NIWA
Taihoro Nukurangi

Ecological assessment of 24 watercourse sites on the Wairau Plains

Prepared for Marlborough District Council

July 2016

Prepared by:
Mary de Winton
Josh Smith
Brian Smith
Rohan Wells
Kathryn Reeve
Ralph Dickson

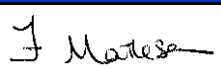
For any information regarding this report please contact:

Mary de Winton
Group Manager
Aquatic Plants
+64-7-856 1797
mary.dewinton@niwa.co.nz

National Institute of Water & Atmospheric Research Ltd
PO Box 11115
Hamilton 3251

Phone +64 7 856 7026

NIWA CLIENT REPORT No: HAM2016-058
Report date: July 2016
NIWA Project: MDC15203

Quality Assurance Statement		
	Reviewed by:	Fleur Matheson
	Formatting checked by:	Alison Bartley
	Approved for release by:	David Roper

Contents

Tables

Figures

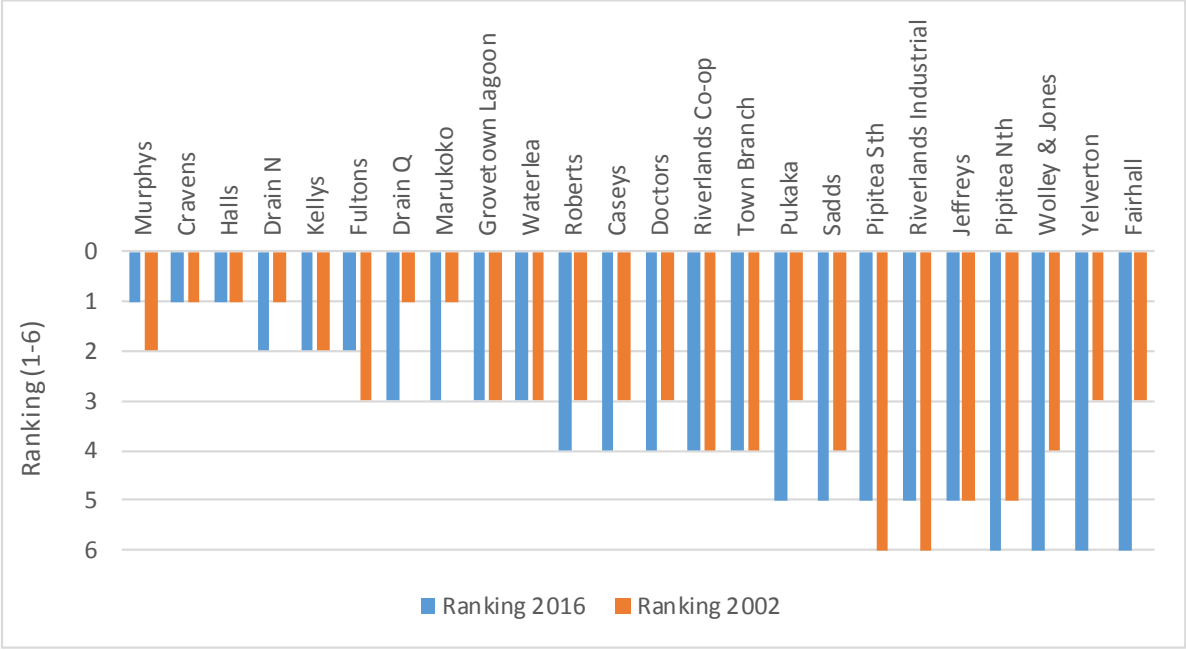
Executive summary

Marlborough District Council (MDC) commissioned NIWA to undertake an ecological assessment of 24 watercourse sites on the Wairau Plains to meet Condition 18 of Resource Consent U070702. This assessment of current ecological health of the watercourses should assist with ongoing management of theses watercourses for drainage purposes by MDC staff and inform the staff about the need for future targeted studies.

Sites surveyed in March 2002 were used again and a comparable suite of ecological factors were assessed in March 2016 using similar or more recently developed survey techniques. Amongst the assessed watercourse factors were physical profile, depth and water velocity, water quality, riparian condition, vegetation composition and abundance, macroinvertebrate composition and abundance and fish community diversity and abundance.

Each assessed factor was independently graded from A (best) to D (worst). Ecologically, the more diverse fish communities scored higher, as did the presence of more ecologically sensitive macroinvertebrate communities, while moderate abundance of in-stream macrophytes was considered ecologically beneficial.

Overall ecological rankings from 1 (best) to 6 (worst) were based on the gradings and were broadly compared to the rankings for watercourse sites in 2002.



The 2016 ecological ranking had four dry sites as the lowest (6th) ranked, with Pipitea North, Woolley and Jones, Yelverton and Fairhall having no aquatic habitat available at the time of the survey. The next poorest or 5th ranked sites, which were wet at the time of the survey, were Pukaka, Sadds (limited assessment), Pipitea South, Riverlands Industrial and Jeffreys. Fourth ranked sites were Roberts, Caseys, Doctors, Riverlands Co-op and Town Branch. Slightly better 3rd ranked sites were Marukoko, Grovetown Springs Lagoon, Drain Q and Waterlea. Drain N, Kellys and Fultons ranked second and the best sites were Cravens, Halls and Murphys.

The inclusion of four watercourses that were dry in 2016 at 6th rank represents the most obvious change since 2002. The remainder of 2016 results were generally similar to ranks assessed in 2002. Eight sites were in the same ranked position as 2002, with nine sites varying by only one rank. The remaining three sites changed by two ranks.

The majority of changes represented minor to moderate deterioration in ecological condition since 2002. Four sites improved, but two of these, Riverlands Industrial and Pipitea South, moved up one rank because the bottom 6th ranking was given to dry sites in 2016. Of the three sites that dropped by two ranks, Marukoko and Pukaka appeared to have poorer water quality and macroinvertebrate habitat in 2016, but for Drain Q the change seemed to be related to reduced water depth and flows producing poorer quality habitat.

A major driver of ecological change appeared to be drying of watercourses and reduction in their water depth and flow compared with 2002. The March 2016 sampling was undertaken during a summer drought with lower flows than in 2002. An identified trend of reducing aquifer levels over the past decade may also have contributed to reduced water availability by 2016. A secondary influence since 2002 may be water quality deterioration at select sites, although this needs to be confirmed by additional sampling.

The ecological values of watercourses on the Wairau Plains were limited by modified channels, heavy siltation and excessive in-channel vegetation dominated by invasive weeds. Indications are that fine sediments are aggrading within the drainage systems to the detriment of instream values. Further targeted studies of the long term effects on instream values of removal of sand /silt and deepening of water depth of discrete drainage reaches is warranted.

Ongoing herbicide applications by MDC is likely to prevent a build-up of excessive vegetation that can impact on instream ecological values. However, moderate levels of vegetation are likely to afford habitat for biota. We recommend management to retain moderate amounts of diverse macrophytes while preventing high channel occupancy or surface coverage of watercourses. A reduction in the occurrence of invasive submerged weeds noted in 2016 is likely attributable to the continuing herbicide application programmes of MDC.

1 Introduction

MDC is required to manage aquatic weeds in order to maintain an effective drainage network on the Wairau Plains (MDC 2008). The principal aquatic weed control methods include hand clearing, mechanical excavation, weed cutting, and the use of aquatic herbicides (MDC 2008).

Use of aquatic herbicides in the watercourses of the Wairau Plains is a discretionary activity and resource consent for herbicide use was granted in 2009 (Consent no. U070702). Changes to Condition 18 of this Resource Consent (7th April 2015) then set out the requirement for a repeat assessment of the ecological condition of 24 watercourses on the Wairau Plains, which were first assessed in 2002 (Young et al. 2002). The proposition was that determining current ecological health of watercourses would inform MDC of management options for watercourse maintenance by herbicide application or other means for the purposes of drainage (MDC 2008).

The initial report (Young et al. 2002) identified a complex array of potential factors that influence the ecology of watercourses of the Wairau Plains, including degree of connectivity with Wairau aquifer, drought, floods, tidal influence, gradient, and land use. However, the watercourses were able to be subjectively ranked according to perceived ecological condition. Knowledge of the current ecological condition and any apparent changes since 2002 would inform the adaptive management approaches undertaken by MDC in maintaining the drainage network and managing excessive weed growth.

This report presents ecological assessment results for 24 watercourses in mid-March 2016. Sites for assessment included Caseys, Cravens, Doctors, Drains N and Q, Fairhall, Fultons, Grovetown Spring Lagoon, Halls, Jeffreys, Kellys, Marukoko, Murphys, Pipitea North, Pipitea South, Pukaka, Riverlands Co-op, Riverlands Industrial, Roberts, Sadds, Town Branch, Waterlea, Woolley and Jones and Yelverton. Descriptions of the bed profile, depth and water velocity are provided. Current water quality, macrophyte development (aquatic plants) and riparian condition have also been assessed. Community composition and abundance of macroinvertebrates and fish is described.

The report concludes with overall rankings for ecological condition of the 24 watercourses in 2016. These rankings are broadly compared with rankings provided for the same watercourses in 2002 (Young et al. 2002).

2 Methods

2.1 Field survey sites

Sites were relocated as far as possible from Young et al. (2002) based on maps, grid references (where provided) and photographs. At each relocated site, GPS references (NZTM) were established for future reference and photo-points taken.

Sites at the watercourses of Pipitea North, Woolley and Jones, Yelverton, Fairhall and Sadds were dry and not sampled in 2016. However, Sadds had a downstream section that held water, with fish and macroinvertebrates sampled at this location. We were denied landowner access to the original site at Pukaka and an alternative site was assessed (Figure 1).

Eight sampled watercourses were located in rural upland areas (Figure 1). These were Doctors, Cravens, Drains N and Q, Halls, Kellys, Sadds and Grovetown Spring Lagoon (hereafter referred to as Grovetown Lagoon). Seven watercourses were associated with the township of Blenheim (Figure 1). These were Murphys, Caseys, Fultons, Waterlea, Town Branch, Riverlands Co-op and Riverlands Industrial. A further five watercourses, Pukaka, Roberts, Pipitea South, Marukoko and Jeffreys were located in lower elevation coastal areas.

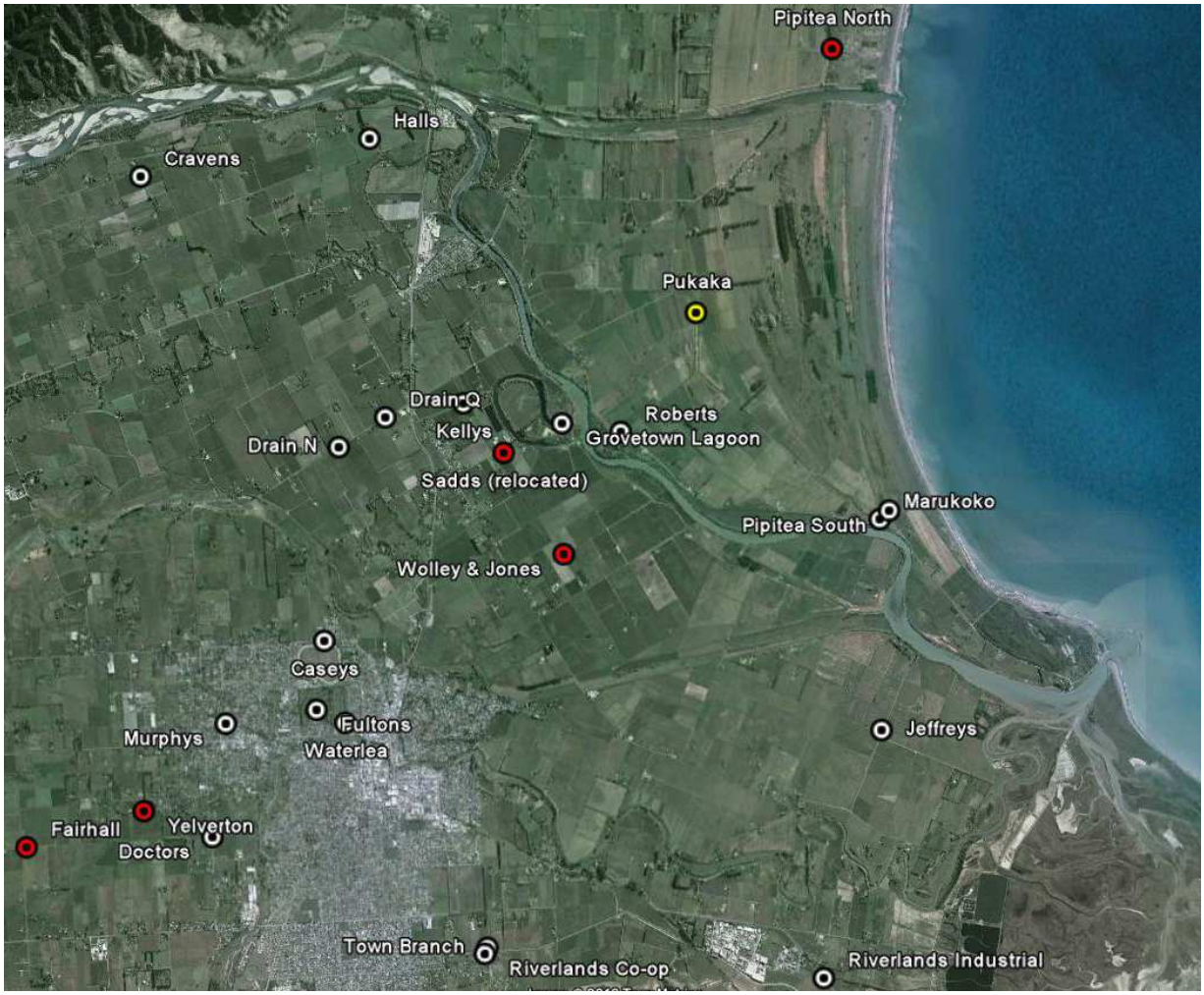


Figure 1: Location of the sampling sites in 2016 marked in white, with dry sites marked in red and relocated site marked in yellow.

2.2 Physical habitat, aquatic plants and riparian condition

Channel profiles, water velocity and vegetation development were simultaneously assessed. Measurements were made at 0.2 to 1 m intervals across the watercourse from true left bank to true right bank. At each measurement point, height to the top of the bank was measured, or water depth to the bed. Water velocity measurements (30 second) were made at c. 0.1m water depth at each distance interval using a velocity meter (SonTech FlowTracker ADV). Velocity measurements were prevented by macrophytes development in some areas. Watercourse discharge was estimated[1] as cross-sectional area x (average velocity x 0.85 correction factor for bed roughness). These discharge estimates are recognised as limited and a temporal 'snap-shot' that may not indicate average conditions.

Canopy height from the watercourse bed or the batter bank was measured at each horizontal measurement point. Plant species present and their % cover were recorded within 0.5 m radius of each point. Plant metrics for macrophyte channel cross-sectional volume (CAV) and macrophyte channel water surface area (SA) were estimated from profile plots and compared to suggested guidelines for instream values (Matheson et al. 2012).

Bed substrate composition at each site was determined by at least 100 measurements of instream benthic particles. Measurements were made over a 50–100 m reach using the Wolman pebble count (Wolman 1953). The following size classifications were used to characterise the relative abundance of encountered particles: silt/sand (<2 mm), small gravel (2–4 mm), small medium gravel (4–16 mm), medium large gravel (16–32 mm), large gravel (32–64 mm), small cobble (64–128 mm), large cobble (128–256 mm), small wood (diameter <100 mm) and large wood (diameter >100 mm). Due to deep water (>2 m) at Roberts and Marukoko, the benthic substrate composition was assessed using a combination of bankside observations and instream observations by a NIWA staff member traversing the waterway. Because fine sediment dominated at all sites, data were plotted as particle size by relative abundance for each sampling site.

2.3 Water quality

A surface water sample from each site (2L) was chilled and delivered overnight to the NIWA Hamilton Water Quality Laboratory for processing according to standard analytical methods. Samples were analysed for nitrate (NO_3-N), ammonium (NH_4-N), dissolved reactive phosphorus (DRP), total nitrogen (TN), total phosphorus (TP), total suspended solids (SS), inorganic (fixed) suspended solids (FSS), organic (volatile) suspended solids (VSS). Additional samples for indicator bacteria (*E. coli*) were delivered to Hills Laboratories (Grovetown Park, Blenheim) and analysed by membrane filtration followed by count on mFC agar, incubated at 44.5°C for 22 hours.

Spot measurements of DO, temperature, turbidity, conductivity and pH were made using a calibrated (3 point NTU, 1 point conductivity, pH and DO) Horiba U-50 multi-parameter water quality meter. A black disc measurement (200mm disk for water clarity above 1.5 m, 60 mm disk for 0.5m to 1.5m) was made in each assessed reach where depth was sufficient and instream vegetation did not obscure the measurement.

[1] http://www.mostreamteam.org/Documents/datasheets/Discharge.pdf

2.4 Macroinvertebrates

All sampled sites for macroinvertebrates were indicative of soft-bottomed waterways. Macroinvertebrate collection involved semi-quantitative sampling protocols (P2) following Stark et al. (2001) along a 50–100 m reach using a triangular kick net (0.5 mm mesh). Ten 10 replicates samples of 0.3 m^2 were collected along each reach to provide a single pooled sample of approximately 3 m^2 (Stark et al. 2001, Collier and Kelly 2005).

Macroinvertebrate habitats were sampled proportionally to their availability, and this mostly involved sampling of watercourse banks, macrophytes, overhanging and trailing vegetation, and to a lesser extent woody debris and gravels. Due to water depths >2 m at Roberts and Marukoko, macroinvertebrates were sampled from the banks, and included sweeps of macrophytes, encroaching pasture grasses and weeds as well as the banks themselves.

Each macroinvertebrate sample was elutriated, sieved (500 µm) to remove superfluous fine sediment and organic material, labelled and preserved in 70% isopropyl alcohol on site. In the laboratory samples were identified to the lowest taxonomic level possible, mostly using the identification guides of Cowley (1978), Towns and Peters (1996), Winterbourn (1973), Winterbourn et al. (2006).

Due to the volume of organic debris associated with each sample, samples were initially sorted using a series of nested sieves and each sieve fraction scanned for rare taxa. Samples were split where appropriate to aid in the sorting process of very common taxa. Each taxon was assigned a coded-abundance category based on its abundance following Stark (1998); R (rare) = 1–4 individuals; C (common) = 5–19; A (abundant) = 20–99; VA (very abundant) = 100–499; and VVA (very abundant) = 500+.

The following macroinvertebrate indices were calculated:

- Taxa Richness: a measure of total biodiversity at each site.
- EPT taxa richness: a measure of total number of the sensitive Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisfly) taxa. This excludes the micro Hydroptilidae caddisflies as their pollution tolerances differ from other EPT taxa.
- %EPT taxa: a measure of the biodiversity of sensitive species relative to the total biodiversity at each site. Hydroptilidae caddisflies were excluded from this index.
- %EPT abundance: a measure of the total numbers of sensitive species relative to the total number of macroinvertebrates at each site. Hydroptilidae caddisflies were excluded from the index as their number can proliferate under degraded conditions.
- %dominant taxon: percentage contribution of total numbers by a numerically dominant taxon.
- Macroinvertebrate Community Index (MCI): a single derived score for each site based on presence-absence data that can be used to measures changes in macroinvertebrate community composition (scores >120 = excellent; 100–119 = good; 80–99 = fair; < 80 = poor). Values for soft-bottom streams were used in the calculation of this score.
- Semi-Quantitative Macroinvertebrate Community Index (SQMCI): a single derived score for each site based on relative abundance of taxa collected using semi-

quantitative procedures. As for MCI, this metric can be used to measures changes in macroinvertebrate community composition (scores >6.00 = excellent; 5.00–5.99 = good; 4–4.99 = fair; < 4.00 = poor). As for the calculation of the MCI, soft-bottom scores assigned to macroinvertebrates were used in the calculation of this metric.

Quantitative biotics such as the QMCI (Quantitative Macroinvertebrate Community Index) were not calculated due to the macroinvertebrate sampling using semi-quantitative protocols.

To determine similarity of the macroinvertebrate communities between sites, presence-absence data from each site were used to calculate a non-metric multidimensional scaling (NMDS) ordination plot. Statistical analysis was conducted using R (R Core Team 2013) and multivariate analysis was conducted using package 'vegan' (Oksanen et al. 2015).

2.5 Fish

A synoptic survey of fish presence was undertaken at each site using one or more of three methods that is most appropriate for the site conditions. To maintain consistency with sampling carried out in 2002 the same site location and method were used for each site. However, these methods were standardised into 100 m reaches of the watercourse for electric fishing (Smith-Root LR-24 back-pack machine), spotlighting (30 watt light) and fyke netting.

The quick set-up operation on the LR-24 electric fishing machine was used at every site. This is where the machine will read the water conductivity and set machine settings (voltage, pulse width and frequency) to best suit the conditions being fished. Two spotlighting sites (Riverlands Co-op and Town Branch) were also checked with the electric fishing machine (spot fished 20 m) to pick up likely species that were not seen by spotlighting. A limited reach length that contained water at the relocated site for Sadds was spotlighted in 2016.

Fyke netting was standardised to 150 m reaches with five nets (fine mesh, 5mm fyke nets) deployed overnight. Setting of fyke nets in addition to one of the previous methods was made at two sites; Cravens to augment the sighting of a giant kokopu, and Grovetown Lagoon to catch additional species where dense macrophytes made electric fishing difficult.

All fish caught from the fykes and electric fishing were identified, measured to the nearest millimetre and released where they had been caught. Where possible fish were hand netted when spotlighting to confirm identification. All sites were marked with a field GPS at the top and the bottom of each reach and notes on watercourse variables and fish habitat were recorded. Fish results from the 2016 survey have been entered into the New Zealand Freshwater Fish database (NZFFD) and can also been seen in Appendix F of this report.

2.6 Ecological rankings

We attributed grades to each of the assessed factors ranging from A (best) to D (worst) on the basis of the ecological and community quality of the sites. An overall ranking (see discussion) was based on all grades.

3 Results

3.1 Physical habitat

In March 2016, five of the sites sampled in 2002 were dry. Dry sites comprised Yelverton and Fairhall amongst the upper order watercourses feeding to the Opawa River, Woolley and Jones and Sadds in the drainage network feeding to the Lower Wairau River and the coastal watercourse Pipitea North. This, together with lower water levels in many watercourses suggested a lower ground water table, or reduced contribution from surface run-off, in the 2016 summer compared to 2002. Anecdotally, it is suggested that certain watercourses, such as Yelverton, have dried over the last decade and this is in keeping with an identified trend of reducing aquifer levels over the past decade (Wöhling et al. 2016).

Six of the sampled watercourses were over 4 m in width and all had maximum water depths greater than 0.35 m). However, these larger systems exhibited a wide range in velocity measurements and estimated discharge. Watercourse specific information on all profiles and velocity are found in Appendix A.

Eleven watercourses were moderate (1.6 to 3.8 m) in width (Table 1). Of these, three shallow (<0.25 m) watercourses with low to negligible flows were Riverlands Industrial, Riverlands Co-op and the Pukaka site which is closest to the coast. Other low elevation sites of moderate width, Jeffries, Roberts and Pipitea South, had deeper water but also had negligible flows in 2016. However, in 2002 Roberts was noted as having “good flowing water”, so our later observations may not be typical of the watercourse and instead reflect flood gate status or level of pumping into the lower Wairau River that is noted for this site (Young et al. 2002). Low flows in Jeffreys and Pipitea South in 2002 were attributed to the actions of control gates and tidal or river height influences on these low gradient systems. Other moderate size systems included Fultons and Kellys, which had a relatively high estimated discharge, with some flow measured at the remainder of this size of watercourses (Table 1).

Drain N and Q were narrow (≤1.5 m width) with shallow channels (average depth <0.2 m), but had flowing water (Table 1).

The beds of all watercourses were dominated (>50%) by fine silt/sand (Figure 2), with substrates at ten sites comprised entirely of sand and silt. Fine sediment was up to 0.4–1 m deep at some sites, and smothered the original gravel and cobble bed at Pukaka, Roberts and Sadds. High levels of fine sediment were often associated with sluggish flow and/or macrophyte dominance.

Ten sampled sites had between 5% and 43% mixture of gravels and wood present (Figure 2) with higher amounts of hard substrates in some of the higher elevation systems (Kellys, Waterlea, Fultons, Caseys, Murphys, and Doctors).

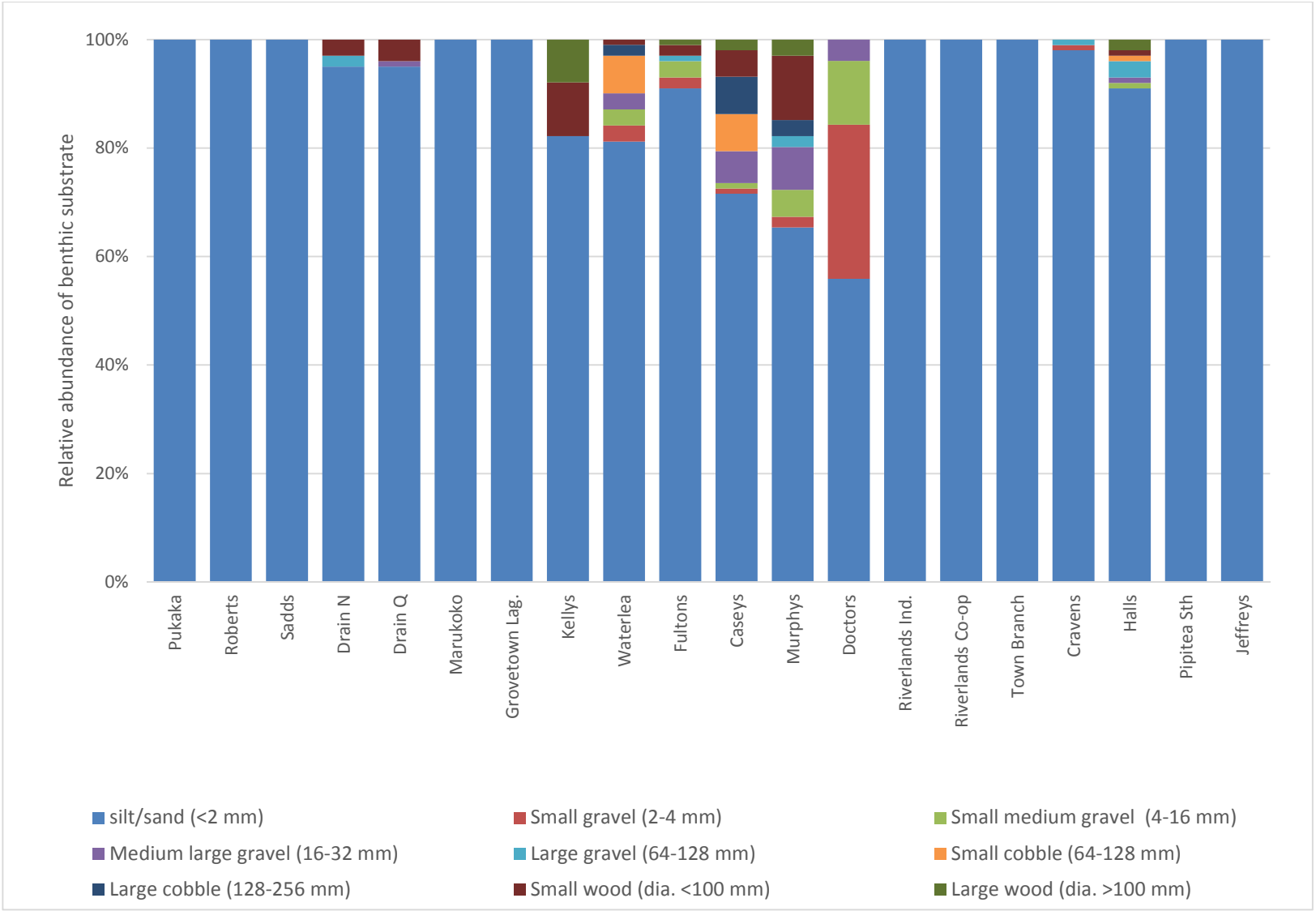


Figure 2: Composition of benthic substrates at surveyed watercourse sites.

Table 1: Hydrological summary for the 24 surveyed watercourse sites on the Wairau Plains. Darker shading indicates higher values.

Watercourse	Watercourse width (m)	Maximum depth (m)	Average depth (m)	Maximum velocity (m s^{-1})	Mean velocity (m s^{-1})	Estimated discharge (m^3 s^{-1})
Caseys	4.0	0.38	0.19	0.05	0.010	0.0064
Cravens	4.5	0.63	0.43	0.24	0.094	0.1546
Doctors	4.3	0.54	0.37	0.11	0.047	0.0632
Drain N 1	1.5	0.4	0.31	0.23	0.105	0.0410
Drain N 2	1.0	0.19	0.13	0.07	0.038	0.0043
Drain N 3	1.0	0.23	0.13	0.18	0.040	0.0045
Drain Q lower	1.4	0.12	0.09	0.14	0.044	0.0047
Drain Q middle	0.4	0.12	0.10	0.05	0.027	0.0009
Drain Q upper	0.4	0.15	0.08	0.14	0.058	0.0015
Fulton	3.0	0.68	0.58	0.41	0.259	0.3800
Grovetown Lagoon	2.8	0.5	0.32	0.06	0.039	0.0297
Halls	1.6	0.26	0.17	0.37	0.147	0.0349
Jeffreys	3.8	0.78	0.46	0.00	0.000	0.0000
Kellys	2.3	0.44	0.35	0.39	0.238	0.1613
Marukoko	8.0	0.88	0.59	0.09	0.027	0.1072
Murphys	7.0	0.44	0.28	0.25	0.104	0.1717
Pipitea South	2.2	0.33	0.22	0.00	0.000	0.0000
Pukaka	3.5	0.11	0.07	0.00	0.000	0.0000
Riverlands Co-op	3.0	0.21	0.14	0.05	0.008	0.0028
Riverlands Industrial	2.5	0.1	0.08	0.01	0.008	0.0014
Roberts Lower	4.4	0.85	0.70	0.00	0.000	0.0000
Roberts upper	4.6	0.75	0.61	0.00	0.000	0.0000
Town Branch	3.0	0.38	0.32	0.03	0.025	0.0206
Waterlea	2.2	0.41	0.27	0.31	0.165	0.0841

The best aquatic habitat (A grade) was attributed to watercourse sites that were less prone to drying (i.e., deeper with good flows) including Cravens, Doctors, Fultons, Grovetown Lagoon, Halls, Kellys Maukoko, Murphys, Town Branch and Waterlea. Secondary in grading (B grade) were shallow systems with perceivable flow that included Caseys, Drain N and Q and Riverlands Co-op, and the deep but poorly flowing Roberts and Jeffreys. C Grade sites were shallow with negligible flow that included Pipitea South, Pukaka and Riverlands Industrial. The sites that were dry or nearly dry presented little aquatic habitat and were prescribed a D grade.

3.2 Water quality

Water temperatures in 2016 showed five watercourses (Figure 3) had temperatures that were considerably higher than the reported background temperature of the Wairau Aquifer at 14 °C (Young et al. 2002) including Riverlands Co-op, Caseys, Pukaka, Marakoko and Pipitea South. In contrast the temperatures measured for Murphys, Kellys, Halls, Cravens, Fultons, Drain Q and N and Grovetown Lagoon suggest aquifer water comprises a large proportion of the flow.

Conductivity was high at six of the sites (Figure 3), with values at Jefferys especially, and other coastal watercourse sites of Pipitea South and Marukoko, suggesting a coastal saline influence. High conductivity at inland watercourses of Riverlands Co-op, Riverlands Industrial and Doctors is suggestive of leaching by nutrients and salts. High pH (>8) was measured at Riverlands Co-op, Pukaka and Jeffreys.

Super-saturated levels of dissolved oxygen (DO) recorded at Riverlands Co-op and Caseys are likely to be driven by high levels of plant photosynthesis. In contrast, very low DO was recorded at Town Branch, Jeffreys and Pipitea South, with zero levels recorded at Riverlands Industrial (Figure 4). These latter three sites also had the lowest DO measurements in 2002, but Town Branch was supersaturated at that time (Young et al. 2002). At <4 mg DO l^{-1} in 2016, all four of these low DO sites fall into the suggested category of unacceptable (1 day minimum value) and are unlikely to provide for ecological values (Davies-Colley et al. 2013).

The three sites with lowest DO had the highest concentrations of ammonium-N (NH_4-N) together with lowest concentrations of nitrate (NO_3-N) at (Figure 4), in keeping with low nitrification. High total nitrogen levels (TN) were also contributed by high NO_3-N for Riverlands Co-op, Murphys, Town Branch and Fultons (Figure 4), with these four sites also having the highest recorded NO_3-N in 2002 (Young et al. 2002). The highest TN recorded for Pipitea South at 18,000 mg m^{-3} was almost six times greater than the next highest value recorded from Riverlands Co-op, and three times the highest value recorded for Town Branch in 2002. This high measurement may reflect particle-bound inorganic nitrogen in keeping with measured levels of suspended particles.

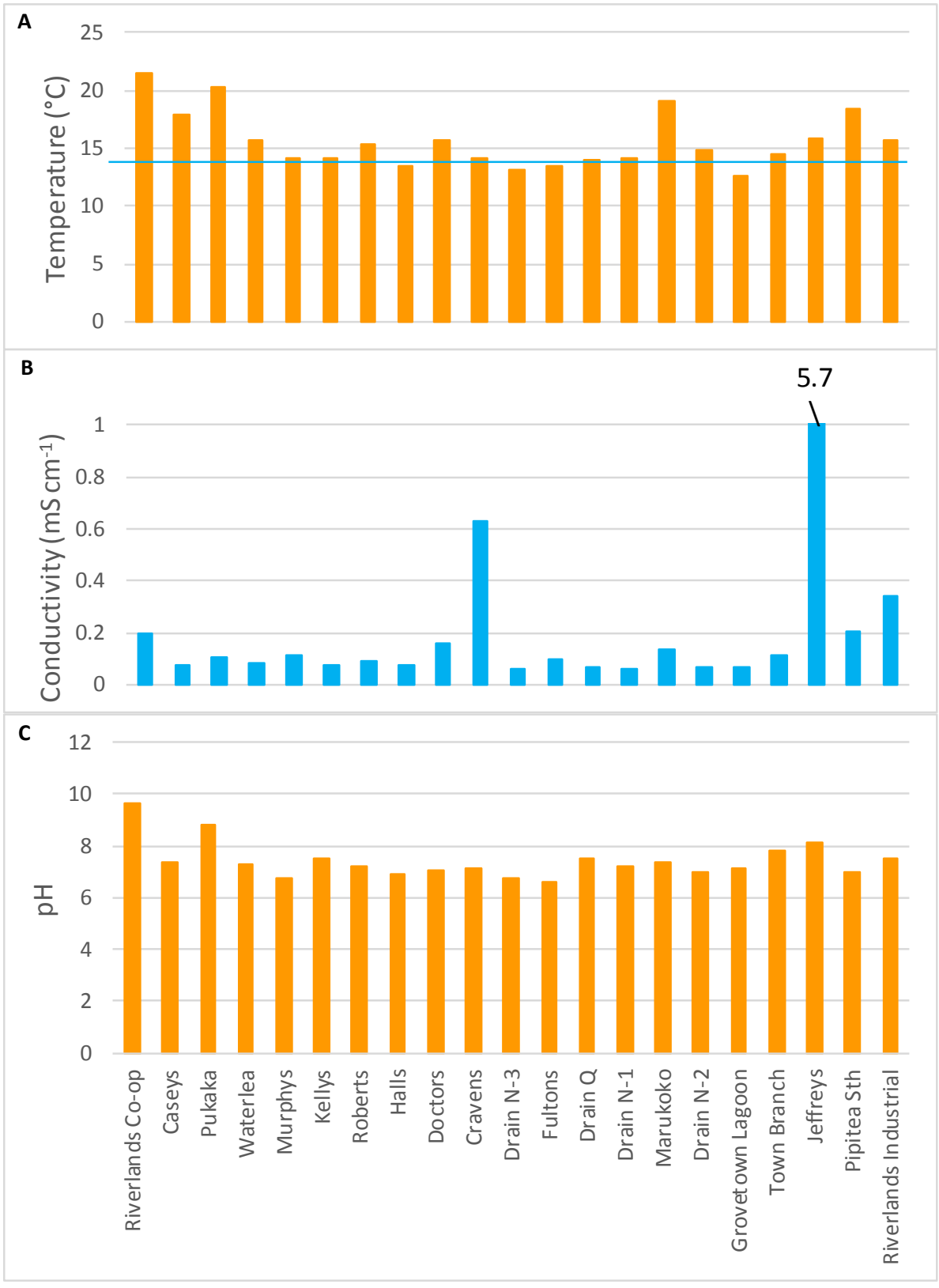


Figure 3: Horiba measurements for each watercourse sampling site. A) temperature (°C), showing a blue line representing background temperature of the Wairau Aquifer, B) conductivity (mS cm^{-1}), C) pH.

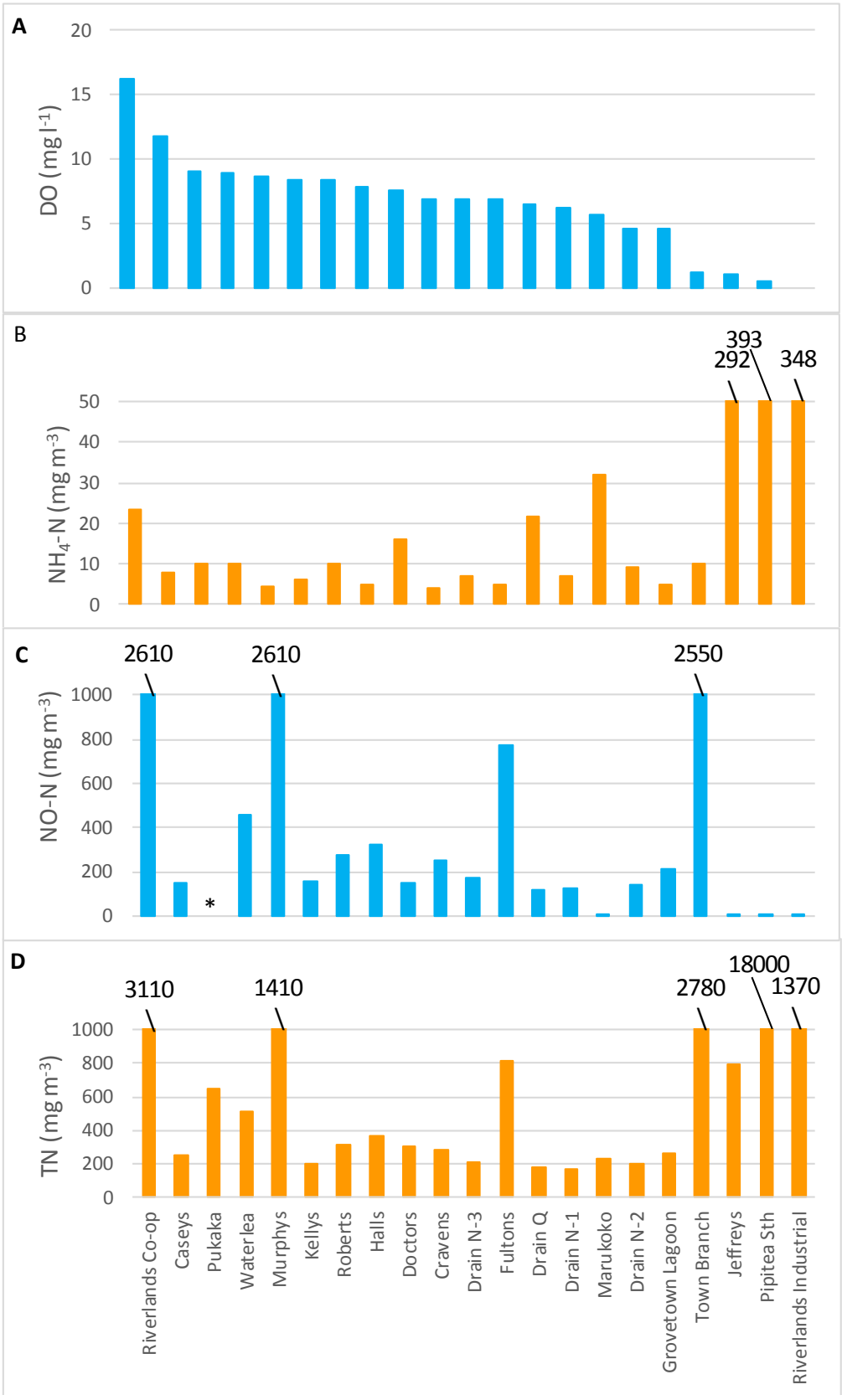


Figure 4: Dissolved oxygen and nitrogen concentration data for each watercourse sampling site. A) Dissolved oxygen (mg l^{-1}, B) Ammonium nitrogen (mg m^{-3}), C) Nitrate nitrogen (mg m^{-3}) D) Total Nitrogen (mg m^{-3}). * = <1 mg m^{-3}.

Dissolved Reactive Phosphorus (DRP) levels were highest at Riverlands Industrial (Figure 5), but concentrations here were half of the 1300 mg m^{-3} for DRP recorded for this site in 2002. Also elevated in DRP were Jeffries and Marukoko (Figure 5), which were also high in 2002 (44 -72 mg m^{-3}), and Riverlands Co-op. Total Phosphorus (TP) was much higher at Pipitea South than any other site, with the next highest value recorded from Riverlands Industrial (Figure 5).

The high TP at Pipitea South was driven by very high levels of Total Suspended Solids (SS, 2,110 g m^{-3}), Inorganic Suspended Solids (ISS) and Turbidity (Figure 6). Other turbid sites in 2016 were Riverlands Industrial, Town Branch and Roberts, while high SS (>10 g m^{-3}) was recorded at Riverlands Industrial, Jeffreys and Pukaka (Figure 6). The sites that had high Turbidity (> 10 NTU) in 2002 were also Riverlands Industrial and Pipitea South together with Riverlands Co-op), with SS >15 g m^{-3} recorded at Riverlands Industrial (54 g m^{-3}), Jeffreys, Pipitea South, Marukoko and Riverlands Co-op (Young et al. 2002).

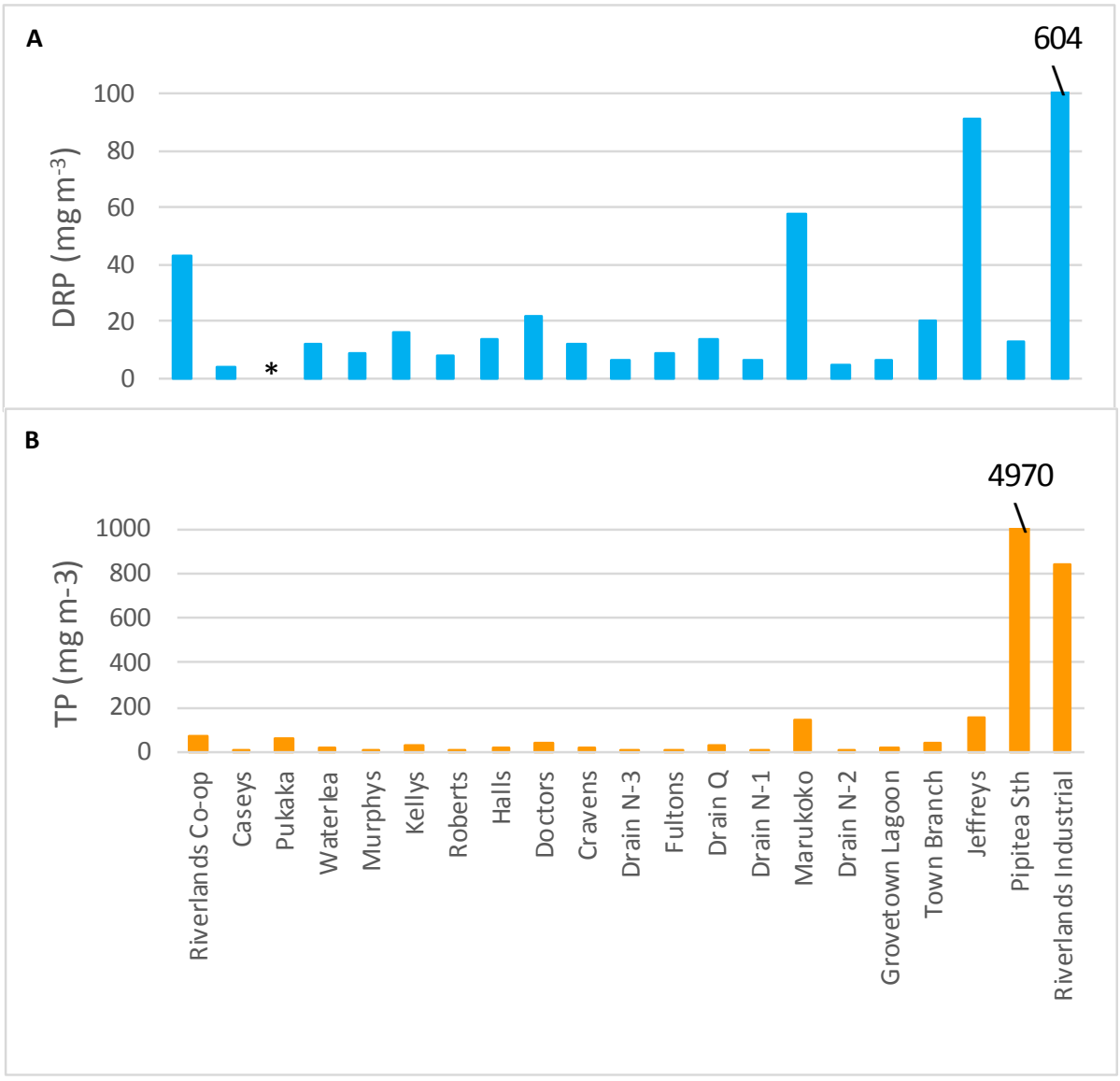


Figure 5: Phosphorus concentration data for each watercourse sampling site. A) Dissolved Reactive Phosphorus (mg m^{-3}), B) Total Phosphorus (mg m^{-3}). * = <1 mg m^{-3}.

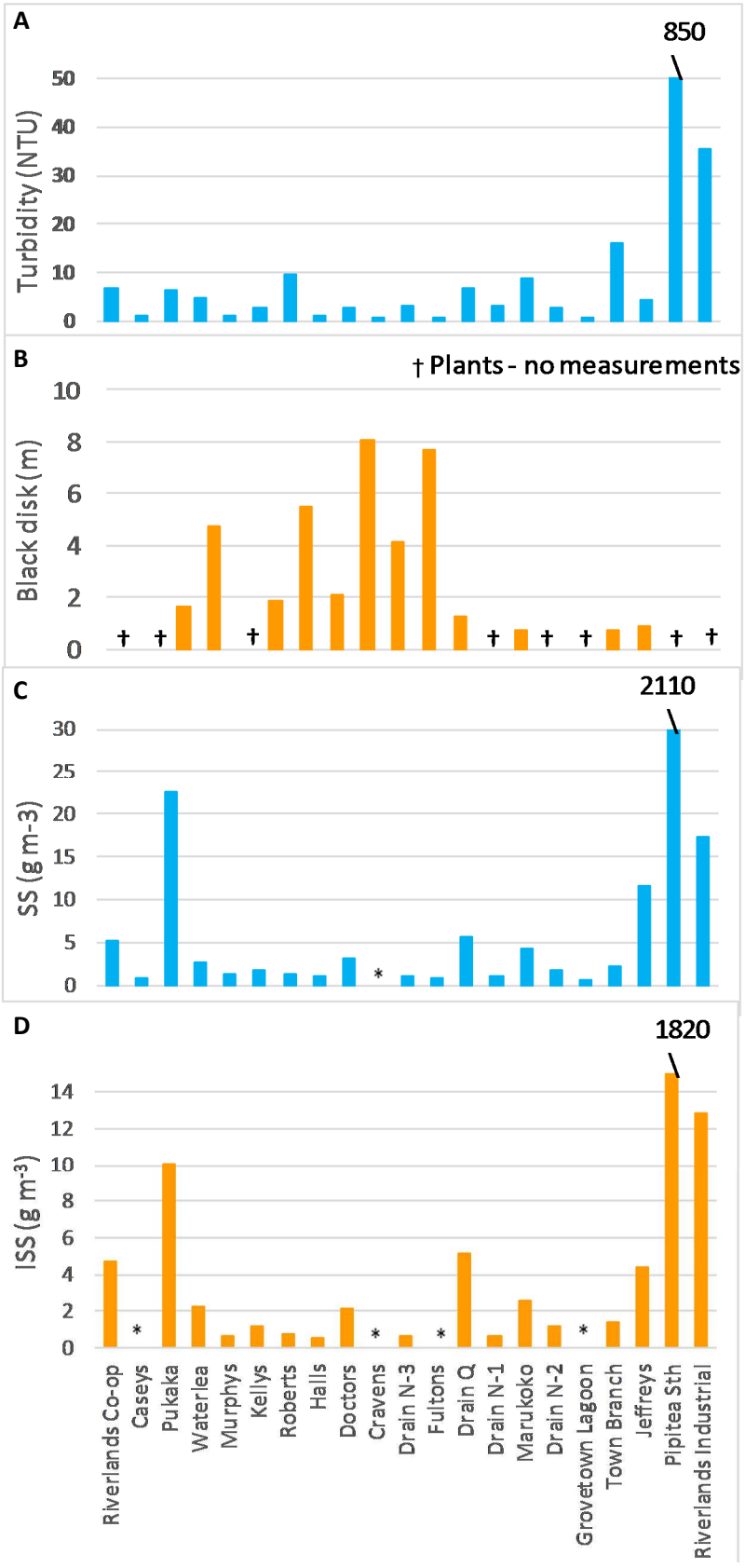


Figure 6: Measurements of water transparency and suspended particles for each watercourse sampling site. A) Turbidity (NTU), B) Black disk (m) with † indicating those sites where plant development obscured readings, C) Suspended Solids (g m^{-3}), D) Inorganic Suspended Solids (g m-3). * = <0.5 g m^{-3}.

Although not directly relevant for ecological assessment, results for *E. coli* levels in watercourse samples (Appendix C) can indicate bacterial contamination associated with other deleterious inputs. In 2016, only Riverlands Co-op exceeded the Alert/Amber Mode level of 260 cfu per 100 mL (MfE 2003). Also recording high *E. coli* (≥130 cfu per 100 mL) in 2016 were Halls, Doctors, Grovetown Lagoon, Waterlea and Kellys. In 2002, Riverlands Industrial had very high bacterial contamination, but levels were also elevated for the same sites of Riverlands Co-op, Halls, Doctors, Grovetown Lagoon, Waterlea and Kellys, as well as Town Branch and Marukoko.

In summary, the best or 'A grade' water quality was evident for Drain N, Grovetown Lagoon, Kellys, Waterlea, Caseys, Cravens and Halls. Some water quality parameters indicated impacts at Fultons, Doctors, Roberts, Murphys and Drain Q and these are considered 'B grade' sites. More substantial impairment was evident for Riverlands Co-op, Town Branch, Marukoko and Pukaka, which are designated 'C grade'. Very poor water quality was evident at Riverlands Industrial, Pipitea South, and Jeffreys, which are 'D grade' sites.

3.3 Aquatic Plants

Thirty-one aquatic plant species were recorded from the wetted channel of the watercourses, in addition to unidentified grasses, algae and bryophytes (Table 2). These included lifeform classes of sprawling marginal plants, emergent marginal plants, submerged species and free floaters. Mixed pasture grasses also extended from the adjacent batter into ten of the watercourses.

The most frequent sprawling marginal aquatic plants were the grass *Agrostis stolonifera* (8 watercourses), *Nasturtium* species (7 watercourses) and native willow weed, *Persicaria decipiens* (5 watercourses). While these species usually fringed the edges of the watercourses, *Agrostis stolonifera* together with *Nasturtium* species, *Ludwigia palustris*, and *Glyceria fluitans* species also grew submerged in clear spring-fed systems, for example in Cravens and Drain N (Figure 7).

Emergent aquatic plants such as *Bolboschoenus fluviatilis* and *Schoenoplectus pungens* were uncommon within the watercourses (2 sites each) and mostly limited to the edge of slow-flowing, low elevation systems, although jointed rush*, Juncus articulatus*, had a sprawling habit within faster flowing systems such as Cravens.

Invasive submerged weeds included *Lagarosiphon major* and *Potamogeton crispus* recorded from five watercourses each, and *Egeria densa* and *Elodea canadensis* from one each (Table 2). These invasive submerged species have the ability to form dense, monospecific stands that differ from the native submerged plant architectures. In the absence of weed management measures, these species are likely to have a greater physical occupancy of the watercourse and influence instream conditions in a potentially deleterious way. We noted a reduction in the distribution of these species since 2002. *E. densa* was recorded in Pukaka for the first time, but was not re-located at Roberts, Kellys and Halls as recorded by Young et al. (2002). *E. canadensis* was again recorded in Kellys, but not in Fultons*. L. major* was recorded for the first time in Pukaka, but only four of the nine watercourses where it was present in 2002. These weeds are susceptible to the herbicide diquat that is used for weed management at some watercourses and ongoing management may have reduced the abundance of these species. Successful weed control may lead to increases in native submerged plants, particularly charophytes that are unaffected by diquat.

Table 2: Average cover recorded from the wetted channel of each watercourse. Darker shading indicates higher values. + indicates present at very low abundance.

Watercourses	Spp. Richness	*Lemna disperma*	Grass	*Agrostis stolonifera*	*Azolla pinnata*	*Nasturtium* sp.	*Nitella* sp. aff. *cristata*	Algae	*Potamogeton crispus*	*Persicaria decipiens*	*Lagarosiphon major*	*Callitriche stagnalis*	*Potamogeton cheesemanii*	Liverwort	*Glyceria fluitans*	*Juncus articulatus*	*Chara globularis*	*Erythranthe guttata*	*Veronica* spp.	Mosses	*Ludwigia palustris*	*Schoenoplectus pungens*	*Triglochin striata*	*Landoltia punctata*	*Bolboschoenus fluviatilis*	*Juncus bulbosus*	*Cyperus ustulatus*	*Nymphaea* sp.	*Ruppia polycarpa*	*Ranunculus sceleratus*	*Persicaria hydropiper*	*Egeria densa*	*Apium nodiflorum*	*Elodea canadensis*	*Sarcocornia quinqueflora*	*Myriophyllum propinquum*
Caseys	*8*	62	7	48	2					1	69			15	11	6																				
Cravens	*6*	4		35	+	3		58				1	+			10																				4
Doctors	*3*	8				16												6	5																	
Drain N 1	*3*	3	13	9															4																	
Drain N 2	*5*	3	14		1		3								3						13															
Drain N 3	*4*	36		1	2	35	5																													
Drain Q 3	*3*	32			+		13																							3	1					
Drain Q 2	*1*						22																													
Drain Q 1	*2*	13					13														3															
Fulton	*4*								38		50			5						6																
Grovetown Lagoon	*5*	2	1			54				5		7						50																		
Halls	*6*	6	3	19		1		35		16															15											
Jeffreys	*3*		4					67															+												4	
Kellys	*6*			18		+	1			1			43												6									21		
Marukoko	*7*	14			3				1								9					6	10	1					31						
Murphys	*4*	2		+							25	15	9															2							
Pipitea South	*2*	100			+												3					15													
Pukaka	*4*										2					8								11								11	+		
Riverlands coop	*7*	+	9			8		27	58	4		5															1								
Riverlands Industrial	*1*	38	8																																
Roberts (lower)	*6*	1			2		37		6				75		7					1															
Roberts (upper)	*3*		27						10		1																									
Town Branch	*2*		7					14																												
Waterlea	*5*	19	47	13										1			23									1										
Total count		*16*	*11*	*7*	*5*	*6*	*7*	*5*	*5*	*5*	*5*	*4*	*3*	*3*	*3*	*3*	*3*	*2*	*2*	*2*	*2*	*2*	*1*	*2*	*2*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*0*	*1*	*1*	*1*

Figure 7: Mosaic of instream vegetation photos. From top left) Riverlands Industrial, with duckweed dominance, top right) Drain N showing submerged *Agrostis stolonifera*, bottom left) Caseys showing excessive vegetation dominated by *Lagarosiphon major* and *Agrostis stolonifera*, and bottom right) Roberts (lower) showing *Potamogeton cheesemanii* with oval surface-floating leaves.

Native submerged species recorded were charophytes (*Nitella* sp. aff *cristata*, *Chara globularis*), which are primarily bottom growing, *Potamogeton cheesemanii,* which seasonally produces floating leaves, *Myriophyllum propinquum* and *Ruppia polycarpa*.

Free floating plants included two species of 'duckweed' (*Lemna disperma* and *Landoltia punctata*) as well as the floating fern *Azolla pinnata*. These free floaters dominated in the still, nutrient-enriched watercourses of Riverlands industrial (Figure 7), Pipitea South and Pukaka, but were limited to the vegetated edges of flowing systems such as Halls, Caseys, Doctors, Waterlea, Drain Q and N.

Sarcocornia quinqueflora, *Schoenoplectus pungens* and *Ruppia polycarpa* reflected the brackish influence at Jeffreys, Pipitea South and Murukoko.

Obstruction to flow conveyance and drainage is the prime reason for managing vegetation in lowland areas to prevent flooding impacts on primary industries and/or infrastructure. However there is also an ecological basis to recognising moderate levels of instream vegetation as beneficial (Matheson et al. 2012). Both the role of excessive vegetation in 'clogging' streams, slowing flows and raising water levels, and the potential for surface covers of plants to reduce re-aeration can have repercussions for ecological condition of watercourses. To capture these likely influences, measures of channel cross-sectional volume (CAV) and water surface area (SA) occupied by vegetation have been suggested as indicators (Matheson et al. 2012). The influence of free floating plants is not incorporated in the CAV measures.

The CAV measure of channel 'clogginess' showed seven watercourses had over 80% of the channel cross-section occupied by vegetation and a further three watercourses had over 50% CAV (Table 3). Sites with high (>50%) CAV) included upper reaches of the Opawa River (Caseys, Waterlea and Fultons), springs (Grovetown Lagoon) drainage network sites (Drain N3, Kellys, Lower Roberts and Riverlands Co-op) and northern watercourses draining to the Wairau River (Cravens and Halls). Matheson et al. (2012) recommended a provisional guideline of ≤50% of channel CAV to protect instream ecological condition, flow conveyance and recreation values.

The SA measure exceeded 50% for eight of the watercourses, which also recorded high CAV% values (Table 3), but high surface covers of free-floating species were also recorded at Pipitea South. In some systems, fruiting tendencies by native species such as *Potamogeton cheesemannii* may lead to a temporarily high SA (Figure 7), such as was seen in Roberts (lower). This seasonality in fruiting tendency needs to be taken into account in assessments. Matheson et al. (2012) recommended a provisional guideline of ≤50% of channel water SA to protect instream aesthetic and recreation values.

Watercourses with very high vegetation development as CAV and SA were Riverlands Co-op, Caseys, Grovetown Lagoon and Roberts (lower), with Halls, Kellys, Waterlea, Cravens and parts of Drain N also likely to be influenced by plant alterations to flow and water chemistry. For instance, supersaturated DO conditions at Riverlands Co-op and Caseys during daylight hours suggest DO depression is equally possible in early hours of the morning due to peak plant respiration. We note SA at Roberts (lower) may be driven by the seasonal surface leaves of native pondweed.

Table 3: Maximum depth of each watercourse, the maximum plant height and the estimated cross-sectional volume (CAV, %) and water surface area (SA, %) occupied by vegetation. Darker shading indicates higher values.

Watercourse	Maximum depth (m)	Maximum plant height (m)	CAV (%)	SA (%)
Caseys	0.38	0.77	100.0	100
Cravens	0.63	0.62	74.4	40
Doctors	0.54	0.6	37.9	31.4
Drain N 1	0.4	0.35	37.6	12.5
Drain N 2	0.19	0.15	46.8	16.4
Drain N 3	0.23	0.38	81.0	60
Drain Q 3	0.12	0.1	18.1	12.5
Drain Q 2	0.12	0.01	10.3	0
Drain Q 1	0.15	0.03	34.8	16.7
Fultons	0.68	0.45	57.5	0
Grovetown Lagoon	0.5	1.6	96.9	93
Halls	0.26	0.66	84.7	54.4
Jeffreys	0.78	1.05	5.6	14.3
Kellys	0.44	1.6	76.3	54.3
Marukoko	0.88	0.9	33.5	32.8
Murphys	0.44	1.8	38.0	20.7
Pipitea South	0.33	0.7	42.7	100
Pukaka	0.11	0.08	30.7	17.1
Riverlands Co-op	0.21	2.3	100.0	91.8
Riverlands Industrial	0.1		0.0	45.7
Roberts (lower)	0.85	0.85	100.0	89.5
Roberts (upper)	0.75	1	22.8	18.2
Town Branch	0.38	0.8	7.1	7.1
Waterlea	0.41	1.5	82.5	58.3

Poor habitat for a diverse aquatic vegetation at Riverlands Industrial included lower water clarity, and the watercourse had mainly grass edges and abundant free floating duckweed. Jeffreys was similar but had a mass of floating algae instead of the free floating plants. Town Branch also had very limited plant diversity and was algal dominated instream. Pukaka had a limited aquatic vegetation dominated by invasive submerged weeds and an alien, free floating duckweed. These watercourses were graded as a D quality.

Waterbodies that had an excessive amount of vegetation scored a C grade. These were Grovetown Lagoon, Caseys, Riverlands Co-op and Roberts (lower). Pipitea South was also included in this group because it had some native diversity but was dominated by free floating duckweed.

Watercourses with moderate amounts of instream vegetation but limited diversity with mostly alien plant species were assigned a B grade. These were Cravens, Doctors, Fultons, Halls, Kellys, Roberts (upper) and Waterlea.

While none of the watercourses were considered to have diverse aquatic vegetation that was free of alien plants and approaching the pristine state, we assigned A grades to those watercourses that had moderate levels of relatively diverse plant species and lifeforms. These were Drains N and Q, Murphys and Marukoko.

3.4 Riparian condition

The sampled sites varied from those that had a more natural course with a well-developed riparian edge, to those that had been highly modified by straightening and entrenching by mechanical excavation with limited development by riparian vegetation.

Most of the sites examined had pasture grasses as the predominant cover on the batter. Along roadsides this vegetation was commonly mowed on the upper edges. However, tall grasses (<1 m) were present at Waterlea, Marukoko, Riverlands Industrial and Riverlands Co-op. The batters at Drain Q, Kellys, Cravens and Town Branch had also been sprayed by local landowners, apparently to maintain a tidy aesthetic. Most of the riparian strips adjacent to agricultural land had been fenced off. Lowland systems with adjacent stopbanks, like Marukoko, appeared to have more extensive retired riparian zones.

One common feature was lack of shade from taller bushes and trees. Notable exceptions were Murphys and Fultons sites within the township of Blenheim, and Halls had large established *Alnus* trees. Some riparian shading was evident at Cravens, Grovetown Lagoon, Sadds, Waterlea, Caseys, Drain N, Riverlands Co-op, Riverlands Industrial and at Drain Q. Low elevation systems including Jeffreys and Pipitea were on low productivity land with some salt marsh, where establishment of larger trees may be difficult.

Shading would help moderate higher water temperatures in the watercourses that are not well connected to the Wairau Aquifer. Taller vegetation is also important for macroinvertebrate adult stages.

Straightened watercourses often had an abrupt edge that limited the plants usually transitioning from dry land to shallow water and probably restricted plant diversity at many sites. Undercutting in these systems may be a source of instream fine sediment.

Very few of the watercourses had natural meanders that create flow variability and habitat diversity at the water edges particularly. Those that could be considered more natural included Halls, which historically has had lower disturbance, Murphys where riparian planting of native and exotic species has been undertaken for beautification, and Cravens, where watercourse enhancements have been made and riparian planting is currently underway. Although Fultons had meanders and was set in a park-like surrounds it was considerably modified by edge revetments.

In summary, A grade condition was recognised for watercourse sites at Halls, Murphys and Cravens that reflected the more natural form and integration of a diverse riparian vegetation. B grades were applied to Fultons, Drains N and Q, which had been enhanced by some plantings and were less entrenched and straightened. Grovetown Lagoon was also included in this group due to the undisturbed and diverse riparian edges.

C grades were provided for moderately entrenched and straightened channels with little riparian development, diversity or shade. This included sites at Caseys, Kellys, Marukoko, Doctors, Pukaka, Riverlands Co-op, Riverlands Industrial, Roberts and Waterlea.

Strongly entrenched and straightened channels with little shading and poor riparian diversity were provided with a D grade, which included Jeffreys and Pipitea South. Town Branch was included in this group due to the abrupt transition from batter to wetted margin, which may have been the result of recent mechanical clearance.

3.5 Macroinvertebrates

No macroinvertebrate sampling was carried out at Jeffreys and Pipitea South due to the strong saline influence, which would have obscured use of this community as bioindicators.

Sixty-four macroinvertebrate taxa were recorded from the remaining sites (Table 4). Individual site biodiversity (taxa richness) ranged from 8–35 taxa (Table 4, Figure 8), with insects contributing the greatest biodiversity component (45 taxa, Figure 9). This included the sensitive mayflies (two species), caddisflies (14 species) and stonefly (one species), the more tolerant Diptera (18 species) taxa and a mixture of taxa characteristic of lentic conditions such as damselflies, true bugs (e.g., backswimmers and water boatmen) and swimming and diving beetles. Molluscs were the most diverse of the non-insects with eight taxa recorded. Non-insect taxa such as crustaceans (seed shrimps and amphipods), worms and *Potamopyrgus* provided the greatest contribution of individual macroinvertebrates at each site (Figure 9).

Eight macroinvertebrate taxa recorded in 2002 were not caught in 2016, including a mayfly and four caddisfly species. Two caddisfly species (*Hydrobiosis budgei* and *Psilochorema bidens*) were considered misidentifications by Young et al. (2002) and almost all other taxa were 'rare' i.e., only 1–4 specimens caught. Failure to re-capture rare taxa over multiple years is most likely due to a low resident population at a sampling site, but this did not, however, negatively impact the biotic indices at these sites in 2016, as overall more taxa were recorded in this survey than in 2002.

The greatest diversity of the more pollution-sensitive EPT taxa (excluding Hydroptilidae micro-caddisflies) were recorded from Waterlea, Kellys, Fultons and Cravens with between 8 and 11 taxa present. Caddisflies comprised the greatest proportion of the EPT taxa at these sites, but only a single stonefly species (*Megaleptoperla*) and two mayfly species (*Austroclima* and *Zephlebia*) were collected. Similarly, %EPT taxa (excluding micro-caddisflies) relative to the total biodiversity contributed at least 32% of the biodiversity (Figure 8). However, due to the large number of non-EPT taxa at each of these sites, overall representation of %EPT abundance was very low (< 10%, Figure 8).

MCI scores for 10 sites were less than 80 and their respective SQMCI scores were less than 3.7 indicating 'poor' water quality (Table 4). Stark and Maxted (2007) considered MCI scores less than 100 and SQMCI scores less than five representative of severe to moderate pollution. The benthic substrate comprised entirely of sand and silt at eight sites sampled in 2016, and three of these sites were characterised by water temperatures greater than 15°C, no measurable flow and high nutrient loading, additionally anoxic smelling sediment was noted during macroinvertebrate sample collection. Riverlands Industrial was the only site considered highly degraded by Young et al. (2002), however in 2016 Riverlands Industrial, Riverlands Co-op and Pukaka had MCI scores less than 54, indicating severely degraded water quality. MCI scores at these sites in 2016 differed as much as 28 when compared to 2002.

Table 4: Macroinvertebrate sampling sites and calculated metrics. MCI and SQMCI metrics calculated using MCI scores for soft-bottomed streams. *data excludes Hydroptilidae genera. + = water quality class based on MCI score. ^ = percent numerical dominance by a taxon.

Site name	Taxa richness	Tot. no. EPT taxa*	%EPT taxa*	%EPT abundance*	%dom. taxon^	MCI	SQMCI	Water quality class+
Pukaka	8	0	0	0	76.1	53.8	3.5	poor
Roberts	20	1	5.0	3.1	30.2	59.0	3.2	poor
Sadds	21	2	9.5	0.2	63.5	66.1	2.8	poor
Drain N	24	4	16.0	0.5	43.3	82.0	3.5	fair
Drain Q	20	3	15.0	0.6	33.4	86.8	3.8	fair
Marukoko	19	1	5.3	0.3	92.3	64.0	3.6	poor
Grovetown Lagoon	18	2	11.1	0.3	39.4	78.1	3.6	poor
Kellys	35	12	34.3	5.8	26.3	94.8	3.7	fair
Waterlea	28	9	32.1	4.8	49.6	87.6	3.5	fair
Fultons	25	8	32.0	9.4	77.2	90.1	4.9	fair
Caseys	19	1	5.3	0.1	57.4	59.6	3.5	poor
Murphys	21	4	19.0	0.2	76.0	84.0	3.4	fair
Doctors	24	4	16.7	0.3	41.5	72.5	2.5	poor
Riverlands Industrial	19	1	5.3	0.5	59.5	46.0	3.0	poor
Riverlands Co-op	23	1	4.3	0.2	25.1	53.3	2.6	poor
Town Branch	15	1	6.7	0.2	40.0	62.0	3.2	poor
Cravens	23	8	34.8	1.4	31.5	93.2	3.2	fair
Halls	22	5	22.7	0.4	55.7	84.4	2.8	fair

Macroinvertebrate community composition were often taxonomically diverse at these sites, but overall habitat quality was too poor to support sensitive mayflies, caddisflies and stoneflies species. Most taxa present were considered tolerant of degraded conditions, and this was reflected with low to mid individual MCI values and overall low MCI site scores (Figure 8). These sites were numerically dominated by worms, snails and hemipterans (water boatmen and backswimmers), with worms contributing up to 76% of the macroinvertebrate abundance at Pukaka. The presence of mosquito larvae, damselflies and a diverse beetle fauna were attributable to the pond-like conditions at this site (Figure 9). Furthermore, a large population of blood-worm midge larvae (*Chironomus*) were recorded from Riverlands Industrial, corroborating the low dissolved oxygen levels and high nutrient loading at this site.

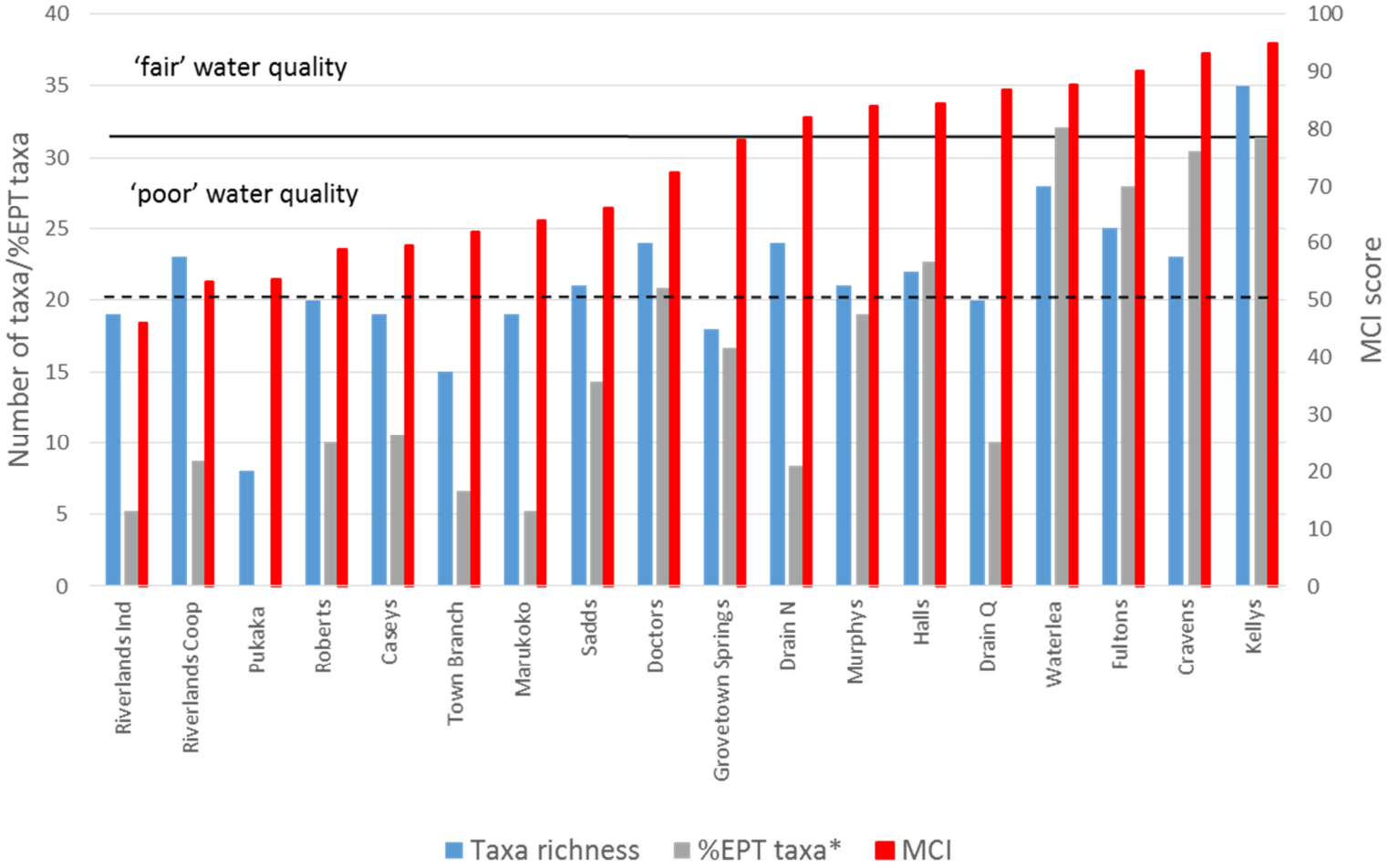


Figure 8: Macroinvertebrate taxa richness (biodiversity), %EPT taxa and MCI scores at 18 sites. Sites ordered from lowest to greatest MCI scores. Sites with MCI scores above the solid black bar = 'fair' water quality, MCI scores below the solid black bar = 'poor' water quality, MCI scores below the dashed line (MCI = 50) indicate severely degraded water quality. *%EPT taxa excludes Hydroptilidae genera.

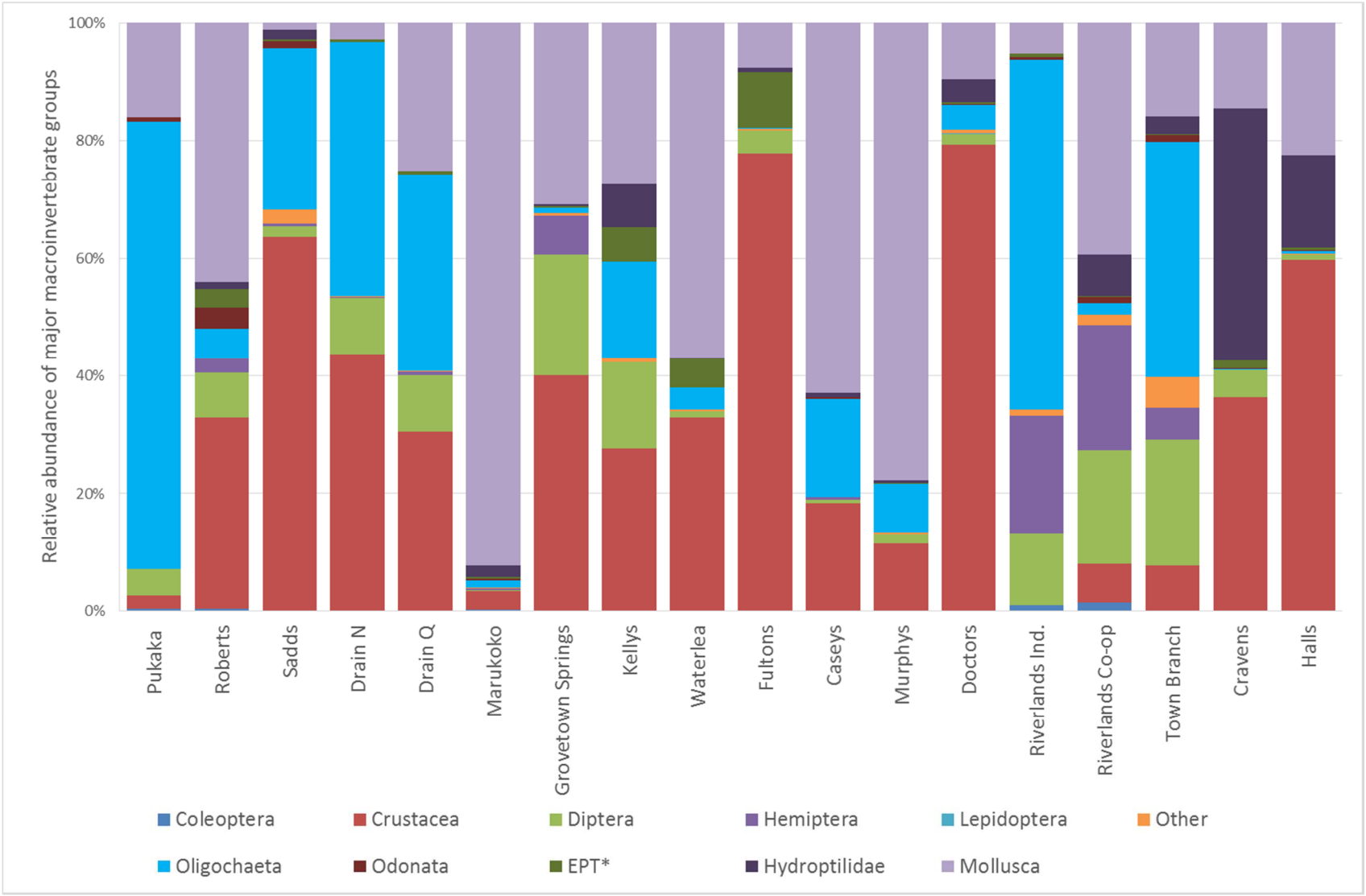


Figure 9: Relative abundance of major macroinvertebrate groups. 'Others' include mites (Acarina), leeches (Hirudinea), nematodes, proboscis worms (Nemertea) and Hydra (Cnidaria). * EPT exclude Hydroptilidae genera.

MCI scores for Caseys, Doctors, Grovetown Lagoon, Marukoko, Roberts, Sadds, and Town Branch sites ranged from 55–78, and SQMCI 2.8–3.2 in the 2016 survey, and were collectively indicative of 'poor' and highly-degraded water quality (Table 4, Figure 8). Flow at Roberts, Sadds, Marukoko, Caseys and Town Branch was generally very sluggish, and the bed was smothered by sand and silt. Consequently, sensitive mayflies and stoneflies were absent from these sites, and instead were dominated by non-insects including worms, ostracods, amphipods and snails, and robust insect taxa such as Diptera. Many of these sites were also characterised by having only one non-hydroptilid caddisfly (*Triplectides*) species present. There was a general increase in the biodiversity at most of these sites from 2002 to 2016, but a decrease in SQMCI and MCI scores (except Doctors). These changes affected Caseys, Grovetown Lagoon and Sadds which shifted from 'fair' to 'poor' water quality in 2016. Low flow in 2016 appeared responsible for the marked decrease in MCI from 91 (2002) to 66 at Sadds, leaving a series of small, muddy pools containing tolerant low scoring MCI taxa dominated by worms and ostracods. A decrease in SQMCI at Caseys, as well as a decrease in MCI by 25 points to 59.6 from 2002 to 2016 appeared to be associated with overall poor habitat quality with slow flow, lower macrophyte abundance (at sampled reach) and decrease in %EPT taxa from 19% to 5%.

Doctors and Grovetown Lagoon were considered borderline 'poor-fair' in 2016 with MCI scores of 72 and 78, and SQMCI 2.5 and 3.6, respectively. Macroinvertebrate communities at these two sites had a moderate taxonomic richness, and even though EPT taxa and %EPT abundance were low, caddisflies with higher MCI values were present. This may have been partly attributable to 40% of the bed comprising of a heterogeneous mix of gravel sizes creating shallow riffles habitat for macroinvertebrates at Doctors and dense macrophyte growth at Grovetown Lagoon providing plenty of habitat for macroinvertebrate colonisation. There was an increase of 11 taxa recorded from Doctors between 2002 to 2016, including two caddisfly species not collected by Young et al. (2002). The MCI score at this site was similar to that obtained by Young et al. (2002), however the SQMCI had markedly decreased from 4.58 to 2.5, and appears to have been associated with an increase in numbers and abundance of low scoring taxa.

Sites with MCI scores of 80 and greater were considered to have 'fair' water quality. This was generally associated with a combination of increasing water velocity (mean maximum velocity 0.29 m s^{-1}) and channel heterogeneity or the presence of gravels, wood, moss and macrophytes providing a variety of habitats for macroinvertebrates. Drain Q appeared to be the exception with an anoxic smelling fine sediment dominated the bed with little instream macrophyte cover. Drain Q and the nearby Drain N were two of the four sites where *Megaleptoperla*, the only stonefly species was recorded. Murphys showed a marked increase in taxa richness as well as SQMCI and MCI compared to 2002 when it was considered to have 'poor' water quality, these improvements were largely credited to the presence of four caddisfly species not recorded in 2002.

SQMCI scores were variable (2.8–4.9) at these sites and were still indicative of 'poor' to 'poor-fair' water quality, however the lower values obtained at many sites may have been attributable to the numerical dominance of mostly non-insect taxa (Figure 9). Mean biodiversity (25, n = 8) was greater at these sites than for those with MCI scores less than 80 (mean 19, n= 10) and EPT taxa contributed at least 28% of the total biodiversity (Table 4). Percentage EPT abundance contributed less than 10% of macroinvertebrate numbers, however this was largely due to the numerical dominance of non-insect taxa at these sites (Figure 9). Hydroptilidae comprised over 40% of the macroinvertebrates recorded from Cravens.

Although the watercourse bed at Cravens, Fulton and Kellys comprised of 83-98% sand and silt the MCI scores exceeded 90. These sites were considered the least degraded of all the macroinvertebrate sampling sites. The high diversity of macroinvertebrates and greater number of sensitive taxa were most likely due to a combination of water velocities exceeding 0.24 m s^{-1} and trailing riparian vegetation, instream woody debris and tree roots, and macrophytes providing a range of suitable habitats. Thirty-five taxa were recorded from Kellys in 2016 (Table 4) comprising 14 insect taxa (12 EPT taxa, excluding hydroptilids) and 11 non-insect taxa.

Nonmetric multidimensional scaling (NMDS) ordinations on the presence-absence of macroinvertebrate taxa were used to compare the macroinvertebrate community composition between sites. Sites with very similar macroinvertebrate communities cluster close together, whereas sites that have different communities are more scattered (Figure 10. The stress of the ordination was relatively low (0.13), indicating that two-dimensions or axes were sufficient to adequately represent the similarities between the communities sampled from each site. 'Stress' refers to how well the distances on an ordination plot reflect actual 'ecological distance' (i.e., dissimilarity) between different communities in the dataset. 'Stress' values <0.2 are considered an acceptable representation of the data (Clarke and Warwick 2001).

An ordination of macroinvertebrate communities indicted results were generally aligned by a combination of MCI scores, flow, and relative abundance of sand and silt (Figure 10). Sites positioned on the right of the NMDS plot (Figure 10) and labelled in pink were biologically grouped by MCI scores of 80 or greater and physically characterised by a more heterogeneous benthic substrate (gravels and woody debris present) and maximum water velocities of at least 0.14 m s^{-1}. These macroinvertebrate communities were on average taxonomically more diverse (20–35 taxa), supported a greater community of EPT species, and the %EPT contributions were considerably higher than sites in the centre and left of the ordination plot. Notably absent from these sites were insects associated with sluggish or standing water such as beetles and water boatmen and backswimmers. The only caddisfly not correlated with these higher MCI scoring sites was *Triplectides cephalotes*, a species more associated with lakes and ponds (Figure 3-8). Doctors and Grovetown Lagoon (labelled in green, Figure 3-8) were less strongly correlated with sensitive insect taxa, and consequently their MCI scores were more representative of borderline 'poor-fair' water quality.

Sites positioned in the centre and left of the NMDS plot (labelled in blue) were clearly defined as having 'poor' or highly degraded water quality (Figure 10). All sites were biologically defined by MCI scores less than 70 and SQMCI scores 3.6 or less, and physically grouped by the benthic substrate comprising 100% sand and silt, the waterbody with little to no flow and many sites were nutrient enriched. Although these sites were often taxonomically diverse, they were strongly correlated with low scoring MCI taxa associated with ponds, lakes or poor habitat quality, such as aquatic caterpillars, damselflies, water boatmen and backswimmers, oligochaetes and a selection of dipterans. Most notably, Riverlands Industrial and Pukaka were positioned on the far left of the ordination plot and considered the most degraded of all the macroinvertebrates sampling sites.

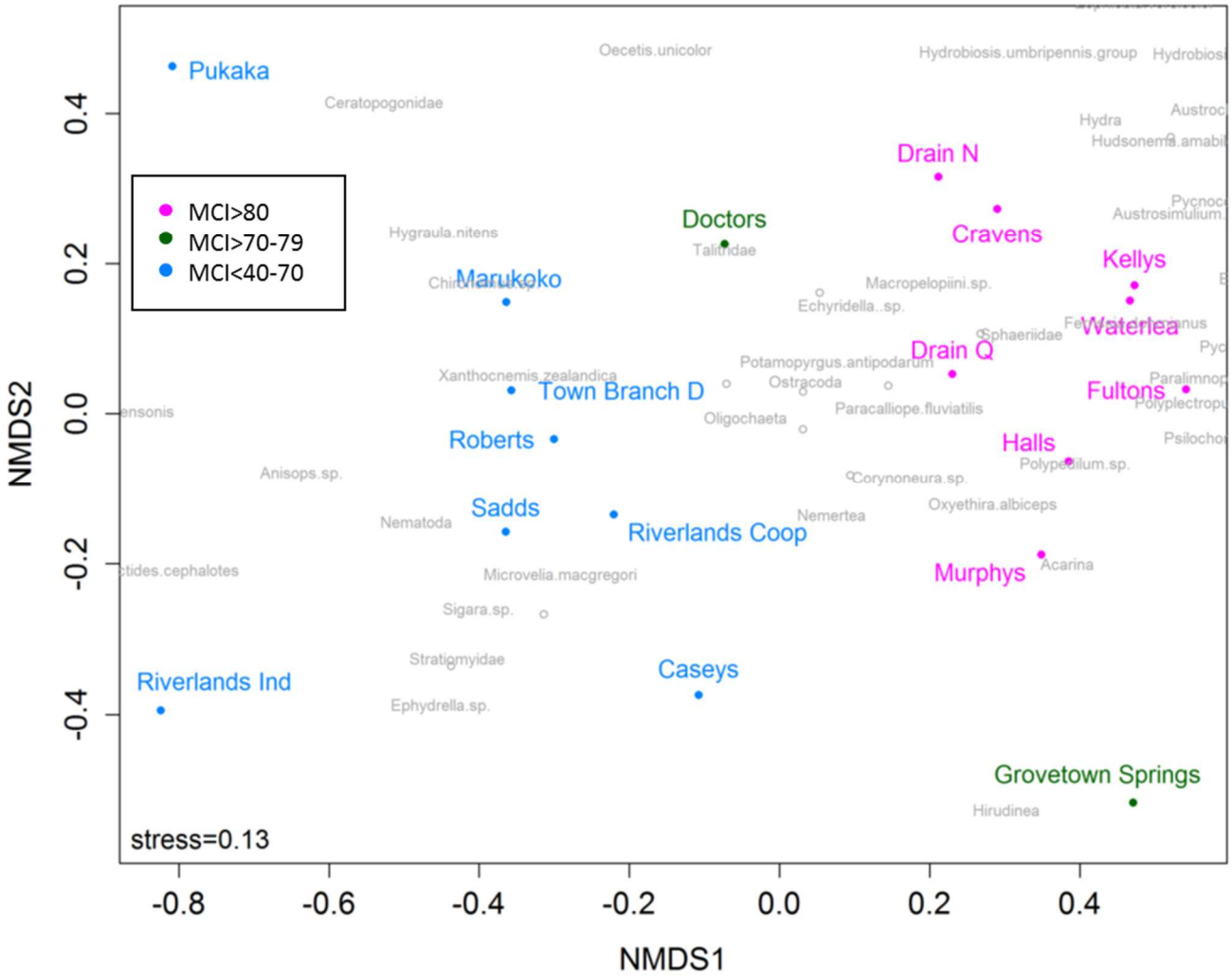


Figure 10: Nonmetric multidimensional scaling (NMDS) ordinations of sampling sites using macroinvertebrate presence absence data from 18 sites. Sites with very similar macroinvertebrate communities cluster close together, whereas sites that have different communities are more scattered.

Grading assigned to macroinvertebrate sampling sites were largely driven by MCI scores. Cravens, Fultons and Kellys were considered the best aquatic macroinvertebrate habitats of all sites and were assigned an A grade. The MCI scores were at least 90 and the sensitive EPT taxa contributed at least 28% of the biodiversity. These sites generally had a more diverse assortment of habitat available due to a combination of good flow as well as submerged macrophytes and instream habitats such as tree roots or trailing vegetation available for macroinvertebrate colonisation.

Sites assigned a B grade included Drain N and Q, Halls, Murphys, and Waterlea, based on MCI scores between 80 and 89. These waterways were typically dominated by sand and silt but gravels, wood, moss and macrophytes provided a variety of habitats for macroinvertebrates. The macroinvertebrate community was moderately diverse at these sites but overall fewer EPT taxa were present (Waterlea was the exception) and therefore %EPT was on average lower than sites with an A grade.

C grades were assigned to Caseys, Doctors, Grovetown Lagoon, Marukoto, Roberts, Sadds and Town Branch Drain. Although these sites were moderately diverse, the MCI scores ranged from 55–78 and were collectively indicative of 'poor' water quality. The bed of these waterways were completely covered by fine silt, and largely dominated by tolerant non-insect taxa such as worms, ostracods, amphipods and snails.

Riverlands Co-op, Riverlands Industrial and Pukaka were assigned D grades based on MCI scores less than 54 signifying severely degraded conditions. The presence of water boatmen and backswimmers, mosquito larvae, damselflies and a diverse beetle fauna were indicative of pond like conditions at these sites. A lack of flow, high nutrient loading and habitat quality too poor to support sensitive species meant these sites were also characteristically dominated by tolerant fauna such as worms and snails.

3.6 Fish

Only one new species **rainbow trout** (*Oncorhynchus mykiss*) was found in the 2016 survey compared with the 2002 survey. The only other record for rainbow trout in the Wairau catchment was in 1969 in the Wairau River by Spring Creek (NZFFD). Rainbow trout were caught by electric fishing at two sample sites (Table 5); three juvenile fish (<100 mm, Appendix F) were caught at Halls and one larger fish (300 mm) at Waterlea. Rainbow trout are rare in this catchment, which is regarded as more of a brown trout fishery when it comes to sports fish. However, rainbow trout are becoming more common in the area with several adult releases in the Branch River (tributary of the Wairau River) from 2009 onwards and there has always been a remnant population in the Wairau and Opawa systems (pers. comm. Vaughan Lynn, Fish and Game Marlborough).

Table 5: Fish species and koura present at sites sampled. Grey cells are sites that were dry in 2016. * Denotes site not sampled for fish in 2002.

	Species present 2002 (blue), 2016 (orange) and both 2002 and 2016 (yellow)									Method used 2016		
Site	**Shortfin eel**	**Longfin eel**	**Inanga**	**Common bully**	**Giant kokopu**	**Black flounder**	**Brown trout**	**Rainbow trout**	**Koura**	**Spotlighting**	**Electric fishing**	**Fykes**
Site 1 - Pipitea North	2002											
Site 2 - Pukaka*	2016 (o)		2016 (c)	2016 (o)						100m		
Site 3 - Roberts	Both (c)	2016 (o)	Both (c)	Both (r)		2016 (r)	2002		Both (c)	100m		
Site 4 - Sadds	Both (c)		2016 (c)	Both (o)						25m		
Site 5 - Drain N	Both (r)	Both (r)	2002	Both (r)	2002		Both (o)		Both (c)	100m		
Site 6 - Drain Q	Both (r)	2016 (r)		2002	2002				2002	100m		
Site 7 - Pipitea South*	2016 (c)											5
Site 8 - Marukoko	Both (a)	Both (o)	Both (a)	Both (c)						100m		5
Site 9 - Grovetown Springs	Both (c)	2016 (c)	Both (c)	Both (c)							100m	2
Site 10 - Kellys	Both (a)	Both (c)	Both (o)	Both (a)		2016 (o)	Both (o)		Both (a)		100m	
Site 11 - Waterlea	Both (a)	2016 (c)					2016 (o)	2016 (r)	Both (c)		100m	
Site 12 - Fultons	Both (o)	Both (r)	Both (o)	Both (c)			Both (o)		Both (c)	100m		
Site 13 - Caseys	Both (r)		Both (c)				2002		Both (o)	100m		
Site 14 - Woolley & Jones	2002											
Site 15 - Murphys	Both (o)	Both (r)	2002	Both (o)					2016 (o)	100m		
Site 16 - Doctors	Both (a)	Both (o)	Both (c)	Both (c)					2016 (c)		100m	
Site 17 - Yelverton	2002											
Site 18 - Riverlands Industrial	2016 (o)										100m	
Site 19 - Riverlands Co-op	Both (a)	2016 (o)	Both (a)	Both (o)						100m	20m	
Site 20 - Town Branch	Both (a)	2016 (o)	Both (c)	Both (r)						100m	20m	
Site 21 - Jeffreys	Both (o)			2016 (o)						100m		
Site 22 - Fairhall	2002		2002						2002			
Site 23 - Cravens	Both (c)	Both (c)	Both (o)	2016 (o)	2016 (r)		Both (o)		Both (o)	100m		2
Site 24 - Halls	Both (a)	Both (o)	Both (o)	Both (r)		2002	Both (o)	2016 (o)	Both (c)		100m	

Shortfin eels (*Anguilla australis*) occurred at all sites (rare to abundant, Table 5, Figure 11 in 2016, including Pukaka and Pipitea South that were not sampled in 2002. Shortfin eels were also found at Riverlands Industrial but were not recorded at this site in 2002. Shortfin eels were that only species found at Riverlands Industrial and Pipitea South as DO at both these site was low (Figure 4). Jeffreys also had a low DO and only shortfin eels and common bullies (*Gobiomorphus cotidianus*) occurred at this site in low numbers (occasional). It is not uncommon to find shortfin eels in waters with low DO and high suspended sediment as shortfins prefer mud and silt substrates and static water (Jellyman 1977, 1979) and do not penetrate as far inland as longfin eels. Shortfins were abundant to common at 12 of the 20 sites sampled. Shortfins were present but rare at three sites, Drain N, Drain Q and Caseys. However, this may be due to the sampling method used at these sites (spotlighting) compared to sites that were electric fished or netted as significantly more eels were caught via these methods compared to spotlighting (David and Hamer 2010) so eels are likely to be under represented at spotlighting sites.

Longfin eels (*Anguilla dieffenbachii*) occurred at 14 of the 20 sites (rare to common, Table 5) in 2016 compared with 8 sites recorded in 2002. Longfin eels are less likely to occur in these lowland sites than shortfin eels as their habitat preferences are slightly different. Longfins prefer water with higher concentrations of DO and longfin elvers prefer substrates of coarse gravel and rock (Jellyman 1977 and 1979), while Hayes at al. (1989) found a negative association with longfin eels and silt. Hence longfin eels are not found at many sites with low water velocities (Figure 12), low DO and high silt loads such as Riverlands industrial, Pipitea South and Jeffreys. However is likely that longfin eels would be found at Pukaka, Sadds and Caseys if other methods than spotlighting were used (i.e., electric fishing and/or netting).

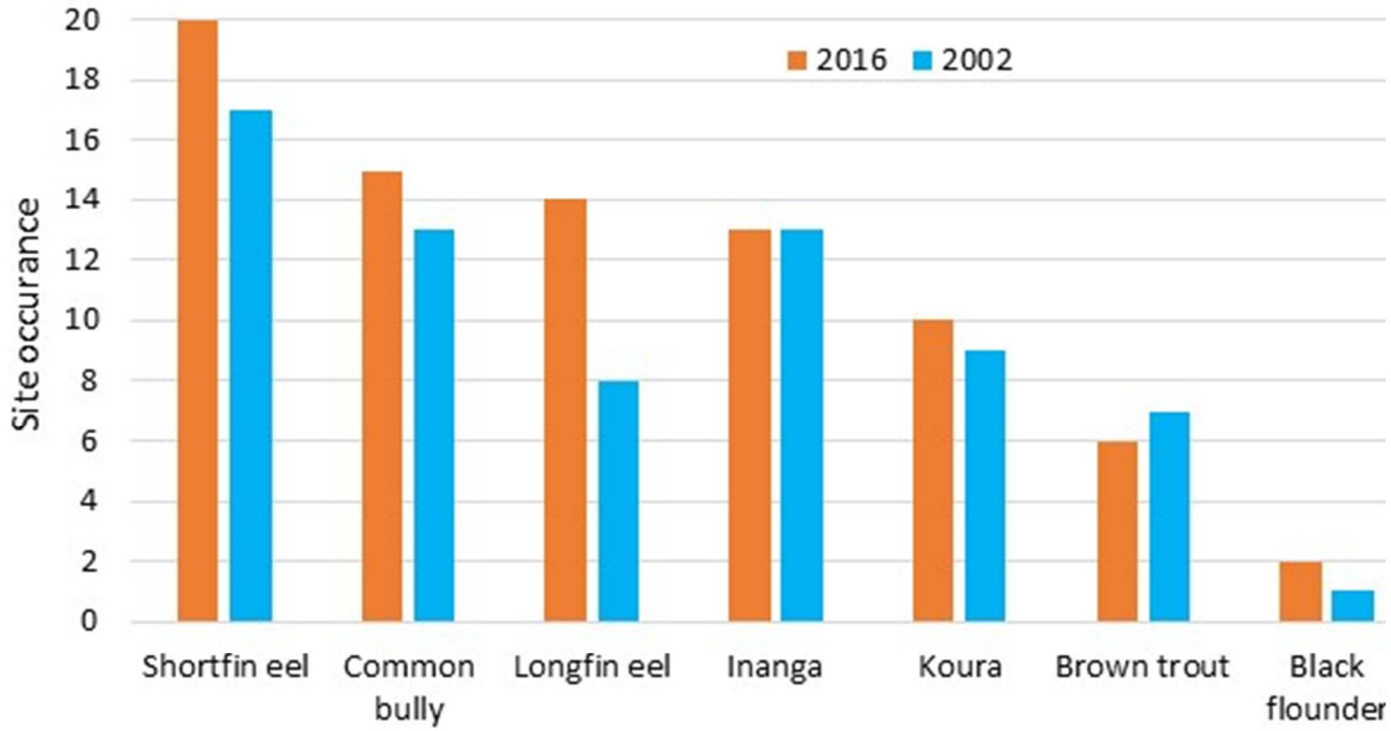


Figure 11: Species presence at all 20 sites sampled 2016 and 2002.

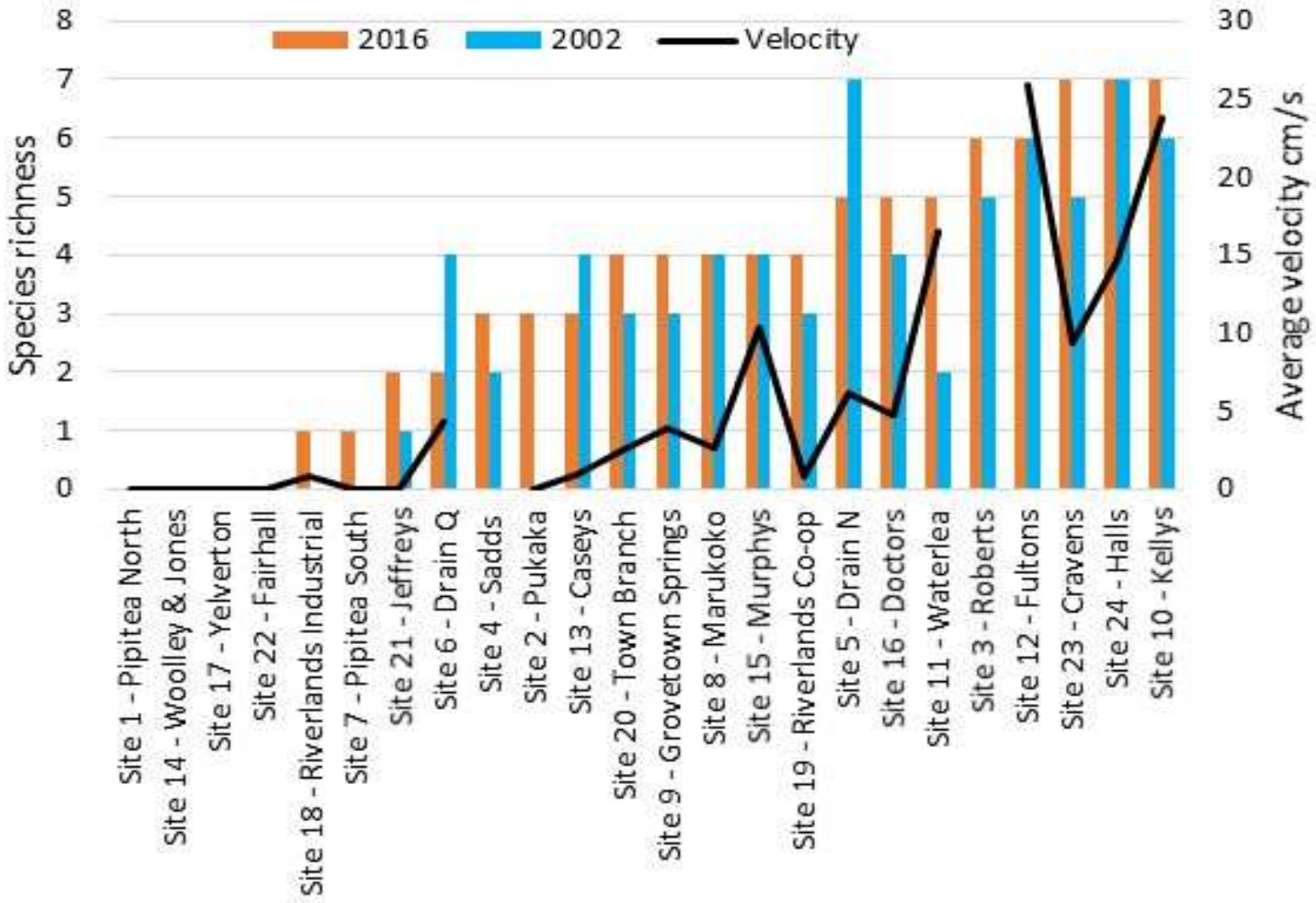


Figure 12: Species richness 2016 and 2002 compared with the average 2016 velocity (cm s^{-1}). No velocity readings were taken at Sadds, and while Roberts had zero flows at the time of the survey this may have been due to tidal conditions.

Figure 13: Large longfin eel (1100 mm) caught by electric fishing at Doctors.

Inanga (*Galaxias maculatus*) were found at 13 of the 20 sites (occasional to abundant, Table 5) which is the same number of sites found in 2002 (excluding dry sites). However, in 2016 inanga were found at Pukaka, which was not sampled in 2002, and Sadds, where no inanga were recorded in 2002. The latter difference may have been due to shifting the sampled site downstream of the 2002 sampling site because it was dry in 2016, and employing a different method (spotlighting).

As in 2002 no inanga were found at sites with little or no flow (Figure 12) and with low DO; Riverlands industrial, Jefferys, and Pipitea South which was not sampled in 2002, can been included in this low DO category. No inanga were found within the sampling reach at Murphys (present 2002) but were observed approximately 800 m downstream and would be expected at this site. Also no inanga were found at Drain N (present 2002) despite good habitat for inanga (i.e., flow, depth, water quality and cover) so it is likely they are in the system but were not encountered during sampling. As in 2002 no inanga were found at Drain Q and Waterlea. A stepped weir and floodgate downstream of the sampling site at Waterlea may explain their absence here despite good habitat (flow and cover) and poor habitat (low flow and little cover) at Drain Q also may explain their absence at this site.

Common Bully (*Gobiomorphus cotidianus*) occurred at 15 of the 20 sites (rare to abundant) in 2016 compared to 13 sites in 2002 (Table 5). Common bullies were not present in 2002 at Jeffreys but were recorded in 2016 despite the low flow DO at this site. Common bullies were also found at Cravens (not present 2002), but in low numbers (two large adults, Figure 14). Common bullies were also present at Pukaka, which was not sampled in 2002. As in 2002 no common bullies were found at Waterlea and Caseys. The weir and floodgate are likely responsible for their absence at Waterlea.

Common bully are likely to be present at Caseys (as inanga are present indicating good connectivity). An increase in sampling reach size and a different survey technique (netting or electric fishing) would likely detect them.

Figure 14: Common bully (110mm) caught spotlighting at Cravens.

Only one **Giant kokopu** (*Galaxias argenteus*) was recorded in the 2016 survey at Cravens and was positively identified by spotlighting but not captured. Two fyke nets set the following night did not capture any kokopu. In the 2002 survey giant kokopu were recorded at both Drain N and Drain Q. In 2016 Drain Q was shallow with little macrophyte cover (Table 3) which may explain why no giant kokopu were detected at this site. There are only a handful of records for giant kokopu in the watercourses surveyed, however, it is likely they are present in several as Drain N, Roberts, Kellys, Fultons, Murphys and Halls have the right habitat and conditions for giant kokopu. However if targeting this species a much greater length of watercourse would need to be surveyed to confirm a population.

Black flounder (*Rhombosolea retiaria*) were found at Roberts and Kellys in 2016, and were recorded only at Halls in 2002. The two black flounder caught electric fishing at Kellys were 240 and 300 mm respectively (Figure 15) while a smaller individual was spotlighted at Roberts. Like giant kokopu it is likely this species will occur at other sites like Cravens, Marukoko and the possibly the lower end of Sadds if sampling effort was increased.

Figure 15: A 300mm black flounder caught at Kellys by electric fishing.

Brown trout (*Salmo trutta*) are common in the rivers and streams in the Marlborough region and have been found in most of the watercourses surveyed either in 2002 or 2016 (occasional, Table 5) that provide the right habitat of depth (<0.3 m) and flow (around 0.4 m s^{-1}, Jowett and Richardson 1995). Though not observed in 2016 at Roberts, an increase in effort is likely to reveal their presence at this site as well as others like Murphys, Marukoko and the lower end of Doctors. Brown trout were observed in Caseys in 2002 but none were observed in 2016 as this watercourse was running low with little flow and cover and was not considered good brown trout habitat in this condition. Several large adult brown trout were observed just below the confluence of the Grovetown Lagoon and the main-stem. The watercourse itself produced no trout but juvenile fish may be present as electric fishing was difficult at this watercourse because of large amounts of macrophytes.

Koura (*Paranephrops zealandicus*) were found at 10 of the 20 sites in 2016 (occasional to abundant, Table 5) compared with 9 sites in 2002 (Figure 11). As with common bully and giant kokopu, no koura were found in Drain Q yet they were recorded in 2002. Low flow and lack of macrophyte cover at this site may explain their absence in 2016. Koura were not observed at most of the low flow/velocity sites (Pukaka, Sadds, Drain Q, Pipitea South, Marukoko, Riverlands Industrial, Riverlands Co-op, Town

Branch and Jeffreys, Figure 12). It is likely that koura are present at Grovetown Lagoon but dense macrophytes at this location made sampling difficult.

Figure 16: Large koura sighted at Cravens.

The increase in fish species records for sites in 2016 compared to the 2002 survey (Table 5 and Figure 12) may well be the result of an increase in sampling effort. In 2016 electric fishing and spotlighting reaches were standardised to 100 m and fyke netting to reaches of 150 m per five fyke nets, compared to an unspecified reach length somewhere between 50 to 100 meters for electric fishing and spotlighting and an unspecified number of fyke nets in 2002. This increase in distance fished will likely increase the number of species caught (David and Hamer 2010).

Drier conditions were evident during the 2016 survey with several sampling sites not containing water. For many of the other sampling sites water depth was much lower in 2016 compared with the 2002 sampling. For example, the three watercourses that had a higher number of species caught in 2002 compared with the 2016 sampling (Figure 12) all had considerably lower water depths in 2016. For example, in 2016 Drain N, Drain Q, and Caseys all had mid-stream depths of 0.4, 0.15 and 0.38 m, respectively, compared with 0.80, 0.40 and 0.60 m respectively in 2002. These differences are likely to explain why depth and velocity sensitive species like inanga, giant kokopu and brown trout (Jowett and Richardson 1995, Jowett 2002) were not found in 2016 at certain sites compared with the 2002 sampling. All of the fish species present in the survey prefer habitat with some degree of flowing water with the exception of giant kokopu which prefers lower water velocities but deeper water (Jowett and Richardson 1995).

Fish diversity was generally higher at the sites with good depth, velocity, cover, temperature and dissolved oxygen, and lower at the sites where these variables were lacking. One variable in particular, water velocity (Figure 12), for fish in these types of systems highlights the importance of flowing water compared with stagnant or very slow moving water. Good water velocity is also an indicator that other instream conditions that are also likely to be present i.e., heathy ranges of dissolved oxygen, temperature and turbidity. Also these watercourses will have a greater diversity of

habitat in terms of flow, depth, substrate and cover resulting in a wider diversity of fish species being present compared to a watercourse that is shallow and with little flow. The only exemption to this trend is Riverlands Co-op where depth and average velocity were low and fish particularly inanga and shortfin eels were abundant. However the dissolved oxygen at this site was the highest of all of the sites (16.24 mg l^{-1}) offsetting low depth and velocity. It is likely that the large amounts of macrophytes just upstream of the Riverlands Co-op site are increasing the levels of dissolved oxygen during the day at this site.

A number of other fish species have been recorded as being present (NZFFD) in the lower Wairau catchment but were not recorded at sites in the current survey. These fish include Yelloweye mullet (*Aldrichetta forsteri*), lamprey (*Geotria australis*), banded kokopu (*Galaxias fasciatus*), giant bully (*Gobiomorphus gobioides*) and common smelt (*Retropinna retropinna*). For some sites restrictions on fish access (i.e., floodgates) might be expected to reduce fish diversity but as a whole most sites above floodgates still had species present that are sensitive to such restrictions.

Of the 20 sites sampled for fish, seven sites (Kellys, Halls, Cravens, Fultons, Roberts, Drain N and Murphys) are considered good habitat for fish (A grade) as the characteristics found at these sites (good water flow, depth, cover, substrate, DO) are conducive to many fish species and as a result the highest species diversity was found at these sites with the exception of Murphys and Drain N. However, these sites have been included in the A grade as the habitat found at these sites is suitable for several species not found in the 2016 survey (i.e., inanga and giant kokopu for both sites and trout for Murphys) but are likely to be present.

Four sites (Waterlea, Doctors, Marukoko and Grovetown Lagoon) were given a B ranking as species diversity was lower at these sites mainly due to poorer habitat being available. However, Waterlea did generally have good fish habitat but access may be an issue here with a stepped weir and floodgate just downstream of the sampling site.

A 'C' grading was given to seven sites (Riverlands Co-op, Town Branch, Caseys, Pukaka, Sadds, Drain Q and Jeffreys) which were a level below the B sites in term of fish habitat (smaller depth ranges, poor water velocities and cover, lower DO and higher turbidity levels) resulting in fewer species found at these sites. Pukaka and Jefferys although presenting poor habitat for fish were included in the C category because two or more fish species were found at these sites albeit in low numbers for Jeffreys.

Two sites (Riverlands Industrial and Pipitea South) are ranked as D sites as only one fish species (shortfin eels) were found and habitat was poor.

4 Discussion

This single 2016 assessment of ecological condition is limited, for instance, there is no longitudinal overview of each system and only one temporal measure. Nevertheless, the results are sufficient to draw broad comparisons with the single assessment results at the same sites in 2002 (Young et al. 2002).

We also note that the method of ecological ranking employed by Young et al. (2002) is not provided in detail, and there is no widely recognised methodology to assess ecological condition for small, soft bottomed watercourses. Our approach has been to grade each assessed component independently, as concluded in sections 3.1 to 3.6, to generate the overall rankings provided in Table 6.

Our ecological rankings show the best overall ecological condition in the sites at Cravens, Halls and Murphys (1st ranked, Table 6). Also near the top end of ecological condition (2nd ranked) were Drain N, Kellys and Fultons (Table 6).

More intermediate overall condition (3rd ranked) were Marukoko, Grovetown Lagoon, Drain Q and Waterlea, which were judged slightly better condition than Roberts, Caseys, Doctors, Riverlands Co-op and Town Branch (4th ranked, Table 6).

Poorest ecological condition (5th ranked) amongst the assessed watercourses was assigned to Pukaka, Sadds (but note limited assessment), Pipitea South, Riverlands Industrial and Jeffreys. The default lowest ranking (6th ranked) was for those watercourses that had no aquatic habitat available at the time of the survey, which were Pipitea North, Woolley and Jones, Yelverton and Fairhall.

Compared with the six ranking levels given by Young et al. (2002), there are strong similarities between surveys (Figure 17). Cravens and Halls have remained in the top ranking, with Kellys still one tier down from best. Watercourses that have remained in a medium condition (our ranking at 3) are Grovetown Lagoon and Waterlea, with Town Branch and Riverlands Co-op still ranked one tier lower. Jeffreys is still recognised in poor condition (our ranking at 5).

The inclusion of a 6th rank solely for watercourses that were dry in 2016 represents the most obvious change since 2002 (Figure 17). Previously Fairhall and Yelverton were in medium condition (rank 3), Woolley and Jones at rank 4 and Pipitea North in poor condition (rank 5). In 2002 Riverlands Industrial and Pipitea South were listed in very poor condition with limited values. In 2016 they were again at the lowest ranking (rank 5) for waterbodies that were wet and could be assessed.

Most other changes in ecological ranking between 2002 and 2016 were minor involving movement of watercourses by 1 rank only. Murphys and Fultons had improved by one position, while Drain N, Doctors, Caseys, Roberts and Sadds (limited assessment) had deteriorated by one position. The exceptions were Drain Q, Marukoko and Pukaka, which all dropped by two positions in ranking between 2002 and 2016.

Marukoko was considered to have relatively poor water quality in 2002, but macroinvertebrates and fish communities were graded higher than other sites with poor water quality, and this watercourse had a large water flow in 2002. Consequently it was included with the highest ranked sites in 2002. In 2016 water flows, macrophytes and fish were graded fairly favourably, but water quality and macroinvertebrates were low graded, possibly due to water level and flow control being exercised here by MDC due to dry summer conditions.

Table 6: Grading of independently assessed components of ecological condition and an overall ranking for 24 watercourses on the Wairau Plains.

Site	Watercourse	Hydrology	Water quality	Macrophytes	Riparian condition	Macro-invertebrates	Fish	Ranking
1	Pipitea Nth	D	-	-	-	-	-	6
2	Pukaka	C	C	D	C	D	C	5
3	Roberts	B	B	B/C	C	C	A	4
4	Sadds	D	-	-	-	C	C	5
5	Drain N	B	A	A	B	B	A	2
6	Drain Q	B	B	A	B	B	C	3
7	Pipitea Sth	C	D	C	D	-	D	5
8	Marukoko	A	C	A	C	C	B	3
9	Grovetown Lagoon	A	A	C	B	C	B	3
10	Kellys	A	A	B	C	A	A	2
11	Waterlea	A	A	B	C	B	B	3
12	Fultons	A	B	B	B	A	A	2
13	Caseys	B	A	C	C	C	C	4
14	Woolley & Jones	D	-	-	-	-	-	6
15	Murphys	A	B	A	A	B	A	1
16	Doctors	A	B	B	C	C	B	4
17	Yelverton	D	-	-	-	-	-	6
18	Riverlands Industrial	C	D	D	C	D	D	5
19	Riverlands Co-op	B	C	C	C	D	C	4
20	Town Branch	A	C	D	D	C	C	4
21	Jeffreys	B	D	D	D	-	C	5
22	Fairhall	D	-	-	-	-	-	6
23	Cravens	A	A	B	A	A	A	1
24	Halls	A	A	B	A	B	A	1

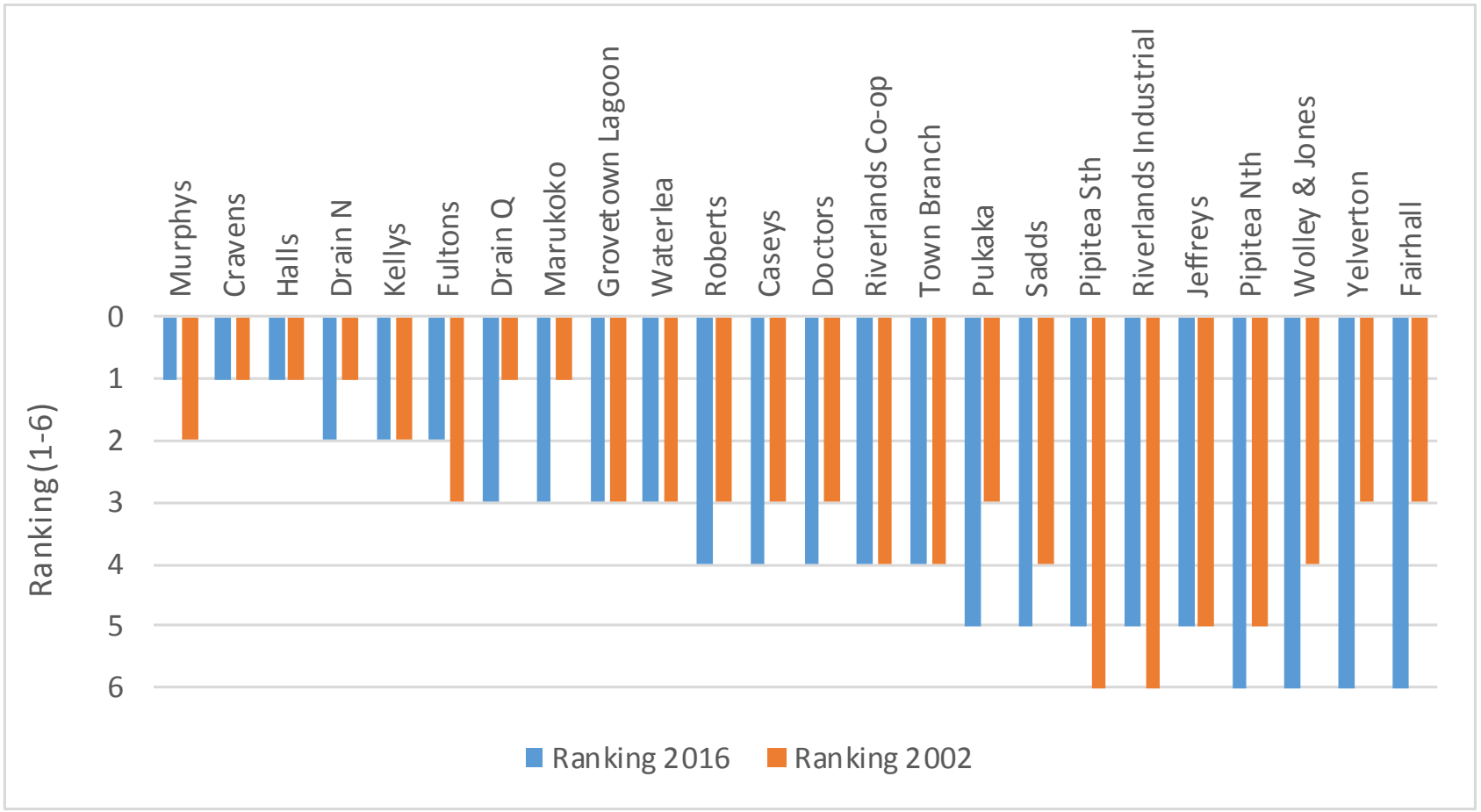


Figure 17: Comparison of ecological rankings for watercourses from best (1) to worst (6) in 2016, and as assessed in 2002 by Young et al. (2002).

It is thought that reduced water depth, flows and poorer habitat at Drain Q in 2016 lowered the grading for fish from 2002, with similar results at Drain N and Caseys, which also showed a slight deterioration.

In 2002 Pukaka was also assessed with poor water quality, but had "a range of relatively sensitive (macroinvertebrate) taxa". By 2016 the MCI score had decreased by 24.2 points. Pukaka was not fished in 2002, but had a relatively poor community present in 2016.

None of the watercourses of the Wairau Plains would be considered to have high ecological values as they have modified channels, are heavily silted and develop excessive in-channel vegetation. These watercourses are managed by MDC primarily to ensure drainage, however, ecological benefits may be maximised.

The 2016 survey documented high levels of fine silt/sand accumulated in the watercourse channels and an average depth of ≤0.19 m in ten of the watercourses. The indications are that fine sediments are aggrading within the drainage systems to the detriment of instream values. The removal of instream sediment by MDC and the deepening of drainage systems as a specific ongoing programme of works could benefit instream values.

Ongoing herbicide applications by MDC is likely prevent a build-up of excessive vegetation that can impact on instream ecological values. However, moderate levels of vegetation are likely to afford habitat for biota. Suggested CAV and SA recommendations (Matheson et al. 2012) may be used to guide the need for, and timing of herbicide application. Another aim should be to reduce the extent and influence of exotic invasive weeds. In this respect we note that recent channel vegetation maintenance by diquat appears to have reduced the occurrence of invasive submerged weeds *Egeria densa*, *Lagarosiphon major*, and *Elodea canadensis*, with likely beneficial increase in native plants that these weeds would have replaced.

5 Conclusions

The majority of watercourses showed minor to moderate deterioration in ecological condition since 2002. The main driver of change is a general drying of watercourses and reduction in their water depth and flow. There is evidence that water supply to the watercourses was reduced at the time of the 2016 survey. Flows in the spring-fed system Spring Creek (Appendix G), which is indicative of the baseline flow regime on the Wairau Plains, show a summer drought at the time of the March 2016 sampling that resulted in flows reduced to 66% that of flows in 2002. In addition, a small but constantly declining trend in aquifer levels has been identified over the past decade (Wöhling et al. 2016). Reduced water availability was most apparent in the lowest ecological rankings for the four watercourses that were dry in 2016. A secondary influence on watercourse deterioration since 2002 may be water quality reduction at select sites, although we note that our water quality assessment is 'snap shot' in nature and additional sampling would be needed to identify trends.

Apparent stream bed aggradation would indicate that further targeted studies of the long term effects on instream values of removal of sand /silt and deepening of water depth of discrete drainage reaches is warranted.

Although a number of watercourses exceeded recommended in-stream vegetation development, the 2016 survey documented a reduction in the occurrence of invasive submerged weeds that is likely attributable to the continuing herbicide application programmes of MDC. Ongoing vegetation management is recommended to retain moderate amounts of diverse macrophytes while preventing high channel occupancy or surface coverage of watercourses.

6 Acknowledgements

Many thanks to Roger Fitzgerald and Steve Bezar (MDC) for co-ordinating access and orientating the team. We appreciate the comments of Roger Fitzgerald (MDC) and Gavin Cooper (GDC Consulting Ltd) aimed at improving the clarity of this report. Many thanks to the land owners who provided our team with access to the watercourses.

7 References

MfE (2003) Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas. Ministry for the Environment: 159.

Clarke, K.R., Warwick, R.M. (2001) Change in Marine Communities: An Approach to Statistical Analysis and Interpretation. *PRIMER-E*, Plymouth, UK. 2nd edition: 172.

Collier, K.J., Kelly, J. (2005) Regional guidelines for ecological assessments of freshwater environments: macroinvertebrate sampling in wadeable streams. *Environment Waikato Technical Report,* 2005/02. Hamilton, Waikato Regional Council (Environment Waikato).

Cowley, D.R. (1978) Studies on the larvae of New Zealand Trichoptera. *New Zealand Journal of Zoology,* 5(4): 639-750.

David, B., Hamer, M. (2010) Regional Guidelines for Ecological Assessments of Freshwater Environments – Standardised Fish Monitoring for Wadeable Streams. *Environment Waikato Technical Report*, 2010/09.

Davies-Colley, R., Franklin, P., Wilcock, R., Clearwater, S., Hickey, C. (2013) National objective framework – temperature, dissolved oxygen and pH. Proposed thresholds for discussion. *NIWA Client Report* HAM2013-056, MFE13504.

Hayes, J.W., Leathwick, J.R., Hanchet, S.M. (1989) Fish distribution patterns and their association with environmental factors in the Mokau River catchment, New Zealand. *New Zealand Journal of Marine and Freshwater Research, 23:* 171-180.

Jellyman, D.J. (1977) Summer upstream migration of juvenile freshwater eels in New Zealand. *New Zealand Journal of Marine and Freshwater Research,* Vol. 11: 71-71.

Jellyman, D.J. (1979) Upstream migration of glass-eels (Anguilla spp.) in the Waikato River. *New Zealand Journal of Marine and Freshwater Research,* Vol. 13: 13-22.

Jowett, I.G. (2002) In-stream habitat suitability criteria for feeding inanga (*Galaxias maculatus*) *New Zealand Journal of Marine and Freshwater Research,* 36: 399-407.

Jowett, I.G., Richardson, J. (1995) Habitat preferences of common, riverine New Zealand native fishes and implications for flow management. *New Zealand Journal of Marine and Freshwater Research,* 29: 13-23.

Marlborough District Council Assets and Services Department (2008) Code of Practice for the application of herbicide and associated additives into and over water. Version 1.1: 53.

Matheson, F., Quinn, J., Hickey, C. (2012) Review of the New Zealand instream plant and nutrient guidelines and development of an extended decision making framework:

Phases 1 and 2 final report. *NIWA Client Report* No: HAM2012-081, prepared for the Ministry of Science & Innovation Envirolink Fund: 127.

Maxted, J.R., Evans, B.F. (2003) Development of standard protocols for macroinvertebrate assessment of soft-bottomed streams in New Zealand. *New Zealand Journal of Marine and Freshwater Research,* 37: 793–807.

Oksanen, J.F., Blanchet, G., Kindt, R., Legendre, P., Minchin, P.R., O'Hara, R.B., Simpson, G. L., Solymos, P., Henry, M.H.H.S., Wagner, H. (2015) *Vegan: Community Ecology Package*. R package version 2.3-0. http://CRAN.R-project.org/package=vegan.

Stark, J.D. (1998) SQMCI: a biotic index for freshwater macroinvertebrate coded-abundance data. *New Zealand Journal of Marine and Freshwater Research,* 32:55-66.

Stark, J.D., Maxted, J.R. (2007) A user guide for the Macroinvertebrate Community Index. Prepared for the Ministry for the Environment. *Cawthron Report,* No. 1166: 58.

Stark, J.D., Boothroyd, I.K.G., Harding, J.S., Maxted, J.R., Scarsbrook, M.R. (2001) Protocols for sampling macroinvertebrates in wadeable streams. New Zealand Macroinvertebrate Working Group Report No. 1. Prepared for the Ministry for the Environment. *Sustainable Management Fund Project*, No. 5103: 57. http://www.cawthron.org.nz/media_new/publications/pdf/2013_09/protocols-full-manual.pdf

Towns, D.R., Peters, W.L. (1996) Leptophlebiidae (Insecta: Ephemeroptera). *Fauna of New Zealand*, 36: 144.

Winterbourn, M.J. (1973) A guide to the freshwater Mollusca of New Zealand. *Tuatara*, 20: 141–159.

Winterbourn, M.J., Gregson, K.L.D. & Dolphin, C.R. (2006) Guide to the Aquatic Insects of New Zealand. *Bulletin of the Entomological Society of New Zealand,* 14: 108.

Wöhling, T., Gosses, M., Davidson, P., Wilson, S. (2016) Analysis of long-term groundwater storage trends in the Wairau aquifer, New Zealand. *Geophysical Research Abstracts,* 18. http://meetingorganizer.copernicus.org/EGU2016/EGU2016-5922.pdf

Young, R., Crowe, A., Strickland, R. (2002) Ecological Assessments of Spring-Fed Streams on the Wairau Plain. *Cawthron Report*, No. 737. Prepared for Marlborough District Council. 32 pp plus Appendices. http://www.marlborough.govt.nz/Environment/Rivers-and-Wetlands/Reports/~/media/Files/MDC/Home/Environment/Rivers%20and%20Wetlands/EcologyOfWairauSprings2002.ashx

Appendix A Site summary

The following pages present a summary description of the physical features of each of the sampled watercourses. Not included here are the dry sites:

1 Pipitea North

4 Sadds

14 Woolley & Jones

17 Yelverton

22 Fairhall

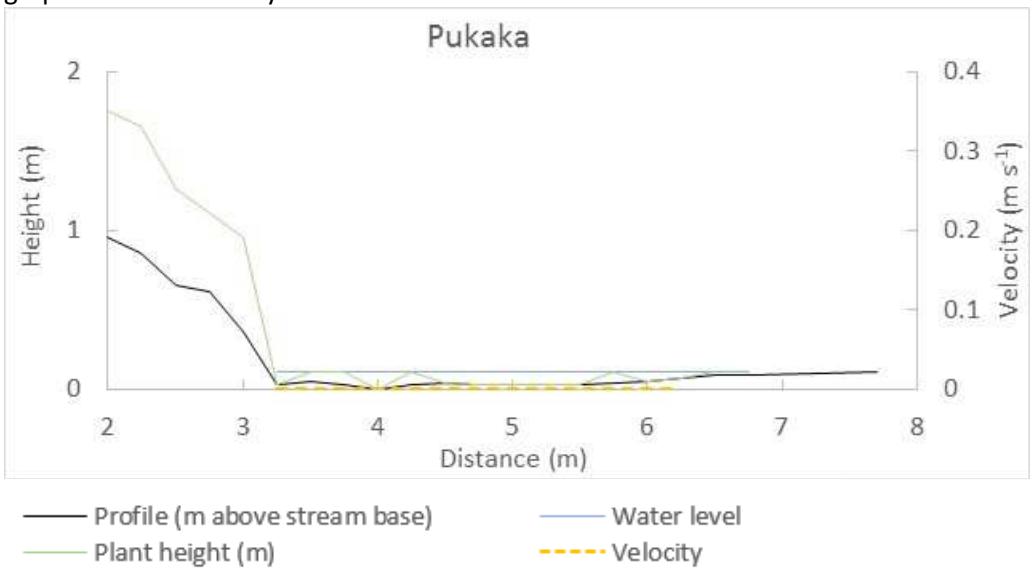
Not that the sample site for Pukaka was shifted downstream from the 2002 baseline due to denied access.

2 Pukaka

Sampling date and GPS references for profile sites

Date	NZTM grid ref
8/03/2016	1683768E 5409354N

Cross-section profile showing ground height, water level, stream bed depth and plant height and graphed water velocity



Watercourse summary data

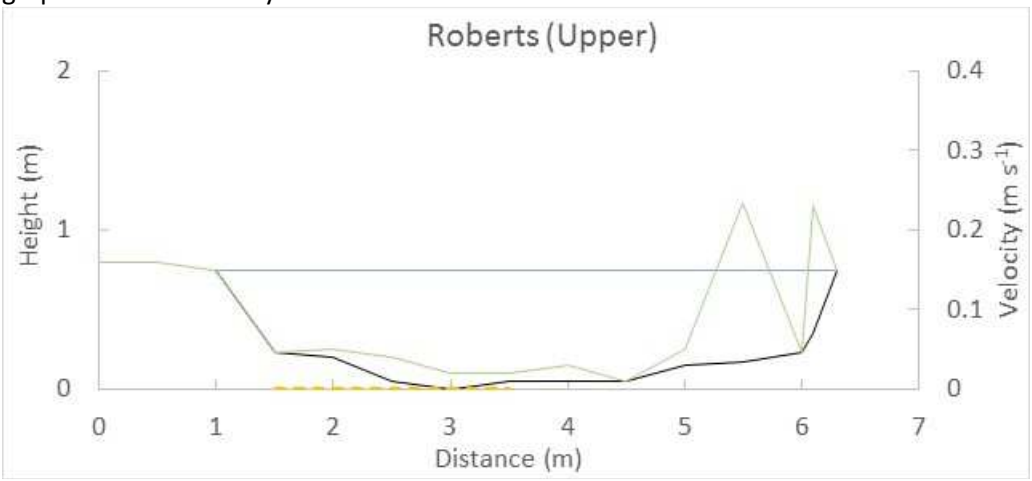
Watercourse width (m)	Maximum depth (m)	Average depth (m)	Maximum velocity (m s^{-1})	Mean velocity (m s^{-1})	Cross-sectional area (m^2)	Estimated discharge (m^3 s^{-1})
3.5	0.11	0.07	0.00	0.000	0.24	0.0000

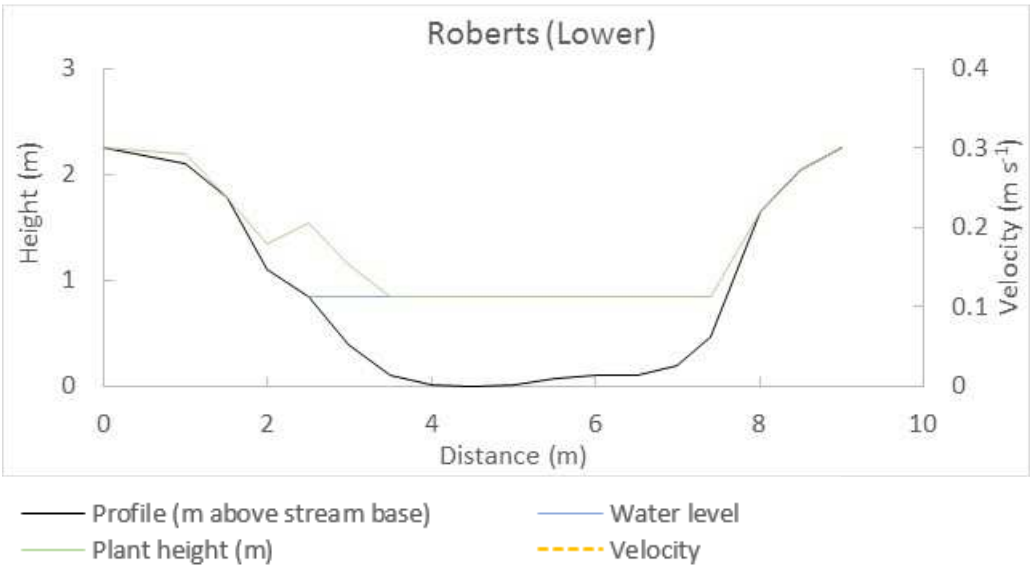
3 Roberts

GPS references for profile sites

	Date	NZTM grid ref
Upper	9/03/2016	1682853E 5407943N
Lower	9/03/2016	1682815E 5407886N

Cross-section profile showing ground height, water level, stream bed depth and plant height and graphed water velocity





Watercourse summary data

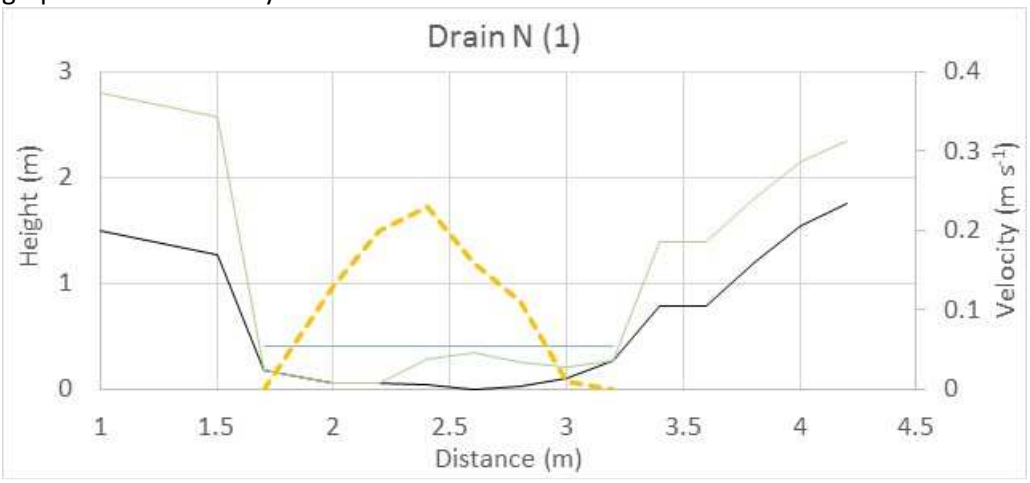
	Watercourse width (m)	Maximum depth (m)	Average depth (m)	Maximum velocity (m s^{-1})	Mean velocity (m s^{-1})	Cross-sectional area (m^2)	Estimated discharge (m^3 s^{-1})
Upper	4.6	0.75	0.61	0.00	0.000	2.81	0.0000
Lower	4.4	0.85	0.70	0.00	0.000	3.09	0.0000

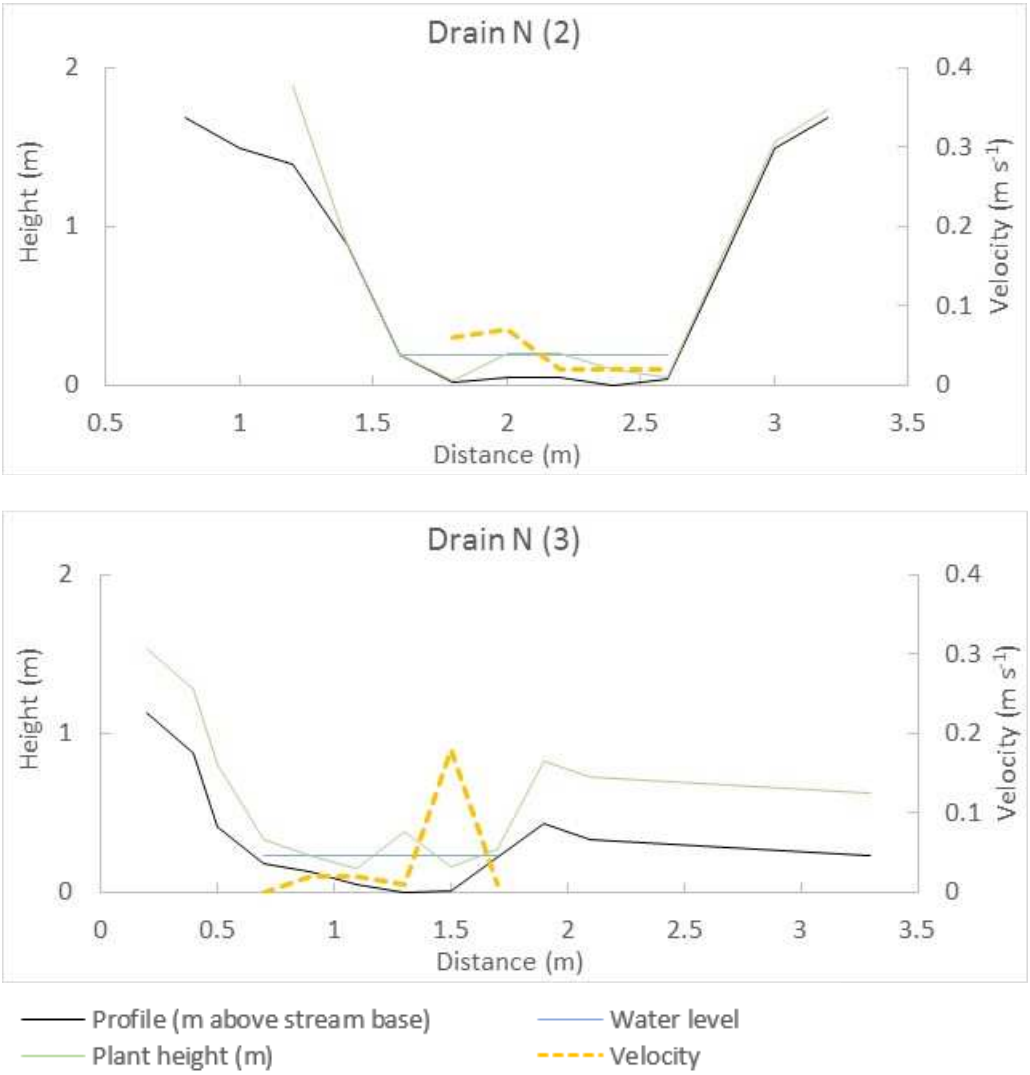
5 Drain N

GPS references for profile sites

	Date	NZTM grid ref
1	7/03/2016	1679480E 5407799N
2	8/03/2016	
3	8/03/2016	

Cross-section profile showing ground height, water level, stream bed depth and plant height and graphed water velocity





Watercourse summary data

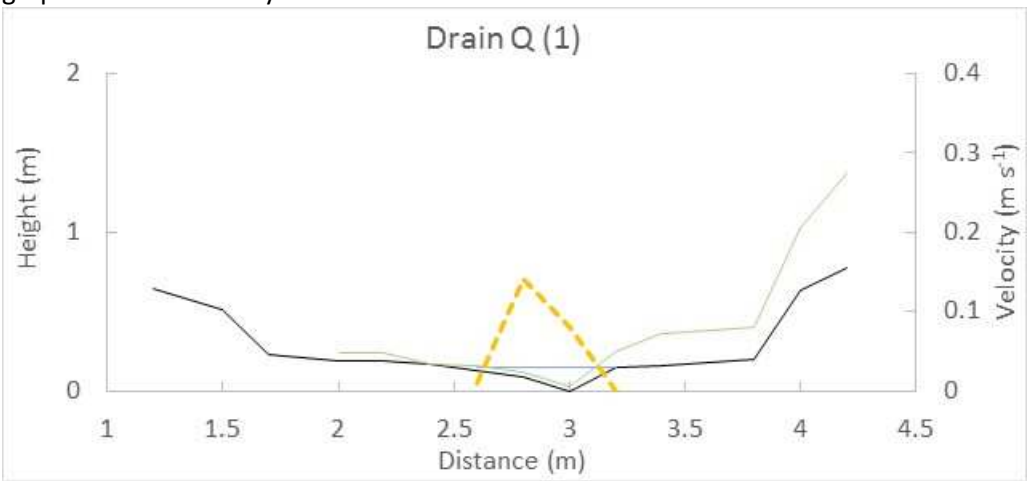
	Watercourse width (m)	Maximum depth (m)	Average depth (m)	Maximum velocity (m s^{-1})	Mean velocity (m s^{-1})	Cross-sectional area (m^2)	Estimated discharge (m^3 s^{-1})
1	1.4	0.12	0.09	0.14	0.044	0.13	0.0047
2	0.4	0.12	0.10	0.05	0.027	0.04	0.0009
3	0.4	0.15	0.08	0.14	0.058	0.03	0.0015

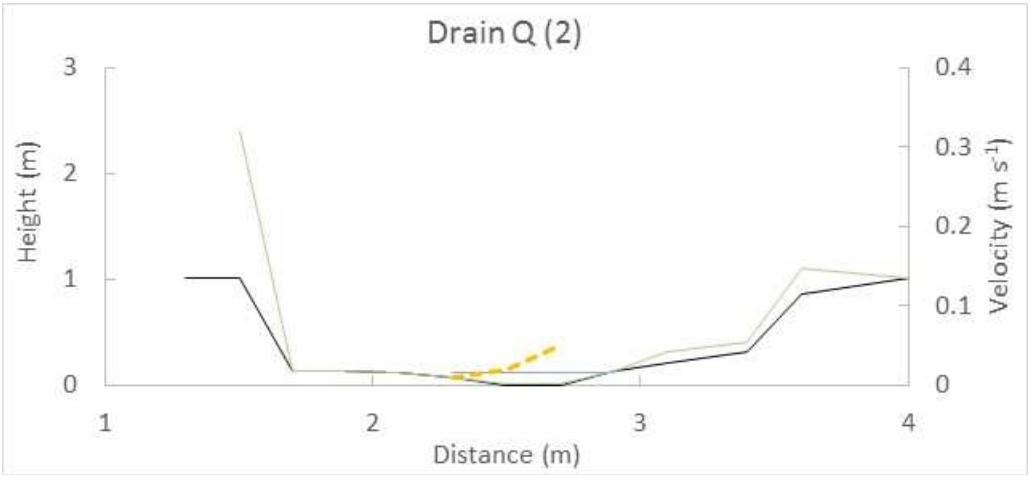
6 Drain Q

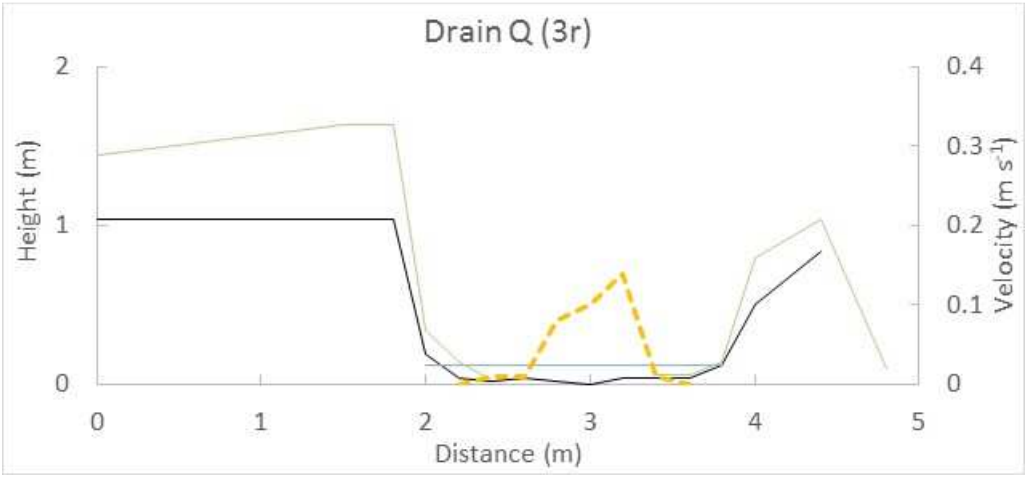
GPS references for profile sites

	Date	NZTM grid ref
1	8/03/2016	1680022E 5408157N
2	8/03/2016	1680040E 5408148N
3	8/03/2016	1680092E 5408170N

Cross-section profile showing ground height, water level, stream bed depth and plant height and graphed water velocity







Profile (m above stream base)
Water level
Plant height (m)
Velocity

Watercourse summary data

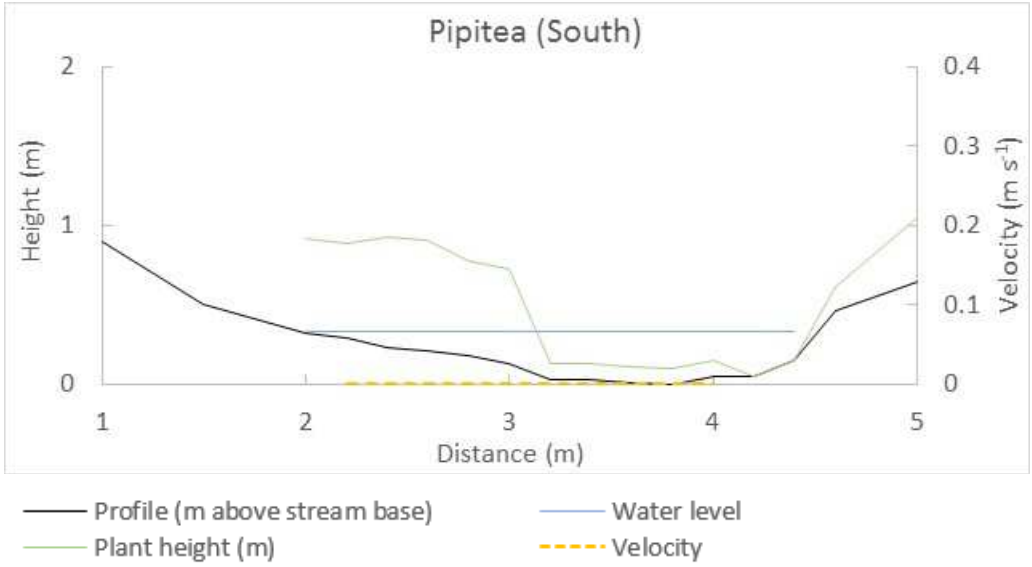
	Watercourse width (m)	Maximum depth (m)	Average depth (m)	Maximum velocity (m s^{-1})	Mean velocity (m s^{-1})	Cross-sectional area (m^2)	Estimated discharge (m^3 s^{-1})
1	1.0	0.23	0.13	0.18	0.040	0.13	0.0045
2	1.0	0.19	0.13	0.07	0.038	0.13	0.0043
3	1.5	0.4	0.31	0.23	0.105	0.46	0.0410

7 Pipitea South

GPS references for profile sites.

Date	NZTM grid ref
8/03/2016	1686052E 5406971N

Cross-section profile showing ground height, water level, stream bed depth and plant height and graphed water velocity



Watercourse summary data

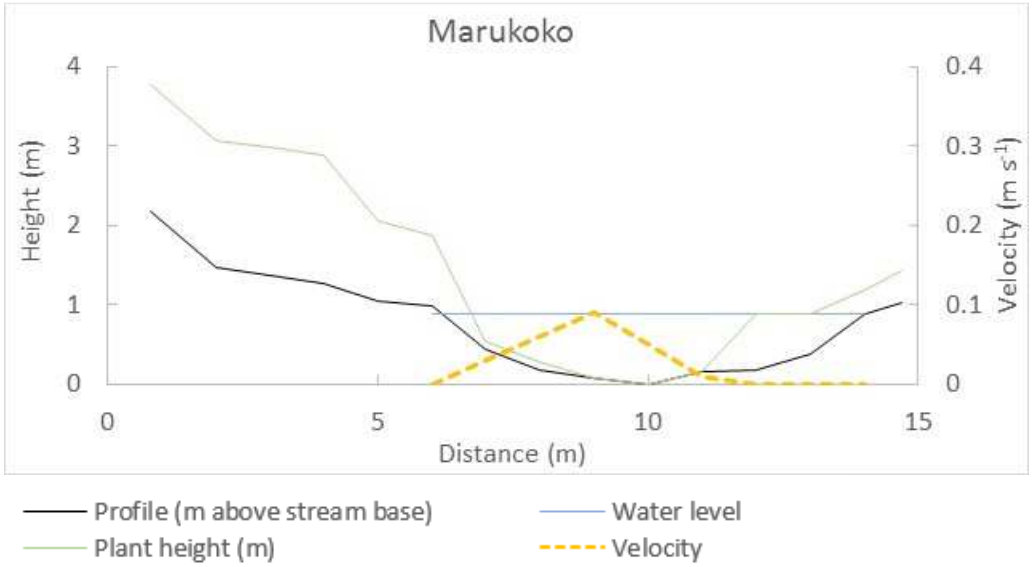
Watercourse width (m)	Maximum depth (m)	Average depth (m)	Maximum velocity ($m\ s^{-1}$)	Mean velocity ($m\ s^{-1}$)	Cross-sectional area (m^2)	Estimated discharge ($m^3\ s^{-1}$)
2.2	0.33	0.22	0.00	0.000	0.48	0.0000

8 Marukoko

GPS references for profile sites.

Date	NZTM grid ref
8/03/2016	1685938E 5406870N

Cross-section profile showing ground height, water level, stream bed depth and plant height and graphed water velocity



Watercourse summary data

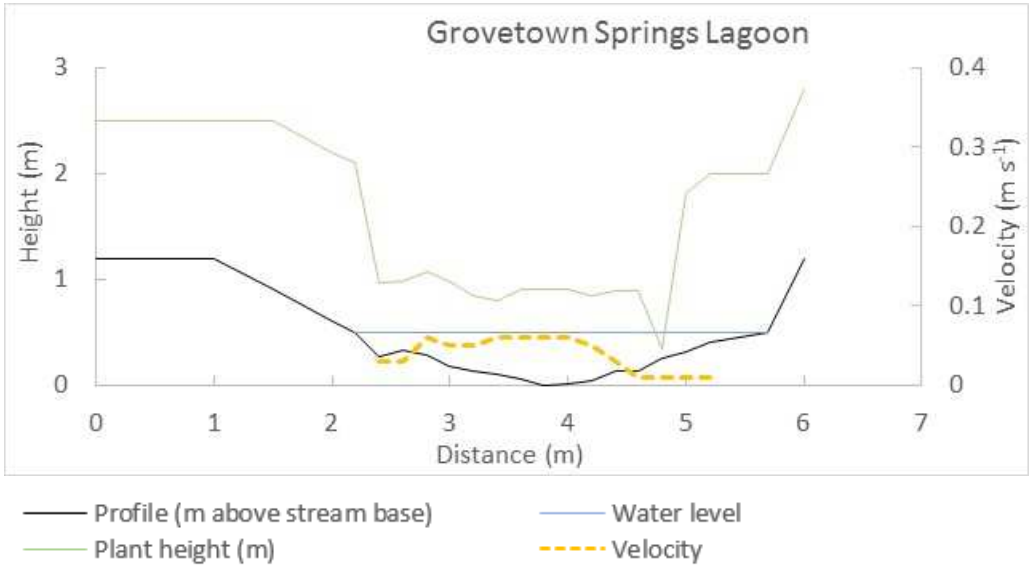
Watercourse width (m)	Maximum depth (m)	Average depth (m)	Maximum velocity (m s^{-1})	Mean velocity (m s^{-1})	Cross-sectional area (m^2)	Estimated discharge (m^3 s^{-1})
8.0	0.88	0.59	0.09	0.027	4.73	0.1072

9 Grovetown Springs Lagoon

GPS references for profile sites.

Date	NZTM grid ref
10/03/2016	1682151E 5408053N

Cross-section profile showing ground height, water level, stream bed depth and plant height and graphed water velocity



Watercourse summary data

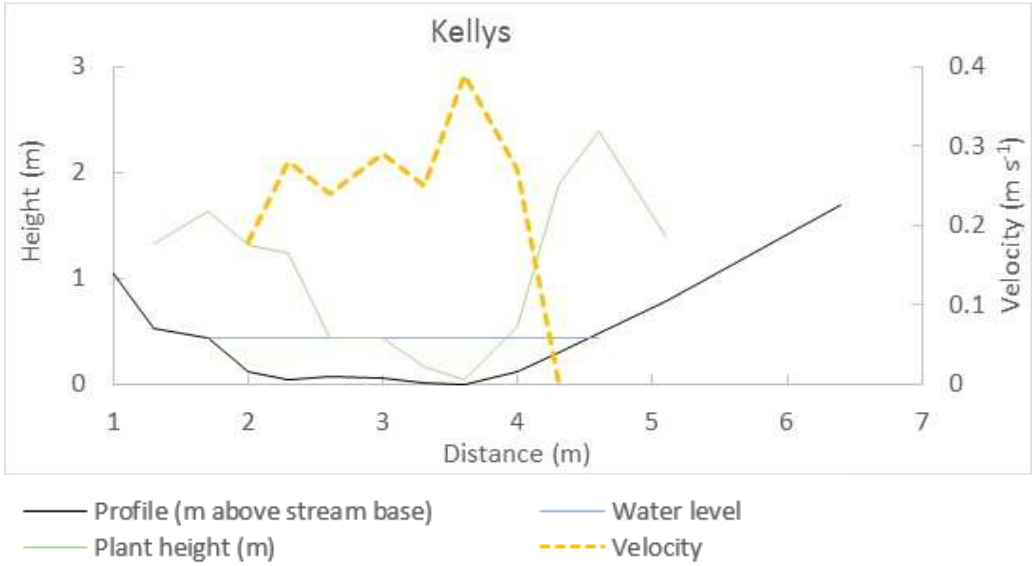
Watercourse width (m)	Maximum depth (m)	Average depth (m)	Maximum velocity (m s^{-1})	Mean velocity (m s^{-1})	Cross-sectional area (m^2)	Estimated discharge (m^3 s^{-1})
2.8	0.5	0.32	0.06	0.039	0.90	0.0297

10 Kellys

GPS references for profile sites.

Date	NZTM grid ref
9/03/2016	1680975E 5408304N

Cross-section profile showing ground height, water level, stream bed depth and plant height and graphed water velocity



Watercourse summary data

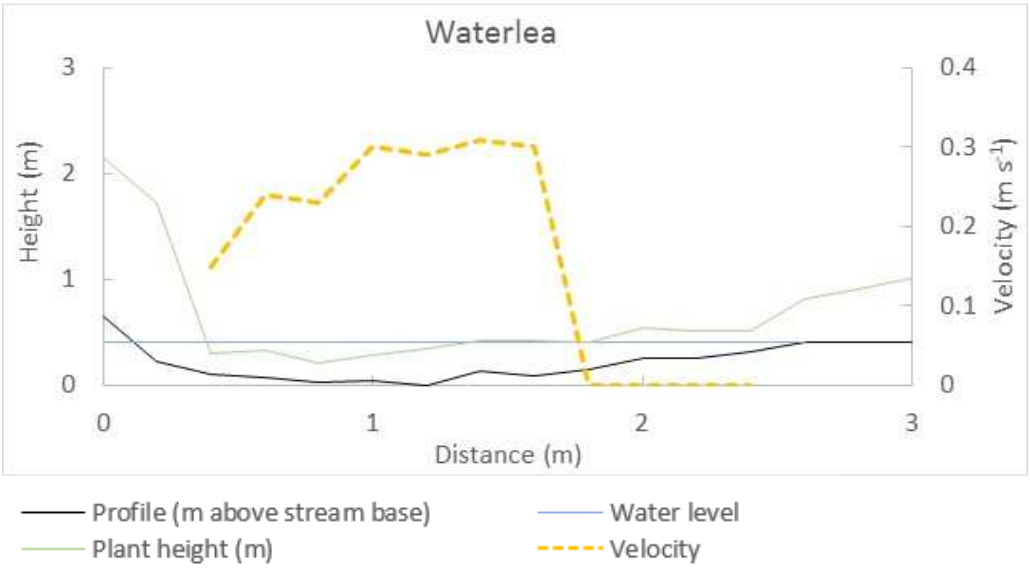
Watercourse width (m)	Maximum depth (m)	Average depth (m)	Maximum velocity (m s^{-1})	Mean velocity (m s^{-1})	Cross-sectional area (m^2)	Estimated discharge (m^3 s^{-1})
2.3	0.44	0.35	0.39	0.238	0.80	0.1613

11 Waterlea

GPS references for profile sites.

Date	NZTM grid ref
7/06/2016	1679522E 5404515N

Cross-section profile showing ground height, water level, stream bed depth and plant height and graphed water velocity.



Watercourse summary data.

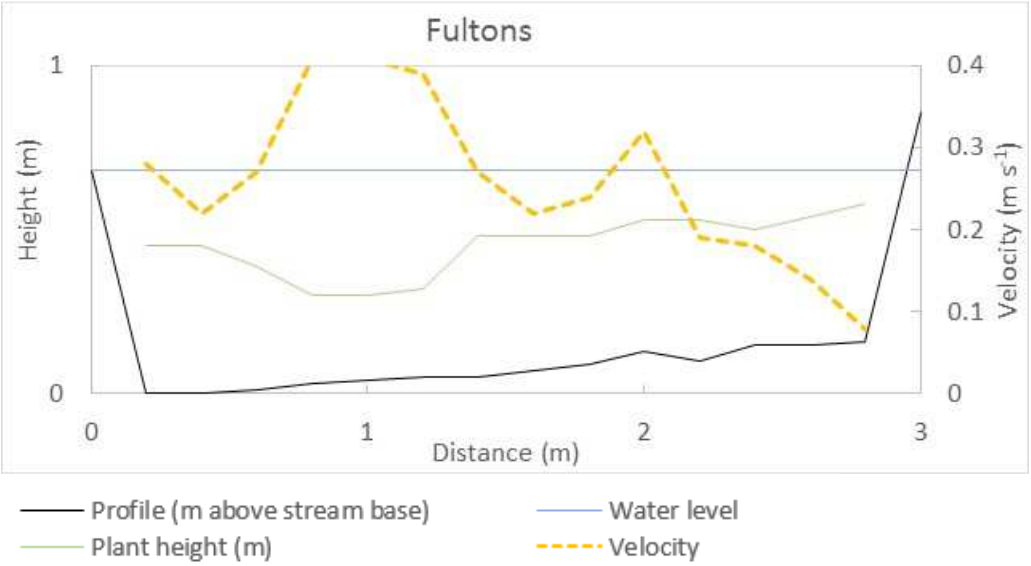
Watercourse width (m)	Maximum depth (m)	Average depth (m)	Maximum velocity (m s^{-1})	Mean velocity (m s^{-1})	Cross-sectional area (m^2)	Estimated discharge (m^3 s^{-1})
2.2	0.41	0.27	0.31	0.165	0.60	0.0841

12 Fultons

GPS references for profile sites.

Date	NZTM grid ref
7/03/2016	1679180E 5404674N

Cross-section profile showing ground height, water level, stream bed depth and plant height and graphed water velocity.



Watercourse summary data.

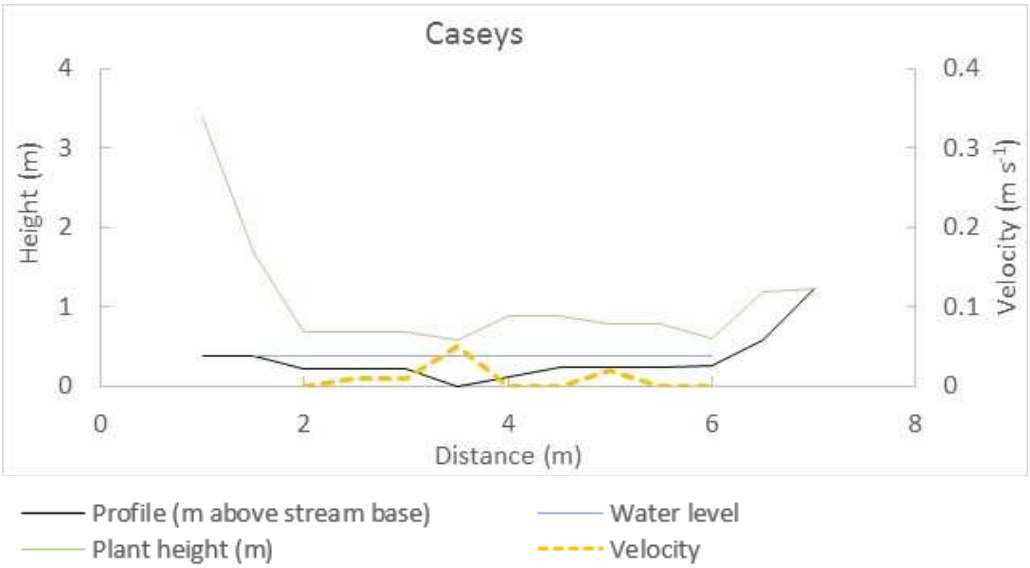
Watercourse width (m)	Maximum depth (m)	Average depth (m)	Maximum velocity (m s^{-1})	Mean velocity (m s^{-1})	Cross-sectional area (m^2)	Estimated discharge (m^3 s^{-1})
3.0	0.68	0.58	0.41	0.259	1.73	0.3800

13 Caseys

GPS references for profile sites.

Date	NZTM grid ref
7/03/2016	1679281E 5405493N

Cross-section profile showing ground height, water level, stream bed depth and plant height and graphed water velocity.



Watercourse summary data

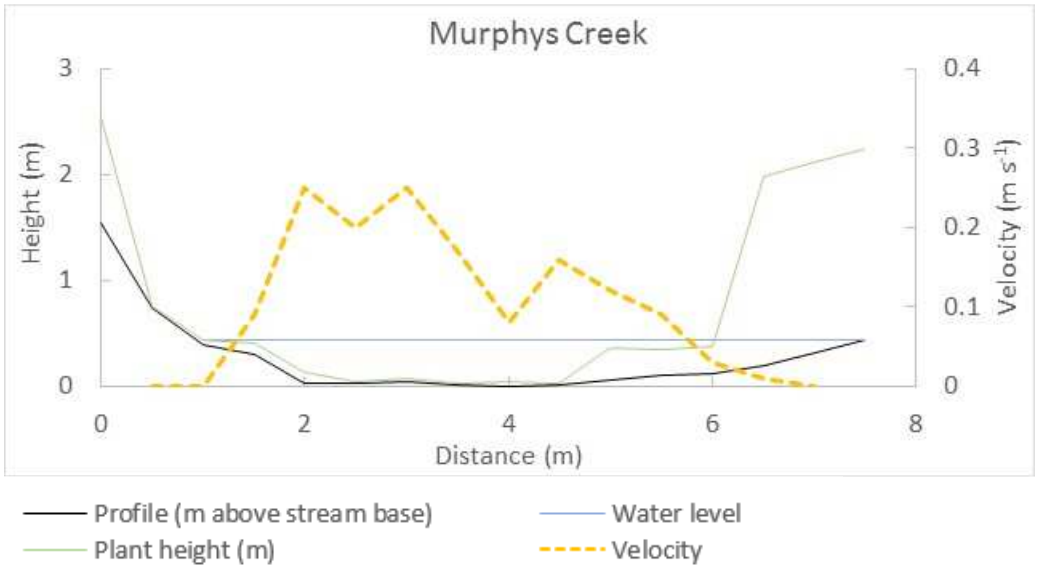
Watercourse width (m)	Maximum depth (m)	Average depth (m)	Maximum velocity (m s^{-1})	Mean velocity (m s^{-1})	Cross-sectional area (m^2)	Estimated discharge (m^3 s^{-1})
4.0	0.38	0.19	0.05	0.010	0.76	0.0064

15 Murphys

GPS references for profile sites.

Date	NZTM grid ref
23/03/2016	1678093E 5404522N

Cross-section profile showing ground height, water level, stream bed depth and plant height and graphed water velocity



Watercourse summary data

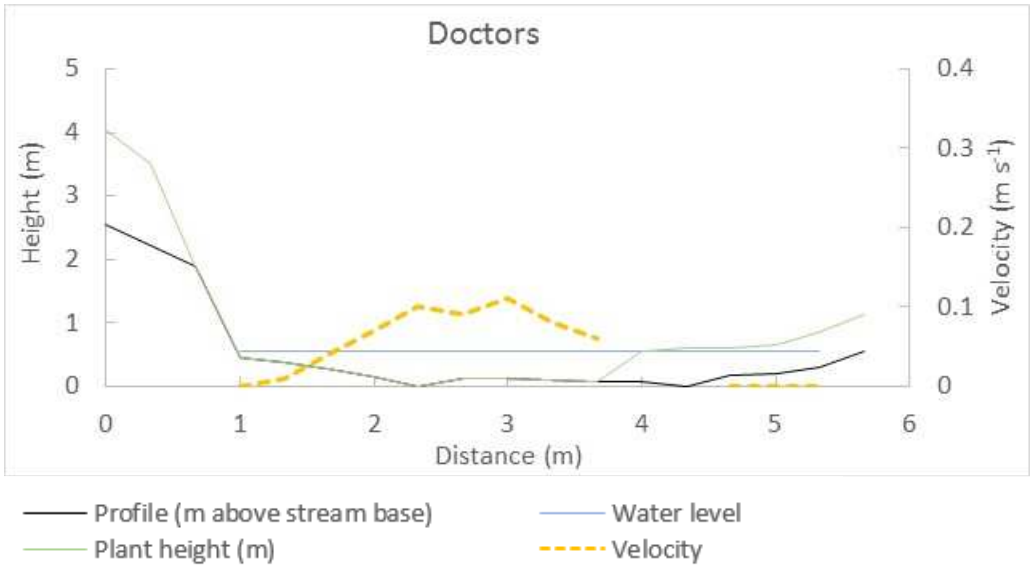
Watercourse width (m)	Maximum depth (m)	Average depth (m)	Maximum velocity (m s^{-1})	Mean velocity (m s^{-1})	Cross-sectional area (m^2)	Estimated discharge (m^3 s^{-1})
7.0	0.44	0.28	0.25	0.104	1.95	0.1717

16 Doctors

GPS references for profile sites.

Date	NZTM grid ref
7/03/2016	1677919E 5403174N

Cross-section profile showing ground height, water level, stream bed depth and plant height and graphed water velocity.



Watercourse summary data

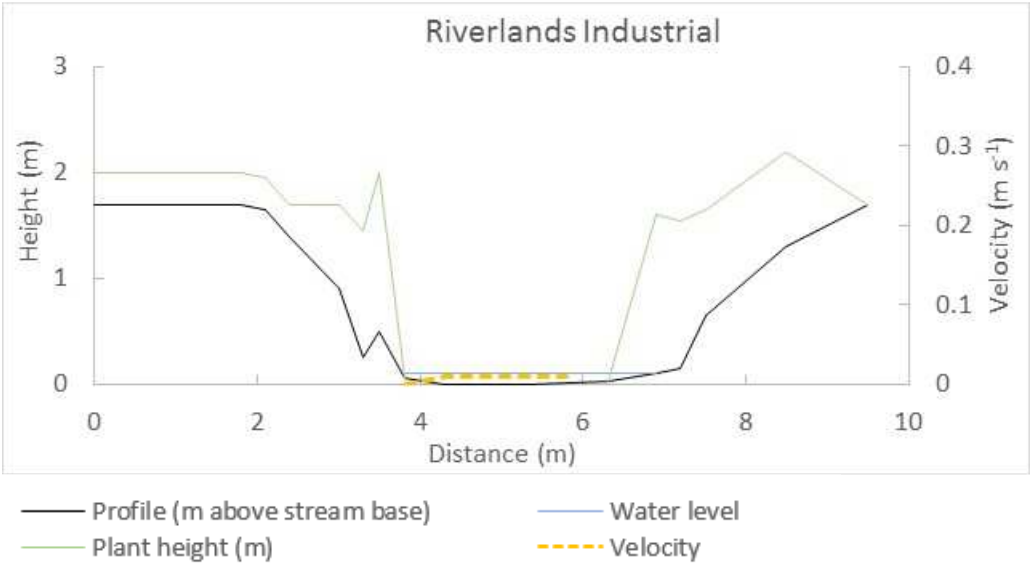
Watercourse width (m)	Maximum depth (m)	Average depth (m)	Maximum velocity (m s^{-1})	Mean velocity (m s^{-1})	Cross-sectional area (m^2)	Estimated discharge (m^3 s^{-1})
4.3	0.54	0.37	0.11	0.047	1.59	0.0632

18 Riverlands Industrial

GPS references for profile sites.

Date	NZTM grid ref
10/03/2016	2595223

Cross-section profile showing ground height, water level, stream bed depth and plant height and graphed water velocity.



Watercourse summary data.

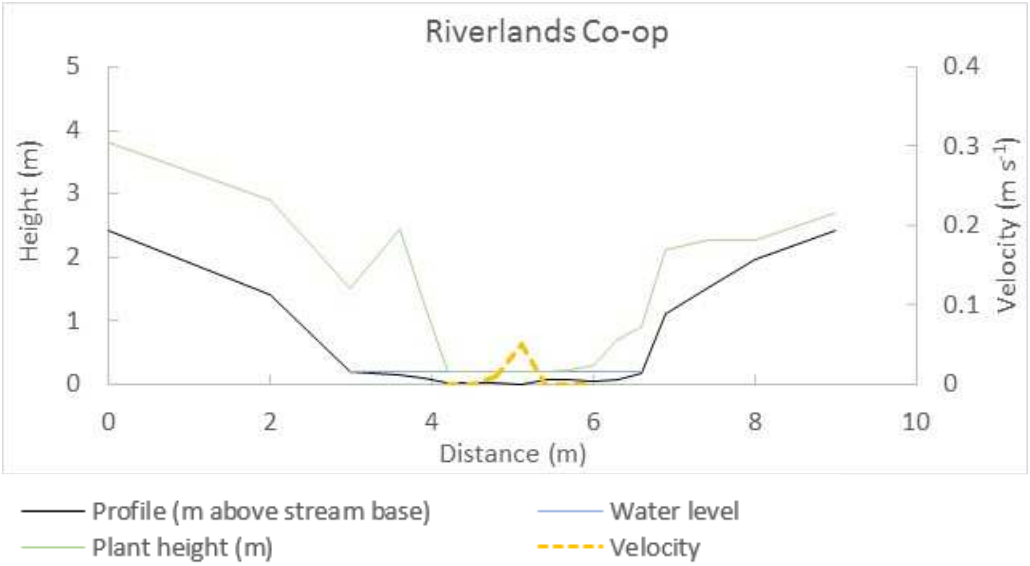
Watercourse width (m)	Maximum depth (m)	Average depth (m)	Maximum velocity (m s^{-1})	Mean velocity (m s^{-1})	Cross-sectional area (m^2)	Estimated discharge (m^3 s^{-1})
2.5	0.1	0.08	0.01	0.008	0.20	0.0014

19 Riverlands Co-op

GPS references for profile sites.

Date	NZTM grid ref
10/03/2016	1681159E 5401746N

Cross-section profile showing ground height, water level, stream bed depth and plant height and graphed water velocity.



Watercourse summary data.

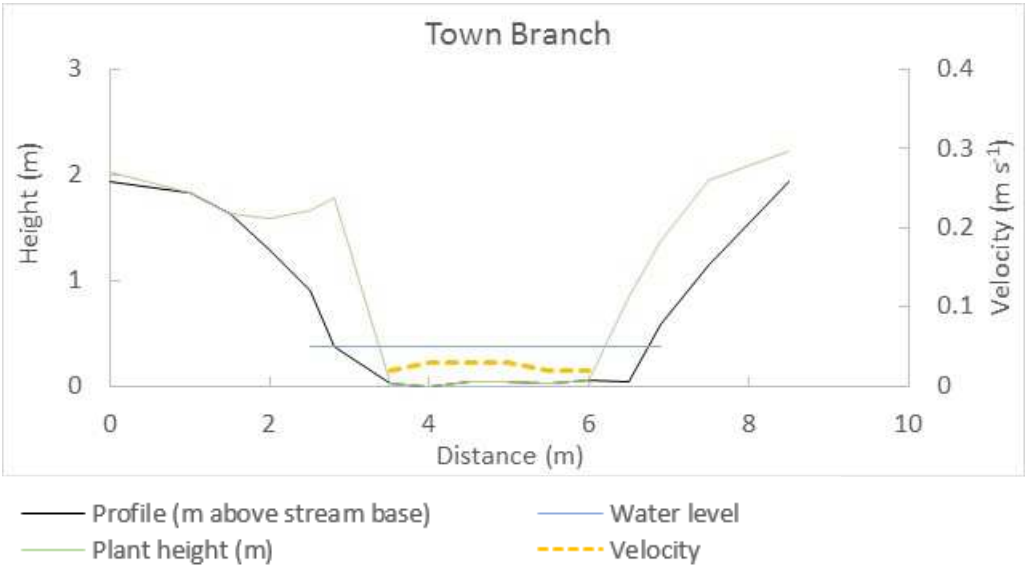
Watercourse width (m)	Maximum depth (m)	Average depth (m)	Maximum velocity (m s^{-1})	Mean velocity (m s^{-1})	Cross-sectional area (m^2)	Estimated discharge (m^3 s^{-1})
3.0	0.21	0.14	0.05	0.008	0.43	0.0028

20 Town Branch

GPS references for profile sites.

Date	NZTM grid ref
10/03/2016	1681191E 5401817N

Cross-section profile showing ground height, water level, stream bed depth and plant height and graphed water velocity.



Watercourse summary data.

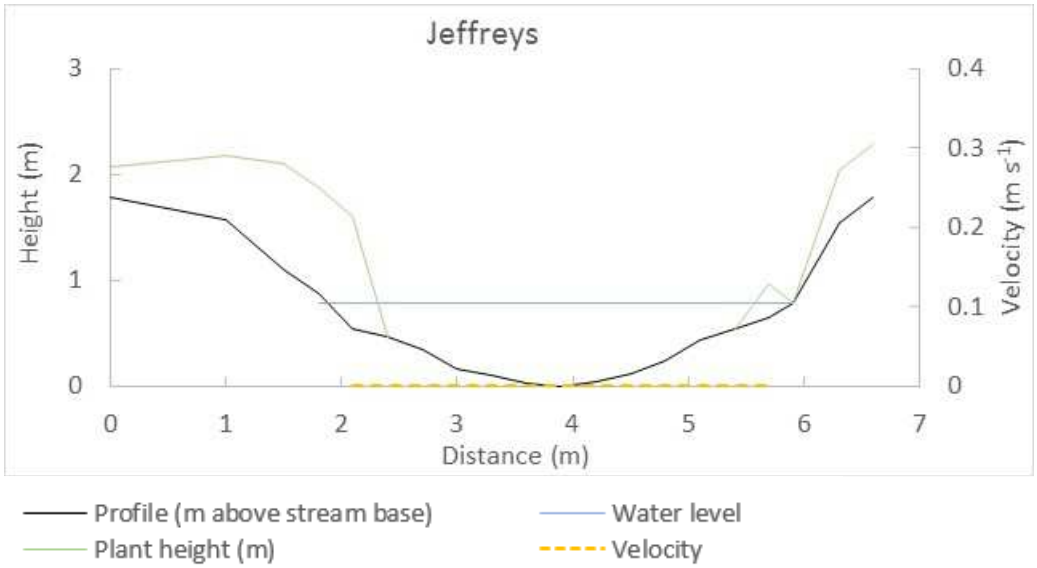
Watercourse width (m)	Maximum depth (m)	Average depth (m)	Maximum velocity (m s^{-1})	Mean velocity (m s^{-1})	Cross-sectional area (m^2)	Estimated discharge (m^3 s^{-1})
3.0	0.38	0.32	0.03	0.025	0.97	0.0206

21 Jeffreys

GPS references for profile sites.

Date	NZTM grid ref
10/03/2016	1685933E 5404358N

Cross-section profile showing ground height, water level, stream bed depth and plant height and graphed water velocity.



Watercourse summary data.

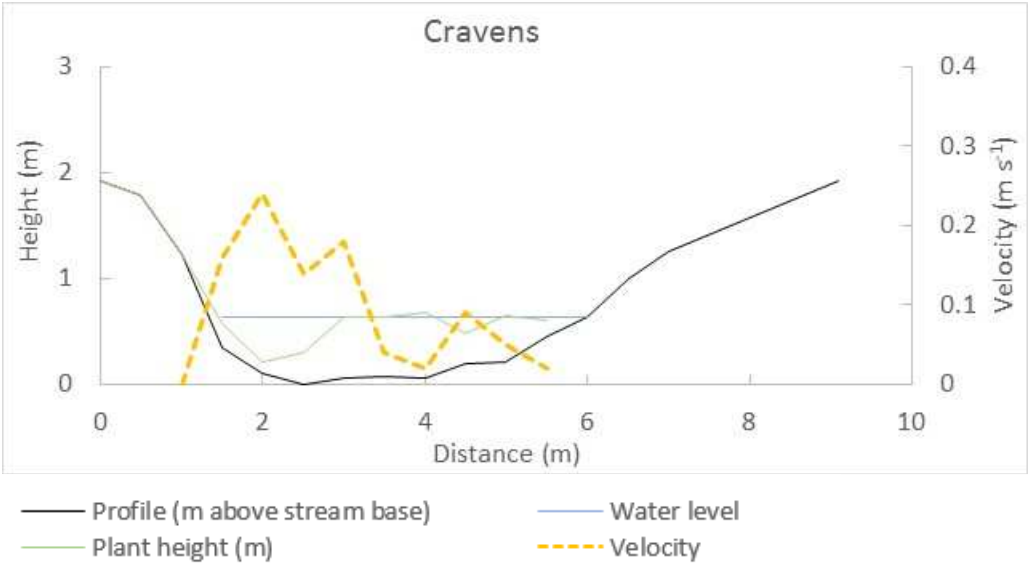
Watercourse width (m)	Maximum depth (m)	Average depth (m)	Maximum velocity (m s^{-1})	Mean velocity (m s^{-1})	Cross-sectional area (m^2)	Estimated discharge (m^3 s^{-1})
3.8	0.78	0.46	0.00	0.000	1.76	0.0000

23 Cravens

GPS references for profile sites.

Date	NZTM grid ref
9/03/2016	1677146E 5411048N

Cross-section profile showing ground height, water level, stream bed depth and plant height and graphed water velocity.



Watercourse summary data.

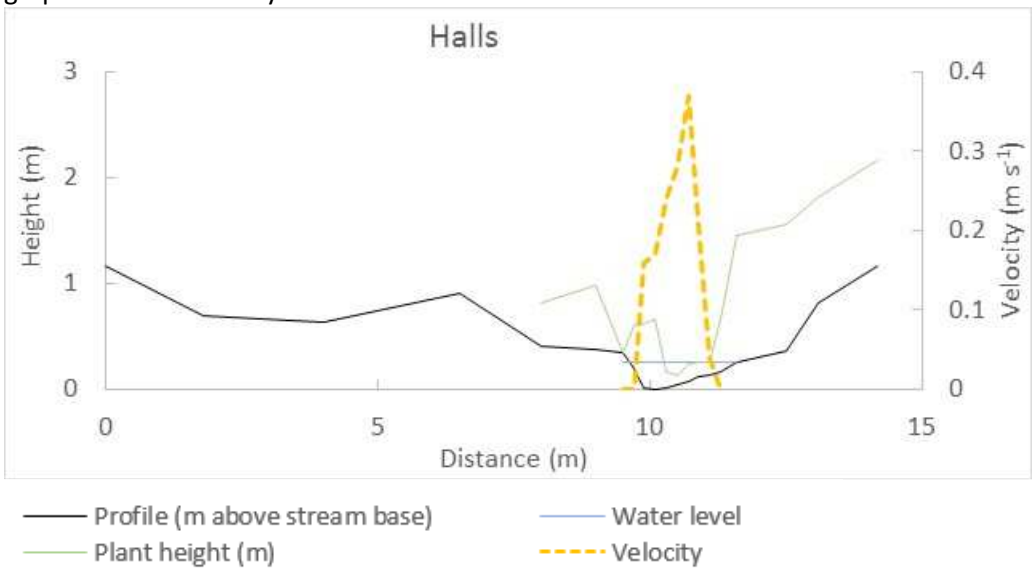
Watercourse width (m)	Maximum depth (m)	Average depth (m)	Maximum velocity (m s^{-1})	Mean velocity (m s^{-1})	Cross-sectional area (m^2)	Estimated discharge (m^3 s^{-1})
4.5	0.63	0.43	0.24	0.094	1.94	0.1546

24 Halls

GPS references for profile sites.

Date	NZTM grid ref
9/03/2016	1679886E 5411470N

Cross-section profile showing ground height, water level, stream bed depth and plant height and graphed water velocity.



Watercourse summary data.

Watercourse width (m)	Maximum depth (m)	Average depth (m)	Maximum velocity (m s^{-1})	Mean velocity (m s^{-1})	Cross-sectional area (m^2)	Estimated discharge (m^3 s^{-1})
1.6	0.26	0.17	0.37	0.147	0.28	0.0349

Appendix B Water Quality data

Watercourse site	DO (mg l^{-1})		Temperature (°C)		Turbidity (NTU)		Conductivity (mS cm^{-1})		pH		Black disk (m)	
	2016	2002	2016	2002	2016	2002	2016	2002	2016	2002	2016	2002
Pukaka	9.08	4.4	20.3	16.3	6.4	4.7	0.103	0.342	8.79	6.9		2.2
Roberts	8.34	8.2	15.3	14.7	9.7	2.4	0.091	0.439	7.19	7	1.9	2.4
Drain N-1	6.2		14.2		3		0.063		7.22			
Drain N-2	4.64	5.6	14.8	13.7	2.6	0.8	0.064	0.09	6.99	6.5		
Drain N-3	6.88		13.17		3		0.063		6.76		4.15	
Drain Q	6.49	7.3	14	14.1	7	1.7	0.065	0.086	7.52	6.4	1.25	3.5
Pipitea Sth	0.56	0.5	18.4	14	850	22	0.203	1.05	6.95	6.4		
Marukoko	5.7	13.5	19	15.6	8.8	6.3	0.132	1.018	7.39	8	0.78	
Grovetown Lagoon	4.6	6.3	12.6	14.1	0.7	0.9	0.067	0.15	7.11	6.6		
Kellys	8.41	8.8	14.2	15.1	2.8	4.1	0.072	0.117	7.54	6.9		2.5
Waterlea	8.96	8.2	15.6	17	4.6	7.4	0.085	0.13	7.29	6.8	1.68	1.4
Fultons	6.83	6.9	13.47	15.2	0.9	1.7	0.094	0.145	6.61	6.3	7.7	5
Caseys	11.79	7.9	17.8	15.9	1.2	1.4	0.078	0.129	7.4	6.3		5
Murphys	8.68	8.1	14.05	15.2	1.1	1.6	0.11	0.155	6.77	6	4.78	3.8
Doctors	7.5	9.9	15.7	17.3	2.8	6.8	0.158	0.212	7.04	6.6	2.13	1.2
Riverlands Industrial	0	0.37	15.6	19.5	35.4	82.4	0.337	0.496	7.54	6.3		0.1
Riverlands Co-op	16.24	9	21.5	21.3	6.7	21	0.199	0.25	9.65	6.9	1	0.35
Town Branch	1.25	9.6	14.5	20.4	16	6.2	0.109	0.217	7.85	7.1	0.78	1.4
Jeffreys	1.09	2.5	15.75	17.6	4.2	6	5.7	4.17	8.12	7.7	0.9	1.1
Cravens	6.92	6.3	14.2	14.6	0.6	1.1	0.63	0.105	7.11	6.7	8.1	6.4
Halls	7.87	7.9	13.4	14.5	1.2	2.4	0.074	0.262	6.93	6.7	5.53	3.1

Watercourse site	SS (g m^{-3})		VSS (g m^{-3})		ISS (g m^{-3})	
	2016	2002	2016	2002	2016	2002
Pukaka	22.6	4	12.5	1	10.1	3
Roberts	1.3	1	<0.5	0.1	0.8	0.9
0.6	1.2	0.6	<0.5		0.7	
Drain N-2	1.7		<0.5	0.6	1.2	0
Drain N-3	1.2		0.5		0.7	
Drain Q	5.7	1	0.6	0.4	5.1	0.6
Pipitea Sth	2110	20	293	9	1820	11
Marukoko	4.4	20	1.8	4	2.6	16
Grovetown Lagoon	0.7	0.8	0.8	0.5	<0.5	0.3
Kellys	1.7	3	<0.5	1	1.2	2
Waterlea	2.8	4	0.5	1	2.3	3
Fultons	0.8	2	0.5	1	<0.5	1
Caseys	0.8	1	<0.5	0.1	<0.5	0.9
Murphys	1.3	2	0.6	1	0.7	1
Doctors	3.1	4	1.0	1	2.1	3
Riverlands Industrial	17.3	54	4.5	12	12.8	42
Riverlands Co-op	5.2	16	<0.5	2	4.7	14
Town Branch	2.3	5	0.9	1	1.4	4
Jeffreys	11.5	40	7.1	9	4.4	31
Cravens	<0.5	3	<0.5	0	<0.5	3
Halls	1.0	3	<0.5	1	0.5	2

Watercourse site	DRP (mg m^{-3})		NH_4-N (mg m^{-3})		NO_3-N (mg m^{-3})		TN (mg m^{-3})		TP (mg m^{-3})	
	2016	2002	2016	2002	2016	2002	2016	2002	2016	2002
Pukaka	<1	120	10	29	<1	5	644	600	60	160
Roberts	8	22	10	46	278	390	318	630	12	24
Drain N-1	6		7		126		169		10	
Drain N-2	5	10	9	11	144	380	202	750	10	22
Drain N-3	6		7		176		210		9	
Drain Q	14	16	22	21	118	460	183	680	27	19
Pipitea Sth	13	180	393	260	1	14	18000	1300	4970	280
Marukoko	58	370	32	12	1	4	231	710	142	440
Grovetown Lagoon	6	12	5	8	214	250	265	480	15	19
Kellys	16	27	6	16	153	460	197	770	24	37
Waterlea	12	24	10	12	458	1300	514	1900	16	34
Fultons	9	15	5	10	772	2600	815	3600	10	16
Caseys	4	15	8	20	149	1700	251	2400	10	15
Murphys	9	15	5	7	2610	3200	1410	4600	11	16
Doctors	22	48	16	17	145	2000	308	3400	38	74
Riverlands Industrial	604	1300	348	510	1	10	1370	3600	841	1900
Riverlands Co-op	43	58	23	77	2610	3300	3110	5300	67	990
Town Branch	20	72	10	51	2550	3700	2780	5500	42	95
Jeffreys	91	750	292	9	4	<2	796	1000	155	810
Cravens	12	17	4	16	253	350	283	520	14	19
Halls	14	33	5	19	320	2300	362	3400	21	45

Appendix C *E. coli* results

Watercourse site	*E. coli* cfu per 100mL	
	2016	2002
Pukaka	< 100	23
Roberts	1	20
Drain N-1	37	
Drain N-2	4	70
Drain N-3	28	
Drain Q	120	55
Pipitea Sth	< 100	10
Marukoko	10	210
Grovetown Lagoon	140	1200
Kellys	130	540
Waterlea	130	380
Fultons	60	140
Caseys	62	80
Murphys	100	140
Doctors	170	210
Riverlands Industrial	10	20000
Riverlands Co-op	370	480
Town Branch	33	980
Jeffreys	3	25
Cravens	2	180
Halls	170	50

Appendix D Macrophyte data

Watercourse	Distance from left bank (m)	Distance from bank top (m)	Water depth (m)	Velocity (m s^{-1})	Canopy height (m)	*Lemna disperma*	Grass	*Agrostis stolonifera*	*Azolla pinnata*	*Persicaria decipiens*	*Lagarosiphon major*	Liverwort	*Glyceria fluitans*	*Juncus articulata*
Caseys	0	0.7	0											
Caseys	0.5	1.2	0											
Caseys	1	1.2	0		3									
Caseys	1.5		0		1.3		20							
Caseys	2		0.2	0	0.5	100	40				50	10		
Caseys	2.5		0.2	0	0.5	50	20		5		100			
Caseys	3		0.2	0	0.5	35		60			100		10	
Caseys	3.5		0.4	0.1	0.6	50		60			100	5		15
Caseys	4		0.3	0	0.8	70		30			70		40	10
Caseys	4.5		0.2	0	0.7	70		40	5	5	90	60		30
Caseys	5		0.1	0	0.5	80		70			70	30	30	
Caseys	5.5		0.1	0	0.5	60		80			30	20	20	
Caseys	6		0.1	0	0.4	40		90	5		10	10		
Caseys	6.5	1	0	0	0.6		100							
Caseys	7	0.4					100							
Caseys	7.5	0					100							
Caseys	8	0					100							

Watercourse	Distance from left bank (m)	Distance from bank top (m)	Water depth (m)	Velocity (m s^{-1})	Canopy height (m)	*Lemna disperma*	*Agrostis stolonifera*	*Azolla pinnata*	*Nasturtium* spp.	Algae	*Callitriche stagnalis*	*Potamogeton cheesemanii*	*Juncus articulata*	*Myriophyllum propinquum*
Cravens	0	0	0	0	0									
Cravens	0.5	0.2	0	0	0									
Cravens	1	0.7	0.1	0	0									
Cravens	1.5		0.3	0.2	0.2		15		10	80	5			
Cravens	2		0.5	0.2	0.1				15	40	5		2	
Cravens	2.5		0.6	0.1	0.3		15		1	50		2	5	
Cravens	3		0.6	0.2	0.6		40			50			35	
Cravens	3.5		0.6	0	0.6	1	85	1		60			50	
Cravens	4		0.6	0	0.6	2	85	1		70			5	
Cravens	4.5		0.4	0.1	0.3		60			70				
Cravens	5		0.4	0.1	0.4	1	40			70			5	10
Cravens	5.5		0.2	0	0.2	40	10			90				30
Cravens	6	1.3												
Cravens	6.5	0.9												
Cravens	7	0.7												
Cravens	9.1	0												

Watercourse	Distance from left bank (m)	Distance from bank top (m)	Water depth (m)	Velocity (m s^{-1})	Canopy height (m)	*Lemna disperma*	Grass	*Nasturtium* spp.	*Erythranthe guttata*	*Veronica* spp.
Doctors	0	0	0	0	1.5					
Doctors	0.3	1			1.3					
Doctors	0.7	2								
Doctors	1		0.1	0	0					
Doctors	1.3		0.2	0	0					
Doctors	1.7		0.3	0	0					
Doctors	2		0.4	0.1	0					
Doctors	2.3		0.5	0.1	0					
Doctors	2.7		0.4	0.1	0					
Doctors	3		0.4	0.1	0					
Doctors	3.3		0.5	0.1	0					
Doctors	3.7		0.5	0.1	0					
Doctors	4		0.5		0.5			60	20	
Doctors	4.3		0.5		0.6			50		50
Doctors	4.7		0.4	0	0.5			20	20	20
Doctors	5		0.3	0	0.5	30		60	20	
Doctors	5.3		0.2	0	0.6	80		40	30	
Doctors	5.7	2	0	0	0.6		100			
Doctors	6.3	1								

Watercourse	Distance from left bank (m)	Distance from bank top (m)	Water depth (m)	Velocity (m s-1)	Canopy height (m)	*Lemna disperma*	Grass	*Agrostis stolonifera*	*Veronica* spp.
Drain N 1	1	0.3			1.3		100		
Drain N 1	1.5	0.5			1.3		100		
Drain N 1	1.7	1.4	0.2	0	1.3		100		
Drain N 1	2		0.3	0.1	0				
Drain N 1	2.2		0.3	0.2	0				
Drain N 1	2.4		0.4	0.2	0.3			20	20
Drain N 1	2.6		0.4	0.2	0.4			25	
Drain N 1	2.8		0.4	0.1	0.2			20	10
Drain N 1	3		0.3	0	0.1	10		10	
Drain N 1	3.2		0.1	0	0	10			
Drain N 1	3.4	1	0	0	0.6		100		
Drain N 1	3.6	1			0.6		100		
Drain N 1	3.8	0.6			0.6		100		
Drain N 1	4	0.2			0.6		100		
Drain N 1	4.2	0			0.6		100		

Watercourse	Distance from left bank (m)	Distance from bank top (m)	Water depth (m)	Velocity (m s-1)	Canopy height (m)	*Lemna disperma*	Grass	*Azolla pinnata*	*Nitella* sp. aff. *cristata*	*Glyceria fluitans*	*Ludwigia palutris*
Drain N 2	0.8	0	0								
Drain N 2	1	0.2					100				
Drain N 2	1.2	0.3			0.5		100				
Drain N 2	1.4	0.8	0								
Drain N 2	1.6	1.5	0.1								
Drain N 2	1.8		0.2	0.1	0				15		
Drain N 2	2		0.1	0.1	0.2	10				10	40
Drain N 2	2.2		0.1	0	0.2	10		5		10	30
Drain N 2	2.4		0.2	0	0.1						20
Drain N 2	2.6		0.2	0	0				3		
Drain N 2	2.8	0.9	0.1		0		100				
Drain N 2	3	0.2			0		100				
Drain N 2	3.2	0			0.1		100				

Watercourse	Distance from left bank (m)	Distance from bank top (m)	Water depth (m)	Velocity (m s-1)	Canopy height (m)	*Lemna disperma*	Grass	*Agrostis stolonifera*	*Azolla pinnata*	*Nasturtium* spp.	*Nitella* sp. aff. *cristata*
Drain N 3	0.2	0	0		0.4		100				
Drain N 3	0.4	0.3	0		0.4		100				
Drain N 3	0.5	0.7	0	0	0.4		100				
Drain N 3	0.7		0.1	0	0.2	60			5	60	
Drain N 3	0.9		0.1	0	0.1	30		5	5	40	
Drain N 3	1.1		0.2	0	0.1	15				40	5
Drain N 3	1.3		0.2	0	0.4	30				70	
Drain N 3	1.5		0.2	0.2	0.2			2			2
Drain N 3	1.7		0	0	0.1	80					20
Drain N 3	1.9	0.7	0		0.4		100				
Drain N 3	2.1	0.8	0		0.4		100				
Drain N 3	3.3	0.9	0		0.4						

Watercourse	Distance from left bank (m)	Distance from bank top (m)	Water depth (m)	Velocity (m s-1)	Canopy height (m)	*Lemna disperma*	Grass	*Nitella* sp. aff. *cristata*	*Ludwigia palutris*	*Agapanthus*	*Ranunculus sceleratus*
Drain Q 1	1.2	0.1	0							100	
Drain Q 1	1.5	0.3	0							101	
Drain Q 1	1.7	0.5	0								
Drain Q 1	2	0.6	0		0.1				30		30
Drain Q 1	2.2	0.6	0		0.1	40			20		
Drain Q 1	2.4	0.6	0			70					
Drain Q 1	2.6		0	0	0	40		20	10		
Drain Q 1	2.8		0.1	0.1	0			15			
Drain Q 1	3		0.2	0.1	0			5			
Drain Q 1	3.2	0.6	0	0	0.1	70					
Drain Q 1	3.4	0.6	0		0.2		20		10		
Drain Q 1	3.8	0.6			0.2		100				
Drain Q 1	4	0.1	0		0.4		100				
Drain Q 1	4.2	0			0.6						

Watercourse	Distance from left bank (m)	Distance from bank top (m)	Water depth (m)	Velocity (m s-1)	Canopy height (m)	*Lemna disperma*	Grass	*Nitella* sp. aff. *cristata*	*Agapanthus*
Drain Q 2	1.3	0	0	0					
Drain Q 2	1.5	0			1.4				100
Drain Q 2	1.7	0.9	0			10			
Drain Q 2	1.9	0.9	0			40			
Drain Q 2	2.1	0.9	0	0		100			
Drain Q 2	2.3		0.1	0	0			40	
Drain Q 2	2.5		0.1	0	0			20	
Drain Q 2	2.7		0.1	0.1	0			5	
Drain Q 2	2.9	0.9	0	0		50			
Drain Q 2	3.1	0.8	0	0	0.1		10		
Drain Q 2	3.4	0.7	0		0.1		10		
Drain Q 2	3.6	0.2	0	0	0.3		10		
Drain Q 2	4	0							

Watercourse	Distance from left bank (m)	Distance from bank top (m)	Water depth (m)	Velocity (m s-1)	Canopy height (m)	*Lemna disperma*	Grass	*Azolla pinnata*	*Nitella* sp. aff. *cristata*	*Ranunculus sceleratus*	*Persicaria hydropiper*
Drain Q 3	0	0	0	0	0.4		100				
Drain Q 3	1.5	0	0	0	0.6		100				
Drain Q 3	1.8	0	0	0	0.6		101				
Drain Q 3	2	0.9	0	0	0.2	40				30	
Drain Q 3	2.2		0.1	0	0.1	90				20	
Drain Q 3	2.4		0.1	0	0	50		1	5		
Drain Q 3	2.6		0.1	0							
Drain Q 3	2.8		0.1	0.1							
Drain Q 3	3		0.1	0.1		3					
Drain Q 3	3.2		0.1	0.1		15					
Drain Q 3	3.4		0.1	0	0	100			30		
Drain Q 3	3.6		0.1	0	0				70		5
Drain Q 3	3.8	0.9	0	0	0		80				20
Drain Q 3	4	0.5	0	0	0.3		100				
Drain Q 3	4.4	0.2			0.2		101				
Drain Q 3	4.8	0			0.1		102				

Watercourse	Distance from left bank (m)	Distance from bank top (m)	Water depth (m)	Velocity (m s-1)	Canopy height (m)	*Potamogeton crispus*	*Persicaria decipiens*	*Lagarosiphon major*	Liverwort	Mosses
Fulton	0	0.2	0.6			50				
Fulton	0.2		0.7	0.3	0.5	65				
Fulton	0.4		0.7	0.2	0.5	20		20		20
Fulton	0.6		0.7	0.3	0.4	20		60		20
Fulton	0.8		0.7	0.4	0.3	60		20		20
Fulton	1		0.6	0.4	0.3	80		20		10
Fulton	1.2		0.6	0.4	0.3	100				
Fulton	1.4		0.6	0.3	0.4	40		60		
Fulton	1.6		0.6	0.2	0.4	70		100		
Fulton	1.8		0.6	0.2	0.4	15		85		
Fulton	2		0.6	0.3	0.4	10		90		
Fulton	2.2		0.6	0.2	0.4			100		
Fulton	2.4		0.5	0.2	0.4	20		80		
Fulton	2.6		0.5	0.1	0.4	10		100		
Fulton	2.8		0.5	0.1	0.4	40		60		
Fulton	3	0.2	0.1						80	20
Fulton	3.1	0								

Watercourse	Distance from left bank (m)	Distance from bank top (m)	Water depth (m)	Velocity (m s-1)	Canopy height (m)	*Lemna disperma*	Grass	*Nasturtium* spp.	*Persicaria decipiens*	*Lagarosiphon major*	*Callitriche stagnalis*	*Erythranthe guttata*
Grovetown Lagoon	0	0	0	0	1.3		100				20	
Grovetown Lagoon	1	0			1.3		5				100	
Grovetown Lagoon	1.5	0.3			1.6		70	20	30		50	
Grovetown Lagoon	2	0.6			1.6		60	45	20		40	10
Grovetown Lagoon	2.2	0.7	0		1.6		50	40	25		20	35
Grovetown Lagoon	2.4		0.2	0	0.7		10	65	20			40
Grovetown Lagoon	2.6		0.2	0	0.7			70	25			45
Grovetown Lagoon	2.8		0.2	0.1	0.8			70	10			30
Grovetown Lagoon	3		0.3	0.1	0.8			65	10			40
Grovetown Lagoon	3.2		0.4	0.1	0.7	5		80				30
Grovetown Lagoon	3.4		0.4	0.1	0.7	5		85				10
Grovetown Lagoon	3.6		0.4	0.1	0.9	5		80				10
Grovetown Lagoon	3.8		0.5	0.1	0.9	5		80				40
Grovetown Lagoon	4		0.5	0.1	0.9	5		50				50
Grovetown Lagoon	4.2		0.5	0.1	0.8	5		50				60
Grovetown Lagoon	4.4		0.4	0	0.8	2		40				70
Grovetown Lagoon	4.6		0.4	0	0.8			15				85
Grovetown Lagoon	4.8		0.3	0	0.1			30			10	70
Grovetown Lagoon	5		0.2	0	1.5			20			30	85
Grovetown Lagoon	5.2		0.1	0	1.6			10	5		65	80
Grovetown Lagoon	5.7	0.7	0		1.5		40				80	10
Grovetown Lagoon	6	0.5			1.6		30				80	

Watercourse	Distance from left bank (m)	Distance from bank top (m)	Water depth (m)	Velocity (m s-1)	Canopy height (m)	*Lemna disperma*	Grass	*Agrostis stolonifera*	*Azolla pinnata*	*Nasturtium* spp.	Algae	*Potamogeton crispus*	*Persicaria decipiens*	*Bulboschoenus fluviatilis*
Halls	0	0	0											
Halls	1.8	0.5	0											
Halls	4	0.5												
Halls	6.5	0.3												
Halls	8	0.8			0.4					5			30	
Halls	9	0.8			0.6		30						80	10
Halls	9.5	0.8	0	0		50	40						70	10
Halls	9.7		0.1	0	0.4		10	15					60	80
Halls	9.9		0.2	0.2	0.6	10		35			50		40	35
Halls	10		0.3	0.2	0.7			10			40		20	20
Halls	10		0.2	0.2	0.2			15			30			
Halls	11		0.2	0.3	0.1					10	15			
Halls	11		0.2	0.4	0.2			10		1	15			
Halls	11		0.1	0.2	0.1			25		1	25			
Halls	11		0.1	0	0.1			50			60			
Halls	11		0.1	0	0.5	40	20	10			80		20	
Halls	12	0.9	0	0	1.2	30	60						5	20
Halls	13	0.8	0	0	1.2		100							20
Halls	13	0.4			1		100							
Halls	14	0			1		100							

Watercourse	Distance from left bank (m)	Distance from bank top (m)	Water depth (m)	Velocity (m s-1)	Canopy height (m)	*Lemna disperma*	Grass	Algae	*Triglochin striata*	*Sarcocornia quinqueflora*
Jeffreys	0	0		0	0.3		100			
Jeffreys	1	0.2			0.6		100			
Jeffreys	1.5	0.7			1		35		70	30
Jeffreys	1.8	0.9	0	0	1		50	50	50	
Jeffreys	2.1		0.2	0	1.1		10	100	1	
Jeffreys	2.4		0.3	0				100		
Jeffreys	2.7		0.4	0				100		
Jeffreys	3		0.6	0				100		
Jeffreys	3.3		0.7	0				100		
Jeffreys	3.6		0.8	0				100		
Jeffreys	3.9		0.8	0				100		
Jeffreys	4.2		0.7	0				40		
Jeffreys	4.5		0.7	0				40		
Jeffreys	4.8		0.5	0				50		
Jeffreys	5.1		0.4	0				25		
Jeffreys	5.4		0.2	0				20		
Jeffreys	5.7		0.1	0	0.3		20	60		
Jeffreys	5.9	1	0				20			60
Jeffreys	6.3	0.2			0.5		100			
Jeffreys	6.6	0			0.5		100			

Watercourse	Distance from left bank (m)	Distance from bank top (m)	Water depth (m)	Velocity (m s-1)	Canopy height (m)	*Lemna disperma*	Grass	*Agrostis stolonifera*	*Nasturtium* spp.	*Nitella* sp. aff. *cristata*	*Persicaria decipiens*	*Potamogeton cheesemanii*	*Veronica* spp.	*Bulboschoenus fluviatilis*	*Elodea canadensis*
Kellys	0	0													
Kellys	1	0.6													
Kellys	1.3	1.2	0		0.8		15				10			25	
Kellys	1.7	1.3	0	0	1.2			25		10	15	10	2	30	10
Kellys	2		0.3	0.2	1.2					10	5	5		25	25
Kellys	2.3		0.4	0.3	1.2							40		15	
Kellys	2.6		0.4	0.2	0.4							70			
Kellys	3		0.4	0.3	0.4							65			65
Kellys	3.3		0.4	0.3	0.2				2			85			65
Kellys	3.6		0.4	0.4	0.1				1			75			10
Kellys	4		0.3	0.3	0.4			50				2			
Kellys	4.3		0.1	0	1.6			95						5	
Kellys	4.6	1.2	0	0	1.9		100							40	
Kellys	5.1	0.9			0.6		100								
Kellys	6.4	0													

Watercourse	Distance from left bank (m)	Distance from bank top (m)	Water depth (m)	Velocity (m s-1)	Canopy height (m)	*Lemna disperma*	Grass	*Azolla pinnata*	*Potamogeton crispus*	*Chara globularis*	*Schoenoplectus pungens*	*Triglochin striata*	*Landoltia punctata*	*Ruppia polycarpa*
Marukoko	0.8	0			1.6		100							
Marukoko	2	0.7			1.6		100							
Marukoko	3	0.8			1.6		100							
Marukoko	4	0.9			1.6		100							
Marukoko	5	1.1			1						70			
Marukoko	6	1.2	0.1	0	0.9	40		5			50	70		
Marukoko	7		0.4	0	0.1				10					30
Marukoko	8		0.7	0.1	0.1					50				
Marukoko	9		0.8	0.1										
Marukoko	10		0.9	0.1										
Marukoko	11		0.7	0										
Marukoko	12		0.7	0	0.7	10		5		30				50
Marukoko	13		0.5	0	0.5	20		6					5	100
Marukoko	14	1.3	0.5	0	0.3	60		7				20		101
Marukoko	15	1.2	0		0.4		80							
Marukoko	15	0			0.6		100							
Marukoko	16	0			0.9		100							

Watercourse	Distance from left bank (m)	Distance from bank top (m)	Water depth (m)	Velocity (m s-1)	Canopy height (m)	*Lemna disperma*	Grass	*Agrostis stolonifera*	*Lagarosiphon major*	*Callitriche stagnalis*	*Potamogeton cheesemanii*	*Nymphaea* spp.
Murphys	0	0	0	0	1		100					
Murphys	0.5	0.8	0	0	0	30						
Murphys	1		0.1	0	0				20			
Murphys	1.5		0.1	0.1	0.1				30			
Murphys	2		0.4	0.3	0.1				5			
Murphys	2.5		0.4	0.2	0						40	
Murphys	3		0.4	0.3	0			5	5		60	
Murphys	3.5		0.4	0.2	0						30	
Murphys	4		0.4	0.1	0				5		10	
Murphys	4.5		0.4	0.2	0				25		2	
Murphys	5		0.4	0.1	0.3				75			
Murphys	5.5		0.3	0.1	0.2				85			
Murphys	6		0.3	0	0.3				60			
Murphys	6.5		0.3	0	1.8				60	50		30
Murphys	7		0.1	0	1.8					80		
Murphys	7.5	1.1	0		1.8					100		
Murphys	8	0	0	0	0							

Watercourse	Distance from left bank (m)	Distance from bank top (m)	Water depth (m)	Velocity (m s-1)	Canopy height (m)	*Lemna disperma*	Grass	*Azolla pinnata*	*Chara globularis*	*Schoenoplectus pungens*	*Triglochin striata*
Pipitea South	1	0	0								
Pipitea South	1.5	0.4	0								
Pipitea South	2	0.6	0	0	0.6	50	30			70	20
Pipitea South	2.2		0	0	0.6	100				50	
Pipitea South	2.4		0.1	0	0.7	100				50	
Pipitea South	2.6		0.1	0	0.7	100				50	
Pipitea South	2.8		0.2	0	0.6	100		5		20	
Pipitea South	3		0.2	0	0.6	100			10	10	
Pipitea South	3.2		0.3	0	0.1	100			10		
Pipitea South	3.4		0.3	0	0.1	100			5		
Pipitea South	3.6		0.3	0	0.1	100			5		
Pipitea South	3.8		0.3	0	0.1	100			5		
Pipitea South	4		0.3	0	0.1	100			5		
Pipitea South	4.2		0.3			100					
Pipitea South	4.4		0.2			100					
Pipitea South	4.6	0.4	0		0.2						60
Pipitea South	5	0.3	0		0.4		100				
Pipitea South	5.4	0	0		0.8		100				

Watercourse	Distance from left bank (m)	Distance from bank top (m)	Water depth (m)	Velocity (m s-1)	Canopy height (m)	Grass	*Lagarosiphon major*	*Juncus articulata*	*Landoltia punctata*	*Persicaria hydropiper*	*Egeria densa*	*Apium nodiflorum*
Pukaka	2	0	0	0	0.8	100						
Pukaka	2.3	0.1		0	0.8	100						
Pukaka	2.5	0.3		0	0.6							
Pukaka	2.8	0.4		0	0.5							
Pukaka	3	0.6		0	0.6			50		10		
Pukaka	3.3		0.1	0	0		5	75			10	
Pukaka	3.5		0.1	0	0.1		5				80	
Pukaka	3.8		0.1	0	0.1		2				40	
Pukaka	4		0.1	0			2		40			
Pukaka	4.3		0.1	0	0.1				30		5	
Pukaka	4.5		0.1	0					20			
Pukaka	4.8		0.1	0					15			
Pukaka	5		0.1	0					15			
Pukaka	5.3		0.1	0					15			
Pukaka	5.5		0.1	0					15			
Pukaka	5.8		0.1	0	0.1						5	
Pukaka	6		0.1	0					5			
Pukaka	6.3		0	0					5			
Pukaka	6.5		0		0						10	
Pukaka	6.8	0.9	0		0.4		10	50			15	5
Pukaka	7.7	0.9	0		0.5	0		100				
Pukaka	8.2	0.1	0		0.6	100						

Watercourse	Distance from left bank (m)	Distance from bank top (m)	Water depth (m)	Velocity (m s-1)	Canopy height (m)	*Lemna disperma*	Grass	*Nasturtium* spp.	*Nitella* sp. aff. *cristata*	Algae	*Potamogeton crispus*	*Persicaria decipiens*	*Lagarosiphon major*	*Callitriche stagnalis*	*Cyperus ustulatus*
Riverlands coop	0	0			1.4		100								
Riverlands coop	2	1			1.5		100								
Riverlands coop	3	2	0		1.3		100								
Riverlands coop	3.6	2.2	0.1	0	2.3		50				50				
Riverlands coop	3.9		0.1		1.2		50				90				
Riverlands coop	4.2		0.2	0	0.2						100				
Riverlands coop	4.5		0.2	0	0.2						100				
Riverlands coop	4.8		0.2	0	0.2					30	30				
Riverlands coop	5.1		0.2	0.1	0.2					25	25				
Riverlands coop	5.4		0.2	0	0.2	1				40	90				
Riverlands coop	5.7		0.2	0	0.2	2		5		30	90				
Riverlands coop	6		0.2	0	0.3			10		60	30			5	
Riverlands coop	6.3		0.2		0.7			30		70		10		5	
Riverlands coop	6.6		0		0.7			40		40	30	30		50	10
Riverlands coop	6.9	1.3	0	0	1		80	30				10			
Riverlands coop	7.4	0.9			0.8		100								
Riverlands coop	8	0.5			0.3		100								
Riverlands coop	9	0			0.3		100								

Watercourse	Distance from left bank (m)	Distance from bank top (m)	Water depth (m)	Velocity (m s-1)	Canopy height (m)	*Lemna disperma*	Grass	Mosses	*Apium nodiflorum*
Riverlands Industrial	0	0			0.3		70		
Riverlands Industrial	1.8	0			0.3		70		
Riverlands Industrial	2.1	0.1			0.3		70		
Riverlands Industrial	2.4	0.3			0.3		70	50	
Riverlands Industrial	3	0.8			0.8		50	70	
Riverlands Industrial	3.3	1.5			1.2		50		
Riverlands Industrial	3.5	1.2			1.5		90		
Riverlands Industrial	3.8		0	0		100	50		
Riverlands Industrial	4.3		0.1	0		80			
Riverlands Industrial	4.8		0.1	0		10			
Riverlands Industrial	5.3		0.1	0		5			
Riverlands Industrial	5.8		0.1	0		5			
Riverlands Industrial	6.3		0.1			30			
Riverlands Industrial	6.9	1.6	0		1.5	90	50		10
Riverlands Industrial	7.2	1.6	0		1.4		100		
Riverlands Industrial	7.5	1.1			1		100		
Riverlands Industrial	8.5	0.4			0.9		100		
Riverlands Industrial	9.5	0							

Watercourse	Distance from left bank (m)	Distance from bank top (m)	Water depth (m)	Velocity (m s-1)	Canopy height (m)	*Lemna disperma*	Grass	*Azolla pinnata*	*Nitella* sp. aff. *cristata*	*Potamogeton crispus*	*Potamogeton cheesemanii*	*Glyceria fluitans*	Mosses
Roberts Lower	0	0					100						
Roberts Lower	1	0.2			0.1		100						
Roberts Lower	1.5	0.5		0	100								
Roberts Lower	2	1.2			0.3								
Roberts Lower	2.5	1.4	0	0	0.7	5	30					80	
Roberts Lower	3		0.5	0	0.8			5			30	70	
Roberts Lower	3.5		0.7	0	0.7				70	20	75		
Roberts Lower	4		0.8	0	0.8	5		5			100		
Roberts Lower	4.5		0.9	0	0.9	2		2		20	100		
Roberts Lower	5		0.8	0	0.8	2		2	20	10	100		
Roberts Lower	5.5		0.8	0	0.8	5		2	60		100		
Roberts Lower	6		0.7	0	0.7				70	10	100		
Roberts Lower	6.5		0.7	0	0.7				80		80		10
Roberts Lower	7		0.7	0	0.7				70		60		
Roberts Lower	7.4	1.4	0.4	0	0.4								
Roberts Lower	8	0.6	0										
Roberts Lower	8.5	0.2											
Roberts Lower	9	0											

Watercourse	Distance from left bank (m)	Distance from bank top (m)	Water depth (m)	Velocity (m s-1)	Canopy height (m)	*Lemna disperma*	Grass	*Potamogeton crispus*	*Lagarosiphon major*
Roberts upper	0	1.1			0.8		100		
Roberts upper	0.5	0.5			0.8		100		
Roberts upper	1	0	0	0			101		
Roberts upper	1.5		0.5	0					
Roberts upper	2		0.6	0	0.1			10	
Roberts upper	2.5		0.7	0	0.2				5
Roberts upper	3		0.8	0	0.1			25	5
Roberts upper	3.5		0.7	0	0.1			20	
Roberts upper	4		0.7	0	0.1			30	
Roberts upper	4.5		0.7	0					
Roberts upper	5		0.6	0	0.1			20	
Roberts upper	5.5		0.6	0	1		100		
Roberts upper	6		0.5	0			100		
Roberts upper	6.1		0.4	0	0.8		100		
Roberts upper	6.3	0		0	0.8		100		
Roberts upper	7	1.1			0.8		100		

Watercourse	Distance from left bank (m)	Distance from bank top (m)	Water depth (m)	Velocity (m s-1)	Canopy height (m)	*Lemna disperma*	Grass	Algae
Town Branch	0	0			0.1		100	
Town Branch	1	0.1					100	
Town Branch	1.5	0.3					100	
Town Branch	2	0.6			0.3		100	
Town Branch	2.5	1			0.8		100	
Town Branch	2.8	1.6	0		1.4		50	20
Town Branch	3.5		0.4	0				
Town Branch	4		0.4	0				25
Town Branch	4.5		0.3	0				25
Town Branch	5		0.3	0				25
Town Branch	5.5		0.4	0				26
Town Branch	6		0.3	0				
Town Branch	6.5	1.9	0.2		0.8		50	
Town Branch	6.9	1.4			0.8		100	
Town Branch	7.5	0.8			0.8		100	
Town Branch	8.5	0			0.3		100	

Watercourse	Distance from left bank (m)	Distance from bank top (m)	Water depth (m)	Velocity (m s-1)	Canopy height (m)	*Lemna disperma*	Grass	*Agrostis stolonifera*	Liverwort	*Chara globularis*	*Juncus bulbosus*
Waterlea	0	1	0	0	1.5		100				
Waterlea	0.2		0.2		1.5		100				
Waterlea	0.4		0.3	0.2	0.2	20		5	5	10	5
Waterlea	0.6		0.3	0.2	0.3					100	5
Waterlea	0.8		0.4	0.2	0.2					100	
Waterlea	1		0.4	0.3	0.3			20		10	
Waterlea	1.2		0.4	0.3	0.4			55		20	
Waterlea	1.4		0.3	0.3	0.3	20		70		20	
Waterlea	1.6		0.3	0.3	0.3	25	60		10	10	
Waterlea	1.8		0.3	0	0.3	80	100				
Waterlea	2		0.2	0	0.3	80	100				
Waterlea	2.2		0.2	0	0.3		100				
Waterlea	2.4		0.1	0	0.2		100				
Waterlea	2.6	1.2	0	0	0.4		100				
Waterlea	2.8		0	0	0.5		100				
Waterlea	3	0	0	0	0.6		100				

Appendix E Macroinvertebrate Data

Coded-abundance categories. The SQMCI uses a fivepoint scale of coded abundances R (rare) = 1–4 individuals; C (common) = 5–19; A (abundant) = 20–99; VA (very abundant) = 100–499; and VVA (very very abundant) = 500+

Site name	Pukaka Drain	Roberts	Sadds	Drain N	Drain Q	Marukoko	Grovetown Lagoon
Site number	**2**	**3**	**4**	**5**	**6**	**8**	**9**
Lepidoptera							
Hygraula nitens		C				A	
Austrolestes colensonis	R	A	A			C	
Xanthocnemis zealandica	R	VA	VVA	R	C	VA	
Ephemeroptera							
Austroclima sepia				C			
Zephlebia versicolor				C			
Plecoptera							
Megaleptoperla diminuta				C	A		
Trichoptera							
Hudsonema amabile							
Hudsonema alienum							
Hydrobiosis umbripennis group							
Hydrobiosis copis							
Hydrobiosis parumbripennis							
Oecetis unicolor							
Oeconesus maori							
Oxyethira albiceps			VA				C
Paroxyethira hendersoni		A	VVA			VVA	
Polyplectropus sp.				R	R		C
Psilochorema tautoru					A		C
Pycnocentrodes sp.							
Pycnocentria evecta							
Triplectides cephalotes			A			VA	
Triplectides dolichos/obsoletus		VA	A				
Diptera							
?Brachydeutera sp.							A
Austrosimulium sp.				C	A		
Ceratopogonidae	C		A				
Chironomus sp.	C	C	A	C		A	
Corynoneura sp.				C	C	C	VA
Culex pervigilans							
Empididae					C		
Ephydrella sp.		C	VA				
Harrisius pallidus							
Lobodiamesa?				C			
Muscidae				A			R
Orthocladiinae		VA	VVA	VVA	VA	C	VVA
Paradixa sp.							R
Paralimnophila sp.					A		
Polypedilum sp.			R	C	C		A
Stratiomyidae				C			
Macropelopiini			VA	A	VVA	A	
Tanytarsus vespertinus		A	A	VA	C	R	

Site name	Pukaka Drain	Roberts	Sadds	Drain N	Drain Q	Marukoko	Grovetown Lagoon
Site number	**2**	**3**	**4**	**5**	**6**	**8**	**9**
Coleoptera							
Enochrus sp.							R
Limnoxenus zealandicus							
Liodessus sp.							
Rhantus sp.							
Hemiptera							
Anisops sp.	R	C	A			A	
Microvelia macgregori		A		C		C	VA
Sigara sp.		A	VA		A	VA	
Mollusca							
Echyridella sp.		R					
Glyptophysa variabilis				C			
Gyraulus corinna							A
Physa acuta		VA	VA				
Potamopyrgus antipodarum		VA	VA	VA	A		
Pseudosuccinea columella	VA	VVA		A	VVA	VVA	VVA
Sphaeriidae				A			
Crustacea		VA		C	VVA		
Ostracoda							
Paracalliope fluviatilis	C	VA	VVA	VVA	VVA	A	A
Talitridae		VVA		VVA	VVA	VVA	VVA
Acarina						R	
Cnidaria			A				C
Hirudinea							
Nematoda							C
Nemertea			VVA		C		
Oligochaeta				C			
Platyhelminthes	VVA	VA	VVA	VVA	VVA	VVA	A

Site name	Kellys	Waterlea	Fultons	Caseys	Murphys	Doctors	Riverlands Ind
Site number	10	11	12	13	15	16	18
Lepidoptera							
Hygraula nitens						C	
Austrolestes colensonis							R
Xanthocnemis zealandica				C		A	A
Ephemeroptera							
Austroclima sepia	VA	R	VA				
Zephlebia versicolor	R						
Plecoptera							
Megaleptoperla diminuta	A	VA					
Trichoptera							
Hudsonema amabile	A	VVA	VA			R	
Hudsonema alienum	R	A	A		R		
Hydrobiosis umbripennis group	C					R	
Hydrobiosis copis	C						
Hydrobiosis parumbripennis	R	C	C				
Oecetis unicolor						A	
Oeconesus maori			C				
Oxyethira albiceps	VA	A	A	A	A	VVA	
Paroxyethira hendersoni	A	A		R		A	
Polyplectropus sp.	C		R		A		
Psilochorema tautoru	R	C	R		C		
Pycnocentrodes sp.		A					
Pycnocentria evecta	C	A					
Triplectides cephalotes							A
Triplectides dolichos/obsoletus	A	A	A	R	R	R	
Diptera							
?Brachydeutera sp.							
Austrosimulium sp.	VA	A					
Ceratopogonidae							
Chironomus sp.	C					A	VVA
Corynoneura sp.	C	A	C		A		C
Culex pervigilans							A
Empididae	C		C				
Ephydrella sp.				C			
Harrisius pallidus	C						
Lobodiamesa?							
Muscidae		R				C	
Orthocladiinae	VA	A	VA		VA	C	
Paradixa sp.			C		R		
Paralimnophila sp.	R	R			R		
Polypedilum sp.	A	C	A	C	VA		
Stratiomyidae				R			C
Macropelopiini	A	A	A		A	C	
Tanytarsus vespertinus	A	A	C			VA	
Coleoptera							
Enochrus sp.				R			
Limnoxenus zealandicus							R
Liodessus sp.							C
Rhantus sp.							R
Hemiptera							
Anisops sp.					R		A
Microvelia macgregori				C		C	VA
Sigara sp.				R	C		VVA
Mollusca							
Echyridella sp.	C						

Site name	Kellys	Waterlea	Fultons	Caseys	Murphys	Doctors	Riverlands Ind
Site number	10	11	12	13	15	16	18
Ferrissia dohrnianus	A	VA	A	VA			
Glyptophysa variabilis							
Gyraulus corinna	VA			R			C
Physa acuta	VA	VVA	A	R	VA	VVA	VA
Potamopyrgus antipodarum	VVA	VVA	VA	VVA	VVA	VVA	
Pseudosuccinea columella				R			R
Sphaeriidae	C	VA	C	VA	VA	A	
Crustacea							
Ostracoda	A	VVA	A	VA	VVA	VVA	
Paracalliope fluviatilis	VVA	VVA	VVA	VVA	VVA	VVA	
Talitridae						R	
Acarina	C	C					
Hydra	A	C				C	
Hirudinea							
Nematoda						A	A
Nemertea			C		A		A
Oligochaeta	VVA	VVA	C	VVA	VVA	VVA	VVA
Platyhelminthes			R		A	A	

Site name	Riverlands Coop	Town Branch D	Cravens	Halls
Site number	19	20	23	24
Lepidoptera				
Hygraula nitens				
Austrolestes colensonis				
Xanthocnemis zealandica	A	A	VA	C
Ephemeroptera				
Austroclima sepia			A	
Zephlebia versicolor			VA	
Plecoptera				
Megaleptoperla diminuta				
Trichoptera				
Hudsonema amabile			A	
Hudsonema alienum				C
Hydrobiosis umbripennis group			A	
Hydrobiosis copis			R	
Hydrobiosis parumbripennis				
Oecetis unicolor				
Oeconesus maori				
Oxyethira albiceps	VA		VVA	VVA
Paroxyethira hendersoni	VA	VA	VVA	A
Polyplectropus sp.			A	A
Psilochorema tautoru			C	R
Pycnocentrodes sp.				R
Pycnocentria evecta			VA	A
Triplectides cephalotes		C		
Triplectides dolichos/obsoletus	C			
Diptera				
?Brachydeutera sp.				
Austrosimulium sp.				A
Ceratopogonidae			A	
Chironomus sp.	A	VVA	C	
Corynoneura sp.	A			
Culex pervigilans				
Empididae				
Ephydrella sp.	A			
Harrisius pallidus				
Lobodiamesa?				
Muscidae	R		R	
Orthocladiinae	VVA	C	VVA	A
Paradixa sp.				
Paralimnophila sp.				R
Polypedilum sp.			A	R
Stratiomyidae	C			
Macropelopiini		A	A	C
Tanytarsus vespertinus	VA			
Coleoptera				
Enochrus sp.				
Limnoxenus zealandicus				
Liodessus sp.				
Rhantus sp.				
Hemiptera				
Anisops sp.	A	R		
Microvelia macgregori	VA			

Site name	Riverlands Coop	Town Branch	Cravens	Halls
Site number	19	20	23	24
Sigara sp.	VVA	VA		
Mollusca				
Echyridella sp.				
Ferrissia dohrnianus				
Glyptophysa variabilis				
Gyraulus corinna	VVA	A		C
Physa acuta	VA	C	VA	A
Potamopyrgus antipodarum	VVA	VVA	VVA	VVA
Pseudosuccinea columella				
Sphaeriidae			VA	VA
Crustacea				
Ostracoda	A	VA	VVA	VVA
Paracalliope fluviatilis	VA	VA	VVA	VVA
Talitridae				R
Acarina				
Hydra				
Hirudinea	A			C
Nematoda	A	VA		
Nemertea				
Oligochaeta	VA	VVA	A	VA
Platyhelminthes	A			

Appendix F New Zealand freshwater fish database cards

FRESHWATER FISH DATABASE FORM								1
Date	**8/3/2016**	River/Lake system **Wairau River**					Catchment number	**601.000**
Time	**1000**	Sampling locality **Pipitea North**						
Observer	**jps**	Access					Altitude (m)	**1**
Organisation	**niwa**	NZMS 260 Map no. **P28**		Coord. **2595441 5974165**			Distance inland (km)	**2**
Fishing method	**unk**	Area fished (m2) or no. nets used		Number of electric fishing passes			Tidal water	
HABITAT DATA								
Water	Colour			Clarity			Temp.	pH
	Average width (m)	Average depth (m)		Maximum depth (m)			Conductivity	
Habitat type (%)	Still	Back-water	Pool	Run	Riffle		Rapid	Casc.
Substrate type (%)	Mud	Sand	Fine gravel	Coarse gravel	Cobble		Boulder	Bed-rock
Fish cover (y/n)	Macrophyte	Instream debris	Undercut bank	Bank veg.				
Catchment vegetation(%)	Native forest	Exotic forest	Farm	Urban zone	Scrub		Swamp land	Other
Riparian vegetation(%)	Native forest	Exotic forest	Grass tussock	Exposed bed	Scrub willow		Raupo flax	Other
Type of river/stream/lake								
Water level			Downstream barrier				Pollution	
Large invertebrate fauna		Koura		Paratya			Freshwater mussel	
Bottom fauna abundance			Predominant species group				Permanent water	
FISH DATA								
Species				Abundance	Length		Habitat/Comments	
Comments **Stream Dry**								

FRESHWATER FISH DATABASE FORM

2

Date	**8/3/2016**	River/Lake system **Wairau River**		Catchment number	**601.000**
Time	**2330**	Sampling locality **Pukaka drain**			
Observer	**jps**	Access		Altitude (m)	**1**
Organisation	**niwa**	NZMS 260 Map no. **P28**	Coord. **2593783 5970930**	Distance inland (km)	**2**
Fishing method	**spo**	Area fished (m2) or no. nets used	Number of electric fishing passes	Tidal water	**n**

HABITAT DATA

Water	Colour				**u**	Clarity		**c**	Temp. **20.3**	pH	**8.7**
	Average width (m)	**6.0**	Average depth (m)		**0.5**	Maximum depth (m)			Conductivity		**10**
Habitat type (%)	Still	**100**	Back-water	**0**	Pool **0**	Run	**0**	Riffle **0**	Rapid **0**	Casc.	**0**
Substrate type (%)	Mud	**50**	Sand	**0**	Fine gravel **0**	Coarse gravel	**50**	Cobble **0**	Boulder **0**	Bed-rock	**0**
Fish cover (y/n)	Macrophyte	**y**	Instream debris	**y**	Undercut bank **y**	Bank veg.	**y**				
Catchment vegetation(%)	Native forest	**0**	Exotic forest	**0**	Farm **100**	Urban zone	**0**	Scrub **0**	Swamp land **0**	Other	**0**
Riparian vegetation(%)	Native forest	**0**	Exotic forest	**0**	Grass tussock **100**	Exposed bed	**0**	Scrub willow **0**	Raupo flax **0**	Other	**0**

Type of river/stream/lake

Water level	Downstream barrier **y**		Pollution
Large invertebrate fauna	Koura	Paratya	Freshwater mussel
Bottom fauna abundance	Predominant species group		Permanent water **y**

FISH DATA

Species		Abundance	Length	Habitat/Comments
Gobiomorphus cotidianus	**Common bully**	**3 (o)**	**60-70**	**sti**
Galaxias maculatus	**Inanga**	**105 (c)**	**b**	**sti**
Anguilla australis	**Shortfin eel**	**5 (o)**	**300-650**	**sti**

Comments **Thick layer of mud on top of gravel thin layer of clear water on top**

FRESHWATER FISH DATABASE FORM

3

Date	**7/3/2016**	River/Lake system **Wairau River**						Catchment number	**601.000**		
Time	**2300**	Sampling locality **Roberts drain**									
Observer	**jps**	Access						Altitude (m)	**1**		
Organisation	**niwa**	NZMS 260 Map no.	**P28**	Coord.	**2592833 5969630**			Distance inland (km)	**2**		
Fishing method	**spo**	Area fished (m2) or no. nets used		Number of electric fishing passes				Tidal water	**y**		

HABITAT DATA

Water	Colour	**u**			Clarity	**c**		Temp.	**15.3**	pH	**7.2**
	Average width (m)	**5.0**	Average depth (m)	**1.2**	Maximum depth (m)			Conductivity			**9**
Habitat type (%)	Still **100**	Back-water **0**	Pool **0**		Run **0**	Riffle **0**		Rapid **0**		Casc. **0**	
Substrate type (%)	Mud **50**	Sand **0**	Fine gravel **0**		Coarse gravel **50**	Cobble **0**		Boulder **0**		Bed-rock **0**	
Fish cover (y/n)	Macrophyte **y**	Instream debris **y**	Undercut bank **y**		Bank veg. **y**						
Catchment vegetation(%)	Native forest **0**	Exotic forest **0**	Farm **100**		Urban zone **0**	Scrub **0**		Swamp land **0**		Other **0**	
Riparian vegetation(%)	Native forest **0**	Exotic forest **0**	Grass tussock **100**		Exposed bed **0**	Scrub willow **0**		Raupo flax **0**		Other **0**	

Type of river/stream/lake

Water level			Downstream barrier	**y**				Pollution			
Large invertebrate fauna	Koura		Paratya					Freshwater mussel			
Bottom fauna abundance			Predominant species group					Permanent water	**y**		

FISH DATA

Species		Abundance		Length	Habitat/Comments
Gobiomorphus cotidianus	**Common bully**	**o**		**a**	**sti**
Galaxias maculatus	**Inanga**	**16**	**(c)**	**60-90**	**sti**
Anguilla australis	**Shortfin eel**	**26**	**(c)**	**300-800**	**sti**
Anguilla dieffenbachii	**Longfin eel**	**2**	**(o)**	**600-600**	**sti**
Rhombosolea retiaria	**Black flounder**	**1**	**(r)**	**100**	**sti**
Paranephrops	**Koura**	**9**	**(o)**	**b**	**sti**

Comments **incoming tide**

FRESHWATER FISH DATABASE FORM

4

Date	**8/3/2016**	River/Lake system **Wairau River**		Catchment number	**601.000**
Time	**2140**	Sampling locality **Sadds trib.**			
Observer	**jps**	Access		Altitude (m)	**2**
Organisation	**niwa**	NZMS 260 Map no. **P28**	Coord. **2591463 5969411**	Distance inland (km)	**9**
Fishing method	**spo**	Area fished (m2) or no. nets used	Number of electric fishing passes	Tidal water	**n**

HABITAT DATA

Water	Colour				**u**	Clarity		**m**	Temp.		pH	
	Average width (m)		Average depth (m)			Maximum depth (m)			Conductivity			
Habitat type (%)	Still	**100**	Back-water	**0**	Pool **0**	Run	**0**	Riffle **0**	Rapid	**0**	Casc.	**0**
Substrate type (%)	Mud	**100**	Sand	**0**	Fine gravel **0**	Coarse gravel	**0**	Cobble **0**	Boulder	**0**	Bed-rock	**0**
Fish cover (y/n)	Macrophyte	**y**	Instream debris	**y**	Undercut bank **y**	Bank veg.	**y**					
Catchment vegetation(%)	Native forest	**0**	Exotic forest	**0**	Farm **100**	Urban zone	**0**	Scrub **0**	Swamp land	**0**	Other	**0**
Riparian vegetation(%)	Native forest	**0**	Exotic forest	**0**	Grass tussock **100**	Exposed bed	**0**	Scrub willow **0**	Raupo flax	**0**	Other	**0**

Type of river/stream/lake

Water level	Downstream barrier		Pollution
Large invertebrate fauna	Koura	Paratya	Freshwater mussel
Bottom fauna abundance	Predominant species group		Permanent water **y**

FISH DATA

Species		Abundance		Length	Habitat/Comments
Gobiomorphus cotidianus	**Common bully**	**2**	**(o)**	**45-80**	**sti**
Galaxias maculatus	**Inanga**	**1**	**(o)**	**90**	**sti**
Anguilla australis	**Shortfin eel**	**10**	**(c)**	**350-550**	**sti**

Comments **Sadds stream dry upstream 25 m spotlighted below culvert**

FRESHWATER FISH DATABASE FORM

5

Date	**8/3/2016**	River/Lake system **Wairau River**		Catchment number	**601.000**
Time	**2216**	Sampling locality **Drain N**			
Observer	**jps**	Access		Altitude (m)	**4**
Organisation	**niwa**	NZMS 260 Map no. **P28**	Coord. **2589602 5969341**	Distance inland (km)	**10**
Fishing method	**spo**	Area fished (m2) or no. nets used	Number of electric fishing passes	Tidal water	**n**

HABITAT DATA

Water	Colour				**u**	Clarity		**c**	Temp.	**14.2**	pH	**7.2**
	Average width (m)	**2.5**	Average depth (m)		**0.6**	Maximum depth (m)			Conductivity			**72**
Habitat type (%)	Still	**0**	Back-water	**0**	Pool **0**	Run	**100**	Riffle **0**	Rapid	**0**	Casc.	**0**
Substrate type (%)	Mud	**50**	Sand	**0**	Fine gravel **0**	Coarse gravel	**50**	Cobble **0**	Boulder	**0**	Bed-rock	**0**
Fish cover (y/n)	Macrophyte	**y**	Instream debris	**y**	Undercut bank **y**	Bank veg.	**y**					
Catchment vegetation(%)	Native forest	**0**	Exotic forest	**0**	Farm **100**	Urban zone	**0**	Scrub **0**	Swamp land	**0**	Other	**0**
Riparian vegetation(%)	Native forest	**0**	Exotic forest	**0**	Grass tussock **100**	Exposed bed	**0**	Scrub willow **0**	Raupo flax	**0**	Other	**0**

Type of river/stream/lake

Water level	Downstream barrier **y**	Pollution	
Large invertebrate fauna	Koura	Paratya	Freshwater mussel
Bottom fauna abundance	Predominant species group	Permanent water	**y**

FISH DATA

Species		Abundance		Length	Habitat/Comments
Gobiomorphus cotidianus	**Common bully**	**1**	**(r)**	**70**	**run**
Anguilla australis	**Shortfin eel**	**2**	**(o)**	**320-600**	**run**
Anguilla dieffenbachii	**Longfin eel**	**1**	**(o)**	**700**	**run**
Salmo trutta	**Brown trout**	**1**	**(o)**	**550**	**run Jack**
Paranephrops	**Koura**	**7**	**(o)**	**b**	**run**

Comments **nice habitat with good flow**

FRESHWATER FISH DATABASE FORM

6

Date	**8/3/2016**	River/Lake system **Wairau River**		Catchment number	**601.000**
Time	**2200**	Sampling locality **Drain Q**			
Observer	**jps**	Access		Altitude (m)	**4**
Organisation	**niwa**	NZMS 260 Map no. **P28**	Coord. **2590072 5969881**	Distance inland (km)	**9**
Fishing method	**spo**	Area fished (m2) or no. nets used	Number of electric fishing passes	Tidal water	**n**

HABITAT DATA

Water	Colour				**u**	Clarity		**c**	Temp. **14.0**	pH	**7.5**
	Average width (m)	**1.1**	Average depth (m)		**0.1**	Maximum depth (m)			Conductivity		**75**
Habitat type (%)	Still **0**	Back-water **0**	Pool **0**			Run **100**	Riffle **0**		Rapid **0**	Casc. **0**	
Substrate type (%)	Mud **50**	Sand **0**	Fine gravel **0**			Coarse gravel **50**	Cobble **0**		Boulder **0**	Bed-rock **0**	
Fish cover (y/n)	Macrophyte **n**	Instream debris **y**	Undercut bank **y**			Bank veg. **y**					
Catchment vegetation(%)	Native forest **0**	Exotic forest **0**	Farm **100**			Urban zone **0**	Scrub **0**		Swamp land **0**	Other **0**	
Riparian vegetation(%)	Native forest **0**	Exotic forest **0**	Grass tussock **100**			Exposed bed **0**	Scrub willow **0**		Raupo flax **0**	Other **0**	

Type of river/stream/lake

Water level	Downstream barrier **y**		Pollution
Large invertebrate fauna	Koura	Paratya	Freshwater mussel
Bottom fauna abundance	Predominant species group		Permanent water **y**

FISH DATA

Species		Abundance	Length	Habitat/Comments
Anguilla australis	**Shortfin eel**	**1 (r)**	**650**	**run**
Anguilla dieffenbachii	**Longfin eel**	**1 (r)**	**1000**	**run**

Comments **Drain low**

FRESHWATER FISH DATABASE FORM

7

Date	**8/3/2016**	River/Lake system **Wairau River**		Catchment number	**601.000**
Time	**1230**	Sampling locality **Pipitea South**			
Observer	**jps**	Access		Altitude (m)	**1**
Organisation	**niwa**	NZMS 260 Map no. **P28**	Coord. **2596089 5968620**	Distance inland (km)	**2**
Fishing method	**fyn**	Area fished (m2) or no. nets used **5**	Number of electric fishing passes	Tidal water	**n**

HABITAT DATA

Water	Colour				**u**	Clarity		**d**	Temp. **18.4**	pH	**6.9**
	Average width (m)	**1.5**	Average depth (m)		**0.5**	Maximum depth (m)			Conductivity		
Habitat type (%)	Still	**100**	Back-water	**0**	Pool **0**	Run	**0**	Riffle **0**	Rapid **0**	Casc.	**0**
Substrate type (%)	Mud	**100**	Sand	**0**	Fine gravel **0**	Coarse gravel	**0**	Cobble **0**	Boulder **0**	Bed-rock	**0**
Fish cover (y/n)	Macrophyte	**y**	Instream debris	**y**	Undercut bank **n**	Bank veg.	**n**				
Catchment vegetation(%)	Native forest	**0**	Exotic forest	**0**	Farm **100**	Urban zone	**0**	Scrub **0**	Swamp land **0**	Other	**0**
Riparian vegetation(%)	Native forest	**0**	Exotic forest	**0**	Grass tussock **100**	Exposed bed	**0**	Scrub willow **0**	Raupo flax **0**	Other	**0**

Type of river/stream/lake			
Water level **l**	Downstream barrier **y**	Pollution	
Large invertebrate fauna	Koura	Paratya	Freshwater mussel
Bottom fauna abundance	Predominant species group	Permanent water **y**	

FISH DATA

Species		Abundance	Length	Habitat/Comments
Anguilla australis	**Shortfin eel**	**51 (c)**	**91-600**	**sti**

Comments **murky drain covered in duckweed. Fine mesh fykes used**

FRESHWATER FISH DATABASE FORM

8

Date	**9/3/2016**	River/Lake system **Wairau River**		Catchment number	**601.000**
Time	**1320**	Sampling locality **Marukoko**			
Observer	**jps**	Access		Altitude (m)	**1**
Organisation	**niwa**	NZMS 260 Map no. **P28**	Coord. **2595990 5968521**	Distance inland (km)	**2**
Fishing method	**fyn**	Area fished (m2) or no. nets used **5**	Number of electric fishing passes	Tidal water	**n**

HABITAT DATA

Water	Colour				**u**	Clarity		**m**	Temp.	**19**	pH	**7.3**	
	Average width (m)	**15.0**	Average depth (m)		**1.5**	Maximum depth (m)			Conductivity			**74**	
Habitat type (%)	Still	**100**	Back-water	**0**	Pool **0**	Run	**0**	Riffle **0**	Rapid	**0**	Casc.	**0**	
Substrate type (%)	Mud	**100**	Sand	**0**	Fine gravel **0**	Coarse gravel	**0**	Cobble **0**	Boulder	**0**	Bed-rock	**0**	
Fish cover (y/n)	Macrophyte	**y**	Instream debris	**y**	Undercut bank **y**	Bank veg.	**y**						
Catchment vegetation(%)	Native forest	**0**	Exotic forest	**0**	Farm **100**	Urban zone	**0**	Scrub **0**	Swamp land	**0**	Other	**0**	
Riparian vegetation(%)	Native forest	**0**	Exotic forest	**0**	Grass tussock **100**	Exposed bed	**0**	Scrub willow **0**	Raupo flax	**0**	Other	**0**	

Type of river/stream/lake

Water level	Downstream barrier		Pollution
Large invertebrate fauna	Koura	Paratya **c**	Freshwater mussel
Bottom fauna abundance	Predominant species group		Permanent water **y**

FISH DATA

Species		Abundance		Length	Habitat/Comments
Anguilla australis	**Shortfin eel**	**143**	**(a)**	**230-870**	**sti**
Anguilla dieffenbachii	**Longfin eel**	**6**	**(o)**	**271-720**	**sti**
Galaxias maculatus	**Inanga**	**1**	**(a)**	**67**	**sti lots seen**
Gobiomorphus cotidianus	**Common bully**	**34**	**(c)**	**27-53**	**sti some eaten by eels**

Comments **Fine mesh fykes**

FRESHWATER FISH DATABASE FORM

25

Date	**9/3/2016**	River/Lake system **Wairau River**		Catchment number	**601.000**
Time	**2230**	Sampling locality **Marukoko**			
Observer	**jps**	Access		Altitude (m)	**1**
Organisation	**niwa**	NZMS 260 Map no. **P28**	Coord. **2595990 5968521**	Distance inland (km)	**2**
Fishing method	**spo**	Area fished (m2) or no. nets used	Number of electric fishing passes	Tidal water	**n**

HABITAT DATA

Water	Colour				**u**	Clarity		**m**	Temp. **19**	pH	**7.3**
	Average width (m)	**15.0**	Average depth (m)		**1.5**	Maximum depth (m)			Conductivity		**74**
Habitat type (%)	Still **100**	Back-water **0**	Pool **0**			Run **0**	Riffle **0**		Rapid **0**	Casc. **0**	
Substrate type (%)	Mud **100**	Sand **0**	Fine gravel **0**			Coarse gravel **0**	Cobble **0**		Boulder **0**	Bed-rock **0**	
Fish cover (y/n)	Macrophyte **y**	Instream debris **y**	Undercut bank **y**			Bank veg. **y**					
Catchment vegetation(%)	Native forest **0**	Exotic forest **0**	Farm **100**			Urban zone **0**	Scrub **0**		Swamp land **0**	Other **0**	
Riparian vegetation(%)	Native forest **0**	Exotic forest **0**	Grass tussock **100**			Exposed bed **0**	Scrub willow **0**		Raupo flax **0**	Other **0**	

Type of river/stream/lake

Water level	Downstream barrier		Pollution
Large invertebrate fauna	Koura	Paratya **c**	Freshwater mussel
Bottom fauna abundance	Predominant species group		Permanent water **y**

FISH DATA

Species		Abundance	Length	Habitat/Comments
Galaxias maculatus	**Inanga**	**a**	**50-110**	
Anguilla australis	**Shortfin eel**	**c**	**b**	**sti**
Anguilla dieffenbachii	**Longfin eel**	**o**	**a**	

Comments **out going tide difficult to see with murky water**

FRESHWATER FISH DATABASE FORM

9

Date	**8/3/2016**	River/Lake system **Wairau River**		Catchment number	**601.000**
Time	**1800**	Sampling locality **Grovetown Springs**			
Observer	**jps**	Access		Altitude (m)	**1**
Organisation	**niwa**	NZMS 260 Map no. **P28**	Coord. **2592158 5969742**	Distance inland (km)	**2**
Fishing method	**efp**	Area fished (m2) or no. nets used	Number of electric fishing passes **1**	Tidal water	**n**

HABITAT DATA

Water	Colour				**u**	Clarity		**c**	Temp. **12.6**	pH	**7.1**
	Average width (m)	**3.5**	Average depth (m)		**0.6**	Maximum depth (m)			Conductivity		**7**
Habitat type (%)	Still	**0**	Back-water	**0**	Pool **0**	Run	**100**	Riffle **0**	Rapid **0**	Casc.	**0**
Substrate type (%)	Mud	**50**	Sand	**20**	Fine gravel **30**	Coarse gravel	**0**	Cobble **0**	Boulder **0**	Bed-rock	**0**
Fish cover (y/n)	Macrophyte	**y**	Instream debris	**y**	Undercut bank **y**	Bank veg.	**y**				
Catchment vegetation(%)	Native forest	**0**	Exotic forest	**0**	Farm **50**	Urban zone	**0**	Scrub **50**	Swamp land **0**	Other	**0**
Riparian vegetation(%)	Native forest	**0**	Exotic forest	**0**	Grass tussock **50**	Exposed bed	**0**	Scrub willow **50**	Raupo flax **0**	Other	**0**

Type of river/stream/lake

Water level	Downstream barrier		Pollution
Large invertebrate fauna	Koura	Paratya	Freshwater mussel
Bottom fauna abundance	Predominant species group		Permanent water **y**

FISH DATA

Species		Abundance	Length	Habitat/Comments
Gobiomorphus cotidianus	**Common bully**	**4 (c)**	**50-90**	**run**
Anguilla australis	**Shortfin eel**	**5 (o)**	**400**	**run 4 missedc eels sf**

Comments **spot fished due to heavy weed growth instream**

FRESHWATER FISH DATABASE FORM

26

Date	**10/3/2016**	River/Lake system **Wairau River**		Catchment number	**601.000**
Time	**1730**	Sampling locality **Grovetown Springs**			
Observer	**jps**	Access		Altitude (m)	**1**
Organisation	**niwa**	NZMS 260 Map no. **P28**	Coord. **2592158 5969742**	Distance inland (km)	**2**
Fishing method	**fyn**	Area fished (m2) or no. nets used **2**	Number of electric fishing passes	Tidal water	**n**

HABITAT DATA

Water	Colour				**u**	Clarity		**c**	Temp. **12.6**	pH	**7.2**
	Average width (m)	**3.5**	Average depth (m)	**0.5**		Maximum depth (m)			Conductivity		**7**
Habitat type (%)	Still	**100**	Back-water	**0**	Pool **0**	Run	**0**	Riffle **0**	Rapid **0**	Casc.	**0**
Substrate type (%)	Mud	**50**	Sand	**30**	Fine gravel **20**	Coarse gravel	**0**	Cobble **0**	Boulder **0**	Bed-rock	**0**
Fish cover (y/n)	Macrophyte	**y**	Instream debris	**y**	Undercut bank **y**	Bank veg.	**y**				
Catchment vegetation(%)	Native forest	**0**	Exotic forest	**0**	Farm **50**	Urban zone	**0**	Scrub **50**	Swamp land **0**	Other	**0**
Riparian vegetation(%)	Native forest	**0**	Exotic forest	**0**	Grass tussock **50**	Exposed bed	**0**	Scrub willow **50**	Raupo flax **0**	Other	**0**

Type of river/stream/lake

Water level	Downstream barrier		Pollution
Large invertebrate fauna	Koura	Paratya **c**	Freshwater mussel
Bottom fauna abundance	Predominant species group		Permanent water **y**

FISH DATA

Species		Abundance	Length	Habitat/Comments
Anguilla dieffenbachii	**Longfin eel**	**4 (o)**	**400-700**	**sti**
Galaxias maculatus	**Inanga**	**2 (o)**	**53-62**	**sti**

Comments **Fine mesh fykes used as electric fishing difficult due to large amounts of weed**

FRESHWATER FISH DATABASE FORM

10

Date	**10/3/2016**	River/Lake system **Wairau River**		Catchment number	**601.000**
Time	**1100**	Sampling locality **Kellys**			
Observer	**jps**	Access		Altitude (m)	**2.5**
Organisation	**niwa**	NZMS 260 Map no. **P28**	Coord. **2590991 5970002**	Distance inland (km)	**8**
Fishing method	**efp**	Area fished (m2) or no. nets used	Number of electric fishing passes **1**	Tidal water	**n**

HABITAT DATA

Water	Colour				**u**	Clarity		**c**	Temp. **14.2**	pH	**7.5**
	Average width (m)	**1.8**	Average depth (m)		**0.5**	Maximum depth (m)			Conductivity		**75**
Habitat type (%)	Still	**0**	Back-water	**0**	Pool **0**	Run	**100**	Riffle **0**	Rapid **0**	Casc.	**0**
Substrate type (%)	Mud	**30**	Sand	**50**	Fine gravel **20**	Coarse gravel	**0**	Cobble **0**	Boulder **0**	Bed-rock	**0**
Fish cover (y/n)	Macrophyte	**y**	Instream debris	**y**	Undercut bank **n**	Bank veg.	**y**				
Catchment vegetation(%)	Native forest	**0**	Exotic forest	**0**	Farm **100**	Urban zone	**0**	Scrub **0**	Swamp land **0**	Other	**0**
Riparian vegetation(%)	Native forest	**0**	Exotic forest	**0**	Grass tussock **100**	Exposed bed	**0**	Scrub willow **0**	Raupo flax **0**	Other	**0**

Type of river/stream/lake

Water level	Downstream barrier		Pollution
Large invertebrate fauna	Koura	Paratya	Freshwater mussel **p**
Bottom fauna abundance	Predominant species group		Permanent water **y**

FISH DATA

Species		Abundance		Length	Habitat/Comments
Anguilla australis	**Shortfin eel**	**a**		**93-570**	**70 sf in first 20m**
Anguilla dieffenbachii	**Longfin eel**	**c**		**84-650**	**run 9 lf in first 20m**
Gobiomorphus cotidianus	**Common bully**	**a**		**23-60**	**run 35 cb in first 20m**
Rhombosolea retiaria	**Black flounder**	**2**	**(o)**	**240-300**	**run**
Salmo trutta	**Brown trout**	**4**	**(c)**	**120-340**	**run**
Galaxias maculatus	**Inanga**	**4**	**(o)**	**60-70**	**run**
Paranephrops	**Koura**	**a**		**b**	**run**

Comments **good fish cover and flow mussels abundant**

FRESHWATER FISH DATABASE FORM

11

Date	**10/3/2016**	River/Lake system **Wairau River**						Catchment number	**601.020**		
Time	**1300**	Sampling locality **Waterlea**									
Observer	**jps**	Access						Altitude (m)	**7**		
Organisation	**niwa**	NZMS 260 Map no.	**P28**	Coord.	**2589528**	**5966260**		Distance inland (km)	**17**		
Fishing method	**efp**	Area fished (m2) or no. nets used		Number of electric fishing passes	**1**			Tidal water	**n**		

HABITAT DATA

Water	Colour					**u**	Clarity		**c**	Temp.	**15.6**	pH	**7.2**
	Average width (m)	**3.3**	Average depth (m)		**0.4**		Maximum depth (m)			Conductivity			**73**
Habitat type (%)	Still	**0**	Back-water	**0**	Pool	**0**	Run	**95**	Riffle **5**	Rapid	**0**	Casc.	**0**
Substrate type (%)	Mud	**50**	Sand	**20**	Fine gravel	**30**	Coarse gravel	**0**	Cobble **0**	Boulder	**0**	Bed-rock	**0**
Fish cover (y/n)	Macrophyte	**y**	Instream debris	**y**	Undercut bank	**y**	Bank veg.	**y**					
Catchment vegetation(%)	Native forest	**0**	Exotic forest	**0**	Farm	**0**	Urban zone	**50**	Scrub **0**	Swamp land	**0**	Other	**50**
Riparian vegetation(%)	Native forest	**0**	Exotic forest	**0**	Grass tussock	**50**	Exposed bed	**0**	Scrub willow **0**	Raupo flax	**0**	Other	**50**
Type of river/stream/lake													
Water level				Downstream barrier		**y**	Pollution						
Large invertebrate fauna		Koura			Paratya				Freshwater mussel				
Bottom fauna abundance			Predominant species group						Permanent water		**y**		

FISH DATA

Species		Abundance	Length	Habitat/Comments
Salmo trutta	**Brown trout**	**2 (o)**	**250-300**	**gen**
Oncorhynchus mykiss	**Rainbow trout**	**1 (r)**	**300**	**gen**
Anguilla australis	**Shortfin eel**	**a**	**134-400**	**gen 23 sf in first 20m**
Anguilla dieffenbachii	**Longfin eel**	**c**	**207-650**	**gen 11 lf in first 20m of rea**
Paranephrops	**Koura**	**c**	**b**	**gen**

Comments

FRESHWATER FISH DATABASE FORM

12

Date	**10/3/2016**	River/Lake system **Wairau River**		Catchment number	**601.020**
Time	**2330**	Sampling locality **Fultons**			
Observer	**jps**	Access		Altitude (m)	**7**
Organisation	**niwa**	NZMS 260 Map no. **P28**	Coord. **2589219 5966353**	Distance inland (km)	**17**
Fishing method	**spo**	Area fished (m2) or no. nets used	Number of electric fishing passes	Tidal water	**n**

HABITAT DATA

Water	Colour				**u**	Clarity	**c**		Temp. **13.5**	pH	**6.6**
	Average width (m)	**4.0**	Average depth (m)	**0.5**		Maximum depth (m)			Conductivity		**66**
Habitat type (%)	Still	**0**	Back-water	**0**	Pool **0**	Run	**100**	Riffle **0**	Rapid **0**	Casc.	**0**
Substrate type (%)	Mud	**20**	Sand	**20**	Fine gravel **20**	Coarse gravel	**40**	Cobble **0**	Boulder **0**	Bed-rock	**0**
Fish cover (y/n)	Macrophyte	**y**	Instream debris	**y**	Undercut bank **y**	Bank veg.	**y**				
Catchment vegetation(%)	Native forest	**0**	Exotic forest	**0**	Farm **0**	Urban zone	**100**	Scrub **0**	Swamp land **0**	Other	**0**
Riparian vegetation(%)	Native forest	**0**	Exotic forest	**0**	Grass tussock **100**	Exposed bed	**0**	Scrub willow **0**	Raupo flax **0**	Other	**0**

Type of river/stream/lake

Water level	Downstream barrier		Pollution
Large invertebrate fauna	Koura	Paratya	Freshwater mussel
Bottom fauna abundance	Predominant species group		Permanent water **y**

FISH DATA

Species		Abundance	Length	Habitat/Comments
Gobiomorphus cotidianus	**Common bully**	**13 (c)**	**65-90**	**run**
Galaxias maculatus	**Inanga**	**6 (o)**	**55-70**	**run**
Anguilla australis	**Shortfin eel**	**2 (o)**	**400-400**	**run**
Salmo trutta	**Brown trout**	**1 (r)**	**260**	**run**
Paranephrops	**Koura**	**c**	**b**	**run**
Anguilla dieffenbachii	**Longfin eel**	**1 (o)**	**300**	

Comments

FRESHWATER FISH DATABASE FORM

13

Date	**7/3/2016**	River/Lake system **Wairau River**		Catchment number	**601.020**
Time	**2130**	Sampling locality **Caseys**			
Observer	**jps**	Access		Altitude (m)	**7**
Organisation	**niwa**	NZMS 260 Map no. **P28**	Coord. **2589439 5967197**	Distance inland (km)	**17**
Fishing method	**spo**	Area fished (m2) or no. nets used	Number of electric fishing passes	Tidal water	**n**

HABITAT DATA

Water	Colour				**u**	Clarity		**m**	Temp. **17.8**	pH	**7.4**
	Average width (m)	**3.0**	Average depth (m)			Maximum depth (m)			Conductivity		**74**
Habitat type (%)	Still	**100**	Back-water	**0**	Pool **0**	Run	**0**	Riffle **0**	Rapid **0**	Casc.	**0**
Substrate type (%)	Mud	**100**	Sand	**0**	Fine gravel **0**	Coarse gravel	**0**	Cobble **0**	Boulder **0**	Bed-rock	**0**
Fish cover (y/n)	Macrophyte	**n**	Instream debris	**y**	Undercut bank **y**	Bank veg.	**y**				
Catchment vegetation(%)	Native forest	**0**	Exotic forest	**0**	Farm **0**	Urban zone	**100**	Scrub **0**	Swamp land **0**	Other	**0**
Riparian vegetation(%)	Native forest	**0**	Exotic forest	**0**	Grass tussock **0**	Exposed bed	**0**	Scrub willow **0**	Raupo flax **0**	Other	**100**

Type of river/stream/lake			
Water level	Downstream barrier		Pollution
Large invertebrate fauna	Koura	Paratya	Freshwater mussel
Bottom fauna abundance	Predominant species group		Permanent water **y**

FISH DATA

Species		Abundance	Length	Habitat/Comments
Galaxias maculatus	**Inanga**	**20 (c)**	**50-80**	**sti**
Anguilla australis	**Shortfin eel**	**1 (r)**	**450**	**sti**
Paranephrops	**Koura**	**4 (o)**	**b**	**sti**

Comments **water level low**

FRESHWATER FISH DATABASE FORM							14
Date	**10/3/2016**	River/Lake system **Wairau River**				Catchment number	**601.020**
Time	**1300**	Sampling locality **Woolley and Jones**					
Observer	**jps**	Access				Altitude (m)	**7**
Organisation	**niwa**	NZMS 260 Map no. **P28**		Coord. **2592143 5968211**		Distance inland (km)	**15**
Fishing method	**unk**	Area fished (m2) or no. nets used		Number of electric fishing passes		Tidal water	**n**

HABITAT DATA

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

FISH DATA

Species	Abundance	Length	Habitat/Comments

Comments **Stream dry**

FRESHWATER FISH DATABASE FORM

15

Date	**7/3/2016**	River/Lake system **Wairau River**		Catchment number	**601.020**
Time	**2100**	Sampling locality **Murphys**			
Observer	**jps**	Access		Altitude (m)	**7**
Organisation	**niwa**	NZMS 260 Map no. **P28**	Coord. **2588103 5966222**	Distance inland (km)	**17**
Fishing method	**spo**	Area fished (m2) or no. nets used	Number of electric fishing passes	Tidal water	**n**

HABITAT DATA

Water	Colour				**u**	Clarity		**c**	Temp.	**14**	pH	**6.7**
	Average width (m)	**6.0**	Average depth (m)		**0.3**	Maximum depth (m)			Conductivity			**11**
Habitat type (%)	Still	**0**	Back-water	**0**	Pool **0**	Run	**100**	Riffle **0**	Rapid	**0**	Casc.	**0**
Substrate type (%)	Mud	**50**	Sand	**0**	Fine gravel **20**	Coarse gravel	**30**	Cobble **0**	Boulder	**0**	Bed-rock	**0**
Fish cover (y/n)	Macrophyte	**n**	Instream debris	**y**	Undercut bank **n**	Bank veg.	**y**					
Catchment vegetation(%)	Native forest	**0**	Exotic forest	**0**	Farm **0**	Urban zone	**100**	Scrub **0**	Swamp land	**0**	Other	**0**
Riparian vegetation(%)	Native forest	**0**	Exotic forest	**0**	Grass tussock **0**	Exposed bed	**0**	Scrub willow **0**	Raupo flax	**0**	Other	**100**

Type of river/stream/lake			
Water level	Downstream barrier		Pollution
Large invertebrate fauna	Koura	Paratya	Freshwater mussel
Bottom fauna abundance	Predominant species group		Permanent water **y**

FISH DATA

Species		Abundance	Length	Habitat/Comments
Gobiomorphus cotidianus	**Common bully**	**3 (o)**	**90-100**	**run**
Anguilla australis	**Shortfin eel**	**7 (c)**	**400-800**	**run**
Anguilla dieffenbachii	**Longfin eel**	**1 (r)**	**900**	**run**
Paranephrops	**Koura**	**3 (o)**	**b**	**run**

Comments **no inanga seen in reach**

FRESHWATER FISH DATABASE FORM

16

Date	**10/3/2016**	River/Lake system **Wairau River**		Catchment number	**601.020**
Time	**1300**	Sampling locality **Doctors**			
Observer	**jps**	Access		Altitude (m)	**7**
Organisation	**niwa**	NZMS 260 Map no. **P28**	Coord. **2588019 5964880**	Distance inland (km)	**17**
Fishing method	**efp**	Area fished (m2) or no. nets used	Number of electric fishing passes **1**	Tidal water	**n**

HABITAT DATA

Water	Colour				**u**	Clarity		**c**	Temp. **15.7**	pH	**7**
	Average width (m)	**5.0**	Average depth (m)		**0.2**	Maximum depth (m)			Conductivity		**15**
Habitat type (%)	Still	**50**	Back-water	**0**	Pool **0**	Run	**50**	Riffle **0**	Rapid **0**	Casc.	**0**
Substrate type (%)	Mud	**100**	Sand	**0**	Fine gravel **0**	Coarse gravel	**0**	Cobble **0**	Boulder **0**	Bed-rock	**0**
Fish cover (y/n)	Macrophyte	**y**	Instream debris	**y**	Undercut bank **y**	Bank veg.	**y**				
Catchment vegetation(%)	Native forest	**0**	Exotic forest	**0**	Farm **100**	Urban zone	**0**	Scrub **0**	Swamp land **0**	Other	**0**
Riparian vegetation(%)	Native forest	**0**	Exotic forest	**0**	Grass tussock **100**	Exposed bed	**0**	Scrub willow **0**	Raupo flax **0**	Other	**0**

Type of river/stream/lake

Water level	Downstream barrier		Pollution
Large invertebrate fauna	Koura	Paratya	Freshwater mussel
Bottom fauna abundance	Predominant species group		Permanent water **y**

FISH DATA

Species		Abundance		Length	Habitat/Comments
Gobiomorphus cotidianus	**Common bully**	**c**		**30-99**	**gen 8 cb in first 20 m**
Galaxias maculatus	**Inanga**	**2**	**(c)**	**65-80**	**gen only 2 caught in first 2**
Anguilla australis	**Shortfin eel**	**71**	**(a)**	**95-650**	**gen 71 sf in the first 20m**
Anguilla dieffenbachii	**Longfin eel**	**4**	**(o)**	**167-1100**	**gen 4 lf in first 20m**
Paranephrops	**Koura**	**o**		**b**	**gen**

Comments

FRESHWATER FISH DATABASE FORM							17
Date	**7/3/2016**	River/Lake system **Wairau River**				Catchment number	**601.020**
Time		Sampling locality **Yeleverton**					
Observer	**jps**	Access				Altitude (m)	**7**
Organisation	**niwa**	NZMS 260 Map no.	**P28**	Coord. **2587082 5965220**		Distance inland (km)	**18**
Fishing method	**unk**	Area fished (m2) or no. nets used		Number of electric fishing passes		Tidal water	**n**

HABITAT DATA

Water	Colour			Clarity		Temp.	pH
	Average width (m)	Average depth (m)		Maximum depth (m)		Conductivity	
Habitat type (%)	Still	Back-water	Pool	Run	Riffle	Rapid	Casc.
Substrate type (%)	Mud	Sand	Fine gravel	Coarse gravel	Cobble	Boulder	Bed-rock
Fish cover (y/n)	Macrophyte	Instream debris	Undercut bank	Bank veg.			
Catchment vegetation(%)	Native forest	Exotic forest	Farm	Urban zone	Scrub	Swamp land	Other
Riparian vegetation(%)	Native forest	Exotic forest	Grass tussock	Exposed bed	Scrub willow	Raupo flax	Other

Type of river/stream/lake						
Water level		Downstream barrier			Pollution	
Large invertebrate fauna	Koura		Paratya		Freshwater mussel	
Bottom fauna abundance		Predominant species group			Permanent water	**y**

FISH DATA

Species	Abundance	Length	Habitat/Comments

Comments **Stream dry**

FRESHWATER FISH DATABASE FORM

18

Date	**9/3/2016**	River/Lake system **Wairau River**		Catchment number	**601.020**
Time	**1700**	Sampling locality **Riverlands Industrial**			
Observer	**jps**	Access		Altitude (m)	**4**
Organisation	**niwa**	NZMS 260 Map no. **P28**	Coord. **2595197 5963142**	Distance inland (km)	**4**
Fishing method	**efp**	Area fished (m2) or no. nets used	Number of electric fishing passes **1**	Tidal water	**n**

HABITAT DATA

Water	Colour				**u**	Clarity		**d**	Temp. **15.6**	pH	**7.5**
	Average width (m)	**3.3**	Average depth (m)		**0.3**	Maximum depth (m)			Conductivity		**33**
Habitat type (%)	Still	**100**	Back-water	**0**	Pool **0**	Run	**0**	Riffle **0**	Rapid **0**	Casc.	**0**
Substrate type (%)	Mud	**100**	Sand	**0**	Fine gravel **0**	Coarse gravel	**0**	Cobble **0**	Boulder **0**	Bed-rock	**0**
Fish cover (y/n)	Macrophyte	**y**	Instream debris	**y**	Undercut bank **y**	Bank veg.	**y**				
Catchment vegetation(%)	Native forest	**0**	Exotic forest	**0**	Farm **50**	Urban zone	**50**	Scrub **0**	Swamp land **0**	Other	**0**
Riparian vegetation(%)	Native forest	**0**	Exotic forest	**0**	Grass tussock **100**	Exposed bed	**0**	Scrub willow **0**	Raupo flax **0**	Other	**0**

Type of river/stream/lake

Water level	Downstream barrier		Pollution
Large invertebrate fauna	Koura	Paratya	Freshwater mussel
Bottom fauna abundance	Predominant species group		Permanent water **y**

FISH DATA

Species	Abundance	Length	Habitat/Comments
Anguilla australis **Shortfin eel**	**8 (o)**	**550-1000**	**sti**

Comments **low Do, large shotfins only**

FRESHWATER FISH DATABASE FORM

19

Date	**6/3/2016**	River/Lake system **Wairau River**		Catchment number	**601.020**
Time	**2100**	Sampling locality **Riverlands Co-op**			
Observer	**jps**	Access		Altitude (m)	**5**
Organisation	**niwa**	NZMS 260 Map no. **P28**	Coord. **2591196 5963445**	Distance inland (km)	**15**
Fishing method	**spo**	Area fished (m2) or no. nets used	Number of electric fishing passes	Tidal water	**n**

HABITAT DATA

Water	Colour				**u**	Clarity		**c**	Temp. **21.5**	pH	**9**
	Average width (m)	**3.0**	Average depth (m)		**0.2**	Maximum depth (m)			Conductivity		**20**
Habitat type (%)	Still	**100**	Back-water	**0**	Pool **0**	Run	**0**	Riffle **0**	Rapid **0**	Casc.	**0**
Substrate type (%)	Mud	**100**	Sand	**0**	Fine gravel **0**	Coarse gravel	**0**	Cobble **0**	Boulder **0**	Bed-rock	**0**
Fish cover (y/n)	Macrophyte	**y**	Instream debris	**y**	Undercut bank **y**	Bank veg.	**y**				
Catchment vegetation(%)	Native forest	**0**	Exotic forest	**0**	Farm **50**	Urban zone	**50**	Scrub **0**	Swamp land **0**	Other	**0**
Riparian vegetation(%)	Native forest	**0**	Exotic forest	**0**	Grass tussock **100**	Exposed bed	**0**	Scrub willow **0**	Raupo flax **0**	Other	**0**

Type of river/stream/lake

Water level	Downstream barrier		Pollution
Large invertebrate fauna	Koura	Paratya	Freshwater mussel
Bottom fauna abundance	Predominant species group		Permanent water **y**

FISH DATA

Species		Abundance	Length	Habitat/Comments
Anguilla australis	**Shortfin eel**	**10 (c)**	**400-600**	**sti**
Galaxias maculatus	**Inanga**	**a**	**b**	**sti very large number of in**

Comments

FRESHWATER FISH DATABASE FORM

27

Date	**10/3/2016**	River/Lake system **Wairau River**						Catchment number	**601.020**		
Time	**1400**	Sampling locality **Riverlands Co-op**									
Observer	**jps**	Access						Altitude (m)	**5**		
Organisation	**niwa**	NZMS 260 Map no.	**P28**	Coord.	**2591196**	**5963445**		Distance inland (km)	**15**		
Fishing method	**efp**	Area fished (m2) or no. nets used		Number of electric fishing passes	**1**			Tidal water	**n**		

HABITAT DATA

Water	Colour	**u**			Clarity	**c**		Temp.	**21.5**	pH	**9**
	Average width (m)	**3.0**	Average depth (m)	**0.2**	Maximum depth (m)			Conductivity			**20**
Habitat type (%)	Still	**100**	Back-water	**0**	Pool	**0**	Run **0**	Riffle **0**	Rapid **0**	Casc.	**0**
Substrate type (%)	Mud	**100**	Sand	**0**	Fine gravel	**0**	Coarse gravel **0**	Cobble **0**	Boulder **0**	Bed-rock	**0**
Fish cover (y/n)	Macrophyte	**y**	Instream debris	**y**	Undercut bank	**y**	Bank veg. **y**				
Catchment vegetation(%)	Native forest	**0**	Exotic forest	**0**	Farm	**50**	Urban zone **50**	Scrub **0**	Swamp land **0**	Other	**0**
Riparian vegetation(%)	Native forest	**0**	Exotic forest	**0**	Grass tussock	**100**	Exposed bed **0**	Scrub willow **0**	Raupo flax **0**	Other	**0**

Type of river/stream/lake

Water level	Downstream barrier		Pollution
Large invertebrate fauna	Koura	Paratya	Freshwater mussel
Bottom fauna abundance	Predominant species group		Permanent water **y**

FISH DATA

Species		Abundance	Length	Habitat/Comments
Anguilla australis	**Shortfin eel**	**a**	**b**	**sti**
Anguilla dieffenbachii	**Longfin eel**	**o**	**b**	**sti**
Gobiomorphus cotidianus	**Common bully**	**r**	**b**	**sti**
Galaxias maculatus	**Inanga**	**a**	**b**	**sti**

Comments **spot fished**

FRESHWATER FISH DATABASE FORM

20

Date	**6/3/2016**	River/Lake system **Wairau River**						Catchment number	**601.020**		
Time	**1500**	Sampling locality **Town Branch**									
Observer	**jps**	Access						Altitude (m)	**5**		
Organisation	**niwa**	NZMS 260 Map no.	**P28**	Coord. **2591201 5963498**				Distance inland (km)	**15**		
Fishing method	**spo**	Area fished (m2) or no. nets used		Number of electric fishing passes				Tidal water	**n**		

HABITAT DATA

Water	Colour				**u**	Clarity		**c**	Temp. **14.5**	pH	**8**
	Average width (m)	**2.5**	Average depth (m)	**0.3**		Maximum depth (m)			Conductivity		**78**
Habitat type (%)	Still **100**	Back-water	**0**	Pool	**0**	Run	**0**	Riffle **0**	Rapid **0**	Casc.	**0**
Substrate type (%)	Mud **100**	Sand	**0**	Fine gravel	**0**	Coarse gravel	**0**	Cobble **0**	Boulder **0**	Bed-rock	**0**
Fish cover (y/n)	Macrophyte **y**	Instream debris	**y**	Undercut bank	**y**	Bank veg.	**y**				
Catchment vegetation(%)	Native forest **0**	Exotic forest	**0**	Farm	**50**	Urban zone	**50**	Scrub **0**	Swamp land **0**	Other	**0**
Riparian vegetation(%)	Native forest **0**	Exotic forest	**0**	Grass tussock	**100**	Exposed bed	**0**	Scrub willow **0**	Raupo flax **0**	Other	**0**

Type of river/stream/lake			
Water level	Downstream barrier **y**	Pollution	
Large invertebrate fauna	Koura	Paratya	Freshwater mussel
Bottom fauna abundance	Predominant species group	Permanent water **y**	

FISH DATA

Species		Abundance	Length	Habitat/Comments
Anguilla australis	**Shortfin eel**	**13 (c)**	**350-700**	**sti**
Galaxias maculatus	**Inanga**	**3 (c)**	**45-80**	**sti more seen out of reach**

Comments

FRESHWATER FISH DATABASE FORM

28

Date	**10/3/2016**	River/Lake system **Wairau River**						Catchment number	**601.020**		
Time	**1500**	Sampling locality **Town Branch**									
Observer	**jps**	Access						Altitude (m)	**5**		
Organisation	**niwa**	NZMS 260 Map no.	**P28**	Coord. **2591201 5963498**				Distance inland (km)	**15**		
Fishing method	**efp**	Area fished (m2) or no. nets used		Number of electric fishing passes	**1**			Tidal water	**n**		

HABITAT DATA

Water	Colour	**u**			Clarity	**c**		Temp.	**14.5**	pH	**7.8**
	Average width (m)	**2.5**	Average depth (m)	**0.3**	Maximum depth (m)			Conductivity	**100**		
Habitat type (%)	Still **100**	Back-water **0**	Pool **0**		Run **0**	Riffle **0**		Rapid **0**	Casc. **0**		
Substrate type (%)	Mud **100**	Sand **0**	Fine gravel **0**		Coarse gravel **0**	Cobble **0**		Boulder **0**	Bed-rock **0**		
Fish cover (y/n)	Macrophyte **y**	Instream debris **y**	Undercut bank **y**		Bank veg. **y**						
Catchment vegetation(%)	Native forest **0**	Exotic forest **0**	Farm **50**		Urban zone **50**	Scrub **0**		Swamp land **0**	Other **0**		
Riparian vegetation(%)	Native forest **0**	Exotic forest **0**	Grass tussock **100**		Exposed bed **0**	Scrub willow **0**		Raupo flax **0**	Other **0**		
Type of river/stream/lake											
Water level			Downstream barrier **y**					Pollution			
Large invertebrate fauna		Koura			Paratya			Freshwater mussel			
Bottom fauna abundance		Predominant species group						Permanent water **y**			

FISH DATA

Species		Abundance	Length	Habitat/Comments
Anguilla australis	**Shortfin eel**	**a**	**b**	**sti**
Anguilla dieffenbachii	**Longfin eel**	**o**	**a**	**sti**
Gobiomorphus cotidianus	**Common bully**	**r**	**a**	**sti**
Galaxias maculatus	**Inanga**	**c**	**b**	**sti**

Comments **20 m spot fished**

FRESHWATER FISH DATABASE FORM

21

Date	**8/3/2016**	River/Lake system **Wairau River**		Catchment number	**601.020**
Time	**2130**	Sampling locality **Jeffreys**			
Observer	**jps**	Access		Altitude (m)	**1**
Organisation	**niwa**	NZMS 260 Map no. **P28**	Coord. **2595925 5966009**	Distance inland (km)	**2**
Fishing method	**spo**	Area fished (m2) or no. nets used	Number of electric fishing passes	Tidal water	**n**

HABITAT DATA

Water	Colour				**u**	Clarity		**m**	Temp.	**15.7**	pH **8.1**
	Average width (m)	**4.0**	Average depth (m)	**0.6**		Maximum depth (m)			Conductivity		**57**
Habitat type (%)	Still	**100**	Back-water	**0**	Pool **0**	Run	**0**	Riffle **0**	Rapid	**0**	Casc. **0**
Substrate type (%)	Mud	**100**	Sand	**0**	Fine gravel **0**	Coarse gravel	**0**	Cobble **0**	Boulder	**0**	Bed-rock **0**
Fish cover (y/n)	Macrophyte	**y**	Instream debris	**y**	Undercut bank **n**	Bank veg.	**y**				
Catchment vegetation(%)	Native forest	**0**	Exotic forest	**0**	Farm **100**	Urban zone	**0**	Scrub **0**	Swamp land	**0**	Other **0**
Riparian vegetation(%)	Native forest	**0**	Exotic forest	**0**	Grass tussock **100**	Exposed bed	**0**	Scrub willow **0**	Raupo flax	**0**	Other **0**

Type of river/stream/lake			
Water level	Downstream barrier		Pollution
Large invertebrate fauna	Koura	Paratya	Freshwater mussel
Bottom fauna abundance	Predominant species group		Permanent water **y**

FISH DATA

Species		Abundance	Length	Habitat/Comments
Anguilla australis	**Shortfin eel**	**6 (o)**	**500-700**	**sti**
Gobiomorphus cotidianus	**Common bully**	**6 (o)**	**35-60**	**sti**

Comments **poor habitat, no flow**

FRESHWATER FISH DATABASE FORM							22
Date	**9/3/2016**	River/Lake system **Wairau River**				Catchment number	**601.020**
Time	**1300**	Sampling locality **Fairhall**					
Observer	**jps**	Access				Altitude (m)	**17**
Organisation	**niwa**	NZMS 260 Map no.	**P28**	Coord. **2585662 5964790**		Distance inland (km)	**7**
Fishing method	**unk**	Area fished (m2) or no. nets used		Number of electric fishing passes		Tidal water	**n**

HABITAT DATA

Water	Colour			Clarity		Temp.	pH
	Average width (m)	Average depth (m)		Maximum depth (m)		Conductivity	
Habitat type (%)	Still	Back-water	Pool	Run	Riffle	Rapid	Casc.
Substrate type (%)	Mud	Sand	Fine gravel	Coarse gravel	Cobble	Boulder	Bed-rock
Fish cover (y/n)	Macrophyte	Instream debris	Undercut bank	Bank veg.			
Catchment vegetation(%)	Native forest	Exotic forest	Farm	Urban zone	Scrub	Swamp land	Other
Riparian vegetation(%)	Native forest	Exotic forest	Grass tussock	Exposed bed	Scrub willow	Raupo flax	Other

Type of river/stream/lake				
Water level		Downstream barrier		Pollution
Large invertebrate fauna	Koura	Paratya	Freshwater mussel	
Bottom fauna abundance		Predominant species group		Permanent water **y**

FISH DATA

Species	Abundance	Length	Habitat/Comments

Comments **Stream dry**

FRESHWATER FISH DATABASE FORM

23

Date	**8/3/2016**	River/Lake system **Wairau River**		Catchment number	**601.020**
Time	**2230**	Sampling locality **Cravens**			
Observer	**jps**	Access		Altitude (m)	**10**
Organisation	**niwa**	NZMS 260 Map no. **P28**	Coord. **2587207 5972777**	Distance inland (km)	**10**
Fishing method	**spo**	Area fished (m2) or no. nets used	Number of electric fishing passes	Tidal water	**n**

HABITAT DATA

Water	Colour				**u**	Clarity		**c**	Temp.	**14.2**	pH	**7.1**
	Average width (m)	**6.0**	Average depth (m)		**0.8**	Maximum depth (m)			Conductivity			**70**
Habitat type (%)	Still	**0**	Back-water	**0**	Pool **0**	Run	**100**	Riffle **0**	Rapid	**0**	Casc.	**0**
Substrate type (%)	Mud	**50**	Sand	**30**	Fine gravel **20**	Coarse gravel	**0**	Cobble **0**	Boulder	**0**	Bed-rock	**0**
Fish cover (y/n)	Macrophyte	**y**	Instream debris	**y**	Undercut bank **y**	Bank veg.	**y**					
Catchment vegetation(%)	Native forest	**0**	Exotic forest	**0**	Farm **100**	Urban zone	**0**	Scrub **0**	Swamp land	**0**	Other	**0**
Riparian vegetation(%)	Native forest	**0**	Exotic forest	**0**	Grass tussock **100**	Exposed bed	**0**	Scrub willow **0**	Raupo flax	**0**	Other	**0**

Type of river/stream/lake

Water level	Downstream barrier		Pollution
Large invertebrate fauna	Koura	Paratya	Freshwater mussel
Bottom fauna abundance	Predominant species group		Permanent water **y**

FISH DATA

Species		Abundance	Length	Habitat/Comments
Anguilla australis	**Shortfin eel**	**9 (c)**	**400-750**	**run**
Gobiomorphus cotidianus	**Common bully**	**2 (o)**	**95-110**	**run**
Galaxias maculatus	**Inanga**	**6 (o)**	**80-100**	**run**
Anguilla dieffenbachii	**Longfin eel**	**2 (o)**	**400-800**	**run**
Salmo trutta	**Brown trout**	**1 (r)**	**400**	**run**
Paranephrops	**Koura**	**2 (o)**	**b**	**run**
Galaxias argenteus	**Giant kokopu**	**1 (r)**	**200**	**run outside of reach**

Comments **good flow and good fish cover**

FRESHWATER FISH DATABASE FORM

29

Date	**10/3/2016**	River/Lake system **Wairau River**		Catchment number	**601.020**
Time	**1000**	Sampling locality **Cravens**			
Observer	**jps**	Access		Altitude (m)	**10**
Organisation	**niwa**	NZMS 260 Map no. **P28**	Coord. **2587114 5972735**	Distance inland (km)	**10**
Fishing method	**fyn**	Area fished (m2) or no. nets used **2**	Number of electric fishing passes	Tidal water	**n**

HABITAT DATA

Water	Colour				**u**	Clarity		**c**	Temp. **14.2**	pH	**7.1**
	Average width (m)	**6.0**	Average depth (m)		**0.8**	Maximum depth (m)			Conductivity		**71**
Habitat type (%)	Still	**0**	Back-water	**0**	Pool **0**	Run	**100**	Riffle **0**	Rapid **0**	Casc.	**0**
Substrate type (%)	Mud	**50**	Sand	**30**	Fine gravel **20**	Coarse gravel	**0**	Cobble **0**	Boulder **0**	Bed-rock	**0**
Fish cover (y/n)	Macrophyte	**y**	Instream debris	**y**	Undercut bank **y**	Bank veg.	**y**				
Catchment vegetation(%)	Native forest	**0**	Exotic forest	**0**	Farm **100**	Urban zone	**0**	Scrub **0**	Swamp land **0**	Other	**0**
Riparian vegetation(%)	Native forest	**0**	Exotic forest	**0**	Grass tussock **100**	Exposed bed	**0**	Scrub willow **0**	Raupo flax **0**	Other	**0**

Type of river/stream/lake

Water level	Downstream barrier		Pollution
Large invertebrate fauna	Koura	Paratya	Freshwater mussel
Bottom fauna abundance	Predominant species group		Permanent water **y**

FISH DATA

Species		Abundance	Length	Habitat/Comments
Anguilla dieffenbachii	**Longfin eel**	**16 (c)**	**450-1200**	**run**

Comments **Fine mesh fykes**

FRESHWATER FISH DATABASE FORM

24

Date	**9/3/2016**	River/Lake system **Wairau River**		Catchment number	**601.020**
Time	**1000**	Sampling locality **Halls**			
Observer	**jps**	Access		Altitude (m)	**3**
Organisation	**niwa**	NZMS 260 Map no. **P28**	Coord. **2589934 5973105**	Distance inland (km)	**8**
Fishing method	**efp**	Area fished (m2) or no. nets used	Number of electric fishing passes **1**	Tidal water	**n**

HABITAT DATA

Water	Colour				**u**	Clarity		**c**	Temp.	**13.4**	pH	**6.9**
	Average width (m)	**3.5**	Average depth (m)		**0.5**	Maximum depth (m)			Conductivity			**69**
Habitat type (%)	Still	**0**	Back-water	**0**	Pool **0**	Run	**100**	Riffle **0**	Rapid	**0**	Casc.	**0**
Substrate type (%)	Mud	**60**	Sand	**40**	Fine gravel **0**	Coarse gravel	**0**	Cobble **0**	Boulder	**0**	Bed-rock	**0**
Fish cover (y/n)	Macrophyte	**y**	Instream debris	**y**	Undercut bank **y**	Bank veg.	**y**					
Catchment vegetation(%)	Native forest	**0**	Exotic forest	**0**	Farm **100**	Urban zone	**0**	Scrub **0**	Swamp land	**0**	Other	**0**
Riparian vegetation(%)	Native forest	**0**	Exotic forest	**0**	Grass tussock **90**	Exposed bed	**0**	Scrub willow **10**	Raupo flax	**0**	Other	**0**

Type of river/stream/lake

Water level	Downstream barrier		Pollution
Large invertebrate fauna	Koura	Paratya	Freshwater mussel
Bottom fauna abundance	Predominant species group		Permanent water **y**

FISH DATA

Species		Abundance	Length	Habitat/Comments
Anguilla australis	**Shortfin eel**	**125 (a)**	**118-445**	**run 125 sf in first 20m**
Anguilla dieffenbachii	**Longfin eel**	**4 (o)**	**500-750**	**run 4 lf from first 20m**
Oncorhynchus mykiss	**Rainbow trout**	**3 (o)**	**70-88**	**run**
Galaxias maculatus	**Inanga**	**4 (o)**	**70-79**	**run**
Salmo trutta	**Brown trout**	**2 (o)**	**110-240**	**run**
Gobiomorphus cotidianus	**Common bully**	**1 (r)**	**103**	**run**
Paranephrops	**Koura**	**12 (o)**	**b**	**run**

Comments **Large amount of sf eels**

Appendix G Spring Creek flows

Flow regime of Spring Creek from 1997 to 2016 (MDC data).