Long-term Monitoring of Aquatic Invertebrates in Christchurch's Waterways: Halswell River Catchment 2011

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AQUATIC RESEARCH & SCIENCE COMMUNICATION CONSULTANTS

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REPORT

Prepared for
Christchurch City Council

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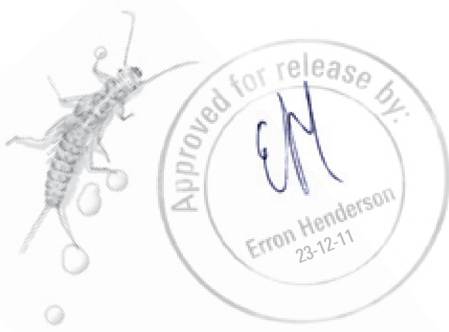

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EXECUTIVE SUMMARY

The Christchurch City Council (CCC), in conjunction with Environment Canterbury (ECan) and the Avon-Heathcote Estuary Ihutai Trust, has instigated a long-term monitoring programme for aquatic invertebrates and habitat of the City's waterways. Invertebrates are useful animals to monitor as they are a good indication of stream health and respond to catchment land use changes. EOS Ecology was commissioned by the CCC to develop and undertake an aquatic invertebrate monitoring program that incorporated the Styx, Otukaikino, Avon, Heathcote, and Halswell River catchments. It was requested by the CCC that each catchment was surveyed once every five years, with two catchments to be surveyed in the first year of the programme.

This report summarises the results of the fourth year of monitoring, where nine sites in the Halswell River catchment were surveyed during March 2011. Sites along the river mainstem as well as tributary waterways were included in the monitoring programme. The sites surveyed had slow water velocity and apart from one site, a soft sand/silt substrate. At five of the sites there was evidence of recent channel clearing (macrophyte and sediment removal) by ECan which no doubt had a profound effect on habitat and aquatic biota. The invertebrate community was moderately diverse, with a total of 46 different taxa identified from the study area and an average of 10–18 taxa found on a site basis. The most diverse groups were caddisflies with 13 taxa and two-winged flies with 12 taxa identified. However, 78% of the overall invertebrate abundance was comprised of only three taxa, the amphipod *Paracalliope fluviatilis* (31%), the freshwater snail *Potamopyrgus antipodarum* (30%) and microcrustacean ostracods (17%).

At all sites the aquatic invertebrate community was rated as being indicative of 'poor' condition by the MCI-sb/QMCI-sb biotic indices. Cleanwater taxa (made up of mayflies, stoneflies, and caddisflies) were limited to caddisflies which were in low abundance (e.g., <5%) and most caddis taxa only occurred at one or two sites. A mayfly, stonefly, and two other caddisfly taxa which were found in surveys conducted in the early 1980's were not found at any of the sites during the current study. Ranking of the nine sites based on seven biotic metrics found the highest ranking sites to be in the Knights Stream and Cases Drain tributaries. The Halswell River mainstem sites were ranked lower than all the tributary sites. Today the aquatic invertebrate fauna of the Halswell River catchment is dominated by pollution-tolerant taxa that are common throughout New Zealand's rural and peri-urban waterways. However, several invertebrate (e.g., freshwater crayfish, freshwater mussel) and fish (e.g., longfin eel, inanga, and lamprey) of conservation concern are found in the catchment, highlighting that even degraded waterways can have significant ecological values.

1 INTRODUCTION

In the Christchurch City Council's (CCC) Long-Term Council Community Plan (LTCCP; Christchurch City Council, 2006a) Christchurch residents identified the retention and restoration of biodiversity and protection of the environment as key factors important to their wellbeing. The LTCCP states that the CCC will know it is succeeding in meeting these community desires when 'our lifestyles reflect our commitment to guardianship of the natural environment in and around Christchurch', when 'biodiversity is restored, protected and enhanced', and when 'we manage our city to minimise damage to the environment' (Christchurch City Council, 2006a). Furthermore, in the recently adopted Surface Water Strategy 2009–2039 (Christchurch City Council, 2010) the CCC's vision is that "the surface water resources of Christchurch support the social, cultural, economic, and environmental well-being of residents, and are managed wisely for future generations."

Inevitably urbanisation of a catchment is detrimental to biodiversity values and the general health of waterways. As a catchment is developed it becomes more impervious to stormwater run-off, causing lower but flashier flows (Suren & Elliott, 2004). Pollutants and fine sediment from road run-off accumulate in the river sediment and the addition of buildings, bridges, culverts, and light pollution impede the dispersal and influence the behaviour of adult aquatic insects (Suren, 2000; Blakely *et al.*, 2006). These factors detrimentally affect the health of our waterways by making the river suitable for only a small subset of the aquatic invertebrates and fish usually found in our streams and rivers. With increasing residential development of the outlying areas of Christchurch City and infill housing occurring in the suburbs, much of the land surrounding our city's waterways has, or is, changing from rural to urban use. This change in land use impacts the health of the catchment's rivers.

To be successful in achieving the community's desire for biodiversity and healthy ecosystems in the face of urban expansion and its negative impacts on waterways, first requires a better understanding of the current state of our waterways. In an attempt to achieve this the CCC, in conjunction with Environment Canterbury (ECan) and the Avon-Heathcote Estuary Ihutai Trust (Batcheler *et al.*, 2006) has decided to instigate a freshwater monitoring programme that will help to determine the existing state of our waterways and monitor any change in health over time. Such monitoring is required for the CCC to successfully identify if they are making headway in achieving a number of the goals outlined in the Surface Water Strategy: 2009–2039 (Christchurch City Council, 2010), including, "improving the water quality of our surface water resources", "improving the ecosystem health of surface water resources", and "protecting and restoring Ngai Tahu values associated with surface water resources".

Furthermore the earthquakes of 4 September 2010, 22 February 2011, and 14 June 2011 caused damage to some of Christchurch's waterways through lateral spreading, inputs of liquefaction sediment, and discharges of wastewater from broken pipes. To assess the impacts of such unpredictable events on aquatic habitats and fauna it is imperative to have adequate pre-impact information against which to compare earthquake effects. Such data was used to assess the impacts of the 22 February 2011 earthquake in the Avon River catchment (see James & McMurtrie, 2011). It is thus important to have such information for all of Christchurch's waterways as a reference point should they be subjected to some major disturbance; be it natural (e.g., earthquake) or human-induced (e.g., chemical spills, dredging).

EOS Ecology was commissioned by the CCC to develop and undertake a suitable freshwater invertebrate monitoring program for the City's main waterways. This incorporated the City's five main river catchments: the Styx, Otukaikino, Avon, Heathcote, and Halswell Rivers. The Styx and Otukaikino River catchments were surveyed in March 2008 (McMurtrie & Greenwood, 2008), the Avon River catchment in March 2009 (McMurtrie, 2009), the Heathcote River catchment in March 2010 (James, 2010), and the Halswell River catchment for this current study in March 2011. This cycle of five-yearly sampling will be repeated to allow for comparisons of temporal change within each catchment as well as between-catchment comparisons. Sampling all five river systems will provide data over a range of catchment land-use types including fully urbanised (Avon River catchment), urban-rural mixture (Heathcote River catchment), rural-urban mixture (Styx River catchment), and a predominantly rural catchment (Halswell and Otukaikino River catchments).

1.1 Aim of this report

This report is designed to provide a summary of the results for the Halswell River catchment. It is not designed to provide any detailed statistical comparison between sites within the same catchment or between other previously surveyed catchments. This marks the completion of the first round of sampling for each catchment and an additional report will be produced that provides more detailed analysis of the data including catchment-wide comparisons.

1.2 Why is monitoring important?

Long-term monitoring of invertebrate communities will tell us how the health of the rivers is changing over time (e.g., is it getting better, worse, or remaining the same). In more sensitive systems such as the Otukaikino and Styx River catchments we would expect the fauna to change more rapidly in response to land use changes (e.g., rural to urban), which will give us an early warning that stream health is declining. In comparison, we would expect those rivers that are already heavily urbanised (e.g., the Avon and Heathcote) to change less over time as their invertebrate fauna may already be limited to pollution-tolerant taxa. Results from the monitoring will also be important in designing restoration and remediation efforts to minimise the impact of urban development on our rivers and potentially to determine the effects of unpredictable major disturbances (e.g., earthquakes and chemical spills). Refer to McMurtrie & Greenwood (2008) for further information on why invertebrates are important to monitor.

2 METHODS

The aim of the monitoring programme was to use the 'River Habitat and its Biota' section of Batcheler *et al*. (2006) as the basis for this monitoring programme. Batcheler *et al*. (2006) recommends sampling 'within the shallower, gravel bottom reaches of the Avon/Otakaro and Heathcote/Opawaho rivers', which are the two main rivers that drain into the Avon-Heathcote Estuary/Ihutai. However, this programme has been broadened to include the Styx, Otukaikino, and Halswell River systems, which are partly or fully within the confines of the Christchurch City boundary.

Due to CCC budgetary limitations, it was not possible to sample all five catchments at one time, thus a yearly programme was developed to sample one catchment per year, with a five-year repeat cycle for each catchment. The catchments will be surveyed in the following order: Otukaikino, Styx, Avon, Heathcote, and Halswell. This report represents the fourth year of the monitoring programme, where the Halswell River catchment has been sampled, while in previous years the Otukaikino and Styx Rivers (first year), Avon River (second year), and Heathcote River (third year) catchments were surveyed (McMurtrie & Greenwood, 2008; McMurtrie, 2009; James, 2010).

2.1 Site selection

Nine sites were selected in the mainstem and tributaries of the Halswell River (Sites 39-47 in Figure 1 and Table 1). Site numbering continues on from the previous years' monitoring of the Styx, Otukaikino, Avon, and Heathcote River catchments (McMurtrie & Greenwood, 2008; McMurtrie, 2009; James, 2010).

Tributary as well as mainstem river sites were included, as the small size of tributaries makes them more susceptible to changes in environmental conditions, such as water quality or sediment inputs. For the other catchments, sampling sites were chosen in areas of riffle habitat, or if this did not exist, in runs with a coarse substratum because these areas typically support the most diverse invertebrate communities that are also the most sensitive to change. However, such habitat is rare in the Halswell River catchment or occurs in parts of the upper catchment that only flow intermittently. Thus the majority of sites sampled had a finer sand or silt substratum. Such habitats typically support an invertebrate community already tolerant of particularly degraded conditions and are unlikely to respond to small changes in water and habitat quality; however these substratum conditions are typical of the Halswell River catchment.

TABLE 1 Locations of the Halswell River mainstem and tributary monitoring sites. Refer to Figure 1 for further information on locations.

Site no.	Site location
39	Nottingham Stream downstream of O'Halloran Drive
40	Creamery Stream downstream of Sabys Road
41	Knights Stream upstream of Trices Road/Ellesmere Road intersection
42	Knights Stream upstream of Whincops Road
43	Halswell River downstream of Early Valley Road
44	Halswell River between Rossendale Winery and Early Valley Road
45	Halswell River at Landsdowne Common
46	Halswell River at Wroots Road
47	Cases Drain upstream of Downies Road

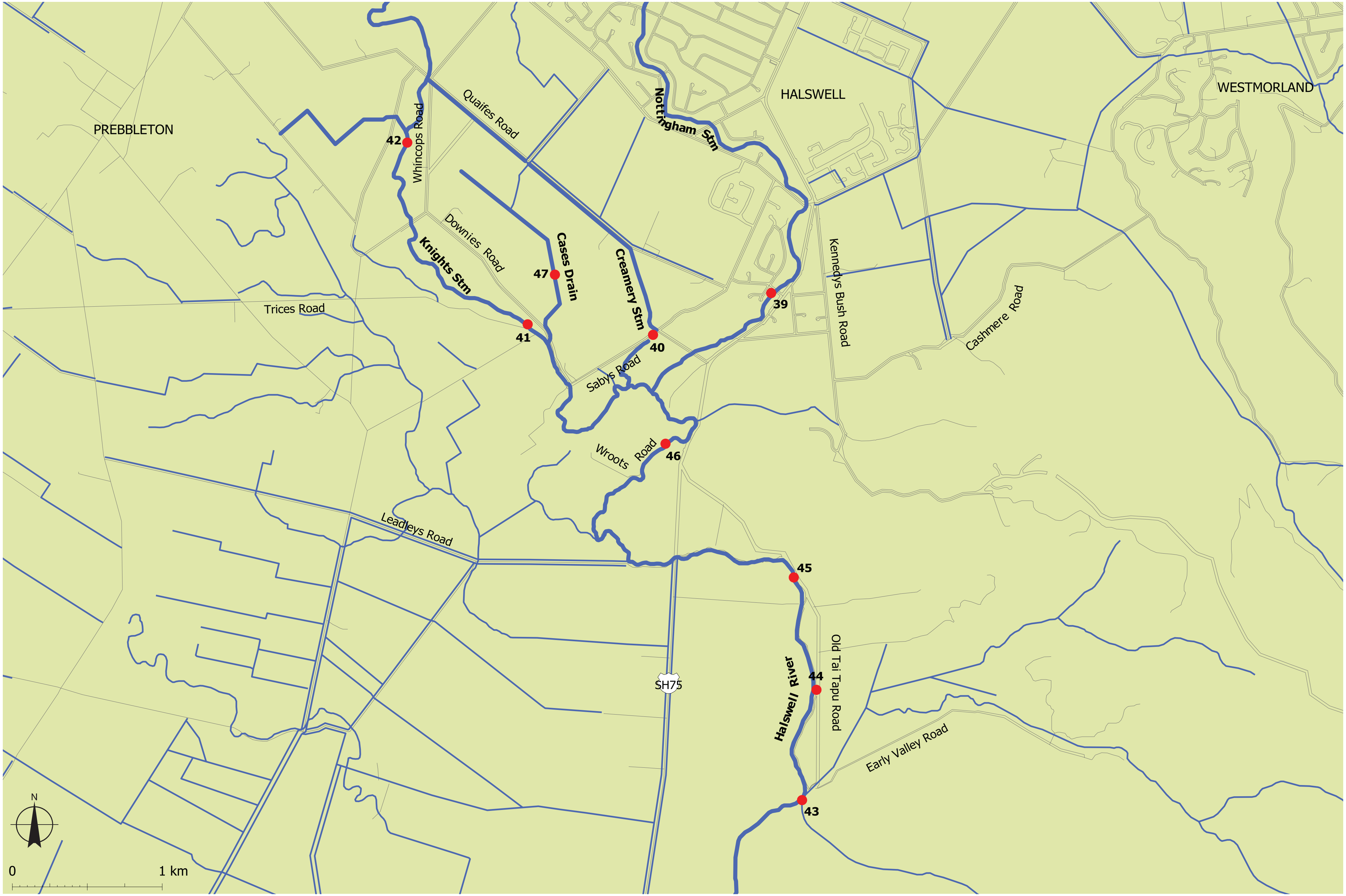


FIGURE 1 Location of the nine sites in the Halswell River catchment surveyed from 28th to 30th March, 2011. Site photographs are provided in Appendix (Section 7.1).

Initial site location was derived using local knowledge and the CCC's Christchurch River Assessment Survey (CREAS) data, with final locations modified to suit the on-site conditions. A site visit with Zoe Dewson (CCC) was carried out on 1 February 2011 before the survey to confirm site locations. The most downstream site in the Halswell River catchment was dictated by the boundary of the CCC with the Selwyn District Council.

2.2 Sampling

Following fine weather conditions, habitat and aquatic invertebrate communities were surveyed between the 28th and 30th March, 2011. At each site three equally-spaced transects were placed across the stream at 10 m intervals (i.e., at 0, 10, and 20 m) and aspects of the instream habitat and aquatic invertebrate community quantified along them. A detailed and quantitative to semi-quantitative methodology was developed to act as a suitable monitoring protocol that would enable a comparable repeat survey of habitat and invertebrate communities.

Instream habitat variables were quantified at equidistant points across each of the three transects, with the first and last measurements across the transect at the water's edge. Habitat variables measured included substrate composition, presence and type of organic material, depths (water, macrophyte, and sediment), and water velocity (Figure 2). General bank attributes, including lower and upper bank height and angles, lower bank undercut, and lower bank vegetative overhang were measured for each bank at each transect. Bank material and stability were also assessed.

The riparian zone condition was assessed within a 5 m band along the 20 m site on either side of the bank. The cover of 15 different vegetation types were estimated on a ranking scale of present (<10%), common (10–50%), and abundant (>50%). The vegetation was assessed three dimensionally so included ground, shrub, and canopy cover levels.

Aquatic benthic invertebrates were collected at each transect by disturbing the substrate across an approximate 1.5 m width and within a 0.3 m band immediately upstream of a conventional kicknet (ca. 500 µm mesh size; Figure 2). The full range of habitat types were surveyed across each transect, including mid-channel and margin areas, inorganic substrate (e.g., the streambed), and macrophytes (aquatic plants). Each invertebrate sample was kept in a separate container, preserved in 60% isopropyl alcohol, and taken to the laboratory for identification. The contents of each sample were passed through a series of nested sieves (2 mm, 1 mm, and 500 µm) and placed in a Bogorov sorting tray (Winterbourn *et al.*, 2006). All invertebrates were counted and identified to the lowest practical level using a binocular microscope and several identification keys. Sub-sampling was utilised for particularly large samples and the unsorted fraction scanned for taxa not already identified.

FIGURE 2 Measuring water velocity at Site 44 (left) and collecting an invertebrate sample at Site 43 (right) in the Halswell River.

2.3 Data analysis

The data describing the substrate composition was simplified by creating a substrate index, such that:

Substrate index = [(0.7 x % boulders) + (0.6 x % large cobbles) + (0.5 x % small cobbles) + (0.4 x % pebbles) + (0.3 x % gravels) + (0.2 x % sand) + (0.1 x % silt) + (0.1 x % concrete/bedrock)] / 10

Where derived values for the substrate index range from 1 (i.e., a substrate of 100% silt) to 7 (i.e., a substrate of 100% boulder); the larger the index, the coarser the overall substrate. In general, coarser substrate (up to cobbles) represents better instream habitat than finer substrate. The same low coefficients for silt and concrete/bedrock reflect their uniform nature and lack of spatial heterogeneity, and in the case of silt, instability during high flow.

Invertebrate data were summarised by taxa richness, abundance of common taxa, and Non-metric Multidimesional Scaling (NMS) axis scores. Biotic indices calculated were the number of Ephemeroptera-Plecoptera-Trichoptera taxa (EPT richness), % EPT, the soft-bottomed Macroinvertebrate Community Index (MCI-sb), Urban Community Index (UCI), and their quantitative equivalents (QMCI-sb and QUCI, respectively). The paragraphs below provide brief clarification of these metrics. For a more detailed description see McMurtrie & Greenwood (2008).

Taxa richness can be used as an indication of stream health or habitat type, where sites with greater taxa richness are usually healthier and/or have a more diverse habitat. NMS is an ordination of data that is often used to examine how communities composed of many different taxa differ between sites. It can graphically describe communities by representing each site as a point (an ordination score) on an x–y plot. The location of each point/site reflects its community composition, as well as its similarity to communities in other sites/points.

EPT refers to three Orders of invertebrates that are generally regarded as 'cleanwater' taxa. These Orders are Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies); forming the acronym EPT. These taxa are relatively intolerant of organic enrichment or other pollutants and habitat degradation. EPT richness and % EPT scores can provide a good indication as to the health of a particular site. The exception to this are the hydroptilid caddisflies (e.g., Trichoptera: Hydroptilidae: *Oxyethira* spp. and *Paroxyethira* spp.), which are algal piercers and often found in high numbers in nutrient enriched waters with high algal content (i.e., many degraded waterways). For this reason EPT metrics are presented without these taxa.

The MCI/QMCI score can be used to determine the level of organic enrichment for stony-bottomed waterways in New Zealand (Stark, 1985). It calculates an overall score for each sample, which is based on pollution-tolerance values for each invertebrate taxon that range from 1 (very pollution tolerant) to 10 (pollution-sensitive). The original MCI was intended for use in waterways with a stony substratum (and is now referred to as MCI-hb). Recently a variant for use in streams with a sand/silt/mud bottom (soft-bottomed) was developed by (Stark & Maxted, 2007) and referred to as the MCI-sb. Eight of the nine Halswell River catchment sites had a soft sand or silt substratum thus MCI-sb was the appropriate variant to use. The other site had a coarser substratum but the difference between the two MCI variants for this site was minimal and would not alter the interpretation of data thus for consistency MCI-sb was used at all sites.

The UCI/QUCI score can be used to determine the health of urban and peri-urban streams by combining tolerance values for invertebrates with presence/absence or abundance invertebrate data (Suren *et al.*, 1998). This biotic index is indicative of habitat relationships, and to some degree incorporates urban impacts.

3 RESULTS

3.1 Habitat

The majority of the Halswell River catchment is of rural land use (stock, horticulture, and lifestyle blocks) with urban areas in the upper Nottingham Stream catchment (Table 2). Apart from some wood-lined channel in the urban parts of Nottingham Stream (Site 39), the banks were comprised of natural earth. With the exception of some plantings of native sedges, shrubs, and trees at a few sites (Sites 39, 40, and 41), the riparian vegetation cover was typically comprised of a grass/herb mix and bare earth. Canopy shade cover was greatest at those sites that had undergone native plantings (Sites 39, 40, and 41), although exotic trees provided some canopy cover at Sites 42 and 44 (Table 2). Canopy cover was generally greater for tributary streams where the smaller size of the waterway allowed for greater cover by trees. Substrate embeddedness was high at all sites which is a reflection of the substratum being mostly in the silt to sand range (Table 2; Figure 3). Only Site 39 had an appreciably coarser substratum being in the gravel to pebble range and not surprisingly this site also had the least fine sediment depth of only a few centimetres (Figure 3). Of the other sites, fine sediment depths were greater in the mainstem sites than in the tributary sites and was greatest at Site 43 where it was almost half a metre deep (Figure 3).

Several aquatic macrophyte genera were present however all had low coverage, as did the other organic material categories (e.g., detritus, woody debris) which was partially a result of the channel clearing (macrophyte and sediment removal) excavations that had occurred at five of the nine sites shortly before they were surveyed (Table 2). Macrophyte depths were minimal at all sites with the maximum average depth (Site 41) being only a few centimetres (Figure 3). They did tend to be greater in the tributary sites rather than the mainstem sites, probably due to the channel clearing that occurred in the mainstem sites. Prior to stream cleaning it would be expected the deeper mainstem sites would have had the greater macrophyte depths. Instream habitat was comprised of only runs at all but Site 39 which had some riffle and pool habitat present (Table 2). The presence of this riffle habitat at Site 39 resulted in this site having the shallowest average water depth of all the sites (Figure 3). Wetted channel widths were greater and more uniform at the mainstem sites (between 4.5 and 5 metres) than the tributaries (between 1.5 and 3.4 metres) (Figure 3). Average water velocities were variable but not particularly high with only three sites having velocities greater than 0.2 m/s (Sites 40, 43, and 45); the highest being Site 43 at 0.33 m/s (Figure 3).

TABLE 2 **Habitat attributes of nine sites in the Halswell River catchment sampled between 28th and 30th March, 2011. For site locations refer to Figure 1 and Table 1.**

Site	Tributaries					Mainstem			
	42 Knights Stream	41 Knights Stream	47 Cases Drain	40 Creamery Stream	39 Nottingham Stream	46 Halswell River	45 Halswell River	44 Halswell River	43 Halswell River
Surrounding land use	100% lifestyle block	50% unfenced rural (horticulture); 50% fenced rural (stock)	100% fenced rural (stock)	50% residential ; 50% fenced rural (stock)	100% residential	100% fenced rural (stock)	50% unfenced rural (horticulture); 50% lifestyle block	100% fenced rural (stock)	100% fenced rural (stock)
Bank material composition	Earth	Earth	Earth	Earth	Box drain (wooden)	Earth	Earth	Earth	Earth
Riparian vegetation	Mostly a mix of unvegetated and grass/herb mix. Some ferns. Canopy of exotic trees.	Mostly planted sedges with native canopy. Some unvegetated areas.	Mostly a mix of unvegetated and grass/herb mix.	Mostly unvegetated. Some moss, grasses, herbs. Planted native shrub and tree canopy.	Mostly planted sedges with native canopy. Some exotic grass and garden plants.	Mostly grass/herb mix.	Mostly grass/herb mix. Some shrubs and trees.	Mostly grass/herb mix. Some exotic shrubs and trees.	Mostly a mix of unvegetated and grass/herb mix.
Canopy cover	>75%	5–25%	<5%	>75%	>75%	<5%	<5%	5–25%	<5%
Substrate embeddedness	>75%	>75%	>75%	50–75%	50–75%	>75%	>75%	>75%	>75%
Habitat type (riffle:pool:run)	0:0:100	0:0:100	0:0:100	0:0:100	10:20:70	0:0:100	0:0:100	0:0:100	0:0:100
Aquatic vegetation and organic material cover	Algals mats: 1% Moss/liverworts: 1% *Ranunculus*: 1% *Mimulus*: 1% Terrestrial roots/ vegetation: 10% Detritus (leaf litter): 10% Woody debris: 1%	Algals mats: 5% *Nitella*: 1% *Ranunculus*: 1% *Rorippa*: 10% *Mimulus*: 10% *Elodea*: 5% *Lemna*: 1% Terrestrial roots/ vegetation: 5% Detritus (leaf litter): 1% Woody debris: 1%	*Potamogeton crispus*: 5% *Myriophyllum*: 1% *Ranunculus*: 1% *Mimulus*: 1% *Rorippa*: 1% *Elodea*: 1% *Lemna*: 1% Terrestrial roots/ vegetation: 1% Detritus (leaf litter): 1% Woody debris: 1%	Algals mats: 20% Moss/liverworts: 1% *Potamogeton crispus*: 5% *Rorippa*: 1% *Lemna*: 1% Terrestrial roots/ vegetation: 5% Detritus (leaf litter): 1% Woody debris: 1%	Algals mats: 20% Moss/liverworts: 15% *Glyceria*: 1% *Rorippa*: 1% Terrestrial roots/ vegetation: 10% Detritus (leaf litter): 10%	*Ranunculus*: 1% *Mimulus*: 1% *Rorippa*: 3% *Elodea*: 10% *Lemna*: 1% Terrestrial roots/ vegetation: 3% Detritus (leaf litter): 1% Woody debris: 1%	*Ranunculus*: 2% *Glyceria*: 1% *Rorippa*: 2% *Lemna*: 1%	*Nitella*: 1% *Ranunculus*: 1% *Glyceria*: 1% *Rorippa*: 5% *Elodea*: 5% Terrestrial roots/ vegetation: 1% Detritus (leaf litter): 1% Woody debris: 1%	*Ranunculus*: 1% *Glyceria*: 1% *Elodea*: 1% Terrestrial roots/ vegetation: 1% Detritus (leaf litter): 1% Woody debris: 1%
Notes	Approx. 60 cm long eel observed.		Recent excavation of channel.		Small bullies observed.	Recent excavation of channel.	Recent excavation of channel. Freshwater mussel shells in spoil left on bank. Small bully and lamprey captured.	Recent excavation of channel. Freshwater mussel shells in spoil left on bank. Small upland bully and small eel captured.	Recent excavation of channel. Freshwater mussel shells in spoil left on bank. Small bullies in shallows.

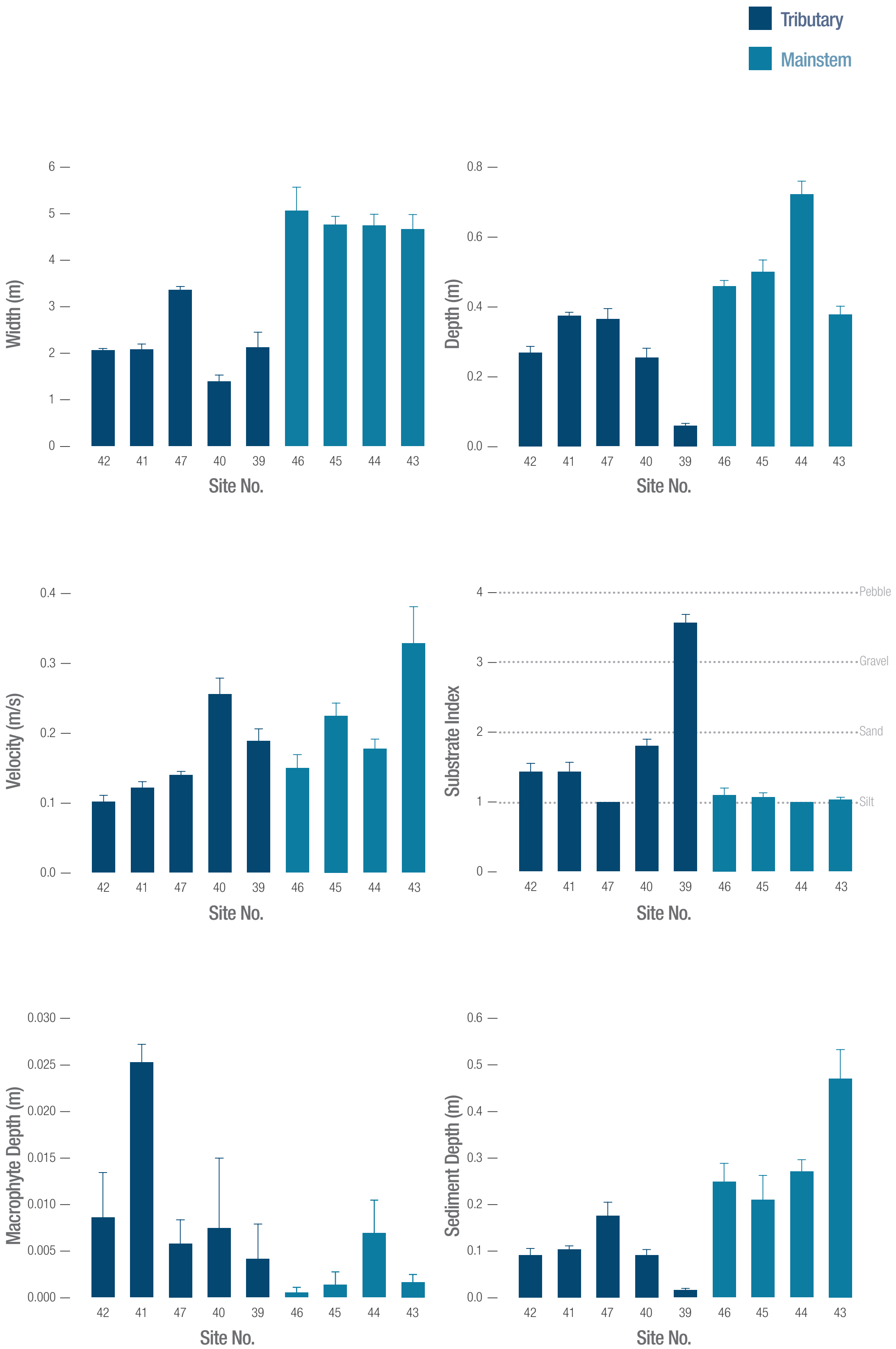


FIGURE 3 Average (+/- 1 SE) aquatic habitat conditions at nine sites in the Halswell River catchment sampled between 28th and 30th March, 2011. For site locations refer to Figure 1 and Table 1.

3.2 Invertebrates

3.2.1 Overview

A total of 46 invertebrate taxa were recorded from the Halswell River catchment. The most diverse groups were the caddisflies (Trichoptera: 13 taxa), followed by two-winged flies (Diptera: 12 taxa), molluscs (Mollusca: 4 taxa), and crustaceans (Crustacea: 4 taxa). Damselflies (Odonata) and flatworms (Platyhelminthes) were each represented by two taxa while mites (Arachnida: Acari), hydra (Cnidaria: Hydrozoa: Hydridae), beetles (Coleoptera), springtails (Hexapoda: Collembola), water boatmen (Hemiptera), leaches (Hirudinea), moths (Lepidoptera), nematodes (Nematoda), and worms (Oligochaeta) were each represented by one taxon.

Overall the community was dominated by the amphipod *Paracalliope fluviatilis* (31%), the freshwater snail *Potamopyrgus antipodarum* (30%) and microcrustacean ostracods (17%). Other relatively abundant taxa included oligochaete worms (7.5%), and three non-biting midge larvae taxa (Orthocladiinae: 2.4%, *Chironomus* sp. A: 2.1%, and Chironominae: 2%). The above mentioned seven taxa accounted for 92.5% of all taxa in samples from the Halswell River catchment. The most widespread taxa (e.g., found in 100% of samples) were the amphipod *P. fluviatilis*, the freshwater snail *P. antipodarum* and microcrustacean ostracods. Other widespread taxa included oligochaete worms and Orthocladiinae midges (found in 26 and 23 of 27 samples respectively; Figure 4).

The cleanwater EPT group was represented by caddisflies (order Trichoptera) only, with both the mayfly (Ephemeroptera) and stonefly (Plecoptera) orders absent. Caddisflies accounted for only 1.5% of total invertebrate abundance, but had a good diversity with 13 different taxa recorded. Of these 13 taxa, only *Triplectides dolichos/obsoletus* (0.65%) had an overall relative abundance greater than 0.5%. *T. dolichos/obsoletus* was also the most widespread caddisfly, being found in 20 of the 27 samples (74% of samples).

3.2.2 Biotic indices

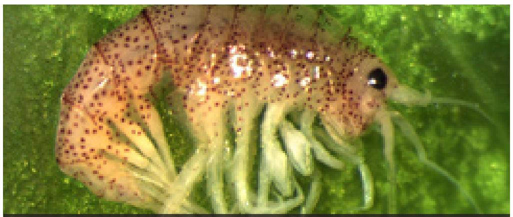
The NMS ordination indicated some separation of invertebrate communities from mainstem river vs. tributary waterways along Axis 1, although there was considerable overlap (Figure 5). Along Axis 1, two mainstem sites (Sites 44 and 46) were distinctly separated from all the other sites and associated with ostracod and cladoceran microcrustaceans, *Chironomus* sp. A midge larvae, and increased channel width and water depth. Along Axis 1 all the other sites (but especially tributary Sites 39, 40 and 47) were associated with the snail *P. antipodarum*, the amphipod *P. fluviatilis,* increased water velocities and a coarser substratum (Figure 5).

Along Axis 2 some site replicate samples were clumped (e.g., Sites 40, 41, 42, and 45) while others were widely spread (e.g., Sites 39 and 47). Samples towards the upper part of Axis 2 were characterised by *Corynoneura scutellata* and *Paradixa* sp. midge larvae, copepod microcrustaceans, *Hydra* anemones, the amphipod *P. fluviatilis* and increased macrophyte depth (Figure 5), while those towards the lower part were associated with Chironominae midge larvae, the snail *P. antipodarum* and Sphaeriidae pea clams (Figure 5).

The overall best site in terms of ranking by seven biotic indices was the most downstream site on Knights Stream (Site 41). This site ranked 1st, 2nd, or 3rd for six of the seven metrics calculated (Table 3). The second-highest ranked site was the Cases Drain site (Site 47) which is geographically closest to Site 41; the highest ranking site (Figure 1), while the other Knights Stream site (Site 42) was ranked third. The four Halswell River mainstem sites had the lowest rankings (Table 3). Site 46 in the Halswell River was ranked the worst site overall, and was the only site to have no EPT taxa.

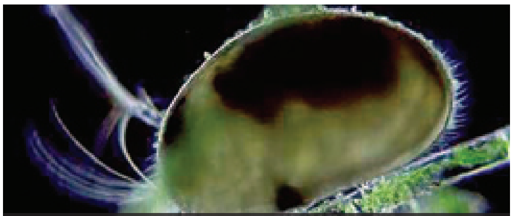
The abundance of EPT taxa was greater in the tributaries than in the Halswell River mainstem (Table 4). Of the four most sensitive (in terms of MCI score) EPT taxa (*Oeconesus* sp., *Plectrocnemia maclachlani*,

Pollution-tolerant Taxa



Paracalliope fluviatilis (31%, widespread)

Potamopyrgus antipodarum (30%, widespread)

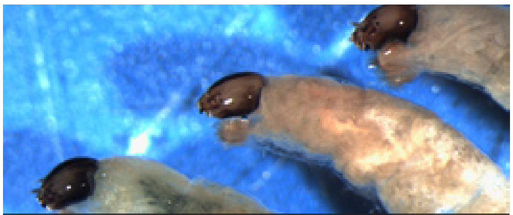


Ostracod (17%, widespread)

S. Moore

Oligochaete worm (7.5%, widespread)

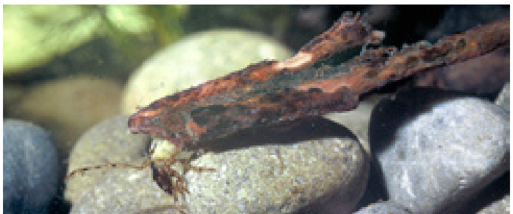
Orthocladiinae midges (2.4%, widespread)



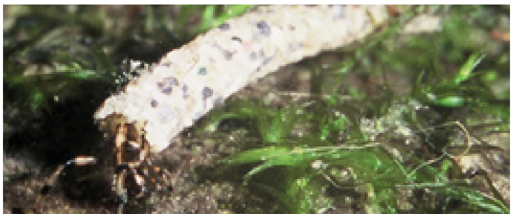
Chironomus sp. A (2.1%)

Chironominae (2%)

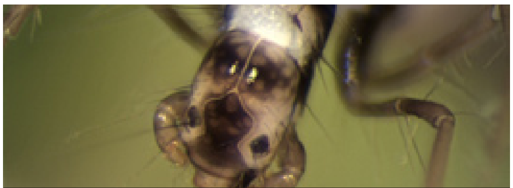
Cleanwater (EPT) Taxa



Triplectides dolichos/obsoletus (0.65%, 20 samples)



Hudsonema amabile (0.2%, seven samples)



Hydroptilidae (early instar larvae of *Oxyethira albiceps* and *Paroxyethira hendersoni;* 0.1%, seven samples)

FIGURE 4 Photographs of the most abundant (% indicated) aquatic invertebrates in the Halswell River catchment from nine sites sampled between 28th and 30th March, 2011. Those designated as “widespread” were found in at least 23 of the 27 samples. Also shown are the EPT taxa that were found in at least seven samples. Unless indicated, photos are by EOS Ecology.

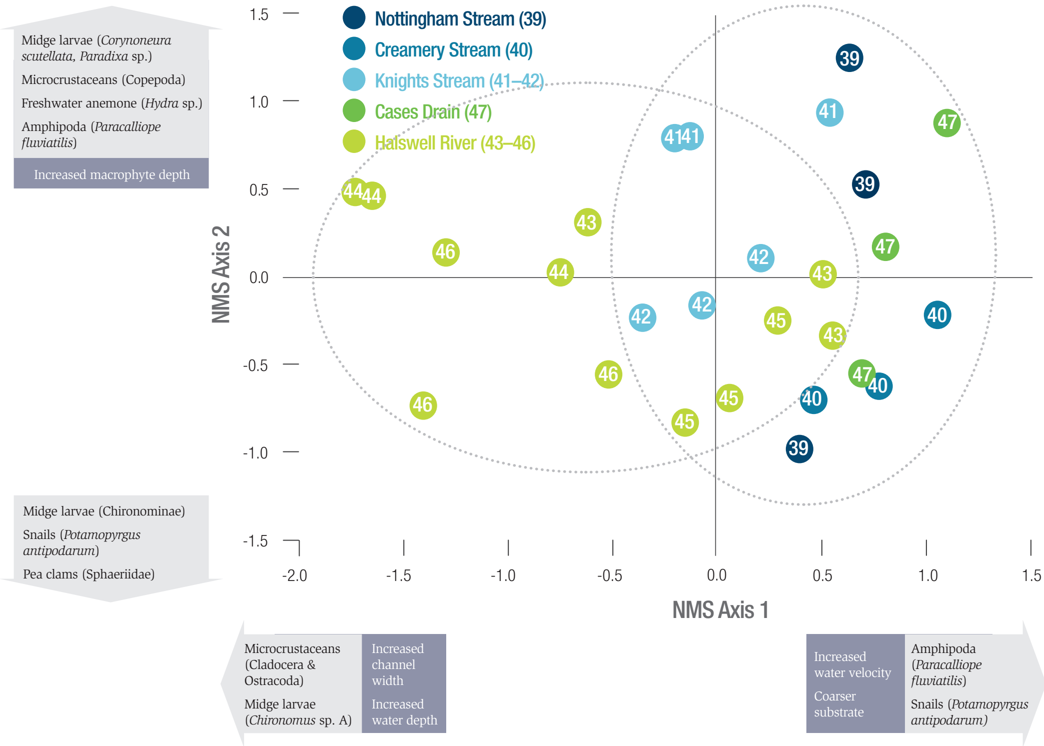


FIGURE 5 Non-metric multidimensional scaling (NMS) ordination of the aquatic invertebrate community from nine sites surveyed in the Halswell River catchment between the 28th and 30th March, 2011. Each site is represented by three replicate samples. The ellipses encompass the mainstem and tributary site groups. Invertebrate taxa and habitat variables correlated with the axes are shown. For site locations see Figure 1.

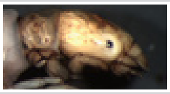
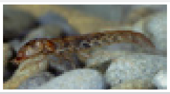
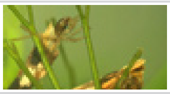
TABLE 3 An overall site ranking (1 (best) – 9 (worst)) of each of the nine sites surveyed in the Halswell River catchment between 28th and 30th March, 2011; with site rank based on the summation of ranks for each biotic index. The possible final ranking score is from 7 (ranking 1 on all variables) to 63 (ranking 9 on all variables). The sites have also been divided into comparative groupings (best, medium, and worst) according to their final score.

Waterway	Site	Biotic Indices							Sum	Final Rank	Grouping
		TAXA	EPT	% EPT	MCI-sb	QMCI-sb	UCI	QUCI			
Knights Stream	41	3	2	1	1	1	5	3	16	1	Best
Cases Drain	47	5	4	4	3	2	3	1	22	2	Best
Knights Stream	42	6	2	2	2	5	1	6	24	3	Best
Creamery Stream	40	1	1	3	7	6	4	4	26	4	Medium
Nottingham Stream	39	2	7	8	6	3	8	2	36	5	Medium
Halswell River	43	8	6	5	9	4	2	5	39	6	Medium
Halswell River	45	9	4	6	4	8	9	7	47	7	Worst
Halswell River	44	6	7	7	5	9	7	9	50	8=	Worst
Halswell River	46	3	9	9	8	7	6	8	50	8=	Worst

Psilochorema sp., and *Polyplectropus* sp.) three were only present at tributary sites (Table 4). Most EPT taxa were only found at one or two sites and only *Hydrobiosis parumbripennis* and the pollution-tolerant *Paroxyethira hendersoni* were found exclusively at mainstem sites (Table 4).

All sites were in the “poor” category in terms of MCI-sb and QMCI-sb scores which are based on tolerance to organic pollution (Figure 6). However, three tributary sites (Sites 39, 41, and 47) were near the “fair” category of the QMCI-sb. Taxa richness was quite variable but tended to be higher among the tributary sites compared to the mainstem (Figure 6). Likewise, EPT taxa richness and percent relative abundance tended to be higher at tributary sites, with the exception of Sites 39 and 47 which were had lower values similar to the mainstem sites (Figure 6). QUCI had negative values at three of the four mainstem sites while positive values were observed at four of the five tributary sites, indicating possibly better habitat in the tributaries (Figure 6).

TABLE 4 The presence of EPT taxa in the mainstem river and tributary waterways of the Halswell River catchment, as indicated by an X from a survey of nine sites between 28th and 30th March, 2011. The sites at which they were found are shown in parentheses. The MCI values indicate the tolerance of the taxa to organic pollution (10 = highly pollution sensitive, 1 = pollution tolerant; (Stark, 1985)). A stream with good water and habitat quality has more pollution sensitive-taxa (and thus higher MCI scores). MCI values are from Stark & Maxted (2007). Unless indicated photos are © Shelley McMurtrie.

EPT taxa (caddisflies only)		MCI Value	Mainstem	Tributaries
Hudsonema amabile		6		X (All sites)
Hudsonema alienum		6	X (Site 45)	X (Site 41)
Hydrobiosis parumbripennis		5	X (Site 43)	
Hydroptilidae (early instar *Oxyethira albiceps* and *Paroxyethira hendersoni*)		2	X (Sites 43, 44, & 46)	X (Sites 40 & 41)
Oecetis sp.		6	X (Site 45)	X (Site 40)
Oeconesus sp.		9		X (Sites 41 & 42)
Oxyethira albiceps		2		X (Site 39)
Paroxyethira hendersoni		2	X (Site 46)	
Plectrocnemia maclachlani		8		X (Site 41)
Psilochorema sp.		8		X (Site 42)
Polyplectropus sp.		8	X (Site 44)	X (Sites 41 & 47)
Triplectides cephalotes		5		X (Site 40)
Triplectides dolichos/obsoletus		5	X (Sites 43, 44, & 45)	X (All sites)
Total EPT taxa			7	11

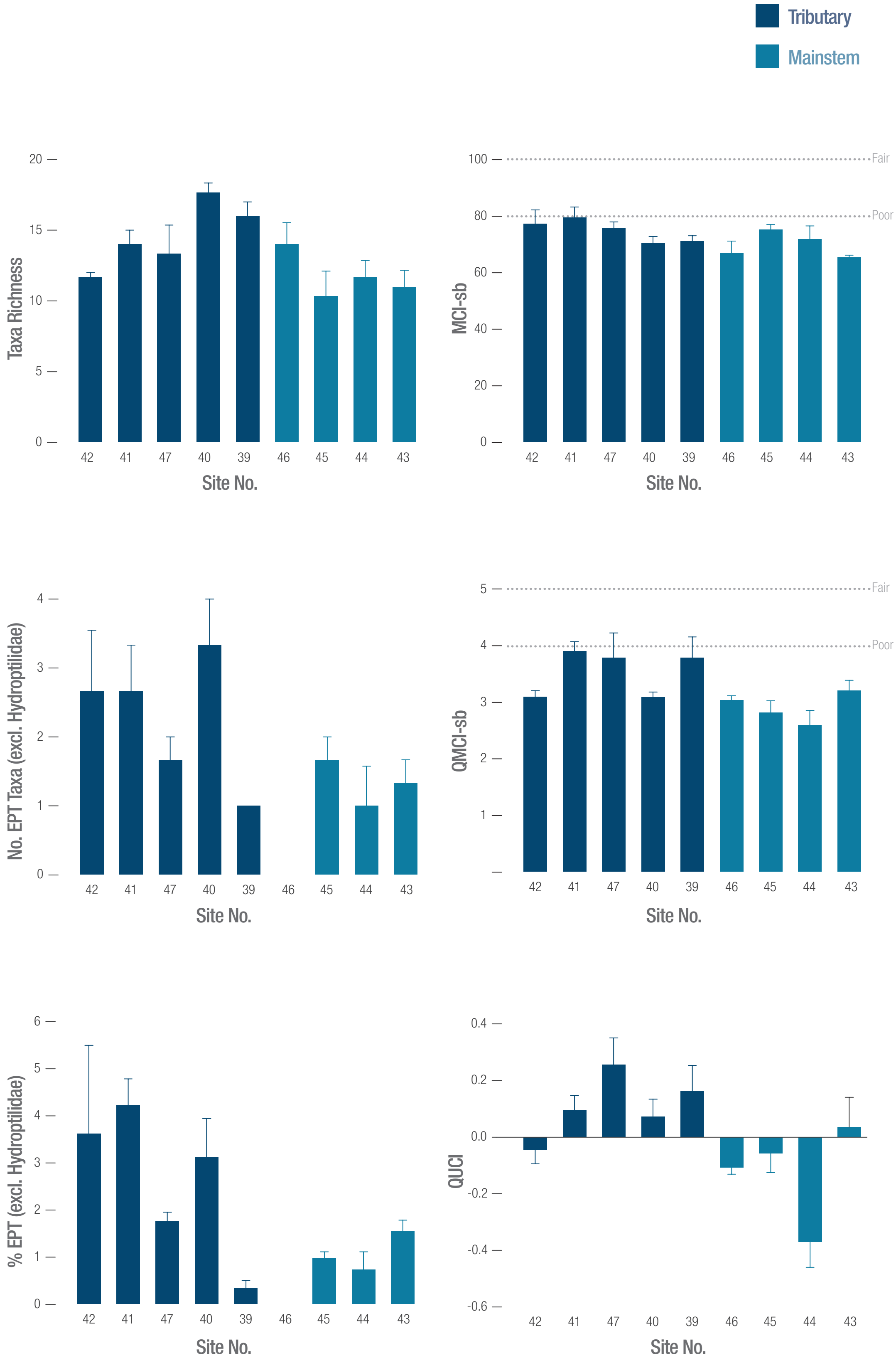
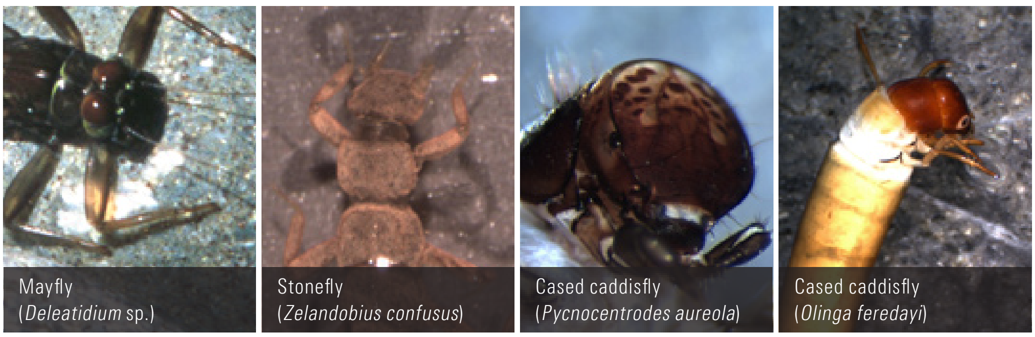


FIGURE 6 Average (+/- 1 SE) biotic indices of invertebrate community health at the nine sites surveyed within the Halswell River catchment between the 28th and 30th March 2011. The dotted lines on the MCI-sb and QMCI-sb graphs indicate the probable level of organic pollution (Stark & Maxted, 2007). Poor conditions are indicated by scores of less than 80 for the MCI-sb and less than 4 for the QMCI-sb.

4 DISCUSSION

Overall health as categorised by the MCI-sb and QMCI-sb scores indicated that all sites in the Halswell River catchment were in ‘poor’ condition. Similarly, all sites in the Heathcote River catchment were in ‘poor’ condition while the Avon River had sites rated as either ‘poor’ or ‘fair’ (McMurtrie, 2009; James, 2010). In contrast, in the rural Otukaikino catchment sites were mostly rated as being in ‘fair’ or ‘good’ condition (McMurtrie & Greenwood, 2008). The invertebrate community of the Halswell River catchment was dominated by taxa typical of those found in lowland soft-bottomed rivers impacted by rural and urban land use with the amphipod *P. fluviatilis,* the freshwater snail *P. antipodarum,* and microcrustacean ostracods accounting for 78% of all invertebrates captured. These same three taxa were also found to account for 80% of the invertebrate fauna in a 2003–2004 catchment-wide survey of the Halswell River within the CCC boundary (EOS Ecology *et al.*, 2005). Lowland springfed waterways have been subjected to a range of pressures ever since the conversion of natural land cover to productive agricultural land; including increased nutrient and sediment inputs, reduced shade and woody debris inputs, and altered hydrological regimes (Quinn, 2000). Many lowland waterways, including much of the Halswell River catchment, have had their channels widened and deepened to facilitate land drainage to transform wetland to productive farmland. Much of the Haswell River catchment is depicted in the CCC’s ‘Black Maps’ in 1856 as raupo swamp/wetlands (Christchurch City Council, 2006b). Parts of the Halswell River and some tributaries are still regularly cleared of sediment and macrophytes by ECan to reduce the potential for flooding, an activity which no doubt has negative impacts on the aquatic flora and fauna. Indeed, the current survey occurred not long after such channel ‘cleaning’ in Cases Drain (Site 47) and all four Halswell River mainstem sites and freshwater mussel shells (*Hydridella menziesi*) were observed in the spoil. This recent cleaning may be partially responsible for the four mainstem sites having the lowest ecological condition rankings.

Cleanwater EPT taxa in the Halswell River catchment were limited to caddisfly taxa. No mayflies or stoneflies were found although mayflies, a stonefly, and some other caddis species were present in the Halswell River catchment in the past. The earliest known detailed aquatic invertebrate surveys of the Halswell River catchment were undertaken in the early 1980’s by Dr. J. Robb of the Christchurch Drainage Board (Robb, 1981). He found four EPT taxa that have now apparently disappeared from the catchment; the mayfly *Deleatidium* sp., stonefly *Zelandobius confusus* (both in Knights Stream and Halswell River), and the cased-caddisflies *Pycnocentrodes aureola* (Halswell River mainstem only) and *Olinga feredayi* (Knights Stream only) (Figure 7). These taxa were absent from other recent surveys such as the 2003–2004 survey by EOS Ecology *et al.* (2005). This indicates that ongoing degradation of the Halswell River catchment has occurred since the 1980’s leading to the extirpation of these more sensitive species.



Mayfly (*Deleatidium* sp.) | Stonefly (*Zelandobius confusus*) | Cased caddisfly (*Pycnocentrodes aureola*) | Cased caddisfly (*Olinga feredayi*)

FIGURE 7 EPT taxa that were found in the Halswell River catchment in the 1980s but have since disappeared (absent in the current survey of nine sites between the 28th and 30th March, 2011).

All of the EPT taxa that have disappeared since the 1980's prefer a stony substratum, indicating the mostly silt and sand streambed observed in the present study is unsuitable for them. The disappearance of these EPT taxa, which all have a winged adult phase, may also be related to riparian habitat effects; such as a lack of continuously vegetated banks, and presence of culverts and light pollution, all which act to fragment habitat and confuse the adults of some species (Blakely *et al.*, 2006; Horvath *et al.*, 2009). The EPT taxa still found in the catchment are also mainly found throughout urban and peri-urban Christchurch, and so are obviously tolerant to some level of habitat degradation. All these taxa occurred in very low numbers and mostly at only one or two sites, meaning their absence at a particular site could be attributed to the small chance of encountering such rare taxa during sampling. Even the Hydroptilid species (*O. albiceps* and *P. hendersoni*) which are algal-piercers and often abundant in nutrient-enriched, unshaded waterways were rare in the Halswell River catchment. The channel clearing (macrophyte and sediment removal) that had occurred at some sites may have been partially responsible for this as it would remove both individuals and habitat. Studies have shown the mechanical removal of macrophytes can remove significant numbers of associated aquatic invertebrates (e.g., Engel, 1990; Dawson *et al.*, 1991; Aldridge, 2000; and Young *et al.*, 2004).

Community health seemed to be related to waterway type (tributary and mainstem), with the four mainstem sites being ranked as the worst sites. The best site was the most downstream site on Knights Stream (Site 41; Figure 8). This site had the highest MCI-sb, QMCI-sb, and % EPT scores and the second-highest EPT taxa score. The worst ranking was shared by two Halswell River mainstem sites (Sites 44 and 46; Figure 8). Site 46, which was the most upstream of the mainstem sites, lacked any EPT taxa and had the second lowest QUCI and MCI-sb scores. Site 44, which was the second most downstream mainstem site, had the lowest QUCI and QMCI-sb scores. The locations of these best and worst sites indicate there is no strong upstream – downstream gradient of habitat quality (e.g., worst sites were not the furthest downstream and best site was not the most upstream in the catchment). It is likely the habitat quality and therefore invertebrate assemblage present at any one site is strongly influenced by the regularity and methods of channel clearing. Of particular concern was the presence of freshwater mussel shells in drain clearing spoil alongside three of the mainstem sites. It must be noted that while sites were ranked from best to worst the differences in biotic metrics were relatively minor and no one site was particularly unique in terms of the invertebrate community present or the quality of habitat.

FIGURE 8 Of the nine Halwell River catchment sites surveyed between the 28th and 30th March, 2011 the best site was on Knights Stream (Site 41; left) while the two worst (worst-equal) sites were on the Halswell River mainstem (Sites 44 and 46; centre and right).

Overall, of the major Christchurch catchments sampled over the past four years (Otukaikino, Styx, Avon, Heathcote, and Halswell) the Halswell River catchment is the most degraded in terms of the aquatic macroinvertebrate community present, closely followed by the Heathcote River catchment (James, 2010) and then the Avon River catchment (McMurtrie, 2009). This is not to say that there are not some parts of the Halswell River catchment that are of high ecological value. Previous work has indicated the presence of some invertebrate and fish species of conservation concern in parts of the catchment (EOS Ecology *et al.*, 2005) (Figure 9). Freshwater crayfish (*Paranephrops zealandicus*) have been found in the Quaifes Rd drains which are upstream of the Creamery Stream site (Site 40). Freshwater mussels (*Hyridella menziesi*) are present in the Halswell River mainstem (as evidenced by freshwater mussel shells in drain clearing spoil at three sites), and longfin eel (*Anguilla dieffenbachii*), inanga (*Galaxias maculatus*), and lamprey (*Geotria australis*) have been found at various sites through the catchment (EOS Ecology *et al.*, 2005).

FIGURE 9 The species of conservation concern present in the Halswell River catchment. The conservation status for freshwater crayfish and mussel (from Hitchmough *et al.*, 2007) and longfin eel, inanga, and lamprey (from Allibone *et al.*, 2010) are shown.

5 ACKNOWLEDGEMENTS

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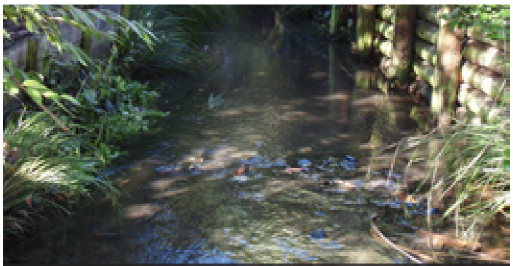
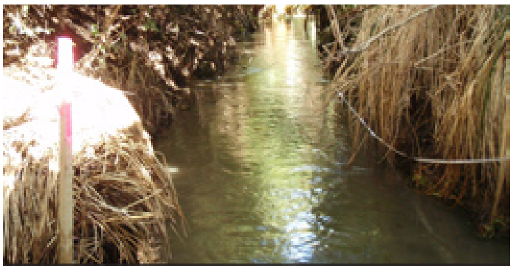
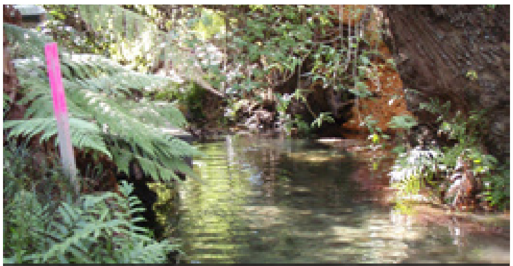
7 APPENDICES

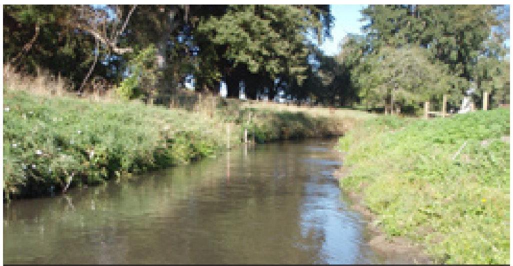
7.1 Appendix I: Site photographs


SITE 39 Nottingham Stream downstream of O'Halloran Drive (looking downstream from top of site)


SITE 40 Creamery Stream downstream of Sabys Road (looking downstream from top of site

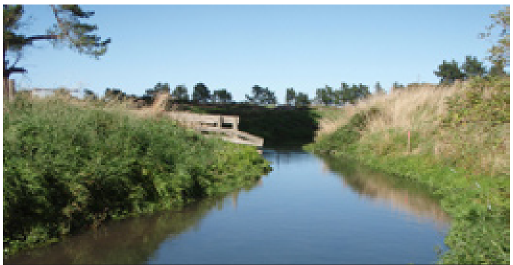

SITE 41 Knights Stream upstream of Trices Road/Ellesmere Road intersection (looking upstream from bottom of site)


SITE 42 Knights Stream upstream of Whincops Road (looking downstream from top of site)


SITE 43 Halswell River downstream of Early Valley Road (looking downstream from top of site)


SITE 44 Halswell River between Rossendale Winery and Early Valley Road (looking downstream from top of site)


SITE 45 Halswell River at Landsdowne Common (looking downstream from top of site)


SITE 46 Halswell River at Wroots Road (looking downstream from top of site)


SITE 47 Cases Drain upstream of Downies Road (looking downstream from top of site)

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