Heathcote River, Linwood Canal, and Banks Peninsula Aquatic Ecology 2020

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EXECUTIVE SUMMARY

This report describes the current state and trends in aquatic ecology and sediment quality of the Heathcote River catchment, Linwood Canal and Banks Peninsula waterways, following the most recent round of monitoring in 2020.

Monitoring data from 2020 indicate that riparian and instream habitat quality is unchanged compared to previous years at most of the monitoring sites. Most sites have minimal buffering with riparian vegetation and are poorly shaded, but most have natural banks. Three new monitoring sites on Banks Peninsula are well-shaded by trees and shrubs.

Sediment concentrations of common stormwater contaminants exceeded consent target levels at 14 of the 18 sites sampled in 2020. Two sites on Cashmere Stream and two Banks Peninsula sites complied with consent targets for all sediment quality parameters. Sediment lead concentrations have declined on average 78% since the 1980s, due to the banning of leaded petrol in the 1990s. In the Heathcote catchment, zinc concentrations normalised to percent mud content showed no increasing or decreasing trend over time.

Invertebrate community composition in 2020 was similar to previous years in the Heathcote and Linwood Canal catchments, being dominated by pollution-tolerant snails and crustaceans that are common in Christchurch urban waterways. However, pollution-sensitive mayflies and stoneflies were recorded from the Banks Peninsula waterways, as well as the locally endemic net-wing midge *Neocurupira chiltoni*. Kākahi (freshwater mussels) have been discovered in the Heathcote River and a recent survey of kākahi in Cashmere Stream suggests it has a stable population and reasonable recruitment.

The range of fish species caught in the Heathcote and Linwood Canal catchments in 2020 was also similar to previous years and the catch was dominated by native species. Fewer sites with brown trout records and lower fish densities in 2020 were most likely due to the combination of cooler temperatures and later fish sampling in 2020 compared with 2015. Monitoring data from 2015 and 2020 indicate that bluegill bully populations have recovered following a decline in numbers after the Canterbury earthquakes of 2010 and 2011.

Consent attribute target levels for macrophyte and filamentous algae cover have been met at most monitoring sites over the last ten years. In contrast, consent targets for fine sediment cover were not met at most of the sites monitored. Compliance with consent targets for sediment quality parameters is more variable, with most sites complying with total PAH targets and most sites not complying with zinc targets. Compliance with consent targets for zinc declined from 2015 to 2020, due to increased mud in 2020 samples. Invertebrate QMCI scores were low across all sites in 2020 but there is no overall increasing or decreasing trend evident across the sites monitored every five years. Thus, there is no indication of a declining or improving trend in ecological health that could be attributable to stormwater discharges or other landuse impacts.

Recommendations include: increased riparian planting to increase waterway shade and reduce the need for aquatic weed removal; consider removal of metal-contaminated sediments in stormwater basins and waterways; a kākahi survey in the Heathcote River and regular monitoring of kākahi in Cashmere Stream; trout spawning surveys; a botanical survey of Avoca Salt Marsh; fish surveys in stormwater facilities; ecology monitoring of restoration projects; improved fish passage for banded kokopu at Glenstrae Stream; and a review of ecology monitoring results once the Heathcote River dredging project is complete.

1. INTRODUCTION

Christchurch City Council (CCC) monitors water quality, sediment quality, and aquatic ecology at numerous sites across Christchurch and Banks Peninsula. Water quality monitoring is undertaken monthly, while aquatic ecology and sediment quality monitoring is undertaken at five-yearly intervals in each major catchment. This monitoring is required as part of the council's Comprehensive Stormwater Network Discharge Consent (CRC190445) and it is also part of the council's long-term environmental monitoring programme.

This year, aquatic ecology and sediment quality monitoring was undertaken in the Heathcote River/Ōpāwaho catchment, Linwood Canal/City Outfall Drain, and at several sites on Banks Peninsula. The Heathcote catchment was previously sampled in 2010 and 2015, while Linwood Canal has only previously been sampled in 2015, and 2020 is the first round of ecology sampling for the Banks Peninsula sites.

The purpose of this report is to present the results of the most recent ecology and sediment quality monitoring, describe the state of the monitored waterways, and identify any trends over time. The following key components are included in this report:

- Current state and trends of aquatic ecology and sediment quality.
- Comparison of monitoring data to relevant standards and guidelines.
- Discussion of any environmental trends in relation to potential stormwater impacts.
- Details of other relevant ecological matters not covered by routine monitoring.

This report does not include a detailed analysis of the monthly water quality monitoring undertaken by CCC. Those data are summarised separately as part of an annual city-wide summary report (e.g., Marshall & Noakes 2019).

2. METHODS

2.1. Sampling Sites

Eighteen sites were sampled in 2020 for the aquatic ecology monitoring programme. The sampling sites comprised 11 wadeable and three non-wadeable sites in the Heathcote River catchment, one wadeable site in Linwood Canal, and three wadeable Banks Peninsula sites (Figure 1 and Figure 2, Table 1). Nine of the wadeable ecology sites in the Heathcote catchment were sampled previously for habitat and invertebrates in 2010 (James 2010) and all of the 15 Heathcote and Linwood Canal sites were sampled for habitat, invertebrates, and fish in 2015 (Boffa Miskell 2015), except for Site H31 at Warren Crescent, which is a new site. Fish sampling was also undertaken in 2011 (Taylor & Blair 2012), but there was little overlap with the present monitoring sites, so the data are not discussed in detail here. This is the first round of monitoring for the three Banks Peninsula sites. A fourth Banks Peninsula site (Purau Drain No. 1) that forms part of the CCC monitoring programme was not sampled because it was dry. Sediment quality sampling occurred at 18 sites in 2020 and earlier data were available from 1980 (Rob 1988), 2003 (provided by Jenni Gadd at NIWA) and 2015 (Gadd 2015).

Figure 1: CCC Heathcote River ecology and sediment quality monitoring sites.

Figure 2: CCC Banks Banks Peninsula ecology and sediment quality monitoring sites.

Table 1: Ecology (E) and sediment quality (S) monitoring sites in 2020. Asterisks indicate non-wadeable sites.

Site code	Sampling Type	Waterway	Site name/ Location	Easting	Northing
B1	E, S	Stream Reserve Drain	Above outfall to Governors Bay	1572024	5170197
B3	E, S	Balguerie Stream	Downstream of Settlers Hill	1597738	5149584
B4	E, S	Aylmers Stream	Downstream of Rue Jolie, next to Bruce Tce	1596924	5149100
H9	S	Haytons Stream	At retention basin[1]	1566099	5177644
H14	S	Curletts Road Stream	At Southern Motorway	1566393	5178380
H10	S	Curletts Road Stream	Upstream of the Heathcote River confluence	1566928	5177710
H16	E, S	Cashmere Stream	At Sutherlands Road	1566085	5173988
H26	E	Cashmere Stream	At Penruddock Rise	1567914	5175090
H5	S	Cashmere Stream	At Worsleys Road	1569030	5175155
H25	E	Cashmere Brook	At Ashgrove Terrace	1570261	5176357
H17	E	Steamwharf Stream	Upstream of Dyers Road	1575057	5177800
O2	E, S	Linwood Canal	Linwood Canal / City Outfall Drain	1575371	5178440
H31	E, S	Heathcote River	At Warren Crescent	1566034	5177340
H30	E, S	Heathcote River	At showgrounds	1566515	5177435
H29	E, S	Heathcote River	Downstream of Spreydon Domain	1567970	5177166
H6	E, S	Heathcote River	At Rose Street	1568706	5175928
H24	E, S	Heathcote River	Downstream of Barrington Street	1570156	5176178
H23	E, S	Heathcote River	Downstream of Colombo Street (Beckenham Library)	1570840	5176855
H22	E, S	Heathcote River	Downstream of Tennyson Street	1571519	5177234
H19*	E	Heathcote River	At Aynsley Terrace	1572926	5176809
H11*	E, S	Heathcote River	At Catherine Street	1574421	5177899
H2*	E, S	Heathcote River	At Tunnel Road	1575098	5177535

Note: [1] The Haytons Stream sediment sampling site is in the Heathcote River opposite the new discharge point from the upgraded stormwater facility. The coordinates above are at the sampling point.

The headwaters of the Heathcote River arise as springs amongst residential and industrial landuse to the southwest of Christchurch, near the suburbs of Hillmorton and Wigram. The Heathcote River is joined by Curletts Road Stream immediately downstream of Curletts Road. Curlletts Road Stream is a small waterway that drains a primarily industrial catchment. Cashmere Stream is the Heathcote River's major tributary and it drains a mixture of residential and rural landuse. Most of the new residential development underway in the Heathcote catchment is concentrated in the Cashmere Stream catchment. Cashmere Stream joins the Heathcote River in the suburb of Cashmere, before winding along the foot of the Port Hills and discharging into the Estuary of the Heathcote and Avon Rivers / Ihutai. Steamwharf Stream arises as springs and piped headwaters near Thistledown Reserve, then flows through a mix of paddocks and residential housing, before discharging into the estuarine reaches of the Heathcote River at the intersection of Ferry Road and Tunnel Road.

The Heathcote River's primary source of baseflow is from springs, but runoff from the Port Hills is the major source of flow and fine sediment load to the river following rain events. Water levels in the lower river are tidally influenced, with the magnitude of tidal fluctuations increasing with distance downstream from around St Martins Road. The Woolston Barrage directs flood flows through the Woolston Cut, which was built in 1986 to alleviate flood risk in the lower Heathcote River. The barrage gates are closed during normal flows, directing river flows and tides around the Woolston Loop.

Linwood Canal drains residential and commercial landuse in the eastern suburbs of Christchurch. Upstream of St Johns Street the waterway is known as Outfall Drain, and it is straight and concrete-lined. Downstream of St Johns Street the waterway is known as Linwood Canal and although it remains straight, it has predominantly natural banks and bed. The lower reaches of Linwood Canal are tidal, although the tidal amplitude is limited by tide gates located at the mouth of the estuary, downstream of Humphries Drive.

Two of the Banks Peninsula sites are in Akaroa and one site is in Governors Bay. All three Banks Peninsula streams drain steep hill country with a mixture of regenerating bush, farmland and low density residential landuse.

Ecology monitoring occurred from 7 March to 10 May 2020, under baseflow conditions. Monitoring would normally be completed by the end of April, but it was extended into May this year, due to disruptions caused by the COVID-19 global pandemic. This involved the country being under lockdown from 26 March to 27 April, during which period non-essential work (such as ecology monitoring) was prohibited. Potential impacts of the delayed fieldwork on ecological data are discussed in Section 4.

2.2. Differences in Ecology Sampling Methods Between Years

All sampling years involved sampling ecology and habitat along a 20 m reach, with detailed measurements along three equally spaced transects. The same sampling methods were used in 2015 and 2020, with the exception that macroinvertebrates were processed using full counts in 2015 and fixed counts in 2020 (see Section 2.5 for macroinvertebrate methods).

The major differences between the old (2010) and the new (2015 and 2020) monitoring methods were as follows:

- Field-measured water quality:
    - Not measured in 2010.
    - Dissolved oxygen, temperature, pH, and conductivity measured once per site (new methods).
- At each transect, detailed habitat measurements at:
    - 3 or 12 points or site-wide estimates (old methods).
    - 5 points (new methods). Only edge habitat sampled at non-wadeable sites.
- At each transect, velocity measured at:
    - 10 points per transect (old methods).
    - 1 point per transect (new methods). Mid-channel for wadeable sites; approximately 1.5 m (safely wadable) from edge for non-wadeable sites.

- Invertebrate kicknet samples per site:
  - 3 (old methods). Each sample is approximately 0.45 m^2 (1.5 x 0.3 m).
  - 1 (new methods). Each sample is approximately 0.6 m^2 (2.0 x 0.3 m). Only edge habitat sampled at non-wadeable sites.
- Fish sampling:
  - Not sampled in 2010.
  - Either electric fishing or a mixture of fyke nets and minnow traps (new methods).

2.3. Habitat and Water Quality Sampling

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): wetted width, 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 Hanna water quality meter (model HI 9829).

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.

2.4. Sediment Quality

Sediment samples were collected by 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. 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.

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 from 10 to 15 May 2020.

2.5. Macroinvertebrates

Benthic macroinvertebrates were sampled at each 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 and were sent to Biolive consultants for identification and enumeration. 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). This method differs to the full count with subsampling method used in previous years, reflecting a change to standard methods used by CCC. The change in laboratory protocols was in response to recommendations by Stark (2018) that fixed counts should be used for kicknet samples.

2.6. Fish

The fish community was sampled using backpack electric fishing at 12 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 six 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. All habitat types within the reach were sampled without bias (e.g., pools, riffles, undercuts and backwaters). For the remaining sites, sampling 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 not included in the total tally.

2.7. Data Analyses

2.7.1. Data Management

All ecology and sediment quality data collected in 2020 was collated into a single Excel spreadsheet. In addition, summary data from 2020 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 in electronic form at the time this report was submitted, and they are available from CCC on request.

2.7.2. Habitat and Water Quality Data

Field-measured water quality results were tabulated and compared against relevant freshwater outcomes and receiving water standards in the Canterbury Land and Water Regional Plan (LWRP).

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 2).

Prior to 2015, 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 2015 and 2020, these parameters were estimated as per other transect data (i.e., the average of five measurements per transect, and the site average obtained by the mean of three transects). Only a single measurement for velocity per site was recorded in 2010.

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.

Table 2: Consent Attribute Target Levels for monitoring sites on different waterways. All targets are maximums, unless stated otherwise.

Waterway	Minimum QMCI	Fine sediment (<2 mm) cover	Total macrophyte cover	Long filamentous algae (>2 cm) cover
Heathcote River, Linwood Canal	3.5	30%	60%	30%
Cashmere Stream, Banks Peninsula sites	5	20%	30%	20%

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, fine sediment cover, emergent and total macrophyte cover, and long filamentous algae cover. Tukey post-hoc tests were used to examine the statistical significance of site x year interactions, particularly in terms of any increasing or decreasing trends in habitat quality over time.

2.7.3. Sediment Quality Data

Total PAHs were calculated by summing the following 18 PAHs listed in the ANZECC (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 ANZECC (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 (Gadd 2015).

Sediment quality data from the 18 sites sampled in 2020 were summarised and tabulated for comparison against consent attribute target levels and ANZECC (2018) upper guideline values (Table 3). Sediment quality data from 2020 were compared against data collected in 1980, 2003, and 2015 (data provided by NIWA). There were 12 sites with a minimum of three years of monitoring data from 1980 data to 2020. Some samples were not taken at the same location each year, but were considered close enough for comparison if they were within approximately 500 m, with no tributaries between the locations. Differences in mean values amongst sites for 2020 data were assessed using one-way analysis of variance. 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.

Table 3: Consent Attribute Target Levels and ANZECC (2018) upper guidelines for sediment quality.

Parameter	Consent upper limit concentration (mg/kg dry weight)	ANZECC GV-high guideline (mg/kg dry weight)
Copper	65	270
Lead	50	220
Zinc	200	410
Total PAHs	10	50

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 hard-bottomed streams for all sites except for the following six sites, where we used soft-bottom tolerance scores: H2, H11, H17, H19, H31, and O2. Hard and soft-bottomed tolerance scores were based on the dominant substrate present (Stark & Maxted 2007). MCI and QMCI scores can be interpreted as per the quality classes of Stark & Maxted (2007), as summarised in Table 4.

The MCI, QMCI, and EPT indices were developed for assessing ecological health of wadeable streams. Non-wadeable and tidally-influenced river reaches often have naturally fine bed sediments, which are not favoured by pollution-sensitive invertebrate taxa. Therefore, macroinvertebrate for the tidal and non-wadeable reaches of the lower Heathcote River (Sites H2, H11, and H19) and Linwood Canal (Site O2) should be interpreted with caution, as pollution will not necessarily be the cause of low MCI, QMCI, or EPT scores in these reaches.

Table 4: Interpretation of MCI and QMCI scores (from Stark & Maxted 2007).

Quality Class	MCI	QMCI
Excellent	>119	>5.99
Good	100-119	5.00-5.90
Fair	80-99	4.00-4.99
Poor	<80	<4.00

As with reach-scale habitat data, it was not possible to conduct two-way ANOVA or trend analyses on the five-yearly macroinvertebrate data, due to a lack of replication.

Macroinvertebrate community composition was also compared amongst sites and over time using non-metric multi-dimensional scaling (NMDS), a form of ordination. The ordination was based on a Bray-Curtis dissimilarity matrix, using square-root transformed data on percent abundance and the Vegan package in R. Percent abundance was used, rather than total abundance, because of the different sampling areas and sorting methods (total count vs fixed count) used over time. Spearman rank correlation was used to reveal which taxa most closely correlated with NMDS axis scores. Habitat data from the wadeable sites were also correlated with NMDS axis scores.

There were 14 sites where both invertebrates and sediment quality were sampled. For these sites, NMDS axis scores for 2020 were correlated against concentrations of copper, lead and zinc, which are all common stormwater contaminants. There were only four sites with invertebrate data that had nearby monthly water quality monitoring sites. This was considered too small a data set to undertake correlations between water quality and NMDS axis scores.

QMCI scores were compared with the Consent Attribute Target Levels of 3.5 for Heathcote River and Linwood Canal sites and 5 for Cashmere Stream and Banks Peninsula sites (Table 2).

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 not statistical comparison was possible, due to the lack of replication.

3. RESULTS

3.1. Habitat and Water Quality

Water temperatures were cool (<15 °C) at all sites sampled in 2020, ranging from a minimum of 10.2 °C at Site B3 (Balguerie Stream) to a maximum of 14.2 °C at Site H25 (Cashmere Brook, Table 5). Temperatures measured at the Heathcote and Linwood Canal catchment sites were cooler in 2020 (mean = 13.0 °C, range = 11.2 to 14.2 °C) than those measured in 2015 (mean = 16.6 °C, range = 13.6 to 19.5 °C), reflecting cooler ambient temperatures during the late autumn sampling in 2020. Dissolved oxygen saturation exceeded (i.e., complied with) the LWRP freshwater outcome of 70% at all sites in 2020, except for Site O2 (Linwood Canal), Site H29 (Heathcote River at Spreydon Domain), and Site H31 (Heathcote River at Warren Crescent, Table 5). Dissolved oxygen levels at the Linwood Canal site were only 23%, which is very low. Anoxic sediments and a hydrocarbon sheen were observed at the Linwood Canal site, which suggests oxygen-depleted groundwater was entering the site. This may reflect either a natural wetland source or locally contaminated groundwater. Aside from Linwood Canal, oxygen saturation levels were generally comparable to those measured in 2015.

Conductivity was in the range of 100 to 340 µS/cm for all sites, except for the two most downstream sites on the Heathcote River (Sites H2 and H11) that are estuarine, so they have elevated conductivity and salinity (Table 5). For the non-estuarine sites, conductivity was typically higher (>250 µS/cm) at sites on the mainstem of the Heathcote River or

Linwood Canal than in tributaries or Banks Peninsula Streams. Higher conductivity in non-saline waters of the Heathcote River likely reflects the influence of urban landuse on water quality. Water pH was circum-neutral (i.e., around pH 7) and within LWRP receiving environment standards of pH 6.5 to 8.5 for all sites.

Table 5: Field-measured water quality in 2020. Values in red do not comply with a relevant LWRP Freshwater Outcome or receiving environment standard.

Site number	Waterway	Location	Dissolved oxygen (%)	Temperature (°C)	pH	Conductivity (µS/cm)
B1	Stream Reserve Drain	Above outfall to Governors Bay	82.4	12.2	7.57	208
B3	Balguerie Stream	Downstream of Settlers Hill	96.7	10.2	7.56	105
B4	Aylmers Stream	Downstream of Rue Jolie, next to Bruce Tce	98.5	10.5	7.37	221
H16	Cashmere Stream	At Sutherlands Road	100.1	13.8	6.98	256
H26	Cashmere Stream	At Penruddock Rise	96.5	13.5	7.25	250
H25	Cashmere Brook	At Ashgrove Terrace	79.5	14.2	7.33	101.8
H17	Steamwharf Stream	Upstream of Dyers Road	83.2	14.0	7.30	188
O2	Linwood Canal	Linwood Canal / City Outfall Drain	**22.8**	12.7	7.00	315
H31	Heathcote River	At Warren Crescent	**69.8**	13.8	7.00	335
H30	Heathcote River	At showgrounds	83.2	11.3	6.81	137
H29	Heathcote River	Downstream of Spreydon Domain	**65.5**	12.3	7.76	308
H6	Heathcote River	At Rose Street	87.0	11.2	7.31	302
H24	Heathcote River	Downstream of Barrington Street	98.9	14.1	7.61	254
H23	Heathcote River	Downstream of Colombo Street (Beckenham Library)	85.0	13.7	7.41	257
H22	Heathcote River	Downstream of Tennyson Street	87.9	13.1	7.11	284
H19	Heathcote River	At Aynsley Terrace	78.4	12.3	7.16	299
H11	Heathcote River	At Catherine Street	92.2	12.6	7.87	3796
H2	Heathcote River	At Tunnel Road	76.4	12.0	7.25	4004
LWRP Freshwater Outcome or Receiving Environment Standard			**≥70**	**<20**	**6.5 -8.5**	**–**

Representative site photographs from the monitoring sites are shown in Figure 3 to Figure 5, and photographs of all sites are in Appendix 1.

Numerous changes have occurred in the Heathcote River catchment since the 2015 round of monitoring. These changes include new residential developments in the Cashmere Stream catchment, new and upgraded stormwater treatment facilities in the upper Heathcote and Cashmere Stream catchments, and waterway restoration in upper Cashmere Stream. Other developments have included the Port Hills fires, and bank stabilisation and dredging in the mid to lower reaches of the Heathcote River. Linwood Canal and Steamwharf Stream have also seen some sediment removal and limited bank works. All these changes and activities have had the potential to impact on aquatic ecosystems directly or indirectly. Notable local activities and habitat changes at monitoring sites between 2015 and 2020 are summarised in Table 6 and illustrated in Figure 4 and Figure 5.

Figure 3: Site B3 on Balguerie Stream (left) and Site B4 on Aylmers Stream (right) are new monitoring sites, characterised by stony beds, a variety of hydraulic habitats, and reasonable shading from riparian trees.

Riparian habitat is highly modified at most sites sampled, typically comprising a narrow strip (<3 m wide) of long grass, sedges (*Carex* spp), or native plantings. Sites with extensive native tree cover in the riparian zone throughout the length of the site include the three Banks Peninsula sites (Sites B1, B3, and B4), and Site H31 (Heathcote River at Warren Crescent). These four sites all provide corresponding high shade to the waterway (>70% shade, Figure 6). Channel shading is more variable and generally low at the remaining sites, although shade also exceeds 70% at Site H30 (Heathcote at the showgrounds), where native trees cover most of the sampling site.

Stream banks at the monitoring sites are primarily comprised of a mixture of natural earth and stone. However, there are numerous locations where banks have been armoured with rock or wood to improve bank stability, primarily to protect roads and private property. Stream banks are more natural at the Banks Peninsula sites, reflecting less intense urban development. The mid-reaches of the Heathcote River, between Ferniehurst Street and Beckenham, were the subject of a major bank stabilisation project over 2018 and 2019. This involved a mixture of bank treatments, ranging from simply adding large rocks to the base of banks, to more extensive rock placement and bank battering, through to gabion baskets (Figure 5). Mitigation for the loss of natural river banks at multiple locations included the addition of large “e-rocks” at the base of the bank in some locations, the addition of cobble clusters at two locations (including Site H23 at Colombo Street), PVC tubes inserted into the bank to provide potential fish habitat, and native riparian plantings. The ecological effects of bank stabilisation and habitat mitigation measures are discussed in Section 4.3 below. Further bank stabilisation work was underway in the Heathcote River at the time of writing, with the work mainly associated with dredging in the tidal reaches downstream of St Martins Road.

Figure 4: Cashmere Stream monitoring sites H16 (at Sutherlands Road) and H26 (at Penruddock Rise) in 2015 and 2020.

Waterway widths and depths are generally lowest for Banks Peninsula sites, Heathcote River headwater sites, and smaller tributaries (Figure 7 and Figure 8). There is an overall trend of increasing depth with downstream in the Heathcote River, but the greatest depths were seen at the most upstream site, Site 31 at Warren Crescent. A local resident who has lived near the Warren Crescent site for several decades indicated that the river used to be shallower and swifter at that location prior to the 2010/2011 earthquakes. That suggests that the earthquakes may have increased the bed level downstream, resulting in a backwatering effect and greater water depths at the Warren Crescent site.

At the wadeable sites, mean wetted widths in 2020 ranged from 1.06 m at Site B1 (Stream Reserve Drain at Governors Bay) to 8.9 m at Site O2 (Linwood Canal), while mean depth ranged from 4 cm at Site B1 to 36 cm at Site H31 (Heathcote River at Warren Crescent). Two-way ANOVA revealed significant differences amongst sites for width ($P<0.001$) and depth ($P<0.001$), and a significant site by year interaction for depth ($P=0.025$). Differences in water depth between sampling years were greatest at Site H26 (Cashmere Stream at Penruddock Rise) and Site H17 (Steamwharf Stream). Mean water depth at Site H26 dropped from 68 cm in 2015 to 28 cm in 2020, due to the site being moved upstream to avoid a deep scour pool that had developed. Mean water depth at Site H17 increased from 9 cm in 2015 to 21 cm in 2020, likely reflecting the influence of sediment removal and greater macrophyte cover in 2020.

Figure 5: Heathcote River monitoring sites H26 (downstream of Colombo Street), H22 (Tennyson Street), and H11 (Catherine Street) in 2015 and 2020.

Table 6: Notable activities at or near monitoring sites between 2015 and 2020.

Site Code	Site location	Activity
H16	Cashmere Stream at Sutherlands Road.	Removal of riparian vegetation prior to waterway restoration.
H26	Cashmere Stream at Penruddock Rise	Tree removal on true left and associated scour pool. Site moved 5 m upstream to avoid the new scour pool that is unwadeable.
H17	Steamwharf Stream	Fine sediment removal.
H9	Haytons Stream at Retention Basin	Wigram Stormwater Retention Basin has been upgraded. Discharge and sediment sampling location moved downstream.
H14	Curletts Road Drain at Southern Motorway	New stormwater basins added immediately downstream of sediment sampling location.
H23	Heathcote River downstream of Colombo Street	Bank stabilisation with large rocks, including addition of cobble clusters as habitat to offset loss of natural banks and undercuts.
H22	Heathcote River downstream of Tennyson Street	Bank stabilisation with gabion baskets on the true left bank.
H19	Heathcote River at Aynsley Terrace	Immediately upstream of dredging reach, influenced by high turbidity from dredging. Site has since been dredged.
H11	Heathcote River at Catherine Street	River dredging, bank stabilisation, footbridge removal, tree removal, and native plantings on true left bank.
O2	Linwood Canal	Sediment removal, plus bank works and native plantings on true left bank associated with new cycleway.

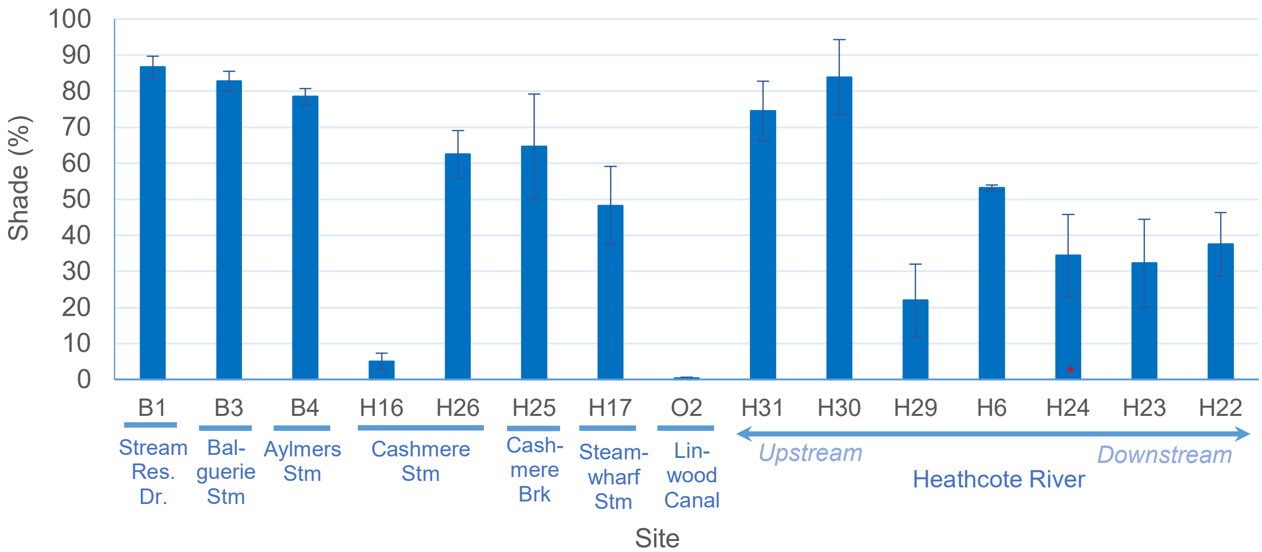

Figure 6: Mean (±1 SE) waterway shading at the 15 wadeable sites in 2020.

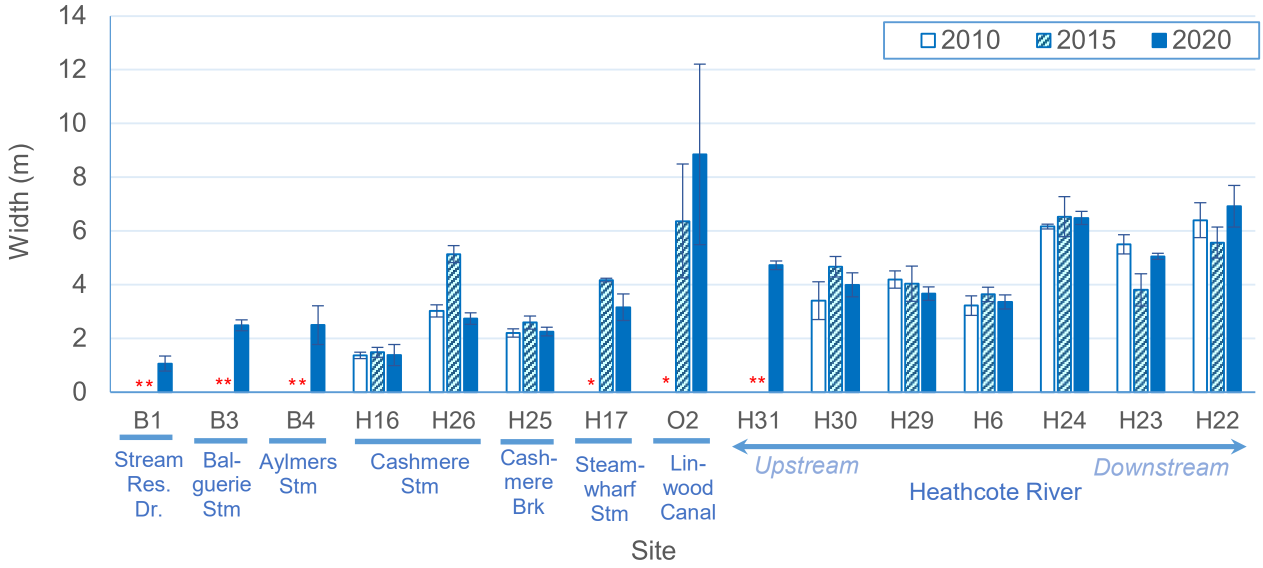

Figure 7: Mean (±1 SE) water width at the 15 wadeable sites. Asterisks indicate no data collected for that year.

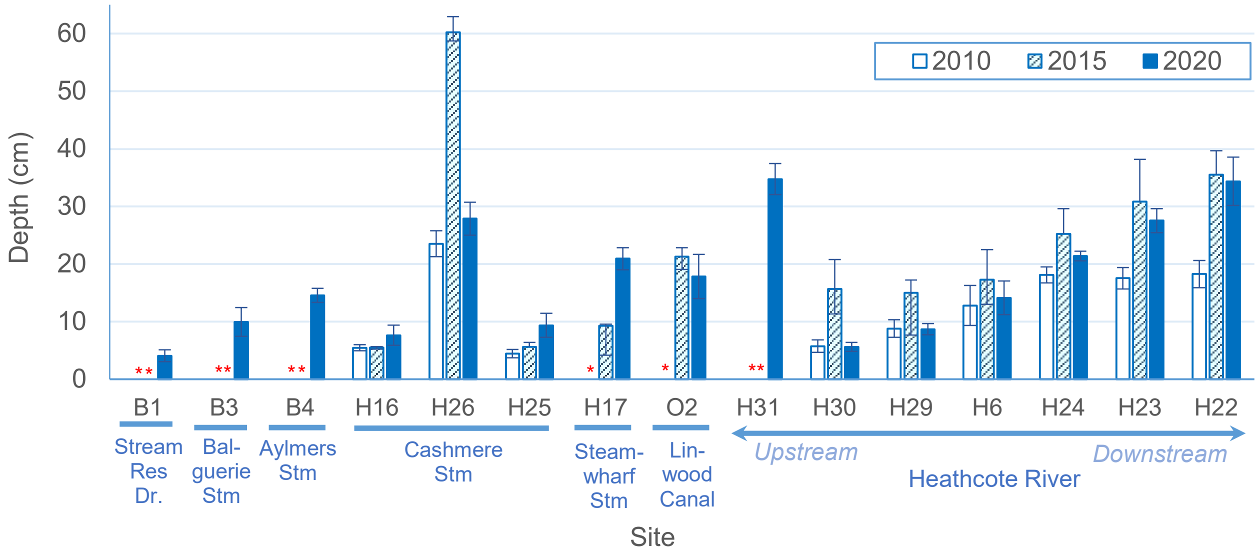

Figure 8: Mean (±1 SE) water depth at the 15 wadeable sites. Asterisks indicate no data collected for that year.

Water velocity at the wadeable sites in 2020 varied from site to site, but was generally greater in the mainstem Heathcote River sites, where there is greater flow (Figure 9). Mean velocity in 2020 was 0.20 m/s at the tributary and Banks Peninsula sites, and 0.31 m/s at the wadeable Heathcote River sites. Mean water velocity drops to 0.11 m/s at the tributary and Banks Peninsula sites if Site H26 is excluded, which had a particularly high mean velocity of 0.88 m/s (Figure 9). Two-way ANOVA of water velocity revealed a significant site by year interaction (P=0.002), largely driven by the increase in mean velocity at Site H26 from 0.29 m/s in 2015 to 0.88 m/s in 2020, associated with the site moving upstream into swift riffle habitat in 2020.

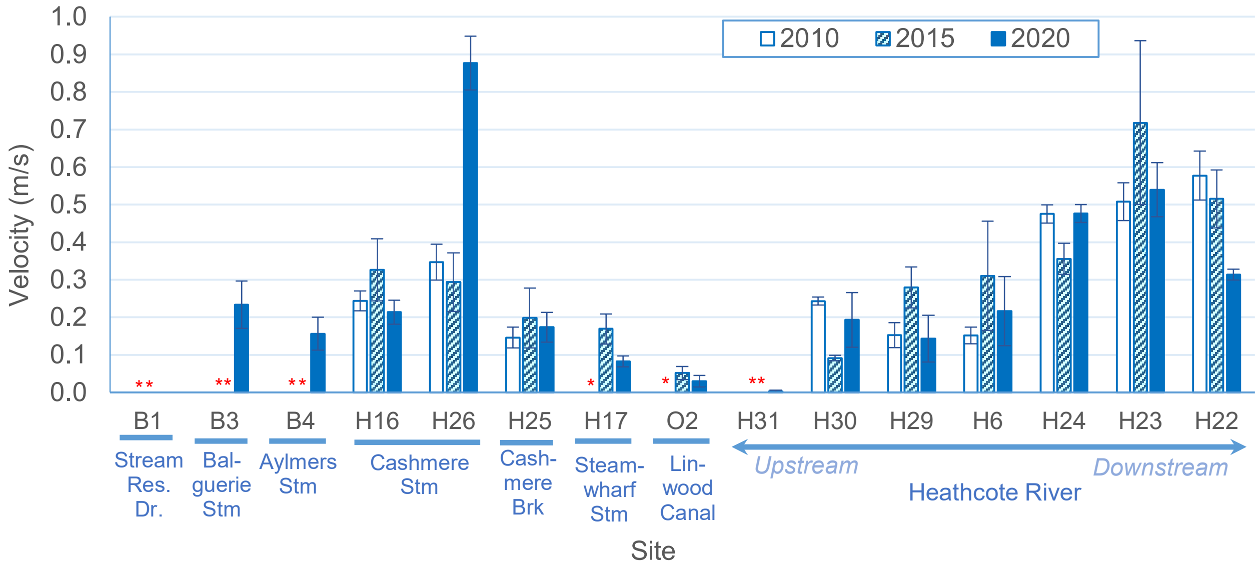

Figure 9: Mean (±1 SE) water velocity at the 15 wadeable sites. Asterisks indicate no data collected for that year.

Substrate index scores in 2020 were typically in the range of 4 to 5, indicating a dominance of pebble and gravel-sized sediments (Figure 10). Site B3 (Balguerie Stream) and Site B4 (Aylmers Stream) had the largest mean substrate scores, reflecting the greater dominance of cobbles and boulders at those sites. Sites dominated by fine sediments (<2 mm diameter) included Site H17 (Steamwharf Stream), Site H31 (Heathcote at Warren Crescent), and Site O2 (Linwood Canal). All the non-wadeable sites were also dominated by fine sediments. The only notable change in substrate index between years was at Site H26 (Cashmere Stream at Penruddick Rise), where coarser sediments were recorded in 2020, due to the site being moved upstream from a pool into more riffle-dominated habitat.

Mean fine sediment depth was low (<5 cm) at most sites in 2020, except for at Sites H17 (Steamwharf Stream), O2 (Linwood Canal), and H31 (Heathcote at Warren Crescent, Figure 11). Two-way ANOVA revealed a significant site by year interaction (P<0.001), with the greatest differences in fine sediment between years occurring at Sites H17 and H30 (Heathcote at showgrounds). Mean sediment depth declined from 61 to 24 cm at Site H17 between 2015 and 2020, and declined from 23 to 0 cm at Site H30 over the same period. Sediment removal occurred in Steamwharf Stream between the two monitoring periods, which explains the reduced fine sediment depth there. It is unclear why fine sediment depths have declined at Site H30, although there was considerable variation in the 2015 data (indicated by wide error bars in Figure 11), so the differences could be due to random variation.

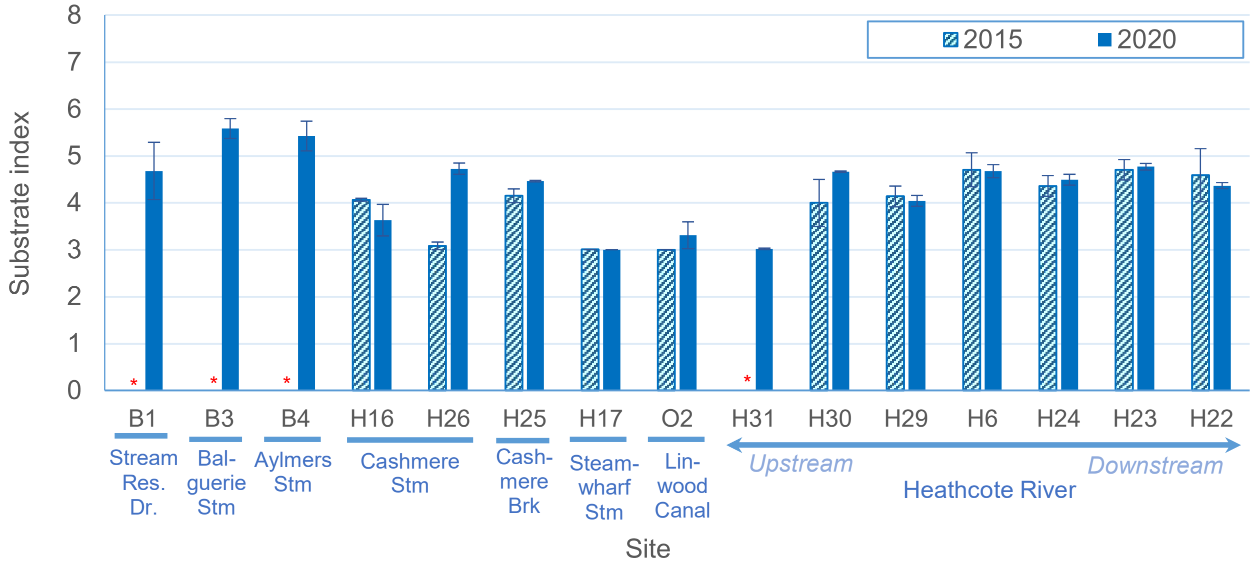

Figure 10: Mean (±1 SE) substrate index score at the 15 wadeable sites. Asterisks indicate no data collected for that year.

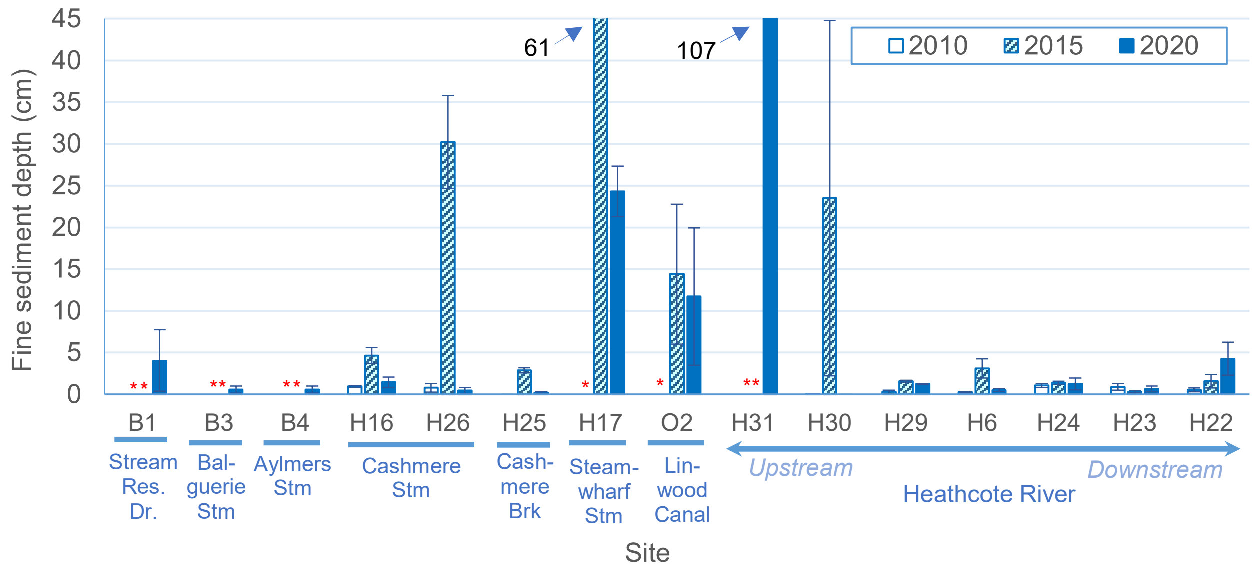

Figure 11: Mean (±1 SE) depth of fine sediment (<2 mm diameter) at the 15 wadeable sites. Asterisks indicate no data collected for that year.

Fine sediment cover at monitoring sites in 2020 was high and exceeded consent target levels at all except for three sites (Figure 12). While some sites had substrates dominated by fine sediments, others had predominantly stony bed sediments overlain with a thin layer of fine sediment. Sites with predominately stony bed sediments overlain with relatively high fine sediment cover included all three Banks Peninsula sites, Site H26 in Cashmere Stream, and Sites H30, H29, H6, and H22 in the Heathcote River.

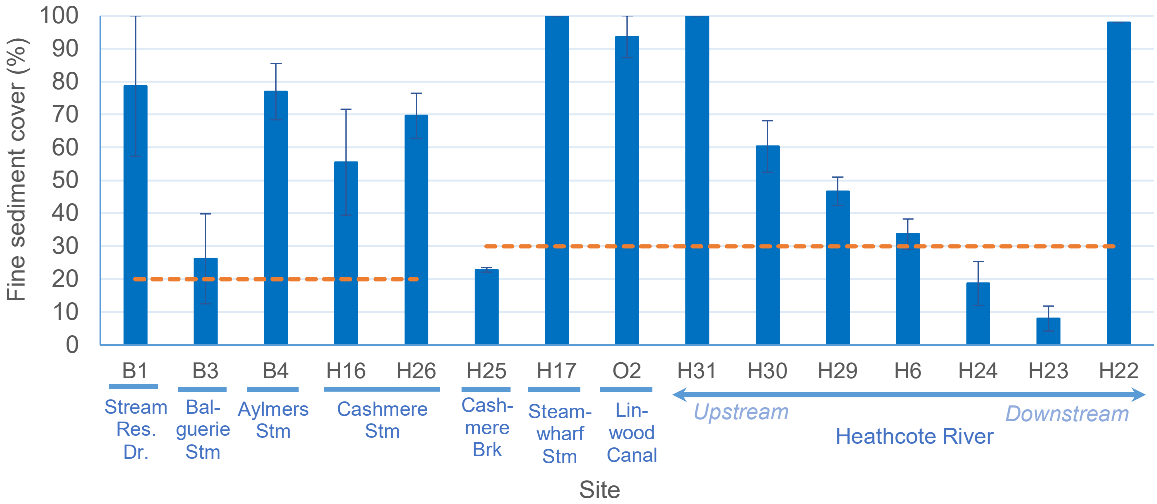

Figure 12: Mean (±1 SE) percent bed cover with fine sediment (<2 mm diameter) at the 15 wadeable sites for 2020 and relevant consent attribute target levels (dashed lines).

Fine sediment cover data was not previously collected using comparable methods to those used in 2020. However, substrate composition data was collected using similar methods in 2015 and 2020, so percent bed cover with silt and sand (<2 mm) can be used to infer fine sediment cover. In 2020, more sites complied with consent attribute target levels for fine sediment cover when using the indirect indicator of percent silt and sand than when the direct measure of fine sediment cover was used (Figure 13). That is because the method for assessing substrate composition does not account for stony substrates overlain with a thin layer of fine sediment. Two-way ANOVA revealed a significant site by year interaction ($P<0.001$). The greatest change in percent silt and sand cover between sites and sampling years was at Site H26 (Cashmere Stream at Penruddock Rise), where mean silt and sand cover declined from 97% in 2015 to 9% in 2020 (Figure 13). This was associated with the sampling site shifting from pool to riffle habitat between sampling years.

Emergent macrophyte cover in 2020 was low and well below the LWRP Freshwater Outcome of 30% cover for Spring-fed – Plains Urban waterways at all sites sampled (Figure 14). Emergent macrophyte cover was also low in 2015. Low cover with emergent macrophytes reflects the dominance of submerged macrophytes in most of the springfed waterways sampled. Low macrophyte cover in the three Banks Peninsula streams is due to a combination of high flood frequency, stony sediments, and high levels of shade.

Total macrophyte cover in 2020 was below (i.e., complied with) consent target levels at most wadeable sites, except for Site H24 (Heathcote River at Barrington Street) and Site H23 (Heathcote River at Colombo Street, Figure 15). Total macrophyte cover was dominated by submerged macrophyte taxa, with the invasive macrophyte *Potamogeton crispus* (curly-leaf pondweed) often dominating. Macrophyte cover was overall greater in 2020 than in 2015, but two-way ANOVA revealed a significant site by year interaction ($P<0.001$), reflecting high variation in amongst sites and years (Figure 15). While there was considerable variation amongst sites, macrophyte cover in 2020 was very low (<20%) at all sites that had high levels of shade (>70% shade).

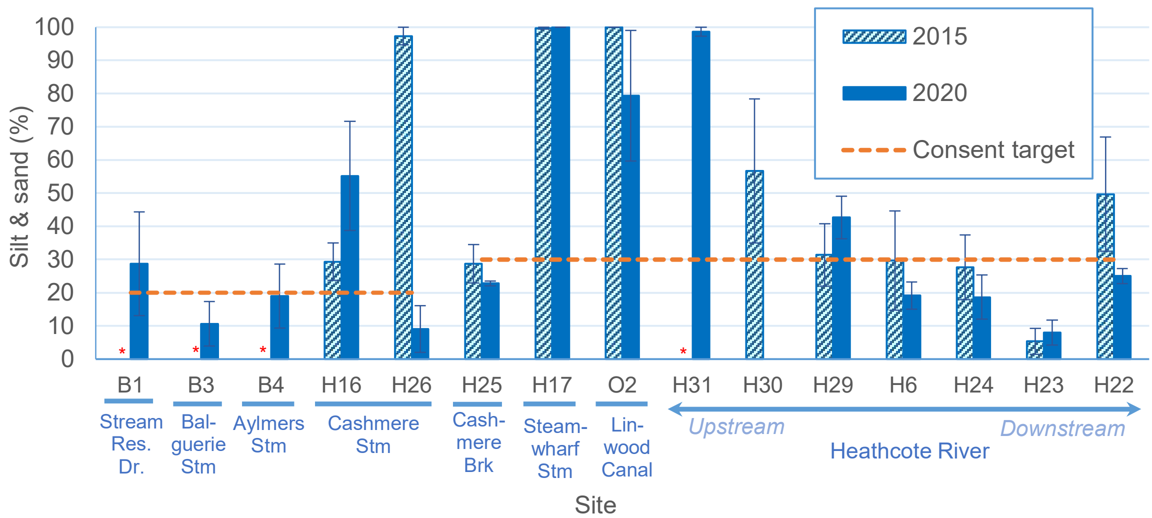

Figure 13: Mean (±1 SE) percent silt and sand substrate (<2 mm diameter) compared with consent attribute target levels (dashed lines). Asterisks indicates no data collected for that site.

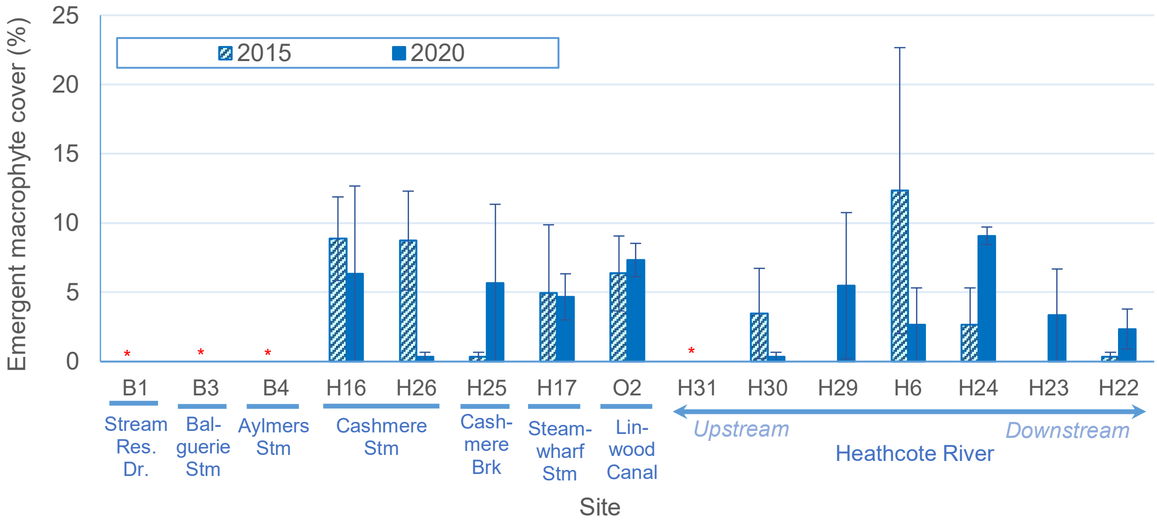

Figure 14: Mean bed cover (±1 SE) with emergent macrophytes. Asterisks indicate no data collected for that year.

Bed cover with long filamentous algae (>2 cm long) in 2020 was low (<15% cover) and complied with consent target levels at all sites (Figure 16). This is similar to previous years, although high algal cover has been reported previously at several sites previously. Low periphyton cover is typical in macrophyte-dominated springfed waterways, such as Linwood Canal, and the Heathcote River and its tributaries. Low cover with long filamentous algae in the Banks Peninsula streams likely reflects a combination of good shading and regular flushing flows.

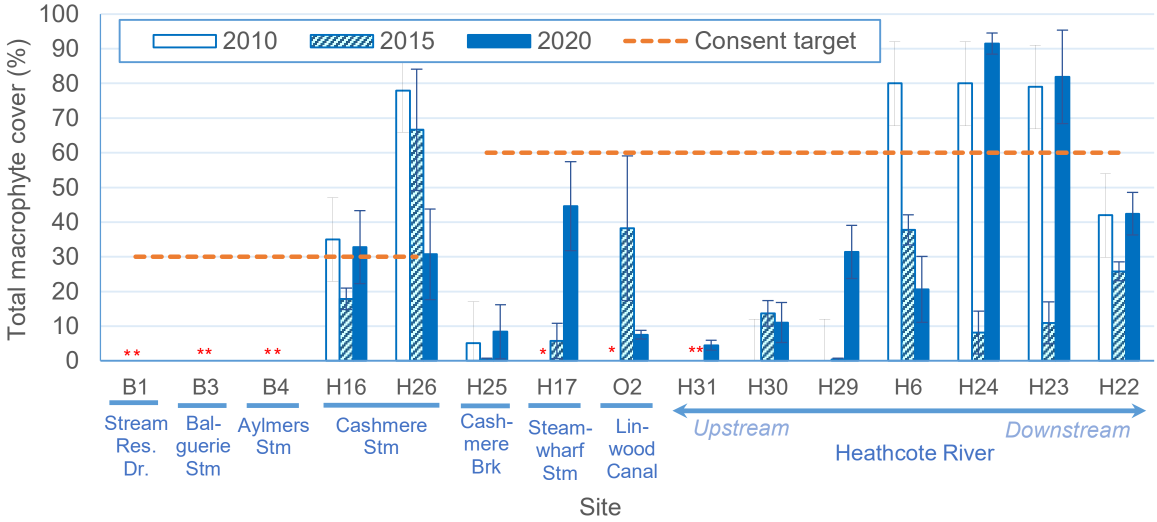

Figure 15: Bed cover with total macrophytes compared with consent attribute target levels (dashed lines). Asterisks indicate no data collected for that year.

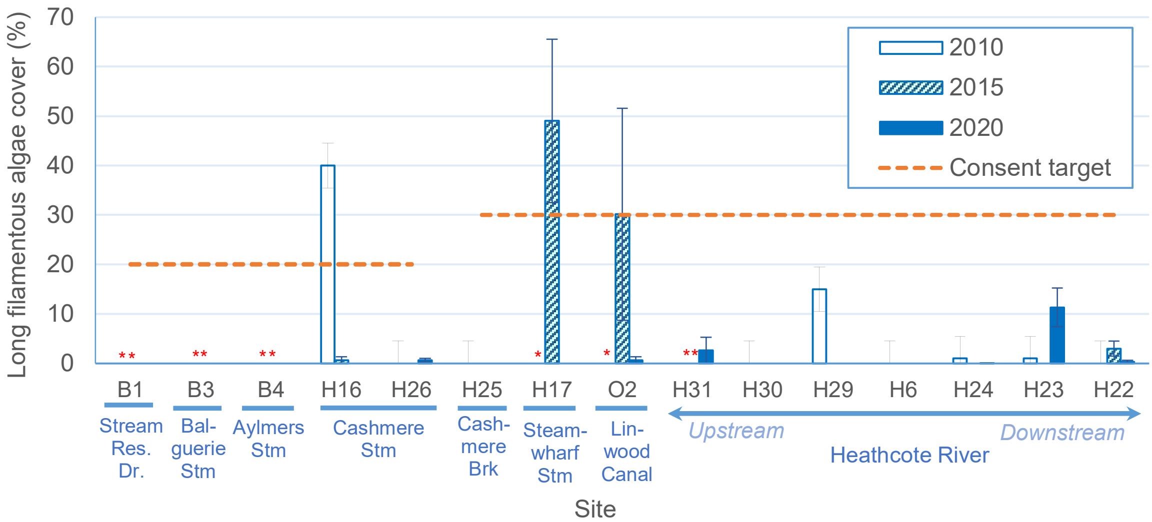

Figure 16: Mean (±1 SE). percent bed cover with long filamentous algae, compared with consent attribute target levels (dashed lines). Asterisks indicate no data collected for that year. No error bars are shown for 2010 as they are based on a site-wide estimate, with no replicates.

3.2. Sediment Quality

Sediment quality data from 2020 is summarised in Table 7 and all laboratory results are in Appendix 2. Mean total organic carbon (TOC) content varied amongst sites, ranging from a low of 0.7 g/100 g at Site H16 (Cashmere Stream at Sutherlands Road) up to 15.2 g/100 g at Site H31 (Heathcote at Warren Crescent), and did not show any strong patterns amongst sites. Variations in TOC content will reflect the combined influences of underlying geology, adjacent landuse, and local hydrology. Mean total phosphorus varied greatly amongst sites, from a low of 270 mg/kg at Site H16 (Cashmere Stream at Sutherlands Road) to a high of 2,500 mg/kg at Site H10 (Curletts Road Stream at Southern Motorway, Table 7). There are no consent attribute target levels or ANZECC (2018) guidelines for sediment TOC or total phosphorus.

In 2020, zinc had the highest concentrations of the three metals tested, while lead and copper concentrations were considerably lower (Table 7). Metal concentrations were lowest at the three Banks Peninsula sites and the two Cashmere Stream sites, and highest at Curletts Road Stream immediately downstream of the Southern Motorway (Site H14). Mean zinc concentrations exceeded consent attribute target levels at 13 of the 18 sites sampled, and they also exceeded the ANZECC (2018) upper guideline value (GV–high) level at seven of the 18 sites. Mean lead concentrations exceeded consent attribute target levels at eight sites and also exceeded the GV–high at one site (Site H14). Mean copper concentrations exceeded consent attribute target levels at four sites and also exceed the GV–high level at one site (Site H14). Total PAHs were relatively low at all sites and just exceeded the consent attribute target of 10 mg/kg at Site H2 (Heathcote River at Tunnel Road).

The two Cashmere Stream sites and two of the Banks Peninsula sites complied with consent attribute target levels for all the parameters tested (Table 7). However, 14 of the 18 sites did not comply with consent attribute target levels for at least one sediment quality parameter, including:

- Six sites that exceeded consent targets for only one parameter;
- Four sites that exceeded consent targets for two parameters; and
- Four sites that exceeded consent targets for three parameters.

Table 7: Mean sediment quality data for 2020. Units are mg/kg except for total organic carbon (TOC), which is g/100 g. Total PAHs are normalised to 1% TOC. Values exceeding consent targets are in orange, values exceeding consent targets and the ANZECC (2018) Guideline Value-high are in red.

Site code	Site name/ Location	Copper	Lead	Zinc	Total PAHs	Phosphorus	TOC
Banks Peninsula Sites							
B1	Stream Reserve Drain	20	20	160	0.2	1230	7.7
B3	Balguerie Stream	26	36	**228**	0.2	1193	10.7
B4	Aylmers Stream	49	31	194	0.2	1330	11.2
Heathcote Tributary Sites							
H9	Haytons Stream at retention basin	17	30	**600**	0.3	1103	5.3
H14	Curletts Road Stream at Southern Motorway	**867**	**220**	**4633**	0.4	2500	9.7
H10	Curletts Road Stream upstream of the Heathcote River confluence	**126**	**50**	**613**	0.7	477	1.8
H16	Cashmere Stream at Sutherlands Road	4	8	39	1.6	270	0.7
H5	Cashmere Stream at Worsleys Road	10	17	115	0.5	577	2.1
O2	Linwood Canal	30	**53**	**687**	1.6	820	2.3
Heathcote River Sites							
H31	Warren Crescent	29	**83**	**214**	0.3	900	15.2
H30	Showgrounds	18	27	**230**	0.3	1073	5.1
H29	Spreydon Domain	**93**	**58**	**693**	0.6	1393	7.7
H6	Rose Street	**96**	**102**	**687**	5.3	1107	7.0
H24	Barrington Street	34	**55**	**397**	3.1	850	5.5
H23	Colombo Street	20	33	**333**	5.9	597	2.6
H22	Tennyson Street	29	39	**420**	3.4	747	3.6
H11	Catherine Street	40	**56**	**397**	1.6	877	4.7
H2	Tunnel Road	9	19	130	**10.0**	493	1.1
Consent Attribute Target Level		65	50	200	10	–	–
ANZECC 2018 GV-high		270	220	410	50	–	–

Consent attribute target levels are the same as default guideline value (DGV) levels in the ANZECC (2018) sediment quality guidelines. The ANZECC (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. This means that there is an increased risk of adverse ecological effects due to sediment toxicity at most sites sampled and a higher level of risk at the seven sites that exceed GV-high levels.

Sediment copper concentrations have varied over time from 1980 to 2020, but they have typically been below consent attribute target levels (Figure 17). Copper concentrations were higher in 2020 than 2015 at nine of the ten sites where sampling occurred on both dates, but no overall increasing trend is apparent when compared with data from 1980. Thus, when comparing 2020 and 1980 data, five sites had higher copper concentrations in 2020 and five sites had lower concentrations in 2020. Copper concentrations have been well below the ANZECC (2018) GV-high level of 270 mg/kg on all occasions, except for once in 1980, at Site H6 (Heathcote River at Rose Street).

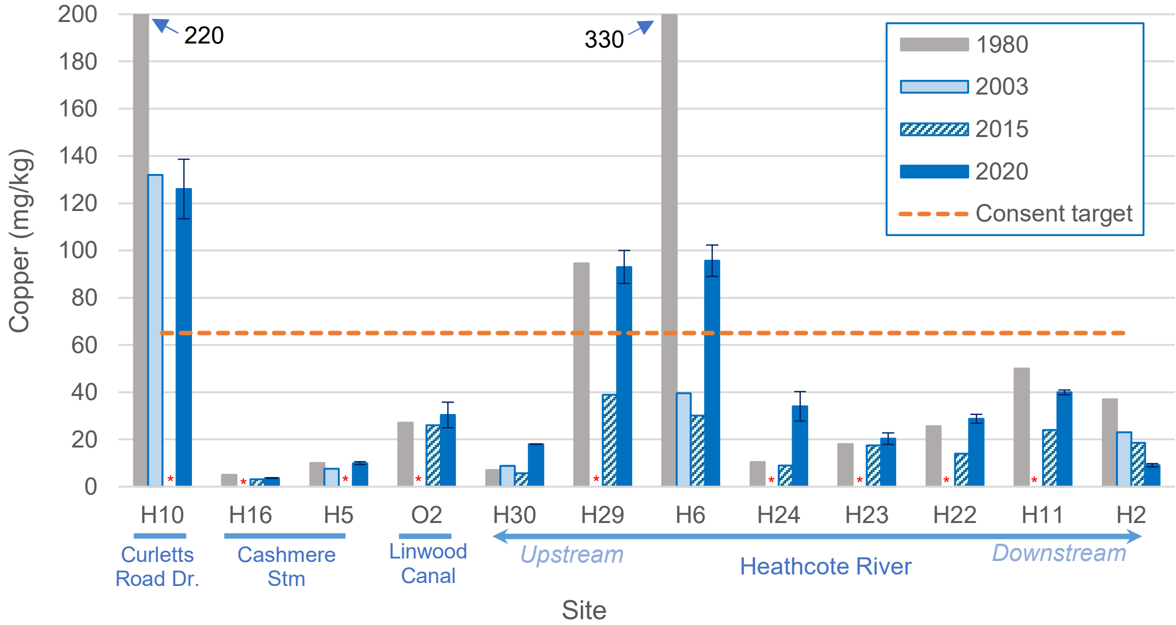

Figure 17: Sediment copper concentrations compared to consent attribute target levels. Data are means ±1 SE for 2020 and single grab samples for previous years. Asterisks indicate no data collected for that year.

Sediment lead concentrations have also varied considerably over time, with numerous sites exceeding the consent attribute target level, but no sites have exceeded the GV-high level since the 1980s (Figure 18). The most notable trend over time is that lead concentrations declined at most sites between 1980 and subsequent monitoring in 2003, 2015, and 2020. Mean lead concentration reduced by 78% for the ten sites with lead data for 1980 and 2020, declining from 202 mg/kg in 1980 to 45 mg/kg in 2020. There was no overall increasing or decreasing trend in lead concentrations across sites between 2015 and 2020.

Zinc concentrations in sediment were higher in 2020 at nine out of 12 sites sampled in 1980, two out of five sites sampled in 2003, and at nine of the ten sites sampled in 2015 and 2020 (Figure 19). At the five sites sampled in both 2003 and 2020, mean zinc concentrations were 420 mg/kg in 2003 and 355 mg/kg in 2020. However, at the ten sites sampled in both 2015 and 2020, mean zinc concentrations were 204 mg/kg in 2015, and 401 mg/kg in 2020. Taken at face value, the data suggest zinc concentrations, and by implication the catchment zinc load, increased from 2015 and 2020. However, comparison of mud (particles < 63 µm) content across sampling years indicates that there was also greater mud content in 2020 samples compared with previous years at many sites (Figure 20). At the ten sites sampled in both 2015 and 2020, mean mud content was 20% in 2015 and 31% in 2020. Metal concentrations are typically higher in sediments with a higher proportion of mud, because the contaminant binding capacity of sediments increases with decreasing grain size (ANZECC 2018). Therefore, greater zinc concentrations in 2020 reflect the greater proportion of fine sediments present, which act as a magnet or sponge for heavy metals.

Normalising zinc concentrations to 1% mud (as per Gadd 2015) shows the impact of sediment texture on zinc levels (Figure 21). Thus, zinc concentrations normalised to mud content were lower in 2020 at six out of 11 sites sampled in 1980, four out of five sites in 2003, and five out of ten sites sampled in both 2015 and 2020. Normalising zinc concentrations to mud content may not change zinc toxicity, but it does help indicate potential metal sources. The fact that there is no overall increasing or decreasing trends of normalised zinc concentrations suggests no overall trend in the supply of zinc to the Heathcote catchment.

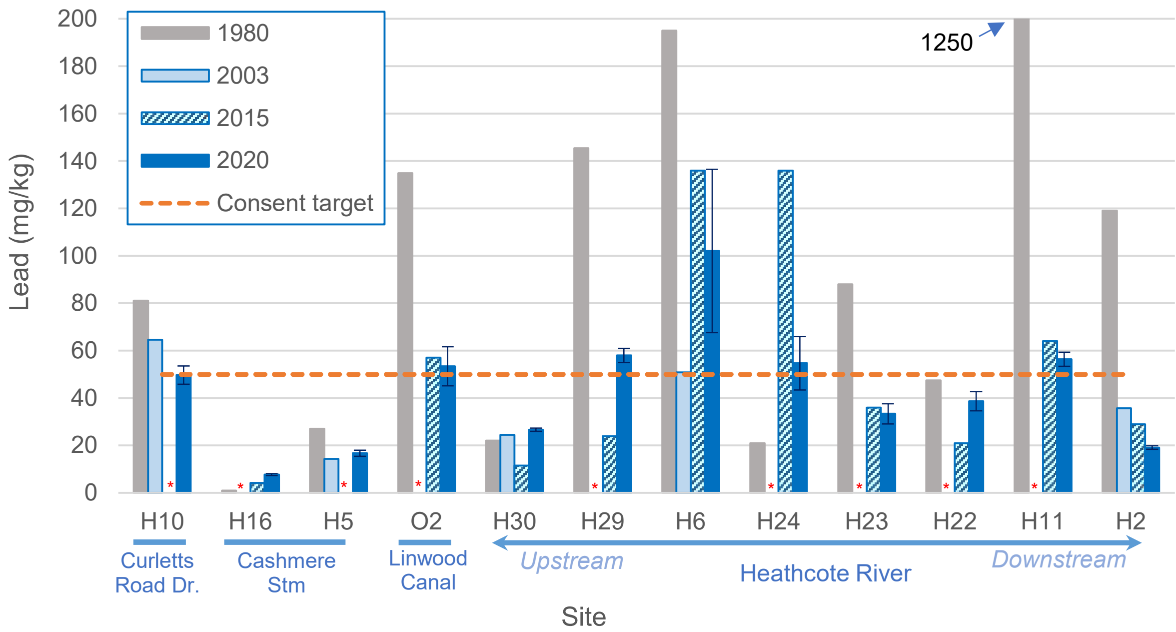

Figure 18: Sediment lead concentrations compared to consent target attribute levels. Data are means ±1 SE for 2020 and single grab samples for previous years.

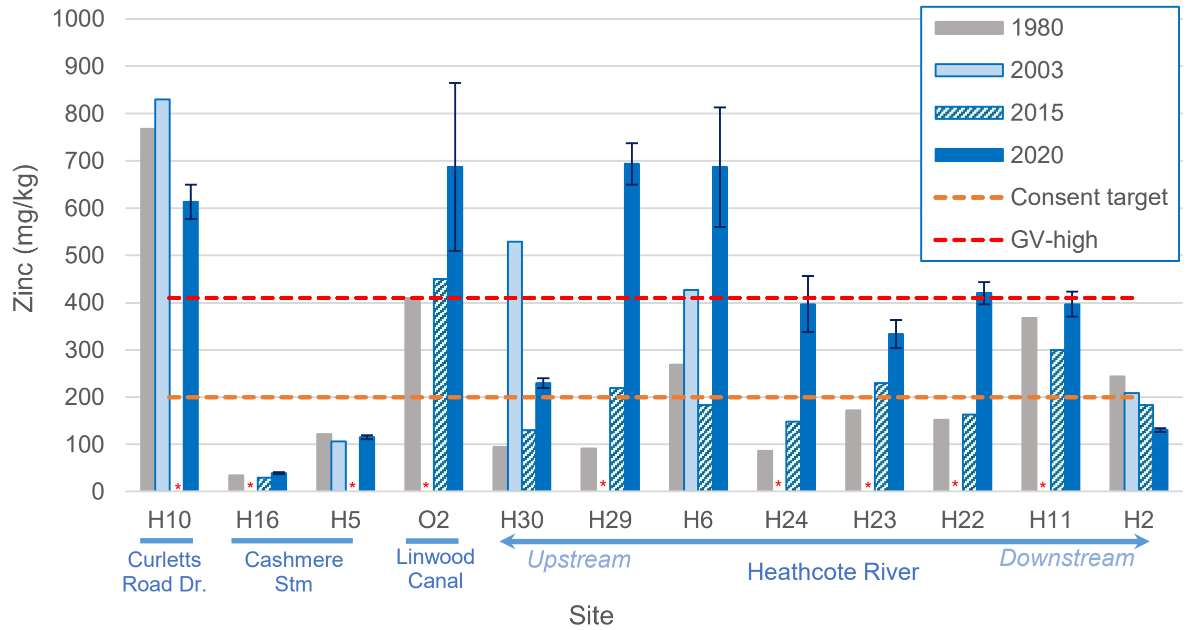

Figure 19: Sediment zinc concentrations compared to consent target attribute levels and the ANZECC (2018) high level guideline (GV-high). Data are means ±1 SE for 2020 and single grab samples for previous years. Asterisks indicate no data for that year.

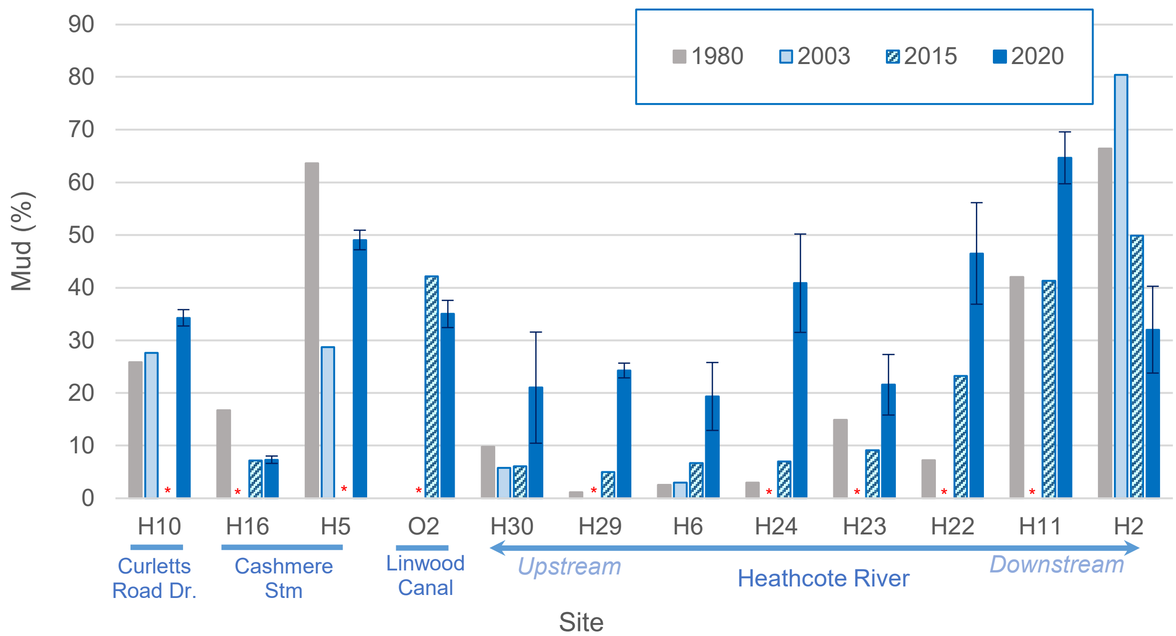

Figure 20: Percent mud (<63 µm) in sediment samples. Data are means ±1 SE for 2020 and single grab samples for previous years. Asterisks indicate no data for that year.

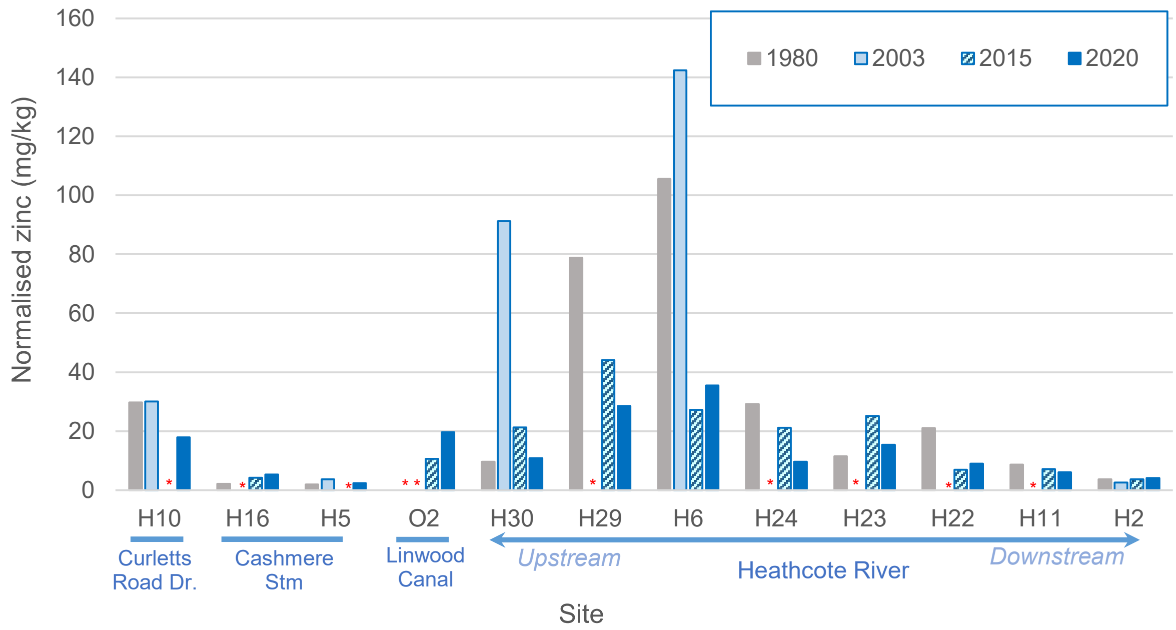

Figure 21: Zinc concentrations normalised to percent content. Data are means for 2020 and single grab samples for previous years. Asterisks indicate no data for that year.

Total PAHs were low and variable at most sites sampled in 2015 and 2020 (Figure 22). Total PAHs exceeded the consent attribute target level at three of the ten sites monitored in 2015 and was at the target limit of 10 mg/kg at one site in 2020.

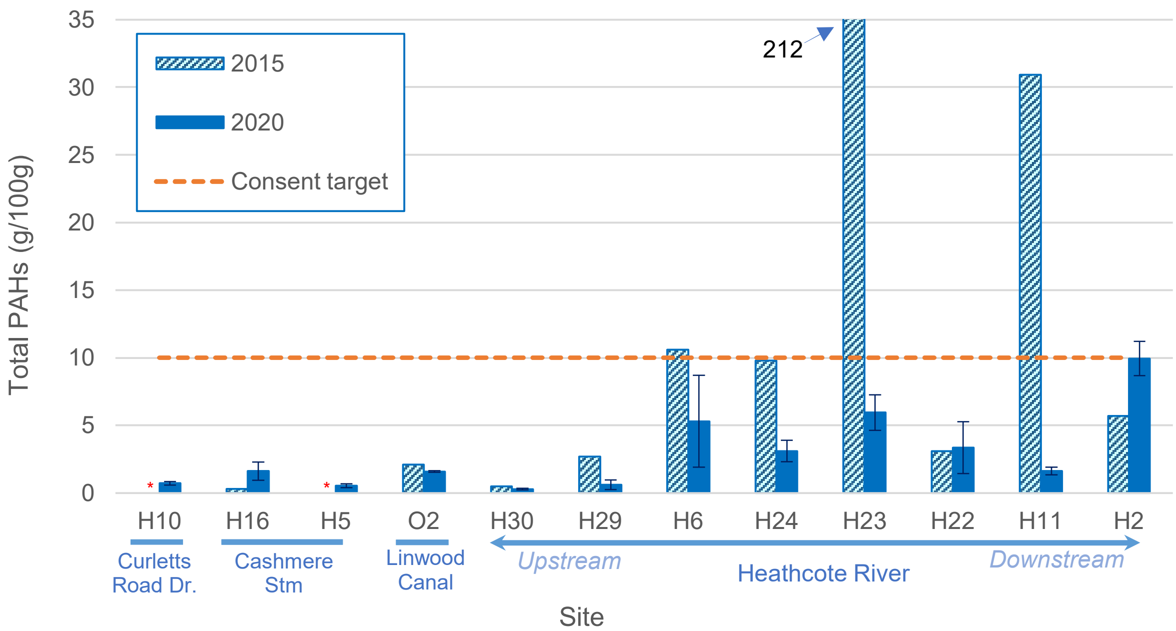

Figure 22: Sediment total PAH concentrations compared to consent target attribute levels. Data are means ±1 SE for 2020 and single grab samples for 1980 and 2015. Asterisks indicate no data for that year.

Sediment phosphorus concentrations increased between 2015 and 2020 at seven of the ten sites sampled on both occasions. Phosphorus is closely associated with fine sediments, and greater phosphorus content in 2020 reflects the greater proportion of mud in samples from 2020.

3.3. Macroinvertebrates

Invertebrate taxa richness in 2020 ranged from a low of 11 at Site H24 (Heathcote River at Barrington Street) to a high of 26 at Site H17 (Steamwharf Stream, Figure 23). For the nine sites with invertebrate data from all three sampling occasions, mean taxa richness per site was 23 in 2010, 15 in 2015, and 15 in 2020. Higher taxa richness in 2010 reflects the greater area sampled per site in 2010 (a total of 1.35 m² sampled per site) compared to 2015 and 2020 (0.6 m² sampled per site). The most marked difference in taxa richness between 2015 and 2020 was observed at Site H17 (Steamwharf Stream), where the taxa count increased from 15 taxa in 2015 to 26 in 2020, despite the same sampling effort (Figure 23). In 2015 Site H17 had the highest cover with long filamentous algae and the greatest fine sediment depths of any sites sampled, and water depths were considerably shallower than in 2020, all of which may have reduced habitat quality for invertebrates compared to 2020. There was no indication of an overall increasing or decreasing trend in taxa richness across monitoring sites between 2015 and 2020.

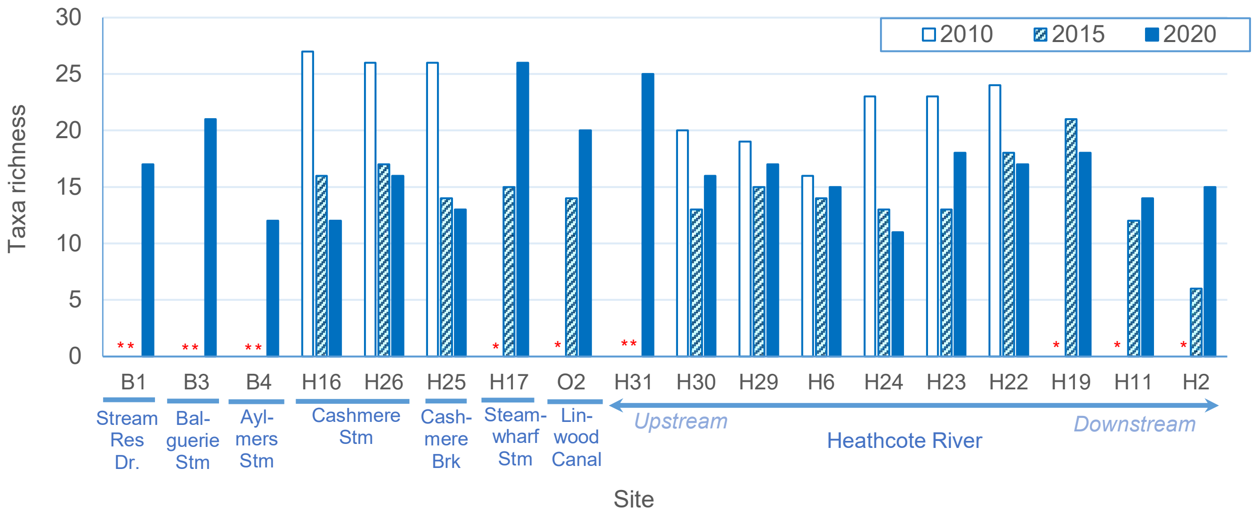

Figure 23: Invertebrate taxa richness at each monitoring site. Asterisks indicate no data collected for that year.

Invertebrate community composition at the Heathcote catchment and Linwood Canal sites was similar in 2020 to previous years (Figure 24). The fauna was dominated by the amphipod crustacean *Paracalliope fluviatilis*, the common mud snail *Potamopyrgus antipodarum*, and ostracod crustaceans. These three pollution-tolerant taxa are very common in Christchurch waterways, and they have comprised over 70% of the total invertebrate count at the Heathcote catchment and Linwood Canal monitoring sites each year. The cased caddisfly *Hudsonema amabile* is the only EPT taxon to be in the top ten most abundant taxa, although it has always comprised <3% of total abundance. Seven of the ten most abundant taxa in 2020 had MCI scores of 3 or lower, which indicates they are very tolerant of poor water quality and habitat quality. The highest MCI score amongst the ten most abundant taxa was for *H. amabile*, which has an MCI score of 6.

P. antipodarum snails and ostracod crustaceans also dominated the invertebrate community at the three Banks Peninsula sites in 2020, comprising 64% of the total invertebrate count (Figure 25). However, the pollution-sensitive mayfly *Deleatidium* (MCI = 8) was the third most abundant taxon, with two other EPT taxa also in the top ten: the cased caddisfly *Olinga* (MCI = 9) and the stonefly *Austroperla* (MCI = 9). Overall, the Banks Peninsula sites were dominated by pollution-tolerant taxa, but they have a greater range of pollution-sensitive taxa than sites in the Heathcote or Linwood Canal catchments.

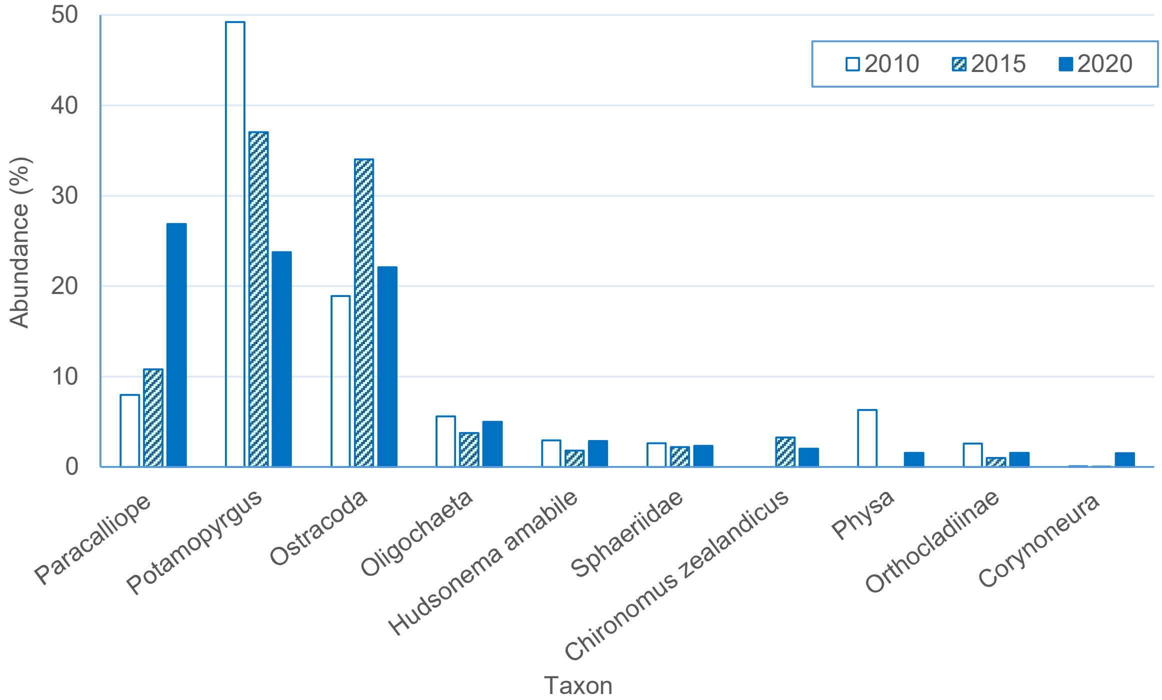

Figure 24: Abundance of the ten most common taxa across all sites (excluding Banks Peninsula) in 2020 compared to previous years.

Only two pollution-sensitive invertebrate taxa (MCI scores ≥7) were recorded from the Heathcote and Linwood Canal catchments in 2020: the free-living caddisfly *Psilochorema bidens* and cranefly (Tipulidae) larvae in the Eriopterini tribe (MCI = 9, Table 8). While *P. bidens* has previously been recorded at these monitoring sites, 2020 was the first year that Eriopterini were recorded. Eriopterini have an MCI score of 9 (out of a maximum possible of 10) and five specimens were recorded at Site H23 (Heathcote River at the showgrounds). A single specimen of *P. bidens* was recorded at Site 25 (Cashmere Brook) in 2015, but none were recorded in 2010 or 2020. This suggests that *P. bidens* is present in very low numbers at this site and their absence in 2020 does not necessarily mean they are locally extinct.

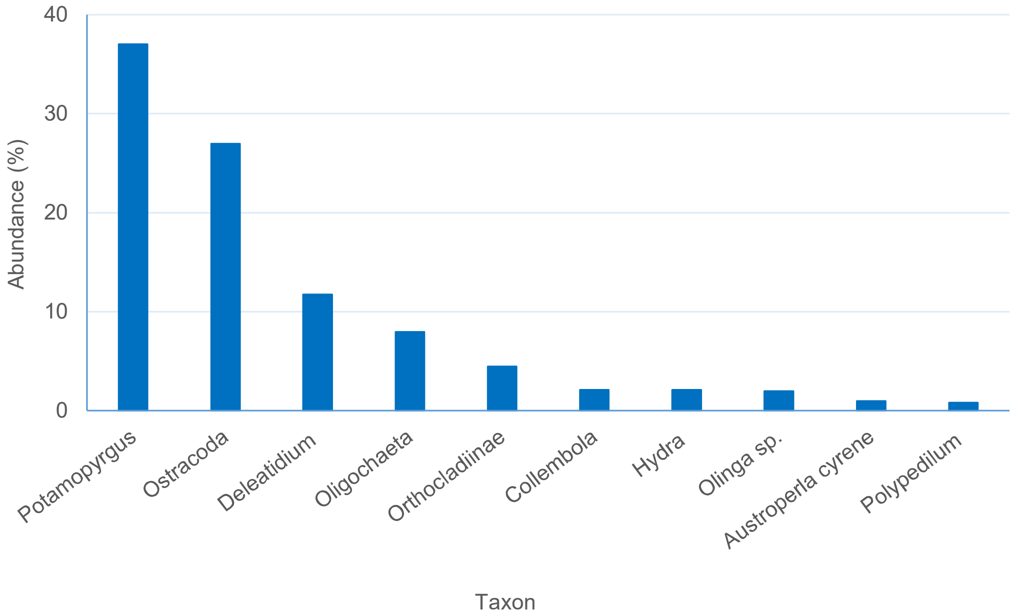

Figure 25: Abundance of the ten most common taxa across the three Banks Peninsula sites in 2020.

In the Heathcote and Linwood Canal catchments, four of the 15 sites monitored in 2020 recorded pollution-sensitive taxa, compared with four of 15 sites monitored in 2015 and three of the ten sites monitored in 2010. This indicates that there was no overall increasing or decreasing trend in the presence of sensitive taxa over the ten-year monitoring period.

A total of ten pollution-sensitive taxa (MCI scores ≥ 7) were recorded from the three Banks Peninsula sites in 2020 (Table 8). Pollution-sensitive taxa included one mayfly taxon (*Deleatidium*), one stonefly species (*Austroperla cyrene*), six caddisfly taxa (*Olinga*, *Polyplectropus*, *Psilochorema bidens*, *P. tauroru*, *Tarapsyche olis*, and *Philoreithrus agilis*), the net-wing midge *Neocururpira chiltoni*, and Hydraenidae beetles. The number of pollution sensitive taxa recorded at each site ranged from one at Site B4 (Aylmers Stream) to seven taxa at Site B3 (Balguerie Stream). Site B3 was also the only site where *N. chiltoni* was recorded, which is endemic to Banks Peninsula and has an At Risk – Naturally Uncommon threat status (Andrew et al. 2012). No other invertebrate taxa with a conservation status were recorded during invertebrate sampling.

Table 8: Pollution-sensitive invertebrate taxa (MCI scores[1] of ≥7) at monitoring sites from 2010 to 2020.

Waterway	Site	2010	2015	2020
Stream Reserve Drain (Governors Bay)	B1	No data	No data	*Deleatidium* *Austroperla cyrene* *Polyplectropus* *Psilochorema tautoru* *Tarapsyche olis*
Balguerie Stream (Akaroa)	B3	No data	No data	*Deleatidium* *Archichauliodes diversus* *Hydraenidae* *Neocurupira chiltoni* *Olinga* *Philorheithrus agilis* *Psilochorema bidens*
Aylmers Stream (Akaroa)	B4	No data	No data	*Deleatidium*
Cashmere Stream	H16	*P. bidens*	*P. bidens*	*P. bidens*
	H26	*P. bidens*	*P. bidens*	*P. bidens*
Cashmere Brook	H25	No taxa with MCI ≥ 7	*P. bidens*	No taxa with MCI ≥ 7
Heathcote River	H6	No taxa with MCI ≥ 7	*P. bidens*	*P. bidens*
	H23	No taxa with MCI ≥ 7	No taxa with MCI ≥ 7	Eriopterini

Note: Only sites with MCI scores ≥ 7 on at least one monitoring occasion are shown. Sites with no data were not sampled that year.

Caddisflies (Trichoptera) are the only EPT taxon recorded from the Heathcote and Linwood Canal catchments since regular monitoring commenced in 2010. However, mayflies (Ephemeroptera) and stoneflies (Plecoptera), as well as caddisflies, were recorded from the Banks Peninsula waterways. EPT taxa richness is very low overall in the Heathcote and Linwood Canal catchments and relatively high in the Banks Peninsula waterways (Figure 26). Low EPT taxa richness is typical for urban waterways such as those in the Heathcote and Linwood Canal catchments (Suren 2000). In 2020, EPT taxa richness ranged from a minimum of zero at Sites H2 (Heathcote River at Tunnel Road), H11 (Heathcote at Catherine Street) and O2 (Linwood Canal), to a maximum of six taxa at Site B3 (Balguerie Stream, Figure 26). EPT taxa richness in 2020 followed a similar pattern to previous years, where richness is typically greater in the upper reaches of the Heathcote River and Cashmere Stream and lowest in Linwood Canal and the estuarine reaches of the Heathcote River (Sites H2 and H11). The lack of EPT taxa in Linwood Canal and the estuarine reaches of the Heathcote River reflect the fine bed sediments and tidal influence at these sites. There is no indication of an increasing or decreasing trend in EPT taxa richness over time across the sites sampled.

[1] Hard bottom MCI scores used.

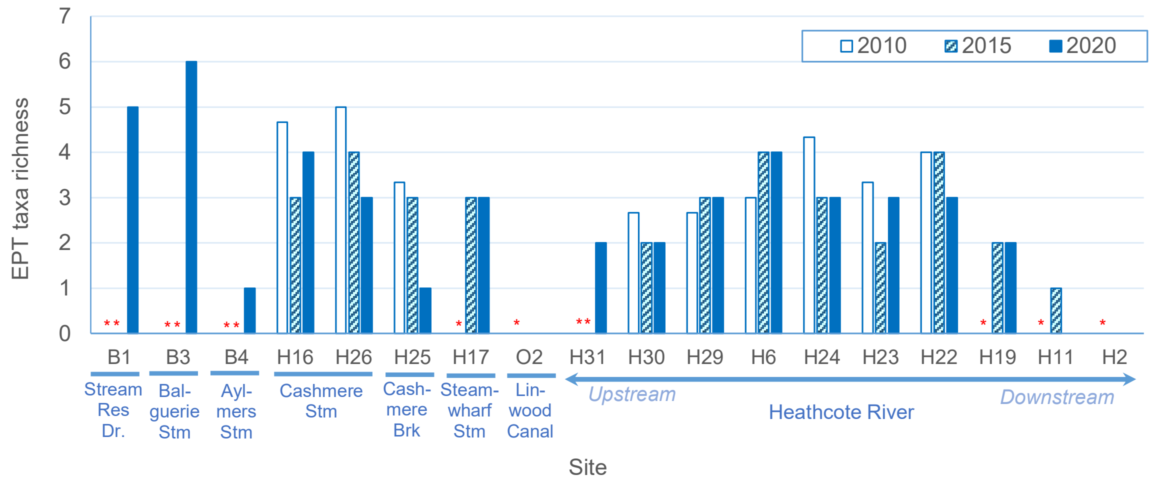

Figure 26: EPT taxa richness at each monitoring site. Asterisks indicate no data collected for that year.

Percent EPT abundance is low overall at all the sites sampled, with all sites recording less than 31% EPT abundance and most sites with less than 20% EPT, for all monitoring years (Figure 27). In 2020, percent EPT ranged from a low of zero at several sites to a maximum of 30% at Site B3 (Balguerie Stream). EPT abundance has fluctuated over the years, but there is no indication of an overall increasing or decreasing trend (Figure 27).

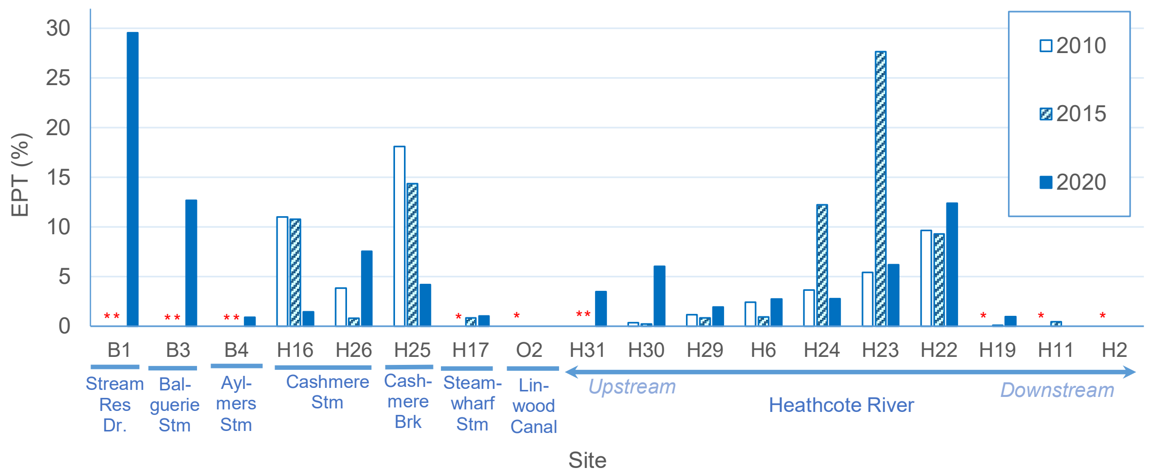

Figure 27: Percent EPT abundance at each monitoring site. Asterisks indicate no data collected for that year.

MCI scores at wadeable, non-tidal sites in 2020 ranged from a low of 45 at Site O2 (Linwood Canal) to a high of 106 at Site B3 (Balguerie Stream, Figure 28). As with previous years, all Heathcote and Linwood Canal catchment sites had MCI scores below 80, which is indicative of poor quality (Table 4). The only exception was Site H16 (Cashmere Stream at Sutherlands Road), which had an MCI score of 80, which puts it at the bottom of the "fair" category (Figure 28). Sites B1 (Stream Reserve Drain) and B3 (Balguerie Stream) were the only sites to record MCI scores >100, which is indicative of good quality. There is no indication of an overall increasing or decreasing trend in MCI scores at the Heathcote and Linwood Canal catchment monitoring sites over time.

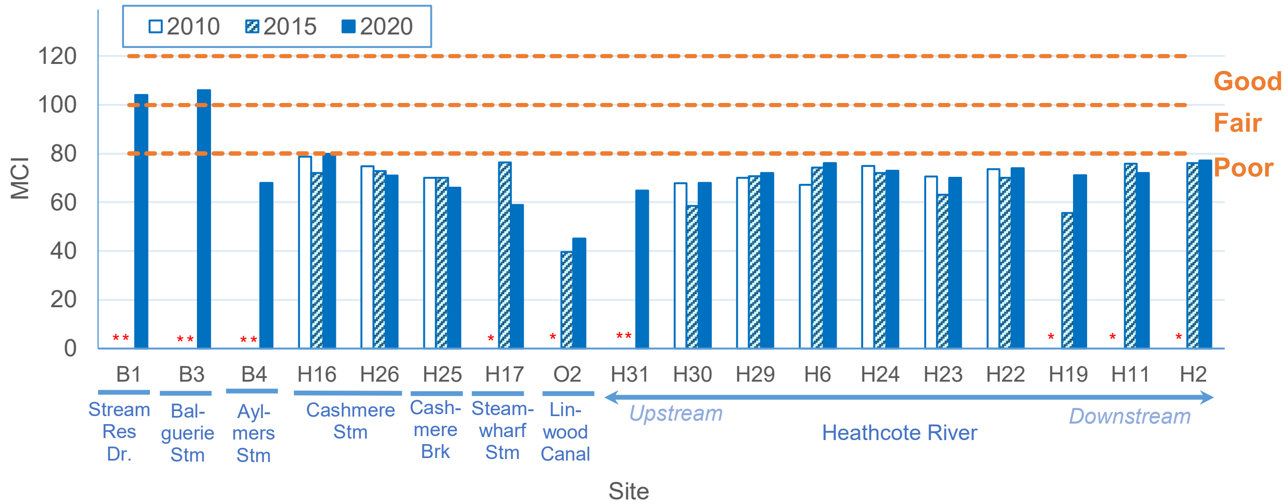

Figure 28: MCI scores at each monitoring site. Asterisks indicate no data collected for that year.

QMCI scores in 2020 met or exceeded consent target levels at 5 of the 15 wadeable Heathcote and Linwood Canal monitoring sites, and did not meet the consent target level at any of the three Banks Peninsula streams (Figure 29). Overall, QMCI scores at all sites are indicative of fair (QMCI 4 to 5) or poor (QMCI <4) quality, with no sites having QMCI scores that are indicative of good or better quality (i.e., QMCI scores >5). For the nine sites with invertebrate data for all three monitoring years, mean QMCI scores were lowest overall in 2015 (mean = 3.5) and highest in 2020 (mean = 4.0), but there was no indication of an overall increasing or decreasing trend.

Freshwater crayfish (*Paranephrops zealandicus*), also known as wai kōura or kēwai, were caught during electric fishing in 2020 at Site H24 (Heathcote River at Barrington Street) and Site H26 (Cashmere Stream at Penruddock Rise, Figure 30). Wai kōura are valued mahinga kai and they also have an At Risk – Declining threat status (Grainger et al. 2018). Wai kōura were also caught previously at Site H24 in 2015 (Boffa 2015), and at Site H23 (Heathcote at Colombo Street), and at several sites along Cashmere Stream in 2011 (Taylor & Blair 2012). Wai kōura were also observed in Cashmere Stream immediately upstream of its confluence with Hoon Hay Valley Drain, during a separate survey in 2020 (Instream 2020a).

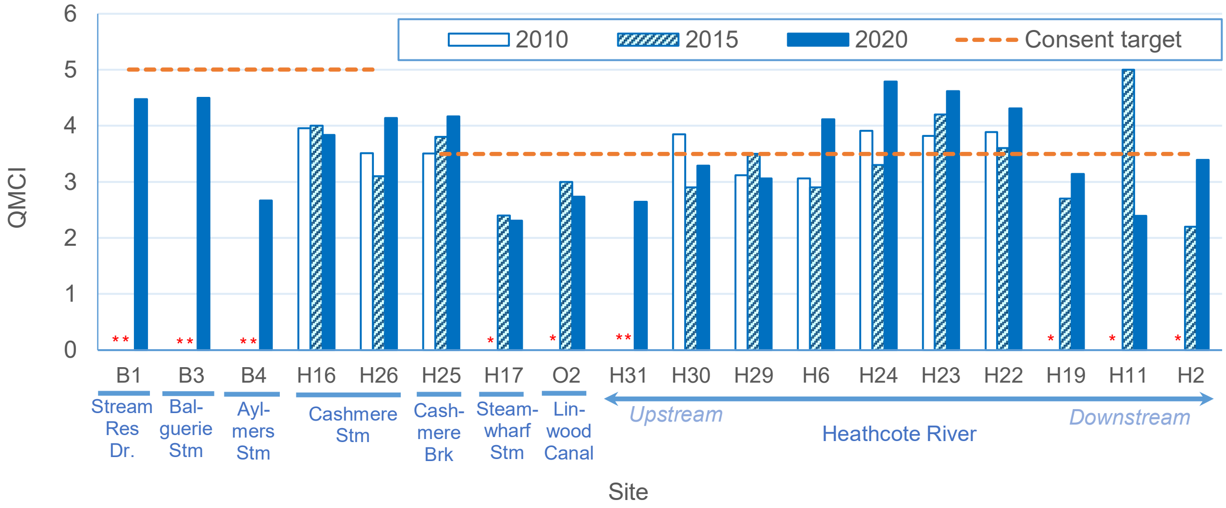

Figure 29: QMCI scores at each monitoring site, compared with consent attribute target levels (dashed lines). Asterisks indicate no data collected for that year.

Freshwater mussels (*Echyridella menziesii*), also known as kākahi, are abundant in the lower reaches of Cashmere Stream (Instream 2020a), and they have recently been found in the lower Heathcote River (see Section 4.1), but no live kākahi have been detected during routine invertebrate monitoring. Kākahi are mahinga kai and are also of conservation interest, with an At Risk – Declining threat status (Grainger et al. 2018).

Figure 30: Wai kōura or kēwai (freshwater crayfish) from the Heathcote River at Barrington Street (Site H24).

The NMDS ordination yielded a two-dimensional solution with a stress value of 0.19 for all sites and 0.18 for the wadeable sites only, indicating a fair relationship with the underlying similarity matrix (Clarke 1993). Site H2 (Heathcote River at Tunnel Road) is the most downstream site in the Heathcote River and it was located in the upper right of the ordination plot, reflecting its distinctive estuarine fauna (Figure 31). Site 11 (Heathcote at Catherine Street) was located far to the left of the ordination in 2015, because of the near-complete dominance of *Paracallipe* amphipods in the sample. Samples from Site O2 (Linwood Canal) in 2015 and 2020 were located close together, but apart from the other sites, mainly due to the abundance of the pollution-tolerant midge *Chironomus zelandicus* at this site. *C. zealandicus* can be indicative of degraded conditions because it is tolerant of very low dissolved oxygen concentrations.

Of interest is whether there were any major shifts in invertebrate composition over time that could suggest a change in environmental conditions. The greatest shifts in community composition between 2015 and 2020 occurred at Site H11 (Heathcote at Catherine Street), Site H26 (Cashmere Stream at Penruddock Rise), Site H29 (Heathcote at Spreydon Domain), Site H17 (Steamwharf Stream), and Site H6 (Heathcote at Rose Street). However, in all cases, the shift was associated with a change in the relative dominance of *P. antipodarum*, *Paracalliope*, or Ostracoda, which are all pollution-tolerant taxa. There was no clear declining or improving trend in invertebrate community composition over time at any site, with considerable overlap of samples from different years in ordination space.

Axis 2 scores were positively correlated ($P<0.01$) with water velocity, total macrophyte cover, and total PAHs, and negatively correlated ($P<0.01$) with percent bed cover with silt and sand (<2 mm).

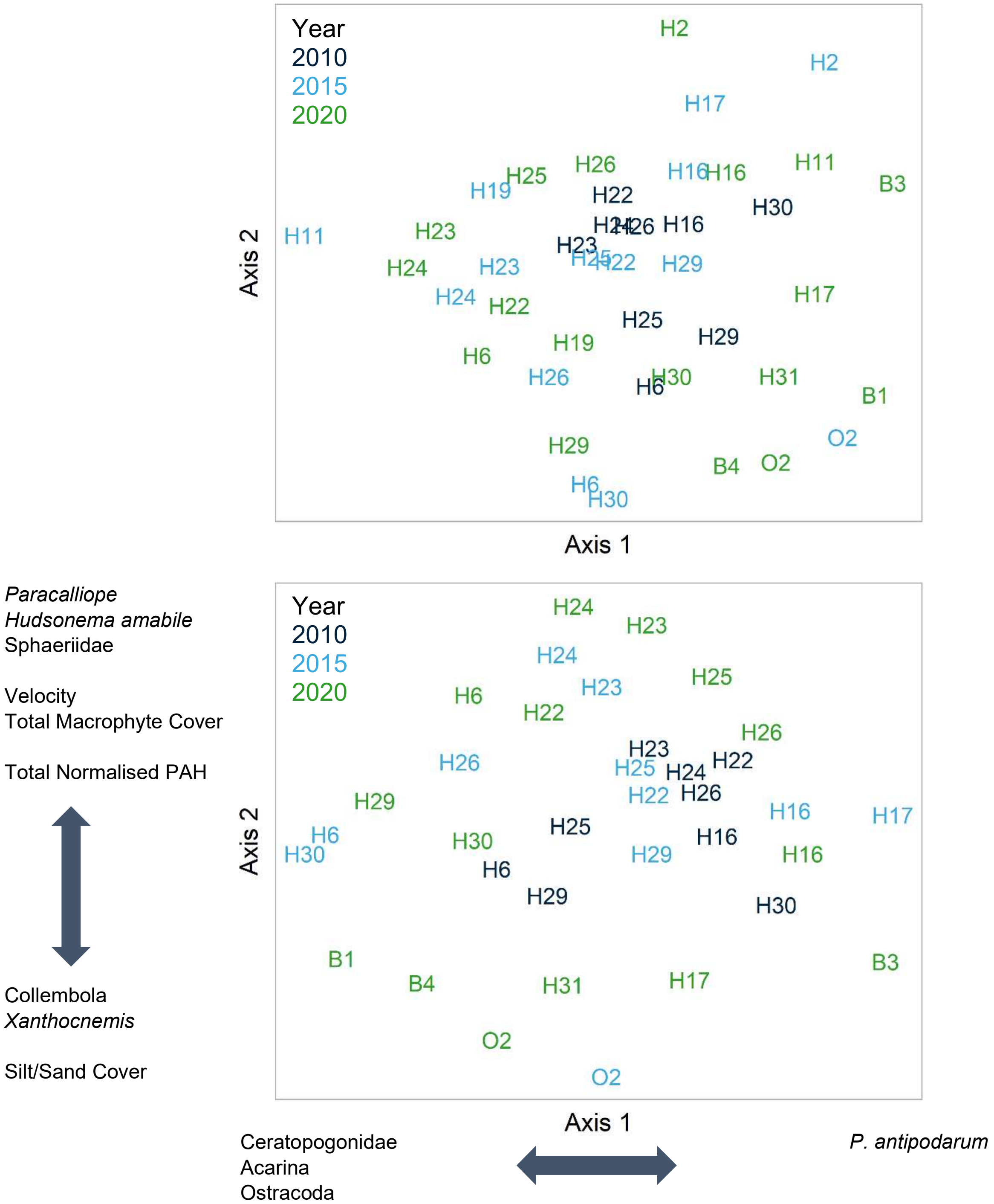

Figure 31: NMDS plot of invertebrate communities for all sites (top) and wadeable sites only (bottom). Coloured text indicates site codes and colours refer to sampling years. Habitat parameters and species most strongly correlated with wadeable site axis scores (P<0.01) are shown. Plot stress is 0.19 for all sites, and 0.18 for wadeable sites.

3.4. Fish

A total of 14 fish species were caught across the 18 sites sampled in 2020, with 11 species caught in the Heathcote and Linwood Canal catchments and seven caught in the three Banks Peninsula streams. All the fish species caught were native, except for one introduced species, brown trout (Figure 32, Figure 33, Table 9,). Shortfin eels (*Anguilla australis*) were the most widespread species and they were found at 16 of the 18 sites. Common bullies (*Gobiomorphus cotidianus*) were found at 14 of the sites and they were the most abundant fish species overall. Longfin eel (*A. dieffenbachii*) were also relatively widespread, being found at 12 sites, but they were generally found in low numbers.

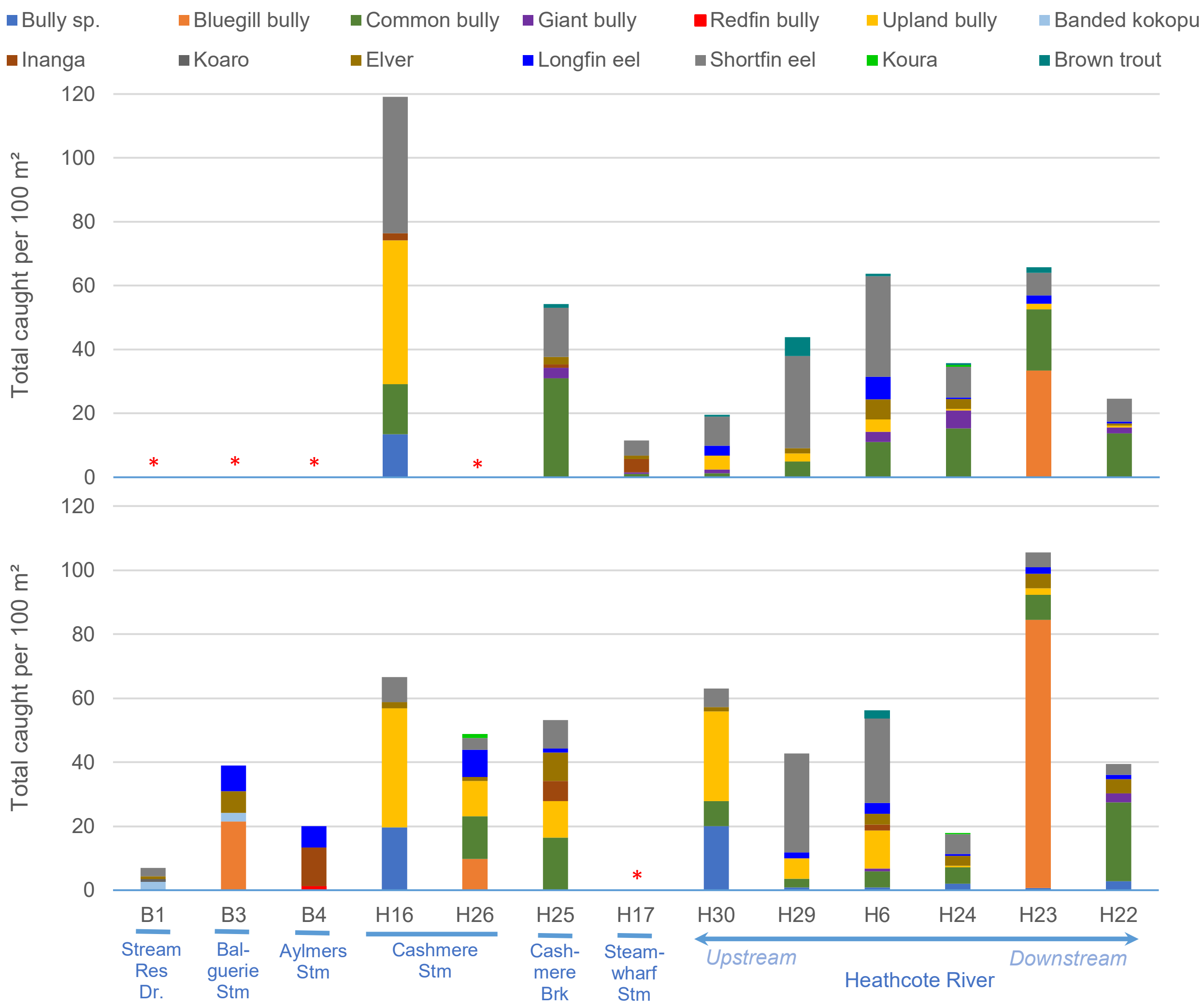

Figure 32: Comparison of electric fishing results at wadeable sites from 2015 (top) and 2020 (bottom). Asterisks indicates no electric fishing data available for that date.

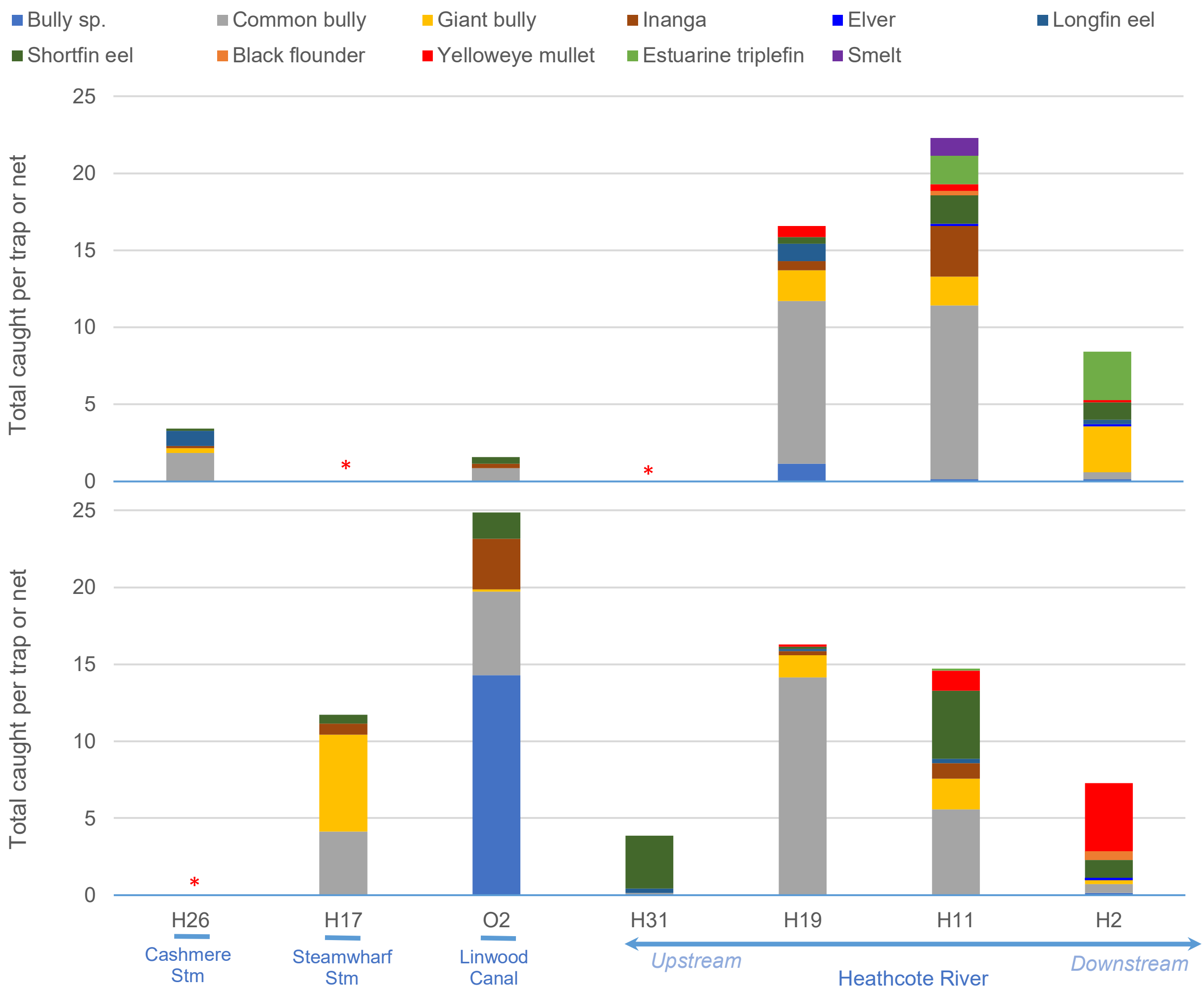

Figure 33: Comparison of trapping results at non-wadeable sites from 2015 (top) and 2020 (bottom). Asterisk indicates no trapping data available for that date. Sites H17 in 2015 and H26 in 2020 were sampled by electric fishing.

Fish species' distributions in 2020 followed distinctive patterns, based on habitat preferences. Thus, estuarine triplefin (*Forsterygion nigripenne*, also known as cockabullies), black flounder (*Rhombosolea retiaria*), and yelloweye mullet (*Aldrichetta forsteri*) are typically most abundant in estuarine environments, and they were only found at the two most downstream sites in the Heathcote River (Table 9). Bluegill bullies (*G. hubbsi*) are swift-water specialists and they were only found amongst riffle habitats at Sites B3 (Balguerie Stream), H26 (Cashmere Stream at Penruddock Rise), and H23 (Heathcote River at Colombo Street). Redfin bully (*G. huttoni*), banded kokopu (*Galaxias fasciatus*), and koaro (*G. brevipinnis*) were restricted to Banks Peninsula sites. These three species are widespread on Banks Peninsula, but they are very uncommon in Christchurch waterways. Other fish species were more widespread, reflecting a combination of suitable habitat and a general lack of significant fish barriers downstream of most monitoring locations.

Table 9: Fish caught during electric fishing and trapping surveys in 2020. Data are number of fish caught, with the size range (in mm) in brackets.

Waterway	Site	Bluegill bully	Common bully	Giant bully	Redfin bully	Upland bully	Bully sp.	Banded kokopu	Inanga	Koaro	Longfin eel	Shortfin eel	Elver	Black flounder	Yelloweye mullet	Wai kōura	Brown trout	Estuarine triplefin
Stream Reserve Drain	B1							3 (54-70)		1 (155)		3 (218-284)	1 (118)					
Balguerie Stream	B3	16 (44-69)						2 (129-170)			6 (364-781)		5 (103-111)					
Aylmers Stream	B4				1 (100)				9 (50-60)		5 (268-490)							
Cashmere Stream	H16					19 (37-62)	10 (22-79)					4 (149-512)	1 (110)					
	H26	8 (45-53)	11 (42-115)			9 (46-63)					7 (251-1108)	3 (211-240)	1 (97)			1 (32)		
Cashmere Brook	H25		13 (54-107)			9 (50-71)			5 (66-94)		1 (143)	7 (139-673)	7 (91-105)					
Steamwharf Stream	H17		29 (76-115)	44 (112-164)					5 (79-128)			4 (467-709)						
Linwood Canal	O2		38 (40-92)	1 (106)			100 (23-74)		23 (27-90)			12 (124-555)						
Heathcote River	H31		1 (110)								2 (574-624)	24 (388-870)						
	H30		11 (40-49)			39 (37-64)	28 (25-38)					8 (182-466)	2 (109-112)					
upstream	H29		3 (105-110)			7 (38-66)	1 (38)				2 (198-224)	34 (111-456)						
	H6		6 (75-114)	1 (171)		14 (36-60)	1 (30)		2 (50-60)		4 (118-745)	31 (102-560)	4 (76-116)				3 (262-324)	
	H24		10 (50-112)			1 (55)	4 (35-41)				1 (685)	12 (145-827)	6 (99-135)			1 (31)		
	H23	127 (35-63)	12 (44-104)			3 (51-57)	1 (32)				3 (188-461)	7 (137-470)	7 (91-140)					
	H22		51 (40-128)	6 (102-159)			6 (30-46)				3 (379-568)	7 (108-448)	9 (86-131)					
	H19		99 (66-120)	10 (115-158)					2 (95-105)		1 (351)	1 (690)						
downstream	H11		39 (64-96)	14 (95-170)					7 (64-110)		2 (345-470)	31 (215-878)			9 (111-229)			1 (61)
	H2		4 (73-99)	2 (131-164)			1 (44)					8 (155-825)	1 (102)	4 (31-55)	31 (93-324)			

A total of four native fish species with a conservation status were caught from the Heathcote and Linwood Canal catchments in 2020 (Table 10). These species are bluegill bully, giant bully (*G. gobioides*), inanga (*G. maculatus*), and longfin eel, which all have an At Risk threat status (Dunn et al. 2018). All these species were also recorded in 2015. An additional At Risk species, koaro, was recorded from Site B1 (Stream Reserve Drain), one of the new Banks Peninsula sites sampled in 2020.

Table 10: Conservation status and distribution of fish species and wai kōura caught in 2020.

Common name	Scientific name	Conservation status	River Distribution
Common bully	*Gobiomorphus cotidianus*	Not threatened	Widespread
Upland bully	*G. breviceps*	Not threatened	Widespread
Giant bully	*G. gobioides*	Naturally uncommon	Widespread
Bluegill bully	*G. hubbsi*	Declining	Riffle Habitat, Banks Peninsula
Redfin bully	*G. huttoni*	Not threatened, Locally uncommon	Banks Peninsula (mostly)
Inanga	*Galaxias maculatus*	Declining	Widespread
Banded kokopu	*G. fasciatus*	Not threatened, Locally uncommon	Banks Peninsula (mostly)
Koaro	*G. brevipinnis*	Declining	Banks Peninsula
Shortfin eel	*Anguilla australis*	Not threatened	Widespread
Shortfin eel	*A. australis*	Not threatened	Widespread
Black flounder	*Rhombosolea retiaria*	Not threatened	Lower River
Yelloweye mullet	*Aldrichetta forsteri*	Not threatened	Lower River
Estuarine triplefin	*Forsterygion nigripenne*	Not threatened	Estuarine
Brown trout	*Salmo trutta*	Introduced and naturalised	Widespread
Wai kōura	*Paranephrops zealandicus*	Declining	Widespread (but sparse)

Note: Conservation status for fish is from Dunn et al. (2018) and for wai kōura is from Grainger et al (2018).

A similar core of fish species was caught in 2015 and 2020, and a mean of five fish species were caught per site in both years. However, fish taxa richness declined at eight sites between 2015 and 2020, and taxa richness increased at only two sites over the same period (Figure 34). The decline in taxa richness was mainly caused by reduced numbers of brown trout in 2020; brown trout were recorded at six sites in 2015, compared with only one site in 2020. Low trout numbers were caught at most sites in 2015, with a single fish caught at four of the six sites they were recorded, so even a small decline in their abundance would explain their absence at many sites in 2020. Electric fishing occurred later in the year, with cooler water temperatures in 2020, which is a likely cause of reduced trout numbers. This potential explanation is backed up by the observation of reduced densities of shortfin eel and common bully at most sites electric-fished in both 2015 and 2020 (Figure 35 and Figure 36). Shortfin eel and common bully were the two most abundant species overall and they are relatively pollution-tolerant (Joy & Death 2004). Hence, reduced numbers of shortfin eel and common bully in 2020 is more likely to do the later timing of the fish survey in 2020 than declining water quality or habitat over that period.

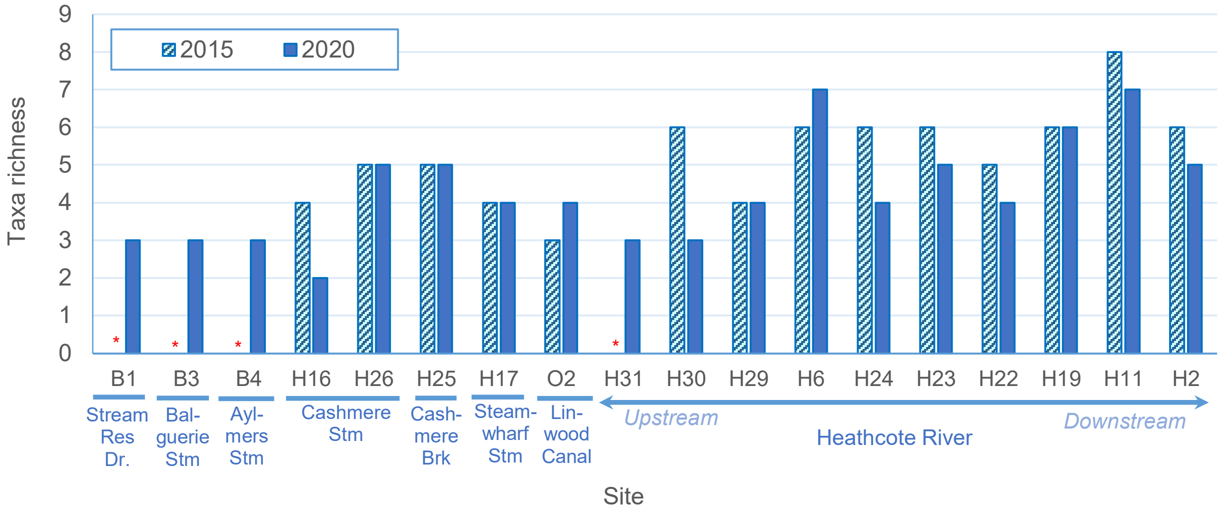

Figure 34: Number of fish species caught per site in 2015 and 2020. Asterisks indicate no fishing data available for that date.

Common smelt (*Retropinna retropinna*) was the only species caught in 2015 that was not caught in 2020. Common smelt were caught at one location in 2015, Site H11 (Heathcote River at Catherine Street). Common smelt are a predominantly estuarine species and, much like yelloweye mullet, their abundance at a given location can be highly variable, because they move about in shoals. The absence of common smelt in 2020 is therefore more likely due to random chance than an underlying habitat or water quality issue.

Four other fish species have been recorded in the New Zealand Freshwater Fish Database, but have not been caught during routine monitoring over the last ten years. This includes one introduced species, goldfish (*Carassius auratus*), and three native species, banded kokopu, redfin bully, and lamprey (*Geotria australis*). Goldfish were recorded once in the upper Heathcote River in 1989 and have not been recorded since. A single juvenile lamprey was caught from the Heathcote River downstream of Colombo Street (monitoring Site H23) during fish salvage work conducted for the bank stabilisation project. Redfin bully were also caught during fish salvage work, with three fish caught in Steamwharf Stream in 2018 and one fish caught in the Heathcote River beside Riverlaw Terrace in 2020 (Figure 37). Banded kokopu were caught in 2018 in Glenstrae Stream, which flows into the estuary at McCormacks Bay. Redfin bully and lamprey have turned up very infrequently in the Heathcote River and Steamwharf Stream, despite considerable fishing effort, so their numbers are clearly very low in both these catchments. However, banded kokopu have been observed in Glenstrae Stream numerous times over the last two years (G. Burrell pers. obs.), which suggests the presence of a stable population.

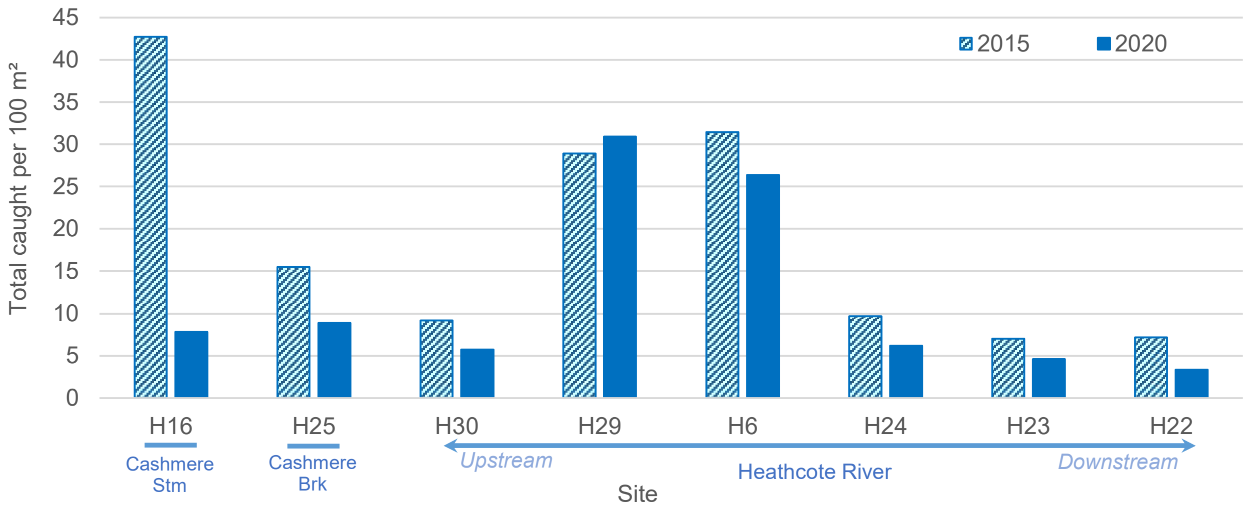

Figure 35: Shortfin eels caught per site during electric fishing in 2015 and 2020.

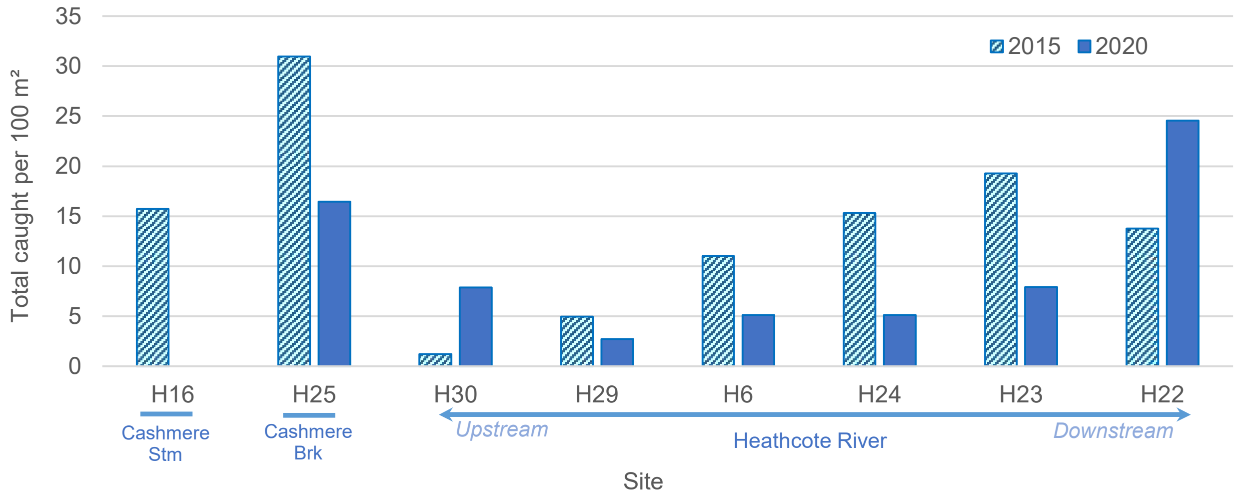

Figure 36: Common bullies caught per site during electric fishing in 2015 and 2020.

Taylor & Blair (2012) observed a decline in bluegill bully densities at several Heathcote catchment sites following the Canterbury earthquakes of 2010 and 2011, associated with earthquake-derived sedimentation. Affected sites included locations near Site H26 (Cashmere Stream at Penruddock Rise), H23 (Heathcote River at Colombo Street), and Site H22 (Heathcote River at Tennyson Street). Bluegill bullies were not caught at Site H22 in 2015 or 2020, which suggests persistent impacts of earthquake-related sedimentation on bluegill bully habitat at this location. In contrast, bluegill bully densities were markedly higher at Site H23 in 2020 (84 per 100 m²) than in 2015 (33 per 100 m²), or 2011 (<5 fish per 100 m²), and in both 2015 and 2020 they exceeded pre-earthquake densities of 15–20 fish per m² reported by Taylor & Blair (2012). Bluegill bully densities at Site H26 in 2020 were comparable to pre-earthquake, again suggesting population recovery at this site. These data suggest that, on balance, the bluegill bully population in the Heathcote catchment has recovered to pre-earthquake levels.

Overall, the Heathcote and Linwood Canal catchment fish community is similar to that present in other Christchurch urban waterways. However, the overall conservation value of these waterways is elevated by the presence of At Risk longfin eel, inanga, bluegill bully, and giant bully at monitoring sites, along with recent discoveries of Threatened lamprey, and locally uncommon redfin bully and banded kokopu. The fish fauna present in the three Banks Peninsula waterways is typical for small streams on Bank Peninsula but is distinct from most streams in Christchurch city.

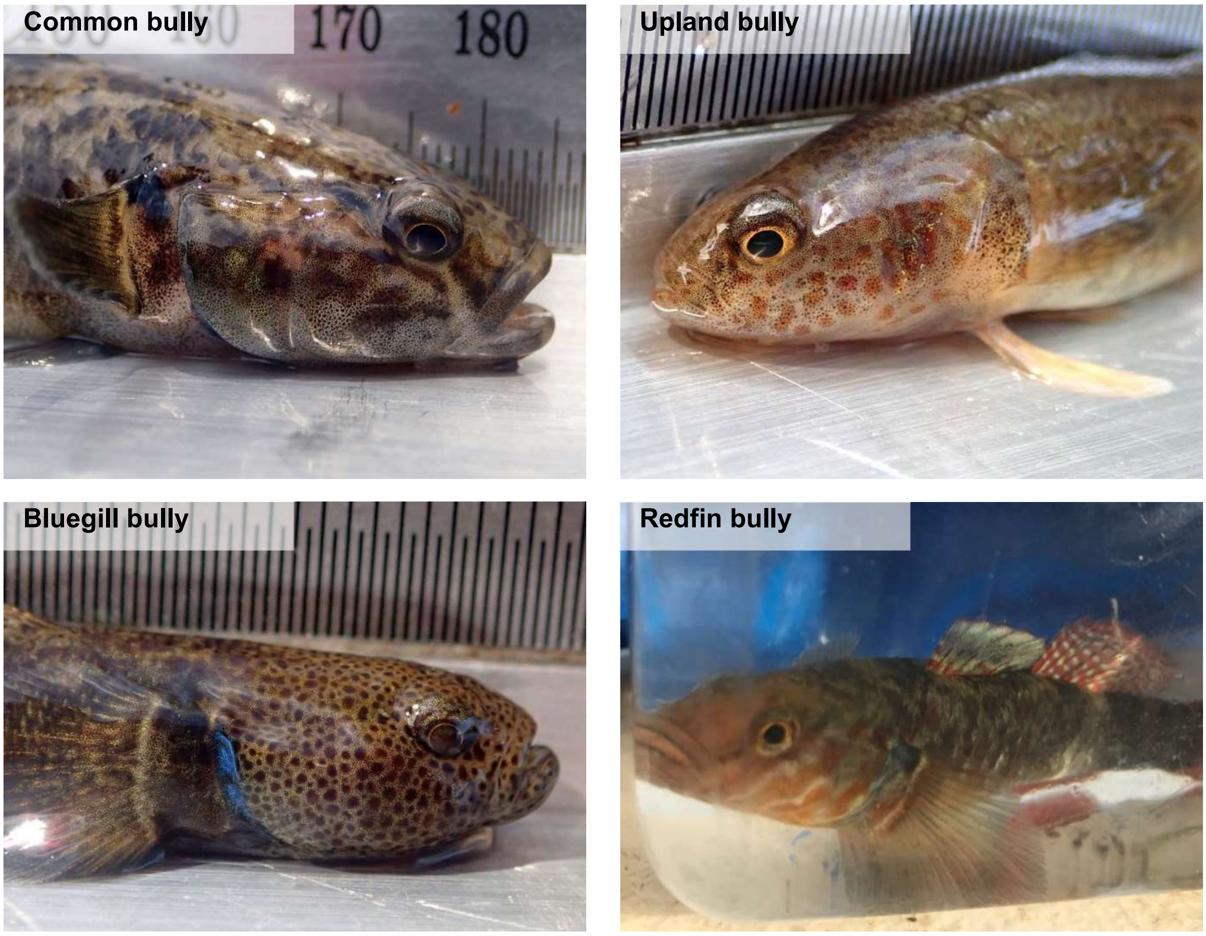

Figure 37: Different bully species caught in the Heathcote River catchment in 2020.

4. DISCUSSION

4.1. Current State and Trends in Aquatic Ecology

Monitoring data from 2020 indicate that instream and riparian habitat quality is similar to previous years at most of the Heathcote and Linwood Canal monitoring sites. The banks and beds of most waterways are comprised of natural earth and stone substrates. However, most sites have minimal buffering with riparian vegetation and have low levels of channel shading. Lack of shading is associated with excessive aquatic weed growth throughout the catchment and aquatic weed is removed by CCC contractors two to three times a year. In contrast, the three Banks Peninsula sites are all well-shaded by trees and lack nuisance plant growths. Higher levels of tree shade are also found amongst some council reserves in the Heathcote catchment. New riparian plantings have been incorporated into bank stabilisation projects along the mid to lower reaches of the Heathcote River, but they are dominated by low-stature grasses and shrubs that will provide little shade when fully grown. There is limited space to fit shade trees between the banks and adjacent roads in some areas, but there are numerous locations along the Heathcote River where more shade trees could be planted.

Sediment concentrations of common stormwater contaminants exceeded consent target levels at 14 of 18 sites sampled in 2020. Two sites on Cashmere Stream and two Banks Peninsula sites complied with consent targets for all sediment quality parameters. These spatial trends in sediment quality reflect patterns in urban development, with a greater proportion of rural landuse in the Cashmere Stream and Banks Peninsula catchments compared to predominantly urban landuse in the Heathcote and Linwood Canal catchments. It is therefore unsurprising that sediment metal concentrations are the highest at Curletts Road Stream immediately downstream of the Southern Motorway (Site H14), which drains an industrial catchment and a motorway, and where levels of copper, lead, and zinc all exceed ANZECC (2018) upper guideline levels.

The most marked trend in sediment quality over time has been a 78% reduction in lead concentrations since the 1980s. A decline in sediment lead concentrations was also observed in the Avon River catchment (Instream 2019), and it is associated with the nation-wide banning of leaded petrol for cars in 1996, in response to public health risks. Mean lead concentrations had dropped by 74% in 2015, nineteen years after the removal of lead from petrol, indicating a rapid environmental response to legislative change. Banning of copper brake pads in cars is being promoted by some New Zealand local authorities, because brake pads are a major source of copper in urban waterways. However, copper is not the major contaminant of concern in the Heathcote and Linwood Canal catchments, with copper levels within consent attribute targets at 14 of the 18 sites sampled in 2020.

Zinc is the contaminant of greatest concern in the Heathcote and Linwood Canal catchments, because zinc concentrations exceed guidelines at many locations. Curletts Road Stream appears to be the major contributor of zinc to the Heathcote River, because zinc levels in the Heathcote River increase downstream of the Curletts Road confluence and then decline downstream of the Cashmere Stream confluence (i.e., downstream of Site H6 at Rose Street).

Unpainted and poorly painted galvanised steel roofs are the major source of zinc in the Heathcote River catchment, while roads are also a significant source, because zinc is present in tyres (CCC 2016; O'Sullivan et al. 2017). The rate of residential development in the Heathcote catchment increased following the Canterbury earthquakes of 2010 and 2011. However, all new subdivisions are associated with stormwater treatment facilities and modern roofs such as Colorsteel® leach relatively low levels of zinc.

Greater mud and zinc levels in sediments are of ecological concern, particularly if they are also associated with greater fine sediment deposition across each sampling site. However, measurements of substrate composition, fine sediment cover, and fine sediment depth showed no overall increasing trend in fine sediment over time (Section 3.1). Therefore, elevated mud and zinc in 2020 sediment samples appears to be restricted to depositional areas and the spatial extent and depth of these deposits have not increased over time. Mean mud content in all sediment quality samples was 39% in 2020, which is higher than the mean of 22% in 2015, but comparable to the mean of 33% in 2003, and lower than the mean of 47% mud in 1980[2]. This suggests no overall increasing trend in mud content in sediment samples over time. Furthermore, in 2020 mean mud content at the three Banks Peninsula sites was 56%, which was higher than the average of all sites in 2020, despite low levels of catchment development. Thus, higher mud content in 2020 compared with 2015 is unlikely due to stormwater discharges or catchment development. Rather, the differences are more likely due to variation in sample collection by different field parties, or simply random variation. Potential management responses to elevated zinc levels, such as sediment removal, should focus on sites dominated by fine sediments that have very high zinc concentrations, such as Site H14 (Curletts Road Stream at the Southern Motorway).

Invertebrate community composition in 2020 was similar to previous years in the Heathcote and Linwood Canal catchments, being dominated by pollution-tolerant snails and crustaceans that are common to urban Christchurch waterways. The abundance and diversity of pollution-sensitive EPT taxa remains extremely low in the Heathcote and Linwood Canal catchments, lower than any other catchments monitored in the district. Thus, a total of seven EPT taxa, comprised solely of caddisflies, were recorded form the 15 Heathcote and Linwood Canal sites in 2020. This compares with a total of ten EPT taxa recorded from the three Banks Peninsula sites in 2020, 12 EPT taxa recorded from the 18 Avon monitoring sites in 2019 (Instream 2019), 15 EPT taxa recorded from nine Otukaikino catchment sites in 2017 (Boffa Miskell 2017), and 18 EPT taxa from 12 Styx catchment sites in 2018 (Instream 2018a).

Pollution-sensitive mayflies and stoneflies have not been recorded at any site in the Heathcote or Avon River catchments for at least the last decade (Instream 2019; data in this report). Mayflies and stoneflies were last recorded from the Heathcote catchment during a survey in 1989-91, where the mayflies *Deleatidium* and *Coloburiscus humeralis* and the stonefly *Zelandobius confusus* were found in Cashmere Stream (Robb 1994). While mayflies and stoneflies are widespread in Banks Peninsula streams, it is clear from repeated sampling at multiple sites that they are locally extinct in Christchurch's two major urban rivers.

Wai kōura (freshwater crayfish) and kākahi (freshwater mussels) are valued both as mahinga kai and because of their At Risk threat status (Grainger et al. 2018). Wai kōura were recorded in low numbers during electric fishing in at several sites in the Heathcote

[2] Annual means include all sites for which data was available, not just the subset of sites where sampling occurred every year.

River and Cashmere Stream in 2015 and 2020. A recent survey found kākahi widespread in the lower 2.2 km of Cashmere Stream (Instream 2020b). Kākahi densities in Cashmere Stream were higher in 2020 than a previous survey in 2007, and there was a greater proportion of small individuals, indicating a younger population and reasonable recruitment (Instream 2020b). This indicates that the Cashmere Stream kākahi population has persisted, despite potential pressure on their population associated with sedimentation from the Canterbury earthquakes of 2010-2011, the Port Hills fires of 2017, and ongoing catchment development.

Until recently, no live kākahi had been recorded from the Heathcote River or Linwood Canal. However, 36 live kākahi were collected in July 2020 during a salvage operation prior to dredging, between Armstrong Avenue and Beckford Road (Instream unpublished data). All the kākahi found appeared to be in good condition, with low levels of shell erosion (Figure 38). Four kākahi were found above the low tide mark, but most were found in the deeper central channel, at depths of approximately 0.5-0.6 m and amongst sandy sediments. Kākahi densities in the Heathcote River appeared similar to parts of the Avon River recently surveyed (Instream 2020a) and some sections of Cashmere Stream (Instream 2020b), but they were much lower than in the Styx River, which has very high kākahi numbers (Instream 2018a).

Shell lengths for the Heathcote River kākahi ranged from 55 to 99 mm, with a mean length of 74 mm. This is very similar to an average shell length of 75 mm for Cashmere Stream kākahi (Instream 2020b). Based on data from Cashmere Stream, the limited data available for the Heathcote River population suggests there is reasonable numbers of younger kākahi present and therefore that recruitment is occurring. However, it would be prudent to undertake further sampling to confirm this, given the relatively low sample size from the Heathcote River. Overall, the kākahi populations of Cashmere Stream and the Heathcote River are of local ecological significance, given the relative lack of kākahi in Christchurch urban streams.

Figure 38: Heathcote River kākahi (left) and in-situ above the low tide mark (right).

The range of fish species caught in the Heathcote and Linwood Canal catchments in 2020 was similar to previous years and the catch was dominated by native species. Fewer sites with brown trout records and lower fish densities in 2020 were most likely due to the combination of cooler temperatures and later fish sampling in 2020 compared with 2015. The most notable trend in fish populations in the Heathcote catchment over the last decade was a decline in bluegill bully densities following the Canterbury earthquakes of 2010 and 2011, associated with earthquake-induced sedimentation (Taylor & Blair 2012). Based on fish monitoring data from 2015 and 2020, bluegill bully populations appear to have recovered.

Trout spawning occurs amongst suitable silt-free gravels in the Heathcote catchment. Trout spawning has previously been recorded at various locations along the Heathcote River, from as far upstream as the showgrounds (near Site H30), downstream to just above Wilsons Road (Taylor & Blair 2012). Trout spawning has been observed in the Heathcote River upstream of Cashmere Stream recently (Clinton Webb, Instream, Pers. Obs), but the river was too turbid downstream of Cashmere Stream to undertake trout spawning surveys in 2019 and 2020, so the overall status of trout spawning in the river is uncertain.

Inanga spawn in the lower reaches of the Heathcote River, at the upper limit of the saltwater influence, amongst dense riparian vegetation during spring tides. Since the 2010-2011 Canterbury earthquakes, the inanga spawning reach in the Heathcote River has shifted downstream compared to pre-earthquake, with the spawning reach now extending from just downstream of Grange Road in Opawa to just upstream of Garlands Road, near the Tannery shopping complex (Orchard & Hickford 2016). A CCC trial of leaving riparian grass long during the inanga spawning season increased the quality of spawning habitat and was associated with increased spawning in the Heathcote River (Orchard 2017). A recent survey discovered inanga spawning in Linwood Canal downstream of Dyers Road and confirmed inanga continue to spawn in Steamwharf Stream, a known spawning location (Orchard 2018). The author of that survey recommended monitoring of inanga spawning and adult inanga, and cautioned that impacts on inanga spawning should be assessed before making any changes to the opening regime of the Linwood Canal tide gates.

Many of New Zealand's native fish species migrate between freshwater and the sea to complete their life cycle. Fish passage to and from the sea can be obstructed by natural barriers, such as waterfalls, as well as artificial barriers, including weirs, culverts, tide gates, dams, and pump stations. Culverts are common fish barriers on Banks Peninsula, because of the combination of steep terrain and because many road culverts were built before fish passage was a design consideration. However, there are relatively few barriers in the Heathcote and Linwood Canal catchments recorded in the New Zealand Fish Passage Assessment Tool website[3]. This partly reflects the dominance of bridges over culverts in the catchment and partly also reflects a lack of barrier assessments. A study of fish-friendly tide gates in three tributaries of the Heathcote River (including Steamwharf Stream) concluded that the gates were not impeding fish recruitment (Instream 2018b). However, the study also found that the Avoca Valley Stream tide gates were restricting the amount of saline water reaching upstream saltmarsh plant communities, and adjustments to the gate opening regime were therefore recommended. Follow-up monitoring of the saltmarsh communities was also recommended but it has not yet occurred.

A survey of fish barriers in Christchurch city waterways identified potential issues with fish passage through Wigram Retention Basin at the showgrounds and the new Curletts Road stormwater facility downstream of the Southern Motorway (Instream 2020c). Large numbers

[3] https://fishpassage.niwa.co.nz/

of eels were caught during a recent upgrade of Wigram Retention Basin, however recruitment into the basin is likely limited by swift velocities through the pipe culvert outlet structure. Both Curletts and Wigram stormwater facilities have open waterways upstream, so fish passage is necessary both into the ponds and further upstream. In stormwater ponds with only a piped network upstream, passage into the stormwater ponds may be unnecessary or discouraged, especially if the ponds dry out. However, downstream fish passage should always be provided, regardless of the pond configuration, to avoid trapping migratory fish and preventing them from completing their life cycle.

There is very little information on fish communities within new stormwater basins. This is a priority area of study, given the increasing number stormwater facilities been built and given their potential to both impede fish passage and to provide fish habitat. CCC recently commissioned a study that will identify and prioritise fish passage barriers throughout the district. It would be beneficial to couple that piece of work with surveys of fish communities downstream, within, and upstream of stormwater facilities of varying age, size, and construction.

The discovery of banded kokopu in Glenstrae Stream (Figure 39) is surprising for several reasons. First, it is the first record of banded kokopu in the city for 50 years. According to Freshwater Fish Database records, banded kokopu were caught in the Avon River in 1970, but there are few details associated with the record and there have been no records since then. Second, the Glenstrae discovery was also the first record of any fish collected from steep waterways along the Christchurch side of the Port Hills. Until this discovery, it had generally been assumed that the Port Hills tributaries do not support permanent fish populations, because many of them lack permanent flow. While they do not have a threatened conservation status, banded kokopu are uncommon in Canterbury, outside of Banks Peninsula, on the Plains side of the Port Hills. Third, to get to the Glenstrae Stream location from the estuary, banded kokopu juveniles must navigate through a 240 m long pipe culvert and then climb up a near-vertical 2.5 m concrete wall. The Glenstrae banded kokopu population highlights the importance of considering fish passage and fish habitat, even in unlikely locations. In response to the banded kokopu discovery, native riparian plantings have been undertaken by CCC and the Drayton Reserve volunteer group. Fish passage enhancement is also recommended at this location, to improve the likelihood of juvenile banded kokopu reaching the upstream habitat.

Figure 39: Banded kokopu (left) and their habitat in Glenstrae Stream (right).

4.2. Comparison to Consent Attribute Target Levels

The council's Comprehensive Stormwater Network Discharge Consent (CRC190445) includes consent attribute target levels for total macrophyte cover, long filamentous algae cover, fine sediment cover, QMCI scores, and sediment concentrations of copper, lead, zinc, and total PAHs. Consent targets for macrophyte cover and filamentous algae cover have been met at most sites over the last ten years (Table 11). In contrast, consent targets for fine sediment cover were not met at most of the sites monitored. Compliance with consent targets for sediment quality parameters is more variable, with most sites complying with total PAH targets and most sites not complying with zinc targets (Table 7).

There is no indication of an increasing or decreasing trend in compliance with consent targets for macrophyte cover or fine sediment cover from 2010 to 2020. Although fine sediment cover was generally high in 2020, it is uncertain whether compliance with consent targets has changed over time, because fine sediment cover was not measured using a consistent and comparable method over time. Substrate composition data can be used to infer fine sediment cover, but it underestimates impacts caused by thin layers of fine sediment deposited on stones, which is widespread in Banks Peninsula and Heathcote catchment waterways. Compliance with macrophyte cover is largely achieved via contractors weeding most waterways two to three times a year. The primary cause for excessive macrophyte growth in city waterways is a lack of shade from trees.

Compliance with consent targets for copper and total PAHs have shown little change over time. More sites have complied with consent targets for lead in sediment since the 1980s, reflecting the ban on leaded petrol in 1996. Compliance with consent targets for zinc in sediments has worsened over time, reducing from compliance at six sites out of ten monitored in 2015 down to two sites in 2020. However, when zinc data are normalised by mud content, there is no trend over time.

Of particular interest is the consent target for QMCI, because the QMCI is an indicator of invertebrate community health, and invertebrates are influenced by both water quality and habitat. Consent attribute target levels have consistently been met at half the Heathcote River and Linwood Canal sites and none of the Banks Peninsula sites from 2010 to 2020 (Table 11). Although QMCI scores have been low across all sites, there has been no overall increasing or decreasing trend evident across all the sites monitored every five years. This suggests that there is no indication of a declining trend that could be attributable to stormwater discharges or other landuse impacts.

Overall, invertebrate communities in the Heathcote catchment appear stable. This may seem surprising, given the long list of catchment pressures on ecological health (see Section 3.1) and also given the number of habitat restoration projects in the catchment (see Section 4.4 below). However, invertebrate communities at most monitoring sites are dominated by pollution-tolerant species, which are insensitive to further degradation. In addition, recovery of invertebrate communities at restoration sites may be limited by the combined effects of ongoing degraded water quality, sedimentation, heavy metals in bed sediments, thick organic deposits, and an inadequate source of potential colonists (Harding et al. 2016). In summary, ecological restoration within an urban catchment will take entail large-scale improvements of multiple pressures over a long time. This underscores the importance of protecting higher-value ecological sites (e.g., Banks Peninsula sites) from urban development.

Table 11: Compliance with Consent Attribute Target Levels at wadeable sites over time. Note that fewer sites were sampled in 2010 and 2015. Asterisk indicates fine sediment cover calculated using silt and sand data from substrate composition data.

Parameter	Consent target level	Complying sites each year		
		2010 (7 sites)	**2015** (9 sites)	**2020** (10 sites)
Heathcote River and Linwood Canal (excl Cashmere Stream)				
Minimum QMCI	3.5	5	5	5
Maximum fine sediment (<2 mm) cover	30%	-	4*	3 / 5*
Maximum total macrophyte cover	60%	4	9	8
Maximum filamentous algae cover	30%	7	7	10
Banks Peninsula (incl Cashmere Stream)		**2010** (2 sites)	**2015** (2 sites)	**2020** (5 sites)
Minimum QMCI	5	0	0	0
Maximum fine sediment (<2 mm) cover	20%	-	0*	0 / 3*
Maximum total macrophyte cover	30%	0	1	3
Maximum filamentous algae cover	20%	1	2	5

4.3. Impacts of Dredging and Bank Stabilisation

Dredging and bank stabilisation in the Heathcote River are two major projects that have had the potential to affect aquatic ecosystems at monitoring sites over the last five years. The following paragraphs discuss both these projects and their potential effects on aquatic ecology.

The lower reaches of the Heathcote River were regularly dredged to improve flood water conveyance up until 1989. Dredging then ceased due to impacts on bank stability and increased consideration of ecological values (Peters et al 2019). Dredging re-commenced upstream of Woolston Cut in October 2018, with the goal of restoring flood capacity lost after the 2010 and 211 earthquakes. At the time of writing, dredging was nearing completion, with the work located near Armstrong Avenue in Opawa, having dredged 3.5 km of the lower river.

Key environmental concerns of dredging are associated with fine sediment generation and physical destruction of fish and aquatic habitat. Silt curtains were initially used to isolate discrete locations of digging, to minimise suspended sediment impacts downstream and to allow for fish to be trapped and relocated prior to digging. However, the curtains were abandoned as they were unable to effectively seal the dredging sites, mainly due to tidal flow reversals. Fish trapping and relocation continued prior to dredging each site, coupled with increased checks of dredged sediments for fish, continuous monitoring of turbidity, and a shortened work week to reduce the amount of time the river was turbid. A total of 11,791 fish were caught and relocated during the first 13 months of dredging (Burrell & Brown 2020).

Impacts on eels were of concern, due to their propensity to burrow into fine sediment when disturbed, rather than swim away, as were potential impacts on inanga spawning habitat.

Heathcote River monitoring sites H19 (Aynsley Terrace) and H11 (Catherine Street) were within the dredging reach, with both sites affected by turbid water and the Catherine Street site also affected by dredging and subsequent bank stabilisation work and native plantings. QMCI scores increased slightly at the Aynsley Terrace site from 2.7 in 2015 to 3.1 in 2020, while QMCI scores decreased markedly at the Catherine Street site, from 5.0 in 2015 down to 2.4 in 2020. The decline in QMCI scores at the Catherine Street site was associated with a shift in the dominant invertebrate taxa, *Paracalliope* amphipods (MCI = 5) comprising 96% of total abundance in 2015 to *Potamopyrgus* snails (MCI = 4) dominating in 2020. *Paracalliope* are typically associated with macrophytes, which were abundant in 2015, but absent in 2020. The lack of macrophytes in 2020 were associated with the replacement of fine sediments with angular stones along the banks of the recently dredged section. Macrophytes will presumably re-establish along the dredged section, once fine sediments accumulate and provide a suitable substrate to grow in.

Potential impacts of dredging on fish communities are currently being monitored using several techniques. Eels that are caught prior to dredging are being tagged with Passive Integrated Transponder tags (similar to those used for microchipping pets) prior to release, to monitor their response to relocation. Fish communities are also being monitored every two months by deploying fyke nets at six locations along the river, including sites upstream and within the area affected by dredging. The monitoring programme includes checks for any tagged eels. Preliminary monitoring results indicate that species diversity pre- and post-dredging is similar, with common bullies dominating the catch, and giant bully, inanga, shortfin eel, and longfin eel caught at all sites from November 2019 to March 2020 (Lees 2020). Preliminary review of tagging data indicates eels are returning to dredged sections of the river. Results of the eel tagging and fish monitoring programmes will be evaluated later in 2020, once the dredging project has ended. An inanga spawning survey has also been recommended for the next spawning season in autumn 2021.

As noted in Section 3.1 above, bank stabilisation works occurred along the mid-reaches of the Heathcote River, between Ferniehurst Street and Beckenham, over 2018 and 2019. Bank stabilisation works included a range of engineering solutions to reduce risk of bank slumping and impacts on roading and other infrastructure. Two ecology monitoring sites were within the footprint of the bank stabilisation works, so 2015 and 2020 monitoring data can be compared to evaluate potential impacts of the project.

At Site H23, downstream of Colombo Street, bank stabilisation works included bank recontouring and lining the toe of the bank with large rocks. Mitigation measures included native riparian plantings, placement of “e-rocks” at the stream edge for habitat, and placement of cobble clusters across the channel to provide habitat. No appreciable change was observed in mean depth, velocity, width, or substrate composition between 2015 and 2020. Macrophyte cover was much higher in 2020, but that more likely reflected the influence of macrophyte clearance activities, than bank stabilisation treatments. There was little difference in invertebrate community metrics between years, although this was the first time pollution-sensitive Eriopterini dipterans were recorded at the site. The fish community was also similar between monitoring years, although At Risk bluegill bully densities were markedly higher in 2020 (84 per 100 m²) than in 2015 (33 per 100 m²). Bluegill bullies prefer swift, stony habitats, so their abundance at the Colombo Street site suggests the modified habitat is very suitable. It is uncertain whether a component of the bank stabilisation mitigation measures was responsible for the increase in bluegill bully numbers. That is because the physical habitat monitoring was of insufficient fine detail to determine whether there were significantly more individual habitat features such as cobble clusters at the site compared to other sampling locations. However, it is clear that the bank works have not adversely impacted biological communities and in fact the bluegill bully population appears to be thriving.

Bank stabilisation works were also conducted at Site H22 at Tennyson Street, where rock-filled gabion baskets were placed along the true left bank. Mitigation at this site included native riparian planting at the top of the bank, and placement of PVC tubes into the gabion baskets and large rocks at the base of the wall to provide additional fish habitat. Flood-derived sediments had built up along the lower tier of the gabion wall and some weeds were growing in the sediment. Substrate composition, water depth, and channel width were similar in 2015 and 2020, but mean water velocity was lower in 2020. However, there was little difference in invertebrate community composition between years. The total fish catch per unit effort was higher in 2020 (40 fish per 100 m²) than in 2015 (25 fish per 100 m²), mainly due to increased numbers of common bully. Most fish were caught along the gabion wall. Overall, the ecology monitoring data indicate no negative impact of the bank works on invertebrate and fish communities, with fish numbers higher along the gabion wall. Habitat could be further enhanced by planting native sedges along the lower tier of the wall, to provide better cover for larger fish.

4.4. Waterway Restoration Projects

While there are numerous pressures on waterways in urban Christchurch, waterway restoration is also happening at an unprecedented rate. Much of the restoration work is occurring as part of larger projects aimed at repairing earthquake-damaged waterways and restoring the flood-carrying capacity of city rivers to pre-earthquake levels. However, there are also some ongoing restoration projects that are led by community groups, with support from CCC.

Examples of recent and proposed restoration projects in the Heathcote catchment include:

- **Upper Cashmere Stream.** The headwaters of Cashmere Stream, upstream of Sutherlands Road, are being progressively restored by the Cashmere Stream Care Group, CCC, and Environment Canterbury. Over the last five years, approximately 330 m of stream habitat has been restored, including the replacement of a straight channel with a winding channel, along with the addition of woody debris and large rocks for fish habitat, deeper pools, and dense native plantings (Figure 40). The remaining 160 m of drain upstream of Sutherlands Road was being restored at the time of writing.

- **Cashmere Stream & Sutherlands Basin.** Approximately 1 km of Cashmere Stream and 850 m of its tributary, Quarry Road Drain, are to be restored downstream of Sutherlands Road within the next few years. This will be done as part of an integrated stormwater project that will include large, interconnected wetlands for detaining peak flows and treating water prior to discharge. Kākahi translocation has been suggested as a way of accelerating the recovery of kākahi in the newly restored sections of Cashmere Stream (Instream 2020b).

- **Miln Drain.** Miln Drain is a tributary of Cashmere Stream upstream of Cashmere Road. Approximately 780 m of Miln Drain has been realigned and enhanced with native plantings, as part of the Eastman stormwater development. Prior to realignment, the drain was artificially straight with poor quality habitat and choked with macrophytes. The new waterway alignment includes lower gradient banks, the addition of stumps for fish cover, and native plantings along its length. The new alignment is currently poorly shaded, so it still has high macrophyte cover.

- **Henderson Drain & Sparks Road Wetland.** The recently-completed Sparks Road stormwater facility included the creation of extensive wetland habitat and the realignment and enhancement of approximately 550 m of Henderson Drain.

- **Wigram Basin.** The Wigram Retention Basin, originally built in 1993, was recently extended to provide extra flood detention and 3.4 hectares of wetland was added to increase stormwater quality treatment. The basin captures and treats water from the Hayton Stream catchment, which has a predominantly industrial catchment and is a major source of contaminants into the Heathcote River. High levels of zinc and other stormwater contaminants have built up in the basin over time, and removal of the contaminated sediment may be warranted. Potential issues with fish passage at the outlet of the ponds have been identified and CCC engineers are looking at options for enhancing passage.

- **Curletts Basin.** The recently-completed Curletts Basin stormwater facility is located at the corner of the Southern Motorway and Curletts Road. Its purpose is to detain flood flows and provide some stormwater quality treatment. The facility is densely planted with native wetland species and Curletts Road Stream has been realigned to flow through the wetland. Plants appear to be establishing quickly and providing good cover to the stream's low flow channel. Sediments immediately upstream of the stormwater facility (Site H14) are heavily polluted zinc and other metals, and contaminated sediments may need to be removed to improve water quality downstream.

- **Steamwharf Stream.** Bank regrading and native vegetation planting was undertaken to enhance inanga spawning habitat in Steamwharf Stream upstream of Dyers Road in 2018. The recent work complemented major restoration efforts in the 1990s, which involved extensive bank regrading and native plantings. It also complemented ongoing native planting, and weed and pest control work undertaken by the Steamwharf Stream Restoration Group. While the scale of the 2018 restoration in Steamwharf Stream is small compared to other projects listed above, it is an example of the many small and ongoing waterway enhancement projects happening in the Heathcote catchment.

The new and restored waterways described above have the potential to greatly increase the value and extent of aquatic habitats in the Heathcote catchment. Ecological monitoring of these new habitats is recommended, to evaluate the effectiveness of different restoration techniques and to identify any potential issues with waterway designs, such as fish passage through stormwater facilities.

Figure 40: Upper Cashmere Stream in October 2016 (left) and June 2020 (right), after restoration.

Figure 41: Curletts Basin after rainfall in May 2020.

5. RECOMMENDATIONS

Based on the results and discussion presented above, we recommend the following:

- Plant more trees to shade waterways. This will reduce the amount of cost and disturbance caused by frequent regular aquatic weed removal. Many new riparian plantings are dominated by low grasses and shrubs, with taller-growing trees limited to one bank, to allow for machinery access for waterway maintenance (mainly aquatic weed removal). Only planting one side of a waterway often results in insufficient shade for preventing nuisance growths, unless the channel is very narrow (<1 m wide). If both sides of a waterway are planted up, access to the waterway for aquatic weed removal will become less necessary.

- Consider removal of contaminated sediments from Wigram Basin and in Curletts Road Stream downstream of the Southern Motorway. Both these locations have high levels of sediment contamination and may be a source of degraded water quality downstream.

- Conduct a survey for kākahi in the Heathcote River and its tributaries. The recent discovery of kākahi in the mainstem of the Heathcote River was a surprise, as it was previously assumed kākahi were either absent or in very low numbers in the river. The survey would best be conducted during clear summer baseflows after weed clearance has occurred, so it is easier to see the riverbed.

- Regular monitoring of kākahi in Cashmere Stream. Recent monitoring indicates the population is in reasonable health, but it is under pressure from rapid catchment development. Monitoring every 1-2 years is therefore recommended, given the significance of the population and rate of change in catchment landuse.

- Undertake trout spawning surveys in Cashmere Stream and the Heathcote River. This should be a priority, as the water in Cashmere Stream has been too turbid for spawning surveys to be conducted for the last two years.

- Undertake a botanical survey of the Avoca Salt Marsh. The salt marsh was last surveyed in May and June 2018, shortly after the new Avoca Valley Stream tide gates were installed. A botanical survey would establish whether the new tide gates have affected the salt marsh plant community and whether any changes to the gate opening regime are needed.

- Undertake fish surveys in stormwater facilities to assess the fish communities present and identify opportunities for enhancing habitat and fish passage. This work should be a priority, given the number of new stormwater basins that are being installed, the lack of ecological data associated with these basins, and the legal requirement to provide for fish passage under the Freshwater Fisheries regulations 1983.

- Ecological monitoring of waterway restoration projects. Ecological monitoring of newly restored and created aquatic habitats is recommended, to evaluate the effectiveness of different restoration techniques.

- Enhance fish passage in Glenstrae Stream, where the only population of banded kokopu are found in the city. This could be a joint project between the Drayton Reserve volunteers, CCC, and Environment Canterbury, as all groups have an interest in fish passage and Glenstrae Stream.

- Review and communicate results of Heathcote River dredging ecological data once dredging is completed later this year. Climate change and sea level rise will likely create greater pressure to dredge rivers to reduce flood risk, but there is little data on the ecological effects of dredging in New Zealand. Monitoring results from the Heathcote dredging project will therefore be relevant to local authorities throughout the country faced with the challenges of climate change.

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APPENDIX 1: SITE PHOTOGRAPHS FROM 2020

Figure 1: Site B1 (Stream Reserve Drain above outfall to Governors Bay) – upstream looking downstream.

Figure 2: Site B3 (Balguerie Stream downstream of Settlers Hill) – downstream looking upstream.

Figure 3: Site B4 (Aylmers Stream downstream of Rue Jolie, next to Bruce Tce) – upstream looking downstream.

Figure 4: Site H9 (Haytons Stream at retention basin). View of the Heathcote River sediment sampling location, taken from upstream of the retention basin discharge channel on the left, looking downstream.

Figure 5: Site H14 (Curletts Road Stream at Southern Motorway) - downstream looking upstream.

Figure 6: Site H10 (Curletts Road Stream upstream of the Heathcote River confluence) - upstream looking downstream.

Figure 7: Site H16 (Cashmere Stream at Sutherlands Road) – upstream looking downstream.

Figure 8: Site H26 (Cashmere Stream at Penruddock Rise) – upstream looking downstream.

Figure 9: Site H5 (Cashmere Stream at Worsleys Road) – downstream looking upstream.

Figure 10: Site H25 (Cashmere Brook at Ashgrove Terrace) – upstream looking downstream.

Figure 11: Site H17 (Steamwharf Stream upstream of Dyers Road) – downstream looking upstream.

Figure 12: Site O2 (Linwood Canal / City Outfall Drain) – upstream looking downstream.

Figure 13: Site H31 (Heathcote River at Warren Crescent) – upstream looking downstream

Figure 14: Site H30 (Heathcote River at Canterbury Park/ Showgrounds) – downstream looking upstream.

Figure 15: Site H29 (Heathcote River downstream of Spreydon Domain) – downstream looking upstream.

Figure 16: Site H6 (Heathcote River at Rose Street) – downstream looking upstream.

Figure 17: Site H24 (Heathcote River downstream of Barrington Street) – upstream looking downstream.

Figure 18: Site H23 (Heathcote River downstream of Colombo Street (Beckenham Library)) – upstream looking downstream

Figure 19: Site H22 (Heathcote River downstream of Tennyson Street) – downstream looking upstream.

Figure 20: Site H19 (Heathcote River on Aynsley Terrace (at eastern tip of King George V Reserve) – downstream looking upstream

Figure 21: Site H11 (Heathcote River at Catherine Street) – downstream looking upstream.

Figure 22: Site H2 (Heathcote River at Tunnel Road) – upstream looking downstream.

APPENDIX 2: SEDIMENT QUALITY LABORATORY RESULTS

Hill Laboratories
TRIED, TESTED AND TRUSTED

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Certificate of Analysis

SPv1

Client:	Instream Consulting Limited	**Lab No:**	2363753
Contact:	G Burrell	**Date Received:**	11-May-2020
	C/- Instream Consulting Limited	**Date Reported:**	04-Jun-2020
	PO Box 28173	**Quote No:**	103910
	Christchurch 8242	**Order No:**	20350401
		Client Reference:	5-Yearly Monitoring
		Submitted By:	G Burrell

Sample Type: Sediment

Sample Name:		BP01a 10-May-2020 9:30 am	BP01b 10-May-2020 9:40 am	BP01c 10-May-2020 9:45 am	BP04a 10-May-2020 11:35 am	BP04b 10-May-2020 11:40 am
Lab Number:		2363753.1	2363753.2	2363753.3	2363753.4	2363753.5
Individual Tests						
Dry Matter	g/100g as rcvd	50	24	22	16.7	26
Total Recoverable Copper	mg/kg dry wt	18.8	22	20	52	46
Total Recoverable Lead	mg/kg dry wt	22	19.8	18.8	31	30
Total Recoverable Phosphorus	mg/kg dry wt	1,220	1,150	1,320	1,350	1,330
Total Recoverable Zinc	mg/kg dry wt	134	178	168	189	182
Total Organic Carbon*	g/100g dry wt	4.6	8.5	10.1	9.8	11.3
7 Grain Sizes Profile as received*						
Dry Matter of Sieved Sample*	g/100g as rcvd	38	31	26	18.7	24
Fraction >/= 2 mm*	g/100g dry wt	53.6	3.6	1.3	2.1	54.0
Fraction < 2 mm, >/= 1 mm*	g/100g dry wt	14.0	1.0	0.5	0.5	2.4
Fraction < 1 mm, >/= 500 µm*	g/100g dry wt	5.5	0.7	0.6	0.4	0.8
Fraction < 500 µm, >/= 250 µm*	g/100g dry wt	3.1	2.0	2.2	2.0	1.6
Fraction < 250 µm, >/= 125 µm*	g/100g dry wt	3.0	4.2	6.3	9.6	7.0
Fraction < 125 µm, >/= 63 µm*	g/100g dry wt	6.9	11.5	12.0	22.8	14.5
Fraction < 63 µm*	g/100g dry wt	14.0	77.0	77.1	62.8	19.8
Haloethers Trace in SVOC Soil Samples by GC-MS						
Bis(2-chloroethoxy) methane	mg/kg dry wt	< 0.11	< 0.3	< 0.3	< 0.4	< 0.3
Bis(2-chloroethyl)ether	mg/kg dry wt	< 0.11	< 0.3	< 0.3	< 0.4	< 0.3
Bis(2-chloroisopropyl)ether	mg/kg dry wt	< 0.11	< 0.3	< 0.3	< 0.4	< 0.3
4-Bromophenyl phenyl ether	mg/kg dry wt	< 0.11	< 0.3	< 0.3	< 0.4	< 0.3
4-Chlorophenyl phenyl ether	mg/kg dry wt	< 0.11	< 0.3	< 0.3	< 0.4	< 0.3
Nitrogen containing compounds Trace in SVOC Soil Samples, GC-MS						
N-Nitrosodiphenylamine + Diphenylamine	mg/kg dry wt	< 0.3	< 0.5	< 0.5	< 0.7	< 0.5
2,4-Dinitrotoluene	mg/kg dry wt	< 0.3	< 0.5	< 0.5	< 0.7	< 0.5
2,6-Dinitrotoluene	mg/kg dry wt	< 0.3	< 0.5	< 0.5	< 0.7	< 0.5
Nitrobenzene	mg/kg dry wt	< 0.11	< 0.3	< 0.3	< 0.4	< 0.3
N-Nitrosodi-n-propylamine	mg/kg dry wt	< 0.3	< 0.5	< 0.5	< 0.7	< 0.5
Organochlorine Pesticides Trace in SVOC Soil Samples by GC-MS						
Aldrin	mg/kg dry wt	< 0.11	< 0.3	< 0.3	< 0.4	< 0.3
alpha-BHC	mg/kg dry wt	< 0.11	< 0.3	< 0.3	< 0.4	< 0.3
beta-BHC	mg/kg dry wt	< 0.11	< 0.3	< 0.3	< 0.4	< 0.3
delta-BHC	mg/kg dry wt	< 0.11	< 0.3	< 0.3	< 0.4	< 0.3
gamma-BHC (Lindane)	mg/kg dry wt	< 0.11	< 0.3	< 0.3	< 0.4	< 0.3
4,4'-DDD	mg/kg dry wt	< 0.11	< 0.3	< 0.3	< 0.4	< 0.3
4,4'-DDE	mg/kg dry wt	< 0.11	< 0.3	< 0.3	< 0.4	< 0.3
4,4'-DDT	mg/kg dry wt	< 0.3	< 0.5	< 0.5	< 0.7	< 0.5

Sample Type: Sediment						
Sample Name:		BP01a 10-May-2020 9:30 am	BP01b 10-May-2020 9:40 am	BP01c 10-May-2020 9:45 am	BP04a 10-May-2020 11:35 am	BP04b 10-May-2020 11:40 am
Lab Number:		2363753.1	2363753.2	2363753.3	2363753.4	2363753.5
Organochlorine Pesticides Trace in SVOC Soil Samples by GC-MS						
Dieldrin	mg/kg dry wt	< 0.11	< 0.3	< 0.3	< 0.4	< 0.3
Endosulfan I	mg/kg dry wt	< 0.3	< 0.5	< 0.5	< 0.7	< 0.5
Endosulfan II	mg/kg dry wt	< 0.5	< 0.5	< 0.5	< 0.7	< 0.5
Endosulfan sulphate	mg/kg dry wt	< 0.3	< 0.5	< 0.5	< 0.7	< 0.5
Endrin	mg/kg dry wt	< 0.3	< 0.5	< 0.5	< 0.7	< 0.5
Endrin ketone	mg/kg dry wt	< 0.3	< 0.5	< 0.5	< 0.7	< 0.5
Heptachlor	mg/kg dry wt	< 0.11	< 0.3	< 0.3	< 0.4	< 0.3
Heptachlor epoxide	mg/kg dry wt	< 0.11	< 0.3	< 0.3	< 0.4	< 0.3
Hexachlorobenzene	mg/kg dry wt	< 0.11	< 0.3	< 0.3	< 0.4	< 0.3
Polycyclic Aromatic Hydrocarbons Trace in SVOC Soil Samples*						
Acenaphthene	mg/kg dry wt	< 0.10	< 0.11	< 0.13	< 0.17	< 0.11
Acenaphthylene	mg/kg dry wt	< 0.10	< 0.11	< 0.13	< 0.17	< 0.11
Anthracene	mg/kg dry wt	< 0.10	< 0.11	< 0.13	< 0.17	< 0.11
Benzo[a]anthracene	mg/kg dry wt	< 0.10	< 0.11	< 0.13	< 0.17	< 0.11
Benzo[a]pyrene (BAP)	mg/kg dry wt	< 0.11	< 0.3	< 0.3	< 0.4	< 0.3
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	< 0.11	< 0.3	< 0.3	< 0.4	< 0.3
Benzo[g,h,i]perylene	mg/kg dry wt	< 0.11	< 0.3	< 0.3	< 0.4	< 0.3
Benzo[k]fluoranthene	mg/kg dry wt	< 0.11	< 0.3	< 0.3	< 0.4	< 0.3
1&2-Chloronaphthalene	mg/kg dry wt	< 0.10	< 0.16	< 0.18	< 0.3	< 0.15
Chrysene	mg/kg dry wt	< 0.10	< 0.11	< 0.13	< 0.17	< 0.11
Dibenzo[a,h]anthracene	mg/kg dry wt	< 0.11	< 0.3	< 0.3	< 0.4	< 0.3
Fluoranthene	mg/kg dry wt	< 0.10	0.26	< 0.13	< 0.17	0.12
Fluorene	mg/kg dry wt	< 0.10	< 0.11	< 0.13	< 0.17	< 0.11
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	< 0.11	< 0.3	< 0.3	< 0.4	< 0.3
2-Methylnaphthalene	mg/kg dry wt	< 0.10	< 0.11	< 0.13	< 0.17	< 0.11
Naphthalene	mg/kg dry wt	< 0.10	< 0.11	< 0.13	< 0.17	< 0.11
Phenanthrene	mg/kg dry wt	< 0.10	0.15	< 0.13	< 0.17	< 0.11
Pyrene	mg/kg dry wt	< 0.10	0.23	< 0.13	< 0.17	0.12
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES*	mg/kg dry wt	< 0.3	< 0.6	< 0.6	< 0.8	< 0.5
Benzo[a]pyrene Toxic Equivalence (TEF)*	mg/kg dry wt	< 0.3	< 0.6	< 0.6	< 0.8	< 0.5
Phenols Trace in SVOC Soil Samples by GC-MS						
4-Chloro-3-methylphenol	mg/kg dry wt	< 0.5	< 0.5	< 0.5	< 0.7	< 0.5
2-Chlorophenol	mg/kg dry wt	< 0.2	< 0.3	< 0.3	< 0.4	< 0.3
2,4-Dichlorophenol	mg/kg dry wt	< 0.2	< 0.3	< 0.3	< 0.4	< 0.3
2,4-Dimethylphenol	mg/kg dry wt	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
3 & 4-Methylphenol (m- + p-cresol)	mg/kg dry wt	< 0.4	0.6	0.8	< 0.7	< 0.5
2-Methylphenol (o-Cresol)	mg/kg dry wt	< 0.2	< 0.3	< 0.3	< 0.4	< 0.3
2-Nitrophenol	mg/kg dry wt	< 0.4	< 0.5	< 0.5	< 0.7	< 0.5
Pentachlorophenol (PCP)	mg/kg dry wt	< 6	< 6	< 6	< 7	< 6
Phenol	mg/kg dry wt	< 0.3	< 0.5	< 0.5	< 0.7	< 0.5
2,4,5-Trichlorophenol	mg/kg dry wt	< 0.3	< 0.5	< 0.5	< 0.7	< 0.5
2,4,6-Trichlorophenol	mg/kg dry wt	< 0.3	< 0.5	< 0.5	< 0.7	< 0.5
Plasticisers Trace in SVOC Soil Samples by GC-MS						
Bis(2-ethylhexyl)phthalate	mg/kg dry wt	< 0.5	1.2	1.1	1.7	1.1
Butylbenzylphthalate	mg/kg dry wt	< 0.3	< 0.5	< 0.5	< 0.7	< 0.5
Di(2-ethylhexyl)adipate	mg/kg dry wt	< 0.2	< 0.3	< 0.3	< 0.4	< 0.3
Diethylphthalate	mg/kg dry wt	< 0.3	< 0.5	< 0.5	< 0.7	< 0.5
Dimethylphthalate	mg/kg dry wt	< 0.3	< 0.5	< 0.5	< 0.7	< 0.5
Di-n-butylphthalate	mg/kg dry wt	< 0.3	< 0.5	< 0.5	< 0.7	< 0.5
Di-n-octylphthalate	mg/kg dry wt	< 0.3	< 0.5	< 0.5	< 0.7	< 0.5

Sample Type: Sediment						
Sample Name:		BP01a 10-May-2020 9:30 am	BP01b 10-May-2020 9:40 am	BP01c 10-May-2020 9:45 am	BP04a 10-May-2020 11:35 am	BP04b 10-May-2020 11:40 am
Lab Number:		2363753.1	2363753.2	2363753.3	2363753.4	2363753.5
Other Halogenated compounds Trace in SVOC Soil Samples by GC-MS						
1,2-Dichlorobenzene	mg/kg dry wt	< 0.3	< 0.5	< 0.5	< 0.7	< 0.5
1,3-Dichlorobenzene	mg/kg dry wt	< 0.3	< 0.5	< 0.5	< 0.7	< 0.5
1,4-Dichlorobenzene	mg/kg dry wt	< 0.3	< 0.5	< 0.5	< 0.7	< 0.5
Hexachlorobutadiene	mg/kg dry wt	< 0.3	< 0.5	< 0.5	< 0.7	< 0.5
Hexachloroethane	mg/kg dry wt	< 0.3	< 0.5	< 0.5	< 0.7	< 0.5
1,2,4-Trichlorobenzene	mg/kg dry wt	< 0.11	< 0.3	< 0.3	< 0.4	< 0.3
Other SVOC Trace in SVOC Soil Samples by GC-MS						
Benzyl alcohol	mg/kg dry wt	< 1.1	< 3	< 3	< 4	< 3
Carbazole	mg/kg dry wt	< 0.11	< 0.3	< 0.3	< 0.4	< 0.3
Dibenzofuran	mg/kg dry wt	< 0.11	< 0.3	< 0.3	< 0.4	< 0.3
Isophorone	mg/kg dry wt	< 0.11	< 0.3	< 0.3	< 0.4	< 0.3

Sample Name:		BP04c 10-May-2020 11:50 am	BP03a 10-May-2020 2:30 pm	BP03b 10-May-2020 2:31 pm	BP03c 10-May-2020 2:36 pm	
Lab Number:		2363753.6	2363753.7	2363753.8	2363753.9	
Individual Tests						
Dry Matter	g/100g as rcvd	16.5	27	23	23	-
Total Recoverable Copper	mg/kg dry wt	49	24	34	21	-
Total Recoverable Lead	mg/kg dry wt	32	33	49	25	-
Total Recoverable Phosphorus	mg/kg dry wt	1,310	1,160	1,000	1,420	-
Total Recoverable Zinc	mg/kg dry wt	210	230	270	185	-
Total Organic Carbon*	g/100g dry wt	12.5	9.7	10.4	12.0	-
7 Grain Sizes Profile as received*						
Dry Matter of Sieved Sample*	g/100g as rcvd	16.6	29	20	25	-
Fraction >/= 2 mm*	g/100g dry wt	4.6	0.6	4.8	2.0	-
Fraction < 2 mm, >/= 1 mm*	g/100g dry wt	0.9	0.4	1.1	1.2	-
Fraction < 1 mm, >/= 500 µm*	g/100g dry wt	1.2	0.4	0.5	0.8	-
Fraction < 500 µm, >/= 250 µm*	g/100g dry wt	2.9	1.2	1.9	2.3	-
Fraction < 250 µm, >/= 125 µm*	g/100g dry wt	9.0	8.1	8.0	9.7	-
Fraction < 125 µm, >/= 63 µm*	g/100g dry wt	15.8	21.9	23.6	19.6	-
Fraction < 63 µm*	g/100g dry wt	65.6	67.4	60.1	64.4	-
Haloethers Trace in SVOC Soil Samples by GC-MS						
Bis(2-chloroethoxy) methane	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	-
Bis(2-chloroethyl)ether	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	-
Bis(2-chloroisopropyl)ether	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	-
4-Bromophenyl phenyl ether	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	-
4-Chlorophenyl phenyl ether	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	-
Nitrogen containing compounds Trace in SVOC Soil Samples, GC-MS						
N-Nitrosodiphenylamine + Diphenylamine	mg/kg dry wt	< 0.7	< 0.5	< 0.5	< 0.5	-
2,4-Dinitrotoluene	mg/kg dry wt	< 0.7	< 0.5	< 0.5	< 0.5	-
2,6-Dinitrotoluene	mg/kg dry wt	< 0.7	< 0.5	< 0.5	< 0.5	-
Nitrobenzene	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	-
N-Nitrosodi-n-propylamine	mg/kg dry wt	< 0.7	< 0.5	< 0.5	< 0.5	-
Organochlorine Pesticides Trace in SVOC Soil Samples by GC-MS						
Aldrin	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	-
alpha-BHC	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	-
beta-BHC	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	-
delta-BHC	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	-
gamma-BHC (Lindane)	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	-
4,4'-DDD	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	-
4,4'-DDE	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	-
4,4'-DDT	mg/kg dry wt	< 0.7	< 0.5	< 0.5	< 0.5	-
Dieldrin	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	-

Sample Type: Sediment						
Sample Name:		BP04c 10-May-2020 11:50 am	BP03a 10-May-2020 2:30 pm	BP03b 10-May-2020 2:31 pm	BP03c 10-May-2020 2:36 pm	
Lab Number:		2363753.6	2363753.7	2363753.8	2363753.9	
Organochlorine Pesticides Trace in SVOC Soil Samples by GC-MS						
Endosulfan I	mg/kg dry wt	< 0.7	< 0.5	< 0.5	< 0.5	-
Endosulfan II	mg/kg dry wt	< 0.7	< 0.5	< 0.5	< 0.5	-
Endosulfan sulphate	mg/kg dry wt	< 0.7	< 0.5	< 0.5	< 0.5	-
Endrin	mg/kg dry wt	< 0.7	< 0.5	< 0.5	< 0.5	-
Endrin ketone	mg/kg dry wt	< 0.7	< 0.5	< 0.5	< 0.5	-
Heptachlor	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	-
Heptachlor epoxide	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	-
Hexachlorobenzene	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	-
Polycyclic Aromatic Hydrocarbons Trace in SVOC Soil Samples*						
Acenaphthene	mg/kg dry wt	< 0.17	< 0.11	< 0.12	< 0.12	-
Acenaphthylene	mg/kg dry wt	< 0.17	< 0.11	< 0.12	< 0.12	-
Anthracene	mg/kg dry wt	< 0.17	< 0.11	< 0.12	< 0.12	-
Benzo[a]anthracene	mg/kg dry wt	< 0.17	< 0.11	< 0.12	< 0.12	-
Benzo[a]pyrene (BAP)	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	-
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	-
Benzo[g,h,i]perylene	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	-
Benzo[k]fluoranthene	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	-
1&2-Chloronaphthalene	mg/kg dry wt	< 0.3	< 0.15	< 0.17	< 0.17	-
Chrysene	mg/kg dry wt	< 0.17	< 0.11	< 0.12	< 0.12	-
Dibenzo[a,h]anthracene	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	-
Fluoranthene	mg/kg dry wt	0.18	0.18	0.21	< 0.12	-
Fluorene	mg/kg dry wt	< 0.17	< 0.11	< 0.12	< 0.12	-
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	-
2-Methylnaphthalene	mg/kg dry wt	< 0.17	< 0.11	< 0.12	< 0.12	-
Naphthalene	mg/kg dry wt	< 0.17	< 0.11	< 0.12	< 0.12	-
Phenanthrene	mg/kg dry wt	< 0.17	0.11	< 0.12	< 0.12	-
Pyrene	mg/kg dry wt	0.17	0.19	0.20	< 0.12	-
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES*	mg/kg dry wt	< 0.8	< 0.5	< 0.6	< 0.6	-
Benzo[a]pyrene Toxic Equivalence (TEF)*	mg/kg dry wt	< 0.8	< 0.5	< 0.6	< 0.6	-
Phenols Trace in SVOC Soil Samples by GC-MS						
4-Chloro-3-methylphenol	mg/kg dry wt	< 0.7	< 0.5	< 0.5	< 0.5	-
2-Chlorophenol	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	-
2,4-Dichlorophenol	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	-
2,4-Dimethylphenol	mg/kg dry wt	< 0.4	< 0.4	< 0.4	< 0.4	-
3 & 4-Methylphenol (m- + p-cresol)	mg/kg dry wt	< 0.7	< 0.5	< 0.5	< 0.5	-
2-Methylphenol (o-Cresol)	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	-
2-Nitrophenol	mg/kg dry wt	< 0.7	< 0.5	< 0.5	< 0.5	-
Pentachlorophenol (PCP)	mg/kg dry wt	< 7	< 6	< 6	< 6	-
Phenol	mg/kg dry wt	< 0.7	< 0.5	< 0.5	< 0.5	-
2,4,5-Trichlorophenol	mg/kg dry wt	< 0.7	< 0.5	< 0.5	< 0.5	-
2,4,6-Trichlorophenol	mg/kg dry wt	< 0.7	< 0.5	< 0.5	< 0.5	-
Plasticisers Trace in SVOC Soil Samples by GC-MS						
Bis(2-ethylhexyl)phthalate	mg/kg dry wt	2.3	4.7	3.8	6.0	-
Butylbenzylphthalate	mg/kg dry wt	< 0.7	0.5	< 0.5	< 0.5	-
Di(2-ethylhexyl)adipate	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	-
Diethylphthalate	mg/kg dry wt	< 0.7	< 0.5	< 0.5	< 0.5	-
Dimethylphthalate	mg/kg dry wt	< 0.7	< 0.5	< 0.5	< 0.5	-
Di-n-butylphthalate	mg/kg dry wt	< 0.7	< 0.5	< 0.5	< 0.5	-
Di-n-octylphthalate	mg/kg dry wt	< 0.7	< 0.5	< 0.5	< 0.5	-

Sample Type: Sediment						
Sample Name:		BP04c 10-May-2020 11:50 am	BP03a 10-May-2020 2:30 pm	BP03b 10-May-2020 2:31 pm	BP03c 10-May-2020 2:36 pm	
Lab Number:		2363753.6	2363753.7	2363753.8	2363753.9	
Other Halogenated compounds Trace in SVOC Soil Samples by GC-MS						
1,2-Dichlorobenzene	mg/kg dry wt	< 0.7	< 0.5	< 0.5	< 0.5	-
1,3-Dichlorobenzene	mg/kg dry wt	< 0.7	< 0.5	< 0.5	< 0.5	-
1,4-Dichlorobenzene	mg/kg dry wt	< 0.7	< 0.5	< 0.5	< 0.5	-
Hexachlorobutadiene	mg/kg dry wt	< 0.7	< 0.5	< 0.5	< 0.5	-
Hexachloroethane	mg/kg dry wt	< 0.7	< 0.5	< 0.5	< 0.5	-
1,2,4-Trichlorobenzene	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	-
Other SVOC Trace in SVOC Soil Samples by GC-MS						
Benzyl alcohol	mg/kg dry wt	< 4	< 3	< 3	< 3	-
Carbazole	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	-
Dibenzofuran	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	-
Isophorone	mg/kg dry wt	< 0.4	< 0.3	< 0.3	< 0.3	-

Analyst's Comments

The matrix in sample 2363753.5 has affected some of the System Monitoring Compounds in the SVOC analysis, whereby the recoveries for 2-fluorophenol and Phenol-d5 were 37% and 39% respectively. Therefore the phenolic related compounds may be underestimated.

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 Laboratories, 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%.	-	1-9
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%.	-	1-9
Dry Matter (Env)	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	1-9
Total Recoverable digestion	Nitric / hydrochloric acid digestion. US EPA 200.2.	-	1-9
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	1-9
Total Recoverable Lead	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, trace level. US EPA 200.2.	0.04 mg/kg dry wt	1-9
Total Recoverable Phosphorus	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, screen level. US EPA 200.2.	40 mg/kg dry wt	1-9
Total Recoverable Zinc	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, trace level. US EPA 200.2.	0.4 mg/kg dry wt	1-9
Total Organic Carbon*	Acid pretreatment to remove carbonates present followed by Catalytic Combustion (900°C, O2), separation, Thermal Conductivity Detector [Elementar Analyser].	0.05 g/100g dry wt	1-9
Semivolatile Organic Compounds Trace in Soil by GC-MS	Sonication extraction, GPC cleanup, GC-MS FS analysis. Tested on as received sample.	0.002 - 6 mg/kg dry wt	1-9
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	1-9
Fraction >/= 2 mm*	Wet sieving with dispersant, as received, 2.00 mm sieve, gravimetry.	0.1 g/100g dry wt	1-9
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	1-9
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	1-9

Sample Type: Sediment			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
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	1-9
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	1-9
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	1-9
Fraction < 63 µm*	Wet sieving with dispersant, as received, 63 µm sieve, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-9

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

Dates of testing are available on request. Please contact the laboratory for more information.

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.

Kim Harrison MSc
Client Services Manager - Environmental

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Certificate of Analysis

SPv1

Client:	Instream Consulting Limited	**Lab No:**	2363933
Contact:	G Burrell	**Date Received:**	11-May-2020
	C/- Instream Consulting Limited	**Date Reported:**	09-Jun-2020
	PO Box 28173	**Quote No:**	103910
	Christchurch 8242	**Order No:**	20350401
		Client Reference:	5-Yearly Monitoring
		Submitted By:	G Burrell

Sample Type: Sediment

Sample Name:		HEATH22a 11-May-2020 9:50 am	HEATH22b 11-May-2020 9:50 am	HEATH22c 11-May-2020 9:50 am	HEATH23a 11-May-2020 10:44 am	HEATH23b 11-May-2020 10:50 am
Lab Number:		2363933.1	2363933.2	2363933.3	2363933.4	2363933.5
Individual Tests						
Dry Matter	g/100g as rcvd	40	33	35	49	42
Total Recoverable Copper	mg/kg dry wt	25	30	31	17	19
Total Recoverable Lead	mg/kg dry wt	31	40	45	25	36
Total Recoverable Phosphorus	mg/kg dry wt	630	830	780	570	650
Total Recoverable Zinc	mg/kg dry wt	380	460	420	290	320
Total Organic Carbon*	g/100g dry wt	2.2	4.8	3.9	2.4	2.0
7 Grain Sizes Profile as received*						
Dry Matter of Sieved Sample*	g/100g as rcvd	38	28	34	37	46
Fraction >/= 2 mm*	g/100g dry wt	7.4	5.4	5.1	22.7	7.9
Fraction < 2 mm, >/= 1 mm*	g/100g dry wt	0.2	0.4	0.5	2.3	1.5
Fraction < 1 mm, >/= 500 µm*	g/100g dry wt	0.4	1.2	0.8	2.3	8.2
Fraction < 500 µm, >/= 250 µm*	g/100g dry wt	10.1	6.0	2.7	17.7	35.6
Fraction < 250 µm, >/= 125 µm*	g/100g dry wt	30.8	13.9	8.1	28.8	20.2
Fraction < 125 µm, >/= 63 µm*	g/100g dry wt	22.8	23.2	21.6	12.6	8.2
Fraction < 63 µm*	g/100g dry wt	28.3	50.1	61.1	13.6	18.4
Haloethers Trace in SVOC Soil Samples by GC-MS						
Bis(2-chloroethoxy) methane	mg/kg dry wt	< 0.15	< 0.18	< 0.17	< 0.13	< 0.15
Bis(2-chloroethyl)ether	mg/kg dry wt	< 0.15	< 0.18	< 0.17	< 0.13	< 0.15
Bis(2-chloroisopropyl)ether	mg/kg dry wt	< 0.15	< 0.18	< 0.17	< 0.13	< 0.15
4-Bromophenyl phenyl ether	mg/kg dry wt	< 0.15	< 0.18	< 0.17	< 0.13	< 0.15
4-Chlorophenyl phenyl ether	mg/kg dry wt	< 0.15	< 0.18	< 0.17	< 0.13	< 0.15
Nitrogen containing compounds Trace in SVOC Soil Samples, GC-MS						
N-Nitrosodiphenylamine + Diphenylamine	mg/kg dry wt	< 0.3	< 0.4	< 0.4	< 0.3	< 0.3
2,4-Dinitrotoluene	mg/kg dry wt	< 0.3	< 0.4	< 0.4	< 0.3	< 0.3
2,6-Dinitrotoluene	mg/kg dry wt	< 0.3	< 0.4	< 0.4	< 0.3	< 0.3
Nitrobenzene	mg/kg dry wt	< 0.15	< 0.18	< 0.17	< 0.13	< 0.15
N-Nitrosodi-n-propylamine	mg/kg dry wt	< 0.3	< 0.4	< 0.4	< 0.3	< 0.3
Organochlorine Pesticides Trace in SVOC Soil Samples by GC-MS						
Aldrin	mg/kg dry wt	< 0.15	< 0.18	< 0.17	< 0.13	< 0.15
alpha-BHC	mg/kg dry wt	< 0.15	< 0.18	< 0.17	< 0.13	< 0.15
beta-BHC	mg/kg dry wt	< 0.15	< 0.18	< 0.17	< 0.13	< 0.15
delta-BHC	mg/kg dry wt	< 0.15	< 0.18	< 0.17	< 0.13	< 0.15
gamma-BHC (Lindane)	mg/kg dry wt	< 0.15	< 0.18	< 0.17	< 0.13	< 0.15
4,4'-DDD	mg/kg dry wt	< 0.15	< 0.18	< 0.17	< 0.13	< 0.15
4,4'-DDE	mg/kg dry wt	< 0.15	< 0.18	< 0.17	< 0.13	< 0.15
4,4'-DDT	mg/kg dry wt	< 0.3	< 0.4	< 0.4	< 0.3	< 0.3

Sample Type: Sediment						
Sample Name:		HEATH22a 11-May-2020 9:50 am	HEATH22b 11-May-2020 9:50 am	HEATH22c 11-May-2020 9:50 am	HEATH23a 11-May-2020 10:44 am	HEATH23b 11-May-2020 10:50 am
Lab Number:		2363933.1	2363933.2	2363933.3	2363933.4	2363933.5
Organochlorine Pesticides Trace in SVOC Soil Samples by GC-MS						
Dieldrin	mg/kg dry wt	< 0.15	< 0.18	< 0.17	< 0.13	< 0.15
Endosulfan I	mg/kg dry wt	< 0.3	< 0.4	< 0.4	< 0.3	< 0.3
Endosulfan II	mg/kg dry wt	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Endosulfan sulphate	mg/kg dry wt	< 0.3	< 0.4	< 0.4	< 0.3	< 0.3
Endrin	mg/kg dry wt	< 0.3	< 0.4	< 0.4	< 0.3	< 0.3
Endrin ketone	mg/kg dry wt	< 0.3	< 0.4	< 0.4	< 0.3	< 0.3
Heptachlor	mg/kg dry wt	< 0.15	< 0.18	< 0.17	< 0.13	< 0.15
Heptachlor epoxide	mg/kg dry wt	< 0.15	< 0.18	< 0.17	< 0.13	< 0.15
Hexachlorobenzene	mg/kg dry wt	< 0.15	< 0.18	< 0.17	< 0.13	< 0.15
Polycyclic Aromatic Hydrocarbons Trace in SVOC Soil Samples*						
Acenaphthene	mg/kg dry wt	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Acenaphthylene	mg/kg dry wt	0.24	< 0.10	< 0.10	0.14	0.18
Anthracene	mg/kg dry wt	0.47	0.11	0.11	0.31	0.28
Benzo[a]anthracene	mg/kg dry wt	1.19	0.45	0.46	1.04	1.13
Benzo[a]pyrene (BAP)	mg/kg dry wt	1.27	0.60	0.57	1.19	1.32
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	1.34	0.73	0.64	1.46	1.51
Benzo[g,h,i]perylene	mg/kg dry wt	0.72	0.37	0.32	0.52	0.86
Benzo[k]fluoranthene	mg/kg dry wt	0.55	0.26	0.24	0.54	0.50
1&2-Chloronaphthalene	mg/kg dry wt	< 0.11	< 0.13	< 0.12	< 0.10	< 0.10
Chrysene	mg/kg dry wt	1.17	0.53	0.46	1.10	1.23
Dibenzo[a,h]anthracene	mg/kg dry wt	< 0.15	< 0.18	< 0.17	< 0.13	< 0.15
Fluoranthene	mg/kg dry wt	2.7	1.05	1.04	2.5	3.0
Fluorene	mg/kg dry wt	0.34	< 0.10	< 0.10	0.15	0.15
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	0.80	0.42	0.37	0.62	0.92
2-Methylnaphthalene	mg/kg dry wt	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Naphthalene	mg/kg dry wt	< 0.10	< 0.10	< 0.10	< 0.10	0.93
Phenanthrene	mg/kg dry wt	2.2	0.47	0.56	1.28	1.73
Pyrene	mg/kg dry wt	2.6	1.09	1.04	2.4	2.9
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES*	mg/kg dry wt	1.8	0.8	0.8	1.7	1.9
Benzo[a]pyrene Toxic Equivalence (TEF)*	mg/kg dry wt	1.8	0.8	0.8	1.7	1.8
Phenols Trace in SVOC Soil Samples by GC-MS						
4-Chloro-3-methylphenol	mg/kg dry wt	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
2-Chlorophenol	mg/kg dry wt	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
2,4-Dichlorophenol	mg/kg dry wt	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
2,4-Dimethylphenol	mg/kg dry wt	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
3 & 4-Methylphenol (m- + p-cresol)	mg/kg dry wt	< 0.4	< 0.4	< 0.4	0.6	< 0.4
2-Methylphenol (o-Cresol)	mg/kg dry wt	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
2-Nitrophenol	mg/kg dry wt	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
Pentachlorophenol (PCP)	mg/kg dry wt	< 6	< 6	< 6	< 6	< 6
Phenol	mg/kg dry wt	< 0.3	0.4	< 0.4	< 0.3	< 0.3
2,4,5-Trichlorophenol	mg/kg dry wt	< 0.3	< 0.4	< 0.4	< 0.3	< 0.3
2,4,6-Trichlorophenol	mg/kg dry wt	< 0.3	< 0.4	< 0.4	< 0.3	< 0.3
Plasticisers Trace in SVOC Soil Samples by GC-MS						
Bis(2-ethylhexyl)phthalate	mg/kg dry wt	1.9	1.9	1.0	1.1	0.6
Butylbenzylphthalate	mg/kg dry wt	< 0.3	< 0.4	< 0.4	< 0.3	< 0.3
Di(2-ethylhexyl)adipate	mg/kg dry wt	< 0.2	< 0.2	< 17 [#1]	< 0.2	< 0.2
Diethylphthalate	mg/kg dry wt	< 0.3	< 0.4	< 0.4	< 0.3	< 0.3
Dimethylphthalate	mg/kg dry wt	< 0.3	< 0.4	< 0.4	< 0.3	< 0.3
Di-n-butylphthalate	mg/kg dry wt	< 0.3	< 0.4	< 0.4	< 0.3	< 0.3
Di-n-octylphthalate	mg/kg dry wt	< 0.3	< 0.4	< 0.4	< 0.3	< 0.3

Sample Type: Sediment						
Sample Name:		HEATH22a 11-May-2020 9:50 am	HEATH22b 11-May-2020 9:50 am	HEATH22c 11-May-2020 9:50 am	HEATH23a 11-May-2020 10:44 am	HEATH23b 11-May-2020 10:50 am
Lab Number:		2363933.1	2363933.2	2363933.3	2363933.4	2363933.5
Other Halogenated compounds Trace in SVOC Soil Samples by GC-MS						
1,2-Dichlorobenzene	mg/kg dry wt	< 0.3	< 0.4	< 0.4	< 0.3	< 0.3
1,3-Dichlorobenzene	mg/kg dry wt	< 0.3	< 0.4	< 0.4	< 0.3	< 0.3
1,4-Dichlorobenzene	mg/kg dry wt	< 0.3	< 0.4	< 0.4	< 0.3	< 0.3
Hexachlorobutadiene	mg/kg dry wt	< 0.3	< 0.4	< 0.4	< 0.3	< 0.3
Hexachloroethane	mg/kg dry wt	< 0.3	< 0.4	< 0.4	< 0.3	< 0.3
1,2,4-Trichlorobenzene	mg/kg dry wt	< 0.15	< 0.18	< 0.17	< 0.13	< 0.15
Other SVOC Trace in SVOC Soil Samples by GC-MS						
Benzyl alcohol	mg/kg dry wt	< 1.5	< 1.8	< 1.7	< 1.3	< 1.5
Carbazole	mg/kg dry wt	0.16	< 0.18	< 0.17	0.13	< 0.15
Dibenzofuran	mg/kg dry wt	0.17	< 0.18	< 0.17	< 0.13	< 0.15
Isophorone	mg/kg dry wt	< 0.15	< 0.18	< 0.17	< 0.13	< 0.15

Sample Name:		HEATH23c 11-May-2020 11:05 am	HEATH24a 11-May-2020 11:35 am	HEATH24b 11-May-2020 11:36 am	HEATH24c 11-May-2020 11:42 am	HEATH05a 11-May-2020 12:53 pm
Lab Number:		2363933.6	2363933.7	2363933.8	2363933.9	2363933.10
Individual Tests						
Dry Matter	g/100g as rcvd	44	38	39	43	61
Total Recoverable Copper	mg/kg dry wt	25	46	31	25	8.9
Total Recoverable Lead	mg/kg dry wt	39	71	60	33	15.4
Total Recoverable Phosphorus	mg/kg dry wt	570	980	840	730	520
Total Recoverable Zinc	mg/kg dry wt	390	510	370	310	107
Total Organic Carbon*	g/100g dry wt	3.4	8.2	5.4	2.9	1.94
7 Grain Sizes Profile as received*						
Dry Matter of Sieved Sample*	g/100g as rcvd	46	32	44	45	59
Fraction >/= 2 mm*	g/100g dry wt	3.9	8.7	7.1	7.6	0.8
Fraction < 2 mm, >/= 1 mm*	g/100g dry wt	0.5	2.1	1.4	1.0	0.2
Fraction < 1 mm, >/= 500 µm*	g/100g dry wt	1.4	3.0	7.0	3.0	0.4
Fraction < 500 µm, >/= 250 µm*	g/100g dry wt	16.6	6.2	25.3	19.2	1.1
Fraction < 250 µm, >/= 125 µm*	g/100g dry wt	26.3	9.0	21.4	16.5	13.2
Fraction < 125 µm, >/= 63 µm*	g/100g dry wt	18.6	13.3	12.1	13.4	38.6
Fraction < 63 µm*	g/100g dry wt	32.7	57.7	25.6	39.3	45.7
Haloethers Trace in SVOC Soil Samples by GC-MS						
Bis(2-chloroethoxy) methane	mg/kg dry wt	< 0.14	< 0.16	< 0.16	< 0.14	< 0.10
Bis(2-chloroethyl)ether	mg/kg dry wt	< 0.14	< 0.16	< 0.16	< 0.14	< 0.10
Bis(2-chloroisopropyl)ether	mg/kg dry wt	< 0.14	< 0.16	< 0.16	< 0.14	< 0.10
4-Bromophenyl phenyl ether	mg/kg dry wt	< 0.14	< 0.16	< 0.16	< 0.14	< 0.10
4-Chlorophenyl phenyl ether	mg/kg dry wt	< 0.14	< 0.16	< 0.16	< 0.14	< 0.10
Nitrogen containing compounds Trace in SVOC Soil Samples, GC-MS						
N-Nitrosodiphenylamine + Diphenylamine	mg/kg dry wt	< 0.3	< 0.4	< 0.4	< 0.3	< 0.2
2,4-Dinitrotoluene	mg/kg dry wt	< 0.3	< 0.4	< 0.4	< 0.3	< 0.2
2,6-Dinitrotoluene	mg/kg dry wt	< 0.3	< 0.4	< 0.4	< 0.3	< 0.2
Nitrobenzene	mg/kg dry wt	< 0.14	< 0.16	< 0.16	< 0.14	< 0.10
N-Nitrosodi-n-propylamine	mg/kg dry wt	< 0.3	< 0.4	< 0.4	< 0.3	< 0.2
Organochlorine Pesticides Trace in SVOC Soil Samples by GC-MS						
Aldrin	mg/kg dry wt	< 0.14	< 0.16	< 0.16	< 0.14	< 0.10
alpha-BHC	mg/kg dry wt	< 0.14	< 0.16	< 0.16	< 0.14	< 0.10
beta-BHC	mg/kg dry wt	< 0.14	< 0.16	< 0.16	< 0.14	< 0.10
delta-BHC	mg/kg dry wt	< 0.14	< 0.16	< 0.16	< 0.14	< 0.10
gamma-BHC (Lindane)	mg/kg dry wt	< 0.14	< 0.16	< 0.16	< 0.14	< 0.10
4,4'-DDD	mg/kg dry wt	< 0.14	< 0.16	< 0.16	< 0.14	< 0.10
4,4'-DDE	mg/kg dry wt	< 0.14	< 0.16	< 0.16	< 0.14	< 0.10
4,4'-DDT	mg/kg dry wt	< 0.3	< 0.4	< 0.4	< 0.3	< 0.2
Dieldrin	mg/kg dry wt	< 0.14	< 0.16	< 0.16	< 0.14	< 0.10

Sample Type: Sediment						
Sample Name:		HEATH23c 11-May-2020 11:05 am	HEATH24a 11-May-2020 11:35 am	HEATH24b 11-May-2020 11:36 am	HEATH24c 11-May-2020 11:42 am	HEATH05a 11-May-2020 12:53 pm
Lab Number:		2363933.6	2363933.7	2363933.8	2363933.9	2363933.10
Organochlorine Pesticides Trace in SVOC Soil Samples by GC-MS						
Endosulfan I	mg/kg dry wt	< 0.3	< 0.4	< 0.4	< 0.3	< 0.2
Endosulfan II	mg/kg dry wt	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Endosulfan sulphate	mg/kg dry wt	< 0.3	< 0.4	< 0.4	< 0.3	< 0.2
Endrin	mg/kg dry wt	< 0.3	< 0.4	< 0.4	< 0.3	< 0.2
Endrin ketone	mg/kg dry wt	< 0.3	< 0.4	< 0.4	< 0.3	< 0.2
Heptachlor	mg/kg dry wt	< 0.14	< 0.16	< 0.16	< 0.14	< 0.10
Heptachlor epoxide	mg/kg dry wt	< 0.14	< 0.16	< 0.16	< 0.14	< 0.10
Hexachlorobenzene	mg/kg dry wt	< 0.14	< 0.16	< 0.16	< 0.14	< 0.10
Polycyclic Aromatic Hydrocarbons Trace in SVOC Soil Samples*						
Acenaphthene	mg/kg dry wt	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Acenaphthylene	mg/kg dry wt	0.14	0.21	0.10	0.14	< 0.10
Anthracene	mg/kg dry wt	0.31	0.48	0.19	0.28	< 0.10
Benzo[a]anthracene	mg/kg dry wt	1.02	2.0	0.76	1.01	< 0.10
Benzo[a]pyrene (BAP)	mg/kg dry wt	1.14	2.1	0.87	1.14	< 0.10
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	1.41	2.6	1.05	1.41	< 0.10
Benzo[g,h,i]perylene	mg/kg dry wt	0.51	1.04	0.40	0.51	< 0.10
Benzo[k]fluoranthene	mg/kg dry wt	0.48	1.10	0.40	0.49	< 0.10
1&2-Chloronaphthalene	mg/kg dry wt	< 0.10	< 0.11	< 0.11	< 0.10	< 0.10
Chrysene	mg/kg dry wt	1.04	2.0	0.76	1.04	< 0.10
Dibenzo[a,h]anthracene	mg/kg dry wt	< 0.14	< 0.16	< 0.16	< 0.14	< 0.10
Fluoranthene	mg/kg dry wt	2.5	5.2	1.72	2.5	< 0.10
Fluorene	mg/kg dry wt	0.14	< 0.10	< 0.10	< 0.10	< 0.10
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	0.61	1.15	0.48	0.58	< 0.10
2-Methylnaphthalene	mg/kg dry wt	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Naphthalene	mg/kg dry wt	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Phenanthrene	mg/kg dry wt	1.38	1.97	0.75	1.30	< 0.10
Pyrene	mg/kg dry wt	2.3	5.1	1.67	2.4	< 0.10
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES*	mg/kg dry wt	1.6	3.0	1.2	1.6	< 0.3
Benzo[a]pyrene Toxic Equivalence (TEF)*	mg/kg dry wt	1.6	3.0	1.2	1.6	< 0.3
Phenols Trace in SVOC Soil Samples by GC-MS						
4-Chloro-3-methylphenol	mg/kg dry wt	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
2-Chlorophenol	mg/kg dry wt	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
2,4-Dichlorophenol	mg/kg dry wt	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
2,4-Dimethylphenol	mg/kg dry wt	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
3 & 4-Methylphenol (m- + p-cresol)	mg/kg dry wt	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
2-Methylphenol (o-Cresol)	mg/kg dry wt	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
2-Nitrophenol	mg/kg dry wt	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
Pentachlorophenol (PCP)	mg/kg dry wt	< 6	< 6	< 6	< 6	< 6
Phenol	mg/kg dry wt	< 0.3	< 0.4	< 0.4	< 0.3	< 0.2
2,4,5-Trichlorophenol	mg/kg dry wt	< 0.3	< 0.4	< 0.4	< 0.3	< 0.2
2,4,6-Trichlorophenol	mg/kg dry wt	< 0.3	< 0.4	< 0.4	< 0.3	< 0.2
Plasticisers Trace in SVOC Soil Samples by GC-MS						
Bis(2-ethylhexyl)phthalate	mg/kg dry wt	1.5	2.2	0.7	1.0	< 0.5
Butylbenzylphthalate	mg/kg dry wt	< 0.3	0.4	< 0.4	< 0.3	< 0.2
Di(2-ethylhexyl)adipate	mg/kg dry wt	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Diethylphthalate	mg/kg dry wt	< 0.3	< 0.4	< 0.4	< 0.3	< 0.2
Dimethylphthalate	mg/kg dry wt	< 0.3	< 0.4	< 0.4	< 0.3	< 0.2
Di-n-butylphthalate	mg/kg dry wt	< 0.3	< 0.4	< 0.4	< 0.3	< 0.2
Di-n-octylphthalate	mg/kg dry wt	< 0.3	< 0.4	< 0.4	< 0.3	< 0.2

Sample Type: Sediment						
Sample Name:		HEATH23c 11-May-2020 11:05 am	HEATH24a 11-May-2020 11:35 am	HEATH24b 11-May-2020 11:36 am	HEATH24c 11-May-2020 11:42 am	HEATH05a 11-May-2020 12:53 pm
Lab Number:		2363933.6	2363933.7	2363933.8	2363933.9	2363933.10
Other Halogenated compounds Trace in SVOC Soil Samples by GC-MS						
1,2-Dichlorobenzene	mg/kg dry wt	< 0.3	< 0.4	< 0.4	< 0.3	< 0.2
1,3-Dichlorobenzene	mg/kg dry wt	< 0.3	< 0.4	< 0.4	< 0.3	< 0.2
1,4-Dichlorobenzene	mg/kg dry wt	< 0.3	< 0.4	< 0.4	< 0.3	< 0.2
Hexachlorobutadiene	mg/kg dry wt	< 0.3	< 0.4	< 0.4	< 0.3	< 0.2
Hexachloroethane	mg/kg dry wt	< 0.3	< 0.4	< 0.4	< 0.3	< 0.2
1,2,4-Trichlorobenzene	mg/kg dry wt	< 0.14	< 0.16	< 0.16	< 0.14	< 0.10
Other SVOC Trace in SVOC Soil Samples by GC-MS						
Benzyl alcohol	mg/kg dry wt	< 1.4	< 1.6	< 1.6	< 1.4	< 1.0
Carbazole	mg/kg dry wt	< 0.14	0.28	< 0.16	< 0.14	< 0.10
Dibenzofuran	mg/kg dry wt	< 0.14	< 0.16	< 0.16	< 0.14	< 0.10
Isophorone	mg/kg dry wt	< 0.14	< 0.16	< 0.16	< 0.14	< 0.10

Sample Name:		HEATH05b 11-May-2020 12:56 pm	HEATH05c 11-May-2020 1:00 pm	HEATH16a 11-May-2020 1:20 pm	HEATH16b 11-May-2020 1:25 pm	HEATH16c 11-May-2020 1:30 pm
Lab Number:		2363933.11	2363933.12	2363933.13	2363933.14	2363933.15
Individual Tests						
Dry Matter	g/100g as rcvd	50	54	76	64	57
Total Recoverable Copper	mg/kg dry wt	11	10	4	3.6	3.5
Total Recoverable Lead	mg/kg dry wt	19.3	15.5	7.8	8.4	7.0
Total Recoverable Phosphorus	mg/kg dry wt	620	590	260	270	280
Total Recoverable Zinc	mg/kg dry wt	119	119	37	38	43
Total Organic Carbon*	g/100g dry wt	2.3	2.1	0.27	0.73	1.01 #2
7 Grain Sizes Profile as received*						
Dry Matter of Sieved Sample*	g/100g as rcvd	58	57	71	71	64
Fraction >/= 2 mm*	g/100g dry wt	1.0	0.2	1.8	0.7	5.4
Fraction < 2 mm, >/= 1 mm*	g/100g dry wt	0.3	0.1	0.2	0.3	0.3
Fraction < 1 mm, >/= 500 µm*	g/100g dry wt	0.4	0.4	0.4	0.4	0.4
Fraction < 500 µm, >/= 250 µm*	g/100g dry wt	1.3	1.1	13.2	15.0	11.8
Fraction < 250 µm, >/= 125 µm*	g/100g dry wt	11.4	9.8	58.1	60.6	47.7
Fraction < 125 µm, >/= 63 µm*	g/100g dry wt	33.6	38.9	20.3	14.7	26.5
Fraction < 63 µm*	g/100g dry wt	52.0	49.5	5.9	8.1	7.9
Haloethers Trace in SVOC Soil Samples by GC-MS						
Bis(2-chloroethoxy) methane	mg/kg dry wt	< 0.12	< 0.11	< 0.10	< 0.10	< 0.11
Bis(2-chloroethyl)ether	mg/kg dry wt	< 0.12	< 0.11	< 0.10	< 0.10	< 0.11
Bis(2-chloroisopropyl)ether	mg/kg dry wt	< 0.12	< 0.11	< 0.10	< 0.10	< 0.11
4-Bromophenyl phenyl ether	mg/kg dry wt	< 0.12	< 0.11	< 0.10	< 0.10	< 0.11
4-Chlorophenyl phenyl ether	mg/kg dry wt	< 0.12	< 0.11	< 0.10	< 0.10	< 0.11
Nitrogen containing compounds Trace in SVOC Soil Samples, GC-MS						
N-Nitrosodiphenylamine + Diphenylamine	mg/kg dry wt	< 0.3	< 0.3	< 0.16	< 0.19	< 0.3
2,4-Dinitrotoluene	mg/kg dry wt	< 0.3	< 0.3	< 0.2	< 0.2	< 0.3
2,6-Dinitrotoluene	mg/kg dry wt	< 0.3	< 0.3	< 0.2	< 0.2	< 0.3
Nitrobenzene	mg/kg dry wt	< 0.12	< 0.11	< 0.10	< 0.10	< 0.11
N-Nitrosodi-n-propylamine	mg/kg dry wt	< 0.3	< 0.3	< 0.16	< 0.19	< 0.3
Organochlorine Pesticides Trace in SVOC Soil Samples by GC-MS						
Aldrin	mg/kg dry wt	< 0.12	< 0.11	< 0.10	< 0.10	< 0.11
alpha-BHC	mg/kg dry wt	< 0.12	< 0.11	< 0.10	< 0.10	< 0.11
beta-BHC	mg/kg dry wt	< 0.12	< 0.11	< 0.10	< 0.10	< 0.11
delta-BHC	mg/kg dry wt	< 0.12	< 0.11	< 0.10	< 0.10	< 0.11
gamma-BHC (Lindane)	mg/kg dry wt	< 0.12	< 0.11	< 0.10	< 0.10	< 0.11
4,4'-DDD	mg/kg dry wt	< 0.12	< 0.11	< 0.10	< 0.10	< 0.11
4,4'-DDE	mg/kg dry wt	< 0.12	< 0.11	< 0.10	< 0.10	< 0.11
4,4'-DDT	mg/kg dry wt	< 0.3	< 0.3	< 0.2	< 0.2	< 0.3
Dieldrin	mg/kg dry wt	< 0.12	< 0.11	< 0.10	< 0.10	< 0.11

Sample Type: Sediment						
Sample Name:		HEATH05b 11-May-2020 12:56 pm	HEATH05c 11-May-2020 1:00 pm	HEATH16a 11-May-2020 1:20 pm	HEATH16b 11-May-2020 1:25 pm	HEATH16c 11-May-2020 1:30 pm
Lab Number:		2363933.11	2363933.12	2363933.13	2363933.14	2363933.15
Organochlorine Pesticides Trace in SVOC Soil Samples by GC-MS						
Endosulfan I	mg/kg dry wt	< 0.3	< 0.3	< 0.2	< 0.2	< 0.3
Endosulfan II	mg/kg dry wt	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Endosulfan sulphate	mg/kg dry wt	< 0.3	< 0.3	< 0.2	< 0.2	< 0.3
Endrin	mg/kg dry wt	< 0.3	< 0.3	< 0.16	< 0.19	< 0.3
Endrin ketone	mg/kg dry wt	< 0.3	< 0.3	< 0.2	< 0.2	< 0.3
Heptachlor	mg/kg dry wt	< 0.12	< 0.11	< 0.10	< 0.10	< 0.11
Heptachlor epoxide	mg/kg dry wt	< 0.12	< 0.11	< 0.10	< 0.10	< 0.11
Hexachlorobenzene	mg/kg dry wt	< 0.12	< 0.11	< 0.10	< 0.10	< 0.11
Polycyclic Aromatic Hydrocarbons Trace in SVOC Soil Samples*						
Acenaphthene	mg/kg dry wt	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Acenaphthylene	mg/kg dry wt	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Anthracene	mg/kg dry wt	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Benzo[a]anthracene	mg/kg dry wt	0.14	< 0.10	< 0.10	< 0.10	< 0.10
Benzo[a]pyrene (BAP)	mg/kg dry wt	0.14	< 0.11	< 0.10	< 0.10	< 0.11
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	0.16	< 0.11	< 0.10	< 0.10	< 0.11
Benzo[g,h,i]perylene	mg/kg dry wt	< 0.12	< 0.11	< 0.10	< 0.10	< 0.11
Benzo[k]fluoranthene	mg/kg dry wt	< 0.12	< 0.11	< 0.10	< 0.10	< 0.11
1&2-Chloronaphthalene	mg/kg dry wt	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Chrysene	mg/kg dry wt	0.13	< 0.10	< 0.10	< 0.10	< 0.10
Dibenzo[a,h]anthracene	mg/kg dry wt	< 0.12	< 0.11	< 0.10	< 0.10	< 0.11
Fluoranthene	mg/kg dry wt	0.31	< 0.10	< 0.10	< 0.10	< 0.10
Fluorene	mg/kg dry wt	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	< 0.12	< 0.11	< 0.10	< 0.10	< 0.11
2-Methylnaphthalene	mg/kg dry wt	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Naphthalene	mg/kg dry wt	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Phenanthrene	mg/kg dry wt	0.21	< 0.10	< 0.10	< 0.10	< 0.10
Pyrene	mg/kg dry wt	0.31	< 0.10	< 0.10	< 0.10	< 0.10
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES*	mg/kg dry wt	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
Benzo[a]pyrene Toxic Equivalence (TEF)*	mg/kg dry wt	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
Phenols Trace in SVOC Soil Samples by GC-MS						
4-Chloro-3-methylphenol	mg/kg dry wt	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
2-Chlorophenol	mg/kg dry wt	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
2,4-Dichlorophenol	mg/kg dry wt	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
2,4-Dimethylphenol	mg/kg dry wt	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
3 & 4-Methylphenol (m- + p-cresol)	mg/kg dry wt	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
2-Methylphenol (o-Cresol)	mg/kg dry wt	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
2-Nitrophenol	mg/kg dry wt	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
Pentachlorophenol (PCP)	mg/kg dry wt	< 6	< 6	< 6	< 6	< 6
Phenol	mg/kg dry wt	< 0.3	< 0.3	< 0.2	< 0.2	< 0.3
2,4,5-Trichlorophenol	mg/kg dry wt	< 0.3	< 0.3	< 0.2	< 0.2	< 0.3
2,4,6-Trichlorophenol	mg/kg dry wt	< 0.3	< 0.3	< 0.2	< 0.2	< 0.3
Plasticisers Trace in SVOC Soil Samples by GC-MS						
Bis(2-ethylhexyl)phthalate	mg/kg dry wt	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Butylbenzylphthalate	mg/kg dry wt	0.2	< 0.3	< 0.2	< 0.2	< 0.3
Di(2-ethylhexyl)adipate	mg/kg dry wt	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Diethylphthalate	mg/kg dry wt	< 0.3	< 0.3	< 0.2	< 0.2	< 0.3
Dimethylphthalate	mg/kg dry wt	< 0.3	< 0.3	< 0.2	< 0.2	< 0.3
Di-n-butylphthalate	mg/kg dry wt	< 0.3	< 0.3	< 0.2	< 0.2	< 0.3
Di-n-octylphthalate	mg/kg dry wt	< 0.3	< 0.3	< 0.2	< 0.2	< 0.3

Sample Type: Sediment						
Sample Name:		HEATH05b 11-May-2020 12:56 pm	HEATH05c 11-May-2020 1:00 pm	HEATH16a 11-May-2020 1:20 pm	HEATH16b 11-May-2020 1:25 pm	HEATH16c 11-May-2020 1:30 pm
Lab Number:		2363933.11	2363933.12	2363933.13	2363933.14	2363933.15
Other Halogenated compounds Trace in SVOC Soil Samples by GC-MS						
1,2-Dichlorobenzene	mg/kg dry wt	< 0.3	< 0.3	< 0.16	< 0.19	< 0.3
1,3-Dichlorobenzene	mg/kg dry wt	< 0.3	< 0.3	< 0.16	< 0.19	< 0.3
1,4-Dichlorobenzene	mg/kg dry wt	< 0.3	< 0.3	< 0.16	< 0.19	< 0.3
Hexachlorobutadiene	mg/kg dry wt	< 0.3	< 0.3	< 0.16	< 0.19	< 0.3
Hexachloroethane	mg/kg dry wt	< 0.3	< 0.3	< 0.16	< 0.19	< 0.3
1,2,4-Trichlorobenzene	mg/kg dry wt	< 0.12	< 0.11	< 0.10	< 0.10	< 0.11
Other SVOC Trace in SVOC Soil Samples by GC-MS						
Benzyl alcohol	mg/kg dry wt	< 1.2	< 1.1	< 1.0	< 1.0	< 1.1
Carbazole	mg/kg dry wt	< 0.12	< 0.11	< 0.10	< 0.10	< 0.11
Dibenzofuran	mg/kg dry wt	< 0.12	< 0.11	< 0.10	< 0.10	< 0.11
Isophorone	mg/kg dry wt	< 0.12	< 0.11	< 0.10	< 0.10	< 0.11

Analyst's Comments

The matrix in sample 2363933.11 has affected some of the System Monitoring Compounds in the SVOC analysis, whereby 2-fluorophenol was 35% and Phenol-d5 was 35%. Therefore the phenolic compounds may be underestimated.

It has been noted that the duplicate for the SVOC analysis on sample 2363933.1, which was run as part of our in-house QC procedure, showed greater variation than would normally be expected. This may reflect the heterogeneity of the sample.

[#1] Due to some interference found in the chromatography, the sample was diluted and re-analysed. Hence the higher detection limit reported.

[#2] It should be noted that the replicate analyses performed on this sample as part of our in-house Quality Assurance procedures showed greater variation than would normally be expected. This may reflect the heterogeneity of the sample. The average of the results of the replicate analyses has been reported. Rep 1 = 1.16 g/100g and Rep = 0.85 g/100g

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 Laboratories, 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%.	-	1-15
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%.	-	1-15
Dry Matter (Env)	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	1-15
Total Recoverable digestion	Nitric / hydrochloric acid digestion. US EPA 200.2.	-	1-15
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	1-15
Total Recoverable Lead	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, trace level. US EPA 200.2.	0.04 mg/kg dry wt	1-15
Total Recoverable Phosphorus	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, screen level. US EPA 200.2.	40 mg/kg dry wt	1-15
Total Recoverable Zinc	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, trace level. US EPA 200.2.	0.4 mg/kg dry wt	1-15
Total Organic Carbon*	Acid pretreatment to remove carbonates present followed by Catalytic Combustion (900°C, O2), separation, Thermal Conductivity Detector [Elementar Analyser].	0.05 g/100g dry wt	1-15
Semivolatile Organic Compounds Trace in Soil by GC-MS	Sonication extraction, GPC cleanup, GC-MS FS analysis. Tested on as received sample.	0.002 - 6 mg/kg dry wt	1-15

Sample Type: Sediment			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
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	1-15
Fraction >/= 2 mm*	Wet sieving with dispersant, as received, 2.00 mm sieve, gravimetry.	0.1 g/100g dry wt	1-15
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	1-15
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	1-15
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	1-15
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	1-15
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	1-15
Fraction < 63 µm*	Wet sieving with dispersant, as received, 63 µm sieve, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-15

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

Dates of testing are available on request. Please contact the laboratory for more information.

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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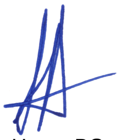

Ara Heron BSc (Tech)
Client Services Manager - Environmental

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Certificate of Analysis

SPv1

Client:	Instream Consulting Limited	**Lab No:**	2365301
Contact:	G Burrell	**Date Received:**	13-May-2020
	C/- Instream Consulting Limited	**Date Reported:**	19-Jun-2020
	PO Box 28173	**Quote No:**	103910
	Christchurch 8242	**Order No:**	20350401
		Client Reference:	5 Yearly Monitoring
		Submitted By:	G Burrell

Sample Type: Sediment

Sample Name:		HEATH06a 12-May-2020 1:30 pm	HEATH06b 12-May-2020 1:38 pm	HEATH06c 12-May-2020 1:48 pm	HEATH29a 12-May-2020 2:22 pm	HEATH29b 12-May-2020 2:29 pm
Lab Number:		2365301.1	2365301.2	2365301.3	2365301.4	2365301.5
Individual Tests						
Dry Matter	g/100g as rcvd	33	43	26	24	28
Total Recoverable Copper	mg/kg dry wt	84	96	107	91	82
Total Recoverable Lead	mg/kg dry wt	69	171	66	61	52
Total Recoverable Phosphorus	mg/kg dry wt	1,030	1,360	930	1,230	1,650
Total Recoverable Zinc	mg/kg dry wt	570	550	940	690	620
Total Organic Carbon*	g/100g dry wt	5.0	5.9	10.1	8.8	7.6
7 Grain Sizes Profile as received*						
Dry Matter of Sieved Sample*	g/100g as rcvd	44	50	27	27	31
Fraction >/= 2 mm*	g/100g dry wt	47.8	16.3	8.8	13.4	19.9
Fraction < 2 mm, >/= 1 mm*	g/100g dry wt	1.6	1.8	0.7	0.9	1.3
Fraction < 1 mm, >/= 500 µm*	g/100g dry wt	3.1	3.0	1.9	1.7	5.2
Fraction < 500 µm, >/= 250 µm*	g/100g dry wt	16.5	15.2	6.4	5.9	14.2
Fraction < 250 µm, >/= 125 µm*	g/100g dry wt	15.9	27.0	27.5	28.5	20.9
Fraction < 125 µm, >/= 63 µm*	g/100g dry wt	7.8	15.7	25.3	25.7	16.6
Fraction < 63 µm*	g/100g dry wt	7.4	21.1	29.5	23.9	22.0
Haloethers Trace in SVOC Soil Samples by GC-MS						
Bis(2-chloroethoxy) methane	mg/kg dry wt	< 0.18	< 0.14	< 0.3	< 0.3	< 0.3
Bis(2-chloroethyl)ether	mg/kg dry wt	< 0.18	< 0.14	< 0.3	< 0.3	< 0.3
Bis(2-chloroisopropyl)ether	mg/kg dry wt	< 0.18	< 0.14	< 0.3	< 0.3	< 0.3
4-Bromophenyl phenyl ether	mg/kg dry wt	< 0.18	< 0.14	< 0.3	< 0.3	< 0.3
4-Chlorophenyl phenyl ether	mg/kg dry wt	< 0.18	< 0.14	< 0.3	< 0.3	< 0.3
Nitrogen containing compounds Trace in SVOC Soil Samples, GC-MS						
N-Nitrosodiphenylamine + Diphenylamine	mg/kg dry wt	< 0.4	< 0.3	< 0.5	< 0.5	< 0.5
2,4-Dinitrotoluene	mg/kg dry wt	< 0.4	< 0.3	< 0.5	< 0.5	< 0.5
2,6-Dinitrotoluene	mg/kg dry wt	< 0.4	< 0.3	< 0.5	< 0.5	< 0.5
Nitrobenzene	mg/kg dry wt	< 0.18	< 0.14	< 0.3	< 0.3	< 0.3
N-Nitrosodi-n-propylamine	mg/kg dry wt	< 0.4	< 0.3	< 0.5	< 0.5	< 0.5
Organochlorine Pesticides Trace in SVOC Soil Samples by GC-MS						
Aldrin	mg/kg dry wt	< 0.18	< 0.14	< 5 [#1]	< 0.3	< 0.3
alpha-BHC	mg/kg dry wt	< 0.18	< 0.14	< 0.3	< 0.3	< 0.3
beta-BHC	mg/kg dry wt	< 0.18	< 0.14	< 0.3	< 0.3	< 0.3
delta-BHC	mg/kg dry wt	< 0.18	< 0.14	< 0.3	< 0.3	< 0.3
gamma-BHC (Lindane)	mg/kg dry wt	< 0.18	< 0.14	< 0.3	< 0.3	< 0.3
4,4'-DDD	mg/kg dry wt	< 0.18	< 0.14	< 0.3	< 0.3	< 0.3
4,4'-DDE	mg/kg dry wt	< 0.18	< 0.14	< 0.3	< 0.3	< 0.3
4,4'-DDT	mg/kg dry wt	< 0.4	< 0.3	< 0.5	< 0.5	< 0.5

Sample Type: Sediment						
Sample Name:		HEATH06a 12-May-2020 1:30 pm	HEATH06b 12-May-2020 1:38 pm	HEATH06c 12-May-2020 1:48 pm	HEATH29a 12-May-2020 2:22 pm	HEATH29b 12-May-2020 2:29 pm
Lab Number:		2365301.1	2365301.2	2365301.3	2365301.4	2365301.5
Organochlorine Pesticides Trace in SVOC Soil Samples by GC-MS						
Dieldrin	mg/kg dry wt	< 0.18	< 0.14	< 0.3	< 0.3	< 0.3
Endosulfan I	mg/kg dry wt	< 0.4	< 0.3	< 0.5	< 0.5	< 0.5
Endosulfan II	mg/kg dry wt	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Endosulfan sulphate	mg/kg dry wt	< 0.4	< 0.3	< 0.5	< 0.5	< 0.5
Endrin	mg/kg dry wt	< 0.4	< 0.3	< 0.5	< 0.5	< 0.5
Endrin ketone	mg/kg dry wt	< 0.4	< 0.3	< 0.5	< 0.5	< 0.5
Heptachlor	mg/kg dry wt	< 0.18	< 0.14	< 0.3	< 0.3	< 0.3
Heptachlor epoxide	mg/kg dry wt	< 0.18	< 0.14	< 0.3	< 0.3	< 0.3
Hexachlorobenzene	mg/kg dry wt	< 0.18	< 0.14	< 0.3	< 0.3	< 0.3
Polycyclic Aromatic Hydrocarbons Trace in SVOC Soil Samples*						
Acenaphthene	mg/kg dry wt	< 0.10	0.16	< 0.12	< 0.13	< 0.11
Acenaphthylene	mg/kg dry wt	0.14	0.66	0.12	< 0.13	< 0.11
Anthracene	mg/kg dry wt	0.25	0.86	0.15	< 0.13	< 0.11
Benzo[a]anthracene	mg/kg dry wt	1.06	5.4	0.76	0.18	0.12
Benzo[a]pyrene (BAP)	mg/kg dry wt	1.22	6.9	0.9	< 0.3	< 0.3
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	1.24	7.4	0.9	0.3	< 0.3
Benzo[g,h,i]perylene	mg/kg dry wt	0.89	5.5	0.6	< 0.3	< 0.3
Benzo[k]fluoranthene	mg/kg dry wt	0.53	2.8	0.4	< 0.3	< 0.3
1&2-Chloronaphthalene	mg/kg dry wt	< 0.13	< 0.10	< 0.16	< 0.18	< 0.15
Chrysene	mg/kg dry wt	1.08	6.1	0.78	0.19	0.11
Dibenzo[a,h]anthracene	mg/kg dry wt	< 0.18	1.13	< 0.3	< 0.3	< 0.3
Fluoranthene	mg/kg dry wt	2.7	11.1	1.72	0.34	0.16
Fluorene	mg/kg dry wt	0.11	0.23	< 0.12	< 0.13	< 0.11
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	0.87	5.4	0.6	< 0.3	< 0.3
2-Methylnaphthalene	mg/kg dry wt	< 0.10	< 0.10	< 0.12	< 0.13	< 0.11
Naphthalene	mg/kg dry wt	< 0.10	0.11	< 0.12	< 0.13	< 0.11
Phenanthrene	mg/kg dry wt	1.57	4.9	0.91	0.14	< 0.11
Pyrene	mg/kg dry wt	2.7	12.1	1.76	0.40	0.20
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES*	mg/kg dry wt	1.8	10.3	1.3	< 0.6	< 0.5
Benzo[a]pyrene Toxic Equivalence (TEF)*	mg/kg dry wt	1.7	10.2	1.3	< 0.6	< 0.5
Phenols Trace in SVOC Soil Samples by GC-MS						
4-Chloro-3-methylphenol	mg/kg dry wt	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
2-Chlorophenol	mg/kg dry wt	< 0.2	< 0.2	< 0.3	< 0.3	< 0.3
2,4-Dichlorophenol	mg/kg dry wt	< 0.2	< 0.2	< 0.3	< 0.3	< 0.3
2,4-Dimethylphenol	mg/kg dry wt	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
3 & 4-Methylphenol (m- + p-cresol)	mg/kg dry wt	< 0.4	< 0.4	< 0.5	< 0.5	< 0.5
2-Methylphenol (o-Cresol)	mg/kg dry wt	< 0.2	< 0.2	< 0.3	< 0.3	< 0.3
2-Nitrophenol	mg/kg dry wt	< 0.4	< 0.4	< 0.5	< 0.5	< 0.5
Pentachlorophenol (PCP)	mg/kg dry wt	< 6	< 6	< 6	< 6	< 6
Phenol	mg/kg dry wt	< 0.4	< 0.3	< 0.5	< 0.5	< 0.5
2,4,5-Trichlorophenol	mg/kg dry wt	< 0.4	< 0.3	< 0.5	< 0.5	< 0.5
2,4,6-Trichlorophenol	mg/kg dry wt	< 0.4	< 0.3	< 0.5	< 0.5	< 0.5
Plasticisers Trace in SVOC Soil Samples by GC-MS						
Bis(2-ethylhexyl)phthalate	mg/kg dry wt	< 0.8	< 0.6	2.8	1.3	1.2
Butylbenzylphthalate	mg/kg dry wt	< 0.4	< 0.3	< 0.5	< 0.5	< 0.5
Di(2-ethylhexyl)adipate	mg/kg dry wt	< 0.2	< 0.2	< 0.3	< 0.3	< 0.3
Diethylphthalate	mg/kg dry wt	< 0.4	< 0.3	< 0.5	< 0.5	< 0.5
Dimethylphthalate	mg/kg dry wt	< 0.4	< 0.3	< 0.5	< 0.5	< 0.5
Di-n-butylphthalate	mg/kg dry wt	< 0.4	< 0.3	< 0.5	< 0.5	< 0.5
Di-n-octylphthalate	mg/kg dry wt	< 0.4	< 0.3	< 0.5	< 0.5	< 0.5

Sample Type: Sediment						
Sample Name:		HEATH06a 12-May-2020 1:30 pm	HEATH06b 12-May-2020 1:38 pm	HEATH06c 12-May-2020 1:48 pm	HEATH29a 12-May-2020 2:22 pm	HEATH29b 12-May-2020 2:29 pm
Lab Number:		2365301.1	2365301.2	2365301.3	2365301.4	2365301.5
Other Halogenated compounds Trace in SVOC Soil Samples by GC-MS						
1,2-Dichlorobenzene	mg/kg dry wt	< 0.4	< 0.3	< 0.5	< 0.5	< 0.5
1,3-Dichlorobenzene	mg/kg dry wt	< 0.4	< 0.3	< 0.5	< 0.5	< 0.5
1,4-Dichlorobenzene	mg/kg dry wt	< 0.4	< 0.3	< 0.5	< 0.5	< 0.5
Hexachlorobutadiene	mg/kg dry wt	< 0.4	< 0.3	< 0.5	< 0.5	< 0.5
Hexachloroethane	mg/kg dry wt	< 0.4	< 0.3	< 0.5	< 0.5	< 0.5
1,2,4-Trichlorobenzene	mg/kg dry wt	< 0.18	< 0.14	< 0.3	< 0.3	< 0.3
Other SVOC Trace in SVOC Soil Samples by GC-MS						
Benzyl alcohol	mg/kg dry wt	< 1.8	< 1.4	< 3	< 3	< 3
Carbazole	mg/kg dry wt	< 0.18	0.40	< 0.3	< 0.3	< 0.3
Dibenzofuran	mg/kg dry wt	< 0.18	< 0.14	< 0.3	< 0.3	< 0.3
Isophorone	mg/kg dry wt	< 0.18	< 0.14	< 0.3	< 0.3	< 0.3

Sample Name:		HEATH29c 12-May-2020 2:36 pm	HEATH30a 12-May-2020 3:15 pm	HEATH30b 12-May-2020 3:30 pm	HEATH30c 12-May-2020 3:40 pm	HEATH02a 13-May-2020 7:28 am
Lab Number:		2365301.6	2365301.7	2365301.8	2365301.9	2365301.10
Individual Tests						
Dry Matter	g/100g as rcvd	26	31	34	29	69
Total Recoverable Copper	mg/kg dry wt	106	18.1	18	18	9.6
Total Recoverable Lead	mg/kg dry wt	61	26	28	26	19.7
Total Recoverable Phosphorus	mg/kg dry wt	1,300	1,110	1,050	1,060	520
Total Recoverable Zinc	mg/kg dry wt	770	220	250	220	132
Total Organic Carbon*	g/100g dry wt	6.6	4.7	5.9	4.6	1.08
7 Grain Sizes Profile as received*						
Dry Matter of Sieved Sample*	g/100g as rcvd	27	37	32	31	71
Fraction >/= 2 mm*	g/100g dry wt	16.4	32.4	9.4	7.3	0.4
Fraction < 2 mm, >/= 1 mm*	g/100g dry wt	0.9	0.6	1.0	0.7	0.2
Fraction < 1 mm, >/= 500 µm*	g/100g dry wt	1.2	1.5	1.9	1.8	0.3
Fraction < 500 µm, >/= 250 µm*	g/100g dry wt	6.3	18.3	10.5	14.3	0.8
Fraction < 250 µm, >/= 125 µm*	g/100g dry wt	23.1	33.5	23.0	32.2	5.0
Fraction < 125 µm, >/= 63 µm*	g/100g dry wt	25.4	14.7	20.5	14.1	46.5
Fraction < 63 µm*	g/100g dry wt	26.8	< 0.1	33.6	29.5	46.8
Haloethers Trace in SVOC Soil Samples by GC-MS						
Bis(2-chloroethoxy) methane	mg/kg dry wt	< 0.5	< 0.2	< 0.18	< 0.3	< 0.10
Bis(2-chloroethyl)ether	mg/kg dry wt	< 0.5	< 0.2	< 0.18	< 0.3	< 0.10
Bis(2-chloroisopropyl)ether	mg/kg dry wt	< 0.5	< 0.2	< 0.18	< 0.3	< 0.10
4-Bromophenyl phenyl ether	mg/kg dry wt	< 0.5	< 0.2	< 0.18	< 0.3	< 0.10
4-Chlorophenyl phenyl ether	mg/kg dry wt	< 0.5	< 0.2	< 0.18	< 0.3	< 0.10
Nitrogen containing compounds Trace in SVOC Soil Samples, GC-MS						
N-Nitrosodiphenylamine + Diphenylamine	mg/kg dry wt	< 0.9	< 0.4	< 0.4	< 0.5	< 0.17
2,4-Dinitrotoluene	mg/kg dry wt	< 0.9	< 0.4	< 0.4	< 0.5	< 0.2
2,6-Dinitrotoluene	mg/kg dry wt	< 0.9	< 0.4	< 0.4	< 0.5	< 0.2
Nitrobenzene	mg/kg dry wt	< 0.5	< 0.2	< 0.18	< 0.3	< 0.10
N-Nitrosodi-n-propylamine	mg/kg dry wt	< 0.9	< 0.4	< 0.4	< 0.5	< 0.17
Organochlorine Pesticides Trace in SVOC Soil Samples by GC-MS						
Aldrin	mg/kg dry wt	< 0.5	< 0.2	< 0.18	< 0.3	< 0.10
alpha-BHC	mg/kg dry wt	< 0.5	< 0.2	< 0.18	< 0.3	< 0.10
beta-BHC	mg/kg dry wt	< 0.5	< 0.2	< 0.18	< 0.3	< 0.10
delta-BHC	mg/kg dry wt	< 0.5	< 0.2	< 0.18	< 0.3	< 0.10
gamma-BHC (Lindane)	mg/kg dry wt	< 0.5	< 0.2	< 0.18	< 0.3	< 0.10
4,4'-DDD	mg/kg dry wt	< 0.5	< 0.2	< 0.18	< 0.3	< 0.10
4,4'-DDE	mg/kg dry wt	< 0.5	< 0.2	< 0.18	< 0.3	< 0.10
4,4'-DDT	mg/kg dry wt	< 0.9	< 0.4	< 0.4	< 0.5	< 0.2
Dieldrin	mg/kg dry wt	< 0.5	< 0.2	< 0.18	< 0.3	< 0.10

Sample Type: Sediment						
Sample Name:		HEATH29c 12-May-2020 2:36 pm	HEATH30a 12-May-2020 3:15 pm	HEATH30b 12-May-2020 3:30 pm	HEATH30c 12-May-2020 3:40 pm	HEATH02a 13-May-2020 7:28 am
Lab Number:		2365301.6	2365301.7	2365301.8	2365301.9	2365301.10
Organochlorine Pesticides Trace in SVOC Soil Samples by GC-MS						
Endosulfan I	mg/kg dry wt	< 0.9	< 0.4	< 0.4	< 0.5	< 0.2
Endosulfan II	mg/kg dry wt	< 0.9	< 0.5	< 0.5	< 0.5	< 0.5
Endosulfan sulphate	mg/kg dry wt	< 0.9	< 0.4	< 0.4	< 0.5	< 0.2
Endrin	mg/kg dry wt	< 0.9	< 0.4	< 0.4	< 0.5	< 0.17
Endrin ketone	mg/kg dry wt	< 0.9	< 0.4	< 0.4	< 0.5	< 0.2
Heptachlor	mg/kg dry wt	< 0.5	< 0.2	< 0.18	< 0.3	< 0.10
Heptachlor epoxide	mg/kg dry wt	< 0.5	< 0.2	< 0.18	< 0.3	< 0.10
Hexachlorobenzene	mg/kg dry wt	< 0.5	< 0.2	< 0.18	< 0.3	< 0.10
Polycyclic Aromatic Hydrocarbons Trace in SVOC Soil Samples*						
Acenaphthene	mg/kg dry wt	< 0.3	< 0.10	< 0.10	< 0.11	< 0.10
Acenaphthylene	mg/kg dry wt	< 0.3	< 0.10	< 0.10	< 0.11	< 0.10
Anthracene	mg/kg dry wt	< 0.3	< 0.10	< 0.10	< 0.11	0.19
Benzo[a]anthracene	mg/kg dry wt	0.7	0.11	< 0.10	< 0.11	0.64
Benzo[a]pyrene (BAP)	mg/kg dry wt	0.7	< 0.2	< 0.18	< 0.3	0.85
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	0.8	< 0.2	< 0.18	< 0.3	0.83
Benzo[g,h,i]perylene	mg/kg dry wt	0.6	< 0.2	< 0.18	< 0.3	0.65
Benzo[k]fluoranthene	mg/kg dry wt	< 0.5	< 0.2	< 0.18	< 0.3	0.31
1&2-Chloronaphthalene	mg/kg dry wt	< 0.4	< 0.14	< 0.13	< 0.15	< 0.10
Chrysene	mg/kg dry wt	0.7	0.11	< 0.10	< 0.11	0.62
Dibenzo[a,h]anthracene	mg/kg dry wt	< 0.5	< 0.2	< 0.18	< 0.3	0.12
Fluoranthene	mg/kg dry wt	1.5	0.17	< 0.10	0.12	1.23
Fluorene	mg/kg dry wt	< 0.3	< 0.10	< 0.10	< 0.11	< 0.10
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	< 0.5	< 0.2	< 0.18	< 0.3	0.64
2-Methylnaphthalene	mg/kg dry wt	< 0.3	< 0.10	< 0.10	< 0.11	0.13
Naphthalene	mg/kg dry wt	< 0.3	< 0.10	< 0.10	< 0.11	0.29
Phenanthrene	mg/kg dry wt	0.7	0.11	< 0.10	< 0.11	0.59
Pyrene	mg/kg dry wt	1.5	0.21	< 0.10	0.15	1.40
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES*	mg/kg dry wt	< 1.1	< 0.5	< 0.5	< 0.5	1.2
Benzo[a]pyrene Toxic Equivalence (TEF)*	mg/kg dry wt	< 1.1	< 0.5	< 0.5	< 0.5	1.2
Phenols Trace in SVOC Soil Samples by GC-MS						
4-Chloro-3-methylphenol	mg/kg dry wt	< 0.9	< 0.5	< 0.5	< 0.5	< 0.5
2-Chlorophenol	mg/kg dry wt	< 0.5	< 0.2	< 0.2	< 0.3	< 0.2
2,4-Dichlorophenol	mg/kg dry wt	< 0.5	< 0.2	< 0.2	< 0.3	< 0.2
2,4-Dimethylphenol	mg/kg dry wt	< 0.5	< 0.4	< 0.4	< 0.4	< 0.4
3 & 4-Methylphenol (m- + p-cresol)	mg/kg dry wt	< 0.9	< 0.4	< 0.4	< 0.5	< 0.4
2-Methylphenol (o-Cresol)	mg/kg dry wt	< 0.5	< 0.2	< 0.2	< 0.3	< 0.2
2-Nitrophenol	mg/kg dry wt	< 0.9	< 0.4	< 0.4	< 0.5	< 0.4
Pentachlorophenol (PCP)	mg/kg dry wt	< 9	< 6	< 6	< 6	< 6
Phenol	mg/kg dry wt	< 0.9	< 0.4	< 0.4	< 0.5	< 0.2
2,4,5-Trichlorophenol	mg/kg dry wt	< 0.9	< 0.4	< 0.4	< 0.5	< 0.2
2,4,6-Trichlorophenol	mg/kg dry wt	< 0.9	< 0.4	< 0.4	< 0.5	< 0.2
Plasticisers Trace in SVOC Soil Samples by GC-MS						
Bis(2-ethylhexyl)phthalate	mg/kg dry wt	2.3	< 0.8	< 0.7	< 0.9	< 0.5
Butylbenzylphthalate	mg/kg dry wt	< 0.9	< 0.4	< 0.4	< 0.5	< 0.2
Di(2-ethylhexyl)adipate	mg/kg dry wt	< 0.5	0.4	< 0.2	< 0.3	< 0.2
Diethylphthalate	mg/kg dry wt	< 0.9	< 0.4	< 0.4	< 0.5	< 0.2
Dimethylphthalate	mg/kg dry wt	< 0.9	< 0.4	< 0.4	< 0.5	< 0.2
Di-n-butylphthalate	mg/kg dry wt	< 0.9	< 0.4	< 0.4	< 0.5	< 0.2
Di-n-octylphthalate	mg/kg dry wt	< 0.9	< 0.4	< 0.4	< 0.5	< 0.2

Sample Type: Sediment						
Sample Name:		HEATH29c 12-May-2020 2:36 pm	HEATH30a 12-May-2020 3:15 pm	HEATH30b 12-May-2020 3:30 pm	HEATH30c 12-May-2020 3:40 pm	HEATH02a 13-May-2020 7:28 am
Lab Number:		2365301.6	2365301.7	2365301.8	2365301.9	2365301.10
Other Halogenated compounds Trace in SVOC Soil Samples by GC-MS						
1,2-Dichlorobenzene	mg/kg dry wt	< 0.9	< 0.4	< 0.4	< 0.5	< 0.17
1,3-Dichlorobenzene	mg/kg dry wt	< 0.9	< 0.4	< 0.4	< 0.5	< 0.17
1,4-Dichlorobenzene	mg/kg dry wt	< 0.9	< 0.4	< 0.4	< 0.5	< 0.17
Hexachlorobutadiene	mg/kg dry wt	< 0.9	< 0.4	< 0.4	< 0.5	< 0.17
Hexachloroethane	mg/kg dry wt	< 0.9	< 0.4	< 0.4	< 0.5	< 0.17
1,2,4-Trichlorobenzene	mg/kg dry wt	< 0.5	< 0.2	< 0.18	< 0.3	< 0.10
Other SVOC Trace in SVOC Soil Samples by GC-MS						
Benzyl alcohol	mg/kg dry wt	< 5	< 2	< 1.8	< 3	< 1.0
Carbazole	mg/kg dry wt	< 0.5	< 0.2	< 0.18	< 0.3	< 0.10
Dibenzofuran	mg/kg dry wt	< 0.5	< 0.2	< 0.18	< 0.3	< 0.10
Isophorone	mg/kg dry wt	< 0.5	< 0.2	< 0.18	< 0.3	< 0.10

Sample Name:		HEATH02b 13-May-2020 7:32 am	HEATH02c 13-May-2020 7:38 am	HEATH31a 13-May-2020 11:27 am	HEATH31b 13-May-2020 11:30 am	HEATH31c 13-May-2020 11:35 am
Lab Number:		2365301.11	2365301.12	2365301.13	2365301.14	2365301.15
Individual Tests						
Dry Matter	g/100g as rcvd	70	69	15.9	14.4	11.2
Total Recoverable Copper	mg/kg dry wt	10	7.8	28	33	25
Total Recoverable Lead	mg/kg dry wt	20	17.7	74	120	55
Total Recoverable Phosphorus	mg/kg dry wt	500	460	920	1,100	680
Total Recoverable Zinc	mg/kg dry wt	136	123	240	240	162
Total Organic Carbon*	g/100g dry wt	1.02	1.16	12.6	15.6	17.4
7 Grain Sizes Profile as received*						
Dry Matter of Sieved Sample*	g/100g as rcvd	74	75	19.7	16.8	13.9
Fraction >/= 2 mm*	g/100g dry wt	0.3	0.4	9.1	6.2	15.4
Fraction < 2 mm, >/= 1 mm*	g/100g dry wt	0.4	0.5	0.9	2.0	1.8
Fraction < 1 mm, >/= 500 µm*	g/100g dry wt	0.3	0.4	1.9	3.0	2.5
Fraction < 500 µm, >/= 250 µm*	g/100g dry wt	1.5	1.3	3.9	4.7	5.7
Fraction < 250 µm, >/= 125 µm*	g/100g dry wt	14.6	25.2	7.3	8.8	12.7
Fraction < 125 µm, >/= 63 µm*	g/100g dry wt	51.8	54.0	32.0	29.9	29.5
Fraction < 63 µm*	g/100g dry wt	31.1	18.2	44.9	45.4	32.4
Haloethers Trace in SVOC Soil Samples by GC-MS						
Bis(2-chloroethoxy) methane	mg/kg dry wt	< 0.10	< 0.10	< 0.4	< 0.5	< 0.6
Bis(2-chloroethyl)ether	mg/kg dry wt	< 0.10	< 0.10	< 0.4	< 0.5	< 0.6
Bis(2-chloroisopropyl)ether	mg/kg dry wt	< 0.10	< 0.10	< 0.4	< 0.5	< 0.6
4-Bromophenyl phenyl ether	mg/kg dry wt	< 0.10	< 0.10	< 0.4	< 0.5	< 0.6
4-Chlorophenyl phenyl ether	mg/kg dry wt	< 0.10	< 0.10	< 0.4	< 0.5	< 0.6
Nitrogen containing compounds Trace in SVOC Soil Samples, GC-MS						
N-Nitrosodiphenylamine + Diphenylamine	mg/kg dry wt	< 0.17	< 0.17	< 0.8	< 0.9	< 1.1
2,4-Dinitrotoluene	mg/kg dry wt	< 0.2	< 0.2	< 0.8	< 0.9	< 1.1
2,6-Dinitrotoluene	mg/kg dry wt	< 0.2	< 0.2	< 0.8	< 0.9	< 1.1
Nitrobenzene	mg/kg dry wt	< 0.10	< 0.10	< 0.4	< 0.5	< 0.6
N-Nitrosodi-n-propylamine	mg/kg dry wt	< 0.17	< 0.17	< 0.8	< 0.9	< 1.1
Organochlorine Pesticides Trace in SVOC Soil Samples by GC-MS						
Aldrin	mg/kg dry wt	< 0.10	< 0.10	< 0.4	< 0.5	< 0.6
alpha-BHC	mg/kg dry wt	< 0.10	< 0.10	< 0.4	< 0.5	< 0.6
beta-BHC	mg/kg dry wt	< 0.10	< 0.10	< 0.4	< 0.5	< 0.6
delta-BHC	mg/kg dry wt	< 0.10	< 0.10	< 0.4	< 0.5	< 0.6
gamma-BHC (Lindane)	mg/kg dry wt	< 0.10	< 0.10	< 0.4	< 0.5	< 0.6
4,4'-DDD	mg/kg dry wt	< 0.10	< 0.10	< 0.4	< 0.5	< 0.6
4,4'-DDE	mg/kg dry wt	< 0.10	< 0.10	< 0.4	< 0.5	< 0.6
4,4'-DDT	mg/kg dry wt	< 0.2	< 0.2	< 0.8	< 0.9	< 1.1
Dieldrin	mg/kg dry wt	< 0.10	< 0.10	< 0.4	< 0.5	< 0.6

Sample Type: Sediment						
Sample Name:		HEATH02b 13-May-2020 7:32 am	HEATH02c 13-May-2020 7:38 am	HEATH31a 13-May-2020 11:27 am	HEATH31b 13-May-2020 11:30 am	HEATH31c 13-May-2020 11:35 am
Lab Number:		2365301.11	2365301.12	2365301.13	2365301.14	2365301.15
Organochlorine Pesticides Trace in SVOC Soil Samples by GC-MS						
Endosulfan I	mg/kg dry wt	< 0.2	< 0.2	< 0.8	< 0.9	< 1.1
Endosulfan II	mg/kg dry wt	< 0.5	< 0.5	< 0.8	< 0.9	< 1.1
Endosulfan sulphate	mg/kg dry wt	< 0.2	< 0.2	< 0.8	< 0.9	< 1.1
Endrin	mg/kg dry wt	< 0.17	< 0.17	< 0.8	< 0.9	< 1.1
Endrin ketone	mg/kg dry wt	< 0.2	< 0.2	< 0.8	< 0.9	< 1.1
Heptachlor	mg/kg dry wt	< 0.10	< 0.10	< 0.4	< 0.5	< 0.6
Heptachlor epoxide	mg/kg dry wt	< 0.10	< 0.10	< 0.4	< 0.5	< 0.6
Hexachlorobenzene	mg/kg dry wt	< 0.10	< 0.10	< 0.4	< 0.5	< 0.6
Polycyclic Aromatic Hydrocarbons Trace in SVOC Soil Samples*						
Acenaphthene	mg/kg dry wt	0.11	< 0.10	< 0.19	< 0.3	< 0.3
Acenaphthylene	mg/kg dry wt	0.14	0.13	< 0.19	< 0.3	< 0.3
Anthracene	mg/kg dry wt	0.30	0.28	< 0.19	< 0.3	< 0.3
Benzo[a]anthracene	mg/kg dry wt	1.03	0.93	< 0.19	0.3	< 0.3
Benzo[a]pyrene (BAP)	mg/kg dry wt	1.15	1.04	< 0.4	< 0.5	< 0.6
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	1.10	1.01	< 0.4	0.5	< 0.6
Benzo[g,h,i]perylene	mg/kg dry wt	0.78	0.66	< 0.4	< 0.5	< 0.6
Benzo[k]fluoranthene	mg/kg dry wt	0.46	0.40	< 0.4	< 0.5	< 0.6
1&2-Chloronaphthalene	mg/kg dry wt	< 0.10	< 0.10	< 0.3	< 0.3	< 0.4
Chrysene	mg/kg dry wt	0.99	0.90	0.24	0.4	< 0.3
Dibenzo[a,h]anthracene	mg/kg dry wt	0.15	0.15	< 0.4	< 0.5	< 0.6
Fluoranthene	mg/kg dry wt	1.96	1.74	0.56	0.8	0.5
Fluorene	mg/kg dry wt	0.15	0.12	< 0.19	< 0.3	< 0.3
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	0.76	0.67	< 0.4	< 0.5	< 0.6
2-Methylnaphthalene	mg/kg dry wt	0.13	0.16	< 0.19	< 0.3	< 0.3
Naphthalene	mg/kg dry wt	0.28	0.35	< 0.19	< 0.3	< 0.3
Phenanthrene	mg/kg dry wt	1.07	0.94	0.38	0.7	0.4
Pyrene	mg/kg dry wt	2.1	1.87	0.62	0.9	0.6
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES*	mg/kg dry wt	1.7	1.5	< 0.9	< 1.0	< 1.3
Benzo[a]pyrene Toxic Equivalence (TEF)*	mg/kg dry wt	1.6	1.5	< 0.9	< 1.0	< 1.3
Phenols Trace in SVOC Soil Samples by GC-MS						
4-Chloro-3-methylphenol	mg/kg dry wt	< 0.5	< 0.5	< 0.8	< 0.9	< 1.1
2-Chlorophenol	mg/kg dry wt	< 0.2	< 0.2	< 0.4	< 0.5	< 0.6
2,4-Dichlorophenol	mg/kg dry wt	< 0.2	< 0.2	< 0.4	< 0.5	< 0.6
2,4-Dimethylphenol	mg/kg dry wt	< 0.4	< 0.4	< 0.4	< 0.5	< 0.6
3 & 4-Methylphenol (m- + p-cresol)	mg/kg dry wt	< 0.4	< 0.4	< 0.8	< 0.9	< 1.1
2-Methylphenol (o-Cresol)	mg/kg dry wt	< 0.2	< 0.2	< 0.4	< 0.5	< 0.6
2-Nitrophenol	mg/kg dry wt	< 0.4	< 0.4	< 0.8	< 0.9	< 1.1
Pentachlorophenol (PCP)	mg/kg dry wt	< 6	< 6	< 8	< 9	< 11
Phenol	mg/kg dry wt	< 0.2	< 0.2	< 0.8	< 0.9	< 1.1
2,4,5-Trichlorophenol	mg/kg dry wt	< 0.2	< 0.2	< 0.8	< 0.9	< 1.1
2,4,6-Trichlorophenol	mg/kg dry wt	< 0.2	< 0.2	< 0.8	< 0.9	< 1.1
Plasticisers Trace in SVOC Soil Samples by GC-MS						
Bis(2-ethylhexyl)phthalate	mg/kg dry wt	< 0.5	0.7	< 1.5	< 1.7	< 3
Butylbenzylphthalate	mg/kg dry wt	< 0.2	< 0.2	< 0.8	< 0.9	< 1.1
Di(2-ethylhexyl)adipate	mg/kg dry wt	< 0.2	< 0.2	< 0.4	< 0.5	< 0.6
Diethylphthalate	mg/kg dry wt	< 0.2	< 0.2	< 0.8	< 0.9	< 1.1
Dimethylphthalate	mg/kg dry wt	< 0.2	< 0.2	< 0.8	< 0.9	< 1.1
Di-n-butylphthalate	mg/kg dry wt	< 0.2	< 0.2	< 0.8	< 0.9	< 1.1
Di-n-octylphthalate	mg/kg dry wt	< 0.2	< 0.2	< 0.8	< 0.9	< 1.1

Sample Type: Sediment						
Sample Name:		HEATH02b 13-May-2020 7:32 am	HEATH02c 13-May-2020 7:38 am	HEATH31a 13-May-2020 11:27 am	HEATH31b 13-May-2020 11:30 am	HEATH31c 13-May-2020 11:35 am
Lab Number:		2365301.11	2365301.12	2365301.13	2365301.14	2365301.15
Other Halogenated compounds Trace in SVOC Soil Samples by GC-MS						
1,2-Dichlorobenzene	mg/kg dry wt	< 0.17	< 0.17	< 0.8	< 0.9	< 1.1
1,3-Dichlorobenzene	mg/kg dry wt	< 0.17	< 0.17	< 0.8	< 0.9	< 1.1
1,4-Dichlorobenzene	mg/kg dry wt	< 0.17	< 0.17	< 0.8	< 0.9	< 1.1
Hexachlorobutadiene	mg/kg dry wt	< 0.17	< 0.17	< 0.8	< 0.9	< 1.1
Hexachloroethane	mg/kg dry wt	< 0.17	< 0.17	< 0.8	< 0.9	< 1.1
1,2,4-Trichlorobenzene	mg/kg dry wt	< 0.10	< 0.10	< 0.4	< 0.5	< 0.6
Other SVOC Trace in SVOC Soil Samples by GC-MS						
Benzyl alcohol	mg/kg dry wt	< 1.0	< 1.0	< 4	< 5	< 6
Carbazole	mg/kg dry wt	< 0.10	< 0.10	< 0.4	< 0.5	< 0.6
Dibenzofuran	mg/kg dry wt	0.11	0.12	< 0.4	< 0.5	< 0.6
Isophorone	mg/kg dry wt	< 0.10	< 0.10	< 0.4	< 0.5	< 0.6

Sample Name:		OUT02a 13-May-2020 9:33 am	OUT02b 13-May-2020 9:37 am	OUT02c 13-May-2020 9:40 am	HEATH11a 13-May-2020 8:14 am	HEATH11b 13-May-2020 7:58 am
Lab Number:		2365301.16	2365301.17	2365301.18	2365301.19	2365301.20
Individual Tests						
Dry Matter	g/100g as rcvd	52	61	35	37	50
Total Recoverable Copper	mg/kg dry wt	23	27	41	39	39
Total Recoverable Lead	mg/kg dry wt	41	50	69	55	52
Total Recoverable Phosphorus	mg/kg dry wt	550	690	1,220	820	810
Total Recoverable Zinc	mg/kg dry wt	480	540	1,040	370	370
Total Organic Carbon*	g/100g dry wt	1.75	1.57	3.6	3.6	4.2
7 Grain Sizes Profile as received*						
Dry Matter of Sieved Sample*	g/100g as rcvd	57	62	43	48	40
Fraction >/= 2 mm*	g/100g dry wt	1.3	0.5	0.5	8.4	12.0
Fraction < 2 mm, >/= 1 mm*	g/100g dry wt	0.1	0.2	0.5	0.9	0.5
Fraction < 1 mm, >/= 500 µm*	g/100g dry wt	0.3	0.5	1.0	1.2	0.7
Fraction < 500 µm, >/= 250 µm*	g/100g dry wt	1.3	3.3	0.7	9.1	1.7
Fraction < 250 µm, >/= 125 µm*	g/100g dry wt	26.9	33.4	24.4	6.2	4.0
Fraction < 125 µm, >/= 63 µm*	g/100g dry wt	38.5	28.6	32.8	12.2	6.9
Fraction < 63 µm*	g/100g dry wt	31.6	33.4	40.1	62.1	74.2
Haloethers Trace in SVOC Soil Samples by GC-MS						
Bis(2-chloroethoxy) methane	mg/kg dry wt	< 0.12	< 0.10	< 0.4	< 0.17	< 0.12
Bis(2-chloroethyl)ether	mg/kg dry wt	< 0.12	< 0.10	< 0.4	< 0.17	< 0.12
Bis(2-chloroisopropyl)ether	mg/kg dry wt	< 0.12	< 0.10	< 0.4	< 0.17	< 0.12
4-Bromophenyl phenyl ether	mg/kg dry wt	< 0.12	< 0.10	< 0.4	< 0.17	< 0.12
4-Chlorophenyl phenyl ether	mg/kg dry wt	< 0.12	< 0.10	< 0.4	< 0.17	< 0.12
Nitrogen containing compounds Trace in SVOC Soil Samples, GC-MS						
N-Nitrosodiphenylamine + Diphenylamine	mg/kg dry wt	< 0.3	< 0.2	< 0.7	< 0.4	< 0.3
2,4-Dinitrotoluene	mg/kg dry wt	< 0.3	< 0.2	< 0.7	< 0.4	< 0.3
2,6-Dinitrotoluene	mg/kg dry wt	< 0.3	< 0.2	< 0.7	< 0.4	< 0.3
Nitrobenzene	mg/kg dry wt	< 0.12	< 0.10	< 0.4	< 0.17	< 0.12
N-Nitrosodi-n-propylamine	mg/kg dry wt	< 0.3	< 0.2	< 0.7	< 0.4	< 0.3
Organochlorine Pesticides Trace in SVOC Soil Samples by GC-MS						
Aldrin	mg/kg dry wt	< 3 [#1]	< 2 [#1]	< 4 [#2]	< 0.17	< 0.12
alpha-BHC	mg/kg dry wt	< 0.12	< 0.10	< 0.4	< 0.17	< 0.12
beta-BHC	mg/kg dry wt	< 0.12	< 0.10	< 0.4	< 0.17	< 0.12
delta-BHC	mg/kg dry wt	< 0.12	< 0.10	< 0.4	< 0.17	< 0.12
gamma-BHC (Lindane)	mg/kg dry wt	< 0.12	< 0.10	< 0.4	< 0.17	< 0.12
4,4'-DDD	mg/kg dry wt	< 0.12	< 0.10	< 0.4	< 0.17	< 0.12
4,4'-DDE	mg/kg dry wt	< 0.12	< 0.10	< 0.4	< 0.17	< 0.12
4,4'-DDT	mg/kg dry wt	< 0.3	< 0.2	< 0.7	< 0.4	< 0.3
Dieldrin	mg/kg dry wt	< 0.12	< 0.10	< 0.4	< 0.17	< 0.12

Sample Type: Sediment						
Sample Name:		OUT02a 13-May-2020 9:33 am	OUT02b 13-May-2020 9:37 am	OUT02c 13-May-2020 9:40 am	HEATH11a 13-May-2020 8:14 am	HEATH11b 13-May-2020 7:58 am
Lab Number:		2365301.16	2365301.17	2365301.18	2365301.19	2365301.20
Organochlorine Pesticides Trace in SVOC Soil Samples by GC-MS						
Endosulfan I	mg/kg dry wt	< 0.3	< 0.2	< 0.7	< 0.4	< 0.3
Endosulfan II	mg/kg dry wt	< 0.5	< 0.5	< 0.7	< 0.5	< 0.5
Endosulfan sulphate	mg/kg dry wt	< 0.3	< 0.2	< 0.7	< 0.4	< 0.3
Endrin	mg/kg dry wt	< 0.3	< 0.2	< 0.7	< 0.4	< 0.3
Endrin ketone	mg/kg dry wt	< 0.3	< 0.2	< 0.7	< 0.4	< 0.3
Heptachlor	mg/kg dry wt	< 0.12	< 0.10	< 0.4	< 0.17	< 0.12
Heptachlor epoxide	mg/kg dry wt	< 0.12	< 0.10	< 0.4	< 0.17	< 0.12
Hexachlorobenzene	mg/kg dry wt	< 0.12	< 0.10	< 0.4	< 0.17	< 0.12
Polycyclic Aromatic Hydrocarbons Trace in SVOC Soil Samples*						
Acenaphthene	mg/kg dry wt	< 0.10	< 0.10	< 0.17	< 0.10	< 0.10
Acenaphthylene	mg/kg dry wt	< 0.10	< 0.10	< 0.17	0.11	< 0.10
Anthracene	mg/kg dry wt	< 0.10	< 0.10	< 0.17	0.12	0.19
Benzo[a]anthracene	mg/kg dry wt	0.18	0.17	0.34	0.55	0.50
Benzo[a]pyrene (BAP)	mg/kg dry wt	0.26	0.24	0.5	0.77	0.65
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	0.30	0.29	0.6	0.77	0.67
Benzo[g,h,i]perylene	mg/kg dry wt	0.20	0.18	0.5	0.47	0.40
Benzo[k]fluoranthene	mg/kg dry wt	< 0.12	< 0.10	< 0.4	0.28	0.26
1&2-Chloronaphthalene	mg/kg dry wt	< 0.10	< 0.10	< 0.3	< 0.12	< 0.10
Chrysene	mg/kg dry wt	0.23	0.21	0.40	0.58	0.53
Dibenzo[a,h]anthracene	mg/kg dry wt	< 0.12	< 0.10	< 0.4	< 0.17	< 0.12
Fluoranthene	mg/kg dry wt	0.41	0.41	0.79	1.13	0.86
Fluorene	mg/kg dry wt	< 0.10	< 0.10	< 0.17	< 0.10	< 0.10
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	0.20	0.18	0.3	0.50	0.44
2-Methylnaphthalene	mg/kg dry wt	< 0.10	< 0.10	< 0.17	0.14	0.21
Naphthalene	mg/kg dry wt	< 0.10	< 0.10	< 0.17	0.31	0.42
Phenanthrene	mg/kg dry wt	0.17	0.18	0.26	0.60	0.52
Pyrene	mg/kg dry wt	0.44	0.44	0.84	1.31	0.97
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES*	mg/kg dry wt	0.4	0.3	< 0.8	1.1	0.9
Benzo[a]pyrene Toxic Equivalence (TEF)*	mg/kg dry wt	0.4	0.3	< 0.8	1.1	0.9
Phenols Trace in SVOC Soil Samples by GC-MS						
4-Chloro-3-methylphenol	mg/kg dry wt	< 0.5	< 0.5	< 0.7	< 0.5	< 0.5
2-Chlorophenol	mg/kg dry wt	< 0.2	< 0.2	< 0.4	< 0.2	< 0.2
2,4-Dichlorophenol	mg/kg dry wt	< 0.2	< 0.2	< 0.4	< 0.2	< 0.2
2,4-Dimethylphenol	mg/kg dry wt	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
3 & 4-Methylphenol (m- + p-cresol)	mg/kg dry wt	< 0.4	< 0.4	< 0.7	< 0.4	< 0.4
2-Methylphenol (o-Cresol)	mg/kg dry wt	< 0.2	< 0.2	< 0.4	< 0.2	< 0.2
2-Nitrophenol	mg/kg dry wt	< 0.4	< 0.4	< 0.7	< 0.4	< 0.4
Pentachlorophenol (PCP)	mg/kg dry wt	< 6	< 6	< 7	< 6	< 6
Phenol	mg/kg dry wt	< 0.3	< 0.2	< 0.7	< 0.4	< 0.3
2,4,5-Trichlorophenol	mg/kg dry wt	< 0.3	< 0.2	< 0.7	< 0.4	< 0.3
2,4,6-Trichlorophenol	mg/kg dry wt	< 0.3	< 0.2	< 0.7	< 0.4	< 0.3
Plasticisers Trace in SVOC Soil Samples by GC-MS						
Bis(2-ethylhexyl)phthalate	mg/kg dry wt	3.0	3.3	6.8	1.8	1.5
Butylbenzylphthalate	mg/kg dry wt	< 0.3	0.3	< 0.7	< 0.4	< 0.3
Di(2-ethylhexyl)adipate	mg/kg dry wt	< 0.2	< 0.2	< 0.4	< 0.2	< 0.2
Diethylphthalate	mg/kg dry wt	< 0.3	< 0.2	< 0.7	< 0.4	< 0.3
Dimethylphthalate	mg/kg dry wt	< 0.3	< 0.2	< 0.7	< 0.4	< 0.3
Di-n-butylphthalate	mg/kg dry wt	< 0.3	< 0.2	< 0.7	< 0.4	< 0.3
Di-n-octylphthalate	mg/kg dry wt	< 0.3	< 0.2	< 0.7	< 0.4	< 0.3

Sample Type: Sediment						
Sample Name:		OUT02a 13-May-2020 9:33 am	OUT02b 13-May-2020 9:37 am	OUT02c 13-May-2020 9:40 am	HEATH11a 13-May-2020 8:14 am	HEATH11b 13-May-2020 7:58 am
Lab Number:		2365301.16	2365301.17	2365301.18	2365301.19	2365301.20
Other Halogenated compounds Trace in SVOC Soil Samples by GC-MS						
1,2-Dichlorobenzene	mg/kg dry wt	< 0.3	< 0.2	< 0.7	< 0.4	< 0.3
1,3-Dichlorobenzene	mg/kg dry wt	< 0.3	< 0.2	< 0.7	< 0.4	< 0.3
1,4-Dichlorobenzene	mg/kg dry wt	< 0.3	< 0.2	< 0.7	< 0.4	< 0.3
Hexachlorobutadiene	mg/kg dry wt	< 0.3	< 0.2	< 0.7	< 0.4	< 0.3
Hexachloroethane	mg/kg dry wt	< 0.3	< 0.2	< 0.7	< 0.4	< 0.3
1,2,4-Trichlorobenzene	mg/kg dry wt	< 0.12	< 0.10	< 0.4	< 0.17	< 0.12
Other SVOC Trace in SVOC Soil Samples by GC-MS						
Benzyl alcohol	mg/kg dry wt	< 1.2	< 1.0	< 4	< 1.7	< 1.2
Carbazole	mg/kg dry wt	< 0.12	< 0.10	< 0.4	< 0.17	< 0.12
Dibenzofuran	mg/kg dry wt	< 0.12	< 0.10	< 0.4	< 0.17	< 0.12
Isophorone	mg/kg dry wt	< 0.12	< 0.10	< 0.4	< 0.17	< 0.12

Sample Name:		HEATH11c 13-May-2020 8:21 am				
Lab Number:		2365301.21				
Individual Tests						
Dry Matter	g/100g as rcvd	36	-	-	-	-
Total Recoverable Copper	mg/kg dry wt	42	-	-	-	-
Total Recoverable Lead	mg/kg dry wt	62	-	-	-	-
Total Recoverable Phosphorus	mg/kg dry wt	1,000	-	-	-	-
Total Recoverable Zinc	mg/kg dry wt	450	-	-	-	-
Total Organic Carbon*	g/100g dry wt	6.3	-	-	-	-
7 Grain Sizes Profile as received*						
Dry Matter of Sieved Sample*	g/100g as rcvd	39	-	-	-	-
Fraction >/= 2 mm*	g/100g dry wt	27.1	-	-	-	-
Fraction < 2 mm, >/= 1 mm*	g/100g dry wt	1.0	-	-	-	-
Fraction < 1 mm, >/= 500 µm*	g/100g dry wt	1.5	-	-	-	-
Fraction < 500 µm, >/= 250 µm*	g/100g dry wt	2.6	-	-	-	-
Fraction < 250 µm, >/= 125 µm*	g/100g dry wt	3.8	-	-	-	-
Fraction < 125 µm, >/= 63 µm*	g/100g dry wt	6.3	-	-	-	-
Fraction < 63 µm*	g/100g dry wt	57.7	-	-	-	-
Haloethers Trace in SVOC Soil Samples by GC-MS						
Bis(2-chloroethoxy) methane	mg/kg dry wt	< 0.17	-	-	-	-
Bis(2-chloroethyl)ether	mg/kg dry wt	< 0.17	-	-	-	-
Bis(2-chloroisopropyl)ether	mg/kg dry wt	< 0.17	-	-	-	-
4-Bromophenyl phenyl ether	mg/kg dry wt	< 0.17	-	-	-	-
4-Chlorophenyl phenyl ether	mg/kg dry wt	< 0.17	-	-	-	-
Nitrogen containing compounds Trace in SVOC Soil Samples, GC-MS						
N-Nitrosodiphenylamine + Diphenylamine	mg/kg dry wt	< 0.4	-	-	-	-
2,4-Dinitrotoluene	mg/kg dry wt	< 0.4	-	-	-	-
2,6-Dinitrotoluene	mg/kg dry wt	< 0.4	-	-	-	-
Nitrobenzene	mg/kg dry wt	< 0.17	-	-	-	-
N-Nitrosodi-n-propylamine	mg/kg dry wt	< 0.4	-	-	-	-
Organochlorine Pesticides Trace in SVOC Soil Samples by GC-MS						
Aldrin	mg/kg dry wt	< 0.17	-	-	-	-
alpha-BHC	mg/kg dry wt	< 0.17	-	-	-	-
beta-BHC	mg/kg dry wt	< 0.17	-	-	-	-
delta-BHC	mg/kg dry wt	< 0.17	-	-	-	-
gamma-BHC (Lindane)	mg/kg dry wt	< 0.17	-	-	-	-
4,4'-DDD	mg/kg dry wt	< 0.17	-	-	-	-
4,4'-DDE	mg/kg dry wt	< 0.17	-	-	-	-
4,4'-DDT	mg/kg dry wt	< 0.4	-	-	-	-
Dieldrin	mg/kg dry wt	< 0.17	-	-	-	-

Sample Type: Sediment						
Sample Name:		HEATH11c 13-May-2020 8:21 am				
Lab Number:		2365301.21				
Organochlorine Pesticides Trace in SVOC Soil Samples by GC-MS						
Endosulfan I	mg/kg dry wt	< 0.4	-	-	-	-
Endosulfan II	mg/kg dry wt	< 0.5	-	-	-	-
Endosulfan sulphate	mg/kg dry wt	< 0.4	-	-	-	-
Endrin	mg/kg dry wt	< 0.4	-	-	-	-
Endrin ketone	mg/kg dry wt	< 0.4	-	-	-	-
Heptachlor	mg/kg dry wt	< 0.17	-	-	-	-
Heptachlor epoxide	mg/kg dry wt	< 0.17	-	-	-	-
Hexachlorobenzene	mg/kg dry wt	< 0.17	-	-	-	-
Polycyclic Aromatic Hydrocarbons Trace in SVOC Soil Samples*						
Acenaphthene	mg/kg dry wt	0.11	-	-	-	-
Acenaphthylene	mg/kg dry wt	0.11	-	-	-	-
Anthracene	mg/kg dry wt	0.22	-	-	-	-
Benzo[a]anthracene	mg/kg dry wt	0.51	-	-	-	-
Benzo[a]pyrene (BAP)	mg/kg dry wt	0.58	-	-	-	-
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	0.73	-	-	-	-
Benzo[g,h,i]perylene	mg/kg dry wt	0.40	-	-	-	-
Benzo[k]fluoranthene	mg/kg dry wt	0.33	-	-	-	-
1&2-Chloronaphthalene	mg/kg dry wt	< 0.12	-	-	-	-
Chrysene	mg/kg dry wt	0.52	-	-	-	-
Dibenzo[a,h]anthracene	mg/kg dry wt	< 0.17	-	-	-	-
Fluoranthene	mg/kg dry wt	1.00	-	-	-	-
Fluorene	mg/kg dry wt	0.15	-	-	-	-
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	0.45	-	-	-	-
2-Methylnaphthalene	mg/kg dry wt	0.21	-	-	-	-
Naphthalene	mg/kg dry wt	0.39	-	-	-	-
Phenanthrene	mg/kg dry wt	0.57	-	-	-	-
Pyrene	mg/kg dry wt	1.09	-	-	-	-
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES*	mg/kg dry wt	0.9	-	-	-	-
Benzo[a]pyrene Toxic Equivalence (TEF)*	mg/kg dry wt	0.9	-	-	-	-
Phenols Trace in SVOC Soil Samples by GC-MS						
4-Chloro-3-methylphenol	mg/kg dry wt	< 0.5	-	-	-	-
2-Chlorophenol	mg/kg dry wt	< 0.2	-	-	-	-
2,4-Dichlorophenol	mg/kg dry wt	< 0.2	-	-	-	-
2,4-Dimethylphenol	mg/kg dry wt	< 0.4	-	-	-	-
3 & 4-Methylphenol (m- + p-cresol)	mg/kg dry wt	< 0.4	-	-	-	-
2-Methylphenol (o-Cresol)	mg/kg dry wt	< 0.2	-	-	-	-
2-Nitrophenol	mg/kg dry wt	< 0.4	-	-	-	-
Pentachlorophenol (PCP)	mg/kg dry wt	< 6	-	-	-	-
Phenol	mg/kg dry wt	< 0.4	-	-	-	-
2,4,5-Trichlorophenol	mg/kg dry wt	< 0.4	-	-	-	-
2,4,6-Trichlorophenol	mg/kg dry wt	< 0.4	-	-	-	-
Plasticisers Trace in SVOC Soil Samples by GC-MS						
Bis(2-ethylhexyl)phthalate	mg/kg dry wt	1.5	-	-	-	-
Butylbenzylphthalate	mg/kg dry wt	< 0.4	-	-	-	-
Di(2-ethylhexyl)adipate	mg/kg dry wt	0.3	-	-	-	-
Diethylphthalate	mg/kg dry wt	< 0.4	-	-	-	-
Dimethylphthalate	mg/kg dry wt	< 0.4	-	-	-	-
Di-n-butylphthalate	mg/kg dry wt	< 0.4	-	-	-	-
Di-n-octylphthalate	mg/kg dry wt	< 0.4	-	-	-	-

Sample Type: Sediment						
	Sample Name:	HEATH11c 13-May-2020 8:21 am				
	Lab Number:	2365301.21				
Other Halogenated compounds Trace in SVOC Soil Samples by GC-MS						
1,2-Dichlorobenzene	mg/kg dry wt	< 0.4	-	-	-	-
1,3-Dichlorobenzene	mg/kg dry wt	< 0.4	-	-	-	-
1,4-Dichlorobenzene	mg/kg dry wt	< 0.4	-	-	-	-
Hexachlorobutadiene	mg/kg dry wt	< 0.4	-	-	-	-
Hexachloroethane	mg/kg dry wt	< 0.4	-	-	-	-
1,2,4-Trichlorobenzene	mg/kg dry wt	< 0.17	-	-	-	-
Other SVOC Trace in SVOC Soil Samples by GC-MS						
Benzyl alcohol	mg/kg dry wt	< 1.7	-	-	-	-
Carbazole	mg/kg dry wt	< 0.17	-	-	-	-
Dibenzofuran	mg/kg dry wt	< 0.17	-	-	-	-
Isophorone	mg/kg dry wt	< 0.17	-	-	-	-

Analyst's Comments

The matrix in samples 2365301.3, .5 and .8 has affected some of the System Monitoring Compounds in the SVOC analysis, whereby 2-fluorophenol was 31%, 30% & 31% and Phenol-d5 was 36%, 36% & 35% respectively. Therefore the phenolic compounds may be underestimated.

It has been noted that the spikes for SVOC on sample 2365301.21, were run as part of our in-house QC procedure, had lower than expected recoveries for Aldrin at 36% and 35%. Therefore the result maybe underestimated.

It has been noted that the duplicate for the SVOC analysis on sample 2365301.6, which was run as part of our in-house QC procedure, showed greater variation than would normally be expected. This may reflect the heterogeneity of the sample.

[#1] Due to some interference found in the chromatography, the sample was diluted and re-analysed for Aldrin. Hence the higher detection limit reported.

[#2] Due to some interference found in the chromatography, the detection limit was raised. Hence the higher detection limit reported.

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 Laboratories, 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%.	-	1-21
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%.	-	1-21
Dry Matter (Env)	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	1-21
Total Recoverable digestion	Nitric / hydrochloric acid digestion. US EPA 200.2.	-	1-21
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	1-21
Total Recoverable Lead	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, trace level. US EPA 200.2.	0.04 mg/kg dry wt	1-21
Total Recoverable Phosphorus	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, screen level. US EPA 200.2.	40 mg/kg dry wt	1-21
Total Recoverable Zinc	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, trace level. US EPA 200.2.	0.4 mg/kg dry wt	1-21

Sample Type: Sediment			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Total Organic Carbon*	Acid pretreatment to remove carbonates present followed by Catalytic Combustion (900°C, O2), separation, Thermal Conductivity Detector [Elementar Analyser].	0.05 g/100g dry wt	1-21
Semivolatile Organic Compounds Trace in Soil by GC-MS	Sonication extraction, GC-MS analysis. Tested on as received sample. In-house based on US EPA 8270.	0.002 - 6 mg/kg dry wt	1-21
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	1-21
Fraction >/= 2 mm*	Wet sieving with dispersant, as received, 2.00 mm sieve, gravimetry.	0.1 g/100g dry wt	1-21
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	1-21
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	1-21
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	1-21
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	1-21
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	1-21
Fraction < 63 µm*	Wet sieving with dispersant, as received, 63 µm sieve, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-21

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

Dates of testing are available on request. Please contact the laboratory for more information.

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.

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

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Certificate of Analysis

SPv2

Client:	Instream Consulting Limited	**Lab No:**	2366857
Contact:	G Burrell	**Date Received:**	15-May-2020
	C/- Instream Consulting Limited	**Date Reported:**	07-Jul-2020
	PO Box 28173	**Quote No:**	103910
	Christchurch 8242	**Order No:**	20350401
		Client Reference:	5 yearly Monitoring
		Submitted By:	G Burrell

Sample Type: Sediment

Sample Name:		HEATH14a 15-May-2020 12:03 pm	HEATH14b 15-May-2020 12:06 pm	HEATH14c 15-May-2020 12:10 pm	HEATH10a 15-May-2020 11:13 am	HEATH10b 15-May-2020 11:18 am
Lab Number:		2366857.1	2366857.2	2366857.3	2366857.4	2366857.5
Individual Tests						
Dry Matter	g/100g as rcvd	26	26	27	45	53
Total Recoverable Copper	mg/kg dry wt	870	890	840	111	151
Total Recoverable Lead	mg/kg dry wt	230	220	210	44	57
Total Recoverable Phosphorus	mg/kg dry wt	2,300	2,800	2,400	510	460
Total Recoverable Zinc	mg/kg dry wt	4,500	4,800	4,600	540	650
Total Organic Carbon*	g/100g dry wt	10.1	10.0	8.9	1.95	1.72
7 Grain Sizes Profile as received*						
Dry Matter of Sieved Sample*	g/100g as rcvd	30	29	31	57	57
Fraction >/= 2 mm*	g/100g dry wt	2.1	1.3	1.5	4.8	1.5
Fraction < 2 mm, >/= 1 mm*	g/100g dry wt	0.3	0.4	0.4	0.4	0.3
Fraction < 1 mm, >/= 500 µm*	g/100g dry wt	0.4	0.5	0.7	0.6	0.6
Fraction < 500 µm, >/= 250 µm*	g/100g dry wt	1.0	0.9	0.8	4.3	4.5
Fraction < 250 µm, >/= 125 µm*	g/100g dry wt	4.0	4.4	7.1	26.3	28.2
Fraction < 125 µm, >/= 63 µm*	g/100g dry wt	17.0	16.7	22.2	32.4	29.6
Fraction < 63 µm*	g/100g dry wt	75.2	75.9	67.4	31.3	35.3
Haloethers Trace in SVOC Soil Samples by GC-MS						
Bis(2-chloroethoxy) methane	mg/kg dry wt	< 0.3	< 0.3	< 0.3	< 0.14	< 0.11
Bis(2-chloroethyl)ether	mg/kg dry wt	< 0.3	< 0.3	< 0.3	< 0.14	< 0.11
Bis(2-chloroisopropyl)ether	mg/kg dry wt	< 0.3	< 0.3	< 0.3	< 0.14	< 0.11
4-Bromophenyl phenyl ether	mg/kg dry wt	< 0.3	< 0.3	< 0.3	< 0.14	< 0.11
4-Chlorophenyl phenyl ether	mg/kg dry wt	< 0.3	< 0.3	< 0.3	< 0.14	< 0.11
Nitrogen containing compounds Trace in SVOC Soil Samples, GC-MS						
N-Nitrosodiphenylamine + Diphenylamine	mg/kg dry wt	< 0.5	< 0.5	< 0.5	< 0.3	< 0.3
2,4-Dinitrotoluene	mg/kg dry wt	< 0.5	< 0.5	< 0.5	< 0.3	< 0.3
2,6-Dinitrotoluene	mg/kg dry wt	< 0.5	< 0.5	< 0.5	< 0.3	< 0.3
Nitrobenzene	mg/kg dry wt	< 0.3	< 0.3	< 0.3	< 0.14	< 0.11
N-Nitrosodi-n-propylamine	mg/kg dry wt	< 0.5	< 0.5	< 0.5	< 0.3	< 0.3
Organochlorine Pesticides Trace in SVOC Soil Samples by GC-MS						
Aldrin	mg/kg dry wt	< 3	< 3	< 3	< 0.14	< 0.11
alpha-BHC	mg/kg dry wt	< 0.3	< 0.3	< 0.3	< 0.14	< 0.11
beta-BHC	mg/kg dry wt	< 0.3	< 0.3	< 0.3	< 0.14	< 0.11
delta-BHC	mg/kg dry wt	< 0.3	< 0.3	< 0.3	< 0.14	< 0.11
gamma-BHC (Lindane)	mg/kg dry wt	< 0.3	< 0.3	< 0.3	< 0.14	< 0.11
4,4'-DDD	mg/kg dry wt	< 0.3	< 0.3	< 0.3	< 0.14	< 0.11
4,4'-DDE	mg/kg dry wt	< 0.3	< 0.3	< 0.3	< 0.14	< 0.11
4,4'-DDT	mg/kg dry wt	< 0.5	< 0.5	< 0.5	< 0.3	< 0.3

Sample Type: Sediment						
Sample Name:		HEATH14a 15-May-2020 12:03 pm	HEATH14b 15-May-2020 12:06 pm	HEATH14c 15-May-2020 12:10 pm	HEATH10a 15-May-2020 11:13 am	HEATH10b 15-May-2020 11:18 am
Lab Number:		2366857.1	2366857.2	2366857.3	2366857.4	2366857.5
Organochlorine Pesticides Trace in SVOC Soil Samples by GC-MS						
Dieldrin	mg/kg dry wt	< 0.3	< 0.3	< 0.3	< 0.14	< 0.11
Endosulfan I	mg/kg dry wt	< 0.5	< 0.5	< 0.5	< 0.3	< 0.3
Endosulfan II	mg/kg dry wt	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Endosulfan sulphate	mg/kg dry wt	< 0.5	< 0.5	< 0.5	< 0.3	< 0.3
Endrin	mg/kg dry wt	< 0.5	< 0.5	< 0.5	< 0.3	< 0.3
Endrin ketone	mg/kg dry wt	< 0.5	< 0.5	< 0.5	< 0.3	< 0.3
Heptachlor	mg/kg dry wt	< 0.3	< 0.3	< 0.3	< 0.14	< 0.11
Heptachlor epoxide	mg/kg dry wt	< 0.3	< 0.3	< 0.3	< 0.14	< 0.11
Hexachlorobenzene	mg/kg dry wt	< 0.3	< 0.3	< 0.3	< 0.14	< 0.11
Polycyclic Aromatic Hydrocarbons Trace in SVOC Soil Samples*						
Acenaphthene	mg/kg dry wt	< 0.12	< 0.12	< 0.11	< 0.10	< 0.10
Acenaphthylene	mg/kg dry wt	< 0.12	< 0.12	< 0.11	< 0.10	< 0.10
Anthracene	mg/kg dry wt	< 0.12	< 0.12	< 0.11	< 0.10	< 0.10
Benzo[a]anthracene	mg/kg dry wt	0.22	0.21	0.21	0.12	0.11
Benzo[a]pyrene (BAP)	mg/kg dry wt	< 0.3	< 0.3	< 0.3	< 0.14	0.13
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	0.5	0.4	0.4	< 0.14	0.16
Benzo[g,h,i]perylene	mg/kg dry wt	0.4	0.3	0.3	< 0.14	< 0.11
Benzo[k]fluoranthene	mg/kg dry wt	< 0.3	< 0.3	< 0.3	< 0.14	< 0.11
1&2-Chloronaphthalene	mg/kg dry wt	< 0.17	< 0.17	< 0.16	< 0.10	< 0.10
Chrysene	mg/kg dry wt	0.40 [#1]	0.34	0.41 [#1]	< 0.10	0.12
Dibenzo[a,h]anthracene	mg/kg dry wt	< 0.3	< 0.3	< 0.3	< 0.14	< 0.11
Fluoranthene	mg/kg dry wt	0.59	0.51	0.54	0.16	0.26
Fluorene	mg/kg dry wt	< 0.12	< 0.12	< 0.11	< 0.10	< 0.10
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	< 0.3	< 0.3	< 0.3	< 0.14	< 0.11
2-Methylnaphthalene	mg/kg dry wt	< 0.12	< 0.12	< 0.11	< 0.10	< 0.10
Naphthalene	mg/kg dry wt	< 0.12	< 0.12	< 0.11	< 0.10	< 0.10
Phenanthrene	mg/kg dry wt	0.25	0.20	0.25	< 0.10	0.17
Pyrene	mg/kg dry wt	0.86	0.76	0.83	0.17	0.28
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES*	mg/kg dry wt	< 0.6	< 0.6	< 0.6	< 0.4	< 0.3
Benzo[a]pyrene Toxic Equivalence (TEF)*	mg/kg dry wt	< 0.6	< 0.6	< 0.6	< 0.4	< 0.3
Phenols Trace in SVOC Soil Samples by GC-MS						
4-Chloro-3-methylphenol	mg/kg dry wt	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
2-Chlorophenol	mg/kg dry wt	< 0.3	< 0.3	< 0.3	< 0.2	< 0.2
2,4-Dichlorophenol	mg/kg dry wt	< 0.3	< 0.3	< 0.3	< 0.2	< 0.2
2,4-Dimethylphenol	mg/kg dry wt	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
3 & 4-Methylphenol (m- + p-cresol)	mg/kg dry wt	< 0.5	< 0.5	< 0.5	< 0.4	< 0.4
2-Methylphenol (o-Cresol)	mg/kg dry wt	< 0.3	< 0.3	< 0.3	< 0.2	< 0.2
2-Nitrophenol	mg/kg dry wt	< 0.5	< 0.5	< 0.5	< 0.4	< 0.4
Pentachlorophenol (PCP)	mg/kg dry wt	< 6	< 6	< 6	< 6	< 6
Phenol	mg/kg dry wt	< 0.5	< 0.5	< 0.5	< 0.3	< 0.3
2,4,5-Trichlorophenol	mg/kg dry wt	< 0.5	< 0.5	< 0.5	< 0.3	< 0.3
2,4,6-Trichlorophenol	mg/kg dry wt	< 0.5	< 0.5	< 0.5	< 0.3	< 0.3
Plasticisers Trace in SVOC Soil Samples by GC-MS						
Bis(2-ethylhexyl)phthalate	mg/kg dry wt	75	72	64	2.2	2.2
Butylbenzylphthalate	mg/kg dry wt	0.6	0.7	0.7	< 0.3	< 0.3
Di(2-ethylhexyl)adipate	mg/kg dry wt	< 0.3	< 0.3	< 0.3	< 0.2	< 0.2
Diethylphthalate	mg/kg dry wt	< 0.5	< 0.5	< 0.5	< 0.3	< 0.3
Dimethylphthalate	mg/kg dry wt	< 0.5	< 0.5	< 0.5	< 0.3	< 0.3
Di-n-butylphthalate	mg/kg dry wt	< 0.5	< 0.5	< 0.5	< 0.3	< 0.3
Di-n-octylphthalate	mg/kg dry wt	< 0.5	< 0.5	< 0.5	< 0.3	< 0.3

Sample Type: Sediment						
Sample Name:		HEATH14a 15-May-2020 12:03 pm	HEATH14b 15-May-2020 12:06 pm	HEATH14c 15-May-2020 12:10 pm	HEATH10a 15-May-2020 11:13 am	HEATH10b 15-May-2020 11:18 am
Lab Number:		2366857.1	2366857.2	2366857.3	2366857.4	2366857.5
Other Halogenated compounds Trace in SVOC Soil Samples by GC-MS						
1,2-Dichlorobenzene	mg/kg dry wt	< 0.5	< 0.5	< 0.5	< 0.3	< 0.3
1,3-Dichlorobenzene	mg/kg dry wt	< 0.5	< 0.5	< 0.5	< 0.3	< 0.3
1,4-Dichlorobenzene	mg/kg dry wt	< 0.5	< 0.5	< 0.5	< 0.3	< 0.3
Hexachlorobutadiene	mg/kg dry wt	< 0.5	< 0.5	< 0.5	< 0.3	< 0.3
Hexachloroethane	mg/kg dry wt	< 0.5	< 0.5	< 0.5	< 0.3	< 0.3
1,2,4-Trichlorobenzene	mg/kg dry wt	< 0.3	< 0.3	< 0.3	< 0.14	< 0.11
Other SVOC Trace in SVOC Soil Samples by GC-MS						
Benzyl alcohol	mg/kg dry wt	< 3	< 3	< 3	< 1.4	< 1.1
Carbazole	mg/kg dry wt	< 0.3	< 0.3	< 0.3	< 0.14	< 0.11
Dibenzofuran	mg/kg dry wt	< 0.3	< 0.3	< 0.3	< 0.14	< 0.11
Isophorone	mg/kg dry wt	< 0.3	< 0.3	< 0.3	< 0.14	< 0.11

Sample Name:		HEATH10c 15-May-2020 11:25 am	HEATH09a 15-May-2020 10:43 am	HEATH09b 15-May-2020 10:47 am	HEATH09c 15-May-2020 10:51 am	
Lab Number:		2366857.6	2366857.7	2366857.8	2366857.9	
Individual Tests						
Dry Matter	g/100g as rcvd	59	36	27	29	-
Total Recoverable Copper	mg/kg dry wt	116	12.0	25	14.9	-
Total Recoverable Lead	mg/kg dry wt	48	22	42	27	-
Total Recoverable Phosphorus	mg/kg dry wt	460	1,080	1,330	900	-
Total Recoverable Zinc	mg/kg dry wt	650	220	920	660	-
Total Organic Carbon*	g/100g dry wt	1.67	3.7	7.0	5.1	-
7 Grain Sizes Profile as received*						
Dry Matter of Sieved Sample*	g/100g as rcvd	66	41	22	35	-
Fraction >/= 2 mm*	g/100g dry wt	0.7	6.0	5.7	5.1	-
Fraction < 2 mm, >/= 1 mm*	g/100g dry wt	0.1	0.3	1.1	0.9	-
Fraction < 1 mm, >/= 500 µm*	g/100g dry wt	0.4	0.7	1.9	1.5	-
Fraction < 500 µm, >/= 250 µm*	g/100g dry wt	12.5	2.3	20.3	22.8	-
Fraction < 250 µm, >/= 125 µm*	g/100g dry wt	24.3	18.4	26.1	39.2	-
Fraction < 125 µm, >/= 63 µm*	g/100g dry wt	25.7	32.0	21.1	13.2	-
Fraction < 63 µm*	g/100g dry wt	36.3	40.3	23.8	17.4	-
Haloethers Trace in SVOC Soil Samples by GC-MS						
Bis(2-chloroethoxy) methane	mg/kg dry wt	< 0.10	< 0.17	< 0.3	< 0.2	-
Bis(2-chloroethyl)ether	mg/kg dry wt	< 0.10	< 0.17	< 0.3	< 0.2	-
Bis(2-chloroisopropyl)ether	mg/kg dry wt	< 0.10	< 0.17	< 0.3	< 0.2	-
4-Bromophenyl phenyl ether	mg/kg dry wt	< 0.10	< 0.17	< 0.3	< 0.2	-
4-Chlorophenyl phenyl ether	mg/kg dry wt	< 0.10	< 0.17	< 0.3	< 0.2	-
Nitrogen containing compounds Trace in SVOC Soil Samples, GC-MS						
N-Nitrosodiphenylamine + Diphenylamine	mg/kg dry wt	< 0.2	< 0.4	< 0.5	< 0.4	-
2,4-Dinitrotoluene	mg/kg dry wt	< 0.2	< 0.4	< 0.5	< 0.4	-
2,6-Dinitrotoluene	mg/kg dry wt	< 0.2	< 0.4	< 0.5	< 0.4	-
Nitrobenzene	mg/kg dry wt	< 0.10	< 0.17	< 0.3	< 0.2	-
N-Nitrosodi-n-propylamine	mg/kg dry wt	< 0.2	< 0.4	< 0.5	< 0.4	-
Organochlorine Pesticides Trace in SVOC Soil Samples by GC-MS						
Aldrin	mg/kg dry wt	< 0.10	< 0.17	< 0.3	< 0.2	-
alpha-BHC	mg/kg dry wt	< 0.10	< 0.17	< 0.3	< 0.2	-
beta-BHC	mg/kg dry wt	< 0.10	< 0.17	< 0.3	< 0.2	-
delta-BHC	mg/kg dry wt	< 0.10	< 0.17	< 0.3	< 0.2	-
gamma-BHC (Lindane)	mg/kg dry wt	< 0.10	< 0.17	< 0.3	< 0.2	-
4,4'-DDD	mg/kg dry wt	< 0.10	< 0.17	< 0.3	< 0.2	-
4,4'-DDE	mg/kg dry wt	< 0.10	< 0.17	< 0.3	< 0.2	-
4,4'-DDT	mg/kg dry wt	< 0.2	< 0.4	< 0.5	< 0.4	-
Dieldrin	mg/kg dry wt	< 0.10	< 0.17	< 0.3	< 0.2	-

Sample Type: Sediment						
Sample Name:		HEATH10c 15-May-2020 11:25 am	HEATH09a 15-May-2020 10:43 am	HEATH09b 15-May-2020 10:47 am	HEATH09c 15-May-2020 10:51 am	
Lab Number:		2366857.6	2366857.7	2366857.8	2366857.9	
Organochlorine Pesticides Trace in SVOC Soil Samples by GC-MS						
Endosulfan I	mg/kg dry wt	< 0.2	< 0.4	< 0.5	< 0.4	-
Endosulfan II	mg/kg dry wt	< 0.5	< 0.5	< 0.5	< 0.5	-
Endosulfan sulphate	mg/kg dry wt	< 0.2	< 0.4	< 0.5	< 0.4	-
Endrin	mg/kg dry wt	< 0.2	< 0.4	< 0.5	< 0.4	-
Endrin ketone	mg/kg dry wt	< 0.2	< 0.4	< 0.5	< 0.4	-
Heptachlor	mg/kg dry wt	< 0.10	< 0.17	< 0.3	< 0.2	-
Heptachlor epoxide	mg/kg dry wt	< 0.10	< 0.17	< 0.3	< 0.2	-
Hexachlorobenzene	mg/kg dry wt	< 0.10	< 0.17	< 0.3	< 0.2	-
Polycyclic Aromatic Hydrocarbons Trace in SVOC Soil Samples*						
Acenaphthene	mg/kg dry wt	< 0.10	< 0.10	< 0.11	< 0.10	-
Acenaphthylene	mg/kg dry wt	< 0.10	< 0.10	< 0.11	< 0.10	-
Anthracene	mg/kg dry wt	< 0.10	< 0.10	< 0.11	< 0.10	-
Benzo[a]anthracene	mg/kg dry wt	< 0.10	< 0.10	0.12	< 0.10	-
Benzo[a]pyrene (BAP)	mg/kg dry wt	< 0.10	< 0.17	< 0.3	< 0.2	-
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	< 0.10	< 0.17	< 0.3	< 0.2	-
Benzo[g,h,i]perylene	mg/kg dry wt	< 0.10	< 0.17	< 0.3	< 0.2	-
Benzo[k]fluoranthene	mg/kg dry wt	< 0.10	< 0.17	< 0.3	< 0.2	-
1&2-Chloronaphthalene	mg/kg dry wt	< 0.10	< 0.12	< 0.16	< 0.15	-
Chrysene	mg/kg dry wt	< 0.10	< 0.10	< 0.11	< 0.10	-
Dibenzo[a,h]anthracene	mg/kg dry wt	< 0.10	< 0.17	< 0.3	< 0.2	-
Fluoranthene	mg/kg dry wt	0.11	0.10	0.25	< 0.10	-
Fluorene	mg/kg dry wt	< 0.10	< 0.10	< 0.11	< 0.10	-
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	< 0.10	< 0.17	< 0.3	< 0.2	-
2-Methylnaphthalene	mg/kg dry wt	< 0.10	< 0.10	< 0.11	< 0.10	-
Naphthalene	mg/kg dry wt	< 0.10	< 0.10	< 0.11	< 0.10	-
Phenanthrene	mg/kg dry wt	< 0.10	< 0.10	0.12	< 0.10	-
Pyrene	mg/kg dry wt	0.12	0.11	0.26	0.11	-
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES*	mg/kg dry wt	< 0.3	< 0.4	< 0.6	< 0.5	-
Benzo[a]pyrene Toxic Equivalence (TEF)*	mg/kg dry wt	< 0.3	< 0.4	< 0.6	< 0.5	-
Phenols Trace in SVOC Soil Samples by GC-MS						
4-Chloro-3-methylphenol	mg/kg dry wt	< 0.5	< 0.5	< 0.5	< 0.5	-
2-Chlorophenol	mg/kg dry wt	< 0.2	< 0.2	< 0.3	< 0.2	-
2,4-Dichlorophenol	mg/kg dry wt	< 0.2	< 0.2	< 0.3	< 0.2	-
2,4-Dimethylphenol	mg/kg dry wt	< 0.4	< 0.4	< 0.4	< 0.4	-
3 & 4-Methylphenol (m- + p-cresol)	mg/kg dry wt	< 0.4	< 0.4	< 0.5	< 0.4	-
2-Methylphenol (o-Cresol)	mg/kg dry wt	< 0.2	< 0.2	< 0.3	< 0.2	-
2-Nitrophenol	mg/kg dry wt	< 0.4	< 0.4	< 0.5	< 0.4	-
Pentachlorophenol (PCP)	mg/kg dry wt	< 6	< 6	< 6	< 6	-
Phenol	mg/kg dry wt	< 0.2	< 0.4	< 0.5	< 0.4	-
2,4,5-Trichlorophenol	mg/kg dry wt	< 0.2	< 0.4	< 0.5	< 0.4	-
2,4,6-Trichlorophenol	mg/kg dry wt	< 0.2	< 0.4	< 0.5	< 0.4	-
Plasticisers Trace in SVOC Soil Samples by GC-MS						
Bis(2-ethylhexyl)phthalate	mg/kg dry wt	2.1	< 0.7	1.0	< 0.8	-
Butylbenzylphthalate	mg/kg dry wt	< 0.2	< 0.4	< 0.5	< 0.4	-
Di(2-ethylhexyl)adipate	mg/kg dry wt	< 0.2	< 0.2	< 0.3	< 0.2	-
Diethylphthalate	mg/kg dry wt	< 0.2	< 0.4	< 0.5	< 0.4	-
Dimethylphthalate	mg/kg dry wt	< 0.2	< 0.4	< 0.5	< 0.4	-
Di-n-butylphthalate	mg/kg dry wt	< 0.2	< 0.4	< 0.5	< 0.4	-
Di-n-octylphthalate	mg/kg dry wt	< 0.2	< 0.4	< 0.5	< 0.4	-

Sample Type: Sediment						
Sample Name:		HEATH10c 15-May-2020 11:25 am	HEATH09a 15-May-2020 10:43 am	HEATH09b 15-May-2020 10:47 am	HEATH09c 15-May-2020 10:51 am	
Lab Number:		2366857.6	2366857.7	2366857.8	2366857.9	
Other Halogenated compounds Trace in SVOC Soil Samples by GC-MS						
1,2-Dichlorobenzene	mg/kg dry wt	< 0.2	< 0.4	< 0.5	< 0.4	-
1,3-Dichlorobenzene	mg/kg dry wt	< 0.2	< 0.4	< 0.5	< 0.4	-
1,4-Dichlorobenzene	mg/kg dry wt	< 0.2	< 0.4	< 0.5	< 0.4	-
Hexachlorobutadiene	mg/kg dry wt	< 0.2	< 0.4	< 0.5	< 0.4	-
Hexachloroethane	mg/kg dry wt	< 0.2	< 0.4	< 0.5	< 0.4	-
1,2,4-Trichlorobenzene	mg/kg dry wt	< 0.10	< 0.17	< 0.3	< 0.2	-
Other SVOC Trace in SVOC Soil Samples by GC-MS						
Benzyl alcohol	mg/kg dry wt	< 1.0	< 1.7	< 3	< 2	-
Carbazole	mg/kg dry wt	< 0.10	< 0.17	< 0.3	< 0.2	-
Dibenzofuran	mg/kg dry wt	< 0.10	< 0.17	< 0.3	< 0.2	-
Isophorone	mg/kg dry wt	< 0.10	< 0.17	< 0.3	< 0.2	-

Analyst's Comments

#1 Chrysene is higher than expected when compared to Benzo[a]anthracene. It is possible that Benzo(l)phenanthrene is present which co-elutes with Chrysene.

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 Laboratories, 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%.	-	1-9
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%.	-	1-9
Dry Matter (Env)	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	1-9
Total Recoverable digestion	Nitric / hydrochloric acid digestion. US EPA 200.2.	-	1-9
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	1-9
Total Recoverable Lead	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, trace level. US EPA 200.2.	0.04 mg/kg dry wt	1-9
Total Recoverable Phosphorus	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, screen level. US EPA 200.2.	40 mg/kg dry wt	1-9
Total Recoverable Zinc	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, trace level. US EPA 200.2.	0.4 mg/kg dry wt	1-9
Total Organic Carbon*	Acid pretreatment to remove carbonates present followed by Catalytic Combustion (900°C, O2), separation, Thermal Conductivity Detector [Elementar Analyser].	0.05 g/100g dry wt	1-9
Semivolatile Organic Compounds Trace in Soil by GC-MS	Sonication extraction, GC-MS analysis. Tested on as received sample. In-house based on US EPA 8270.	0.002 - 6 mg/kg dry wt	1-9
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	1-9
Fraction >/= 2 mm*	Wet sieving with dispersant, as received, 2.00 mm sieve, gravimetry.	0.1 g/100g dry wt	1-9
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	1-9
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	1-9

Sample Type: Sediment			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
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	1-9
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	1-9
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	1-9
Fraction < 63 µm*	Wet sieving with dispersant, as received, 63 µm sieve, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-9

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

Dates of testing are available on request. Please contact the laboratory for more information.

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