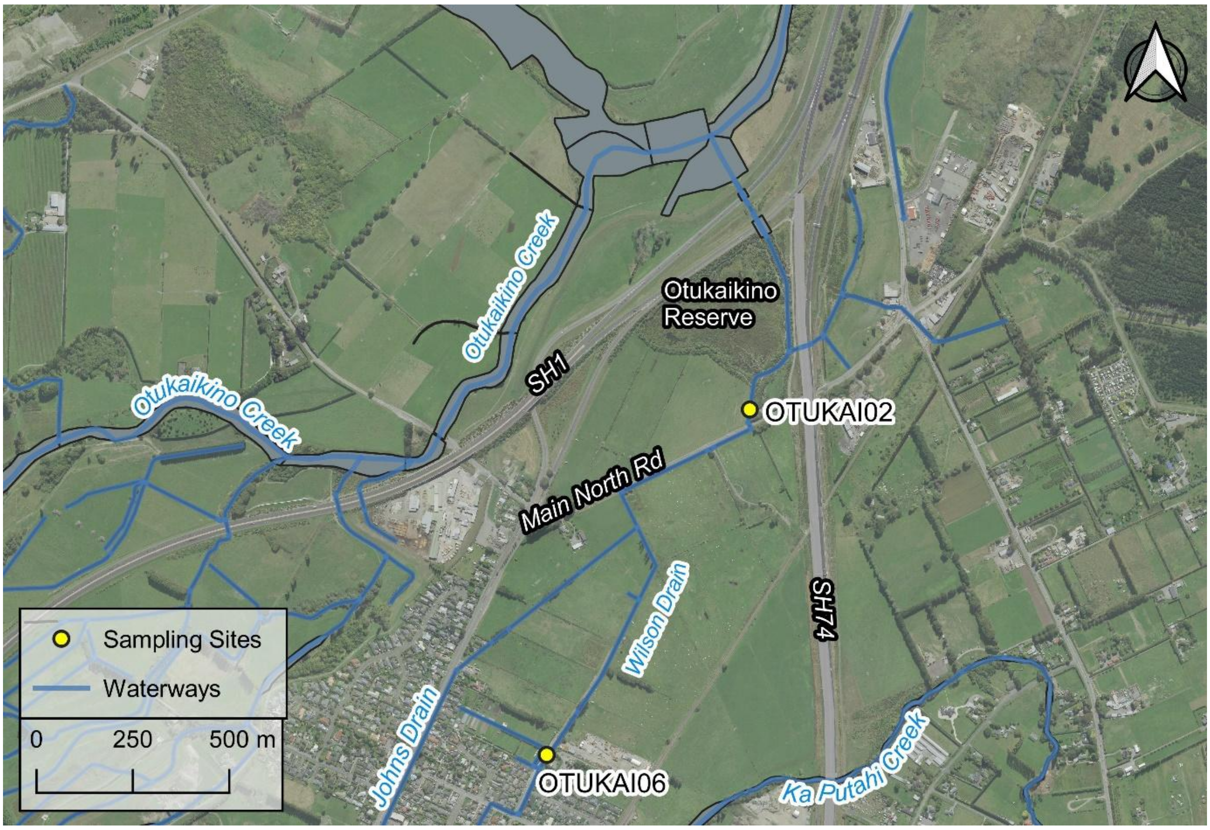

Figure 3: Wilsons Drain annual ecology monitoring sites.

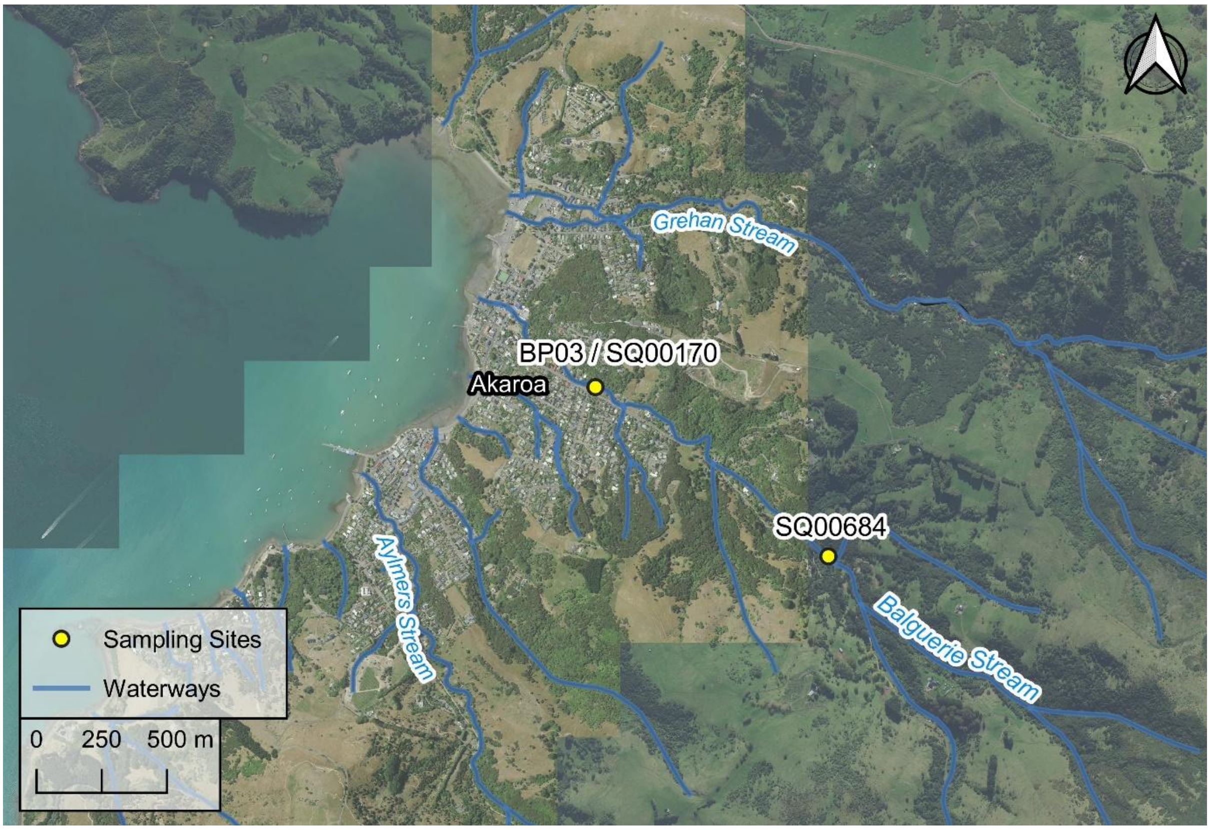

Figure 4: Balguerie Stream annual ecology monitoring sites.

Table 1: Five-yearly monitoring sites in the Ōtākaro - Avon River catchment sampled in 2024.

Site Code[1]	Waterway	Site Name/Location	Easting (NZTM)	Northing (NZTM)
AVON25	Okeover Stream	University of Canterbury Glasshouses	1566687	5180996
AVON22	Waimairi Stream	Fendalton Park	1567011	5181168
AVON06**	Waimairi Stream	Downstream of Railway Bridge	1568233	5181172
AVON23	Wairarapa Stream	Upstream of Glandovey Road	1567225	5181608
AVON05**	Wairarapa Stream	Downstream of Fendalton Road	1568250	5181303
AVON08**	Riccarton Main Drain	Downstream of Deans Avenue	1568683	5180019
AVON09**	Addington Brook	Upstream of Riccarton Avenue	1569427	5179826
AVON10**	Dudley Creek	North Parade	1572574	5182150
AVON26**	Avon River	Clyde Road	1566766	5180682
AVON07*	Avon River	At Mona Vale	1568334	5181046
AVON21	Avon River	Downstream of Mona Vale Loop	1568634	5180880
AVON12*	Avon River	Carlton Mill Corner	1569737	5181259
AVON19	Avon River	Botanic Garden North Car Park/in Hagley Park	1569390	5180398
AVON18	Avon River	Upstream of Montreal Street/near Durham Street	1570089	5179759
AVON17**	Avon River	Victoria Square Near Armagh Street	1570498	5180473
AVON04*	Avon River	Manchester Street	1570890	5180481
AVON16	Avon River	Downstream of Kilmore Street (Ōtautahi)	1571260	5180717
AVON03**	Avon River	Dallington Terrace/Gayhurst Road	1573560	5181210
AVON13**	Avon River	Avondale Road	1574752	5183557
AVON01**	Avon River	Pages/Seaview Bridge	1577484	5182589
AVON02*	Avon River	Bridge Street	1577691	5180813

Note: [1] * indicates sediment quality site only; ** indicates sediment and ecology site; no symbol means ecology site only. The EMP site code prefix "AVON" has been omitted for ease of tabulation and plotting.

Table 2: Annual ecology monitoring sites. The Cashmere Stream and Wilsons Drain sites were sampled by Instream for CCC in February/March 2024, the other sites were sampled by ECan in November 2023.

Site Code[1]	Waterway	Site Name / Location	Easting (NZTM)	Northing (NZTM)
HEATH28	Cashmere Stream	Behind 420–426 Cashmere Road (upstream of stormwater discharge)	1567362	5174782
HEATH27	Cashmere Stream	Behind 406 Cashmere Road (downstream of stormwater discharge)	1567453	5174866
OTUKAI02	Wilsons Drain	At Main North Road (Ōtūkaikino Reserve)	1571246	5190823
OTUKAI06	Wilsons Drain	At Tyrone Street	1570719	5189928
SQ00684	Balguerie Stream	At Stony Bay Road	1598639	5148931
BP03 / SQ00170	Balguerie Stream	Downstream of Settlers Hill Road	1597746	5149579
SQ00130	Waimairi Stream	Kotare Street	1567032	5181168
SQ00063	Dudley Creek	Corner of Banks Avenue and North Parade Road	1572819	5182466
SQ00129	Avon River	UCSA	1566173	5180855
SQ00128	Avon River	Victoria Square	1570508	5180466

Note: [1] Site codes with an "SQ" prefix are from ECan's monitoring network.

2.2. Habitat and Water Quality

Field sampling methods were unchanged from the previous round of CCC annual and five-yearly monitoring and followed those stipulated in draft Version 10 of the EMP (see Appendix 1). Methods are summarised in the following paragraphs.

At three representative transects located 10 metres apart, the following were collected:

- Bank and riparian habitat (for each bank for a 5 m bank width): surrounding land use, bank material, bank height, bank erosion, bank slope, riparian vegetation, canopy cover (using a spherical densiometer), undercut banks, overhanging vegetation and ground cover vegetation

- Instream habitat (for five locations across each transect, unless otherwise stated): wetted width (once per transect), water depth, fine sediment depth, fine sediment (<2 mm) cover, embeddedness, and substrate composition using the following size classes: silt/sand (<2 mm); gravels (2-16 mm); pebbles (16–64 mm); small cobbles (64–128 mm), large cobbles (128–256 mm), boulders (256–4000 mm) and bedrock/concrete/artificial hard surfaces (>4000 mm) (modified from Harding et al., 2009).

Substrate composition data was converted to a substrate index to aid comparison of data amongst sites and over years. The substrate index was calculated using the following formula (modified from Harding et al. 2009):

Substrate index (SI) = (0.03 x %silt / sand) + (0.04 x %gravel) + (0.05 x %pebble) + (0.06 x (%small cobble + %large cobble)) + (0.07 x %boulder) + (0.08 x %bedrock).

Water velocity was measured once per transect at the mid-channel using a Hach model FH950.1 electromagnetic velocity meter. At the reach scale, the relative percentage of riffle, run, and pool flow habitat was estimated visually.

Field measurements were taken of dissolved oxygen, water temperature, pH and conductivity in an area representative of the site (usually mid-channel). The water quality measurements were made using a calibrated YSI ProDSS water quality meter.

Macrophyte cover and composition, depth, and type (emergent and total) was measured at five locations across each of the three transects. Periphyton cover and composition was also measured at the five locations across each of the three transects. Periphyton categories were adapted from those outlined in Biggs & Kilroy (2000). These categories include: thin mat forming algae (<0.5 mm thick), medium mat forming algae (0.5–3 mm thick), thick mat forming algae (>3 mm thick), short filamentous algae (<20 mm long) and long filamentous algae (>20 mm long). Percentage cover and description of organic matter was also recorded.

ECan undertake a rapid habitat assessment at each annual invertebrate monitoring location. The rapid habitat assessment includes measures of adjacent landuse, riparian buffer width and composition, instream habitat diversity, fine sediment cover, and bed cover with nuisance periphyton and macrophytes. Each habitat parameter is ranked on a scale of 1-10 or 1-20, and the total habitat score can be summed for each site. We expressed the total habitat score as a percent, with higher scores indicating higher quality habitat. See Meredith et al. (2003) for further details of ECan sampling methods.

2.3. Sediment Quality

Sediment samples were collected from Ōtākaro catchment sites. Sample collection involved making multiple sweeps with a sampling container across the stream bed, with at least five subsamples composited into one sample, preferably of at least 1 kilogram. Three replicate samples were collected at each site (no replicates were collected in previous years in the Ōtākaro catchment). Sampling aimed to collect texturally similar sediment between sites, with the preferential collection of fine sediments (<2 mm) to ensure sufficient material for laboratory analysis. Samples were collected from the surface at a depth of no greater than 3 cm. Water was drained off directly from the jars. No sample was collected from Site AVON08 on Riccarton Main Drain. That is because we found insufficient fine sediment deposits along the predominantly concrete-lined waterway, despite searching the 360 m distance between Deans Avenue and Riccarton Avenue.

After collection, samples were placed in a chilly bin containing ice-bricks and transported to Hill Laboratories (an International Accreditation New Zealand laboratory) within 24 hours. Samples stored overnight were kept chilled in a refrigerator.

Sediment samples were analysed at all sites for the following using the most relevant US EPA methods and the <2 mm fraction (where relevant), with the detection limits for each parameter suitable to enable comparison of the results with relevant guideline levels and previous monitoring:

- Particle size distribution using the following size classes: silt and clay (<0.063 mm); fine sand (0.063–0.25 mm); medium sand (0.25–0.50 mm); coarse sand (0.5–2.0 mm); gravel and cobbles (>2 mm).
- Total recoverable copper, lead and zinc.
- Total organic carbon.
- Total phosphorus.

- Polycyclic aromatic hydrocarbons (PAHs).

Sediment sampling fieldwork was undertaken during baseflow conditions.

2.4. Macroinvertebrates

Benthic macroinvertebrates were sampled at each CCC monitoring site by collecting a single kicknet sample from the range of available habitats present, in proportion to the habitat types present, and covering a total area of approximately 0.6 m². Samples were preserved in the field using denatured ethanol prior to laboratory analysis by Biolive taxonomy consultants. In the laboratory invertebrates were counted and identified to species level where possible, using Protocol P2 (individual fixed count of 200 with scan for rare taxa) of (Stark et al. 2001).

ECan also collect kicknet invertebrate samples, although they only sample run habitat (as opposed to all habitat types for CCC sampling) and invertebrates are identified in the laboratory using a variation of Protocol P2 that uses a fixed 100 count and scan for rare taxa (as opposed to the 200 count for CCC sampling). There is likely relatively little effect of the different field sampling methods for most of the streams sampled, as most are lowland, spring-fed streams dominated by run habitat. Similarly, the 100 and 200 count methods provide comparable results for the key biological metrics used (Duggan et al. 2003). See Section 2.7.4 for calculation of invertebrate metrics.

Searches for kākahi, also known as freshwater mussel or *Echyridella menziesii,* were conducted at 16 of the 17 Ōtākaro ecology monitoring sites. The most downstream site – AVON01 at Pages Road – was not searched, as it is saline and kākahi are unlikely to occur in such habitats. The search at Site AVON19 (Avon River at Botanic Gardens) involves searching three separate “sub-sites” that had been searched previously (Instream Consulting 2020a). The timed rapid searches were undertaken to extend CCC’s knowledge of kākahi distribution in the catchment, due to their At Risk conservation status (Grainger et al. 2018). The timed searches involved one or two field staff searching the bed, using a bathyscope if the water was deep, or by snorkel if it was too deep to wade, for a combined total of 30 minutes (i.e., two people searching for 15 minutes or one person searching for 30 minutes). All live kākahi and empty shells seen during the search were counted and the upstream and downstream extent of the search recorded.

2.5. Fish

Fish sampling was undertaken at the Ōtākaro catchment sites. Fishing is not routinely undertaken at the annual monitoring sites. The fish community was sampled using a NIWA EFM300 electric fishing machine at sites where there was an appropriate mix of water depth, velocity, and substrate for electric fishing. Fish were sampled using a combination of fyke nets and Gee minnow traps at sites that were either too deep, velocities were too low, or they were dominated by sediments that were too deep and fine to sample effectively with electric fishing. For the electric fishing sites, the length of stream electric fished at each site was a minimum of 30 m and 30 m² in area (per EMP requirements). All habitat types within the reach were sampled without bias (e.g., pools, riffles, undercuts and backwaters). Trapping involved deploying five Gee Minnow traps baited with marmite and two fyke nets (4 mm mesh and two internal traps, as per Joy et al. (2013)) baited with cat food. Fyke nets were set at a 15–30° angle to the bank, with the leader downstream. Nets and traps were left overnight and checked the following morning.

For both trapping and electric fishing, all fish caught were identified to species level where possible, counted, measured, and released back into the waterway. Fish seen but not caught were recorded as missed fish (e.g. ‘missed bully’ or ‘missed fish’ if identification was uncertain), but missed fish were not included in the total tally.

Both electric fishing and fish trapping were undertaken at four of the five-yearly ecology sites, at sites where it was considered practical and there were little or no other recent fish sampling data using two methods. Previously, monitoring for the EMP has typically involved using only one fishing method for each site. Each fishing method has sampling biases, so using two methods provides a better indication of fish diversity and abundance.

2.6. Consent Attribute Target Levels and Guidelines

Water quality, sediment quality, habitat, and macroinvertebrate data were compared against the relevant consent attribute target levels and EMP guidelines in Table 3. All the ecology and sediment quality monitoring sites in the Ōtākaro catchment are classified as “Spring-fed Plains – Urban” under the Canterbury Land and Water Regional Plan (LWRP). The Wilsons Drain sites are classified as “Spring-fed – Plains”, while the two Cashmere Stream and two Balguerie Stream monitoring sites are classified as “Banks Peninsula”.

Data were also compared to National Policy Statement for Freshwater Management 2020 national bottom line values for some parameters. This was done in two situations: 1) where a consent attribute target level does not exist (dissolved oxygen concentration, MCI, and ASPM); and 2) where the consent attribute target level fell below the national bottom line (fine sediment cover, and QMCI for Spring-fed Plains – Urban waterways).

Consent attribute target levels for sediment quality are the same as default guideline value (DGV) levels in the ANZG (2018) sediment quality guidelines. The ANZG (2018) upper and lower guidelines indicate the overall risk of toxicity effects on biota. Sites meeting the lower DGVs (equal to the consent attribute target levels) have a low risk of toxicity effects, sites exceeding DGVs have an increased risk of adverse effects, and there is a relatively high risk of adverse effects for sites exceeding GV-high levels. Hence, when summarising sediment quality data, we have compared results against both the upper and lower ANZG (2018) guideline values, rather than simply comparing against the lower guideline/consent attribute target level.

2.7. Data Analyses

2.7.1. Data Management

All ecology and sediment quality data collected in 2024 was collated into a single Excel spreadsheet. In addition, summary data from 2024 and all previous years of ecology and sediment monitoring (data provided by CCC) were combined into a single Microsoft Excel spreadsheet. Both spreadsheets were provided to CCC and they are available from CCC on request. All statistical tests described in the following sections were carried out in the statistical computing software ‘R’ (R Core Team 2013).

2.7.2. Habitat and Water Quality

Field-measured water quality results were tabulated and compared against relevant consent attribute target levels and guidelines.

Relevant habitat data that were chosen for statistical analyses included the following parameters: channel width, water depth, water velocity, substrate index, fine sediment (<2 mm diameter) depth, fine sediment cover, and bed cover with emergent macrophytes, total macrophytes, and long filamentous algae (>2 cm long). Of these parameters, consent attribute target levels are associated with bed cover with fine sediment, total macrophytes, and long filamentous algae (Table 3).

Table 3: Consent attribute target levels and other relevant guidelines used in this report.

Parameter	Consent Attribute Target Level	EMP Guideline[1]	NPSFM[2] 2020	ANZG[3] (2018)
Water quality				
Dissolved oxygen		SPU[4] & SP[5]: ≥70% BP[6]: ≥90%	4 mg/L	
Temperature (°C)		≤20		
pH		6.5–8.5		
Fine sediment cover (%)	SPU: 30 SP: 20 BP: 20		21–29	
Sediment quality				
Copper (mg/kg)	65			65 / 270
Lead (mg/kg)	50			50 / 220
Zinc (mg/kg)	200			200 / 410
Total PAHs (mg/kg)	10			10 / 50
Total macrophyte cover (%)	SPU: 60 SP: 50 BP: 30			
Long filamentous algae (>2 cm long) cover (%)	SPU & SP: 30 BP: 20			
Macroinvertebrates				
QMCI[7]	SPU: 3.5 SP: 5 BP: 5		4.5	
MCI[8]			90	
ASPM[9]			0.3	

Notes: [1]From CSNDC EMP Version 10. [2]National Policy Statement for Freshwater Management 2020 national bottom line values. [3]Australia New Zealand Water Quality Guidelines (2018) for sediment quality are DGV / GV-high. [4]Spring-fed Plains – Urban. [5]Spring-fed – Plains. [6]Banks Peninsula. [7]Quantitative Macroinvertebrate Community Index. [8]Macroinvertebrate Community Index. [9]Average Score per Metric.

Prior to 2013, there were single, site-wide estimates for emergent and total macrophyte cover, long filamentous algae cover and fine sediment cover (estimated by summing estimated cover of sediment <2 mm). In 2013, 2019, and 2024, these parameters were estimated as per other transect data (i.e., the average of five (2019 and 2024) or twelve (2013) measurements per transect, and the site average obtained by the mean of three transects), excluding emergent macrophyte cover in 2013. Only a single measurement for velocity was recorded in 2013. Habitat data were averaged for each transect (where relevant), plotted, compared with consent attribute target levels, and inspected for evidence of any patterns over time or amongst sites.

Differences amongst sites over time were assessed using two-way analysis of variance (ANOVA) for the following parameters: width, depth, velocity, substrate index, fine sediment depth, emergent and total macrophyte cover, and long filamentous algae cover. Fine sediment cover was not assessed using ANOVA, due to different sampling methods being used for each sampling year. Data were transformed (rank or arcsine) when required to meet the assumptions of ANOVA.

2.7.3. Sediment Quality

Total PAHs were calculated by summing the following 18 PAHs listed in the (ANZG 2018) guidelines for total PAH: naphthalene, acenaphthylene, acenaphthene, fluorene, anthracene, phenanthrene, fluoranthene, pyrene, benz[a]anthracene, chrysene, benzo[a]pyrene, perylene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[e]pyrene, benzo[ghi]perylene, dibenz[a,h]anthracene and indeno[1,2,3-cd]pyrene. Total PAHs were normalised to 1% TOC, as recommended by (ANZG 2018). Where one or more PAH compound was below the detection limit, half the detection limit was used in the calculation, which is consistent with previous reporting (Boffa Miskell Limited 2016).

Sediment quality data from the 13 Ōtākaro catchment sites sampled in 2024 as part of the five-yearly monitoring programme were summarised and tabulated for comparison against consent attribute target levels and (ANZG 2018) upper guideline values (Table 3). Sediment quality data from 2024 were also compared against data collected in 1980, 2013, 2019, and 2022, using historic data provided by CCC. Differences in mean values amongst sites for 2024 data were assessed using permutation tests. Statistical comparison amongst sites and over time was not possible, due to the lack of replicates. Therefore, these data were just examined visually for any indication of trends.

2.7.4. Macroinvertebrates

The following biological indices were calculated from the raw invertebrate data:

Taxa Richness: The number of different invertebrate taxa (families, genera, species) at a site. Richness may be reduced at impacted sites, but is not a strong indicator of pollution.

%EPT: The percentage of all individuals collected made up of pollution-sensitive Ephemeroptera (mayfly), Plecoptera (stonefly), and Trichoptera (caddisfly) taxa. %EPT is typically reduced at polluted sites, and is particularly sensitive to sedimentation. This metric was calculated excluding pollution-tolerant hydroptilid caddisflies, which can skew %EPT results at sites where they are abundant.

EPT Taxa Richness: The number of different EPT taxa at a site. It is reduced at polluted sites. Calculated without hydroptilid caddisflies included.

MCI and QMCI: The Macroinvertebrate Community Index and the Quantitative MCI (Stark 1985). Invertebrate taxa are assigned scores from 1 to 10 based on their tolerance to organic pollution. Highest scoring taxa (e.g., many EPT taxa) are the least tolerant to organic pollution. The MCI is based on presence-absence data: scores are summed for each taxon in a sample, divided by the total number of taxa collected, then multiplied by a scaling factor of 20. The QMCI requires abundance data: MCI scores are multiplied by abundance for each taxon, summed for each sample, then divided by total invertebrate abundance for each sample. We calculated site MCI and QMCI scores using the tolerance scores for soft-bottomed streams for all sites except for the two Balguerie Stream sites, where hard-bottom tolerance scores were used. Hard and soft-bottomed tolerance scores were based on the dominant substrate present (Stark and Maxted 2007).

ASPM: The Average Score Per Metric combines %EPT, EPT taxa richness and MCI indices into a single metric (Collier 2008). Following recommendations in the National Policy Statement for Freshwater Management 2020, the ASPM was calculated as the average of the following: %EPT / 100, EPT taxa richness / 29, and MCI / 200.

As with reach-scale habitat data, it was not possible to conduct two-way ANOVA analyses on the five-yearly macroinvertebrate data, due to a lack of replication. The five-yearly monitoring data record is also too short to conduct trend analysis on, as a minimum of eight years of annual monitoring is recommended (Snelder *et al.* 2021).

Trend analysis was conducted on annual invertebrate monitoring data using Mann-Kendal trend analysis (Gilbert 1987), using the LWPTrends R library (Snelder et al. 2021; Fraser and Snelder 2021). Mann-Kendal is a robust, non-parametric form of trend analysis, allowing for analysis of non-normally distributed data, as well being able to detect non-linear trends. Outputs from a Mann-Kendal analysis include a directional slope (i.e., indicating whether the parameter is improving or degrading, and the annual rate) as well as a confidence level. Confidence levels may range from 0.5 (no certainty that a trend is present) to 1.0 (100% certainty that a trend is present). Confidence levels were interpreted by applying the categories developed by the Intergovernmental Panel on Climate Change (Stocker *et al.* 2014; Table 4), as used by Land Air Water Aotearoa (LAWA) for national water quality reporting[3]. We note that while trend analysis can be conducted on as few as five years of annual data, a minimum of eight years of invertebrate monitoring data is recommended for trend analysis (Snelder *et al.* 2021). Therefore, we have a lower level of confidence in the results of trend analyses conducted on the CCC datasets from Cashmere Stream that have only five years of data, compared with the ECan datasets that have over ten years of data. Trend analysis was not conducted on annual data from the two Wilsons Drain sites, as only four years of data was available, which was considered insufficient for robust trend analysis.

Table 4: Categorical interpretations of confidence values (C Value), developed by (Stocker et al. 2014).

Category	Slope	C value
Very Likely Improving	Positive	>90
Likely Improving	Positive	67-90
Indeterminate	Positive or negative	50–67
Likely Degrading	Negative	67-90
Very Likely Degrading	Negative	>90

Multiple regression was used to test the relationships between invertebrate index responses to three groups of predictors: physical habitat, water quality, and sediment quality. Each predictor group were first tested separately, due to uneven sample sizes in 2024. For each

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[3] https://www.lawa.org.nz/learn/factsheets/calculating-water-quality-trends-in-rivers-and-lakes

group of predictors, the best model was identified by using “all subsets regression”, which is a method that fits all possible models with different combinations of predictors (Leaps package in R). This created a shortlist of potential best models, with one model for each number of predictors (i.e., best 1-predictor model, best 2-predictor model etc). The best model within each category was identified by calculating the Akaike Information Criterion (AIC). The AIC is a measure used to compare statistical models, balancing goodness of fit with model complexity, to avoid overfitting of factors. When significant factors were identified across multiple model groups, the best models were then combined to create a unified model. This tested the hypothesis that invertebrate indices are influenced water quality and sediment quality (i.e., factors influenced by stormwater discharges), while controlling for differences in physical habitat. We acknowledge that physical habitat properties may also be impacted by stormwater discharges (e.g., fine sediment cover), and this was considered when interpreting the data.

For the water quality data component of the multiple regression analysis, we used median water quality data from January 2021 to December 2023 (dissolved copper, dissolved lead, dissolved zinc, total suspended solids, dissolved reactive phosphorus, and dissolved inorganic nitrogen). Median water quality data was based on monthly water quality samples and the data were provided by CCC.

2.7.5. Fish

The fish catch was converted to catch per unit effort to enable comparison between sites and years. Catch per unit effort was calculated as total catch per 100 m² fished for electric fishing sites and number of fish per net or trap for the trapping and netting sites. Data were compared graphically amongst sites and sampling years, but no statistical comparison was possible, due to the lack of replication.

3. RESULTS

3.1. Habitat and Water Quality

3.1.1. Five-Yearly Monitoring Sites

Water temperatures were cool (≤18 °C) at all the five-yearly sites sampled in 2024 and were well below the EMP Guideline of 20 °C (Table 5). Dissolved oxygen saturation exceeded (i.e., complied with) the EMP Guideline of 70% at all sites. Conductivity was typically in the range of 100 to 200 µS/cm for most wadeable sites, reflecting their common groundwater source of flow (Table 5). Higher conductivity at Riccarton Main Drain (233 µS/cm) and Addington Brook (225 µS/cm) reflects the more industrial catchments they drain and associated stormwater contaminants. Conductivity was greatest at the Avon River at Pages Road site (8,924 µS/cm), reflecting brackish estuarine conditions. Water pH was circum-neutral (i.e., around pH 7) and within the EMP Guideline of pH 6.5 to 8.5 at all sites. Water quality results and patterns amongst sites in 2024 were very similar to those recorded 2019 (Instream Consulting 2019), with no obvious changes.

Adjacent landuse and riparian habitat remains largely unchanged in 2024 compared with 2019 and 2013 (Boffa Miskell Limited 2014; Instream Consulting 2019). As noted previously by Instream Consulting (2019), most sites have minimal riparian buffer widths (typically <2 m), and many have artificial timber or stone banks and are subjected to regular maintenance to maintain a garden-like appearance. This is true for nearly all mid to upper river sites, from Site AVON16 (Avon River downstream of Kilmore Street) upstream. The only exceptions in the upper catchment are Addington Brook AVON09) and Okeover Stream (AVON25), which have natural banks and native plants dominating the riparian zone. Riccarton Main Drain (AVON08) has the most highly modified riparian and bank habitat, with concrete lining and mown grass banks, although there is reasonable shading from tall oak trees. As noted previously by Instream Consulting (2019), the smaller tributary streams are better shaded than the mainstem of the Avon River. Thus, the sites with at least 90% shade recorded in 2024 were Riccarton Main Drain and Waimairi Stream at Fendalton Park (both 90% shade), and Okeover Stream (91%), with near-complete canopy cover from trees and shrubs.

Table 5: Water quality measured at the 17 Ōtākaro five-yearly ecology monitoring sites.

Site No.[1]	Site name	Dissolved oxygen (%)	Temper-ature (°C)	pH	Conduc-tivity (µS/cm)
25	Okeover Stream at University of Canterbury	90	14.2	6.9	174
22	Waimairi Stream at Fendalton Park	93	15.1	7.1	184
06	Waimairi Stream downstream of railway bridge	80	13.8	8.4	161
23	Wairarapa Stream upstream of Glandovey Rd	94	15.3	7.2	170
05	Wairarapa Stream downstream of Fendalton Rd	85	15.5	*	161
08	Riccarton Main Drain Downstream of Deans Ave	89	15.2	7.2	233
09	Addington Brook Upstream of Riccarton Ave	131	17.6	7.9	225
10	Dudley Creek at North Parade	91	18.0	7.5	144
26	Avon River at Clyde Road	92	13.8	6.9	181
21	Avon River downstream of Mona Vale loop	101	18.3	7.1	170
19	Avon River at Botanic Garden	98	14.8	7.4	165
18	Avon River Upstream of Montreal Street	97	15.2	7.1	168
17	Avon River at Victoria Square Near Armagh St	82	15.4	7.0	179
16	Avon River Downstream of Kilmore St (Otautahi)	76	14.2	7.1	173
03	Avon River at Dallington Terrace / Gayhurst Rd	84	16.1	7.5	178
13	Avon River at Avondale Rd	106	15.9	8.0	193
01	Avon River at Pages/ Seaview bridge	90	15.9	7.5	892
EMP Guideline		**≥70**	**≤20**	**6.5 -8.5**	–

Note: [1] The EMP site code prefix "AVON" has been omitted for ease of tabulation and plotting. [2] '*' indicates pH not recorded due to probe failure during sample event.

The Avon River changes character from Site 30 (Gayhurst Road) downstream, with the lower river becoming deeper and broader, and with increasing tidal influence on water levels and vegetation. The lower river is also constrained by stopbanks, resulting in artificially steep banks that greatly limit the development of native riparian vegetation. This is particularly acute at Site AVON01 (Pages Road), where the steep stopbanks are composed of rock and only sparse grasses occur. See Appendix 2 and Appendix 3 for 2024 photographs of the five-yearly and annual monitoring sites, respectively.

The only monitoring sites with a notable difference in riparian and instream habitat between 2019 and 2024 were Addington Brook (AVON09) and Avon River at the Botanic Gardens (AVON19). At the Addington Brook site, native sedges (*Carex* sp.) and flax, or harakeke (*Phormium tenax*) have grown considerably since 2019, resulting in a marked increase in bank cover with native species (Figure 5). At the Avon River site in the Botanic Gardens, native sedges and toetoe (*Austroderia* sp.) have been planted and become well established along the true left bank since 2019 (Figure 6). The strip of native planting is narrow in both instances, but it does contribute to local biodiversity, as well as providing riparian habitat. The new native plantings at the Botanic Gardens site overhang the water, providing additional cover for fish. Changes at both these sites illustrate how quickly native riparian plantings can establish and enhance waterway biodiversity and habitat.

Figure 5: Addington Brook (AVON09) in 2019 (left) and 2024 (right), showing substantial growth in native sedges and flax.

Figure 6: Avon River at Botanic Gardens (AVON19) in 2019 (left) and 2024 (right), showing native sedges and toetoe planted along the bank have become well established since 2019.

As noted previously (Instream 2019), the mainstem Ōtākaro sites are generally wider and deeper than the tributaries, reflecting increasing flow with distance downstream (Figure 7). Despite statistically significant differences in widths, depths, and velocities between sites and between years (ANOVA $P < 0.05$), the differences were typically small and there was no clear pattern over time that could relate in any way to the consented stormwater discharges.

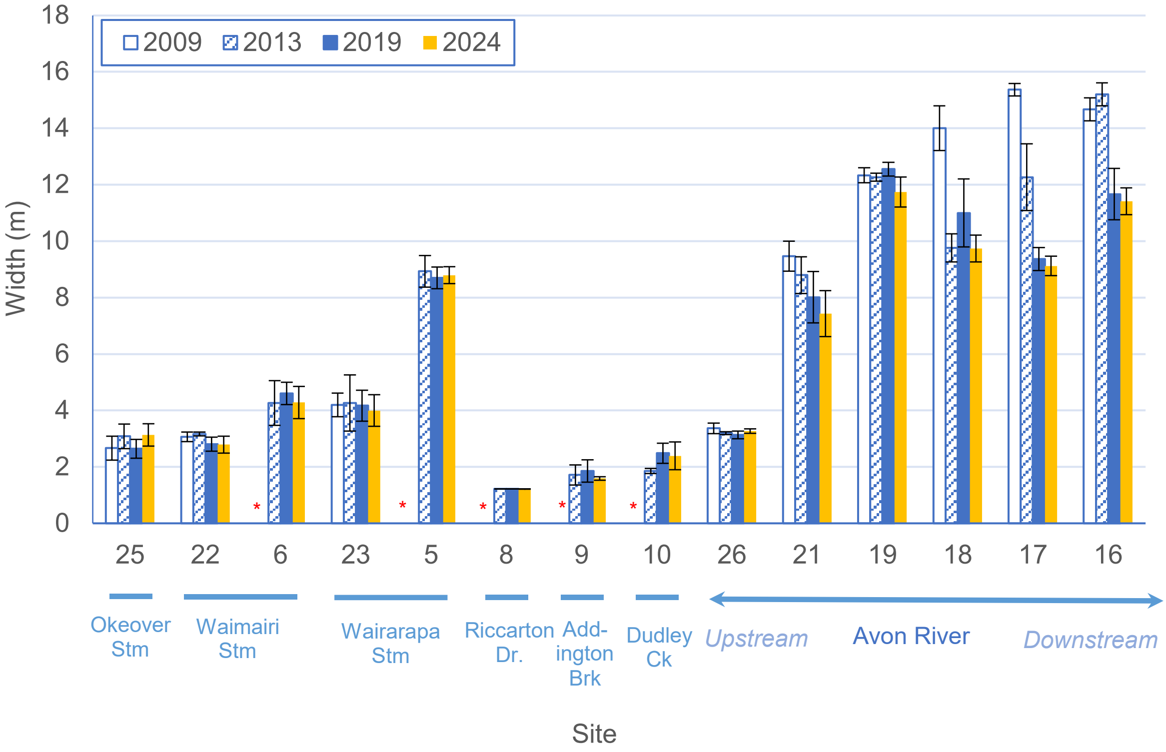

Figure 7: Mean (± 1 SE) width at the 14 wadable sites. Asterisks indicate no data collected for that year

In 2024 bed sediments at wadeable sites were dominated by a slightly greater proportion of silt and sand (substrate index 3) than in previous years, when gravel and pebbles dominated (substrate index 4 to 5; Figure 8). While there were statistically significant differences in substrate index between sites (P = 0.001), there was a weak, but not significant difference between years (P = 0.066), and there was no year x site interaction (P= 0.206). Mean fine sediment depth has been low across the three years of monitoring, ranging from a minimum of 2 cm across all sites in 2019 to a maximum of 4 cm in 2013 (Figure 9). This difference in sediment depth is small and unlikely ecologically meaningful, despite statistically significant differences between sites and years, and a significant site x year interaction (Appendix 4). Bed cover with fine sediment complied with the Consent Attribute Target Level of 30% at 5 out of 14 sites sampled in 2024, compared with 10 out of 15 sites in 2019 and 5 out of 15 sites in 2013 (Figure 10). There were statistically significant differences in fine sediment cover between years, sites, and there was a significant site x year interaction (Appendix 4); however, there is no indication of an increasing trend over time.

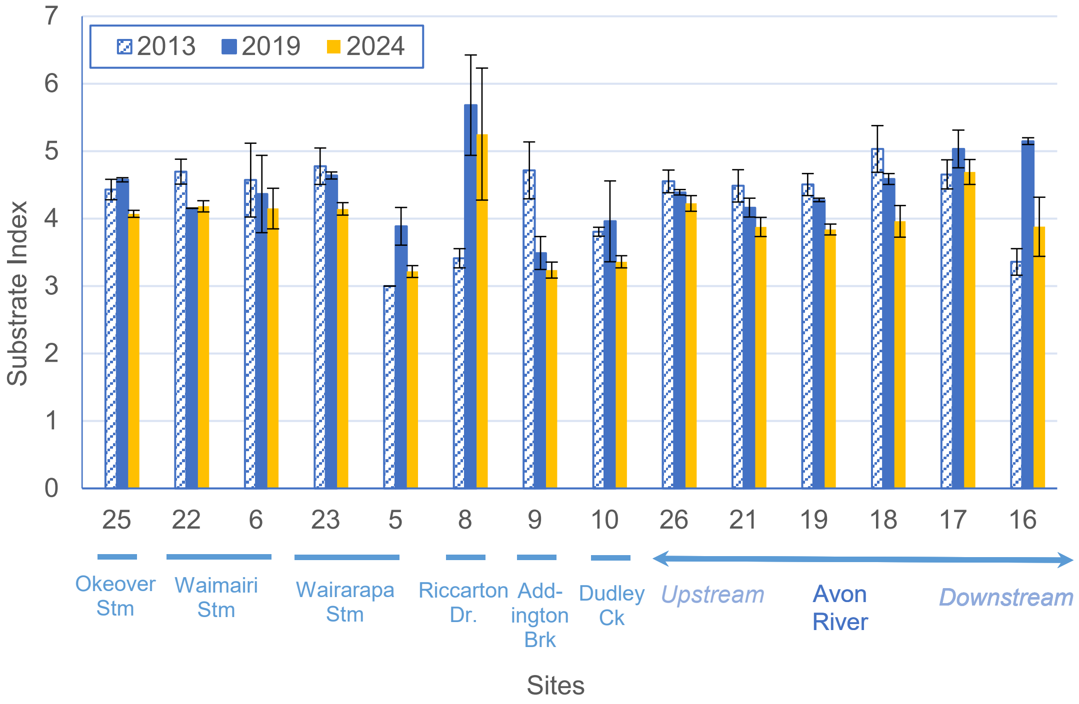

Figure 8: Mean (± 1 SE) substrate index at the 14 wadable sites. Substrate index was not recorded in 2009.

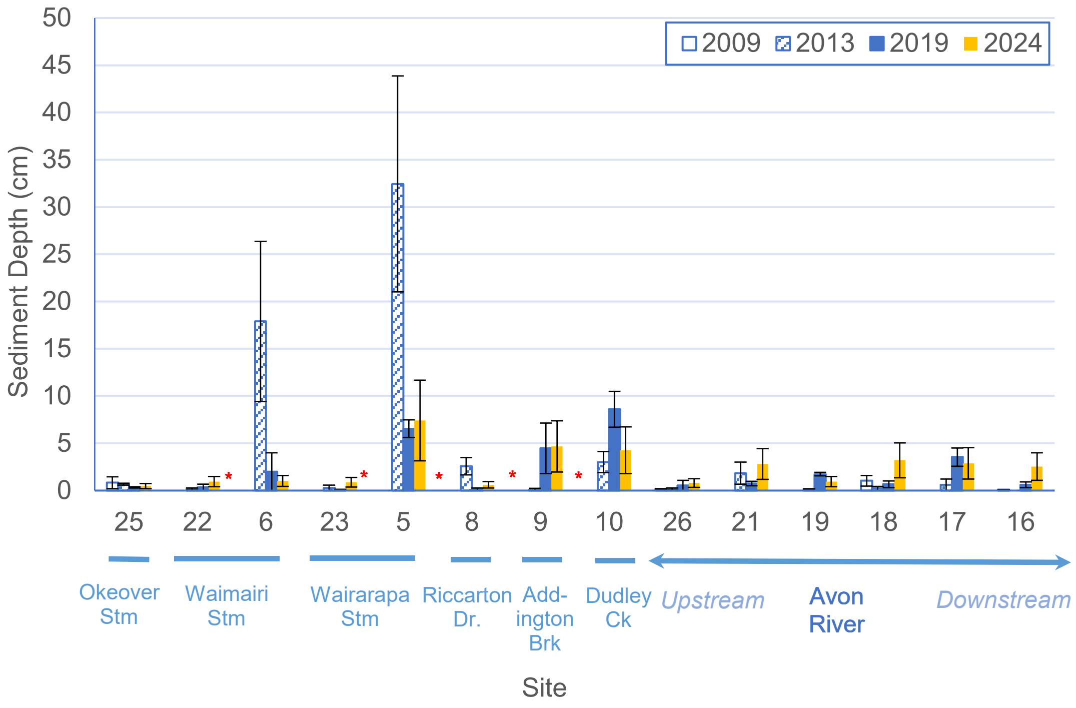

Figure 9: Mean (± 1 SE) depth of fine sediment (<2 mm diameter). Asterisks indicate no data was collected for that year.

In all monitoring years total macrophyte cover has been dominated by submerged species, with mean emergent macrophyte cover across all sites 5% or less for each monitoring year. However, total macrophyte cover is often high and it exceeded the Consent Attribute Target Level (ATL) of 60% at all 10 wadeable sites sampled in 2009, 11 of 15 sites in 2019, and 13 of 14 sites sampled in 2024 (Figure 11). As noted previously, all sites are subject to macrophyte removal by CCC contractors, and variations in macrophyte cover between years typically reflect time since macrophyte clearance prior to monitoring (Instream 2019). In 2024, as with previous years, bed cover with long filamentous algae was low at most wadeable monitoring sites, with the Consent ATL of <30% cover complied with at 12 of 14 sites sampled. There was no significant difference in filamentous algae cover between sites or years (Appendix 4), and not indication of an increasing or decreasing trend over time.

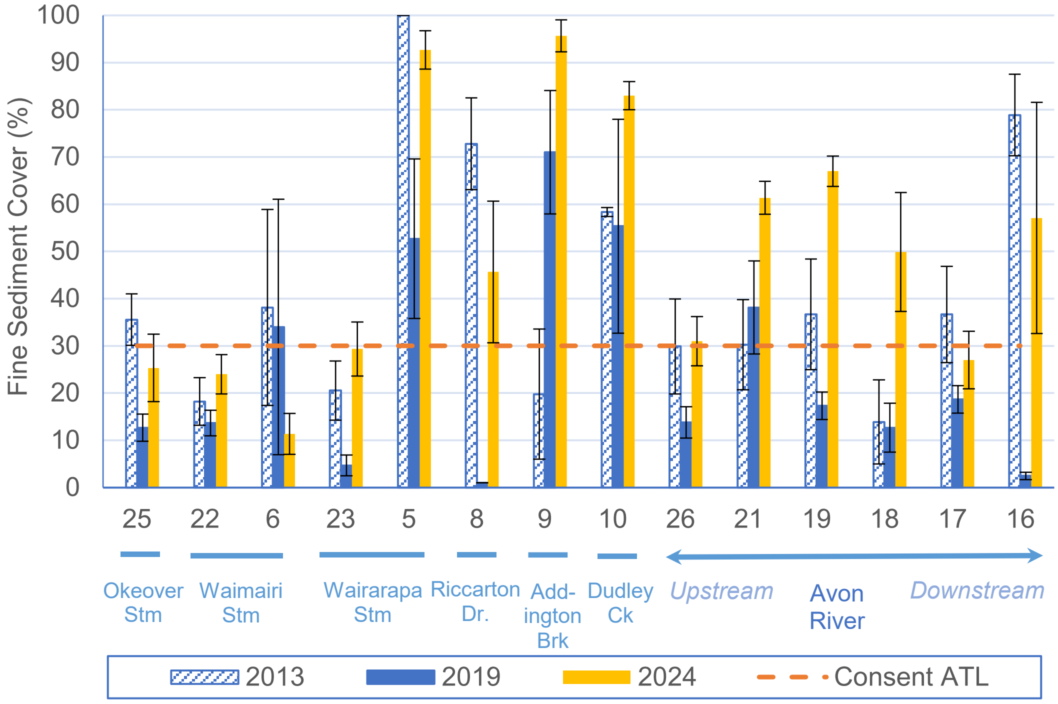

Figure 10: Mean (± 1 SE) fine sediment cover at the 14 wadeable sites. No data was collected in 2009 for fine sediment cover.

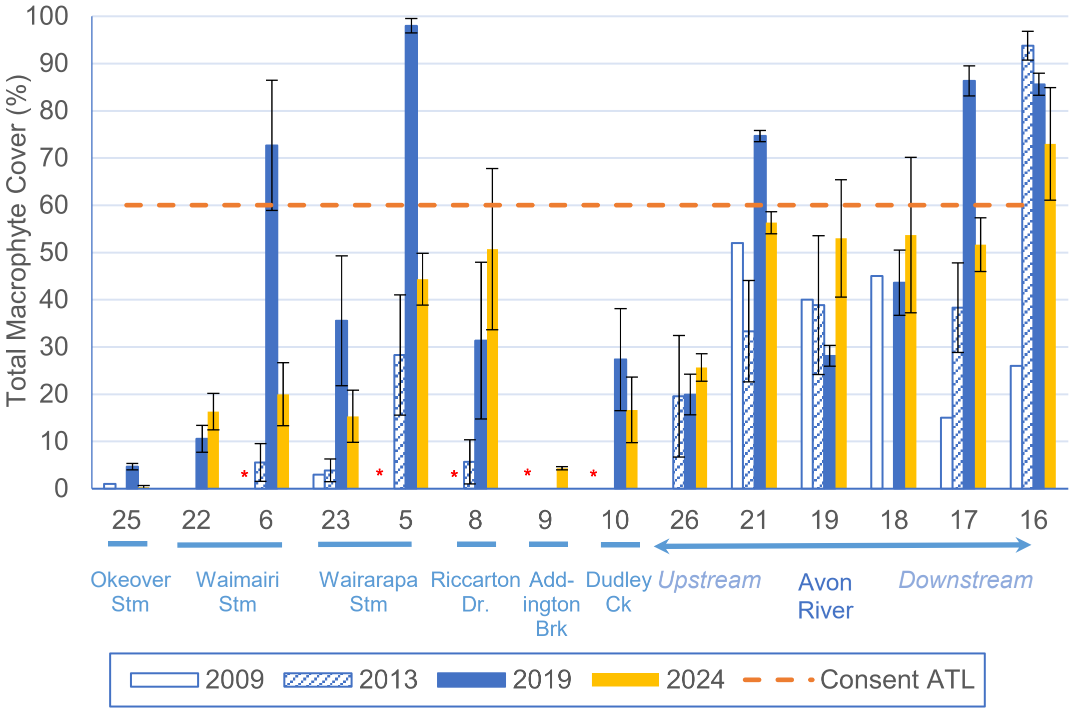

Figure 11: Bed cover with total macrophytes at the 14 wadeable sites. Asterisks indicate no data was collected for that year

3.1.2. Trends at Annual Monitoring Sites

Cashmere Stream and Ōtukaikino Sites

Total macrophyte cover is typically high and exceeds the Consent ATL of 30% at the two annual monitoring sites on Cashmere Stream, while compliance at the two Ōtukaikino annual sites has varied more over time (Figure 12). As noted previously, variations in macrophyte cover in these waterways largely reflect time since macrophyte removal by CCC contractors (Instream 2019; Boffa Miskell 2023), so little can be read into any trends over time. Bed cover with fine sediment has been consistently high (>60%) at all four annual monitoring sites and has always exceeded the Consent ATL of 20% (Figure 12). This is unsurprising, as they are naturally soft-bottomed waterways, so compliance with a guideline designed for hard-bottomed streams is irrelevant[4].

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[4] Wilsons Drain at Tyrone Street has a stony bed that is embedded with fine sediment. Recent investigations for proposed stormwater basins nearby indicate that the gravels are imported and that the bed would naturally be dominated by fine sediments (Kevin Williams, CCC project manager, pers. comm.).

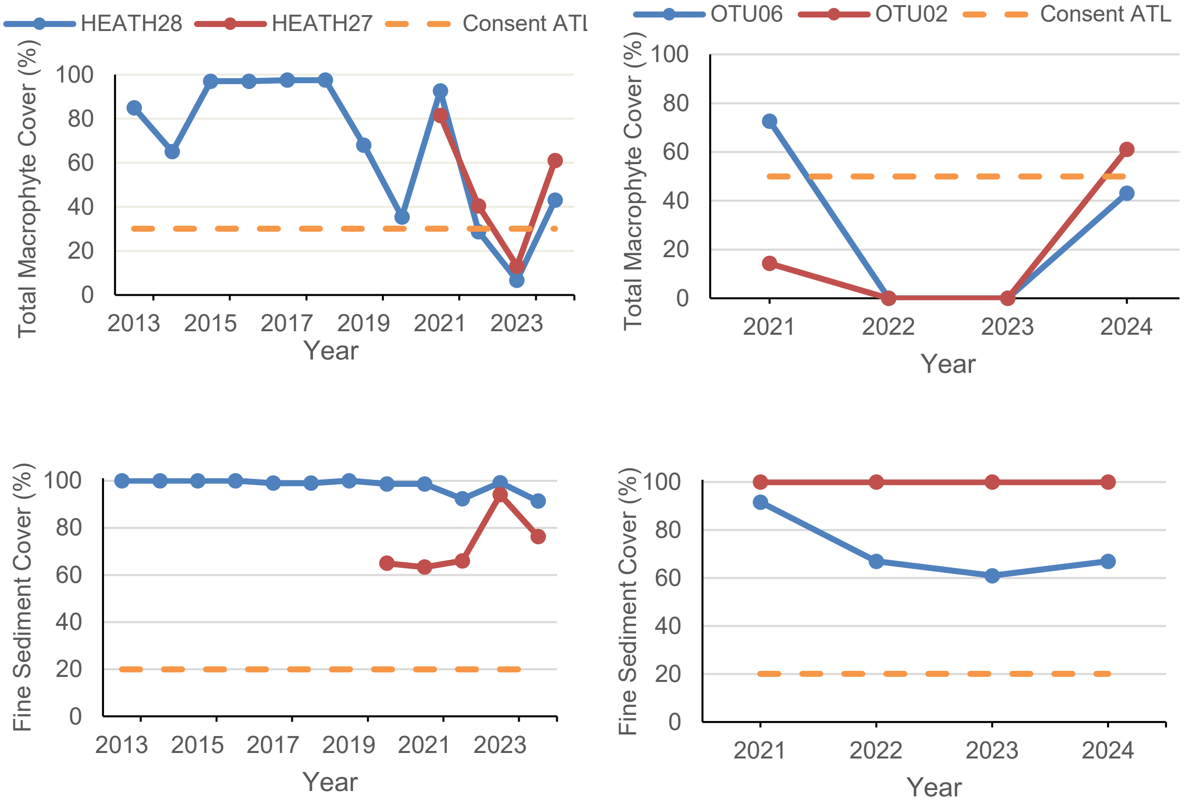

Figure 12: Changes in total macrophyte cover and fine sediment cover over time at CCC annual monitoring sites in Cashmere Stream (left) and Wilsons Drain (right). For both waterways, the upstream site is blue and the downstream site is red.

Balguerie Stream and Avon Catchment Sites

Habitat quality scores have been consistently higher at the two Balguerie Stream monitoring sites than at the four Ōtākaro catchment monitoring sites throughout the twenty-year record of monitoring (Figure 13). This reflects the presence of more intact riparian zones and lack of urban landuse within the Balguerie Stream catchment. Habitat quality has been consistently lower at the more downstream of the two Balguerie Stream sites, reflecting slightly greater impact of both urban and farming landuse. Four of the six ECan sites showed increasing trends in habitat quality, with the trend analyses indicating likely or very likely improving trends (Appendix 4). Dudley Creek and the downstream Balguerie site (at Balguerie Road) had an indeterminate trend (i.e., no obvious increasing or decreasing trend). There was an indeterminate trend in the difference in habitat scores between the upstream and downstream Balguerie Stream sites, indicating no worsening or improving trend at the downstream site compared with upstream.

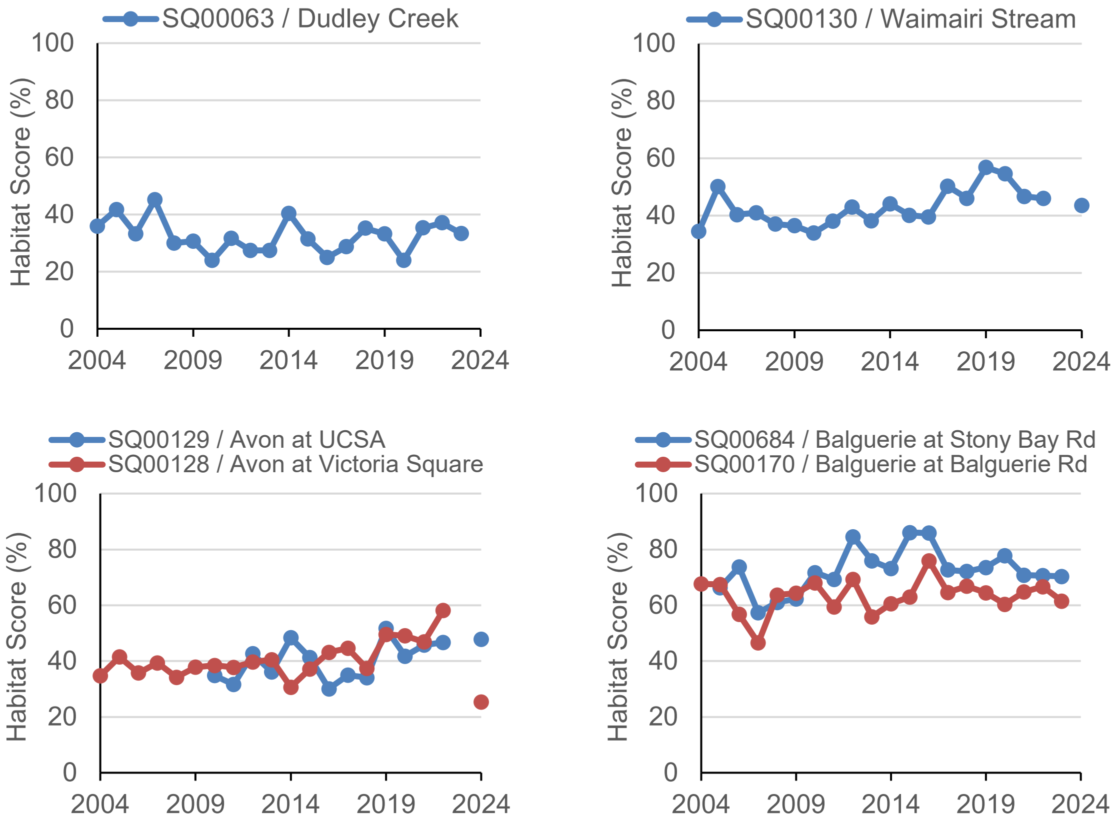

Figure 13: Habitat quality at ECan monitoring sites in the Ōtākaro - Avon River catchment (above and left) and in Balguerie Stream on Banks Peninsula (lower right). For plots with two sites, the upstream site is blue and the downstream site is red.

3.2. Sediment Quality

Sediment quality data from 2024 is summarised in Table 6 and laboratory reports are provided in Appendix 5. Laboratory-analysed sediments from all sites were dominated by particles in the range of fine to medium sand, with corresponding modified substrate index (SI) values falling between 1 (silt/clay) to 3 (medium sand; Table 6). This is consistent with results from previous years (Instream Consulting 2019). Total organic carbon (TOC) content was low at most sites, ranging from a low of 0.48 g/100 g at Site 01 (Avon River at Pages Road), to a high of 7.00 g/100 g at Site 03 (Avon River at Dallington Terrace; Table 6).

In 2024 zinc had the highest concentrations of the three metals tested, while lead concentrations were considerably lower, followed by copper (Table 6). Zinc concentrations exceeded the upper ANZG (2018) Guideline Value (GV-high) at two locations: Addington Brook and Avon River at Dallington Terrace. No other metals exceeded GV-high levels. However, the lower Default Guideline Value (DGV) – which is also the Consent ATL – was exceeded at six sites for zinc and four sites for lead (Table 6). Total PAH concentrations (normalised to 1% TOC) exceeded the GV-high at five locations and the DGV at an additional three sites.

The two most downstream sites in the Avon River complied with consent ATLs for all parameters tested (Table 6). However, 11 of the remaining 13 sites did not meet consent ATLs for at least one sediment quality parameter, including:

- Four sites that exceeded ATLs for only one parameter;
- Five sites that exceeded ATLs for two parameters; and
- Two sites that exceeded ATLs for three parameters.

The ANZG (2018) sediment quality guidelines indicate the overall risk of toxicity effects on biota. Sites meeting lower DGVs have a low risk of effects, sites exceeding DGVs have an increased risk of adverse effects, and there is a relatively high risk of adverse for sites exceeding GV-high values. This suggests that there is an increased risk of adverse ecological effects at most sites sampled, and a higher level of risk at the six sites that exceed the GV-high for total PAHs and/or zinc.

Table 6: Sediment quality at monitoring sites in 2024. Data are site means and units are mg/kg dry weight, except for total organic carbon (TOC), which is g/100 g dry weight, and substrate index (SI), which is unitless. Values exceeding the ANZG (2018) Default Guideline Value (DGV, which is also the consent ATL) are in orange font and values exceeding GV-high are in red.

Site Code	Site	Copper	Lead	Zinc	TOC	SI	Total PAHs
06	Waimairi Stream Downstream of Railway Bridge	18	**165**	166	1.47	2.5	**26**
05	Wairarapa Stream Downstream of Fendalton Road	17	41	133	1.01	2.3	**34**
09	Addington Brook Upstream of Riccarton Avenue	27	**83**	**843**	1.53	3.0	**77**
10	Dudley Creek at North Parade	10	44	**216**	0.65	2.4	**86**
26	Avon River at Clyde Road	12	33	162	0.71	3.9	**350**
07	Avon River at Mona Vale	25	42	**213**	2.69	2.0	6
12	Avon River at Carlton Mill Corner	29	**53**	**245**	3.69	2.7	**23**
17	Avon River at Victoria Square Near Armagh Street	21	34	163	0.84	2.5	**63**
04	Avon River at Manchester Street	22	41	**236**	1.48	2.0	**72**
03	Avon River at Dallington Terrace/Gayhurst Road	52	**115**	**873**	7.00	1.8	9
13	Avon River at Avondale Road	26	45	**390**	3.73	1.4	4
01	Avon River at Pages/Seaview Bridge	6	14	86	0.48	1.9	7
02	Avon River at Bridge Street	9	18	85	0.79	1.7	3
DGV (equates to consent ATL)		**65**	**50**	**200**	N/A	N/A	**10**
GV-high		**270**	**220**	**410**	N/A	N/A	**50**

Notes: Total PAHs are normalised to 1% TOC. N/A indicates no applicable guideline values.

Copper concentrations in sediment have varied over time from 1980 to 2024, but they have almost always been well below the consent ATL of 65 mg/kg (Figure 14). There is no indication of an increasing or decreasing trend in sediment copper concentrations over time, with mean copper concentrations across all sites varying from 33 mg/kg in 1980, to 17 mg/kg in 2013, 29 mg/kg in 2019, and 21 mg/kg in 2024.

Sediment lead concentrations have also varied considerably over time, with numerous sites exceeding the consent ATL of 50 mg/kg, but no sites have exceeded the GV-high level on any occasion (Figure 15). Lead concentrations declined by 59% between 1980 and 2013, with mean concentrations across all sites declining from 123 mg/kg in 1980 to 50 mg/kg in 2013. There has been no trend in sediment lead concentrations since 2013, with a mean concentration of 66 mg/kg in 2019 and 56 mg/kg in 2024.

Sediment zinc concentrations have regularly exceeded the consent ATL of 200 mg/kg at many sites across the four monitoring periods from 1980 to 2024 (Figure 16). There is no evidence of an increasing or decreasing trend in zinc concentrations over time, with mean concentrations across all sites of 274 mg/kg in 1980, 164 mg/kg in 2013, 319 mg/kg in 2019, and 293 mg/kg in 2024.

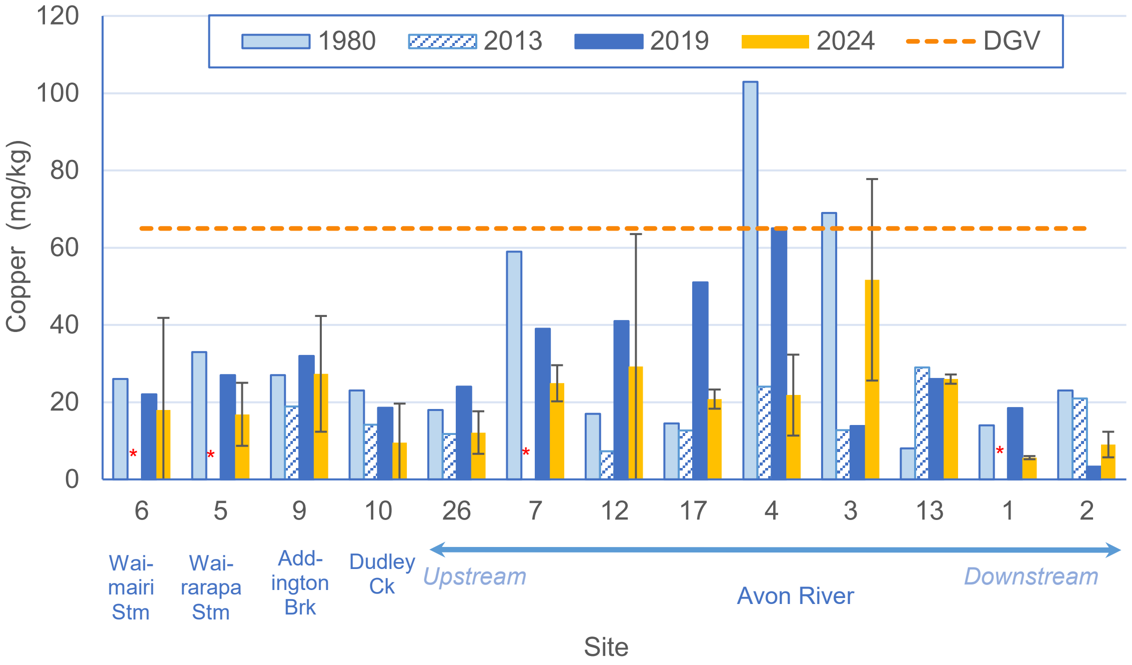

Figure 14: Sediment copper concentrations compared to ANZG (2018) guidelines. Data for 2024 are means (±1 SE); previous data are single values per site. Asterisks indicate no data collected for that date. The DGV is the same as the Consent ATL.

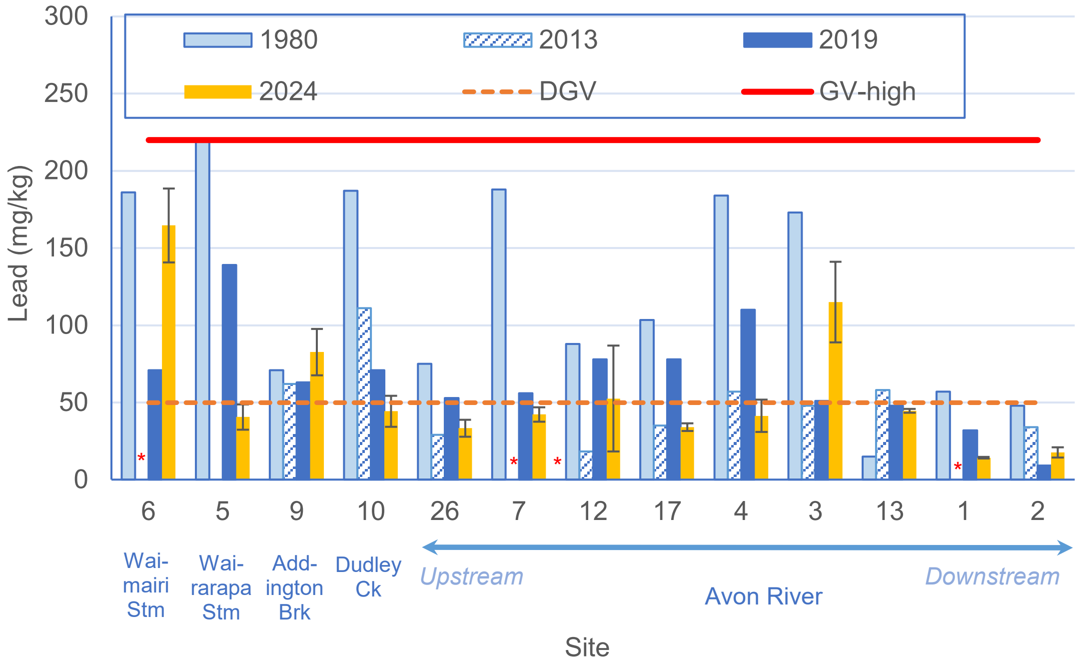

Figure 15: Sediment lead concentrations compared to ANZG (2018) guidelines. Data for 2024 are means (±1 SE); previous data are single values per site. Asterisks indicate no data collected for that date. The DGV is the same as the Consent ATL.

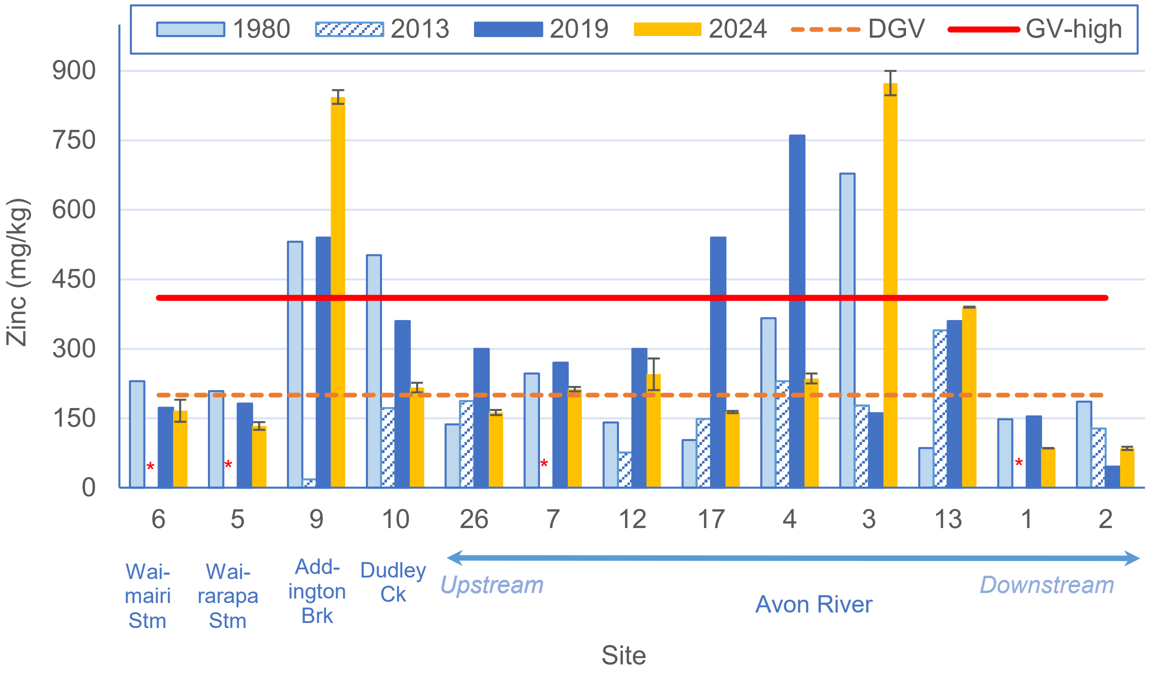

Figure 16: Sediment zinc concentrations compared to ANZG (2018) guidelines. Data for 2024 are means (±1 SE); previous data are single values per site. Asterisks indicate no data collected for that date. The DGV is the same as the Consent ATL.

Total PAH concentrations were markedly higher in 2019 and 2024 than in 2013, with means across all sites of 9 mg/kg in 2013, 19 mg/kg in 2019, and 22 mg/kg in 2024 (Figure 17). It is uncertain whether the increase in PAHs between 2013 and 2019 is representative of a trend or simply indicative of inter-annual variation, due to the lack of regular measurement over time. When normalised to 1% TOC, PAH concentrations in 2024 were much higher than in previous years, with a mean of 58 mg/kg in 2024, compared with means of 12 mg/kg in 2013 and 6 mg/kg in 2019 (Figure 18). Low TOC concentrations in 2024 were the primary cause of the high normalised PAH concentrations relative to 2019, with a mean TOC concentration across all sites of 2.0 g/100 g in 2024, compared with a mean of 4.1 g/100g in 2019 (Figure 19). Evidence for any potential toxic effects on invertebrates is explored in Section 3.3.1.

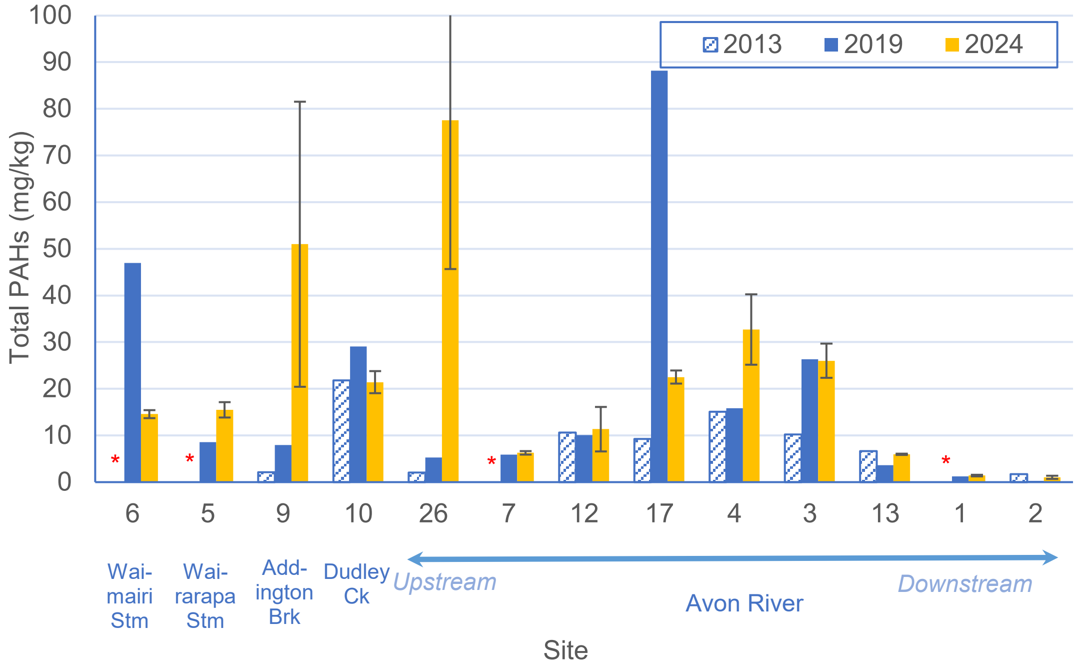

Figure 17: Sediment total PAH concentrations over time. Data for 2024 are means (±1 SE); previous data are single values per site. Asterisks indicate no data collected for that date.

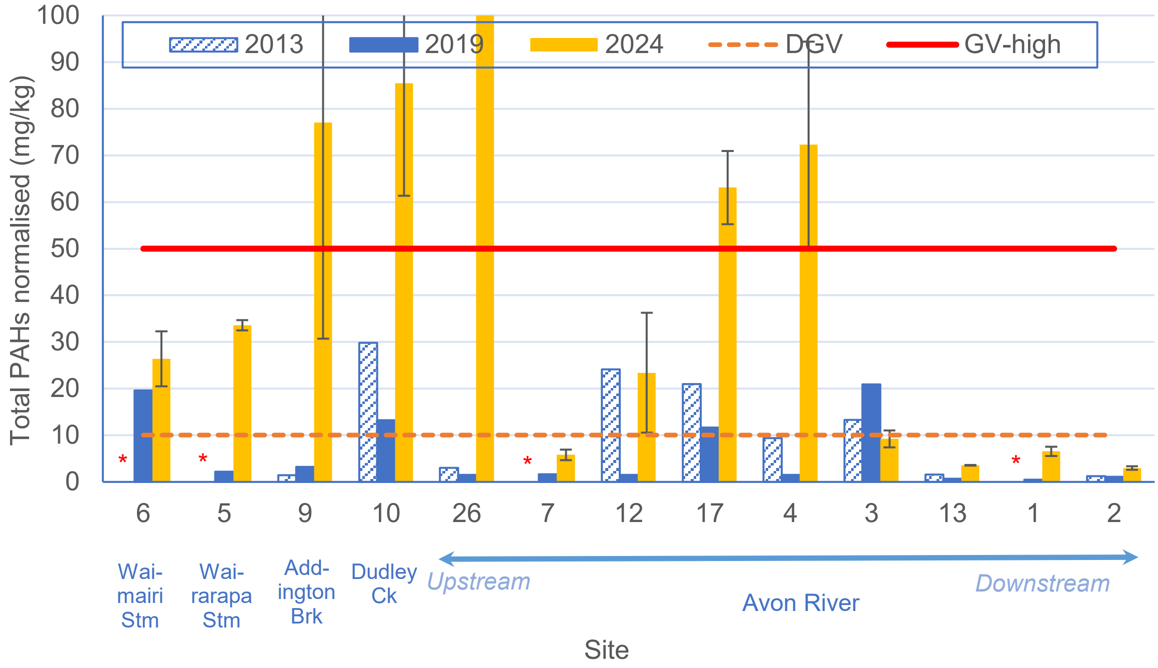

Figure 18: Sediment total PAH concentrations normalised to 1% TOC and compared to ANZG (2018) guidelines. Data for 2024 are means (±1 SE); previous data are single values per site. Asterisks indicate no data collected for that date. The DGV is the same as the consent ATL.

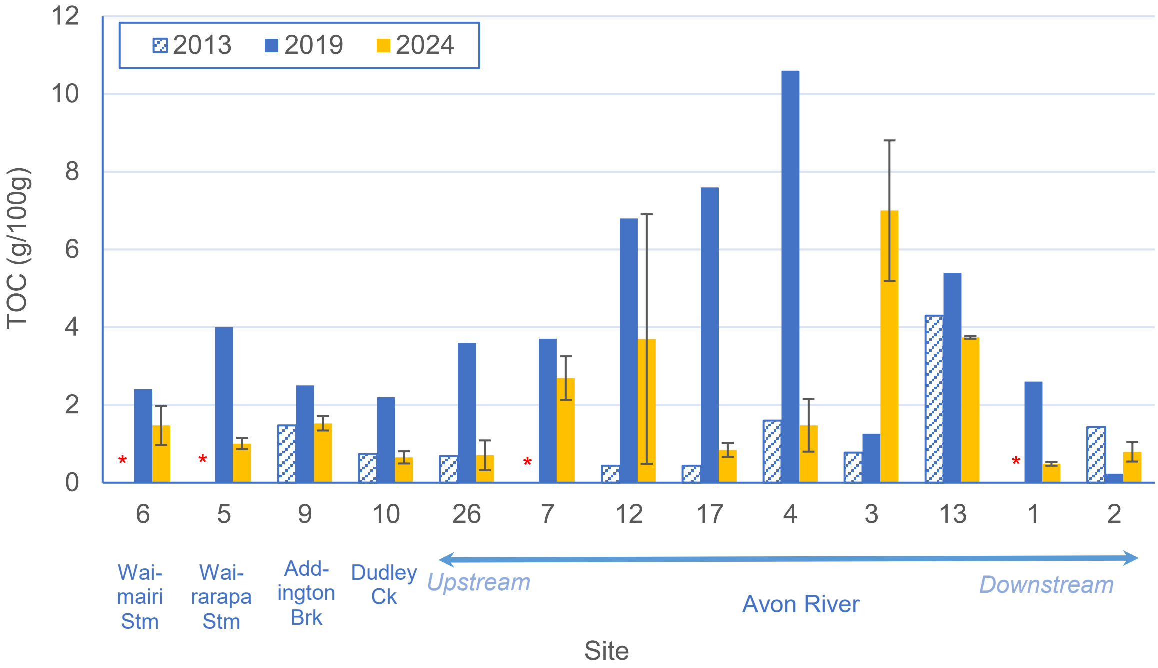

Figure 19: Sediment total organic carbon (TOC) concentrations over time. Data for 2024 are means (±1 SE); previous data are single values per site. Asterisks indicate no data collected for that date.

3.3. Macroinvertebrates

3.3.1. Five-Yearly Monitoring Sites

Invertebrate community composition in 2024 was similar to previous years, being dominated by the amphipod crustacean *Paracalliope fluviatilis* (33% of total abundance across all sites) and the common mud *snail Potamopyrgus antipodarum* (30% abundance; Figure 20). These two pollution-tolerant taxa are very common in Christchurch waterways, and they have dominated the invertebrate community every year. The third most common taxon in 2024 was ostracod crustaceans (11% abundance), which are also a relatively pollution-tolerant taxon. The most abundant EPT taxon, the cased caddisfly *Hudsonema*, was the fourth most abundant taxon, which is a higher ranking than in previous years (previously ranked eight to eleventh from 2009 to 2019), although their overall abundance remains low, comprising 5% of total abundance.

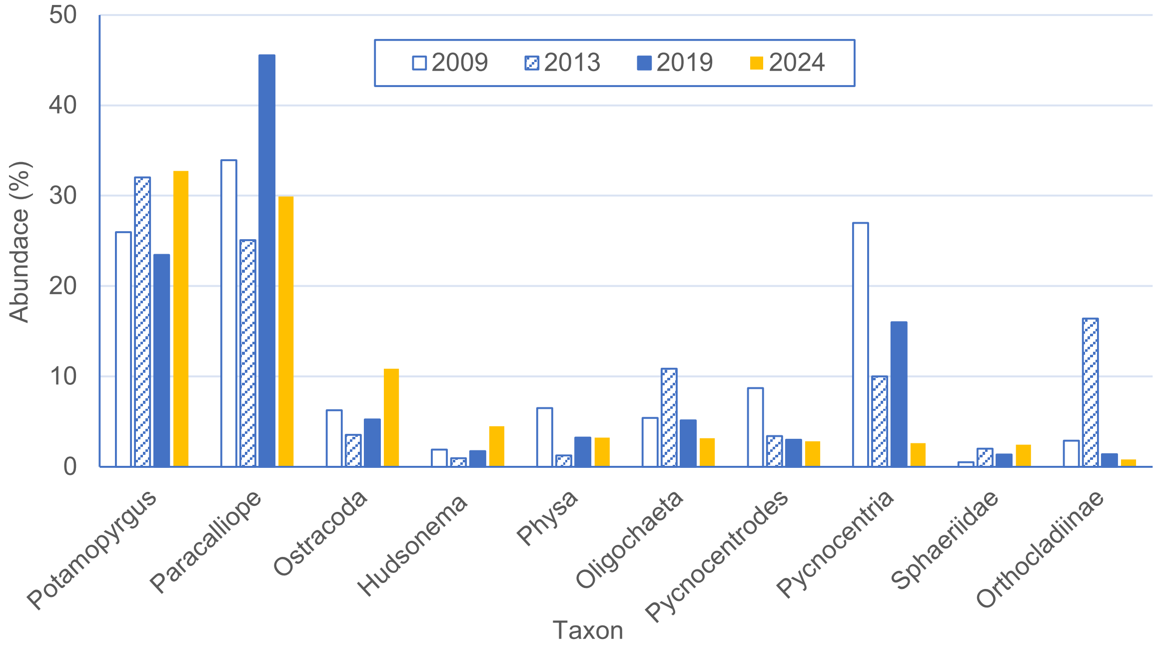

Figure 20: Abundance of the ten most common taxa across all sites in 2024 compared to previous years.

A total of four pollution-sensitive taxa (MCI scores ≥7) were recorded from the Ōtākaro catchment in 2024, all of them cased caddisflies: *Oeconesus*, *Polyplectropus*, *Psilochorema*, and *Pycnocentria*. The same four pollution-sensitive taxa were recorded previously in 2019 and 2009 (Instream Consulting 2019). Eleven of the 17 monitoring sites recorded pollution-sensitive taxa in 2024, compared with nine of 18 monitoring sites in 2019, six of 15 monitored sites in 2013, and nine of the ten sites monitored in 2009 (Table 7). In 2024, one or two individuals of the free-living caddisfly *Psilochorema* were detected at four sites where no pollution-sensitive taxa were recorded previously (Table 7). Conversely, in 2024 no pollution-sensitive taxa were recorded at one site where they had been recorded previously (Site AVON5, Wairarapa Stream). Overall, these changes over time are very small and reflect the low abundance of pollution-sensitive species, with individual taxa sometimes being detected and sometimes not. The relative abundance of EPT taxa has been low in all years of monitoring, ranging from a mean across all sites of 8 %EPT in 2013 to 14 %EPT in 2009, with 11 %EPT recorded in 2024.

Table 7: Pollution-sensitive invertebrate taxa (MCI scores of ≥7) at monitoring sites from 2009 to 2025. Numbers in brackets indicate sites where one or two individuals were collected in 2024, but not in previous years.

Waterway	Site	2009	2013	2019	2024
Okeover Stream	25	*Oeconesus sp.* *Polyplectropus* *Psilochorema* *Pycnocentria*	*Oeconesidae* *Pycnocentria*	*Oeconesus* *Pycnocentria*	*Oeconesus* *Pycnocentria*
Waimairi Stream	22	*Oeconesus sp.* *Psilochorema*	*Psilochorema* *Pycnocentria*	*Oeconesus* *Polyplectropus* *Psilochorema*	*Oeconesus* *Polyplectropus* *Psilochorema* *Pycnocentria (1)*
	6	No data	*Oeconesidae* *Psilochorema* *Pycnocentria*	*Oeconesus* *Psilochorema*	*Psilochorema* *Pycnocentria*
Wairarapa Stream	23	No MCI ≥ 7	No MCI ≥ 7	No MCI ≥ 7	*Psilochorema* (2)
	5	*Oeconesus sp.*	No MCI ≥ 7	*Psilochorema*	No MCI ≥ 7
Riccarton Main Drain	8	No data	No MCI ≥ 7	No MCI ≥ 7	*Psilochorema* (1)
Avon River (upstream)	26	*Psilochorema*	*Oeconesidae* *Psilochorema* *Pycnocentria*	*Psilochorema* *Pycnocentria*	*Psilochorema* *Pycnocentria*
	21	*Oeconesus* *Psilochorema*	No MCI ≥ 7	*Oeconesus* *Psilochorema*	*Psilochorema*
	19	*Psilochorema*	*Psilochorema* *Pycnocentria*	*Psilochorema*	*Psilochorema*
	18	*Psilochorema*	No MCI ≥ 7	*Psilochorema*	*Psilochorema*
	17	No MCI ≥ 7	No MCI ≥ 7	No MCI ≥ 7	*Psilochorema* (1)
Avon River (downstream)	16	No MCI ≥ 7	No MCI ≥ 7	No MCI ≥ 7	*Psilochorema* (1)

The low abundance of EPT taxa is reflected in low MCI and QMCI scores across all sites and years of monitoring (Figure 21, Figure 22). The mean MCI score across all sites in 2024 was 78, with a minimum of 64 and a maximum of 90. This is comparable to previous years, with means of 73 in 2009 and 2013, and 75 in 2019. In 2024 all sites were below the NPSFM national bottom line MCI score of 90, except for AVON25 (Okeover Stream) and AVON22 (Waimairi Stream at Fendalton Park), which both had MCI scores of 90. The mean QMCI score across all sites in 2024 was 4.2, with a minimum of 3.6 at AVON03 (Avon River at Gayhurst Road) and a maximum of 5.3 at AVON25 (Okeover Stream). Mean QMCI scores across all sites in previous years ranged from 3.7 in 2013 to 4.1 in 2019. The consent ATL of 3.5 for QMCI was met at all 17 monitoring sites in 2024. However, the national bottom line of 4.5 for QMCI was met at only five of the 17 monitoring sites.

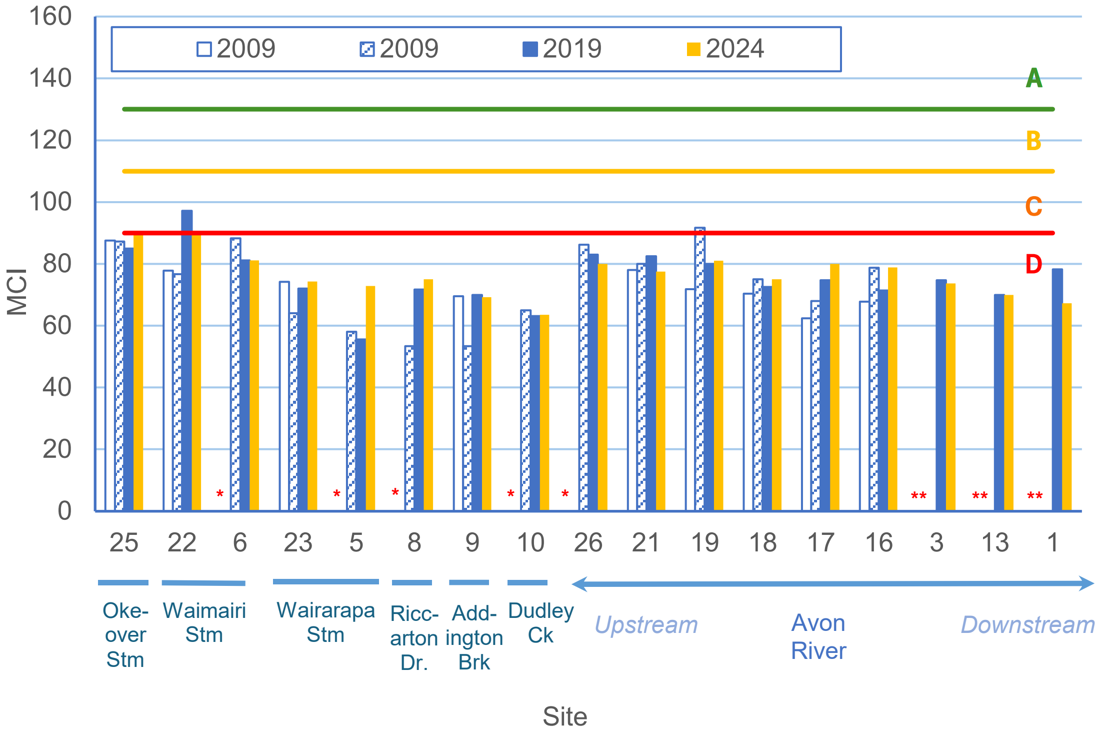

Figure 21: MCI scores at each monitoring site with coloured lines indicating NPSFM attribute bands. The national bottom line MCI score is 90. Asterisks indicate no data collected for that year.

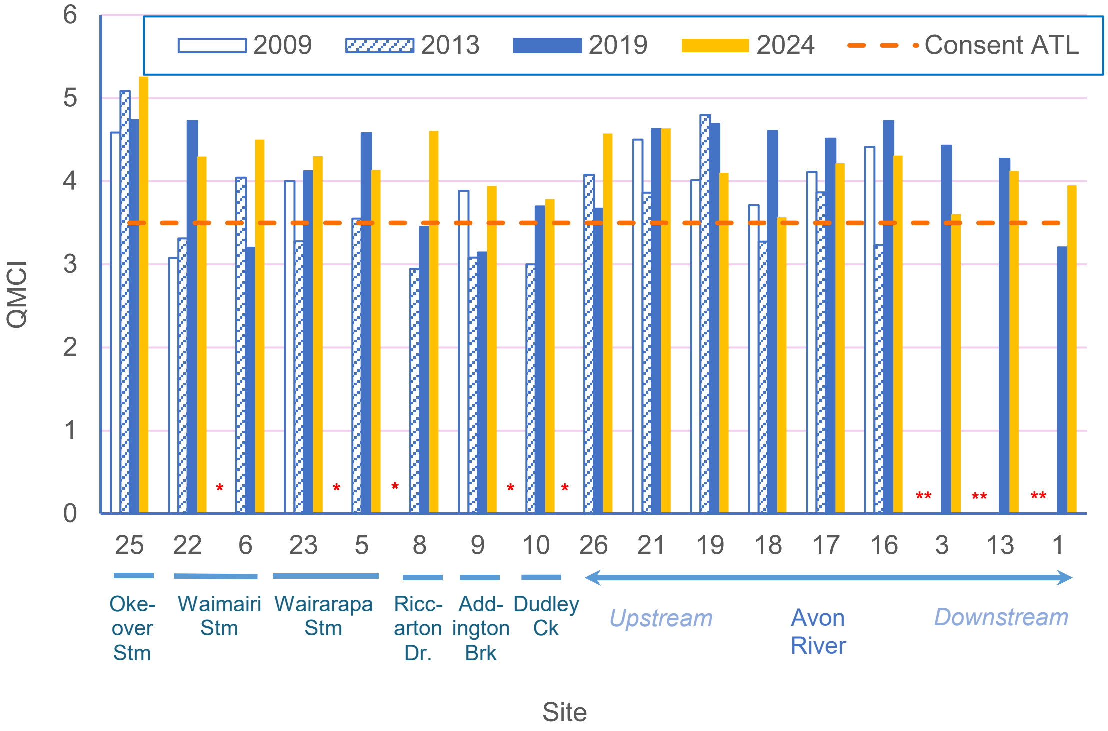

Figure 22: QMCI scores at each monitoring site. Asterisks indicate no data collected for that year.

Models Explaining 2024 Invertebrate Community Results for the Ōtākaro Catchment

Differences in invertebrate community health indices between sites were better explained by variations in physical habitat quality, rather than water quality or sediment quality. The most common associations were with fine sediment (sediment depth, cover, and substrate index), which negatively impacted many of the calculated indices.

The best models for each invertebrate index are provided in Appendix 4 and summarised below:

- **Taxa Richness**: not well explained by any models, presumably because taxa richness is a poor indicator of ecological health.
- **%EPT**: fine sediment cover had a significant negative impact on %EPT.
- **EPT Taxa Richness**: the best model included sediment depth (-ve effect), fine sediment cover (-ve and significant), substrate index (-ve and significant), and total macrophytes (+ve). The overall model was very significant with a moderate to good fit. Water quality and sediment quality were not significant predictors of EPT taxa richness.
- **MCI:** the best model included fine sediment depth (-ve and significant) and fine sediment cover (-ve). Overall model was significant with a moderate to good fit. Water quality and sediment quality were not significant predictors of MCI. Dissolved inorganic nitrogen was nearly significant, however it explained little variance once the physical habitat data was included.
- **QMCI:** the best model included depth (-ve and significant) and velocity (+ve and significant). Overall model was very significant, with a moderate fit. Total zinc was the best sediment quality model (-ve and significant); however, zinc was not significant once the physical habitat drivers were included.

- **ASPM:** the best model was the physical habitat model, including: sediment depth (-ve), substrate index (-ve) and fine sediment cover (-ve and significant).

3.3.2. Trends at Annual Monitoring Sites

CCC Monitoring Sites

Invertebrate QMCI scores have been consistently low at the four CCC annual monitoring sites throughout the monitoring record (Figure 23). The consent ATL of 5 for QMCI was not met on any occasion at any of the four sites. Trend analysis revealed an indeterminate trend for Site HEATH27 and a very likely improving trend for Site HEATH28 (see Appendix 4). The monitoring record is too short for trend analysis of QMCI scores for the two Wilsons Drain sites in the Ōtūkaikino catchment.

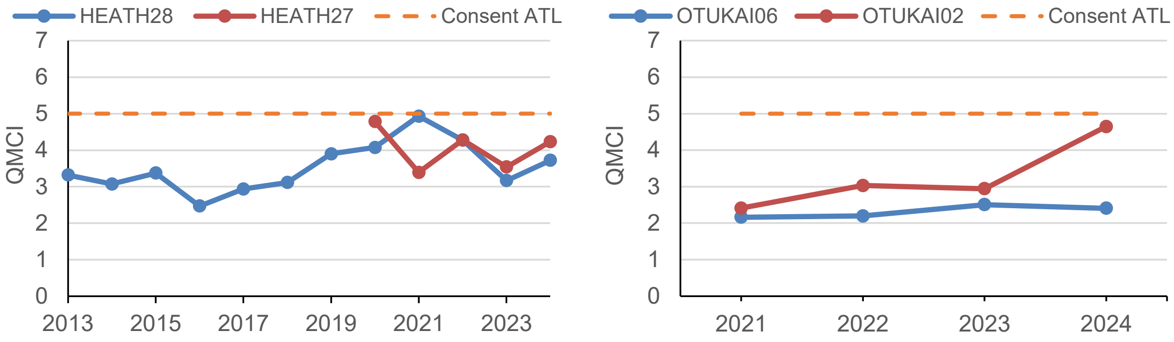

Figure 23: Invertebrate QMCI scores at annual monitoring sites in Cashmere Stream (left) and Wilsons Drain (right). For both waterways, the upstream site is blue and the downstream site is red.

ECan Monitoring Sites

Invertebrate QMCI scores have been consistently higher at the two Balguerie Stream monitoring sites than at the four Ōtākaro catchment monitoring sites throughout the twenty-year record of monitoring (Figure 24). This follows the same pattern as habitat scores (Section 3.1.2) and likely reflects the more intact riparian zones and lack of urban landuse within the Balguerie Stream catchment. As with habitat quality scores, QMCI scores have been consistently lower over time at the more downstream of the two Balguerie Stream sites, reflecting slightly greater impact of both urban and farming landuse. All six of the ECan sites showed increasing trends in QMCI scores over the monitoring record, with trend analyses indicating likely or very likely improving trends (Appendix 4). There was an indeterminate trend in the difference in QMCI scores between the upstream and downstream Balguerie Stream sites, indicating no worsening or improving trend at the downstream site compared with upstream.

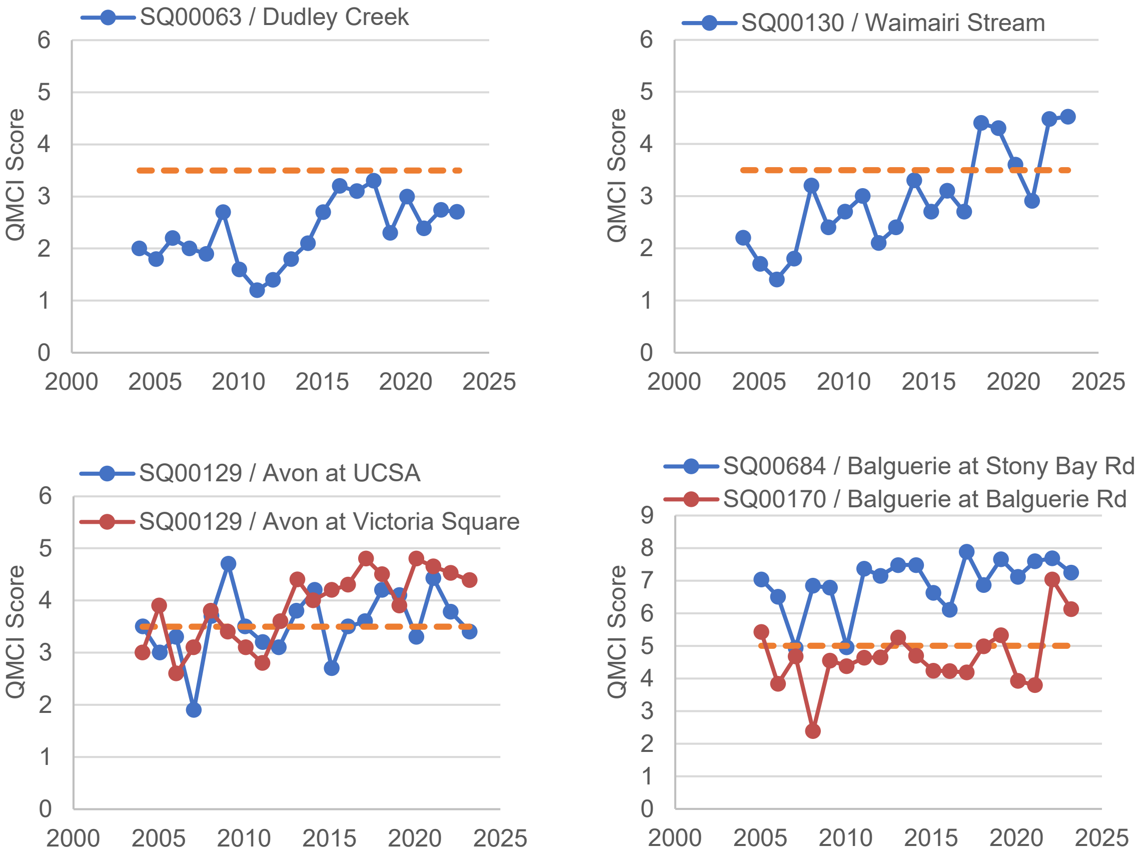

Figure 24: QMCI scores at ECan annual monitoring sites. Dashed horizontal lines indicate Consent Attribute Target Levels. For plots with two sites, the upstream site is blue and the downstream site is red.

3.4. Kākahi

A total of 188 kākahi were found across four of the 16 sites searched in 2024. The highest abundances were seen in the mid-reaches of the Ōtākaro – Avon River, with a total of 98 recorded at Site AVON03 (Avon River at Dallington Terrace/Gayhurst Bridge) during the 30-minute search and 66 recorded at Site AVON13 (Avon River at Avondale Bridge). A single kākahi was recorded at Site AVON05 (Wairarapa Stream), while a total of 23 kākahi were recorded across the three sub-sites sampled at AVON19 (Avon River at Botanic Gardens).

The 2024 kākahi survey confirmed the presence of kākahi at the three locations within the Botanic Gardens where they had been previously recorded, and in comparable densities. The survey also extended the known range of kākahi upstream and downstream in the Ōtākaro catchment, with the first confirmed record of kākahi in Wairarapa Stream, and the most downstream record in the lower Ōtākaro – Avon River (Figure 25). The previously confirmed downstream extent was near the confluence with Horseshoe Lake, where they are very abundant (Instream Consulting 2021a). As with previous surveys, we found no live kākahi in Dudley Creek, or in any other tributaries, and there was a lack of kākahi in the mid-reaches of the Ōtākaro – Avon River between the survey sites at Montreal Street (AVON18) and Kilmore Street (AVON16).

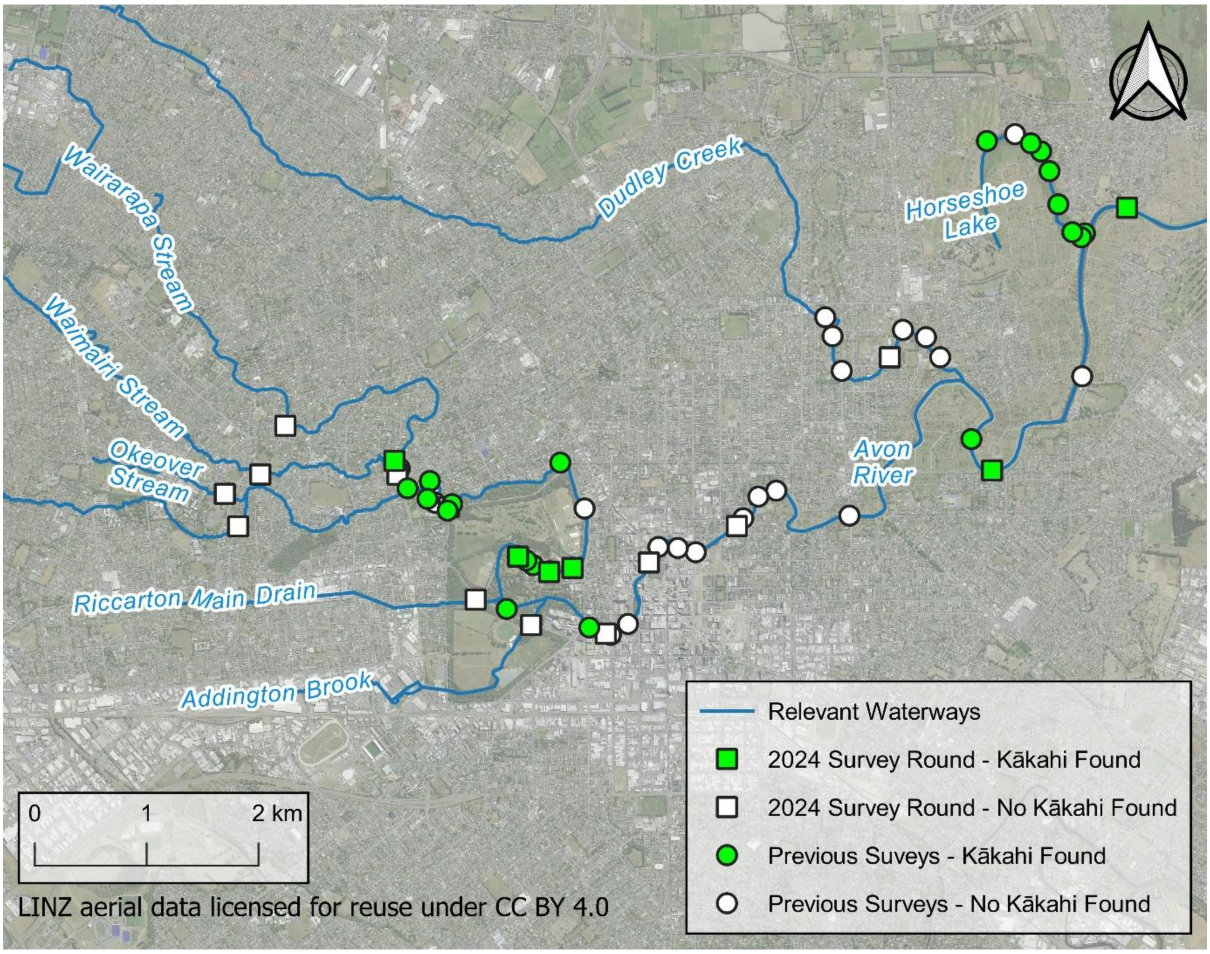

Figure 25: Kākahi records from the Ōtākaro catchment, including data from this survey and previous reports.

3.5. Fish

A total of ten fish species were caught in 2024, comprising nine native species and one introduced species, brown trout (*Salmo trutta,* Table 8). Shortfin eel (*Anguilla australis*) were the most widespread species, and they were found at 16 of the 17 sites. Both upland bully (*Gobiomorphus breviceps*) and longfin eel (*A. dieffenbachii*) were also widespread and were both found at 15 sites. Overall, fish abundance and community composition in 2024 was similar to previous years, with the same core of species found, including shortfin and longfin eel, upland bully, common bully (*G. cotidianus*), bluegill bully (*G. hubbsi*), and inanga (*Galaxias maculatus*; see Figure 26 and Figure 27).

Yelloweye mullet (*Aldrichetta forsteri*) was the only species caught in 2019 that was not recorded in 2024. Yelloweye mullet are primarily a marine species that follow the tide into the lower reaches of rivers, so it is unsurprising that they may be recorded one year and not the next. A single torrentfish (*Cheimarrichthys fosteri*) was caught in 2024 at Site AVON16 (Avon River downstream of Kilmore Street). While no torrentfish were caught during five-yearly monitoring in previous years, a single torrentfish was caught at AVON16 during monitoring of the Avon River Precinct restoration project in 2017 (Boffa Miskell Limited 2020), so they are clearly present in low numbers in this location. Low numbers of smelt and lamprey were also caught in 2017 by (Boffa Miskell Limited 2020); during that survey, a combined total of four lamprey were found at three sites, and a single smelt was found at one site. A single lamprey was also caught in the Avon River in 2022, as part of baseline monitoring for a new rock ramp fishway at Mona Vale (Katie Kerr, CCC Principal Waterways Ecologist, pers. comm.).

A total of five native fish species with a conservation status were caught in 2024. These species are longfin eel, inanga, giant bully, bluegill bully, and torrentfish, which all have an At Risk threat status (Dunn et al. 2018). In addition, the previously recorded lamprey have a Threatened conservation status. As stated in the previous five-yearly report, the widespread occurrence of longfin eels in the catchment is notable, because shortfin eels tend to be more prevalent in highly modified, lowland Canterbury rivers (Instream Consulting 2019). Also noteworthy was the greater prevalence of bluegill bullies in 2024, with 299 fish caught across six sites, compared with 172 across three sites in 2019, and 42 fish across five sites in 2013. Inanga were also more prevalent in 2024, with a total of 598 caught across six sites, compared with 103 fish at three sites in 2019 and six fish across three sites in 2013. The greater prevalence of inanga in 2024 was partly due to increased fish trapping effort, because inanga are more readily caught in traps than by electric fishing (Joy et al. 2013). In addition, high numbers of inanga were caught at Site AVON13 (Avon River at Avondale Road) in 2024 because traps were deployed during a spring tide sequence in the spawning season, so more inanga were present than would occur outside the spawning period.

In summary, and as noted in the previous five-yearly monitoring report (Instream Consulting 2019), the Ōtākaro catchment fish community is similar to that present in other Christchurch waterways. However, the presence of At Risk longfin eel, inanga, bluegill bully, giant bully, and torrentfish, and Threatened lamprey elevates the conservation value of the catchment, given the modified urban setting.

Table 8: Total number of fish caught in 2024. Size range (mm) is in brackets. † = sampled by electric fishing; ‡ = sampled by trapping.

Waterway	Site	Brown Trout	Longfin Eel	Shortfin Eel	Elver	Common Bully	Bluegill Bully	Giant Bully	Upland Bully	Juvenile Bully	Triplefin	Inanga	Torrent-fish	Total Catch
Okeover Stream	25 †‡		4 (742-1301)	1 (572)					11 (34-64)	7 (29-34)				**23**
Waimairi Stream	22 †	3 (81-110)	6 (171-640)	2 (129-392)					6 (40-64)					**17**
	6 †		4 (154-1001)	1 (200)					14 (33-65)	6 (24-32)				**25**
Wairarapa Stream	23 †	1 (115)	2 (624-668)	2 (276-505)					16 (35-64)	5 (30-36)				**26**
	5 †			16 (126-631)					10 (35-59)	3 (20-34)				**29**
Riccarton Main Drain	8 †		1 (135)			2 (60-74)			12 (32-79)	23 (24-36)				**38**
Addington Brook	9 †			4 (212-334)					7 (45-66)	1 (30)				**12**
Dudley Creek	10 †‡		1 (622)	28 (125-844)		5 (48-103)	9 (34-41)		4 (42-53)	12 (23-33)		49 (52-111)		**108**
Avon River	26 †		4 (173-538)	2 (455-550)					13 (34-73)	3 (31-33)				**22**
upstream	21 †		8 (159-931)	5 (134-362)			1 (51)		17 (32-70)	3 (30-32)				**34**
	19 †		7 (167-1162)	12 (153-554)		8 (45-111)	2 (45-55)		27 (34-68)	11 (22-49)		1 (64)		**68**
	18 †‡		14 (154-1048)	16 (151-598)		4 (66-112)	3 (43-49)		11 (37-54)	8 (26-35)		1 (57)		**57**
	17 †		7 (145-543)	6 (95-201)	2 (92-111)	6 (51-91)	25 (35-56)		18 (36-58)	32 (22-38)		2 (39-101)		**98**
	16 †‡		22 (122-812)	9 (170-539)	6 (88-134)	54 (45-114)	259 (31-65)		34 (31-64)	16 (22-34)			1 (92)	**401**
	3 ‡		19 (445-1021)	14 (501-860)		235 (48-126)		4 (82-105)	1 (65)	1 (37)		125 (49-116)		**399**
downstream	13 ‡		2 (623-683)	17 (369-815)		81 (51-110)		2 (62-87)		3 (28-32)		420 (46-120)		**525**
	01 ‡		4 (474-914)	9 (221-974)	1 (94)	12 (55-75)				1 (35)	62 (40-91)			**89**
	Total	**4**	**105**	**144**	**9**	**407**	**299**	**6**	**201**	**135**	**62**	**598**	**1**	**1,971**

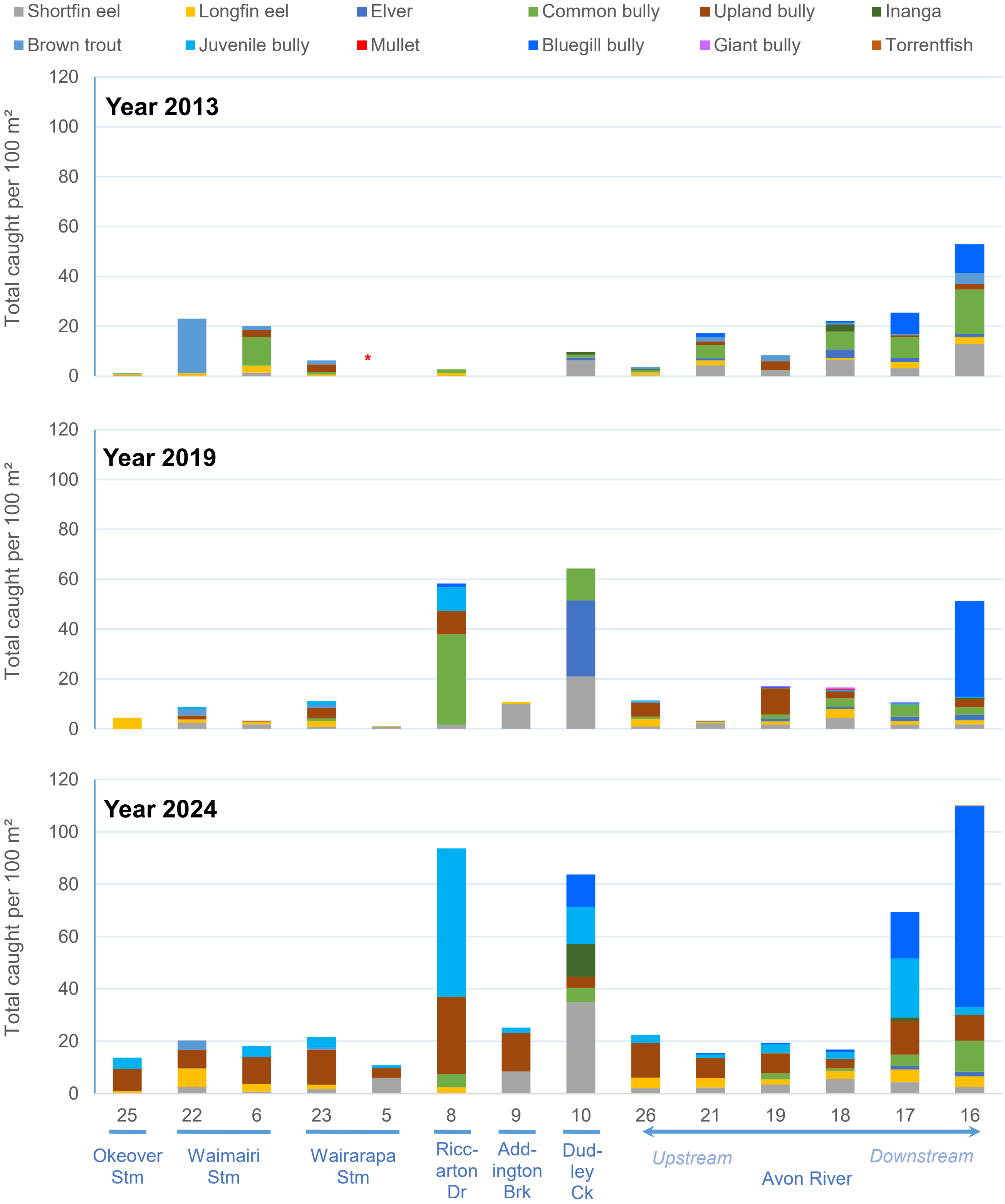

Figure 26: Electric fishing results at monitoring sites from 2013 to 2024. Asterisk indicates no electric fishing data available for that date.

Figure 27: Fish trapping results at monitoring sites in 2019 and 2024. Asterisks indicate no trapping data available for that date.

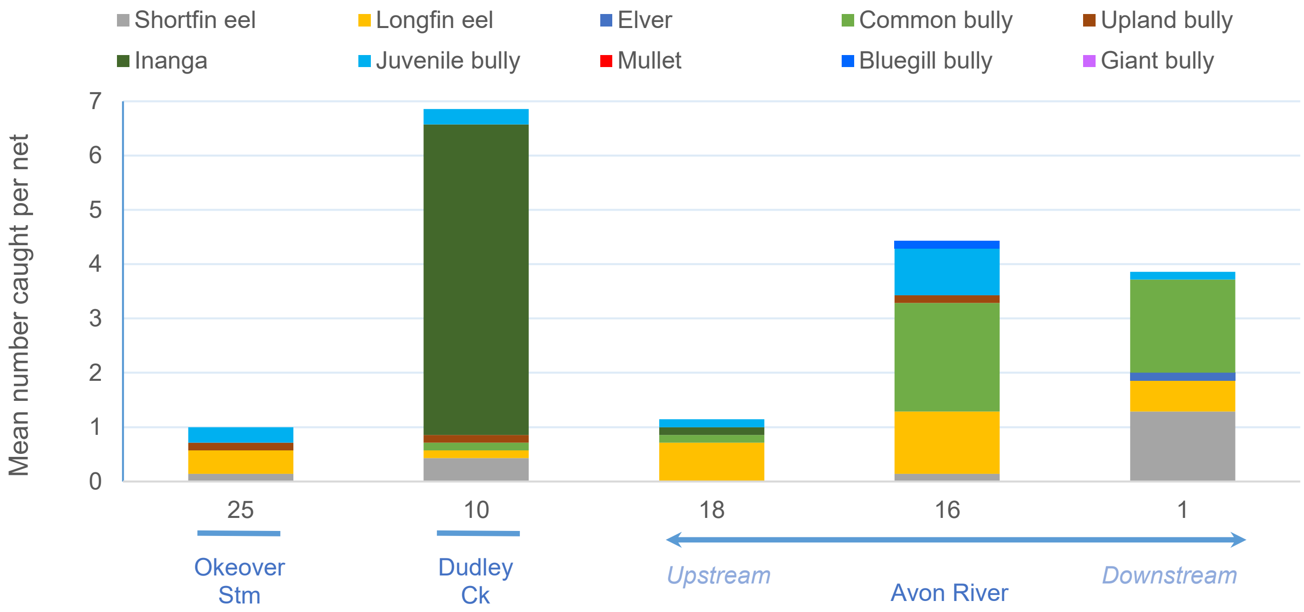

Figure 28: Fish trapping data for 2024, excluding Sites 3 and 13, to enable better comparison of fish numbers at sites with lower densities.

4. DISCUSSION

4.1. Current State and Trends in Aquatic Ecology

The current state of riparian and instream habitat is poor in the Avon – Ōtākaro catchment, particularly when compared to less urbanised Banks Peninsula waterways. A similar conclusion was reached in the previous monitoring report (Instream Consulting 2019), where it was noted that, "*The majority of sites have minimal buffering with riparian vegetation, many have artificial banks (including timber, stone, and concrete), and most have minimal shading. Lack of shading is associated with excessive aquatic weed growth in many locations and aquatic weed is removed by CCC contractors two to three times a year throughout the catchment".*

Invertebrate community health, as measured by QMCI scores, is a key measure of the state of aquatic ecology in the CSNDC EMP. Based on five-yearly monitoring data for the 17 Ōtākaro catchment sites sampled in 2024, 5 sites fell within the NPSFM C band (QMCI of 4.5-5.5) and 12 were in the D band (<4.5). The NPSFM notes that the C band is characterised by a macroinvertebrate community indicative of moderate organic pollution or nutrient enrichment. The D band is below the national bottom line, so sites falling within this band may be considered degraded.

We note that for assigning monitoring sites to bands, the NPSFM requires that QMCI scores are calculated using the median of five years of annual monitoring, to account for natural variation. Based on the most recent five years of monitoring data, median QMCI scores were in the D band for the two Cashmere Stream sites and three of the four Ōtākaro annual monitoring sites (Table 9). Two monitoring sites were in the C band (Avon River at Victoria Square and the downstream Balguerie Stream site), and one site was in the A band (the upstream Balguerie Stream site). The NPSFM grading for ecology monitoring sites is consistent with previous reports that many of the city's waterways are in a degraded state, reflecting the multiple impacts of urban development (including stormwater discharges), while Banks Peninsula waterways are generally in a better state (Instream Consulting 2019; Boffa Miskell Limited 2023).

Given the poor state of city waterways, it is encouraging that seven of the eight annual monitoring sites showed improving trends in QMCI scores (Table 9). The rate of improvement is slow for most sites, but it is ecologically meaningful. For example, there was an annual rate of change 2.4% for the Avon at Victoria Square monitoring site, which is relatively slow. However, this gradual change has resulted in a shift in median QMCI score of 3.1 for the period 2004 to 2008, to a median of 4.5 over the last five years, and an associated shift from NPSFM band D to C. The rate of change has been greatest for the Waimairi Stream site, with an average 4.5% annual increase, and median QMCI scores increasing from 1.8 (2004 to 2008) to 4.3 for the most recent five-year period.

Regression analysis on the five-yearly monitoring data indicates that physical habitat – particularly fine sediment deposition – better explained invertebrate community health than measures of water or sediment quality (see Section 3.3.1). This is not to say that water quality or sediment quality are unimportant, but rather that habitat quality likely has a greater impact. Likely or very likely improving trends in habitat quality were seen at four of the six ECan annual monitoring sites (Appendix 4), but the annual rate of improvement was slow relative to QMCI scores.

Table 9: Median QMCI scores based on the last 5 years of record, associated NPSFM attribute bands, and trends based on the full monitoring record for each site (see trend analysis details in Appendix 4).

Site Name (code)	QMCI	NPSFM Band	Trend
Cashmere Stream behind 420-426 Cashmere Rd (HEATH28)	4.1	D	Very likely improving
Cashmere Stream behind 406 Cashmere Rd (HEATH27)	4.2	D	Indeterminate
Balguerie Stream at Stony Bay Rd (SQ00684)	7.6	A	Very likely improving
Balguerie Stream downstream of Settlers Hill Rd (BP03 / SQ00170)	5.3	C	Likely improving
Waimairi Stream (SQ00130)	4.3	D	Very likely improving
Dudley Creek (SQ00063)	2.7	D	Very likely improving
Avon River at UCSA (SQ00129)	3.8	D	Very likely improving
Avon River at Victoria Square (SQ00128)	4.5	C	Very likely improving

Note: The two Ōtūkaikino annual monitoring sites are excluded from this table, as they only have four years of monitoring data, which is insufficient for NPSFM grading.

Until recently, there was little known about the distribution of At Risk kākahi in the Ōtākaro catchment, and dedicated kākahi surveys were recommended (Instream Consulting 2019). The first dedicated kākahi surveys in the Ōtākaro confirmed their presence at multiple locations in the catchment; however, it was concluded that, with the exception of Horseshoe Lake (where kākahi are very abundant), they were sparsely distributed, with very few kākahi downstream of Hagley Park (Instream Consulting 2020a). It was therefore a surprise finding large numbers of kākahi at the Gayhurst Bridge and Avondale Bridge search sites, the two most downstream search sites we surveyed. An eDNA survey in April/May 2024 also suggested kākahi may be widespread in the lower reaches of the river (James et al. 2024). In March and April 2025, a snorkel survey was conducted in the Ōtākaro by Instream for CCC at over 50 locations between the Fitzgerald Road and Pages Road Bridges. We are currently analysing the results of this latest survey, but preliminary results confirm the presence of kākahi at all sections of the river searched between Fitzgerald Avenue and immediately downstream of Anzac Drive (SH74), by the outlet of Kate Sheppard.

The results of recent surveys indicate that there are relatively high invertebrate values in the mid to lower reaches of the Ōtākaro River, based on the widespread occurrence and relative abundance of At Risk kākahi. This highlights the importance of considering indicators other than the likes of the QMCI for non-wadeable river sections. Although we have been cautious to avoid reporting QMCI data for non-wadeable river sections, because the QMCI index is intended for wadeable waterways, there previously was no comparable invertebrate indicator for the lower river. Regular kākahi monitoring in non-wadeable river reaches could therefore be used to complement conventional kicknet sampling of invertebrates in wadeable river sections in Christchurch.

As noted in Section 3.5, five At Risk and one Threatened native fish species are present in the Ōtākaro catchment. Many of New Zealand's native fish are diadromous, migrating between freshwater and the sea to complete their life cycle. The likely impact of fish barriers – such as culverts, tide gates, and weirs – on native fish distribution was recognised in the previous monitoring report (Instream Consulting 2019). Since then, CCC has identified potential fish barriers throughout the district and prioritised them for remediation (Instream Consulting 2020b; Instream Consulting 2021b; Instream Consulting 2022a; Instream Consulting 2023a). One of the highest priority barriers for remediation was the Mona Vale weir, and it has since been replaced with a natural rock ramp (Figure 29). If the remediation proves successful, removal of this significant fish barrier could provide access to upstream habitat that was previously blocked for fish species with weak climbing ability, such as At Risk inanga (Instream Consulting 2023a). Monitoring of the remediation effectiveness has been undertaken, and results are currently being analysed, although At Risk bluegill bully have already been identified as using the rock ramp as habitat (Katie Kerr, CCC Principal Waterways Ecologist, pers. Comm.).

Figure 29: Mona Vale weir, in 2020 priori to remediation (left) and in 2023, after remediation to enhance fish passage (right).

The previous five-yearly report for the Ōtākaro catchment noted several major waterway restoration projects that were underway or had been recently completed (Instream Consulting 2019). As noted previously, despite the prevalence of highly modified habitat throughout the Ōtākaro catchment, there are examples where positive changes have been made, and these positive changes are ongoing.

Examples of recent restoration projects include:

Avon River Precinct. As noted by Instream Consulting (2019), this project involved narrowing of riffles, addition of cobbles for habitat, fine sediment removal, and native plantings in adjacent “fresh plains” at multiple locations in central Christchurch. Follow-up monitoring has found greater fish abundance at rehabilitated sites, driven particularly by increased abundance of bluegill bullies, but no improvement in invertebrate community health, as indicated by MCI and QMCI scores (Boffa Miskell Limited 2020). Bluegill bully numbers were also high during our 2024 survey, with the greatest densities at AVON16 (Avon at Kilmore Street) and AVON17 (Victoria Square), which were enhanced as part of the Avon River Precinct works.

No. 1 Drain. This project entailed replacement of a shallow, concrete-lined channel with a combination of narrow stream sections and broad stormwater wetland basins, with wetland and riparian planting, over a length of 400 m through the Christchurch Golf Club course in Shirley. Post-restoration monitoring conducted for CCC concluded the restoration has been a success, in terms of improving aquatic habitat, increasing the diversity of invertebrate communities, and increasing the abundance and diversity of fish communities (Instream Consulting 2023b). In addition, inanga were abundant in the new stormwater wetlands, confirming that inanga can navigate upstream through the Horseshoe Lake tide gates, which was a concern raised in the previous monitoring report (Instream Consulting 2019).

Addington Brook. Habitat restoration is currently underway along a 1.1 km length of Addington Brook in Hagley Park (Figure 30). Ecological enhancements include regrading the banks to reduce erosion, native riparian plantings to enhance biodiversity and waterway shade, enhanced instream habitat, and channel realignment (Instream Consulting 2022b). A separate project also aims to improve water quality in Addington Brook, through the addition of a stormwater treatment facility upstream of Hagley Park. Pre-restoration baseline ecology sampling revealed the presence At Risk longfin eel and inanga, with the latter being abundant

(Instream Consulting 2023c). The works are due for completion this year and post-restoration monitoring is planned.

Figure 30: Addington Brook, in April 2022 prior to restoration (left) and immediately following restoration in June 2024 (right), showing bank battering the addition of wood and riffle habitat, and new native plantings.

Timber Lining Renewals. CCC has been trialling options for enhancing fish habitat in timber-lined waterways with limited hydraulic capacity, including numerous locations in the Ōtākaro catchment. The trials include ecological monitoring. An interim report made the following recommendations: naturalise timber-lined waterways wherever possible; install fresh plains where space for naturalisation is limited; increase the density of habitat feature installations; ensure cover is provided for larger fish; provide clear and specific installation guidance to construction contractors; and replace vegetation lost during relining to improve fish cover and waterway shading (Instream Consulting 2025).

Ōtākaro Avon River Corridor (OARC). The OARC covers an area of 602 hectares in the lower river and it holds by far the most significant potential for ecological restoration in the Ōtākaro catchment (Instream Consulting 2019). In the five years since the previous monitoring report, numerous restoration projects have begun, and some have been completed. These projects include:

- Waitaki Street Wetland. Creation of a 2 hectare tidal wetland at Waitaki Street, formed by the breaching of temporary stopbanks upstream of Pages Road bridge. Completed in March 2025.
- Avon Park Wetland. Construction is underway for the creation of a 3.2 hectare wetland upstream of Porrit Park. This will be achieved by removing the existing road, pushing back the stopbanks, regrading the site, and planting it with native species.
- Lake Kate Sheppard. Preliminary plans include ecological restoration of low-lying red-zoned adjoining the existing Lake Kate Sheppard reserve.
- Bexley Wetland. A landscape master plan is under development for a 55 hectare project area in the former Bexley subdivision (Figure 31). This is by far the largest and most ecologically significant restoration project for the OARC. Draft designs envisage ecological restoration across much of the project area, along with establishing permanent stopbanks set further back from the river than the current temporary stopbanks.

Figure 31: Freshwater wetland (left) and saline wetland (right) in the former Bexley subdivision, the site of a large wetland restoration proposal. Photographs taken in April 2024.

4.2. Comparison with Consent Attribute Target Levels

Schedule 7 of the CSNDC includes consent ATLs for sediment metals and PAHs, bed cover with fine sediment, macrophytes, filamentous algae, and QMCI scores. Of the 13 sites sampled for sediment metals in 2024, consent ATLs were complied with at 13 sites for copper, 9 sites for lead, and 6 sites for zinc (Table 10). As noted in Section 3.2, aside from a substantial decline in sediment lead concentrations after the 1980s, there is no indication of an increasing or decreasing trend in sediment metals. In contrast, there was markedly reduced compliance with the consent ATL for total PAHs in 2024, with only 4 from 13 sites complying (Table 10). As noted in Section 3.2, the key cause of reduced PAH compliance was the impact of markedly lower TOC concentrations in 2024; TOC is a toxicity modifier, so lower TOC concentrations resulted in higher potential toxicity for similar PAH concentrations compared to previous years. It is unknown whether this was an anomaly or part of a trend, as sampling is too infrequent to detect trends. However, there is no indication of an impact of higher PAH concentrations on invertebrate communities, based on positive trends in QMCI scores seen at all four annual monitoring sites in the Ōtākaro catchment (Section 3.3.2).

Table 10: Compliance with Consent Attribute Target Levels for sediment quality at sampling sites over time.

Parameter	**Consent Attribute Target Level**	**Complying sites each year No. and percent**			
		1980 (13 sites)	**2013** (9 sites)	**2019** (14 sites)	**2024** (13 sites)
Copper (mg/kg)	65	11 (85%)	9 (100%)	13 (93%)	13 (100%)
Lead (mg/kg)	50	2 (15%)	5 (56%)	4 (29%)	9 (69%)
Zinc (mg/kg)	200	6 (46%)	7 (78%)	5 (36%)	6 (46%)
Total PAHs (mg/kg)	10	-	5 (56%)	10 (71%)	4 (31%)

Note: Dashes indicate data were either not collected, or methods differed from 2019/2024. Total PAHs were normalised to 1% TOC prior to comparison with guidelines, as recommended by ANZG (2018).

The consent ATL for long filamentous algae cover has been met at most wadeable sites in the Ōtākaro catchment over the monitoring record (Table 11), and at all four CCC annual monitoring sites (Table 12). In contrast, there has been more variable compliance over time with the total macrophyte cover consent ATL at all sites. As noted previously, higher macrophyte cover largely reflects the timing of sampling in relation to regular macrophyte removal by CCC contractors; macrophyte cover is unrelated to the consented stormwater discharges (Instream Consulting 2019). The consent ATL for fine sediment cover was complied with at 5 of the 14 wadeable Ōtākaro sites in 2024, compared with 10 of the 15 sites in 2019, and 6 out of 15 sites in 2013 (Table 11). The fine sediment cover ATL has never been complied with at the four annual monitoring sites (Table 12); these are naturally soft-bottomed waterways, so they have naturally high fine sediment cover.

Table 11: Compliance with Consent Attribute Target Levels for ecological values at wadeable sites in the Ōtākaro catchment over time.

Parameter	Consent Attribute Target Level	Complying sites each year No. and percent			
		2009 (10 sites)	**2013** (15 sites)	**2019** (15 sites)	**2024** (14 sites)
Fine sediment cover (%)	<30	-	5 (33%)	10 (67%)	5 (36%)
Total macrophyte cover (%)	<60	10 (100%)	-	10 (67%)	13 (93%)
Long filamentous algae (>2 cm long) cover (%)	<30	10 (100%)	14 (93%)	15 (100%)	12 (86%)
QMCI	>3.5	8 (80%)	7 (47%)	13 (87%)	14 (100%)

Note: Dashes indicate data were either not collected, or methods differed from 2019/2024.

Table 12: Compliance with Consent Attribute Target Levels over time at the four CCC annual monitoring sites.

Parameter	Consent Attribute Target Level	Complying Years for Each Site No. and percent			
		HEATH28 (12 years)	**HEATH27** (5 years[1])	**OTUKAI06** (4 years)	**OTUKAI02** (4 years)
Fine sediment cover (%)	<20	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Total macrophyte cover (%)	SP: <50 BP: <30	2 (17%)	2 (40%)	2 (50%)	3 (75%)
Long filamentous algae (>2 cm long) cover (%)	SP: <30 BP: <20	12 (100%)	5 (100%)	4 (100%)	4 (100%)
QMCI	>5	0 (0%)	0 (0%)	0 (0%)	0 (0%)

Note: Only 4 years of macrophyte data using consistent methods at HEATH27.

Of particular interest to the CSNDC is the consent ATL for QMCI, because the QMCI is an indicator of invertebrate community health, and invertebrates are influenced by both water quality and habitat (Instream Consulting 2019). The consent ATL for QMCI in the Ōtākaro catchment is a minimum of 3.5, and this was met at all 14 wadeable sites in 2024, compared with 14 out of 15 sites in 2019, 7 out of 15 sites in 2013, and 8 out of 10 sites in 2009 (Table 11). In the previous five-yearly monitoring report it was concluded that, *“Although QMCI scores have been overall low across all sites, and have varied within sites over the years, there has been no overall increasing or decreasing trend in QMCI scores evident across all of the sites monitored every five years.”* However, as noted in Section 4.2, annual monitoring data from ECan shows positive trends in QMCI scores at all four of their sites in the Ōtākaro catchment. This has been associated with improved compliance with the consent ATL at three of the four Ōtākaro sites, while the remaining site, Dudley Creek, has a positive trend, but still sits below the consent ATL. Compliance with the consent ATL for QMCI has been low and unchanged at the four CCC annual monitoring sites. This likely reflects the naturally high dominance of fine sediments, which are favoured by pollution-tolerant taxa with low MCI scores.

5. RECOMMENDATIONS

Based on the results and discussion presented above, we make the following recommendations. These include a mixture of recommendations updated from the previous report (Instream Consulting 2019) and new recommendations.

Recommendations Updated from the 2019 Report

- Increase the length and width of riparian planting alongside waterways on public land, to improve stream shading, filtering of contaminants in surface runoff, provide habitat for fish and invertebrates, and reduce the need for mowing grass down to the water’s edge..
    - Update: Restoration efforts are resulting in gradual improvements in riparian and instream habitat. This is evident in the restoration projects highlighted above and may be reflected in improved habitat scores at annual monitoring sites. More habitat restoration is needed throughout the catchment, to help improve the ecological state of waterways.
- Promote the protection and enhancement of the riparian corridor on private land, through public education, and either a strengthening of District Plan rules, or better adherence to existing waterway setback rules, to limit the further loss of natural habitat and aquatic species.
    - Update. This remains a substantial issue that requires addressing.
- Undertake ecological restoration of the Ōtākaro Avon River Corridor. Restoration should include pushing back stopbanks, promoting regeneration of native riparian and estuarine vegetation, and providing opportunities for city residents and visitors to interact with the river.
    - Update: Restoration planning is well underway, and construction is underway or completed in several locations. More activity is planned for the years ahead.
- Monitoring the effectiveness of waterway restoration projects, to better inform future decisions about where to invest restoration money.

    - Update: Ecological monitoring is occurring for most major restoration projects, as evidenced by monitoring of the Avon River Precinct, No 1 Drain, Addington Brook, and for numerous timber lining renewal projects.
- Consider removal of sediments with high zinc concentrations, alongside encouraging source control of zinc throughout the catchment (e.g. via treatment of roof runoff prior to entering the stormwater network).
    - Update: A feasibility report commissioned by CCC recommended undertaking sediment removal trials, due to lack of ecological data supporting the effectiveness of sediment removal (Greenwood et al. 2024). We strongly support their recommendation, given the likely impacts of fine sediment on waterways throughout the district.
- Undertake surveys for At Risk kākahi in the mainstem of the Ōtākaro and in tributaries.
    - Update: This has been done. Now that it has been established that kākahi are widespread in the lower river, we recommend monitoring those populations, focussing on areas with high densities.
- Undertake surveys for Threatened lamprey.
    - Update: This has not been done, but we recommend it is still worth undertaking, given the species' threat status and poor knowledge of their distribution in the catchment.
- Undertake a brown trout spawning survey, to confirm the state of the fishery.
    - Update: A combination of fieldwork and desktop analysis will be undertaken to update trout and inanga spawning maps for the district in 2026.
- Identify fish barriers, prioritise them for remediation, and construct a schedule to progressively remediate barriers over time, starting with the highest priority structures.
    - Update: This has been done. The barrier prioritisation database is updated every one or two years, and CCC focusses remediation efforts on the highest priority barriers.

New Recommendations

- Increase ecology sampling frequency from five-yearly to annual, to improve the ability to detect trends over time, and to be consistent with national protocols.
    - This recommendation was made to CCC in 2024, following preliminary analysis of the 2024 five-yearly and annual monitoring data. This recommendation has been adopted by CCC via the latest update to the EMP, and a new annual monitoring programme commenced in 2025.
- Assess the relative impact of habitat, water and sediment quality on invertebrate communities in waterways across the district.
    - This recommendation is based on our observation in the Ōtākaro catchment that fine sediment appeared to have a greater influence on invertebrate health that water or sediment quality.

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APPENDIX 1: EMP METHODS

The following text is taken from draft Version 10 of the Environmental Monitoring Plan (EMP) for Christchurch City Council's Comprehensive Stormwater Network Discharge Consent (CSNDC). These methods were followed for the five-yearly and annual ecology monitoring described in this report, except where noted otherwise in the Section 2 Methods, in the body of this report. Numbering and formatting is as per the EMP.

6.1.1. Annual and Five-Yearly Aquatic Ecology Monitoring

As per previous surveys, monitoring will continue to be undertaken in March, to ensure no biases due to sampling during different seasons and this being the preferred time for ecological monitoring generally. Surveys will include assessments of habitat, periphyton, macrophytes, macroinvertebrates and fish, using similar methodology to that used in the past and the requirements of current stormwater consents. In the past, annual surveys have only involved the monitoring of invertebrates, but for this monitoring programme these surveys will include the full suite of parameters except fish (i.e. habitat, periphyton, macrophytes and macroinvertebrates).

6.1.2. Habitat, Periphyton and Macrophytes

At each site, an assessment of habitat, periphyton and macrophyte cover shall be carried out at either (a) each of three representative transects, or (b) as a site-wide assessment, as detailed in Table 5. The first transect shall be located at the downstream coordinates for the site and the following two transects located at 10m intervals upstream from this point (unless previous survey methodology deviates from this, in which case, transects shall be located in the same location as previous assessments). Representative photos shall also be taken at each site.

Table 5. Summary of habitat, macrophyte and periphyton data to be collected at aquatic ecology monitoring sites

Parameter	Characteristics	
Bank\riparian (for five metre width at each bank on each transect)	Bank material Bank height Surrounding land use Bank erosion Bank slope	Riparian vegetation Canopy cover Undercut banks Overhanging vegetation Ground cover vegetation
Instream (at five locations on each transect, including each bank and mid-channel)	Wetted width Water depth Fine sediment depth and % cover Embeddedness Substrate composition (modified from Harding *et al*, 2009) - Silt/sand (<2 mm) - Gravels (2-16 mm) - Pebbles (16-64 mm) - Small cobbles (64-128 mm) - Large cobbles (128-256 mm) - Boulders (256-4000 mm) - Bedrock/concrete/artificial hard surfaces (>4000 mm)	
Macrophytes (at five locations on each transect, including each bank and mid-channel)	Emergent macrophyte composition & % cover Total macrophyte composition & % cover Total macrophyte depth Species present and proportion of native versus exotic	
Periphyton (at five locations on each transect, including each bank and mid-channel)	Composition % cover (modified from Biggs & Kilroy, 2000) - Thin mat forming algae (<0.5 mm thick) - Medium mat forming algae (0.5 – 3 mm thick)	

	- Thick mat forming algae (>3 mm thick) - Short filamentous algae (<20 mm long) - Long filamentous algae (>20 mm long)	
Organic matter (at five locations on each transect, including each bank and mid-channel)	% cover and type	
Water flow (at each transect)	Velocity (using a flow meter)	
Flow composition (site-wide assessment)	Still Backwater Pool Run	Riffle Rapid Cascade
Water permanence (site-wide assessment)	Ephemeral Intermittent	Perennial
Water chemistry (site-wide assessment)	Dissolved oxygen (%) Temperature (°C)	pH Conductivity (µS/cm)

6.1.3. Macroinvertebrates

The aquatic benthic invertebrate community shall be assessed using the following methodology:

- One kicknet sample shall be taken at each site (where sites are non-wadeable, the sample shall be taken from marginal sections only);
- Samples shall be collected using the semi-quantitative C1 (hard-bottomed streams) or C2 (soft-bottomed streams) protocols from Stark *et al* (2001);
- Samples shall be processed using Protocol P2 (200 Individual Fixed Count with scan for rare taxa) from Stark *et al* (2001);
- Taxa shall be identified to species level where possible; and
- The following invertebrate indices shall be calculated in accordance with Stark & Maxted (2007):

  - Total abundance
  - Taxa richness
  - Ephemeroptera-Plecoptera-Trichoptera (EPT) taxa richness and percent composition (% EPT)
  - Macroinvertebrate Community Index (MCI) and Quantitative MCI (QMCI)

6.1.4. Fish

Fish at each site shall be sampled using the following methodology (in general accordance with Joy *et al*, 2013):

- The fishing reach shall start at the downstream coordinate for the site and continue upstream until the desired fishing length/area is achieved;
- The fishing reach should be a minimum of 30 metres in length and 30m^2 in area;
- All habitat types within the reach should be sampled (i.e. pools, riffles, underhangs and backwaters);
- Wadeable sites shall be fished using a single pass with an electric fishing machine;
- Non-wadeable site shall be fished as follows:
  - A minimum of five Gee Minnow traps and two fyke nets shall be used
  - Gee Minnow traps shall be baited with marmite
  - Fyke nets are to be baited with chicken, liver or cat food
  - Fyke nets are to be set at a 15° – 30° angle to the bank, with the trailer upstream
- Fish shall be identified to species level where possible, counted, length measured and then released back into the waterway;
- Fish seen but not caught should be recorded as missed fish (e.g. 'missed bully' or 'missed fish' if identification cannot be certain), but not included in the total tally; and
- Fish abundance shall be standardised by Catch Per Unit Effort according to the methodology in Joy *et al* (2013). Electrofishing is considered an active fishing technique (CPUE = fish/m^2), and fyke nets and gee minnow traps are considered passive (i.e. use the soak time to calculate CPUE of fish/net/night).

APPENDIX 2: FIVE-YEARLY MONITORING SITE PHOTOGRAPHS

Figure 1: Avon01 (Avon River at Pages/Seaview Bridge) – Upstream end of reach looking downstream.

Figure 2: Avon03 (Avon River at Dallington Terrace/Gayhurst Road) – Downstream end of reach looking upstream.

Figure 3: Avon05 (Wairarapa Stream Downstream of Fendalton Road) – Upstream end of reach looking downstream.

Figure 4: Avon06 (Waimairi Stream downstream of railway bridge) – Downstream end of reach looking upstream.

Figure 5: Avon08 (Riccarton Main Drain Downstream of Deans Avenue) – Downstream end of reach looking upstream.

Figure 6: Avon09 (Addington Brook Upstream of Riccarton Avenue) – Upstream end of reach looking downstream.

Figure 7: Avon10 (Dudley Creek at North Parade) – Downstream end of reach looking upstream.

Figure 8: Avon13 (Avon River at Avondale Road) – Upstream end of reach looking downstream.

Figure 9: Avon16 (Avon River Downstream of Kilmore Street (Otautahi)) – Downstream end of reach looking upstream.

Figure 10: Avon17 (Avon River at Victoria Square Near Armagh Street) – Downstream end of reach looking upstream.

Figure 11 Avon18 (Avon River Upstream of Montreal Street/near Durham Street) – Downstream end of reach looking upstream.

Figure 12: Avon19 (Avon River at Botanic Garden North Car Park/in Hagley Park) – Upstream end of reach looking downstream.

Figure 13: Avon21 (Avon River Downstream of Mona Vale loop) – Downstream end of reach looking upstream.

Figure 14: Avon22 (Waimairi Stream at Fendalton Park) – Upstream end of reach looking downstream.

Figure 15: Avon23 (Wairarapa Stream upstream of Glandovey Road) – Upstream end of reach looking downstream.

Figure 16: Avon25 (Okeover Stream at University of Canterbury Glasshouses) – Downstream end of reach looking upstream.

Figure 17: Avon26 (Avon River at Clyde Road) – Downstream end of reach looking upstream.

APPENDIX 3: ANNUAL MONITORING SITE PHOTOGRAPHS

Figure 1: HEATH27 (Behind 406 Cashmere Road) – Upstream end of reach looking downstream.

Figure 2: HEATH28 (Behind 406 Cashmere Road) – Downstream end of reach looking upstream.

Figure 3: OTUKAI02 (Wilsons Drain at Main North Road). Downstream end of reach looking upstream.

Figure 4: OTUKAI06 (Wilsons Drain at Tyrone Street). Upstream end of reach looking downstream.

APPENDIX 4: STATISTICAL RESULTS

Response parameter	Fixed effect (random effect)	Test	Data pre-processing	Transformations (log, arcsine, or rank)	Results
CCC Five-Yearly Sites					
Width	Year*Site	Two-way ANOVA	None	Rank	***Site***: DF = 16, F = 171.06, **P < 0.001** ***Year:*** DF = 1, F = 43.30, **P < 0.001** ***Site x Year***: DF = 16, F = 9.98, **P < 0.001**
Depth	Year*Site	Two-way ANOVA	Means for transect	Log	***Site:*** DF = 16, F = 15.07, **P < 0.001** Year: DF = 1, F = 0.35, P = 0.56 Site x Year: DF = 16, F =1.45, P = 0.21
Velocity	Year*Site	Two-way ANOVA	Extract centre point velocity	None	***Site:*** DF = 16, F = 6.93, **P = <0.001** Year: DF = 1, F = 2.35, P = 0.14 Site x Year: DF = 16, F = 0.95, P = 0.53
Substrate index	Year*Site	Two-way ANOVA	Means for transect	None	***Site:*** DF = 16, F = 5.68, **P = 0.001** Year: DF = 1, F = 3.96, P = 0.07 Site x Year: DF = 16, F = 1.55, P = 0.21
Fine sediment depth	Year*Site	Two-way ANOVA	Means for transect	Rank	***Site:*** DF = 16, F = 7.79, **P = <0.001** ***Year:*** DF = 1, F = 22.14, **P = <0.001** ***Site x Year:*** DF = 16, F = 2.35, **P = 0.03**
Emergent macrophyte cover	Year*Site	Two-way ANOVA	Means for transect	Rank	Site: DF = 16, F = 0.30, P = 0.99 Year: DF = 1, F = 1.76, P = 0.20 Site x Year: DF = 16, F = 0.35, P =0.98
Total macrophyte cover	Year*Site	Two-way ANOVA	Means for transect	Rank	***Site:*** DF = 16, F = 4.35, **P = <0.001** ***Year:*** DF = 1, F = 4.63, **P = 0.04** Site x Year: DF = 16, F = 0.53, P = 0.90
Long filamentous algae cover	Year*Site	Two-way ANOVA	Means for transect	Rank	Site: DF = 16, F = 1.17, P = 0.36 Year: DF = 1, F = 2.74, P = 0.11 Site x Year: DF = 16 , F = 0.56, P = 0.88
Sediment: Total copper 2024	Site	Kruskal-Wallis	None	None	$\chi^2(12) = 26.65$, **p < 0.01**

Response parameter	Fixed effect (random effect)	Test	Data pre-processing	Transformations (log, arcsine, or rank)	Results
Sediment: Total lead 2024	Site	Kruskal-Wallis	None	None	$\chi^2(12) = 28.07$, **$p < 0.01$**
Sediment: Total zinc 2024	Site	Kruskal-Wallis	None	None	$\chi^2(12) = 32.60$, **$p < 0.01$**
Sediment: Total PAH 2024	Site	Kruskal-Wallis	None	None	$\chi^2(12) = 26.93$, **$p < 0.01$**
Sediment: Total PAH (Standardised to 1% Total Organic Carbon) 2024	Site	Kruskal-Wallis	None	None	$\chi^2(12) = 29.00$, **$p < 0.01$**
Regression Models for 2024 Five-Yearly Invertebrate Data					
Invertebrate taxa richness 2024	Habitat parameters Sediment quality parameters Water quality parameters	Multiple regression	Habitat: Site/year means. Sediment quality: mean across years. Water quality: median January 2021–December 2023	Rank	No significant models found.
%EPT 2024	Habitat parameters Sediment quality parameters Water quality parameters	Multiple regression	Habitat: Site/year means. Sediment quality: mean across years. Water quality: median January 2021–December 2023	Rank	Best model: Fine sediment cover (T=-2.59, **P = 0.02**) Model fit: F(1,15)=6.7, **P = 0.02**, adjusted $R^2 = 0.26$
EPT Taxa richness 2024	Habitat parameters Sediment quality parameters Water quality parameters	Multiple regression	Habitat: Site/year means. Sediment quality: mean across years. Water quality: median January 2021–December 2023	Rank	Best model: Fine sediment depth (slope=-0.39, **P = 0.02**) + substrate index (slope=-0.98, P = 0.22) + total macrophyte cover (slope=0.02, p=0.10) + fine sediment cover (slope=-0.04, **P = 0.02**) Model fit:

Response parameter	Fixed effect (random effect)	Test	Data pre-processing	Transformations (log, arcsine, or rank)	Results
					F(4,12)=11.2, **P < 0.01,** adjusted R^2 = 0.72
MCI 2024	Habitat parameters Sediment quality parameters Water quality parameters	Multiple regression	Habitat: Site/year means. Sediment quality: mean across years. Water quality: median January 2021–December 2023	None	Best model: sediment depth (slope=-1.32, **P < 0.01**) + fine sediment cover (slope = -0.13, p=0.07) Model fit: F(2,14)=27.3, **P < 0.01,** adjusted R^2 = 0.77
QMCI 2024	Habitat parameters Sediment quality parameters Water quality parameters	Multiple regression	Habitat: Site/year means. Sediment quality: mean across years. Water quality: median January 2021–December 2023	Rank	Best model: Water depth (slope=-0.03, **P < 0.01**) + water velocity (slope=1.02, **P = 0.04**) Model fit: F(2,14)=, **P < 0.01,** adjusted R^2 = 0.57
ASPM 2024	Habitat parameters Sediment quality parameters Water quality parameters	Multiple regression	Habitat: Site/year means. Sediment quality: mean across years. Water quality: median January 2021–December 2023	Rank	Best model: Sediment depth (slope=-0.01, P = 0.06) + substrate index (slope= -0.05, P = 0.14) + fine sediment cover (slope =-0.002, **P = 0.03**) Model fit: F(3,13)=, **P < 0.01,** adjusted R^2 = 0.59
CCC Annual Sites (only included sites with ≥5 years of data)					
Total macrophyte cover		Mann-Kendal Trend Analysis	Site/Year mean	None	HEATH28: Very Likely Improving C = 0.94 Annual change (slope; %): -7.2
Fine sediment cover		Mann-Kendal Trend Analysis	Site/Year mean	None	HEATH 27: Likely Degrading C = 0.89 Annual change (slope; %): 5.4 HEATH28: Very Likely Improving C = 0.99

Response parameter	Fixed effect (random effect)	Test	Data pre-processing	Transformations (log, arcsine, or rank)	Results
					Annual change (slope; %): - 0.2
QMCI		Mann-Kendal Trend Analysis	None	None	HEATH27: Indeterminate C = 0.60 Annual change (slope; %):-1.9 HEATH28: Very Likely Improving C = 0.96 Annual change (slope; %): 3.2
ECan Annual Sites					
Avon River at UCSA: QMCI		Mann-Kendal Trend Analysis	None	None	All years: Very Likely Improving C = 0.91 Annual change (slope; %): 0.9
Avon River at UCSA: Habitat Score		Mann-Kendal Trend Analysis	None	None	All years: Very Likely Improving C = 0.96 Annual change (slope; %): 2.2
Avon River Victoria Square: QMCI		Mann-Kendal Trend Analysis	None	None	All years: Very Likely Improving C = 0.99 Annual change (slope; %): 2.4
Avon River Victoria Square: Habitat Score		Mann-Kendal Trend Analysis	None	None	All years: Very Likely Improving C = 0.97 Annual change (slope; %): 1.7
Dudley Creek at North Parade Rd: QMCI		Mann-Kendal Trend Analysis	None	None	All years: Very Likely Improving C = 0.99 Annual change (slope; %): 2.6

Response parameter	Fixed effect (random effect)	Test	Data pre-processing	Transformations (log, arcsine, or rank)	Results
Dudley Creek at North Parade Rd: Habitat Score		Mann-Kendal Trend Analysis	None	None	All years: Indeterminate C = 0.64 Annual change (slope; %): -0.5
Waimairi Stream at Kotare St: QMCI		Mann-Kendal Trend Analysis	None	None	All years: Very Likely Improving C = 0.99 Annual change (slope; %): 4.5
Waimairi Stream at Kotare St: Habitat Score		Mann-Kendal Trend Analysis	None	None	All years: Very Likely Improving C = 0.99 Annual change (slope; %): 1.2
Balguerie at Balguerie Rd: QMCI		Mann-Kendal Trend Analysis	None	None	All years: Likely Improving C = 0.74 Annual change (slope; %): 0.7
Balguerie at Balguerie Rd: Habitat Score		Mann-Kendal Trend Analysis	None	None	All years: Indeterminate C = 0.64 Annual change (slope; %): 0.1
Balguerie at Stony Bay Rd: QMCI		Mann-Kendal Trend Analysis	None	None	All years: Very Likely Improving C = 0.99 Annual change (slope; %): 0.8
Balguerie at Stony Bay Rd: Habitat Score		Mann-Kendal Trend Analysis	None	None	All years: Likely Improving C = 0.83 Annual change (slope; %): 0.5
Balguerie (Downstream – Upstream; Balguerie Rd – Stoney Bay Rd): QMCI		Mann-Kendal Trend Analysis	None	None	All years: Indeterminate C = 0.58 Annual change (slope; %): -0.6

Response parameter	Fixed effect (random effect)	Test	Data pre-processing	Transformations (log, arcsine, or rank)	Results
Balguerie (Downstream – Upstream; Balguerie Rd – Stoney Bay Rd): Habitat Score		Mann-Kendal Trend Analysis	None	None	All years: Indeterminate C = 0.58 Annual change (slope; %): -1.3

Note: Trend analysis interpretation is derived from https://www.lawa.org.nz/learn/factsheets/calculating-water-quality-trends-in-rivers-and-lakes

APPENDIX 5: LABORATORY RESULTS

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Certificate of Analysis

Client:	Instream Consulting Limited	**Lab No:**	3469192 SPv2
Contact:	G Burrell C/- Instream Consulting Limited PO Box 28173 Christchurch 8242	**Date Received:**	16-Feb-2024
		Date Reported:	10-May-2024 **(Amended)**
		Quote No:	127849
		Order No:	
		Client Reference:	Avon River Sediment
		Submitted By:	Derek Gerber

Sample Type: Sediment

Sample Name:		Avon 26 A 16-Feb-2024 9:20 am	Avon 26 B 16-Feb-2024 9:20 am	Avon 26 C 16-Feb-2024 9:20 am	Avon 06 A 16-Feb-2024 10:20 am	Avon 06 B 16-Feb-2024 10:20 am
Lab Number:		3469192.1	3469192.2	3469192.3	3469192.4	3469192.5
Individual Tests						
Dry Matter	g/100g as rcvd	80	62	74	47	56
Total Recoverable Copper	mg/kg dry wt	13.6	12.6	10.2	19.5	12.5
Total Recoverable Lead	mg/kg dry wt	43	33	24	155	210
Total Recoverable Zinc	mg/kg dry wt	155	177	155	178	147
Total Organic Carbon*	g/100g dry wt	0.33	1.47	0.32	2.4	0.69
7 Grain Sizes Profile as received*						
Dry Matter of Sieved Sample*	g/100g as rcvd	86	72	76	50	77
Fraction >/= 2 mm*	g/100g dry wt	63.0	49.3	44.3	2.3	51.6
Fraction < 2 mm, >/= 1 mm*	g/100g dry wt	10.6	4.3	1.8	0.9	2.4
Fraction < 1 mm, >/= 500 µm*	g/100g dry wt	4.5	3.4	1.1	1.5	1.3
Fraction < 500 µm, >/= 250 µm*	g/100g dry wt	6.4	9.2	8.9	3.1	3.6
Fraction < 250 µm, >/= 125 µm*	g/100g dry wt	12.7	24.7	32.2	17.2	23.1
Fraction < 125 µm, >/= 63 µm*	g/100g dry wt	3.1	9.2	11.7	43.4	19.5
Fraction < 63 µm*	g/100g dry wt	< 0.1	< 0.1	< 0.1	31.5	< 0.1
Polycyclic Aromatic Hydrocarbons Trace in Soil*						
Total of Reported PAHs in Soil	mg/kg dry wt	147	99	4.2	17.3	13.6
1-Methylnaphthalene	mg/kg dry wt	0.30	0.60	0.005	0.051	0.042
2-Methylnaphthalene	mg/kg dry wt	0.31	0.76	0.005	0.049	0.049
Acenaphthene	mg/kg dry wt	0.89	0.91	0.009	0.066	0.041
Acenaphthylene	mg/kg dry wt	0.63	0.84	0.041	0.146	0.113
Anthracene	mg/kg dry wt	4.6	3.3	0.059	0.30	0.22
Benzo[a]anthracene	mg/kg dry wt	10.2	7.5	0.31	1.21	0.96
Benzo[a]pyrene (BAP)	mg/kg dry wt	10.7	8.3	0.46	1.50	1.18
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	11.2	8.6	0.48	1.65	1.33
Benzo[e]pyrene	mg/kg dry wt	5.6	3.8	0.26	0.86	0.67
Benzo[g,h,i]perylene	mg/kg dry wt	6.7	3.9	0.32	1.00	0.79
Benzo[k]fluoranthene	mg/kg dry wt	4.7	3.0	0.172	0.60	0.50
Chrysene	mg/kg dry wt	9.0	6.4	0.28	1.18	0.93
Dibenzo[a,h]anthracene	mg/kg dry wt	1.35	0.99	0.055	0.23	0.169
Fluoranthene	mg/kg dry wt	25	14.7	0.50	2.7	2.1
Fluorene	mg/kg dry wt	1.63	1.93	0.028	0.155	0.120
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	6.8	4.2	0.32	0.99	0.82
Naphthalene	mg/kg dry wt	0.49	0.63	< 0.010	0.066	0.056
Perylene	mg/kg dry wt	2.5	1.70	0.106	0.32	0.27
Phenanthrene	mg/kg dry wt	19.7	12.4	0.24	1.55	1.14
Pyrene	mg/kg dry wt	24	14.9	0.55	2.7	2.1

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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: Sediment

Sample Name:		Avon 26 A 16-Feb-2024 9:20 am	Avon 26 B 16-Feb-2024 9:20 am	Avon 26 C 16-Feb-2024 9:20 am	Avon 06 A 16-Feb-2024 10:20 am	Avon 06 B 16-Feb-2024 10:20 am
Lab Number:		3469192.1	3469192.2	3469192.3	3469192.4	3469192.5
Polycyclic Aromatic Hydrocarbons Trace in Soil*						
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES*	mg/kg dry wt	15.7	11.8	0.66	2.2	1.74
Benzo[a]pyrene Toxic Equivalence (TEF)*	mg/kg dry wt	15.4	11.7	0.65	2.2	1.72

Sample Name:		Avon 06 C 16-Feb-2024 10:20 am	Avon 05 A 16-Feb-2024 10:45 am	Avon 05 B 16-Feb-2024 10:45 am	Avon 05 C 16-Feb-2024 10:45 am	Avon 07 A 16-Feb-2024 11:20 am
Lab Number:		3469192.6	3469192.7	3469192.8	3469192.9	3469192.10
Individual Tests						
Dry Matter	g/100g as rcvd	54	58	55	65	45
Total Recoverable Copper	mg/kg dry wt	22	13.9	16.8	19.8	19.7
Total Recoverable Lead	mg/kg dry wt	129	33	57	32	35
Total Recoverable Zinc	mg/kg dry wt	174	119	156	125	189
Total Organic Carbon*	g/100g dry wt	1.32	1.10	1.20	0.72	1.77
7 Grain Sizes Profile as received*						
Dry Matter of Sieved Sample*	g/100g as rcvd	68	62	61	70	59
Fraction >/= 2 mm*	g/100g dry wt	3.6	2.1	5.2	4.9	2.1
Fraction < 2 mm, >/= 1 mm*	g/100g dry wt	1.0	0.5	1.3	0.9	0.7
Fraction < 1 mm, >/= 500 µm*	g/100g dry wt	1.8	0.8	1.3	2.3	1.0
Fraction < 500 µm, >/= 250 µm*	g/100g dry wt	9.3	14.9	11.5	26.3	7.4
Fraction < 250 µm, >/= 125 µm*	g/100g dry wt	21.8	49.9	42.1	44.9	47.7
Fraction < 125 µm, >/= 63 µm*	g/100g dry wt	33.7	23.5	28.5	16.0	25.0
Fraction < 63 µm*	g/100g dry wt	28.9	8.2	10.2	4.7	16.0
Polycyclic Aromatic Hydrocarbons Trace in Soil*						
Total of Reported PAHs in Soil	mg/kg dry wt	16.7	19.4	18.5	12.4	7.1
1-Methylnaphthalene	mg/kg dry wt	0.033	0.040	0.058	0.016	0.29
2-Methylnaphthalene	mg/kg dry wt	0.032	0.040	0.051	0.016	0.30
Acenaphthene	mg/kg dry wt	0.043	0.064	0.053	0.035	0.029
Acenaphthylene	mg/kg dry wt	0.145	0.124	0.119	0.082	0.068
Anthracene	mg/kg dry wt	0.26	0.30	0.27	0.183	0.150
Benzo[a]anthracene	mg/kg dry wt	1.18	1.33	1.29	0.84	0.44
Benzo[a]pyrene (BAP)	mg/kg dry wt	1.46	1.65	1.61	1.07	0.51
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	1.62	1.83	1.75	1.16	0.55
Benzo[e]pyrene	mg/kg dry wt	0.80	0.90	0.88	0.58	0.29
Benzo[g,h,i]perylene	mg/kg dry wt	0.93	1.12	1.07	0.71	0.34
Benzo[k]fluoranthene	mg/kg dry wt	0.60	0.65	0.66	0.45	0.22
Chrysene	mg/kg dry wt	1.21	1.38	1.27	0.83	0.41
Dibenzo[a,h]anthracene	mg/kg dry wt	0.194	0.22	0.21	0.139	0.070
Fluoranthene	mg/kg dry wt	2.6	3.2	3.1	2.1	1.00
Fluorene	mg/kg dry wt	0.118	0.141	0.118	0.073	0.064
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	0.96	1.12	1.08	0.72	0.33
Naphthalene	mg/kg dry wt	0.054	0.062	0.051	0.031	0.098
Perylene	mg/kg dry wt	0.34	0.36	0.35	0.23	0.124
Phenanthrene	mg/kg dry wt	1.40	1.68	1.52	1.05	0.84
Pyrene	mg/kg dry wt	2.7	3.2	3.1	2.1	1.00
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES*	mg/kg dry wt	2.1	2.4	2.3	1.55	0.75
Benzo[a]pyrene Toxic Equivalence (TEF)*	mg/kg dry wt	2.1	2.4	2.3	1.53	0.74

Sample Name:		Avon 07 B 16-Feb-2024 11:20 am	Avon 07 C 16-Feb-2024 11:20 am	Avon 09 A 16-Feb-2024 12:20 pm	Avon 09 B 16-Feb-2024 12:20 pm	Avon 09 C 16-Feb-2024 12:20 pm
Lab Number:		3469192.11	3469192.12	3469192.13	3469192.14	3469192.15

Sample Type: Sediment

Sample Name:		Avon 07 B 16-Feb-2024 11:20 am	Avon 07 C 16-Feb-2024 11:20 am	Avon 09 A 16-Feb-2024 12:20 pm	Avon 09 B 16-Feb-2024 12:20 pm	Avon 09 C 16-Feb-2024 12:20 pm
Lab Number:		3469192.11	3469192.12	3469192.13	3469192.14	3469192.15
Individual Tests						
Dry Matter	g/100g as rcvd	40	44	56	63	62
Total Recoverable Copper	mg/kg dry wt	33	22	23	27	32
Total Recoverable Lead	mg/kg dry wt	51	41	60	111	77
Total Recoverable Zinc	mg/kg dry wt	240	210	630	1,290	610
Total Organic Carbon*	g/100g dry wt	3.7	2.6	1.29	1.40	1.89
7 Grain Sizes Profile as received*						
Dry Matter of Sieved Sample*	g/100g as rcvd	49	57	58	69	67
Fraction >/= 2 mm*	g/100g dry wt	0.9	0.8	4.5	36.2	31.9
Fraction < 2 mm, >/= 1 mm*	g/100g dry wt	0.7	0.4	3.0	20.8	8.3
Fraction < 1 mm, >/= 500 µm*	g/100g dry wt	1.2	0.7	4.5	11.4	6.4
Fraction < 500 µm, >/= 250 µm*	g/100g dry wt	5.8	6.6	9.3	5.3	5.7
Fraction < 250 µm, >/= 125 µm*	g/100g dry wt	39.0	56.5	23.0	5.5	10.3
Fraction < 125 µm, >/= 63 µm*	g/100g dry wt	31.4	27.1	20.3	4.7	10.9
Fraction < 63 µm*	g/100g dry wt	21.0	8.0	35.4	16.1	26.5
Polycyclic Aromatic Hydrocarbons Trace in Soil*						
Total of Reported PAHs in Soil	mg/kg dry wt	6.1	7.8	19.5	133	10.3
1-Methylnaphthalene	mg/kg dry wt	0.028	0.019	0.026	0.28	0.047
2-Methylnaphthalene	mg/kg dry wt	0.023	0.019	0.030	0.25	0.053
Acenaphthene	mg/kg dry wt	0.022	0.020	0.033	1.64	0.033
Acenaphthylene	mg/kg dry wt	0.062	0.059	0.150	0.40	0.111
Anthracene	mg/kg dry wt	0.125	0.153	0.32	4.7	0.20
Benzo[a]anthracene	mg/kg dry wt	0.42	0.56	1.50	8.8	0.70
Benzo[a]pyrene (BAP)	mg/kg dry wt	0.51	0.68	1.76	9.0	0.87
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	0.59	0.72	1.94	10.4	1.01
Benzo[e]pyrene	mg/kg dry wt	0.29	0.38	1.00	4.7	0.51
Benzo[g,h,i]perylene	mg/kg dry wt	0.36	0.45	1.15	4.9	0.59
Benzo[k]fluoranthene	mg/kg dry wt	0.21	0.28	0.72	3.5	0.37
Chrysene	mg/kg dry wt	0.41	0.56	1.42	8.2	0.74
Dibenzo[a,h]anthracene	mg/kg dry wt	0.072	0.100	0.26	1.14	0.130
Fluoranthene	mg/kg dry wt	0.91	1.25	3.1	23	1.50
Fluorene	mg/kg dry wt	0.070	0.053	0.081	1.92	0.099
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	0.34	0.44	1.18	5.0	0.59
Naphthalene	mg/kg dry wt	0.023	0.028	0.061	0.22	0.074
Perylene	mg/kg dry wt	0.132	0.158	0.41	2.0	0.24
Phenanthrene	mg/kg dry wt	0.58	0.65	1.31	22	0.91
Pyrene	mg/kg dry wt	0.94	1.21	3.1	21	1.55
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES*	mg/kg dry wt	0.75	1.00	2.6	13.2	1.29
Benzo[a]pyrene Toxic Equivalence (TEF)*	mg/kg dry wt	0.74	0.99	2.6	13.0	1.27

Sample Name:		Avon 03 A 15-Feb-2024 10:15 am	Avon 03 B 15-Feb-2024 10:15 am	Avon 03 C 15-Feb-2024 10:15 am	Avon 10 A 15-Feb-2024 10:50 am	Avon 10 B 15-Feb-2024 10:50 am
Lab Number:		3469192.16	3469192.17	3469192.18	3469192.19	3469192.20
Individual Tests						
Dry Matter	g/100g as rcvd	21	18.3	43	69	53
Total Recoverable Copper	mg/kg dry wt	71	61	23	10.9	8.7
Total Recoverable Lead	mg/kg dry wt	145	137	63	38	31
Total Recoverable Zinc	mg/kg dry wt	1,080	1,060	480	230	179
Total Organic Carbon*	g/100g dry wt	8.5	9.1	3.4	0.40	0.93
7 Grain Sizes Profile as received*						
Dry Matter of Sieved Sample*	g/100g as rcvd	22	27	48	74	60
Fraction >/= 2 mm*	g/100g dry wt	2.4	5.3	1.7	8.1	10.1
Fraction < 2 mm, >/= 1 mm*	g/100g dry wt	0.7	1.2	0.7	2.0	1.5

Sample Type: Sediment

Sample Name:		Avon 03 A 15-Feb-2024 10:15 am	Avon 03 B 15-Feb-2024 10:15 am	Avon 03 C 15-Feb-2024 10:15 am	Avon 10 A 15-Feb-2024 10:50 am	Avon 10 B 15-Feb-2024 10:50 am
Lab Number:		3469192.16	3469192.17	3469192.18	3469192.19	3469192.20
7 Grain Sizes Profile as received*						
Fraction < 1 mm, >/= 500 µm*	g/100g dry wt	0.7	1.1	0.8	3.4	1.4
Fraction < 500 µm, >/= 250 µm*	g/100g dry wt	1.5	1.6	5.1	36.2	7.6
Fraction < 250 µm, >/= 125 µm*	g/100g dry wt	12.0	19.0	63.5	46.1	29.2
Fraction < 125 µm, >/= 63 µm*	g/100g dry wt	23.0	23.0	21.5	4.5	9.6
Fraction < 63 µm*	g/100g dry wt	59.7	48.8	6.7	< 0.1	40.7
Polycyclic Aromatic Hydrocarbons Trace in Soil*						
Total of Reported PAHs in Soil	mg/kg dry wt	25	38	23	28	17.2
1-Methylnaphthalene	mg/kg dry wt	0.042	0.079	0.031	0.019	0.011
2-Methylnaphthalene	mg/kg dry wt	0.046	0.069	0.028	0.024	0.014
Acenaphthene	mg/kg dry wt	0.066	0.110	0.092	0.055	0.041
Acenaphthylene	mg/kg dry wt	0.23	0.40	0.140	0.194	0.122
Anthracene	mg/kg dry wt	0.32	0.60	0.35	0.41	0.26
Benzo[a]anthracene	mg/kg dry wt	1.62	2.6	1.68	1.97	1.14
Benzo[a]pyrene (BAP)	mg/kg dry wt	2.2	3.2	2.0	2.4	1.49
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	2.7	3.8	2.3	2.6	1.62
Benzo[e]pyrene	mg/kg dry wt	1.40	1.94	1.18	1.32	0.84
Benzo[g,h,i]perylene	mg/kg dry wt	1.77	2.3	1.38	1.59	1.06
Benzo[k]fluoranthene	mg/kg dry wt	0.97	1.35	0.86	0.98	0.63
Chrysene	mg/kg dry wt	1.66	2.5	1.68	2.0	1.14
Dibenzo[a,h]anthracene	mg/kg dry wt	0.34	0.47	0.30	0.32	0.21
Fluoranthene	mg/kg dry wt	3.7	6.0	3.5	4.8	2.9
Fluorene	mg/kg dry wt	0.134	0.32	0.115	0.104	0.078
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	1.75	2.4	1.41	1.63	1.07
Naphthalene	mg/kg dry wt	0.10	0.12	0.080	0.076	0.035
Perylene	mg/kg dry wt	0.56	0.77	0.48	0.54	0.34
Phenanthrene	mg/kg dry wt	1.59	3.2	1.51	2.1	1.40
Pyrene	mg/kg dry wt	3.7	5.9	3.4	4.5	2.8
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES*	mg/kg dry wt	3.3	4.8	3.0	3.5	2.2
Benzo[a]pyrene Toxic Equivalence (TEF)*	mg/kg dry wt	3.3	4.7	3.0	3.5	2.2

Sample Name:		Avon 10 C 15-Feb-2024 10:50 am	Avon 04 A 15-Feb-2024 11:30 am	Avon 04 B 15-Feb-2024 11:30 am	Avon 04 C 15-Feb-2024 11:30 am	Avon 17 A 15-Feb-2024 12:05 pm
Lab Number:		3469192.21	3469192.22	3469192.23	3469192.24	3469192.25
Individual Tests						
Dry Matter	g/100g as rcvd	62	50	67	46	68
Total Recoverable Copper	mg/kg dry wt	9.1	14.6	17.9	33	31
Total Recoverable Lead	mg/kg dry wt	64	34	28	62	29
Total Recoverable Zinc	mg/kg dry wt	240	198	160	350	145
Total Organic Carbon*	g/100g dry wt	0.62	1.10	0.53	2.8	0.52
7 Grain Sizes Profile as received*						
Dry Matter of Sieved Sample*	g/100g as rcvd	69	62	72	47	67
Fraction >/= 2 mm*	g/100g dry wt	3.3	0.9	1.8	2.6	1.3
Fraction < 2 mm, >/= 1 mm*	g/100g dry wt	0.9	0.5	0.3	0.8	0.5
Fraction < 1 mm, >/= 500 µm*	g/100g dry wt	1.5	0.7	0.3	0.8	2.2
Fraction < 500 µm, >/= 250 µm*	g/100g dry wt	26.7	4.7	5.9	4.5	47.8
Fraction < 250 µm, >/= 125 µm*	g/100g dry wt	58.8	66.3	65.2	49.0	36.9
Fraction < 125 µm, >/= 63 µm*	g/100g dry wt	7.7	19.4	16.1	24.6	6.6
Fraction < 63 µm*	g/100g dry wt	1.0	7.6	10.5	17.7	4.5
Polycyclic Aromatic Hydrocarbons Trace in Soil*						
Total of Reported PAHs in Soil	mg/kg dry wt	25	55	26	26	21
1-Methylnaphthalene	mg/kg dry wt	0.021	0.065	0.021	0.028	0.019
2-Methylnaphthalene	mg/kg dry wt	0.021	0.064	0.033	0.037	0.026

Sample Type: Sediment

	Sample Name:	Avon 10 C 15-Feb-2024 10:50 am	Avon 04 A 15-Feb-2024 11:30 am	Avon 04 B 15-Feb-2024 11:30 am	Avon 04 C 15-Feb-2024 11:30 am	Avon 17 A 15-Feb-2024 12:05 pm
	Lab Number:	3469192.21	3469192.22	3469192.23	3469192.24	3469192.25
Polycyclic Aromatic Hydrocarbons Trace in Soil*						
Acenaphthene	mg/kg dry wt	0.057	0.130	0.033	0.038	0.022
Acenaphthylene	mg/kg dry wt	0.180	0.44	0.21	0.23	0.149
Anthracene	mg/kg dry wt	0.39	0.91	0.34	0.31	0.24
Benzo[a]anthracene	mg/kg dry wt	1.73	4.3	2.1	2.0	1.62
Benzo[a]pyrene (BAP)	mg/kg dry wt	2.1	5.0	2.6	2.5	2.1
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	2.3	5.3	2.8	2.7	2.3
Benzo[e]pyrene	mg/kg dry wt	1.17	2.7	1.42	1.40	1.14
Benzo[g,h,i]perylene	mg/kg dry wt	1.39	3.1	1.57	1.62	1.41
Benzo[k]fluoranthene	mg/kg dry wt	0.84	2.1	1.02	1.01	0.87
Chrysene	mg/kg dry wt	1.70	4.0	2.1	1.94	1.62
Dibenzo[a,h]anthracene	mg/kg dry wt	0.28	0.66	0.35	0.34	0.30
Fluoranthene	mg/kg dry wt	4.3	9.0	3.9	3.7	3.1
Fluorene	mg/kg dry wt	0.137	0.31	0.084	0.089	0.065
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	1.42	3.2	1.66	1.68	1.50
Naphthalene	mg/kg dry wt	0.060	0.184	0.141	0.114	0.082
Perylene	mg/kg dry wt	0.48	1.16	0.59	0.59	0.46
Phenanthrene	mg/kg dry wt	2.2	3.7	1.17	1.26	0.97
Pyrene	mg/kg dry wt	4.1	9.2	3.9	3.8	3.0
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES*	mg/kg dry wt	3.1	7.3	3.8	3.7	3.1
Benzo[a]pyrene Toxic Equivalence (TEF)*	mg/kg dry wt	3.1	7.2	3.7	3.6	3.0

	Sample Name:	Avon 17 B 15-Feb-2024 12:05 pm	Avon 17 C 15-Feb-2024 12:05 pm	Avon 12 A 15-Feb-2024 12:50 pm	Avon 12 B 15-Feb-2024 12:50 pm	Avon 12 C 15-Feb-2024 12:50 pm
	Lab Number:	3469192.26	3469192.27	3469192.28	3469192.29	3469192.30
Individual Tests						
Dry Matter	g/100g as rcvd	56	52	14.1	70	71
Total Recoverable Copper	mg/kg dry wt	16.7	14.7	73	8.0	6.8
Total Recoverable Lead	mg/kg dry wt	36	37	121	22	14.7
Total Recoverable Zinc	mg/kg dry wt	173	172	480	112	143
Total Organic Carbon*	g/100g dry wt	0.88	1.13	10.1	0.84	0.14
7 Grain Sizes Profile as received*						
Dry Matter of Sieved Sample*	g/100g as rcvd	72	68	11.0	73	81
Fraction >/= 2 mm*	g/100g dry wt	0.6	2.8	3.0	18.1	< 0.1
Fraction < 2 mm, >/= 1 mm*	g/100g dry wt	0.3	0.4	0.4	2.0	0.2
Fraction < 1 mm, >/= 500 µm*	g/100g dry wt	4.7	3.9	1.4	11.1	25.7
Fraction < 500 µm, >/= 250 µm*	g/100g dry wt	46.7	38.5	2.7	38.6	65.5
Fraction < 250 µm, >/= 125 µm*	g/100g dry wt	28.7	30.2	9.3	19.0	5.5
Fraction < 125 µm, >/= 63 µm*	g/100g dry wt	11.1	10.2	51.1	5.9	1.4
Fraction < 63 µm*	g/100g dry wt	8.0	14.0	32.0	5.3	1.5
Polycyclic Aromatic Hydrocarbons Trace in Soil*						
Total of Reported PAHs in Soil	mg/kg dry wt	27	27	13.5	23	0.92
1-Methylnaphthalene	mg/kg dry wt	0.018	0.023	0.030	0.026	< 0.002
2-Methylnaphthalene	mg/kg dry wt	0.026	0.030	0.029	0.024	< 0.002
Acenaphthene	mg/kg dry wt	0.025	0.026	0.041	0.079	< 0.002
Acenaphthylene	mg/kg dry wt	0.187	0.190	0.098	0.124	0.006
Anthracene	mg/kg dry wt	0.29	0.25	0.169	0.49	0.009
Benzo[a]anthracene	mg/kg dry wt	2.1	1.90	0.83	1.50	0.071
Benzo[a]pyrene (BAP)	mg/kg dry wt	2.8	2.5	1.14	1.73	0.090
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	2.8	3.0	1.42	1.91	0.104
Benzo[e]pyrene	mg/kg dry wt	1.64	1.49	0.71	0.93	0.050
Benzo[g,h,i]perylene	mg/kg dry wt	1.92	1.85	0.97	1.18	0.064

Sample Type: Sediment

Sample Name:		Avon 17 B 15-Feb-2024 12:05 pm	Avon 17 C 15-Feb-2024 12:05 pm	Avon 12 A 15-Feb-2024 12:50 pm	Avon 12 B 15-Feb-2024 12:50 pm	Avon 12 C 15-Feb-2024 12:50 pm
Lab Number:		3469192.26	3469192.27	3469192.28	3469192.29	3469192.30
Polycyclic Aromatic Hydrocarbons Trace in Soil*						
Benzo[k]fluoranthene	mg/kg dry wt	1.03	1.09	0.52	0.71	0.039
Chrysene	mg/kg dry wt	2.1	2.1	0.92	1.42	0.068
Dibenzo[a,h]anthracene	mg/kg dry wt	0.39	0.38	0.179	0.24	0.013
Fluoranthene	mg/kg dry wt	3.5	4.0	2.0	4.0	0.134
Fluorene	mg/kg dry wt	0.076	0.081	0.097	0.190	0.004
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	1.85	1.93	0.97	1.26	0.064
Naphthalene	mg/kg dry wt	0.076	0.104	< 0.06	0.049	< 0.010
Perylene	mg/kg dry wt	0.57	0.55	0.29	0.39	0.020
Phenanthrene	mg/kg dry wt	1.10	1.45	1.02	2.7	0.043
Pyrene	mg/kg dry wt	4.1	3.9	2.0	3.7	0.135
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES*	mg/kg dry wt	4.0	3.8	1.72	2.6	0.133
Benzo[a]pyrene Toxic Equivalence (TEF)*	mg/kg dry wt	4.0	3.7	1.70	2.5	0.132

Sample Name:		Avon 02 A 15-Feb-2024 3:35 pm	Avon 02 B 15-Feb-2024 3:35 pm	Avon 02 C 15-Feb-2024 3:35 pm	Avon 01 A 15-Feb-2024 4:15 pm	Avon 01 B 15-Feb-2024 4:15 pm
Lab Number:		3469192.31	3469192.32	3469192.33	3469192.34	3469192.35
Individual Tests						
Dry Matter	g/100g as rcvd	67	61	73	69	68
Total Recoverable Copper	mg/kg dry wt	11.0	11.6	4.4	5.4	6.4
Total Recoverable Lead	mg/kg dry wt	18.5	23	11.6	14.8	14.6
Total Recoverable Zinc	mg/kg dry wt	94	105	56	85	89
Total Organic Carbon*	g/100g dry wt	0.96	1.12	0.30	0.44	0.57
7 Grain Sizes Profile as received*						
Dry Matter of Sieved Sample*	g/100g as rcvd	64	60	80	77	78
Fraction >/= 2 mm*	g/100g dry wt	1.2	4.1	1.8	< 0.1	0.2
Fraction < 2 mm, >/= 1 mm*	g/100g dry wt	1.0	0.6	0.7	< 0.1	0.2
Fraction < 1 mm, >/= 500 µm*	g/100g dry wt	0.3	0.3	0.5	< 0.1	0.2
Fraction < 500 µm, >/= 250 µm*	g/100g dry wt	1.1	1.6	3.6	4.9	3.7
Fraction < 250 µm, >/= 125 µm*	g/100g dry wt	44.3	31.9	70.9	73.4	69.7
Fraction < 125 µm, >/= 63 µm*	g/100g dry wt	6.9	2.3	8.5	5.5	6.0
Fraction < 63 µm*	g/100g dry wt	45.2	59.3	14.1	15.9	20.0
Polycyclic Aromatic Hydrocarbons Trace in Soil*						
Total of Reported PAHs in Soil	mg/kg dry wt	0.95	1.99	0.50	1.07	1.64
1-Methylnaphthalene	mg/kg dry wt	0.003	0.006	< 0.002	0.003	0.005
2-Methylnaphthalene	mg/kg dry wt	0.004	0.008	0.002	0.003	0.006
Acenaphthene	mg/kg dry wt	0.002	0.007	< 0.002	0.003	0.004
Acenaphthylene	mg/kg dry wt	0.008	0.016	0.003	0.008	0.011
Anthracene	mg/kg dry wt	0.010	0.034	0.005	0.013	0.015
Benzo[a]anthracene	mg/kg dry wt	0.054	0.117	0.031	0.067	0.114
Benzo[a]pyrene (BAP)	mg/kg dry wt	0.088	0.168	0.046	0.098	0.155
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	0.114	0.21	0.055	0.116	0.182
Benzo[e]pyrene	mg/kg dry wt	0.058	0.103	0.028	0.058	0.090
Benzo[g,h,i]perylene	mg/kg dry wt	0.082	0.141	0.039	0.077	0.117
Benzo[k]fluoranthene	mg/kg dry wt	0.041	0.076	0.021	0.044	0.068
Chrysene	mg/kg dry wt	0.057	0.126	0.034	0.069	0.115
Dibenzo[a,h]anthracene	mg/kg dry wt	0.015	0.024	0.007	0.015	0.022
Fluoranthene	mg/kg dry wt	0.124	0.29	0.071	0.155	0.25
Fluorene	mg/kg dry wt	0.007	0.020	0.003	0.008	0.008
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	0.077	0.137	0.037	0.078	0.119
Naphthalene	mg/kg dry wt	< 0.011	< 0.012	< 0.010	< 0.011	0.011
Perylene	mg/kg dry wt	0.025	0.045	0.011	0.025	0.040
Phenanthrene	mg/kg dry wt	0.044	0.152	0.026	0.067	0.067

Sample Type: Sediment

Sample Name:		Avon 02 A 15-Feb-2024 3:35 pm	Avon 02 B 15-Feb-2024 3:35 pm	Avon 02 C 15-Feb-2024 3:35 pm	Avon 01 A 15-Feb-2024 4:15 pm	Avon 01 B 15-Feb-2024 4:15 pm
Lab Number:		3469192.31	3469192.32	3469192.33	3469192.34	3469192.35
Polycyclic Aromatic Hydrocarbons Trace in Soil*						
Pyrene	mg/kg dry wt	0.129	0.31	0.073	0.154	0.25
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES*	mg/kg dry wt	0.133	0.25	0.069	0.145	0.23
Benzo[a]pyrene Toxic Equivalence (TEF)*	mg/kg dry wt	0.132	0.25	0.068	0.144	0.23

Sample Name:		Avon 01 C 15-Feb-2024 4:15 pm	Avon 13 A 15-Feb-2024 4:45 pm	Avon 13 B 15-Feb-2024 4:45 pm	Avon 13 C 15-Feb-2024 4:45 pm
Lab Number:		3469192.36	3469192.37	3469192.38	3469192.39
Individual Tests					
Dry Matter	g/100g as rcvd	70	32	33	36
Total Recoverable Copper	mg/kg dry wt	5.1	27	25	26
Total Recoverable Lead	mg/kg dry wt	13.4	47	44	43
Total Recoverable Zinc	mg/kg dry wt	83	400	380	390
Total Organic Carbon*	g/100g dry wt	0.44	3.7	3.8	3.7
7 Grain Sizes Profile as received*					
Dry Matter of Sieved Sample*	g/100g as rcvd	75	33	32	40
Fraction >/= 2 mm*	g/100g dry wt	0.2	0.7	1.9	4.7
Fraction < 2 mm, >/= 1 mm*	g/100g dry wt	< 0.1	0.4	0.9	1.6
Fraction < 1 mm, >/= 500 µm*	g/100g dry wt	0.2	0.5	1.2	1.2
Fraction < 500 µm, >/= 250 µm*	g/100g dry wt	4.4	1.4	2.9	3.0
Fraction < 250 µm, >/= 125 µm*	g/100g dry wt	72.3	7.1	10.2	11.2
Fraction < 125 µm, >/= 63 µm*	g/100g dry wt	5.5	14.0	15.8	11.3
Fraction < 63 µm*	g/100g dry wt	17.4	75.9	67.2	67.0
Polycyclic Aromatic Hydrocarbons Trace in Soil*					
Total of Reported PAHs in Soil	mg/kg dry wt	1.98	6.9	6.7	6.3
1-Methylnaphthalene	mg/kg dry wt	0.004	0.013	0.011	0.014
2-Methylnaphthalene	mg/kg dry wt	0.005	0.018	0.015	0.018
Acenaphthene	mg/kg dry wt	0.004	0.017	0.014	0.014
Acenaphthylene	mg/kg dry wt	0.017	0.061	0.052	0.059
Anthracene	mg/kg dry wt	0.016	0.079	0.075	0.072
Benzo[a]anthracene	mg/kg dry wt	0.154	0.43	0.43	0.38
Benzo[a]pyrene (BAP)	mg/kg dry wt	0.21	0.63	0.63	0.60
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	0.23	0.77	0.77	0.73
Benzo[e]pyrene	mg/kg dry wt	0.119	0.39	0.38	0.36
Benzo[g,h,i]perylene	mg/kg dry wt	0.144	0.53	0.51	0.49
Benzo[k]fluoranthene	mg/kg dry wt	0.085	0.32	0.27	0.26
Chrysene	mg/kg dry wt	0.139	0.44	0.45	0.40
Dibenzo[a,h]anthracene	mg/kg dry wt	0.028	0.103	0.097	0.092
Fluoranthene	mg/kg dry wt	0.25	0.94	0.94	0.85
Fluorene	mg/kg dry wt	0.009	0.045	0.034	0.045
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	0.153	0.54	0.52	0.50
Naphthalene	mg/kg dry wt	< 0.011	0.04	0.03	0.03
Perylene	mg/kg dry wt	0.051	0.172	0.170	0.157
Phenanthrene	mg/kg dry wt	0.078	0.39	0.33	0.35
Pyrene	mg/kg dry wt	0.26	0.97	1.00	0.85
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES*	mg/kg dry wt	0.31	0.95	0.94	0.89
Benzo[a]pyrene Toxic Equivalence (TEF)*	mg/kg dry wt	0.31	0.94	0.93	0.88

Analyst's Comments

It has been noted that the duplicate for PAH on sample 3469192.37, was run as part of our in-house QC procedure and showed greater variation than would normally be expected. This may reflect the heterogeneity of the sample.

Amended Report: This certificate of analysis replaces report '3469192-SPv1' issued on 01-Mar-2024 at 2:11 pm. Reason for amendment: Further testing added as per clients request.

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
Individual Tests			
Environmental Solids Sample Drying*	Air dried at 35°C Used for sample preparation. May contain a residual moisture content of 2-5%.	-	1-39
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%.	-	1-39
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	1-39
Total Recoverable digestion	Nitric / hydrochloric acid digestion. US EPA 200.2.	-	1-39
Total Recoverable Copper	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, trace level. US EPA 200.2.	0.2 mg/kg dry wt	1-39
Total Recoverable Lead	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, trace level. US EPA 200.2.	0.08 mg/kg dry wt	1-39
Total Recoverable Zinc	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, trace level. US EPA 200.2.	0.8 mg/kg dry wt	1-39
Total Organic Carbon*	Acid pretreatment to remove carbonates present followed by Catalytic Combustion (O2), separation, Thermal Conductivity Detector [Elementar Analyser].	0.05 g/100g dry wt	1-39
Polycyclic Aromatic Hydrocarbons Trace in Soil*	Sonication extraction, GC-MS/MS analysis. Tested on as received sample. In-house based on US EPA 8270.	0.002 - 0.03 mg/kg dry wt	1-39
7 Grain Sizes Profile as received			
Dry Matter for Grainsize samples (sieved as received)*	Drying for 16 hours at 103°C, gravimetry (Free water removed before analysis).	0.10 g/100g as rcvd	1-39
Fraction >/= 2 mm*	Wet sieving with dispersant, as received, 2.00 mm sieve, gravimetry.	0.1 g/100g dry wt	1-39
Fraction < 2 mm, >/= 1 mm*	Wet sieving using dispersant, as received, 2.00 mm and 1.00 mm sieves, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-39
Fraction < 1 mm, >/= 500 µm*	Wet sieving using dispersant, as received, 1.00 mm and 500 µm sieves, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-39
Fraction < 500 µm, >/= 250 µm*	Wet sieving using dispersant, as received, 500 µm and 250 µm sieves, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-39
Fraction < 250 µm, >/= 125 µm*	Wet sieving using dispersant, as received, 250 µm and 125 µm sieves, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-39
Fraction < 125 µm, >/= 63 µm*	Wet sieving using dispersant, as received, 125 µm and 63 µm sieves, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-39
Fraction < 63 µm*	Wet sieving with dispersant, as received, 63 µm sieve, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-39

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

Testing was completed between 20-Feb-2024 and 10-May-2024. 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

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Certificate of Analysis

Client:	Instream Consulting Limited	**Lab No:**	3469192 SPv1
Contact:	G Burrell C/- Instream Consulting Limited PO Box 28173 Christchurch 8242	**Date Received:**	16-Feb-2024
		Date Reported:	01-Mar-2024
		Quote No:	127849
		Order No:	
		Client Reference:	Avon River Sediment
		Submitted By:	Derek Gerber

Sample Type: Sediment

Sample Name:		Avon 26 A 16-Feb-2024 9:20 am	Avon 26 B 16-Feb-2024 9:20 am	Avon 26 C 16-Feb-2024 9:20 am	Avon 06 A 16-Feb-2024 10:20 am	Avon 06 B 16-Feb-2024 10:20 am
Lab Number:		3469192.1	3469192.2	3469192.3	3469192.4	3469192.5
Individual Tests						
Dry Matter	g/100g as rcvd	80	62	74	47	56
Polycyclic Aromatic Hydrocarbons Trace in Soil*						
Total of Reported PAHs in Soil	mg/kg dry wt	147	99	4.2	17.3	13.6
1-Methylnaphthalene	mg/kg dry wt	0.30	0.60	0.005	0.051	0.042
2-Methylnaphthalene	mg/kg dry wt	0.31	0.76	0.005	0.049	0.049
Acenaphthene	mg/kg dry wt	0.89	0.91	0.009	0.066	0.041
Acenaphthylene	mg/kg dry wt	0.63	0.84	0.041	0.146	0.113
Anthracene	mg/kg dry wt	4.6	3.3	0.059	0.30	0.22
Benzo[a]anthracene	mg/kg dry wt	10.2	7.5	0.31	1.21	0.96
Benzo[a]pyrene (BAP)	mg/kg dry wt	10.7	8.3	0.46	1.50	1.18
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	11.2	8.6	0.48	1.65	1.33
Benzo[e]pyrene	mg/kg dry wt	5.6	3.8	0.26	0.86	0.67
Benzo[g,h,i]perylene	mg/kg dry wt	6.7	3.9	0.32	1.00	0.79
Benzo[k]fluoranthene	mg/kg dry wt	4.7	3.0	0.172	0.60	0.50
Chrysene	mg/kg dry wt	9.0	6.4	0.28	1.18	0.93
Dibenzo[a,h]anthracene	mg/kg dry wt	1.35	0.99	0.055	0.23	0.169
Fluoranthene	mg/kg dry wt	25	14.7	0.50	2.7	2.1
Fluorene	mg/kg dry wt	1.63	1.93	0.028	0.155	0.120
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	6.8	4.2	0.32	0.99	0.82
Naphthalene	mg/kg dry wt	0.49	0.63	< 0.010	0.066	0.056
Perylene	mg/kg dry wt	2.5	1.70	0.106	0.32	0.27
Phenanthrene	mg/kg dry wt	19.7	12.4	0.24	1.55	1.14
Pyrene	mg/kg dry wt	24	14.9	0.55	2.7	2.1
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES*	mg/kg dry wt	15.7	11.8	0.66	2.2	1.74
Benzo[a]pyrene Toxic Equivalence (TEF)*	mg/kg dry wt	15.4	11.7	0.65	2.2	1.72

Sample Name:		Avon 06 C 16-Feb-2024 10:20 am	Avon 05 A 16-Feb-2024 10:45 am	Avon 05 B 16-Feb-2024 10:45 am	Avon 05 C 16-Feb-2024 10:45 am	Avon 07 A 16-Feb-2024 11:20 am
Lab Number:		3469192.6	3469192.7	3469192.8	3469192.9	3469192.10
Individual Tests						
Dry Matter	g/100g as rcvd	54	58	55	65	45

Sample Type: Sediment

Sample Name:		Avon 06 C 16-Feb-2024 10:20 am	Avon 05 A 16-Feb-2024 10:45 am	Avon 05 B 16-Feb-2024 10:45 am	Avon 05 C 16-Feb-2024 10:45 am	Avon 07 A 16-Feb-2024 11:20 am
Lab Number:		3469192.6	3469192.7	3469192.8	3469192.9	3469192.10
Polycyclic Aromatic Hydrocarbons Trace in Soil*						
Total of Reported PAHs in Soil	mg/kg dry wt	16.7	19.4	18.5	12.4	7.1
1-Methylnaphthalene	mg/kg dry wt	0.033	0.040	0.058	0.016	0.29
2-Methylnaphthalene	mg/kg dry wt	0.032	0.040	0.051	0.016	0.30
Acenaphthene	mg/kg dry wt	0.043	0.064	0.053	0.035	0.029
Acenaphthylene	mg/kg dry wt	0.145	0.124	0.119	0.082	0.068
Anthracene	mg/kg dry wt	0.26	0.30	0.27	0.183	0.150
Benzo[a]anthracene	mg/kg dry wt	1.18	1.33	1.29	0.84	0.44
Benzo[a]pyrene (BAP)	mg/kg dry wt	1.46	1.65	1.61	1.07	0.51
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	1.62	1.83	1.75	1.16	0.55
Benzo[e]pyrene	mg/kg dry wt	0.80	0.90	0.88	0.58	0.29
Benzo[g,h,i]perylene	mg/kg dry wt	0.93	1.12	1.07	0.71	0.34
Benzo[k]fluoranthene	mg/kg dry wt	0.60	0.65	0.66	0.45	0.22
Chrysene	mg/kg dry wt	1.21	1.38	1.27	0.83	0.41
Dibenzo[a,h]anthracene	mg/kg dry wt	0.194	0.22	0.21	0.139	0.070
Fluoranthene	mg/kg dry wt	2.6	3.2	3.1	2.1	1.00
Fluorene	mg/kg dry wt	0.118	0.141	0.118	0.073	0.064
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	0.96	1.12	1.08	0.72	0.33
Naphthalene	mg/kg dry wt	0.054	0.062	0.051	0.031	0.098
Perylene	mg/kg dry wt	0.34	0.36	0.35	0.23	0.124
Phenanthrene	mg/kg dry wt	1.40	1.68	1.52	1.05	0.84
Pyrene	mg/kg dry wt	2.7	3.2	3.1	2.1	1.00
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES*	mg/kg dry wt	2.1	2.4	2.3	1.55	0.75
Benzo[a]pyrene Toxic Equivalence (TEF)*	mg/kg dry wt	2.1	2.4	2.3	1.53	0.74

Sample Name:		Avon 07 B 16-Feb-2024 11:20 am	Avon 07 C 16-Feb-2024 11:20 am	Avon 09 A 16-Feb-2024 12:20 pm	Avon 09 B 16-Feb-2024 12:20 pm	Avon 09 C 16-Feb-2024 12:20 pm
Lab Number:		3469192.11	3469192.12	3469192.13	3469192.14	3469192.15
Individual Tests						
Dry Matter	g/100g as rcvd	40	44	56	63	62
Polycyclic Aromatic Hydrocarbons Trace in Soil*						
Total of Reported PAHs in Soil	mg/kg dry wt	6.1	7.8	19.5	133	10.3
1-Methylnaphthalene	mg/kg dry wt	0.028	0.019	0.026	0.28	0.047
2-Methylnaphthalene	mg/kg dry wt	0.023	0.019	0.030	0.25	0.053
Acenaphthene	mg/kg dry wt	0.022	0.020	0.033	1.64	0.033
Acenaphthylene	mg/kg dry wt	0.062	0.059	0.150	0.40	0.111
Anthracene	mg/kg dry wt	0.125	0.153	0.32	4.7	0.20
Benzo[a]anthracene	mg/kg dry wt	0.42	0.56	1.50	8.8	0.70
Benzo[a]pyrene (BAP)	mg/kg dry wt	0.51	0.68	1.76	9.0	0.87
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	0.59	0.72	1.94	10.4	1.01
Benzo[e]pyrene	mg/kg dry wt	0.29	0.38	1.00	4.7	0.51
Benzo[g,h,i]perylene	mg/kg dry wt	0.36	0.45	1.15	4.9	0.59
Benzo[k]fluoranthene	mg/kg dry wt	0.21	0.28	0.72	3.5	0.37
Chrysene	mg/kg dry wt	0.41	0.56	1.42	8.2	0.74
Dibenzo[a,h]anthracene	mg/kg dry wt	0.072	0.100	0.26	1.14	0.130
Fluoranthene	mg/kg dry wt	0.91	1.25	3.1	23	1.50
Fluorene	mg/kg dry wt	0.070	0.053	0.081	1.92	0.099
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	0.34	0.44	1.18	5.0	0.59
Naphthalene	mg/kg dry wt	0.023	0.028	0.061	0.22	0.074
Perylene	mg/kg dry wt	0.132	0.158	0.41	2.0	0.24
Phenanthrene	mg/kg dry wt	0.58	0.65	1.31	22	0.91
Pyrene	mg/kg dry wt	0.94	1.21	3.1	21	1.55

Sample Type: Sediment

Sample Name:		Avon 07 B 16-Feb-2024 11:20 am	Avon 07 C 16-Feb-2024 11:20 am	Avon 09 A 16-Feb-2024 12:20 pm	Avon 09 B 16-Feb-2024 12:20 pm	Avon 09 C 16-Feb-2024 12:20 pm
Lab Number:		3469192.11	3469192.12	3469192.13	3469192.14	3469192.15
Polycyclic Aromatic Hydrocarbons Trace in Soil*						
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES*	mg/kg dry wt	0.75	1.00	2.6	13.2	1.29
Benzo[a]pyrene Toxic Equivalence (TEF)*	mg/kg dry wt	0.74	0.99	2.6	13.0	1.27

Sample Name:		Avon 03 A 15-Feb-2024 10:15 am	Avon 03 B 15-Feb-2024 10:15 am	Avon 03 C 15-Feb-2024 10:15 am	Avon 10 A 15-Feb-2024 10:50 am	Avon 10 B 15-Feb-2024 10:50 am
Lab Number:		3469192.16	3469192.17	3469192.18	3469192.19	3469192.20
Individual Tests						
Dry Matter	g/100g as rcvd	21	18.3	43	69	53
Polycyclic Aromatic Hydrocarbons Trace in Soil*						
Total of Reported PAHs in Soil	mg/kg dry wt	25	38	23	28	17.2
1-Methylnaphthalene	mg/kg dry wt	0.042	0.079	0.031	0.019	0.011
2-Methylnaphthalene	mg/kg dry wt	0.046	0.069	0.028	0.024	0.014
Acenaphthene	mg/kg dry wt	0.066	0.110	0.092	0.055	0.041
Acenaphthylene	mg/kg dry wt	0.23	0.40	0.140	0.194	0.122
Anthracene	mg/kg dry wt	0.32	0.60	0.35	0.41	0.26
Benzo[a]anthracene	mg/kg dry wt	1.62	2.6	1.68	1.97	1.14
Benzo[a]pyrene (BAP)	mg/kg dry wt	2.2	3.2	2.0	2.4	1.49
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	2.7	3.8	2.3	2.6	1.62
Benzo[e]pyrene	mg/kg dry wt	1.40	1.94	1.18	1.32	0.84
Benzo[g,h,i]perylene	mg/kg dry wt	1.77	2.3	1.38	1.59	1.06
Benzo[k]fluoranthene	mg/kg dry wt	0.97	1.35	0.86	0.98	0.63
Chrysene	mg/kg dry wt	1.66	2.5	1.68	2.0	1.14
Dibenzo[a,h]anthracene	mg/kg dry wt	0.34	0.47	0.30	0.32	0.21
Fluoranthene	mg/kg dry wt	3.7	6.0	3.5	4.8	2.9
Fluorene	mg/kg dry wt	0.134	0.32	0.115	0.104	0.078
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	1.75	2.4	1.41	1.63	1.07
Naphthalene	mg/kg dry wt	0.10	0.12	0.080	0.076	0.035
Perylene	mg/kg dry wt	0.56	0.77	0.48	0.54	0.34
Phenanthrene	mg/kg dry wt	1.59	3.2	1.51	2.1	1.40
Pyrene	mg/kg dry wt	3.7	5.9	3.4	4.5	2.8
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES*	mg/kg dry wt	3.3	4.8	3.0	3.5	2.2
Benzo[a]pyrene Toxic Equivalence (TEF)*	mg/kg dry wt	3.3	4.7	3.0	3.5	2.2

Sample Name:		Avon 10 C 15-Feb-2024 10:50 am	Avon 04 A 15-Feb-2024 11:30 am	Avon 04 B 15-Feb-2024 11:30 am	Avon 04 C 15-Feb-2024 11:30 am	Avon 17 A 15-Feb-2024 12:05 pm
Lab Number:		3469192.21	3469192.22	3469192.23	3469192.24	3469192.25
Individual Tests						
Dry Matter	g/100g as rcvd	62	50	67	46	68
Polycyclic Aromatic Hydrocarbons Trace in Soil*						
Total of Reported PAHs in Soil	mg/kg dry wt	25	55	26	26	21
1-Methylnaphthalene	mg/kg dry wt	0.021	0.065	0.021	0.028	0.019
2-Methylnaphthalene	mg/kg dry wt	0.021	0.064	0.033	0.037	0.026
Acenaphthene	mg/kg dry wt	0.057	0.130	0.033	0.038	0.022
Acenaphthylene	mg/kg dry wt	0.180	0.44	0.21	0.23	0.149
Anthracene	mg/kg dry wt	0.39	0.91	0.34	0.31	0.24
Benzo[a]anthracene	mg/kg dry wt	1.73	4.3	2.1	2.0	1.62
Benzo[a]pyrene (BAP)	mg/kg dry wt	2.1	5.0	2.6	2.5	2.1
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	2.3	5.3	2.8	2.7	2.3
Benzo[e]pyrene	mg/kg dry wt	1.17	2.7	1.42	1.40	1.14
Benzo[g,h,i]perylene	mg/kg dry wt	1.39	3.1	1.57	1.62	1.41

Sample Type: Sediment

Sample Name:		Avon 10 C 15-Feb-2024 10:50 am	Avon 04 A 15-Feb-2024 11:30 am	Avon 04 B 15-Feb-2024 11:30 am	Avon 04 C 15-Feb-2024 11:30 am	Avon 17 A 15-Feb-2024 12:05 pm
Lab Number:		3469192.21	3469192.22	3469192.23	3469192.24	3469192.25
Polycyclic Aromatic Hydrocarbons Trace in Soil*						
Benzo[k]fluoranthene	mg/kg dry wt	0.84	2.1	1.02	1.01	0.87
Chrysene	mg/kg dry wt	1.70	4.0	2.1	1.94	1.62
Dibenzo[a,h]anthracene	mg/kg dry wt	0.28	0.66	0.35	0.34	0.30
Fluoranthene	mg/kg dry wt	4.3	9.0	3.9	3.7	3.1
Fluorene	mg/kg dry wt	0.137	0.31	0.084	0.089	0.065
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	1.42	3.2	1.66	1.68	1.50
Naphthalene	mg/kg dry wt	0.060	0.184	0.141	0.114	0.082
Perylene	mg/kg dry wt	0.48	1.16	0.59	0.59	0.46
Phenanthrene	mg/kg dry wt	2.2	3.7	1.17	1.26	0.97
Pyrene	mg/kg dry wt	4.1	9.2	3.9	3.8	3.0
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES*	mg/kg dry wt	3.1	7.3	3.8	3.7	3.1
Benzo[a]pyrene Toxic Equivalence (TEF)*	mg/kg dry wt	3.1	7.2	3.7	3.6	3.0

Sample Name:		Avon 17 B 15-Feb-2024 12:05 pm	Avon 17 C 15-Feb-2024 12:05 pm	Avon 12 A 15-Feb-2024 12:50 pm	Avon 12 B 15-Feb-2024 12:50 pm	Avon 12 C 15-Feb-2024 12:50 pm
Lab Number:		3469192.26	3469192.27	3469192.28	3469192.29	3469192.30
Individual Tests						
Dry Matter	g/100g as rcvd	56	52	14.1	70	71
Polycyclic Aromatic Hydrocarbons Trace in Soil*						
Total of Reported PAHs in Soil	mg/kg dry wt	27	27	13.5	23	0.92
1-Methylnaphthalene	mg/kg dry wt	0.018	0.023	0.030	0.026	< 0.002
2-Methylnaphthalene	mg/kg dry wt	0.026	0.030	0.029	0.024	< 0.002
Acenaphthene	mg/kg dry wt	0.025	0.026	0.041	0.079	< 0.002
Acenaphthylene	mg/kg dry wt	0.187	0.190	0.098	0.124	0.006
Anthracene	mg/kg dry wt	0.29	0.25	0.169	0.49	0.009
Benzo[a]anthracene	mg/kg dry wt	2.1	1.90	0.83	1.50	0.071
Benzo[a]pyrene (BAP)	mg/kg dry wt	2.8	2.5	1.14	1.73	0.090
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	2.8	3.0	1.42	1.91	0.104
Benzo[e]pyrene	mg/kg dry wt	1.64	1.49	0.71	0.93	0.050
Benzo[g,h,i]perylene	mg/kg dry wt	1.92	1.85	0.97	1.18	0.064
Benzo[k]fluoranthene	mg/kg dry wt	1.03	1.09	0.52	0.71	0.039
Chrysene	mg/kg dry wt	2.1	2.1	0.92	1.42	0.068
Dibenzo[a,h]anthracene	mg/kg dry wt	0.39	0.38	0.179	0.24	0.013
Fluoranthene	mg/kg dry wt	3.5	4.0	2.0	4.0	0.134
Fluorene	mg/kg dry wt	0.076	0.081	0.097	0.190	0.004
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	1.85	1.93	0.97	1.26	0.064
Naphthalene	mg/kg dry wt	0.076	0.104	< 0.06	0.049	< 0.010
Perylene	mg/kg dry wt	0.57	0.55	0.29	0.39	0.020
Phenanthrene	mg/kg dry wt	1.10	1.45	1.02	2.7	0.043
Pyrene	mg/kg dry wt	4.1	3.9	2.0	3.7	0.135
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES*	mg/kg dry wt	4.0	3.8	1.72	2.6	0.133
Benzo[a]pyrene Toxic Equivalence (TEF)*	mg/kg dry wt	4.0	3.7	1.70	2.5	0.132

Sample Name:		Avon 02 A 15-Feb-2024 3:35 pm	Avon 02 B 15-Feb-2024 3:35 pm	Avon 02 C 15-Feb-2024 3:35 pm	Avon 01 A 15-Feb-2024 4:15 pm	Avon 01 B 15-Feb-2024 4:15 pm
Lab Number:		3469192.31	3469192.32	3469192.33	3469192.34	3469192.35
Individual Tests						
Dry Matter	g/100g as rcvd	67	61	73	69	68
Polycyclic Aromatic Hydrocarbons Trace in Soil*						
Total of Reported PAHs in Soil	mg/kg dry wt	0.95	1.99	0.50	1.07	1.64
1-Methylnaphthalene	mg/kg dry wt	0.003	0.006	< 0.002	0.003	0.005

Sample Type: Sediment

Sample Name:		Avon 02 A 15-Feb-2024 3:35 pm	Avon 02 B 15-Feb-2024 3:35 pm	Avon 02 C 15-Feb-2024 3:35 pm	Avon 01 A 15-Feb-2024 4:15 pm	Avon 01 B 15-Feb-2024 4:15 pm
Lab Number:		3469192.31	3469192.32	3469192.33	3469192.34	3469192.35
Polycyclic Aromatic Hydrocarbons Trace in Soil*						
2-Methylnaphthalene	mg/kg dry wt	0.004	0.008	0.002	0.003	0.006
Acenaphthene	mg/kg dry wt	0.002	0.007	< 0.002	0.003	0.004
Acenaphthylene	mg/kg dry wt	0.008	0.016	0.003	0.008	0.011
Anthracene	mg/kg dry wt	0.010	0.034	0.005	0.013	0.015
Benzo[a]anthracene	mg/kg dry wt	0.054	0.117	0.031	0.067	0.114
Benzo[a]pyrene (BAP)	mg/kg dry wt	0.088	0.168	0.046	0.098	0.155
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	0.114	0.21	0.055	0.116	0.182
Benzo[e]pyrene	mg/kg dry wt	0.058	0.103	0.028	0.058	0.090
Benzo[g,h,i]perylene	mg/kg dry wt	0.082	0.141	0.039	0.077	0.117
Benzo[k]fluoranthene	mg/kg dry wt	0.041	0.076	0.021	0.044	0.068
Chrysene	mg/kg dry wt	0.057	0.126	0.034	0.069	0.115
Dibenzo[a,h]anthracene	mg/kg dry wt	0.015	0.024	0.007	0.015	0.022
Fluoranthene	mg/kg dry wt	0.124	0.29	0.071	0.155	0.25
Fluorene	mg/kg dry wt	0.007	0.020	0.003	0.008	0.008
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	0.077	0.137	0.037	0.078	0.119
Naphthalene	mg/kg dry wt	< 0.011	< 0.012	< 0.010	< 0.011	0.011
Perylene	mg/kg dry wt	0.025	0.045	0.011	0.025	0.040
Phenanthrene	mg/kg dry wt	0.044	0.152	0.026	0.067	0.067
Pyrene	mg/kg dry wt	0.129	0.31	0.073	0.154	0.25
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES*	mg/kg dry wt	0.133	0.25	0.069	0.145	0.23
Benzo[a]pyrene Toxic Equivalence (TEF)*	mg/kg dry wt	0.132	0.25	0.068	0.144	0.23

Sample Name:		Avon 01 C 15-Feb-2024 4:15 pm	Avon 13 A 15-Feb-2024 4:45 pm	Avon 13 B 15-Feb-2024 4:45 pm	Avon 13 C 15-Feb-2024 4:45 pm
Lab Number:		3469192.36	3469192.37	3469192.38	3469192.39
Individual Tests					
Dry Matter	g/100g as rcvd	70	32	33	36
Polycyclic Aromatic Hydrocarbons Trace in Soil*					
Total of Reported PAHs in Soil	mg/kg dry wt	1.98	6.9	6.7	6.3
1-Methylnaphthalene	mg/kg dry wt	0.004	0.013	0.011	0.014
2-Methylnaphthalene	mg/kg dry wt	0.005	0.018	0.015	0.018
Acenaphthene	mg/kg dry wt	0.004	0.017	0.014	0.014
Acenaphthylene	mg/kg dry wt	0.017	0.061	0.052	0.059
Anthracene	mg/kg dry wt	0.016	0.079	0.075	0.072
Benzo[a]anthracene	mg/kg dry wt	0.154	0.43	0.43	0.38
Benzo[a]pyrene (BAP)	mg/kg dry wt	0.21	0.63	0.63	0.60
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	0.23	0.77	0.77	0.73
Benzo[e]pyrene	mg/kg dry wt	0.119	0.39	0.38	0.36
Benzo[g,h,i]perylene	mg/kg dry wt	0.144	0.53	0.51	0.49
Benzo[k]fluoranthene	mg/kg dry wt	0.085	0.32	0.27	0.26
Chrysene	mg/kg dry wt	0.139	0.44	0.45	0.40
Dibenzo[a,h]anthracene	mg/kg dry wt	0.028	0.103	0.097	0.092
Fluoranthene	mg/kg dry wt	0.25	0.94	0.94	0.85
Fluorene	mg/kg dry wt	0.009	0.045	0.034	0.045
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	0.153	0.54	0.52	0.50
Naphthalene	mg/kg dry wt	< 0.011	0.04	0.03	0.03
Perylene	mg/kg dry wt	0.051	0.172	0.170	0.157
Phenanthrene	mg/kg dry wt	0.078	0.39	0.33	0.35
Pyrene	mg/kg dry wt	0.26	0.97	1.00	0.85
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES*	mg/kg dry wt	0.31	0.95	0.94	0.89
Benzo[a]pyrene Toxic Equivalence (TEF)*	mg/kg dry wt	0.31	0.94	0.93	0.88

Analyst's Comments

It has been noted that the duplicate for PAH on sample 3469192.37, was run as part of our in-house QC procedure and showed greater variation than would normally be expected. This may reflect the heterogeneity of the sample.

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
Polycyclic Aromatic Hydrocarbons Trace in Soil*	Sonication extraction, GC-MS/MS analysis. Tested on as received sample. In-house based on US EPA 8270.	0.002 - 0.03 mg/kg dry wt	1-39
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	1-39

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

Testing was completed between 20-Feb-2024 and 01-Mar-2024. 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.

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Graham Corban MSc Tech (Hons)
Client Services Manager - Environmental