Addington Brook Baseline Aquatic Ecology Survey

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Prepared for:
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EXECUTIVE SUMMARY

Christchurch City Council is proposing to undertake two major projects aimed at improving water quality and physical habitat in Addington Brook. This report describes results of a pre-restoration ecological survey of Addington Brook and nearby Riccarton Stream. Results of this survey will be used as a baseline to compare post-restoration monitoring results against.

Addington Brook has a natural, meandering form and its banks are mostly comprised of natural earth and stone. In contrast, Riccarton Stream is concrete lined and has been artificially straightened. Addington Brook and Riccarton Stream have degraded water quality and habitat conditions. A lack of stormwater treatment negatively affects water quality, with Addington Brook having worse water quality than Riccarton Stream. In Addington Brook, habitat quality is reduced by: a lack of dense riparian planting and insufficient shading to prevent nuisance plant growths; overly steep banks that contribute to bank erosion and sediment deposition; shallow water depths; a lack of pools and riffles; and a lack of instream habitat in the form of cobbles, boulders, and wood.

The aquatic invertebrate community at all sites was dominated by pollution-tolerant snails, crustaceans, and worms. The lack of the amphipod *Paracalliope fluviatilis* in Addington Brook and the dominance of oligochaete worms at two Addington Brook sites is likely due to elevated concentrations of stormwater contaminants.

The fish community was dominated by tolerant native species that are common in modified waterways. However, the presence of inanga and longfin eel was notable, due to their At Risk conservation status. Inanga had not previously been recorded from Addington Brook and they were the most abundant fish species caught during this survey.

We recommend monitoring every 2–3 years following restoration, using the same methods described in this report.

1. INTRODUCTION

Addington Brook is a small tributary of the Ōtākaro – Avon River that flows through Christchurch's Hagley Park and Botanic Gardens. Christchurch City Council has prepared a masterplan for enhancing Addington Brook within Hagley Park. Proposed ecological enhancements include regrading the banks to reduce erosion, native riparian plantings to enhance biodiversity and waterway shade, enhanced instream habitat, and channel realignment. A separate project also aims to improve water quality in Addington Brook, through the addition of a stormwater treatment facility upstream of Hagley Park. A desktop review of ecological values helped inform the masterplan, and the accompanying report included restoration goals (Instream Consulting 2022). Council is hoping to commence physical works for the enhancement project within the next year.

This report describes results of an aquatic ecology survey undertaken in Addington Brook and nearby Riccarton Stream (also known as Riccarton Main Drain). The purpose of the survey was to provide baseline data that can be used to compare against data collected after restoration activities.

2. METHODS

Aquatic habitat, invertebrate, and fish communities were sampled at six locations, including five in Addington Brook and one in Riccarton Stream (Figure 1, Table 1). Sampling sites were chosen to include four locations along Addington Brook where restoration activities are proposed (Sites A–D), plus two reference sites (Sites E and F). The rationale for individual site selection is provided in Table 1. All fieldwork was conducted over 16 January to 7 February 2023, under baseflow conditions.

Stream habitats were sampled using standard ecology sampling methods outlined in the Environmental Monitoring Plan (version 9) of the council's Comprehensive Stormwater Network Discharge consent (CSNDC; consent number CRC190445). The standard methods were supplemented with additional methods to provide more detailed information of relevance to monitoring restoration activities. The additional methods are as follows:

- Each sampling reach was 50 m long. This was done to capture more habitat variation than is achieved by the standard 20 m habitat sampling reach and minimum 30 m fishing reach of the CSNDC methods.
- Transects were located randomly at each site, rather than 10 m apart (CSNDC methods), to provide better representation of habitat variation at each site.
- Both electric fishing and fish trapping was undertaken at all sites. Usually only one method is used for Council monitoring.
    - Each fishing method has sampling biases, so using both methods will give the best estimate of fish diversity.
- For each sampling site, fish cover was measured as follows:
    - Total length of left and right bank with the following fish cover attributes: undercuts, overhanging vegetation, other cover attributes, or no cover.
    - Percentage of the bed with the following fish cover: root mats, macrophytes, fine sediment, leaf litter, cobbles/boulders, woody debris, and algae.
- Riparian buffer width was measured at each transect (each bank separately).

    - Restoration activities include riparian planting, so measuring buffer width will provide useful data to compare pre- and post-restoration.
- Five velocity measurements were made per transect, rather than the single measurement used in the standard methods.
    - Velocity provides a measure of flow habitat variation, so it would be useful having more detailed measurements for pre- and post-restoration comparison.

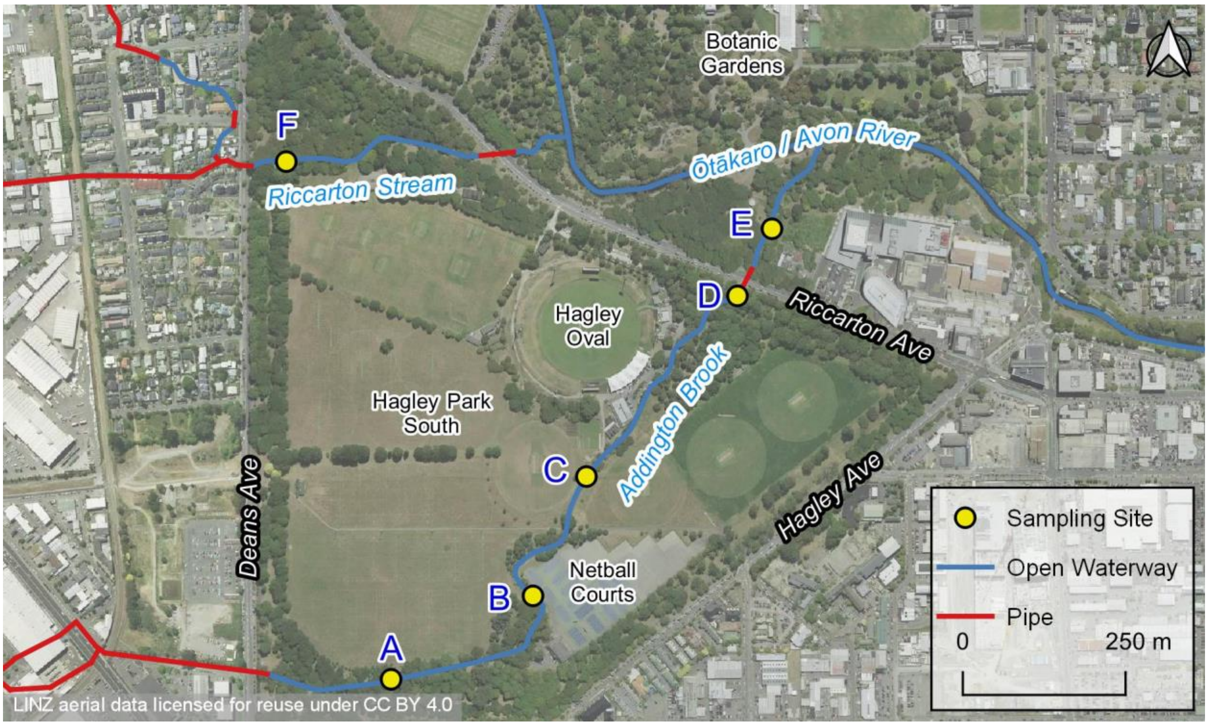

Figure 1: Ecology sampling sites.

Field data were compared to relevant guidelines and standards. Relevant guidelines and Attribute Target Levels from the Environmental Monitoring Programme for the CSNDC include: dissolved oxygen ≥70% saturation, water temperature <20 °C, pH 6.5–8.5; bed cover with macrophytes ≤60%; bed cover with filamentous algae >2 cm long ≤30%. National Policy Statement for Freshwater Management 2020 national bottom line values were used for: bed cover with fine sediment of <2 mm diameter 27%[1]; Macroinvertebrate Community Index (MCI), with a bottom line MCI value of 90, the quantitative MCI (QMCI), with a bottom line value of 4.5[2], and the Average Score Per Metric (ASPM), with a bottom line value of 0.3.

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[1] Based on deposited sediment class 3 (CD/L/Al). This is more stringent than the CSNDC attribute target level of 30%, which is based on the Canterbury Land and Water Regional Plan Freshwater outcome for Spring-fed Plains waterway classes.

[2] The national bottom line QMCI value of 4.5 is more stringent than the CSNDC attribute target level of 3.5, which is based on the Canterbury Land and Water Regional Plan Freshwater Outcome for Spring-fed Plains Urban waterway classes.

Table 1: Sampling site locations and rationale for site selection.

Site	Waterway Name	Site Selection Rationale	Easting (NZTM)	Northing (NZTM)
A	Addington Brook	Straight, steep-sided, and well-shaded; physical habitat enhancement likely constrained by existing exotic trees.	1568896	5179232
B	Addington Brook	Where stream realignment is proposed; moderate shade.	1569114	5179360
C	Addington Brook	Straight section in grassed area with minimal shade.	1569196	5179543
D	Addington Brook	5-yearly monitoring site, with some native plantings and partial shade.	1569428	5179820
E	Addington Brook	Naturalised reference site within Botanic Gardens.	1569481	5179923
F	Riccarton Stream	Concrete-lined reference site; 5-yearly monitoring site.	1568735	5180026

3. RESULTS AND DISCUSSION

3.1. Overview

Addington Brook is mostly piped upstream (west) of Deans Avenue, with the piped network carrying a combination of groundwater baseflow and urban stormwater runoff. Much of Riccarton Stream has also been piped upstream of Deans Avenue, although it does have more open sections in its upper reaches than Addington Brook. From Deans Avenue, both waterways flow through Hagley Park South, before flowing through culverts under Riccarton Avenue, and then flowing through Christchurch Botanic Gardens and into the Ōtākaro / Avon River (Figure 1). Addington Brook generally has a natural, meandering form and its banks are mostly comprised of natural earth and stone. In contrast, Riccarton Stream is concrete lined and has been artificially straightened.

3.2. Water Quality and Habitat

Dissolved oxygen levels were moderate to high at all sites but fell below the guideline value of 70% saturation at Sites E and F (Table 2). Water temperatures were cool, and pH was around neutral, and both were within guideline values. Conductivity varied within a relatively narrow band. Values for all measured water quality parameters were typical for Christchurch urban waterways.

Water clarity was reduced at several sites, with a milky appearance to the water observed at Sites A and D, and the water was slightly turbid at Site E. Reduced clarity and colour was almost certainly due to inflows from dry weather discharges into the stormwater system. This is common in urban waterways with large urban catchments and little stormwater treatment.

Table 2: Field measured water quality. Red values do not meet guidelines.

Site	Dissolved oxygen (%)	Temperature (°C)	pH	Conductivity (µS/cm)
A	**59.0**	18.3	7.08	293
B	82.3	18.9	7.18	276
C	106.8	19.1	7.45	271
D	93.4	18.9	7.47	276
E	**62.8**	18.0	7.23	272
F	92.4	14.8	7.18	251
Guideline	**≥70**	**<20**	**6.5–8.5**	**–**

Riparian vegetation varied markedly amongst the sampling sites, ranging from exotic grasses, with no trees or shrubs at Site C, through to a mixture of exotic tree canopy underplanted with well-established native shrubs and trees at Site E (Figure 2). Most sites were well shaded by tall canopy trees, with mean shade ranging from 68–82%. The exception was Site C, which was in an open section, with a mean shade of only 3% at the water surface. Bank cover with low ‘ground cover’ vegetation exceeded 90% at all sites except Site E, in the Botanic Gardens, where lower vegetated ground cover (56%) was associated with landscaping boulders and pathways. The high level of cover with ground vegetation at most sites would both help prevent bank erosion and intercept overland flow. Riparian buffer widths were narrow at most sites, ranging from 4–6 m. The exception was Site F (Riccarton Stream), where the mean buffer width was 11 m.

Waterway banks were comprised of natural earth at Sites A–D, where overly-steep banks were associated with bank erosion (mean of 30% bank erosion at Sites A–D). The banks were also steep at Sites E and F, but no erosion was recorded, because the banks were made of rock at Site E and concrete at Site F. Mean channel width ranged from a minimum of 1.22 m at Site F on Riccarton Stream to a maximum of 2.02 m at Site D on Addington Brook (Table 3). Mean water depth ranged from 0.16 m at Site F to 0.33 at Site D. Mean water velocity was very slow at all the Addington Brook sites (range of 0.03–0.06 m/s) but was comparatively swift in Riccarton Stream (mean of 0.33 m/s). In Addington Brook, coarse bed sediments (i.e., stones >2 mm diameter) dominated at Sites D and E, while fine sediments dominated at the other three sites. Coarse sediments covered 45% of the bed at Site F on Riccarton Stream, but the entire channel was concrete-lined. Bed cover with fine sediment was high and exceeded guidelines at all sites but was highest at Sites A–D (Table 4).

Stable undercuts were the dominant form of bank cover for fish at Sites A, B, and D, while overhanging vegetation dominated at Site C and boulders at Site E (Figure 3). Roots also provided some bank cover for fish at Site A. Where overhanging vegetation was present, the mean length of overhanging vegetation was 12 cm (taken from transect level measurements). The short mean length of overhanging vegetation reflects regular bank trimming by Council waterway maintenance crews. Waterway maintenance includes bank trimming, removing any potential blockages, and macrophyte removal, and currently occurs three times per year, in April, August, and December (Kirsty Patten, Christchurch City Council, pers. comm.). No bank cover was present at Site F, due to the concrete lining.

Figure 2: Sampling site photographs.

Macrophytes were abundant and provided the dominant form of bed cover for fish at Sites A–C (Figure 4). Deeper deposits of fine sediment also provided reasonable cover at Site C. However, quality instream cover, in the form of woody debris, cobbles, and boulders was generally lacking.

Macrophyte cover was high at Sites A–C and exceeded the guideline value of 60% at Sites B and C (Table 4). Macrophyte cover was highest at Site C, which was also the least shaded. The macrophyte community was almost entirely dominated by the introduced submerged macrophyte *Potamogeton crispus*, which is a widespread weed species in Christchurch waterways. Macrophyte clearance occurred in early December 2022 (Kirsty Patten, Christchurch City Council, pers. comm.), so the high levels of macrophyte cover observed in January/February took less than two months to re-establish. Macrophytes were largely absent from Sites D–F, reflecting the combination of high shading and coarse substrates present (submerged macrophytes require fine sediments for roots to establish). Bed cover with long filamentous algae was low to moderate at most sites, except Site F, where cover was high and exceeded guidelines (Table 4).

Table 3: Mean values of selected physical habitat parameters at each of the ecology sampling sites.

Site	Wetted width (m)	Water depth (m)	Velocity (m/s)	Coarse substrate (%)[1]
A	1.79	0.30	0.03	<1
B	1.87	0.26	0.03	14
C	1.54	0.24	0.04	0
D	2.02	0.33	0.03	61
E	1.64	0.17	0.06	82
F	1.22	0.16	0.33	45

Note: [1] Coarse substrate refers to bed sediments >2 mm diameter (i.e., stones).

Table 4: Mean percent shade and bed cover with fine sediment, macrophytes, and filamentous algae at each of the ecology sampling sites. Red values do not meet guidelines.

Site	Fine sediment cover	Shade	Total macrophyte cover	Long filamentous algae cover
A	**99**	82	56	7
B	**94**	72	**63**	14
C	**100**	3	**82**	15
D	**58**	69	0	7
E	**37**	78	0	20
F	**31**	68	19 / 2[1]	**46**
Guideline	**≤27**	**–**	**≤60**	**≤30**

Note: [1] Macrophyte cover at Site F is given as including / excluding bryophytes.

Habitat conditions at Sites D–F were similar to those reported previously (Boffa Miskell Limited 2014; Instream Consulting 2019). However, sampling at the additional Addington Brook sites revealed a greater range of habitat conditions than previously reported. In particular, the additional sampling at Sites A–C revealed greater dominance of fine sediments and much higher macrophyte cover than at Sites D–F. Macrophytes contribute significant fish cover, but the high levels of macrophyte cover we observed at Sites A–C would negatively affect overnight dissolved oxygen concentrations.

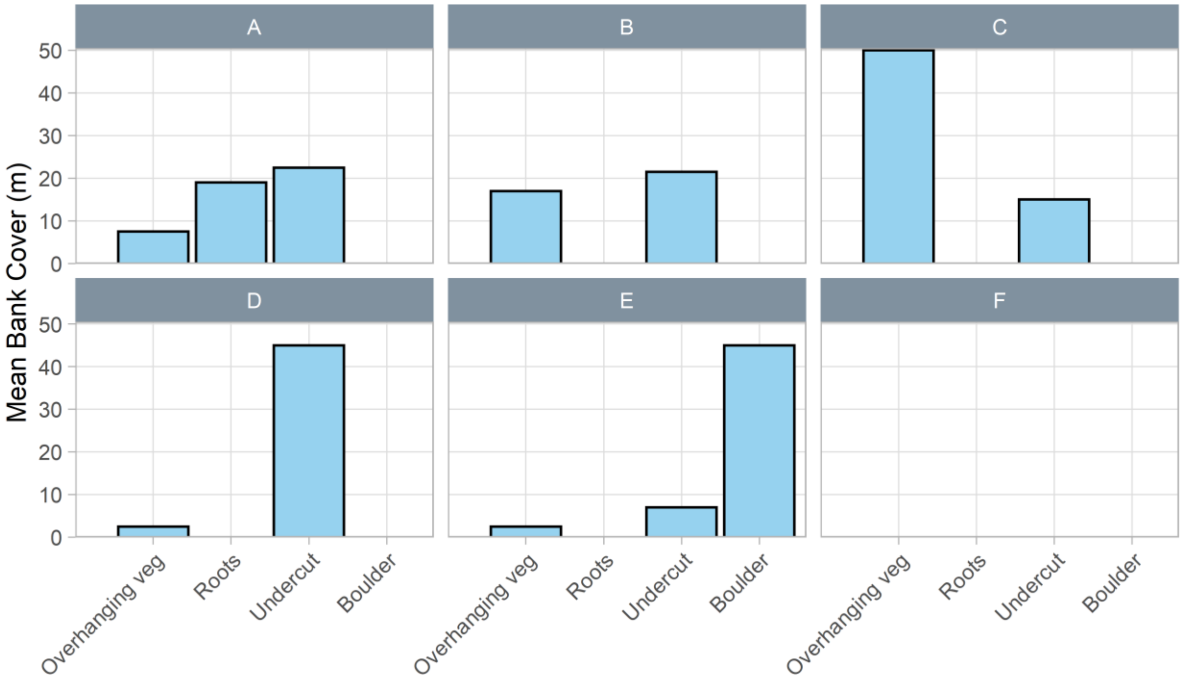

Figure 3: Mean length of each bank with different fish cover attributes at each site. Note reach length is 50 m and cover attributes can overlap (i.e., the total can exceed 50 m at each site).

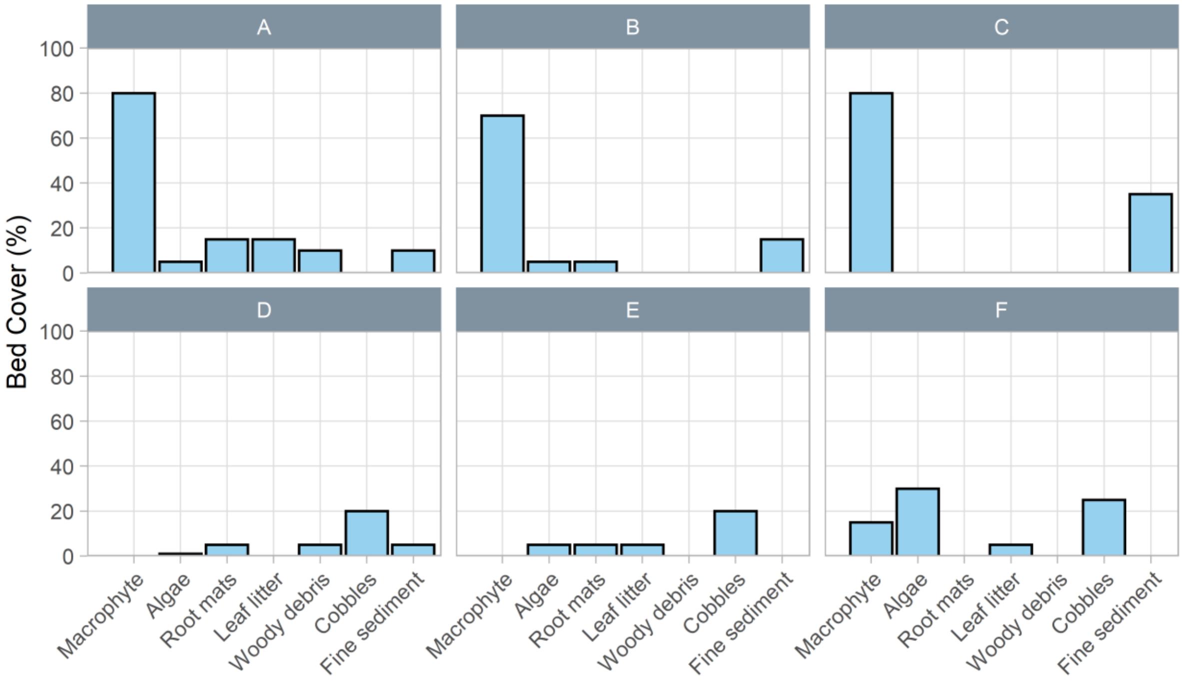

Figure 4: Percent bed cover with fish cover attributes at each site. Cover attributes can overlap.

3.3. Invertebrates

The invertebrate community at all sites was dominated by pollution-tolerant taxa, particularly the common mud snail *Potamopyrgus antipodarum* (Mollusca), which comprised 67% of all invertebrates counted. The common amphipod crustacean *Paracalliope fluviatilis* was the second most abundant taxon, comprising 14% of all invertebrates, but they were only abundant at Site F (Riccarton Stream), where they comprised 73% of invertebrates in the sample. Oligochaete worms were common and widespread, comprising 10% of total abundance, and they were most abundant at Site E, where they comprised 37% of total abundance (Figure 5).

It is unlikely that high oligochaete abundance at Site E was habitat-related, as oligochaetes prefer fine sediments and the site was dominated by coarse sediments, plus other sites had higher fine sediment cover (Table 3, Table 4). High oligochaete abundance at Site E may therefore be due to degraded water quality. This is consistent with previous sediment sampling by the Council, which found particularly high concentrations of zinc at Site E (unpublished Council data)[3]. The lack of *P. fluviatilis* in Addington Brook may also reflect degraded water quality, as there was ample suitable habitat present. Ecotoxicity testing has previously found *P. fluviatilis* to be one of the most sensitive New Zealand freshwater invertebrates to a range of contaminants, including zinc and copper (Hickey 2000). Council water quality monitoring data indicates water quality guidelines are more frequently exceeded at the Addington Brook site than at the Riccarton Stream site, and median concentrations of dissolved copper and zinc in Addington Brook are twice those recorded in Riccarton Stream (Margetts and Poudyal 2022).

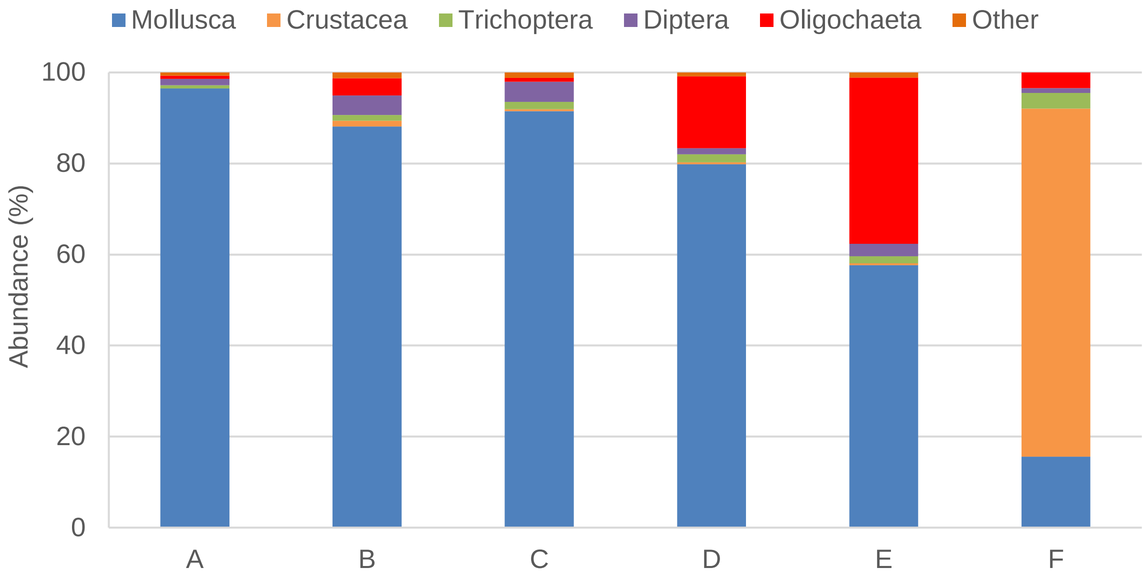

Figure 5: Invertebrate community composition at each sampling site.

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[3] Sampling undertaken for Council and Environment Canterbury as part of the 2019 round of ecology monitoring in the Ōtākaro – Avon catchment (Instream Consulting 2019). The sediment zinc concentration at Site E was 1,100 mg/kg, which was higher than the other four Addington Brook sites sampled and higher than all other Ōtākaro catchment sites.

The only pollution-sensitive invertebrate taxon[4] found was restricted to a single individual of the free-living caddisfly (Trichoptera) *Psilochorema* (MCI=8) found at Site F. No mayflies (Ephemeroptera) or stoneflies (Plecoptera) were found at any of the sites. All three indices of invertebrate community health, the MCI, QMCI, and ASPM, fell below guidelines at all sites (Figure 6). The exception was Site F, where the QMCI score was 4.6, which was just above the national bottom line value of 4.5. The slightly higher QMCI score at Site F was due to a higher relative abundance of *P. fluviatilis*.

Invertebrate community composition was similar to that reported previously for Addington Brook and Riccarton Stream, and other highly modified urban waterways in Christchurch (Instream Consulting 2019). The lack of pollution-sensitive taxa in Addington Brook is very likely due to a combination of poor water quality, associated with a lack of stormwater treatment in the catchment, and degraded habitat, particularly high levels of sediment deposition.

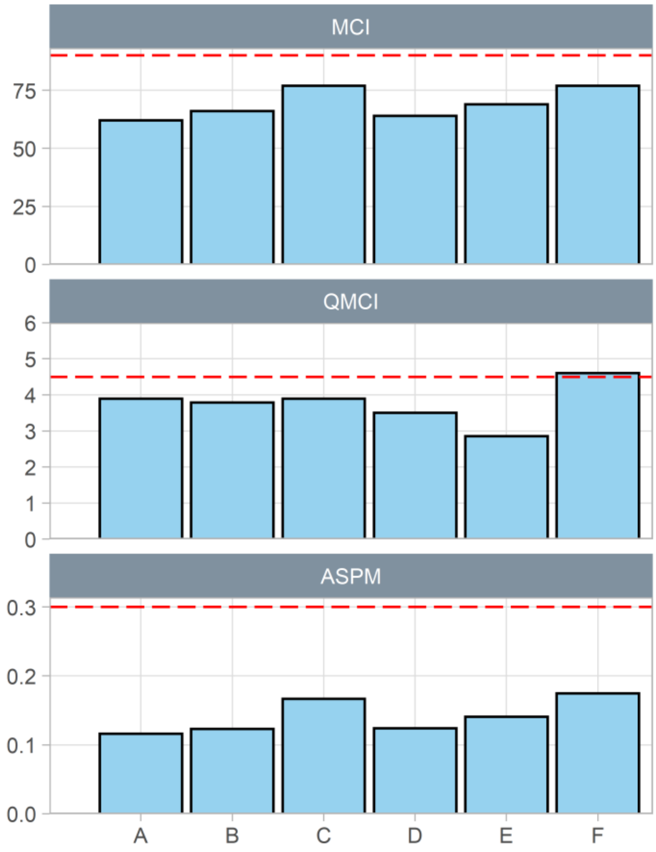

Figure 6: Invertebrate community metrics at each site compared with guidelines (red dashed line).

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[4] Pollution-sensitive taxa are defined here as species with hard-bottomed Macroinvertebrate Community Index (MCI) scores ≥7.

3.4. Fish

A total of five native fish species were caught across the six sites sampled. No introduced or pest fish species were caught. Three species were caught at all six sites, including shortfin eel (*Anguilla australis*), longfin eel (*A. dieffenbachii*), and upland bully (*Gobiomorphus breviceps*). Inanga (*Galaxias maculatus*) were caught at all sites except Site F (Riccarton Stream), while common bully (*Gobiomorphus. cotidianus*) were only caught in low numbers at Sites B, D, and E.

Shortfin eels and inanga were overall the most abundant species, but their abundance varied markedly amongst sites and with fishing method (Figure 7). When considering the combined catch of all fishing methods, inanga were the most abundant species overall, with 130 inanga caught in fyke nets across all sites, although only four inanga were caught in minnow traps, and only one was caught by electric fishing. In contrast, shortfin eels were more frequently caught by electric fishing than either trapping method. Inanga and shortfin eels were most abundant at Sites A and D, where there was some deeper run habitat (>0.3 m deep).

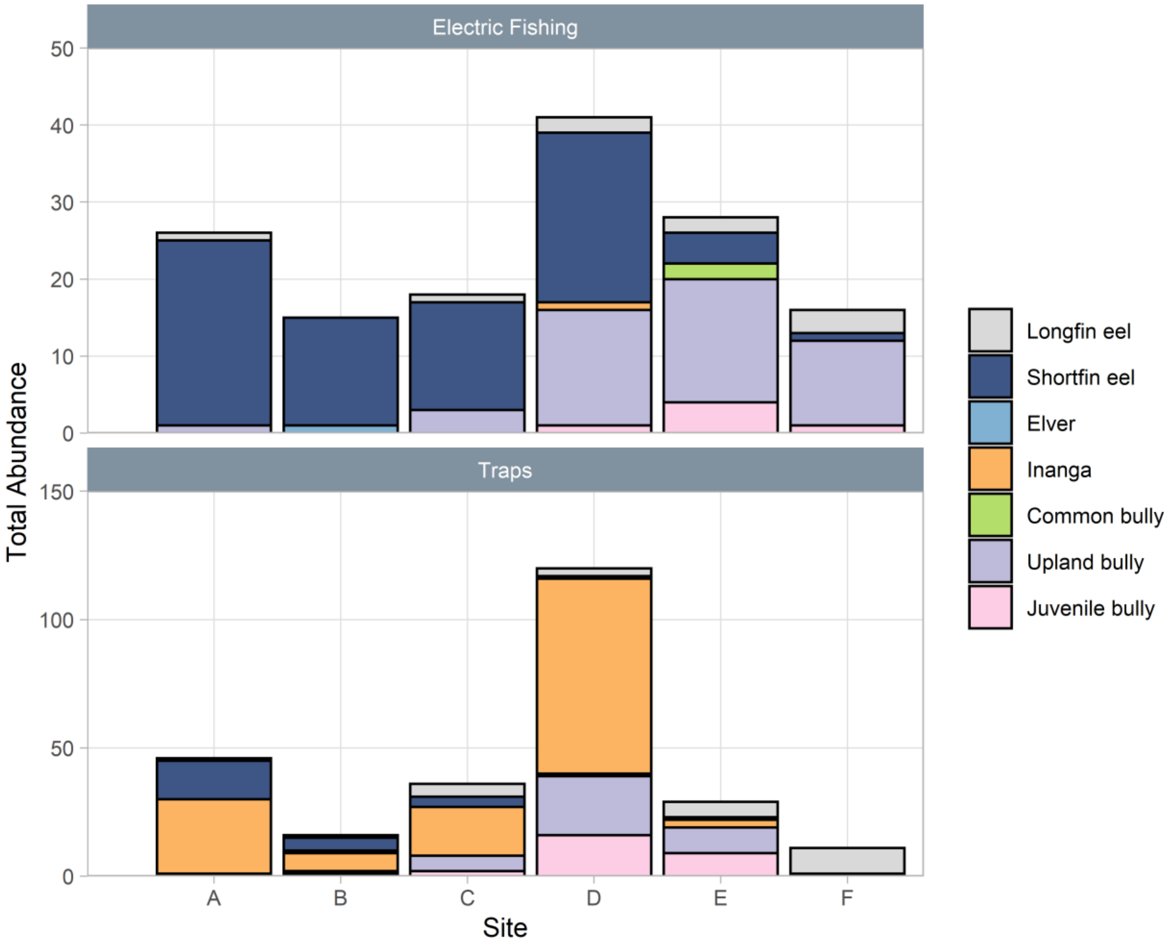

Figure 7: Fish caught using electric fishing and trapping at each site.

New Zealand Freshwater Fish Database records for Addington Brook include the same species we caught, except for inanga. The lack of inanga in previous fishing records is because previous sampling primarily used electric fishing, which is ineffective at catching inanga, whereas we used both electric fishing and trapping. Fish database records for Riccarton Stream include a similar catch to ours, except for the addition of a single bluegill bully (*Gobiomorphus hubbsi*), caught amongst a short gravel section with swift flow at the top of Site F (see Instream Consulting 2019).

Longfin eel, inanga, and bluegill bully all have an At Risk – Declining conservation status (Dunn et al. 2018). Shortfin eel, common bully, and upland bully have a Not Threatened conservation status. Five of the six species caught[5] from the two waterways are diadromous, which means they migrate between freshwater and the sea to complete their life history. Upland bully was the only non-diadromous fish species caught. Juvenile inanga are known as whitebait and their annual spring migration into freshwater supports a valued recreational fishery. Inanga and both eel species are also valued mahinga kai and they support commercial fisheries.

All fish species caught in Addington Brook and Riccarton Stream are tolerant of degraded habitat and water quality, except for bluegill bully (caught previously in Riccarton Stream), which is relatively sensitive (Joy and Death 2004). Both water quality and habitat quality likely limit the abundance of sensitive fish species in both waterways. Stormwater contaminants degrade water quality, while a lack of deeper pool habitat limits habitat available for larger fish, and fine sediment deposits degrade habitat for smaller adult fish and juveniles.

4. SUMMARY AND RECOMMENDATIONS

Ecology sampling in Addington Brook and Riccarton Stream produced similar results to those reported previously (Boffa Miskell Limited 2014; Instream Consulting 2019), with some notable exceptions. In summary:

- Addington Brook and Riccarton Stream have degraded water quality and habitat conditions, as found in previous surveys at Sites D–F.
    - Lack of stormwater treatment affects water quality, while habitat quality is reduced by a lack of dense riparian planting and insufficient shading to prevent nuisance plant growths; overly steep banks that contribute to bank erosion and sediment deposition; shallow water depths; lack of pools and riffles; and a lack of cobbles, boulders, and wood.
- Additional sampling in Addington Brook at Sites A–C revealed a greater prevalence of fine sediments and much higher macrophyte cover than at Sites D–F.
- The invertebrate community at all sites was dominated by pollution-tolerant species, as found in previous surveys.
- The lack of the amphipod *Paracalliope fluviatilis* in Addington Brook and the dominance of oligochaete worms at two Addington Brook sites is more closely associated with elevated concentrations of stormwater contaminants than habitat conditions.
- The fish community was dominated by native species that are common in modified waterways but included At Risk inanga and longfin eel.

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[5] Five species caught during our survey, plus the historic bluegill bully record from Riccarton Stream.

- Inanga was the most abundant fish species caught. They had not previously been caught in Addington Brook, due to a difference in fishing methods.

The above points regarding water quality and habitat were incorporated into restoration recommendations for Addington Brook (Instream Consulting 2022). Council projects to improve stormwater quality treatment and enhance habitat should result in improved conditions for biological communities. However, the timescale for observing changes in the biota will vary by taxa. Diadromous fish may respond quickly, within three years of completing restoration, because they are highly mobile and can therefore respond quickly to habitat and water quality improvements. In contrast, the return of sensitive invertebrate species to Addington Brook may take decades, because they are less mobile and there is a lack of a source of colonists nearby. It is rare to address both water quality and habitat issues as part of an urban restoration project, so post-restoration monitoring will provide valuable information on the degree and timing of biological responses.

We recommend that post-restoration ecological monitoring follows, as a minimum, the same methods described here, including sampling at a similar time of year, to allow a direct comparison with the baseline data. Fish communities may respond quickly to habitat enhancement, so the first round of post-restoration monitoring should occur 2–3 years after restoration works and continue for every 2–3 years subsequently. Monitoring could continue indefinitely, to provide long term data on restoration effects. Alternatively, monitoring could cease after a review of the data indicates further changes to the biological community are unlikely.

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