Technical Report 30

Ecological Technical Report 4: Freshwater Habitat and Species Description and Values

NZ TRANSPORT AGENCY
WAKA KOTAHI

MacKays to Peka Peka Expressway

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Table of Contents

Executive Summary 1

1. Introduction 1

2. Overview 5
   - 2.1. Physical Environment 5
   - 2.2. Waterways Overview – Watershed / Catchments 6
   - 2.3. Social and Planning Context 8

3. Methods and Sampling Effort 8
   - 3.1. Approach 8
   - 3.2. Scoping of Sampling Effort and Locations 10
   - 3.3. Field and Analysis Methods 12

4. Results – Description of Freshwater Systems, Patterns and Trends 19
   - 4.1. Basic System Descriptions 19
   - 4.2. Physical Habitat Qualities 41
   - 4.3. Freshwater Fish Investigation 45
   - 4.4. Aquatic Macro-Invertebrates 50
   - 4.5. Water Quality 58
   - 4.6. Stream Ecological Valuation (Sev) 62

5. Evaluation of Systems, Habitats and Biota 64
   - 5.1. Introduction 64
   - 5.2. Statutory Context 65
   - 5.3. Sensitivity and Tolerances 66
   - Table 20 IBI Wellington Regional Rating (adapted from Joy, 2005) 68
   - 5.4. Water Quality 70
   - 5.5. Regional Condition and Value Conclusion 71

6. Discussion – Aspects Related to the Potential Adverse Aquatic Effects 72
   - 6.1. Fish Passage 73
   - 6.2. Diversions and Rock Armouring 73
   - 6.3. Riparian Vegetation 76
   - 6.4. Sediment Discharge to Freshwater 76
   - 6.5. Stormwater Discharge to Freshwater 78

7. Acknowledgements 79

8. References – 79

Appendices83

APPENDIX 30.A: GLOSSARY OF TERMS 83

APPENDIX 30.B: GWRC FRESHWATER MONITORING RESULTS 85

APPENDIX 30.C PHA & STREAM MORPHOLOGICAL DATE 86

APPENDIX 30.D IBI BASE ANALYSIS 87

APPENDIX 30.E REGIONAL RIVERS MACROINVERTEBRATE METRICS............................ 91

APPENDIX 30.F FISH SURVEY RESULTS 97

APPENDIX 30.G MACROINVERTEBRATE DATA 103

APPENDIX 30.H MACRO-INVERTEBRATE ANALYSIS (DETAIL)..................................... 114

APPENDIX 30.I SEV SCORES AND CALCULATION SHEETS 118

APPENDIX 30.J BML FIELD STUDY WATER QUALITY RESULTS.................................... 127

Tables

Table 1 Sampled waterways (listed north to south).. 10

Table 2 Type of Sampling at Each Site 11

Table 3 Summary of water quality data collected and purpose................................. 13

Table 4 Attributes and Integrity Classes for the Wellington IBI (after Joy, 2005) 17

Table 5 Stream Reach Importance rankings for fish in the Wellington Region. (Modified from Strickland and Quarterman 2001). 17

Table 6 Basic Stream Morphology. 42

Table 7 Measured velocities of waterways within the project area calculated via the SEV methodology 43

Table 8 Analysis of Stream Flows (Source M. Law (BECA, 2011), WRENZ (NIWA) and GWRC) 44

Table 9 Predominant riparian vegetation at each sample reach................................ 44

Table 10 Historic observations from NIWA's National Freshwater Fish Database 47

Table 11 Summary of species caught within each river catchment sampled by EFM.. 48

Table 12 Comparative abundance of EPT groups across the sites 53

Table 13 Summary of MCI and SQMCI scores for sampled sites 56

Table 14 Streams monitored by Greater Wellington Regional Council and the water quality parameters exceeded between 1997 and 2003. 58

Table 15 Summary of the Water Quality Parameters/Contaminants at elevated levels within six representative streams (BECA, 2011)................................. 60

Table 16 Event Sampling of water quality (Ph, Turbidity and TSS) 60

Table 17 SEV factors at each reach which drive the overall SEV score......................... 64

Table 18 Values recognised in the GWRC Freshwater Plan 65

Table 19 Summary of MCI and SQMCI scores for sampled sites 66
Table 20 IBI Wellington Regional Rating (adapted from Joy, 2005) 68
Table 21 Fish sampled within survey sites at risk and declining regionally 68
Table 22 Regional Means for selected metrics 69
Table 23 Tabulated summary of Aquatic Ecological Value 72
Table 24 Percentage of fish by habitat type (Jowett & Richardson, 1995) 74
Table 25 Distribution by percentage abundance of fish species across water depths. 74
Table 26 Fish preference for substrate as percentage distribution across substrate sizes (Jowett & Richardson 1995). 75

Figures

Figure 1 The project MacKay's to PekaPeka Expressway alignment and study area, with potentially affected catchments 4
Figure 2 Freshwater Survey Sites 7
Figure 3 Physical Habitat Assessment scores (Maximum score = 1) 45
Figure 4 Frequency of occurrence of fish species in FWDB records 48
Figure 5 Mean taxa richness at each sample site (n=3) 51
Figure 6 Mean abundance at each sample site. 52
Figure 7 Averaged proportion (%) of EPT taxa present at each site. 52
Figure 8 Average % of EPT as a proportion of the total abundance of catch at each site. 53
Figure 9 Macroinvertebrate community composition (% by Abundance) at each sampled site. 55
Figure 10 Mean MCI Score from each sampling site. 57
Figure 11 Mean QMCI scores for sampled sites 57
Figure 12 Calculated total SEV scores (reference site = KC Ref) 63
Figure 13 Summary of Integrated Biodiversity Index (IBI) scores for sampled sites. 67

Site Photos

Photo 1 - Hadfield Kowhai Stream at the sampling location (looking downstream) 19
Photo 2 - Hadfield Kowhai Stream taken from SH 1 culvert 20
Photo 3 - Existing Hadfield Kowhai culverts under SH 1, with *Mimulus sp* covering waterway 20
Photo 4 - Paetawa Drain near the sampling location under a mass of Mimulus sp 21
Photo 5 - Paetawa Drain, looking upstream, under a mass of *Mimulus sp* 22
Photo 6 Smithfield Drain, within low lying peats 23

Photo 7 - Kakariki Stream at the Expressway location showing overhanging vegetation. 24
Photo 8 - Dense summer growth of blackberry over Kakariki Stream at the sampling location 25
Photo 9 - Ngarara Creek sampling location, downstream of culvert. 25
Photo 10 - Ngarara Creek sampling location upstream of culvert Ngarara Creek – with recently cleared stream bank 26
Photo 11 - Waimeha Stream at the sampling location, showing varied exotic and native vegetation. Stream substrates from recent stream maintenance are visible to the left of photo....... 27
Photo 12 – Waikanae River at the proposed bridge crossing location, with exotic riparian vegetation present, at point of proposed bridge.. 29
Photo 13 – Muaupoko Stream upstream of walkway culvert, stable stream bank provided by scrub grasses and blackberry. 30
Photo 14 – Downstream Muaupoko Stream, 50 meters from confluence with Waikanae River 30
Photo 15 – WWTP Drain at sampling location 31
Photo 16 – Instream debris: crack willow within WWTP Drain... 32
Photo 17 – Mazengarb Stream at the sampling location looking upstream. 33
Photo 18 – Mazengarb Stream substrate –fine sediments over sand.................................. 33
Photo 19 – Wharemauku Stream facing looking West towards proposed Expressway alignment. The stream bank vegetation dominated by exotic water weeds 35
Photo 20 – Wharemauku stream bed.. 36
Photo 21 – Lower Drain 7 at the sampling location, illustrating Instream debris, still water and exotic vegetated stream banks. and corrugated iron sheet, reducing movement in high water 37
Photo 22 – Still water of the lower Drain 7 sampling location. 37
Photo 23 – Upper Drain 7 showing unstable peat dominated substrates in the vicinity of the Expressway alignment.. 38
Photo 24 –A smaller drain entering Drain 7 at the sampling location, with illustrating overhanging vegetation, and partial shading along part of the survey site........ 39
Photo 25 – Whareroa Drain looking south 40
Photo 26 – Wooded instream debris and root structures of exotic pines in Whareroa Drain tributary sampled. 41

Executive Summary

With the exception of the Waikanae River, the streams potentially affected by the MacKays to Peka Peka Expressway Project are typically:

1. Highly modified;
2. Lack riparian margins, or where present are dominated by exotic species;
3. Are deeply incised, erodible;
4. Have low fish diversity dominated by species tolerant of water quality issues;
5. Have aquatic macro-invertebrate communities dominated by species that are robust and tolerant
6. Lack of *Ephemeroptera* (mayfly), *Plecoptera* (stonefly), and *Trichoptera* (caddisfly) (EPT) species that are sensitive to water quality issues and indicators of healthy streams;
7. Have low to very low macroinvertebrate community index MCI and quantitative macroinvertebrate community index (QMCI) scores;
8. Have low to very low Stream Ecological Valuation (SEV) and Physical Habitat Assessment (PHA) values;
9. Have elevated levels of contaminants, including elevated levels of heavy metals, nutrients, E Coli and sediments that in a number of cases exceed guideline trigger levels; and
10. Are likely to often have low Dissolved Oxygen, levels of pH that are highly acidic, and poor water clarity.

Of these the streams sampled, the Waikanae River has highest habitat values and the only system we ranked as of high ecological value. The Wharemauku Stream and Whareroa Tributary ranked as of moderate ecological value. The remaining systems were ranked as of low ecological value.

Despite their low ecological values each stream sampled performs ecological functions that are important to some species.

1. Introduction

1.1. Background

1.2. This technical report is one of a series that report on ecological investigations undertaken along and adjacent to MacKays to Peka Peka Expressway Alignment (the “Project”).

1.3. Once completed, the proposed Expressway will become part of State Highway 1 (SH1), a continuation of the Wellington Northern Corridor, which is one of the seven roads of national significance (RoNS) that were announced as part of the Government Policy Statement (GPS) on Land Transport Funding in May 2009.

1.4. The purpose of this report is to map and describe the values of aquatic ecological systems, and to describe the distribution and abundance of aquatic native flora and fauna that occur along this route. From this work the potential environmental effects to aquatic systems of both the construction and ongoing operation of the proposed "Project" can be assessed and measures to mitigate adverse effects can be developed.

1.5. The proposed "MacKays to Peka Peka Expressway Alignment" is 18.2 km long. Figure 1 shows the proposed route, with a low and uniform altitude ranging from 2–21 m above sea level.

1.6. The proposed road largely follows the existing Western Link Road (WLR) designation and will run through rural, commercial, lifestyle and residential properties; predominantly within Raumati, Paraparaumu, and Waikanae townships. Most of the alignment remains within the existing WLR designation.

1.7. The habitat includes small pockets of native vegetation (e.g. manuka and kanuka), regionally and nationally significant wetlands (e.g. Te Harakeke/Kawakahia Wetland) (Boffa Miskell, 2011), intact dunes, areas of substantial vegetation, flowing water systems, ecologically sensitive areas as well as areas of cultural significance (waahi tapu).

1.8. This report describes the results of the freshwater habitat and species investigations undertaken along waterways associated with the Project from October 2010 to June 2011. These studies cover freshwater fish, aquatic macro-invertebrate, macrophyte and the physical habitat and provided data from which ecological values were determined and effects assessed.

1.9. The objectives of the freshwater investigations for evaluation were:

1.10. To investigate all streams and their physical nature that will potentially be affected (e.g. through stream loss, diversion, or installation of culverts).

1.11. To describe the biology through identification of species and communities inhabiting the various waterways.

1.12. To assess the biological values of streams that will be potentially subject to permanent loss due to stream loss, diversions or culverting.

1.13. To identify all existing fish passage-related issues (i.e. culverts, contaminants) to assist in the assessment of existing system modification, as well as the development of mitigation packages.

1.14. To provide information that will assist post-construction and operational consent condition monitoring and mitigation.

1.15. This report:

1.16. Describes the approach and methods undertaken to investigate freshwater ecological values;

1.17. Describes the freshwater ecosystems, habitats and biota within the proposed road corridor, focusing on those that may be affected by construction and operation;

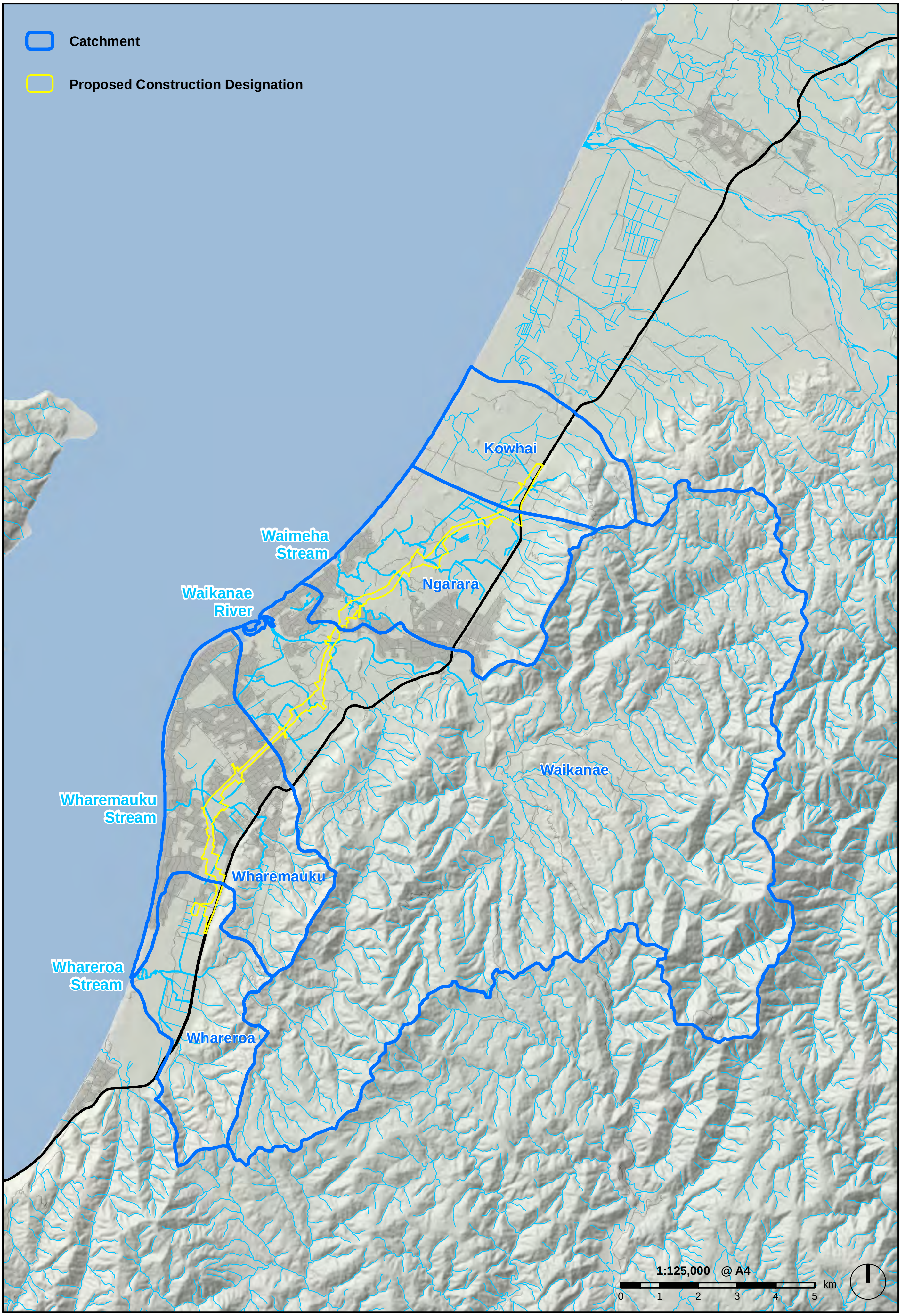
1.18. Presents an ecological evaluation of freshwater ecosystems, habitats and biota; and

1.19. Presents the background material (Stream Ecological Valuations - SEV, diversions) for aquatic mitigation and possible monitoring.

1.2. Effects Assessment Focus

Following the scoping stage of the ecological investigations of the proposed Expressway Project, four focus areas were identified as being the critical aspects in relation to freshwater ecosystem management during construction and operation: confined direct aquatic habitat loss via diversion or culverts, sediment discharge, storm water (water quality) and fish passage. Together these matters account for the greater part of the interaction between the proposed road Expressway alignment and freshwater ecosystems and thus are the focus of the detailed investigations and assessment/mitigation work.

These four focus areas guided development of sampling methodology and the level of sampling effort as well as the analysis carried out for each catchment or stream reach. For example, Stream Ecological Valuations (SEV) were used for reaches that were likely to have to be "re-created", and water quality sampling focused on degree of risk to coastal receiving environments. Finally, the focus areas guided identification of mitigation requirements, for example, freshwater habitat is directly affected to varying degrees at specific places or over discrete reaches, outside of these reaches there are also options for habitat enhancement (through restoration).



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2. Overview

2.1. Physical Environment

2.1.1. Landform topography and geology

The MacKay's to Peka Peka Expressway Project is entirely located within the Foxton Ecological District. That Ecological District has physiographic landform and geology dominated by dynamic dune systems (Ravine, 1992). The plains of the Kāpiti Region have low fertility with parent material of loess and areas of fine alluvium and sand (Leathwick *et al*, 2003). This landscape also includes poorly drained sites including estuaries, wetlands, dune lagoons and a few coastal swamp forest remnants (McEwen, 1987).

The Landcover Database, Version 2 (MfE, 2001), identifies the following land uses within the Region: 26 % indigenous forest, with 11.7% in scrub. Agricultural land use (pasture) occupies 47.7%, with dairy farming almost entirely limited to the alluvial plains of central Wairarapa and the Kāpiti Coast (5% of the district). Planted forestry covers 8.3%, with urban centres making up the remaining 2.3%.

The Kāpiti Coast has seen a reduction of larger scale farms, as land has become less economic, leading to an increase of "lifestyle blocks" (Healy, 1980).

The proposed Expressway alignment traverses three coastal townships: Raumati, Paraparaumu and Waikanae, each of which are subject to levels of urbanisation.

2.1.2. Hydrology/Rainfall

There are five major catchments within the Project area (as shown on Figure 1): Whareroa, Wharemauku, Waimeha, Waikanae and Hadfield/Kowhai, with water draining from springs originating within the Raumati Escarpment (southern range) and coastal foothills (along the length of the alignment). These springs make up the water bodies within this region. The largest water body and catchment is the Waikanae River and catchment.

A number of the studied waterways outlined in this report originate from waterbodies associated with historically drained wetlands, rather than the spring fed hill range streams.

The normal annual rainfall for the alignment has been estimated at around 1,250 mm (taken at Waikanae gauge). The number of rainy days with over 1mm in 24 hours has been estimated at 123 (1980), or roughly a third of the year. The annual average sunshine hours in Paraparaumu are 2040, with the average summer maximum of 17 degrees and winter average minimum of 2 degrees (NIWA & Harkness, 2002).

2.2. Waterways Overview – Watershed / Catchments

For the purposes of describing the freshwater habitats traversed by the proposed Expressway, the area has been separated into catchments. As noted, there are five catchments which are, from south to north, the Whareroa, the Wharemauku, the Waikanae, the Waimeha, and Kowhai/Hadfield Stream. Each catchment has multiple tributaries within the Kāpiti Plains, often arising as springs or wetland areas. Many of these tributaries are artificial channels and drains, formed historically as part of the conversion of the large-scale peat-dominated wetlands of the Kāpiti Coast to agricultural use. In total 15 perennial waterways are crossed, (from South to North) these are:

Whareroa Stream Catchment

Whareroa Stream Tributary (Waterfall Road
Whareroa Drain

Wharemauku Stream Catchment

Drain 7 Lower
Drain 7 Upper
Wharemauku Stream

Waikanae River Catchment

Mazengarb Stream
WWTP Drain
Muaupoko Stream
Waikanae River

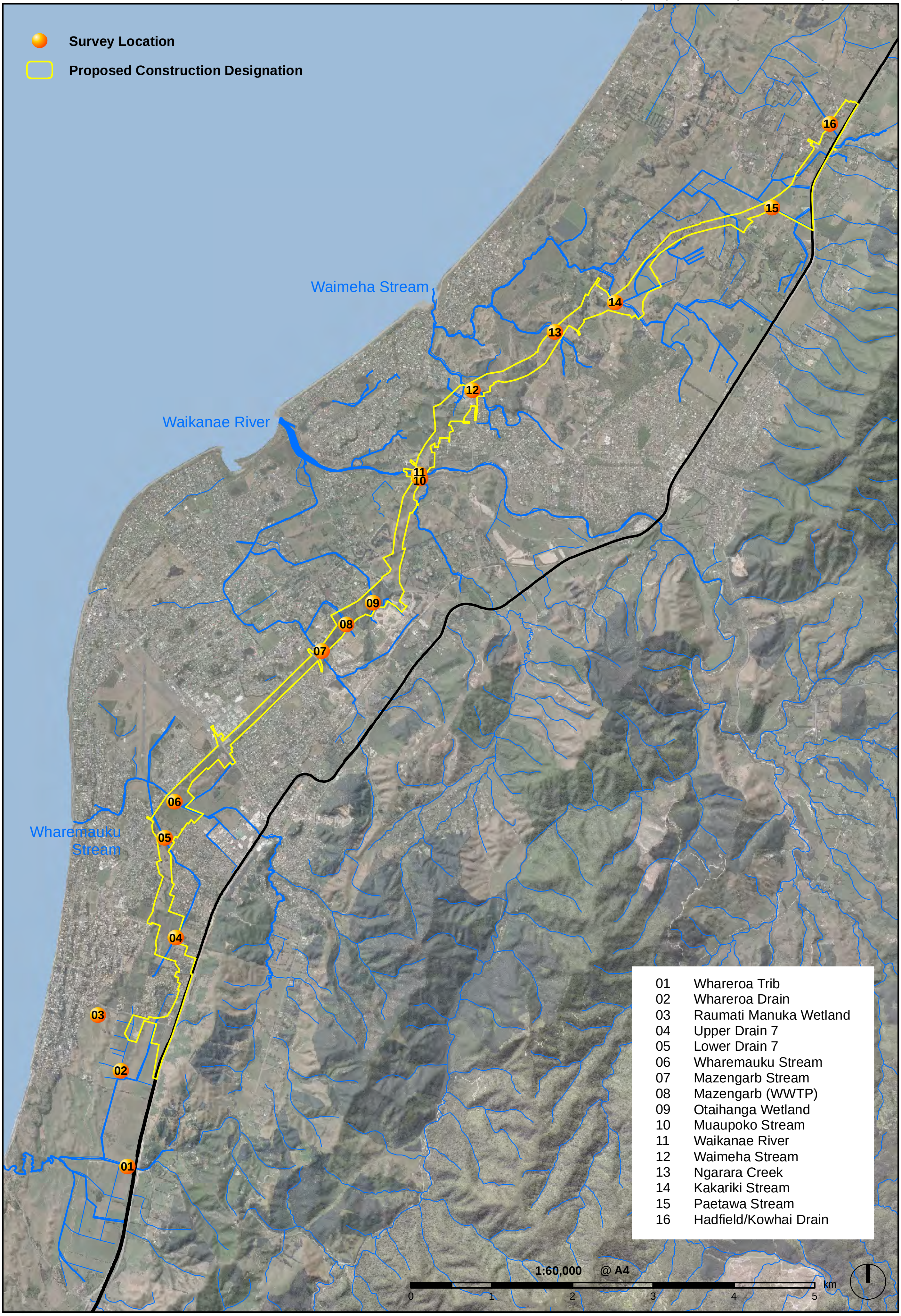
Waimeha Stream Catchment

Waimeha Stream
Ngarara Drain
Kakariki Stream
Smithfield Drain
Paetawa Stream

Kowhai Stream Catchment

Hadfield Drain / Kowhai Stream

There are a large number of lesser waterways that are ephemeral or which are entirely artificial that are mentioned where relevant. However, these waterways are not typically listed in the following tables, for example the Otaihanga landfill drain. Some sampling was also carried out in wetlands not physically connected to streams such as the Raumati Manuka Wetland which is predominantly groundwater-fed. The waterways are shown in Figure 2.



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2.3. Social and Planning Context

The MacKays to Peka Peka Expressway lies within the Greater Wellington Region and entirely within in the Kāpiti Coast District. The Greater Wellington Regional Freshwater Plan (operational -17th December 1999) identifies waterways of value and sets out objectives, policies and methods, including rules, for their management.

The Regional Freshwater Plan (RFP) includes the Waikanae River due to its recreational values, and Waimeha Stream, for having potential fish spawning habitat, as well as the Ngarara Stream as a "Waterbody with Water Quality Indentified as Needing Enhancement for Aquatic Ecosystem Purposes in need of enhancement" (GWRC, 2009).

The Kāpiti Coast District Plan protects areas of ecological and cultural heritage within the district via the Heritage Register. This register includes historic buildings or structures, ecological sites, geological sites, significant trees and areas of waahi tapu as well as QE II covenants.

As part of the development of this report, all these sites of ecological value within the proposed Expressway designation were considered.

3. Methods and Sampling Effort

In conjunction with the field investigations and analysis, a desktop study was carried out which included a review of biological papers and reports (both published and unpublished) as well as databases provided by the Kāpiti Coast District Council (KCDC), GWRC, and national data sets produced by Landcare, DoC, NIWA (Fresh Water Fish Database and Ministry for the Environment (MfE). The Protected Natural Areas Survey Report for the Foxton Ecological District (Ravine 1992) was consulted.

3.1. Approach

A range of survey methodologies have been used and, wherever possible, these have included national protocols and industry standard practices e.g. SEV (Rowe *et al*, 2008), Physical Habitat Sampling (Harding *et al,* 2009), Aquatic Macroinvertebrate Sampling (Stark *et al,* 2001). Some methods were tailored to the Project, the site and to the purposes of the data collection. Following is an overview of the sampling strategy, the sites and areas sampled, and a catalogue of the methodologies employed for collection of the sets of data. More detailed aspects of the methodologies, including aspects that varied from published protocol, are discussed in subsequent sections of this report.

Four “sets” of data were collected for the Project investigations over a period of 8 months to describe the aquatic habitats and their assemblages, and to allow regional importance and sensitivities to be assessed. The four are:

- physical habitat data, i.e. stream morphology, substrate type, riparian condition etc;
- water quality;
- flora (aquatic and riparian);
- fauna (aquatic macro invertebrates and fish data).

Sampling and analysis methods were chosen that would:

- Describe the existing aquatic physical habitat (including water parameters);
- Supplement the existing data in describing the fish communities in the Project area;
- Describe the existing aquatic macro invertebrate communities;
- Identify rare and threatened species within the waterways;
- Allow an evaluation of the conservation / regional significance (value) of the species/ communities and habitat present;
- Allow an evaluation of loss and change of aquatic habitats; and
- Enable mitigation proposals to be developed if the Project were to proceed.

We have also worked with other members of the Project team[1], to identify related information needs such as water quality and hydrology, which provide important context for the freshwater ecological assessments. This information has been provided in the following reports:

- Baseline Water and Sediment Quality Investigation Report (Technical Report 24, Volume 3)
- Sediment Yield Calculations (from Construction Methodology Report – Technical Report 4, Volume 3)
- Erosion & Sediment Control Plan (CEMP Appendix H, Volume 4)
- Generation of Daily Stream flow: Alliance Memorandum Outlining Time Series for Selected Catchments (Hansford / Malcolm 2009; Law, 2011)
- Stormwater Management Devices (from Erosion & Sediment Control Plan – CEMP Appendix H, Volume 4)

Sampling effort and research has focused on the 15 waterways that may be affected by the proposed Expressway specifically those reaches directly affected or not far down stream. A separate Marine Habitat and Species – Description and Values Report (Technical Report 31, Volume 3) has

[1] This Technical Report refers to the Project team as carrying out works on behalf of and as contracted by the NZTA. The NZTA is the requiring authority and the consent holder.

investigated the marine discharge areas associated with possible construction (earthwork) and operational effects.

Table 1 below provides basic waterway data.

Table 1 Sampled waterways (listed north to south)

	Northing (NZTM)	Easting (NZTM)	Altitude a s l.	Distance from Coast (m)	Catchment Name	Catchment Area (ha) (BECA, 2011)	Total Length of Waterway (approximate) (m)
Kowhai Stream Catchment							
Hadfield / Kowhai Stream	1750515	405017	8	3,100	Hadfield/Kowhai	330	2000
Waimeha Stream Catchment							
Paetawa Drain	1750050	405351	8	2,900	Hadfield/Kowhai	148	1500
Smithfield Drain	1750602	405340	6	1,700	Hadfield/Kowhai	32.4	640
Kakariki	1750249	405141	7	2,040	Waimeha	1192	6500
Ngarara Creek	1750249	405141	7	1,540	Waimeha	164	900
Waimeha Stream	1752040	405204	2	1,300	Waimeha	218	2200
Waikanae River Catchment							
Waikanae River	1750139	405239	2	1,900	Waikanae	13005	12000
Otaihanga Wetlands	1750116	405331	7	1967	Waikanae	4.42	
Muaupoko Stream	1750139	405241	2	2,020	Waikanae		5100
Mazengarb (WWTP)	175010	405341	6	2,430	Waikanae	17	600
Mazengarb Stream	1755351	405351	6	2,650	Waikanae	378	4560
Wharemauku Stream Catchment							
Wharemauku	1745933	405452	3	2,450	Wharemauku,	1008	6400
Drain 7 Wharemauku	1745927	405506	3	2,020	Wharemauku	151	2000
Upper Drain 7	1745928	405506	5	1,420	Wharemauku	44	890
Whareroa Stream Catchment							
Whareroa Drain	1745908	405642	6	3200	Whareroa	179	450
Whareroa Trib @ Waterfall Rd	1745913	405719	14	2.5	Whareroa	179	2600

3.2. Scoping of Sampling Effort and Locations

Every waterway traversed by the proposed Expressway alignment was visited and a decision made on the sampling required. All perennial streams underwent a full suite of biological tests including physical habitat, fish, and macro-invertebrate. A smaller number also underwent a suite of water-quality studies.

Biological sampling was always carried out within the portion of stream that will be directly affected by physical works.

No ephemeral drains along the alignment were sampled, however they were all visually inspected and their quality was assessed in contrast to other streams that had received thorough investigations. A judgment call was made as to the value of complete investigations of every drain.

In some waterways only one specific component was studied, e.g. fish sampling and mud fishing in wetlands.

No specific Periphyton sampling was undertaken and macrophyte being found infrequently and generally in low abundances was not made a focus of specific survey, but we recorded in the visual assessment notes.

Invertebrate sampling was not carried out within the wetlands due to insufficient water during the survey period in the Raumati Manuka Wetland and the Otaihanga Wetlands.

All sample site locations and sampling activities by site are listed in Table 2 below.

Table 2 Type of Sampling at Each Site

Name	SEV	PHA	EFM	Macro-invertebrates	Water Quality Sampling Stormwater	Water Quality & Sediment Sampling	Other (photo, site visit)
Hadfields Drain	✓	✓	✓	✓	✓	✓	✓
Paetawa Stream	✓	✓	✓	✓			✓
Smithfield Drain	✓	✓	✓	✓			✓
Kakariki	✓	✓	✓	✓	✓	✓	✓
Ngarara Drain	✓	✓	✓	✓			✓
Waimeha Stream	✓	✓	✓	✓	✓	✓	✓
Waikanae River	✓	✓	✓	✓	✓	✓	✓
Waikanae River Upper Catchment		✓				✓	
Muaupoko Stream	✓	✓	✓	✓			✓
Mazengarb (WWTP)	✓	✓	✓	✓			✓
Mazengarb Stream	✓	✓	✓	✓	✓	✓	✓
Wharemauku	✓	✓	✓	✓	✓	✓	✓
Drain 7 Wharemauku	✓	✓	✓	✓		✓	✓
Upper Drain 7	✓	✓	✓	✓			✓
Whareroa Drain	✓	✓	✓	✓			✓
Whareroa Trib	✓	✓	✓	✓			✓
Otaihanga Wetlands			✓				Mudfish
Raumati Manuka Wetland							Mudfish

3.3. Field and Analysis Methods

As part of the analysis methods, a range of biometrics were used to arrive at comparative metrics to test against regional values. These were as follows: Macroinvertebrate Indices, Fish Integrity of Biodiversity Index (IBI), Water quality sampled against ANZECC (2000) trigger values, and Stream Ecological Valuation (SEV) to arrive at comparative metrics to test against regional values. To set the analysis scene we also established a GIS layer using the REC (River Environment Classifications).

River Environment Classification (REC)

The REC (NIWA 2004) database was used to measure the different lengths of each stream's and to determine the REC class within affected sections of each of the waterways. Since the REC system does not recognise first order streams, the NZMS 260 TOPO mapped streams were used (put in to our GIS layer) to generate a REC, Snelder (NIWA) et al 2004) class zero which extended our assessment to include intermittent/ephemeral streams.

Water sheds (catchment) were defined using GIS and topography layers and were divided into the various sub-catchment and catchment areas. The catchment sizes were calculated and these sizes assisted in determining requirements for fish passage. Generally for this site, catchments greater than 10km2 are generally considered large enough to maintain flow that sustains fish.

Aquatic Macrophyte and Periphyton

During aquatic surveys periphyton was recorded and an estimation made of cover. These observations can be important when considering food webs, problem algae, nutrient dynamics and general biology of the waterway; they are not often associated with value assessments.

Early scoping surveys indicated a general low presence of aquatic macrophyte and periphyton and therefore no particular survey to describe their presence and locations was deemed necessary for the evaluation process.

However, through the physical habitat surveys, SEV and geomorphological surveys observations were made of the presence of aquatic macrophyte species and if there were notable periphyton abundances or mosses and liverwort.

Water Quality

During the collection of the SEV data, basic water quality measurements, pH, dissolved oxygen, turbidity, temperature and total suspended solids (TSS) were recorded in the field by Boffa Miskell. During ecological investigations, BML used a TPS 90FLT Field Lab Multimeter and an Insite IG3150 to carry out basic water quality parameters, and the findings are shown in Appendix 30.J.

Environmental Laboratory Services (ELS) also undertook an extensive water quality study of eight streams which is analysed and described in the Baseline Water and Sediment Quality Investigation (BECA, 2011). Table 3 summarises the sampling protocol and regime which was developed in consultation with Boffa Miskell ecologists.

An attempt was made to carryout water quality sampling at the same locations sampled by the ecological investigations. For various reasons this could not always be achieved, however, these differences were not considered to affect the ecological analysis and interpretation.

Table 3 Summary of water quality data collected and purpose

Purpose	Method	Parameters	Comments
Baseline water quality	Wet and dry weather grab samples (2 rounds)	Field parameters, visual observations, heavy metals, nutrients, hydrocarbons (lab analysis)	To provide an overall picture of water quality for the different streams to be used as a baseline for assessing effects.
Baseline Sediment Sampling	Grab sampling and lab analysis	Heavy metals, nutrients, hydrocarbons	Assess current fine sediment quantities in stream substrate
Water quality during rain events	Grab sampling and lab analysis	Total suspended sediment, turbidity, selected heavy metals	To determine water quality of selected streams during rain events – to determine contaminants released during first flush of a rainfall following a dry period.

Dry weather grab samples

The baseline monitoring programme included two rounds of dry sampling at 8 sites which was conducted in April and May, 2011. During this sampling, water and sediments were collected and analysis was carried out by ELS.

First flush grab samples

Grab samples were taken from 6 sites within the first hour of heavy rain after 3-4 fine days. This was carried out on two separate occasions per site. Laboratory Lab analysis was carried out by ELS. Locations of Dry Weather and First Flush sampling can be found in Table 2

Measurement of physical habitat

The scoring of the sampled physical aquatic habitat (PHA) was based on the 1-20 in-field assessment system using a graded expert score. This assessment was first developed by the ARC (Maxted et al 2000) and is an adaptation of earlier unpublished field models (Stark 1985, 2000), Urban Stream Habitat Assessment (NIWA 1999). This system is also very similar to that used by Environment

Canterbury in Meredith et al (2003) and now also promoted as a “national protocol” by Harding’s et al 2009.

The criteria used in this assessment were:

- Aquatic habitat abundance,
- Aquatic habitat diversity,
- Hydrologic heterogeneity,
- Channel alteration,
- Bank stability,
- Riparian vegetation type
- Riparian zone width

Each of these factors is scored on a scale of 1-20, and the higher the total score for a stream or reach then the better are the habitat opportunities present for native aquatic fauna. The highest possible score using this system is 140 (perennial) or 80 (ephemeral). Any stream which scores less than 20% of the maximum is considered to have severe problems and / or limitations with regard to both the in-stream and riparian values.

SEV – Habitat Descriptions

The SEV was developed by NIWA for the Auckland Regional Council as a tool to provide standardised stream assessments, create a functional measure and provide a method for the calculation of “off-setting” mitigation based on stream quality. The SEV system calculates a stream quality score based on the comparison of stream function parameters between test and reference sites, the reference sites being comparable streams with low levels of disturbance by human activity (Rowe et al, 2008).

The ecological functions that are assessed as part of the SEV are grouped into the following four categories:

- Hydraulic function – processes associated with water storage, movement and transport;
- Biogeochemical function – those related to the processing of minerals, particulates and water chemistry;
- Habitat provision functions – the types, amount and quality of habitats that the stream reach provides for flora and fauna; and
- Native biodiversity function – the occurrence of populations of indigenous native plants and animals that would normally be associated with the stream reach.

An overall SEV score is produced on a scale of 0 to 1, (where 0 = no function and 1 = full and proper functioning).

A formula is provided for an Environmental Compensation Ratio, which indicates the relative amount of stream rehabilitation that might be required to replace functional values lost due to stream impacts. It should be noted that the formula calculates total replacement of functional values, based on a “no net loss” approach. While this is a sustainable approach, a satisfactory mitigation solution may be achievable at a lower threshold which recognises that some adverse effects may be inevitable (Rowe et al, 2008).

The SEV system was applied in this study to assist the valuation of the water bodies along the alignment. At each of the 15 SEV sample sites listed in Table 1, a range of physical habitat characteristics were recorded using standard SEV field sheets. These characteristics included width, depth, velocity, and clarity of the stream, substrate composition, riparian vegetation and shade, temperature, dissolved oxygen, pH, and conductivity.

This data was combined with the other biological criteria (presence/absence of fish species etc) and analysed using the Stream Ecological Valuation Worksheets (V.9 Updated December, 2009).

The SEV analysis requires reference streams. A reference stream is a stream of a type that is representative of the area, and which is in pristine or near pristine condition, i.e. with values that are not influenced by human occupation and land use. In the absence of real stream examples, the SEV tool allows for the generation of a hypothetical stream with natural meander, regenerating native riparian cover with natural substrate for the area, and which shows what the potential for the ‘real’ sites and what measure they should be to be considered “fully” functional.

All waterways within the study area are highly modified and none were suitable as a reference stream. After a review of potential reference sites on the Kāpiti Coast and discussions with DOC, GWRC and KCDC staff it was decided that the model reference sites provided with the SEV workbook were not sufficiently representative of the channels waterbodies within the study area and could not be used. The decision was made to modify the SEV from the Kakariki Stream (which scored well in some metrics) to improve some of the scores particularly the riparian habitat.

Data was analysed in accordance with the methods described in the SEV manual (Rowe *et al*, 2008). The latest version of the SEV calculator was used (designated as Version 8.2, dated 23 December, 2009)

Fish

Mudfish

Mudfish were surveyed independently by a recent graduate, at two potentially affected wetlands (the Raumati Manuka Wetland and Otaihanga Landfill wetlands). 4mm mesh Gee minnow traps were used as described in mudfish monitoring methodology (Ling et al. (2009)). This monitoring technique gives qualitative information on mudfish within a wetland.

In the Raumati Manuka wetland the traps were set for three nights, from the 6th to 9th of December, while at Otaihanga they were set for five nights, on the 9th, 13th, 20th, 21st, 22nd of December

Freshwater fish

Freshwater fish were sampled using an EFM300 backpack electro-fishing machine, which attracts and temporarily stuns fish so they can be captured. Electric fishing machine sampling sites are listed in Table 2 and shown in Figure 2. At each sample reach a total of approximately 40m2 was sampled. This reach area was sampled in 4m sequential lots using a four pass system[2]. All fish netted were identified and measured (length), then stored in a bucket until the reach was fished. They were then returned to their habitat.

We note that other fishing methods, especially night spot-lighting and baited trapping are often used to ensure a full range of species are caught. We did not use any other method because we considered the effort and catch results were sufficiently representative of the fauna present to support an assessment of effects. Those species not observed during our sampling (but in the historic records) were typical of habitat types outside of the areas of investigation (e.g. torrent fish or short jaw kokopu). Furthermore, those fish not caught, but in the historic records were often “rare” occurrences, i.e. short jaw kokopu and lamprey.

In addition we made assumptions in regard to passage requirements and sediment discharge issues that cover off the presence of any of those “rare” species not observed.

The significance of individual species was assessed using the conservation threat status for indigenous freshwater fish (Alibone et al, 2010) and by evaluating their occurrence in the Wellington Region using data from the New Zealand Freshwater Fish Database (NIWA, 2007).

The value of the fish communities was by use of the IBI, (the Fish Index of Biological Integrity (Joy, 2005) system and streams were classified as in Table 4. This included evaluation using and

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2 There is and will currently be some debate over electric fish sampling methodology potentially referring to a new publication favouring a single pass over 150m system as opposed to other multiple pass systems. We greatly favour multiple pass systems as scientific literature shows that single pass sampling typically samples only 50% of the fish fauna present (habitat and species diversity dependent) (Jowett & Richardson 1996, Jacobs & Swink 1982, Price & Peterson 2010). Ideally mutli-pass and multi-method over several time periods should be employed for maximum potential recognition of all diversity. While a single pass system may create data better suited to the National database that reason is not paramount for the sampling undertaken here and in most consent applications.

classification following the regional ranking system of Strickland and Quarterman (2001) set out in Table 5. The latter classification uses the threatened species classification of Molloy and Davis (1994), and was adapted to the updated classification of Alibone et al (2010) and by defining Category A threatened species as equivalent to Acutely Threatened, Category B as Chronically Threatened and Category C as At Risk (see Appendix 30.D).

It should be noted that the new classification evaluates threat of extinction, while the earlier Molloy and Davis prioritisation considered a wider range of criteria including human values (J. Molloy, pers. comm.)[3].

Table 4 Attributes and Integrity Classes for the Wellington IBI (after Joy, 2005)

Total IBI score	Integrity class	Attributes
50 – 60	Excellent	Comparable to the best situations without human disturbance; all regionally expected species for the stream position are present. Site is above the 97th percentile.
42 - 49	Very good	Site is above the 90th percentile of all Wellington sites species richness is slightly less than best for the region.
36 - 41	Good	Site is above the 70th percentile of Wellington sites but species richness and habitat or migratory access reduced some signs of stress.
28 - 35	Fair	Score is just above average but species richness is significantly reduced habitat and or access impaired.
18 - 27	Poor	Site is less than average for Wellington region IBI scores, less than the 50th percentile, thus species richness and or habitat are severely impacted.
6 - 17	Very poor	Site is impacted or migratory access almost non existent
0	No fish	Site is grossly impacted or access non existent

Table 5 Stream Reach Importance rankings for fish in the Wellington Region. (Modified from Strickland and Quarterman 2001).

Original Ranking	This reports value ranking	Description	Criteria
Very important	High	Outstanding value. Both high conservation value AND high diversity.	Supports at least one acutely threatened species; OR at least one chronically threatened plus two at risk species; AND more than five native migratory fish.
Important	Moderate	High value. Either high conservation value OR high diversity.	Supports at least one acutely threatened species; OR at least one chronically threatened plus two at risk species; OR more than five native migratory fish.
NE	Low	Non-exceptional conservation or diversity values.	No acutely threatened species; less than one chronically threatened plus two at risk species; five or fewer native migratory fish.

[3] A review and new threat classification status has recently been published Alibone et al 2009.

Aquatic Macroinvertebrates

Aquatic macroinvertebrates (insects, snails, and worms) were surveyed in conjunction with the fish survey to provide further information on the ecological health of the streams. Samples were collected from each of 15 sample sites, and at each sample site three replicates were collected, giving 42 macro-invertebrate samples in total.

Communities were sampled using the MfE (2001) sampling protocol ‘C2’ (soft-bottomed, semi-quantitative). This involved the use of a 0.5 mm mesh triangular kick net, using the national standard kick-sampling protocol ‘C2’ described by Stark *et al* (2001). Species were identified to the lowest possible taxa (sufficient for MCI allocation) and total abundance counts were recorded (as per Stark 1998 (Protocol P3)).

Six invertebrate indices (taxa richness, EPT taxa, total & EPT true abundance, macroinvertebrate Community Index (MCI), and Quantitative MCI (QMCI) were calculated for each replicate at each site. These biotic indices use the tolerances of New Zealand macroinvertebrate taxa for assessing the health of stony streams and soft bottomed streams. All regional councils that undertake State of Environment monitoring use the MCI and/or SQMCI/QMCI for reporting results (Stark & Maxted 2007).

EPT taxa richness is the number of *Ephemeroptera* (mayfly), *Plecoptera* (stonefly), and *Trichoptera* (caddisfly) taxa in a sample. EPT are most diverse in natural streams and decline with increasing watershed disturbance. MCI (Stark, 1985, Stark & Maxted 2004) is an index based on the presence of variously sensitive invertebrate taxa. It has a sensitivity score (1 to 10) for each invertebrate based on their tolerance to organic pollution (1=highly tolerant, 10=highly sensitive). Streams with MCI scores greater than 120 are considered ‘pristine’ and streams with scores less than 80 are ‘severely polluted’. The QMCI takes into account the abundance of each taxa. The MCI uses only presence-absence data and can be strongly affected by one individual, the SQMCI accounts for a species abundance influence and so the sensitivity weighting of the community is moderated to the most abundant taxa present.

4. Results – Description of Freshwater Systems, Patterns and Trends

4.1. Basic System Descriptions

The following are basic descriptions of the fifteen waterways of the Project area that are directly intersected and affected by the road alignment.

Hadfield Kowhai Stream

Hadfield-Kowhai Stream is the northern most waterway potentially traversed by the proposed Expressway. Hadfield Kowhai has approximately 2.25km of stream (upstream of current SH 1) from its headwater tributary to sample site. Its headwaters originate in a combination of pine and native forest and upland pasture, before crossing over small farm blocks and through two culverts under State Highway 1. The small area of native vegetation (approximately 3 hectares) represents the only natural riparian remaining along this channel. Beyond the sampling site the stream discharges to farm drains (within heavily grazed pastoral land) which eventually discharge at the coast more than 2km downstream (via a small estuary).

At the sampling site the waterway was under a shelterbelt pine canopy, stock fenced within 3 meters, with an understory of long pasture grasses, native grasses, ferns and lesser areas of blackberry. The stream has sharply channelised banks (stable) typical of a modified farm drain, the water quality was good (negligible TSS and NTU), with a pebbled sandy substrate, and low deposited sediments. The habitat is very simple with relatively uniform run (20%), pool (80%) with low velocity flow. At the time of sampling the culvert entrance had an inundation of Monkey Musk (*Mimulus sp)* limiting water flow.

Photo 1 - Hadfield Kowhai Stream at the sampling location (looking downstream)

Photo 2 - Hadfield Kowhai Stream taken from SH 1 culvert

Photo 3 - Existing Hadfield Kowhai culverts under SH 1, with *Mimulus sp* covering waterway

Paetawa Drain

The Paetawa Drain is a channelised waterway, sourced from within a predominantly plantation pine catchment. At the sampling site the drain waterbody runs through rough pasture, partially stock fenced. The stream bank vegetation is made up of overhanging pastoral weeds (almost entirely covering the waterway over the summer months) with occasional *Carex geminata.* Much of the stream banks are under cut, heavily grazed and pugged. The substrate is made up of deep mud (up to 50cm) over sand. It has high levels of suspended solids. The water is made up of pools with occasional runs.

Downstream of the sampling site this drain waterbody combines with a number of other lowland farm drains before entering Ngarara Stream and to eventuate as part of ultimately the Te Harakeke / Kawakahia Wetland system. From the sampling site to the wetland, land use is approximately 50% agriculture and 50% small farm lots, with riparian margins fenced off with occasional areas of native vegetation (mostly planted). .The Paetawa Drain is regularly cleared to maintain stream flows.

Photo 4 - Paetawa Drain near the sampling location under a mass of Mimulus sp

Photo 5 - Paetawa Drain, looking upstream, under a mass of *Mimulus sp*

Smithfield Drain

Smithfield Drain is a deep channelised farm drain created from a network of drained farmland within 500 meters of the sampling location (within rough pasture on peat land), which is currently fenced from stock.

There is no riparian cover upstream, however, at the sample site; overhanging vegetation provides some limited stream shading. The vegetation consists of rank grass, blackberry with occasional Juncus, *Carex,* bracken and flaxes.

The habitat consists of slow runs and pools over a mixed substrate of deep anoxic muds and silts. There is one culvert within this reach, which allowed for fish passage. The Smithfield Drain flows towards the coast to Ngarara Stream (Kakariki) at Nga Manu. This drain is regularly cleared to maintain flows.

Photo 6 - Smithfield Drain, within low lying peats

Kakariki Stream

Kakariki (also commonly referred to as the Ngarara Stream) has a catchment watershed within regenerating native forest and shrub land before meandering through heavily grazed agricultural lowlands, some forested areas and wetlands, and restored park reserve (Nga Manu). The Nga Manu Nature Reserve is hydrologically connected to the Kakariki Stream just upstream of the sampling location.

At the sampling site, the Kakariki is a channelised stream with high quality upstream components, which add to its potential ecological values. The habitat type consists of 80% run and 20% back water combined with in-stream macrophyte (monkey musk, watercress, water pepper) of which provides good fish cover. The substrate type consists of fine gravels, and sands with fine sediments (not anoxic).

The results of the SKM (2008) and GWRC long term monitoring programme showed elevated turbidity, low dissolved oxygen and pH indicative of organic matter and degradation (Technical Report 24, Volume 3), conditions common in small streams in highly rural landscapes. Consistent with these results, the Ngarara Stream (Kakariki) and its tributaries are listed in Appendix 7 of the Regional Policy Statement as “Waterbodies with Water Quality Identified as Needing Enhancement for Aquatic Ecosystem Purposes” (GWRC, 2009).

Nga Manu Nature Reserve has undertaken has retired the stream banks, and native planting has along both sides of the Kakariki Stream in the location of the sampling site. However, most likely as a consequence of the intensive land use upstream, the water quality is degraded. At the sampling site riparian vegetation consisted of some scrub, *Carex geminata*, willow, flaxes, bracken and blackberry.

The deep sided channel, with the overgrown vegetation provides a high level of shading. The habitat type consists of 80% run and 20% back water combined with instream macrophyte (monkey musk, watercress, water pepper) of which provides good fish cover. Nga Manu has retired the stream banks, and native planting has begun, however, as a consequence of the intensive land use upstream, the water quality is suffering. At the point of the alignment the riparian buffer has been created, but exotic weeds still dominate (wheki, blackberry, rank grass and occasional flax and willow). Downstream of the sampling location, the land use pressures decrease and the stream meanders for approximately 4km through lifestyle farmland before entering , beside the regionally significant Te Harakeke / Kawakahia Wetland, before its confluence with the Waimeha Stream.

Photo 7 - Kakariki Stream at the proposed Expressway location showing overhanging vegetation.

Photo 8 - Dense summer growth of blackberry over Kakariki Stream at the sampling location

Ngarara Creek

The headwaters of the Ngarara Creek are located adjacent to the Ferndale Subdivision. Less intensive land uses in this area have resulted in weeds (blackberry and gorse) providing the dominant riparian species. Occasional ferns and mahoe occur on stream banks, but recent clearing of the commercial pine has damaged the riparian vegetation and rendered much of the stream bank unstable. The sampling site was separated by a low gradient culvert under a farm track, which allows for fish passage. Downstream of the culvert the drain has deeply incised banks with still backwater and pool habitat under pine forest. The pool habitat of this portion of the waterbody, mixed combined with the excessive pine leaf litter traps suspended solids, rendering the water dark red/brown in colour. The stream bed sediments consequently have become highly anoxic in this zone, and while the instream debris would normally provide good habitat for fish, the water quality is severely degraded.

Half of the stream site sampled was covered by a thick canopy of pine and willow over bracken and scrub with few natives present e.g. mahoe (*Melicytus ramiflorus*) and hangehange (*Geniostoma rupestre var. ligustrifolium).* wheki (*Dicksonia fibrosa*), downstream of the culvert was scrubland/pasture, recently cleared, which resulted in loss of riparian cover and increased sediments in the water column. The upstream section of Ngarara Creek is subject to regular stream maintenance to improve flows. At the time of this survey, the stream had recently been cleared and dead *Galaxid* species were present.

Photo 9 - Ngarara Creek sampling location, downstream of culvert.

Photo 10 - Ngarara Creek sampling location upstream of culvert Ngarara Creek – with recently cleared stream bank

Waimeha Stream

The Waimeha "Stream" consists of a large (5m wide) drain in grazing rural land. The stream is formed by the confluence of two sources (a draining wetland spring and an urban spring), both within the Waikanae township boundaries. The urban section of this stream, with decent riparian vegetation buffer, has become a backyard feature for many bordering properties. At the time of sampling, the full extent of the Waimeha had recently been cleared by a digger. Downstream riparian vegetation was made up of pasture grass (grazed to the edge), *Carex geminata* and blackberry, with few willows, providing minimal shading. No riparian fencing was present.

The Waimeha is listed in Appendix 1, Table 16, of the Proposed Regional Policy Statement (2009) as a water body with a 'significant indigenous ecosystem'. Studies carried out by SKM in 2008 showed elevated nutrients, bacteriological counts and low toxicant concentrations. Parameters measured (including suspended solids, turbidity, phosphorus and metal concentrations) were low, and below the corresponding guideline value (Technical Report 24, Volume 3). SKM's E Coli concentrations were elevated in stormwater samples at Te Moana Rd (downstream of the alignment) (SKM, 2008).

Along the sampled reach, the habitat consists of run pool 80%/20% flow with a muddy substrate over sand. The Waimeha Stream is also listed as containing habitat for threatened indigenous fish species and being habitat for six of more ingenuous fish species in the catchment, and is listed as having inanga spawning habitat in the catchment. Downstream of the sampling location, the Waimeha Stream meanders adjacent to KCDC Council reserve and Waikanae Golf Course before exiting through the Waimeha Stream mouth.

Photo 11 - Waimeha Stream at the sampling location, showing varied exotic and native vegetation. Stream substrates from recent stream maintenance are visible to the left of photo.

Waikanae River

The Waikanae River is one of the most ecologically significant water bodies in the Kāpiti district and is listed in the Proposed Regional Coastal Policy Statement as having significant amenity, recreational values (Appendix 1, Table 15).

The Waikanae River's main stem system is approximately 19km (500m a.s.l) from the headwaters of the Tararua Forest Park via Reikorangi and Waikanae to the site of the alignment, then a further 1.5km to the coast. The upper reaches of this river is made up of remnant and regenerating native forest and shrub. Below the forest cover is a large farmland reach portion which is a generally open, sometimes braided, section. There is a 2.5km section of the middle reach with a substantial native riparian corridor which has created a buffer from the intensive surrounding rural land uses of the area. These buffer strips measure between 10m and 60m from the river's edge.

The lower reaches (the flatter lowland slopes) are a mixture of rough pasture and treeland over pasture. The section of 1.5km upstream of SH1 is represented by smaller farm lifestyle and rural lots of mixed use e.g. horticultural plots. Downstream of SH1 residential houses, flood control plantings and scattered bush remnants dominate this 3.7km urban section The river is buffered by KCDC Council reserve-land until it reaches the coast. This portion of the river has different levels of riparian functionality; depending on density, composition, maturity, and % cover of native and exotic tree species planted relative to the wide water body (in comparison to other waterbodies traversed by the proposed Expressway streams within the alignment).

The river width ranges from 9m (upper catchment); to 95m at the river mouth, with 15-20m wide being typical at the proposed Waikanae River bridge location. The substrate is made up of a combination of cobbles, pebbles and gravels, with excellent fish habitat provided by the presence of pool, run, riffle and cascades throughout the channel length. Riparian vegetation within the sampling site is made up of native forest (much of which is enhancement planting by local community groups), exotics (willows).

Greater Wellington Regional Council has listed the Waikanae River as a waterway with a significant indigenous ecosystem, i.e. having a high percentage of indigenous vegetation cover, as well as being a habitat for threatened indigenous fish species and providing suitable conditions for spawning inanga.

The Waikanae River is the subject of substantial restoration programmes. An Environmental Strategy for the Waikanae River has been prepared by Greater Wellington Regional Council in conjunction with Kāpiti Coast District Council to help co-ordinate the activities of the different agencies, community groups and landowners involved in protecting and improving the river environment (GWRC, 1999). As outlined in Technical Report 31, Volume 3 (Marine Habitat and Species), the Waikanae Estuary and Scientific Reserve downstream of the proposed Waikanae River crossing are identified as being high value habitats.

Existing studies of the water quality carried out by SKM, 2010 and GWRC Regional State of Environment (SOE) monitoring has generally indicated good quality, with just periodic exceedences of zinc, nutrients, E Coli and acid soluble aluminium. SKM (2010) state the background soil concentrations of aluminium are the likely cause of the elevated levels of this metal in storm water. SOE faunal studies have returned a range of results since 1999, with MCI scores ranging from 76 (poor) in 2002 to 118 (very good). A diverse number of fish species are recorded in this river.

Photo 12 – Waikanae River at the proposed bridge crossing location, with exotic riparian vegetation present, at point of proposed bridge.

Muaupoko Stream

This stream begins its long meander in the upper reaches of native catchment near Mt Maungakawa (382m a.s.l). This is approximately 4 km away from the alignment. The mid reach is dominated by rough pasture grasses with no riparian vegetation or stream shading. The upstream section of the sampled area is agricultural land, with no riparian planting or fencing.

At the sampling site, long pasture grasses and exotics (willow and blackberry) dominate the bank side vegetation. This portion of the stream had stable vegetated banks, and instream macrophyte provided good fish cover.

Below the culvert/public walkway, the stream flows through part of the Waikanae River restoration area, with riparian plantings of planted species, amongst occasional willow (Photo 14). This portion of the stream has very unstable sand banks with no vegetation. The stream measures approximately 2m wide with depths ranging from 0.30–0.70m, and has unstable steep sand banks. The Stream substrate consists of fine gravels, sand with areas of fine mud deposits.

Photo 13 – Muaupoko Stream upstream of walkway culvert, stable stream bank provided by scrub grasses and blackberry.

Photo 14 – Downstream Muaupoko Stream, 50 meters from confluence with Waikanae River

WWTP Drain (Waste Water Treatment Plan)

The WWTP Drain is a small tributary of the Mazengarb Stream. The WWTP Drain originates from drain systems, prior to being mixed with the outflow from the Paraparaumu waste water treatment ponds. This water channel is between 3m and 5m wide with an, and an average depth of 0.40m. As a result of the primary inputs being water from the waste water treatment ponds, the WWTP Drain, is highly nutrient enriched.

The stream in the sampling location is made up of run/pool habitat, with pine and willow roots and branches creating ideal habitat for eel. The stream banks are stable, held by long rank pasture grasses, blackberry and occasional bracken with blackberry dominating. There is significant instream debris. The true left bank has large established pine trees providing partial shade, and downstream the drain is fully shaded by an old stand of macrocarpa and pines with an understorey of scrub exotics e.g. blackberry being dominant, willow weed *(Persicaria maculosa) and* swamp willow herb *(Epilobium pallidiflorum).* At the site of the outlet pipe, the grass verges periodically are mown to water level. Downstream from the sampling site, the long rank grasses and pines continue, which makes up an exotic functioning riparian cover.

A 2007 study carried out by Opus (Reference) found a presence of algal growths including sewerage fungus near the wastewater outlet (15m upstream of sample point).

Photo 15 – WWTP Drain at sampling location

Photo 16 – Instream debris: crack willow within WWTP Drain.

Mazengarb Stream

The Mazengarb Stream (referred to often as Mazengarb Drain) is a tributary of the Muaupoko Stream. The Mazengarb Stream has a number of potential point source discharges of contamination in its catchment including Otaihanga Landfill and Paraparaumu Waste Water Treatment Plant, with the WWTP Drain entering the Mazengarb Stream just downstream of the sampling location. Due to the extensive habitat modification over the years this water body is consequently one of the more studied streams along the proposed Expressway Alignment (GWRC, 2009). Although its headwaters include native forest just east of SH 1, its entire length upstream of the sampling point consists of a highly modified an altered drain (containing 5 culverts), within heavily grazed predominantly rural land and more recently the ponds of a new housing development. The water quality is largely diminished by the upstream confluence of the Mazengarb WWTP Drain.

At the sampling location, the stream flows beneath an old stand of macrocarpa and pine providing full shade cover to the entire sampling reach, with a thick mat of wandering willie (Tradescantia fluminensis) covering the stream banks to the water's edge. The substrate consists of mud over sand, and contains very little stream debris, apart from the odd occasional fallen branches, and leaf litter and pine needles. The habitat is made up of run/pool/riffle combinations. Previous Historical fish surveys have recorded a good diversity of native fish including banded kokopu (Galaxias fasciatus), common smelt (Retropinna retropinna), common bully (Gobiomorphus cotidianus) and eels (Anguilla sp.), and have listed this as a locally important fish habitat (Opus, 2007)

The results of stormwater monitoring in the Mazengarb Stream (SKM, 2010) (downstream of the WWTP and landfill) showed that the stormwater quality was generally 'poor' with many water quality parameters and metal contaminants at levels which did not meet the relevant guideline values. In general, the stormwater samples had low dissolved oxygen, and elevated E coli, acid soluble aluminium (Al), and both dissolved copper (Cu) and zinc (Zn). The site is located in the Mazengarb Reserve (downstream of the alignment). Upstream of the sampling location lies the Paraparaumu WWTP and the tributary draining the 'eastern' edge of the Otaihanga Landfill. In addition, the site also receives drainage from the industrial/commercial area of Te Roto Drive.

Photo 17 – Mazengarb Stream at the sampling location looking upstream.

Photo 18 – Mazengarb Stream substrate –fine sediments over sand

Wharemauku Stream

The Wharemauku Stream is a highly modified urban drain, which originates from the combination of many springs in the forested upper reaches between Maungakawa (382m) and Mataihuka (202m).

The upper reaches is a steep-sided gorge-like reach which is a combination of ex-pine plantation, now rough pasture and young growth (at varying stages) commercial pine (Kāpiti Coast District Council (KCDC) *et al*, 2006). The middle reaches are made up of rough pasture with very little riparian cover and stream protection. Further downstream, the stream is channelised and influenced by urban (Paraparaumu Town) and industrial activities, as well as discharge from adjoining drains from peat lands.

West of SH1, the Wharemauku Stream is predominantly within a District Council reserve and public walkway, with the stream banks very exposed, intensively maintained and regularly mown. Riparian vegetation consists of grasses and water weeds e.g. water pepper (*Persicaria hydropiper),* Willow weed *(Persicaria maculosa),* Swamp willow herb *(Epilobium pallidiflorum),* but there are no shade trees. When the stream banks are mown, spawning habitat for *Galaxiad* species is lost. Fauna at this site may become vulnerable as water temperatures increasing. This lower reach is constrained within an unnatural, high-sided channel with stream edges dominated by introduced grasses and other common stream-side plants. Riparian vegetation consists of grasses and water weeds e.g water pepper (Persicaria hydropiper), Willow weed and swamp willow herb (*Epilobium pallidiflorum*). This lower reach has been highly modified by channelisation, vegetation removal and ongoing bank maintenance to the point where the only indigenous values that remain are those relating to its limited freshwater habitat and its role as a corridor between the upper and lower sections of the stream.

The substrate comprises embedded cobbles and sand with a run/pool habitat with little instream debris. Despite the highly modified nature of the stream, it provides valuable habitat and a migratory pathway for many native fish species (Opus, 2007). Fish surveys by the Department of Conservation (1999) and in 1979 (NIWA New Zealand Freshwater Fish Database) recorded twelve fish species within the Wharemauku Stream and its tributaries, including Shortjawed Kokopu, Giant Kokopu, Koaro and Banded Kokopu. It is possible that other species are also present. For instance, the brown mudfish (*Neochanna apoda*) is known to occur in similar streams on the Kāpiti Coast.

The draft Wharemauku Stream Community Freshwater Plan noted that stream habitat in the Wharemauku Stream is under considerable stress due to the presence of a number of weirs and other structures that help prevent down steam flooding.

The Wellington Regional Freshwater Plan identifies the Wharemauku Stream and its tributaries upstream from the coastal marine area boundary as a waterbody with nationally threatened indigenous fish. The Wharemauku Stream is not listed in the Wellington Regional Freshwater Plan as being a water body with important trout habitat (including spawning areas) and, as a far as we are aware, no trout have been recorded in the wider stream catchment.

Greater Wellington Regional Council undertook a macro invertebrate study at five sample sites in the Wharemauku Stream to assist in the long-term management of macro-invertebrates in the stream. The results of this macroinvertebrate study outlined in the draft Wharemauku Stream Community Freshwater Plan indicate a relatively high abundance of taxa for a modified stream of this nature.

Previous studies have shown that the stormwater quality in the Wharemauku Stream is generally 'poor' with some evidence of localised degradation of the stream bed sediments. Acid soluble aluminium and dissolved copper and dissolved zinc were also elevated relative to the ANZECC (2000) guideline at the 95% level of detection. The combination land use of commercial and /industrial land uses upstream of the sampling site is thought to be responsible for the presence of these heavy metals (Technical Report 24, Volume 3). The MCI values of the Wharemauku Stream ranged from 73 to 106 in 2007 (Opus, 2007), indicating the stream to be of poor to good habitat quality, displaying moderate pollution (Stark and Maxted, 2007).

Photo 19 – Wharemauku Stream facing looking West towards proposed Expressway alignment. The stream bank vegetation dominated by exotic water weeds

Photo 20 – Wharemauku stream bed

Lower Drain 7, Wharemauku

Lower Drain 7, a large tributary of the Wharemauku Stream, is an urban drain of extremely poor quality and low velocity water body within an urban environment, which upstream is used and created as wetland drainage. The catchment is a mix of agriculture, urban and industrial land uses. At the sampling site the drain is channelised, and measures approximately 1.5m wide and 0.15m to 0.2 m deep. The water at this site was still, rusty brown with a highly anoxic odour coming from the deep mud substrate. The riparian vegetation comprises of scrub willow, long ungrazed rank grasses and water weeds such as willow weed *(Persicaria maculosa)* and blackberry *(Rubus sp).* There are large amounts of in-stream debris. Fallen branches and a culvert create permanent stream barriers for water and fish passage. The bank is stable and single wire fenced preventing stock access.

The riparian margin has varying levels of functionality. The upper portion has close to 300m of primarily exotic shade trees and shrubs, predominantly willow, as it cuts though the back of properties. At the site of the alignment willows dominate for 120m over the sample reach. The stream banks consist of long pasture grasses, blackberry and willow shoots. A riparian margin of exotic trees (170m in length) lies between the sampling site, and point of discharge into the Wharemauku approximately 700m away.

Photo 21 – Lower Drain 7 at the sampling location, illustrating Instream debris, still water and exotic vegetated stream banks. and corrugated iron sheet, reducing movement in high water

Photo 22 – Still water of the lower Drain 7 sampling location.

Upper Drain 7, Wharemauku

Upper Drain 7 runs through Raumati Peatlands, a large area of land under the existing WLR designation, and a historical Kāpiti Coast District Council designation which has had varying levels of maintenance over the years. There is a mix of riparian plant associations along this drain, with evidence of planned planting. . The dominant riparian vegetation in this location is blackberry and bracken, with occasional flax, bracken and manuka on the true left of the drain, under a canopy of pine which stand between 10-20 metres back from the drain.

The stream bank is largely stable, but shading is minimal due to the offset distance of the pines from the stream. Gorse and blackberry over bare peat dominates the true right bank over the extent of the reach. In contrast the true right has bare earth of rich peat composition with scattered gorse. The stream substrate was very thick pine needle sludge and fine peats with anoxic odours. The water colour was dark brown to black in appearance. Flows were still to very slow at the time of sampling. even though the single culvert along the sampling reach was clear, allowing for fish passage.

Photo 23 – Upper Drain 7 showing unstable peat dominated substrates in the vicinity of the proposed Expressway alignment.

Photo 24 -A smaller drain entering Drain 7 at the sampling location, with illustrating overhanging vegetation, and partial shading along part of the survey site.

Whareroa Drain

The Whareroa Drain is one of a number of farm drains within the Queen Elizabeth Regional Park Covenant managed farm land. There has been extensive drainage effort within this southern peat soil region over the years, creating waterways with little resemblance to their natural form.

At the sampling site, this water body was a deeply incised drain with highly anoxic mud over the fine sand and peat substrate. The tannins within the water cause dark brown colour. The water body is limited to one habitat type – that of still water. Partially obstructed culverts currently prevent fish passage. The riparian vegetation consists of a canopy of macrocarpa and pine with an understory of gorse and blackberry over half of the reach (30m), while the remainder is grazed to within 1m of the drain. There is seasonal variability of Periphyton and aquatic plants growth. The below photos show the variability of the drain over the 50 metre reach sampled. Fish sampling returned long and short fin eel in small numbers.

Photo 25 – Whareroa Drain looking south

Photo 26 – Wooded instream debris and root structures of exotic pines in Whareroa Drain tributary sampled.

Whareroa Tributary at Waterfall Road

The Whareroa Tributary is 500m south of Whareroa Drain and has some high quality ecological components in contrast to many of the waterways sampled within the alignment and excellent riparian cover in the upper catchment. 500m upstream of the sampling area the channelized drain takes on a natural meandering habitat through a catchment of pine and native forest.

The substrate within the reach ranges from thick (30cm) fine silt (close to the SH 1 crossing), to 0.5mm to gravels and cobbles with minimum silt cover. The habitat varies with pools/runs and a small area of riffles, at the shallowest section. The riparian cover consists of a small portion of willows on the true right bank. The left bank has short grazed pasture to the stream edges.

Historically, there has been a good representation of native fish species sampled within the Whareroa Stream including long fin and short fin eel, banded and shortjaw kokopu, red fin and common bully and inanga.

Downstream of the sampling site the drain runs parallel to a driveway, with stock access into the water at all times. The stream banks are gently contoured and the water shallow at the edges, thus far minimising bank erosion. The sun exposure over summer and elevated water temperatures allows opportunistic algae and stream bank weeds and water weeds to dominate the channel; minimizing flow and reducing water quality.

4.2. Physical Habitat Qualities

Appendix 30.C presents the basic physical habitat parameter data in the SEV work sheets as well as other data collection systems.

4.2.1. Channel Form

The streams along the proposed Expressway alignment are generally set in a sandy soil, with sharply cut bank edges largely as a result of ongoing drainage and channel modifications. The majority of the “drains” have different levels of bank erosion, depending on bank height and water depth as well as the presence and type of riparian vegetation (protection). The average stream widths and depths, at the sample sites, are shown in Table 6.

Typically the lower reaches of the main stems of each waterway have wetted channel widths that range from 3 to 4m. The wetted width occupies on average about 70% of the channel and typically are constrained by a high bank (0.5m in height or greater). These lower reach streams can have flood plains that extend beyond the channel to 100m or more, although in one area at least there is no significant flood plain.

Table 6 Basic Stream Morphology.

Site Name	Average Water Depth (m)	Max Depth (m)	Average width (m)	Channel Width (m)	Dominant Substrate Cover
Whareroa Trib	0.41	0.75	3.8	4.5	Gravel/silt
Whareroa Drain	0.30	0.55	1.95	2.2	silt
Lower Drain 7	0.11	0.7	1.39	1.8	silt
Upper Drain 7	0.53	0.7	2	2	silt
Wharemauku	0.26	0.4	3.96	4.2	fine gravels/sand
Mazengarb Stream	0.59	0.86	3.62	3.8	silt
Mazengarb (WWTP) Stream	0.21	0.41	1.79	1.9	silt
Muaupoko	0.46	0.68	1.93	2.3	silt/sand/gravel
Waikanae	0.41	0.6	16.4	18	cobble/gravel/sand
Waimeha	0.67	1.07	4.41	4.7	silt/sand
Ngarara Creek	0.1	0.27	1.58	2.4	silt/sand
Kakariki	0.37	0.5	1.52	1.8	silt sand
Smithfield	0.27	0.4	1.24	1.9	silt
Paetawa	0.20	0.38	1.74	1.9	silt
Hadfield Kowhai	0.30	0.45	1.44	1.5	silt/sand

4.2.2. Hydrology

Depth profiles are similar throughout the fifteen waterways. Riffles are typically the shallowest habitat. Pools and long slow runs, which are the dominant form within the sampled water bodies, contain the deepest water habitats, averaging 0.4 -0.86m. The Waimeha Stream had the deepest pool encountered measuring 1.7m deep.

4.2.3. Substrates

The dominant stream substrate pattern within the sample sites is fine silt over sand and / or with some peat. These lowland reaches, with typically gentler gradients and lower water velocities, have higher levels of deposited and suspended sediments derived from current and historic land uses, including agriculture and urban development.

In contrast, the bed of the lower reaches of the Waikanae River system is predominantly dominated by gravels and cobble, with little silt and mud (a product of a steeper gradient and much larger flood flows). In general the visible bed is covered in a complex of variously sized gravels and cobbles. Within this substrate are sands and boulders. Nevertheless, sediment was infrequently recorded and the bed habitat can be considered a diverse benthic substrate habitat.

4.2.4. Stream Velocities

The velocities were generally uniform along the sampling points. Table 7 shows the average velocities that were recorded during SEV sampling (low flow conditions). Velocities ranged from nil flow through to 0.34m/s. The results that follow relate to the velocity at the sampling reach and is not indicative of the water flow throughout the entire water body length.

Table 7 Measured velocities of waterways within the Project area calculated via the SEV methodology

Site Name	Stream velocity (m/s)
Hadfield Kowhai Stream	0.07
Paetawa Drain	0.38
Smithfield Drain	0.00
Kakariki Stream	0.04
Ngarara Drain	0.00
Waimeha Stream	0.01
Waikanae River	0.10
Muaupoko Stream	0.12
Mazengarb at WW	0.17
Mazengarb Drain	0.07
Wharemauku	0.01
Lower Drain 7	0.07
Upper Drain 7	0.00
Whareroa Drain	0.34
Whareroa Tributary	0.07

Typically lowland streams and drains are slow moving and have an average velocity of 0.089m/s (Niwa, 2011). The velocities recorded above straddle this mean, with slightly steeper waterways (Paetawa, Whareroa) reaching 0.4 m/s, but most waterways being slightly slower than the national average. In some cases this is probably due to barriers such as terrestrial weed and grass invasion of the channel.

All velocities recorded in this study allow for all fish species passage, however, the waterways with nil flow required extra investigation to establish if there were any blocked culverts or obstacles upstream or downstream of the proposed crossing preventing normal flow through the channels.

Table 8 summarises flow data collated from several sources (BECA, Niwa and GWRC) for the streams being discussed. It shows that velocities are more variable in the smaller water bodies. The biology in these streams are therefore more influenced by irregular flows. For example the Whareroa high water level is 52 times greater than the low flow, whereas in the Muaupoko and Mazengarb Streams the high flows are 33 times and 32 times greater than the low flows respectively.

Table 8 Analysis of Stream Flows (Source M. Law (BECA, 2011), WRENZ (NIWA) and GWRC[4])

% of time flow exceeded	Whareroa Stream L/s	Wharemauku L/s	Waikanae L/s	Waimeha L/s	Ngarara Creek L/s	Ngarara Stream L/s	Paetawa Drain L/s	Muaupoko Stream L/s	Mazengarb Stream L/s	Hadfield L/s
10%	195	684	8890	187	31	139	73	366	129	19
20%	48	167	5800	171	28	127	67	206	72	17
30%	31	109	4390	164	27	122	64	152	54	16
50%	15	52	2790	151	25	113	59	112	40	15
40%	9	30	1770	138	23	103	54	63	22	14
80%	7	25	1380	134	22	100	52	44	15	13
85%	6	23	1180	132	22	98	52	37	13	13
90%	6	21	990	126	21	94	49	29	10	13
95%	5	18	760	112	19	84	44	22	8	11
98%	4	15	750	104	17	78	41	14	5	10
99%	4	13	750	99	16	74	39	11	4	10
Mean Flow L/s	45	158	4766	169	28	126	66	145	51	17

4.2.5. Riparian Condition

Most lengths of streams along the Project alignment have no or little indigenous over reaching or shading riparian vegetation. Many of the streams lie within urban or production landscapes with managed grass edges and exotic trees. The riparian vegetation normally consists of a mixture of short and long grasses with various native and exotic shrubs and weeds and exotic trees. None of the streams, within the sampled locations, have an indigenous canopy. The recorded dominant riparian cover for each surveyed stream is listed in Table 9, following.

Table 9 Predominant riparian vegetation at each sample reach

Site Name	Predominant Riparian Present
Hadfield Kowhai Stream	Pasture/Exotic - Mature pine
Paetawa Drain	Pasture
Smithfield Drain	Pasture
Kakariki Stream	Pasture/ Scrub exotic with few natives
Ngarara Drain	Pasture / Exotic Mature Macrocarpa
Waimeha Stream	Pasture
Waikanae River	Native/ Pasture

[4] WRENZ (Water Resources Explorer New Zealand), a NIWA data base. GWRC (Greater Wellington Regional Council)

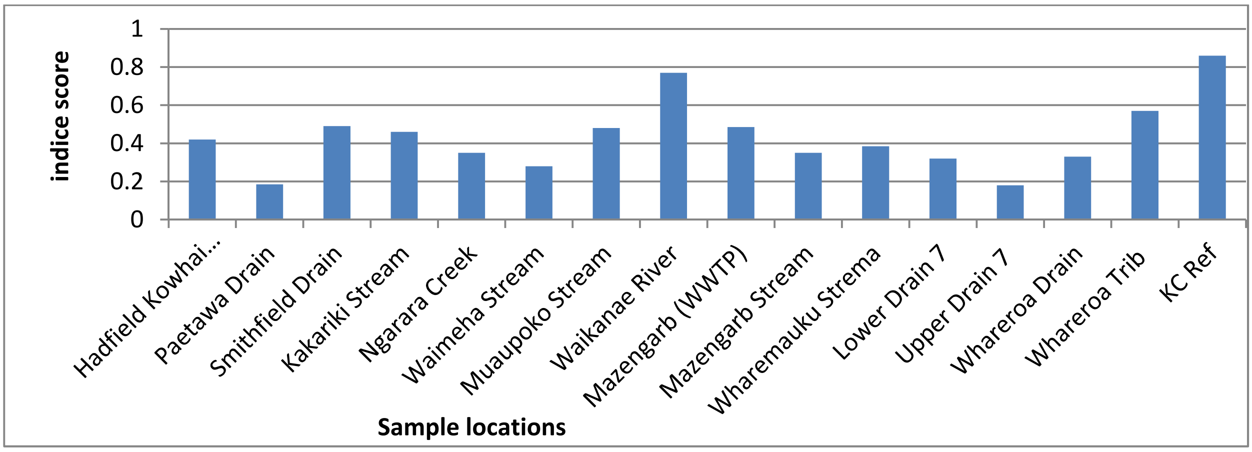
Site Name	Predominant Riparian Present
Muaupoko Stream	Pasture
Mazengarb at WWTP Stream	Pasture/ Exotic old stand Macrocarpa
Mazengarb Stream	Pasture/Exotic old stand Macrocarpa
Wharemauku	Urban managed lawn
Lower Drain 7	Pasture/Exotic - Willows
Upper Drain 7	Council Designation – Scrub - Gorse
Whareroa Drain	Pasture/ Exotic – Mature pine
Whareroa Tributary	Pasture/Exotic –Mature Pine

4.2.6. Physical Habitat Analysis (PHA) Scoring

The results for the sample locations are shown in

Figure 3. The PHA scores reflect a high level of disturbance and appear to be loosely correlated with the modification seen in these lower reaches. Scores typically range from 0.2 to 0.5, reflective of rural and urban land use pattern catchments. Only the Waikanae River and the reference stream scored over 60% of the maximum potential.

Figure 3 Physical Habitat Assessment scores (Maximum score = 1)



4.3. Freshwater Fish Investigation

4.3.1. Freshwater Fish Database (FFDB)

Prior to the BML survey for the MacKays to Peka Peka Expressway a desktop study of the various publications and regional (in some cases unpublished) studies was carried out to establish the likely presence of fish within the Project area. Sources of data included; the Department of Conservation (DOC), previous BML and other consultant and university student's studies, and NIWA "Freshwater

Fish Database" (FFDB) records. We treated "Threatened" and "At Risk" species as Alibone et al 2010 sets out.

General

Eighteen species of fish have been recorded in the FFDB from 6 of the 15 streams within the Project area as follows:

The **Ngarara Stream and Tributary** has been sampled on 38 occasions between 1990 and 2011 (NIWA, 2011). An average of 4 species was recorded during separate fishing attempts, with a maximum of 10 in January 2011 (by Massey University student, studying different fishing techniques). No threatened / at risk species have been recorded.

The **Waimeha** has been sampled (1990 and 1992), with six fish species being recorded, and an "At Risk" species (longfin eel (Declining) was found.

The **Wharemauku** has been sampled on two occasions since 1990. Four fish were recorded in the first, of which two species are "At Risk". The second (a 1999 Department of Conservation survey) established the presence of twelve fish species, including the "At Risk" species; shortjawed kokopu and giant kokopu.

The **Waikanae River** is the most sampled water body along the alignment with 12 surveys recorded on the FFDB from 1990 to 2011. In total 11 species have been recorded. The highest number of species caught on one occasion was nine (in April 1993). One exotic fish species (brown trout) and marine wanderers (yellow eyed mullet and black flounder) were recorded. Four "At Risk" species were recorded, with those being lamprey (recorded on one occasion), longfin eel (10 occasions), red fin bully (10 occasions) and inanga (2 occasions).

> Four of the species recorded are typically found in the lower reaches (i.e. smelt, black flounder, yellow eyed mullet and triple fin) and are often associated with tidal parts of the habitat as well as the lower freshwater. Two species are more typically found in steeper rocky and cobble bottom stream headwaters and prefer habitat with native canopy (shortjaw kokopu and banded kokopu). One of the species (torrent fish) is related to the swift cobble sections and is not in the other waterways of the Project area.

Table 10 lists the fish observed in this these earlier studies.

Table 10 Historic observations from NIWA's National Freshwater Fish Database

* Hand fishing and *Fish Observations reported.

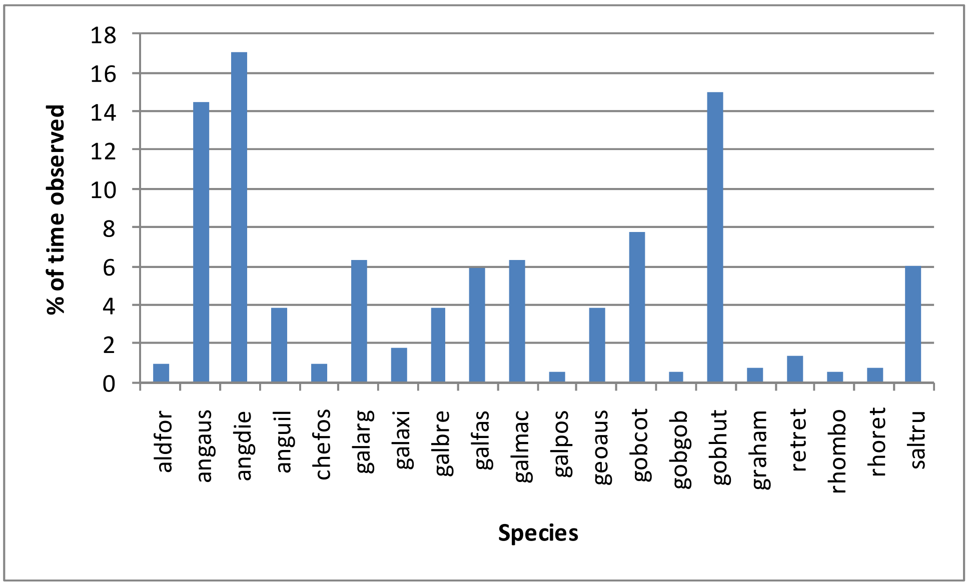
	Common Name	Conservation Status[2]	Found through catchment	Waimeha Stream	Waikanae River	Wharemauku Stream	Whareroa Stream	Ngarara	Ngarara Stream Trib	Fishing Method
Aldrichetta forsteri (tidal)	Yellow eye mullet	Not Threatened	Y		Y	Y				
Anguilla australis	Short fin eel	Declining	Y	Y	Y	Y	Y*	Y	Y	EF
Anguilla dieffenbachii	Long fin eel	Not Threatened	Y	Y	Y*	Y	Y	Y	Y	EF
Cheimarrichthys fosteri	Torrent fish	Declining	Y		Y*	Y				
Galaxias argenteus	Giant kokopu	Declining[PD]	Y			Y	Y	Y		
Galaxias brevipinnis	Koaro	Declining	Y			Y				
Galaxias fasciatus	Banded kokopu	Not Threatened	Y			Y	Y	Y	Y	EF
Galaxias maculatus	Inanga	Not Threatened	Y	Y	Y	Y	Y*	Y	Y	EF
Galaxias postvectis	Shortjaw kokopu	Declining	Y			Y				EF
Geotria australis	Lamprey	Declining	Y		Y	Y				EF
Gobiomorphus cotidianus	Common bully	Not Threatened	Y	Y	Y		Y	Y		EF
Gobiomorphus gobioides	Giant bully	Not Threatened[DP]	Y	Y			Y	Y	Y	EF
Gobiomorphus basalis	Crans bully	Not Threatened	Y					y		EF
Gobiomorphus huttoni	Red fin bully	Declining	Y	Y	Y	Y*	Y*	Y		EF
Grahamina sp. (tidal)	Estuarine triplefin	Not Threatened	Y							EF
Retropinna retropinna	Smelt	Not Threatened	Y		Y	Y				EF
Rhombosolea retiaria	Black flounder	Not Threatened[DP]	Y		Y					EF
Salmo trutta	Brown trout	Introduced and Naturalised	Y		Y*					EF

* Hand fishing and *Fish Observations reported

[2]Threat Classification from Alibone et al, 2009. Note: Qualifiers: DP, Data Poor: PD, Partial Decline

Plotting the frequency of occurrence in the records of each fish species shows that long fin eel, short fin eel and red fin bully are the most commonly recorded fish (Figure 5).

Figure 4 Frequency of occurrence of fish species in FWDB records



4.3.2. MacKays to Peka Peka Investigations

A summary of the number of verified fish taxa sampled at each site during Project investigations is recorded in Table 11. Of the 18 species historically recorded within the wider catchments, sampling carried out for this study recorded eleven species as follows.

Table 11 Summary of species caught within each river catchment sampled by EFM.

Catchment	Site Name	Fish species (with threat status indicated)
Hadfield Kowhai	Hadfield Kowhai Stream	long fin eel*, short fin eel, Banded kokopu
Waimeha	Paetawa Drain	Banded kokopu*, long fin eel*, smelt
Waimeha	Smithfield Drain	long fin eel*, short fin eel,
Waimeha	Kakariki Stream	long fin eel*, short fin eel, common bully, Banded kokopu
Waimeha	Ngarara Creek	long fin eel*, short fin eel,
Waimeha	Waimeha Stream	short fin eel, common bully
Waikanae	Waikanae River	long fin eel*, short fin eel, common bully, red fin bully*,Inanga, flounder
Waikanae	Muaupoko Stream	long fin eel*, short fin eel, common bully, Inanga, smelt
Waikanae	Mazengarb (WWTP)	long fin eel*, short fin eel, common bully
Waikanae	Mazengarb Stream	long fin eel*, short fin eel, common bully
Wharemauku	Wharemauku Stream	long fin eel*, short fin eel, common bully, Inanga, torrent fish, Giant and Banded kokopu, lamprey, red fin bully*, smelt, Koaro,
Wharemauku	Lower Drain 7	long fin eel*, short fin eel, Inanga*,
Whareroa	Whareroa Drain	long fin eel*, short fin eel,
Whareroa	Whareroa Tributary	long fin eel*, short fin eel, common bully

*-"At Risk" - Declining (Albione et al 2010)

The fish not sampled in this reports' surveys, but recorded in historic data were: Crans and Giant bully, torrent fish, shortjawed kokopu, yellow eyed mullet and brown trout.

When our observations from the impact reaches were compared with the national dataset there were a number of differences of note:

- Six fish species have been historically recorded in the Waimeha, of which we recorded three (long fin eel, shortfin eel, & common bully). We did not record three (banded kokopu, giant bully, redfin bully) and added two new species (Banded kokopu and smelt) from our five study reaches;
- Eleven fish species have been historically recorded in the Waikanae catchment of which we recorded seven in our four study reaches;
- Twelve fish species have been historically recorded in the Wharemauku catchment of which we recorded four (shortfin eel, longfin eel, inanga, and common bully). We did not record three (koaro, shortjaw kokopu, redfin bully), and added three new (longfin eel, inanga, and common bully);
- Eight fish species have been historically recorded in the Whareroa stream of which we sampled three;
- The Ngarara stream system has historically recorded nine fish species of which we recorded three. The species not sampled were giant kokopu, inanga, common and redfin bully, giant bully, and Crans bully. We suggest that the study reaches in this catchment were some of the most degraded and that this result should not be unexpected.

Discussion

Increased fishing effort or the addition of other sampling methods, may have identified some additional species in low numbers within our study reaches. However, the survey was limited to the impact reach of each stream as opposed to historic surveys which extend from the estuaries to the catchment headwaters (e.g. the Wharemauku Stream surveys). It is therefore expected that this study would identify a smaller range of resident fish than are listed in the National Freshwater Fish Database (and other sources).

In addition, the stream form and habitat at many of the sample sites were considered to be sub-optimal for a number of native fish that require good water quality and key habitat components, especially so for torrent fish and shortjaw kokopu.

Irrespective of these factors, the larger streams, and in particular those that extend into the eastern foothills, will be acting as corridors for movement of fish within the catchments. In recognition of this we have assumed that all fish identified by the NIWA's National Freshwater Fish Database could be present (migrating through) in regard to mitigation (fish passage) requirements but only those species we sampled for part of the "value" assessment.

4.4. Aquatic Macro-Invertebrates

4.4.1. Species Richness and Composition

In total 60 different aquatic invertebrate taxa were sampled from the 15 water bodies within the Project area. The taxa composition consists of:

- 3 molluscs,
- 1 mite (Hydrarachna),
- 1 worm (Oligochaeta),
- 4 Crab/Shrimp (Crustacea),
- 1 (moth/butterfly) (Lepidoptera),
- 1 Toebiter (Megaloptera),
- 23 fly (Diptera),
- 2 Damselflies and dragonflies (Odonata),
- 3 beetle, (Coleoptera)
- 1 bug (Hemiptera),
- 3 stonefly (Plecoptera),
- 14 caddisfly (Trichoptera) and
- 4 mayfly (Ephemeroptera)

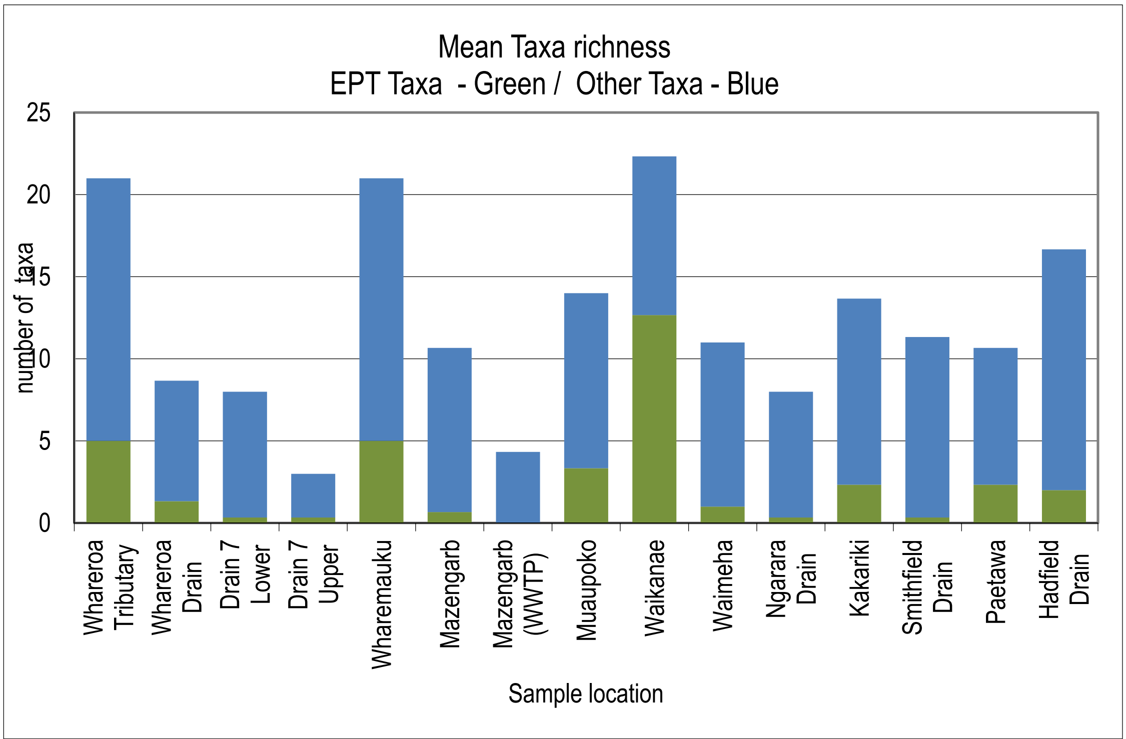
The average number of taxa across the sampled water ways was 17.5 (± 8). The sampling sites returned a broad range of taxa, between 5 and 33, across all of the sampling sites.

In total four taxa of Ephemeroptera (mayfly) were recognised (Deleatidum, Ichthybotus, Austroclima and Nesameletus). Five of the 15 sites had mayfly represented in their communities (i.e. 33%). Deleatidium were the mostly commonly encountered mayfly (21% of samples contained Deleatdium). The other three taxa were less frequently encountered.

Three taxa (10 individuals in total) of stonefly (Plecoptera) were found (Zelandoperla, Zelandobius and Megaloptoperla), and these stonefly were caught at two sites, the Waikanae River and the Whareroa Stream.

Caddisfly (Tricoptera) were the most taxa rich group of the EPT with 14 taxa. Of the fourteen taxa, Tripletides (cased caddis) were most commonly found at 11 sites (73.3%) and from 23 samples (a 51% frequency), but the most abundant Trichoptera were Oxytheria (present only at three sites) and Pycnocentrodes (present only at 3 sites). Figure 6 plots the mean taxa richness (n= 3) per site.

Figure 5 Mean taxa richness at each sample site (n=3)

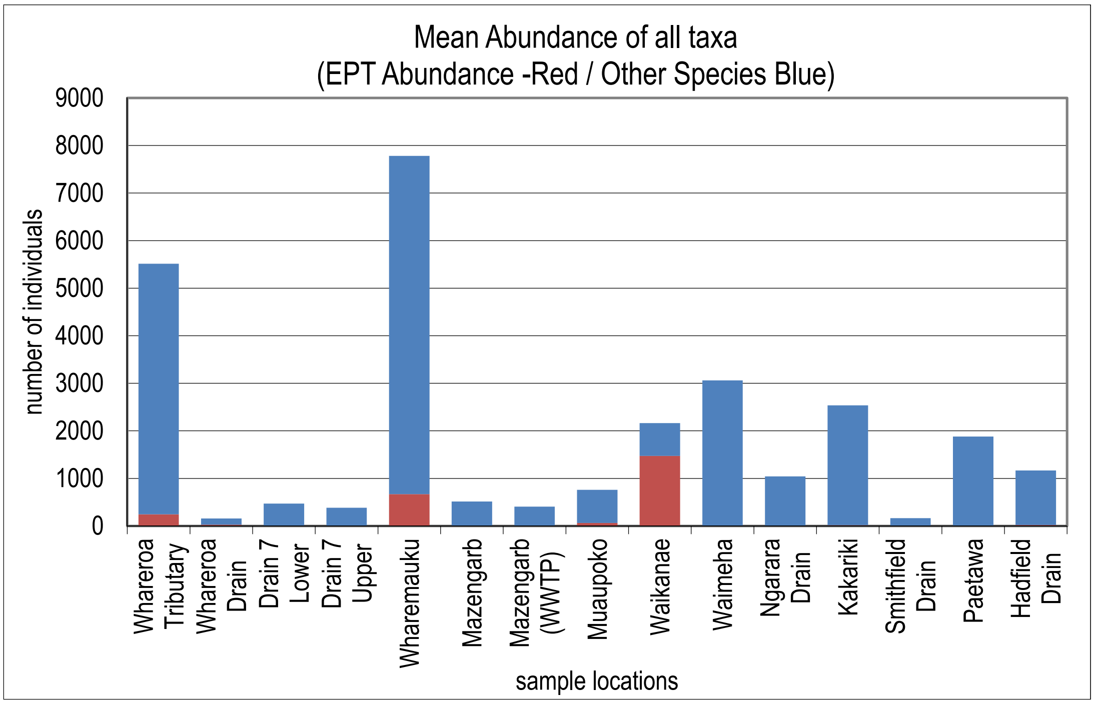


4.4.2. Macro-Invertebrate Abundance

The greatest number of individual invertebrates was from the Mullosca family, with *Potomopyrgus* (23,939 individual) found at 10 of the 15 sites, and comprises 36% of all individuals sampled. Crustacean were also common in the samples with 20,005 *Paracalliope* individuals making up 29% of the total catch.

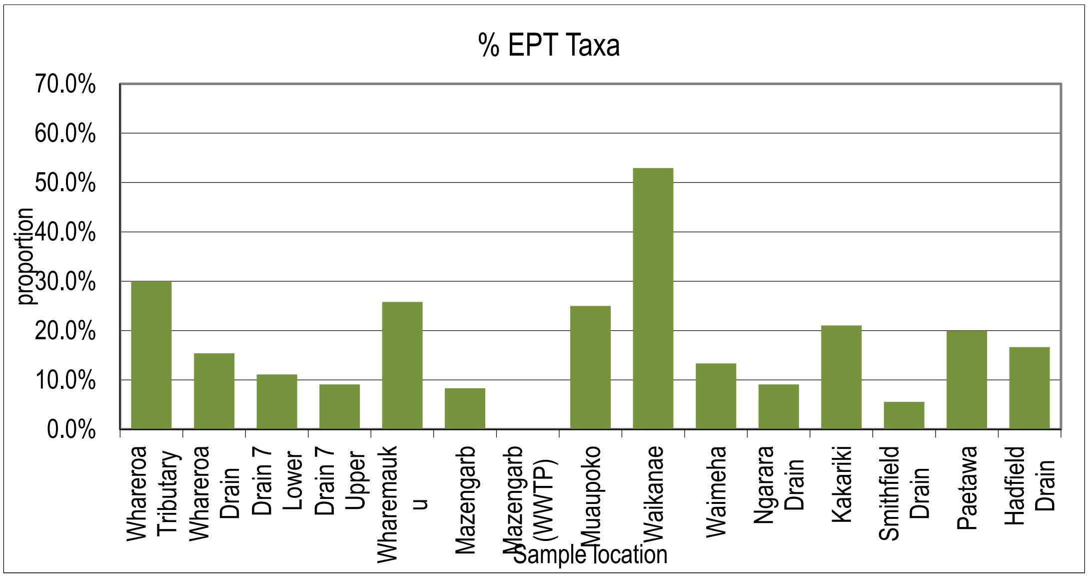
Deleatidium made up 97% of the mayfly abundance caught across all samples, but only totalled 2997 individuals or 3.5 % of the total catch. The other EPT fauna in total summed to 3078 individuals and 3.6% of the total catch. A high scoring MCI Diptera (*Paralimnophila* - MCI 8), was sampled in several sites (Muaupoko, Paetawa and Hadfield Kowhai) but only in very small numbers 2, 9 and 17 respectively.

Figure 6 Mean abundance at each sample site.



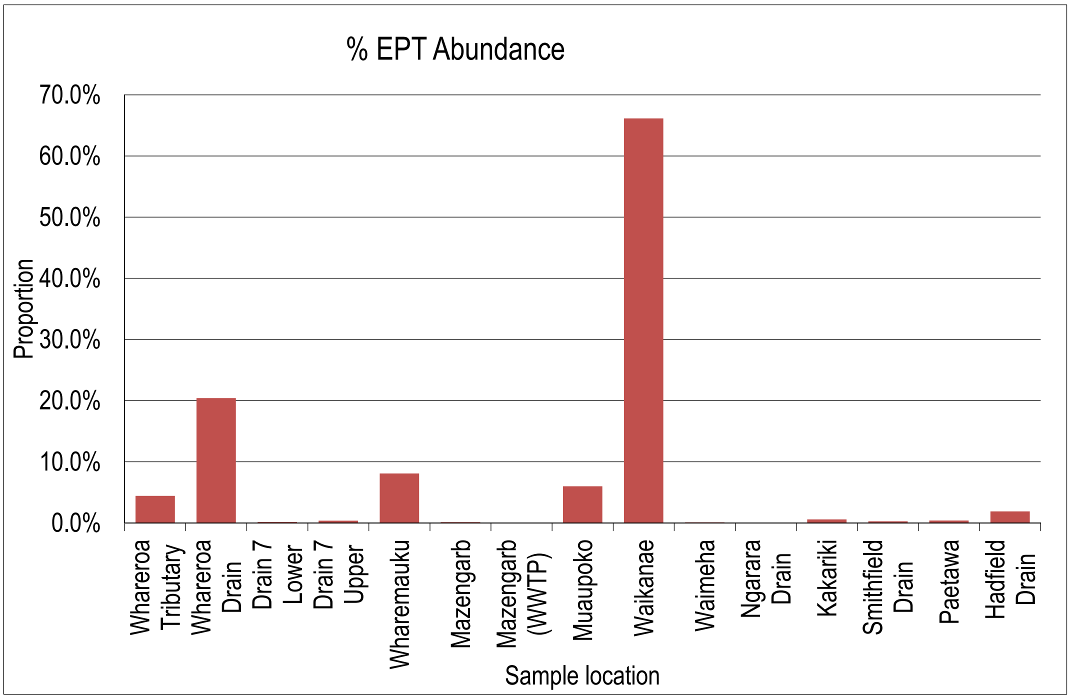
A commonly used comparative biometric is the percentage of a community's richness or abundance that is EPT. Figure 7 plots the percentage representation of the total taxa richness which is made up of ETP taxa (%EPT). It shows that the majority of the sites have low representation of EPT taxa (<10%). The Waikanae and the reference site are the only water bodies to have over 50%, of the taxa present belonging to the EPT groups.

Figure 7 Averaged proportion (%) of EPT taxa present at each site.



A similar biometrics using the abundance of the EPT taxa relative to the abundances of the other groups can also be made and informative. Figure 8 shows the mean (n=3) percent abundance of EPT taxa. Most sites have well below 1% and all but the Whareroa and Waikanae streams have below 20% EPT representation i terms of abundance of EPT taxa.

Figure 8 Average % of EPT as a proportion of the total abundance of catch at each site.



In regard to the ratios of abundances with the EPT group, table 12 shows the numerical dominance of Trichoptera across the sites. Only in the Whareroa Tributary was this pattern different, with Deleatidium dominating this site.

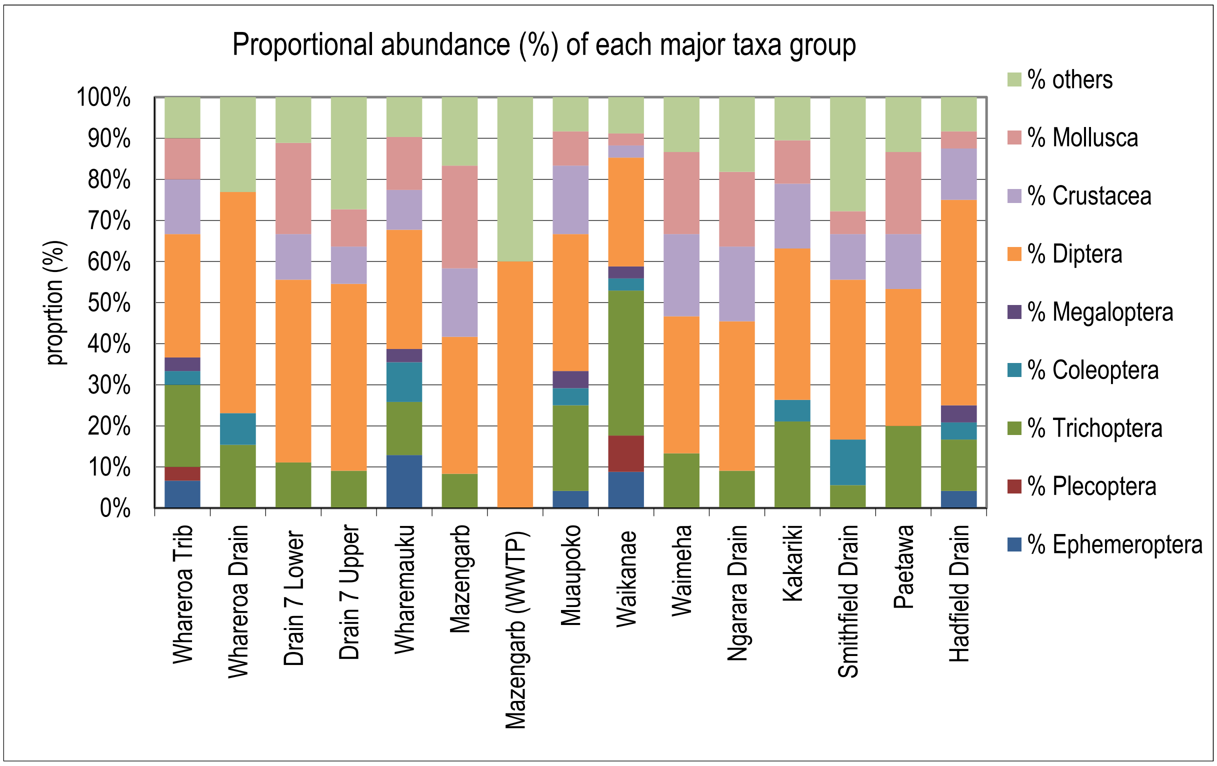
Table 12 Comparative abundance of EPT groups across the sites

	Ephemeroptera	Plecoptera	Trichoptera
Hadfield Kowhai	339	0	86
Paetawa Stream	0	0	254
Smithfield Drain	0	0	12
Kakariki Stream	0	0	361
Ngarara Drain	0	0	17
Waimeha Stream	0	0	77
Waikanae River	22162	118	17048
Muaupoko River	518	0	1044
Mazengarb (WWTP)	0	0	0
Mazengarb Drain	0	0	23
Wharemauku Stream	876	0	7529
Lower Drain 7	29	0	0
Upper Drain 7	0	0	50
Whareroa Drain	0	0	529
Whareroa Tributary	6907	19	363

4.4.3. Community Assemblage

Inspection of the proportions of a community's taxa groups can reveal a lot about the habitat condition and the primary drivers of that habitat: the substrate type, periphyton growth, light levels, water flows etc. There are two aspects: the proportional composition of the taxa groups present and the proportional abundances of the different taxa groups shows the percentage of the total number of taxa present that fall into each of the groups (as listed in the legend in Figure 9). The sites are arranged in no particular order.

Figure 9 Macroinvertebrate community composition (% by Abundance) at each sampled site.



Several sites stand out as having different community composition based on Figure 10. The Waikanae, Mazengarb, Whareroa drain and the Whareroa Tributary. These sites are separated from the rest by the presence of the EPT groups. In all sites, except “Drain 7 lower”, the most highly represented taxa (the community character) are the Crustacea and Mollusca groups. The lower Drain 7 is characterised by Diptera (flys) and in particular chironomids (midges) and mosquitoes.

4.4.4. Sensitivity Indices

Stark & Maxted’s (2004) guide to interpretation of the MCI indices score for soft bottomed streams are given outlined below.

Quality Class	Stark (1998) description	MCI	QMCI
Excellent	Clean	>120	>6.0
Good	Possible mild pollution	100-120	5-6
Fair	Probable moderate pollution	80-100	4-5
Poor	Probable severe pollution	<80	<4

Table 13 provides the sensitivity scores and interprtated "quality" for the 15 streams that were sampled. The results are shown graphically in the following figures 10 & 11.

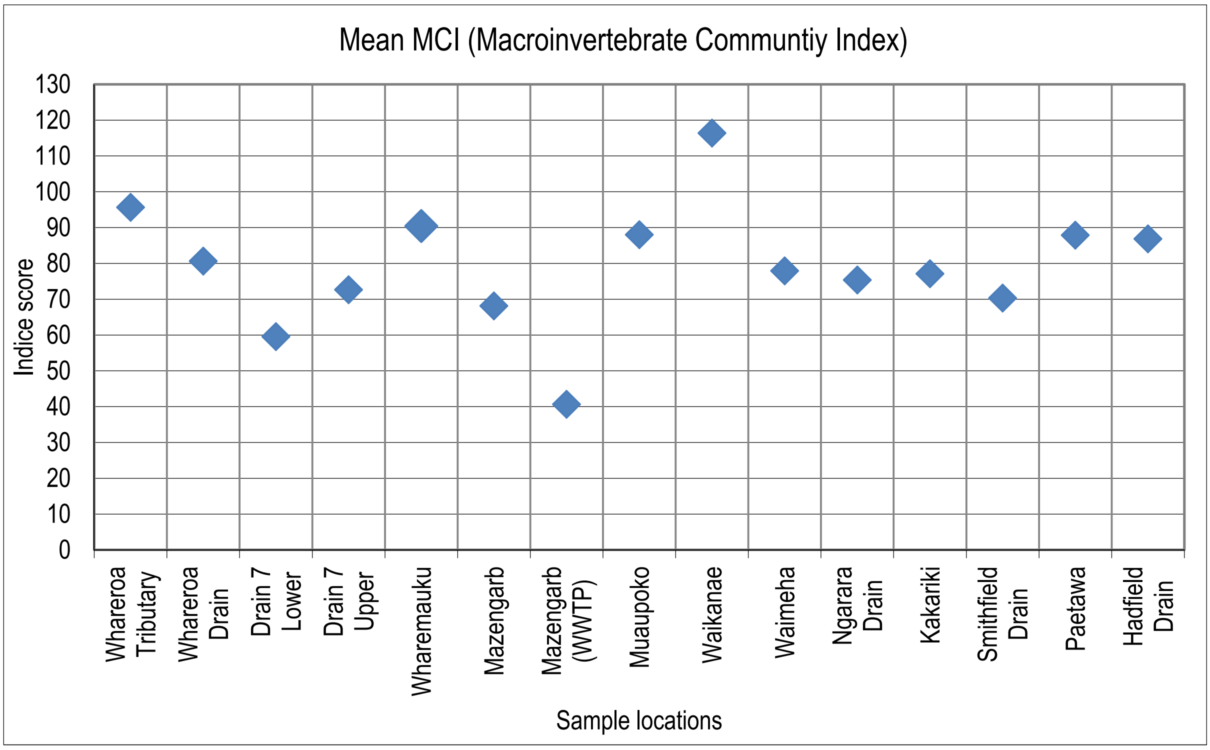
Table 13 Summary of MCI and SQMCI scores for sampled sites

Site/stream	MCI	MCI	QMCI	QMCI
Hadfield Kowhai Stream	Fair	77	Fair	4.7
Paetawa Drain	Fair	87	Fair	4.4
Kakariki Stream	Fair	70	Fair	2.7
Smithfield Drain	Poor	77	Poor	4.5
Ngarara Creek	Poor	75	Fair	4.3
Waimeha Stream	Poor	77	Fair	4.7
Waikanae River	Good	115	Excellent	6.4
Muaupoko Stream	Fair	88	Fair	4.2
Mazengarb (WWTP)	Poor	4	Poor	1.7
Mazengarb Stream	Poor	69	Fair	4.8
Wharemauku	Fair	90	Poor	3.7
Lower Drain 7	Poor	60	Fair	3.1
Upper Drain 7	Poor	73	Poor	2.5
Whareroa Drain	Poor	78	Poor	3.7
Whareroa Trib	Fair	96	Fair	4.3

Mean MCI scores in the Project area sites were generally low, i.e. less than 100 and typically under 90 (Figure 12).

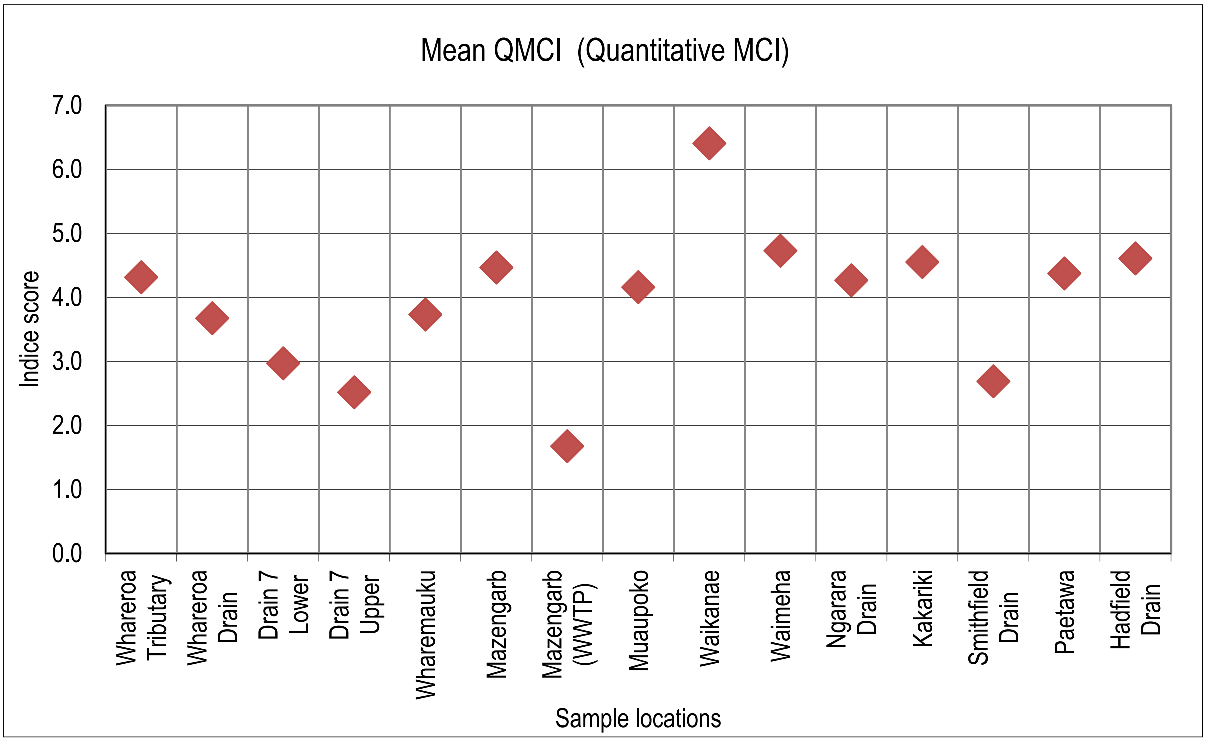
All but two sites scores were either indicating "probable mild pollution", or "possible mild pollution". Only the Waikanae River, in all samples, and the Muaupoko, scored an MCI over 100, (i.e. good with possible mild pollution category).

Figure 10 Mean MCI Score from each sampling site.



The QMCI, which accounts for the abundances of the sensitivity scoring taxa (weighting the score in favour of the most abundant taxa) reflects the "community" condition. Those scores are plotted in Figure 11. The range is from 1.7 ("poor" "probably severe pollution") through to 6.9 (excellent).

Figure 11 Mean QMCI scores for sampled sites



Both sensitivity indices strongly suggest the aquatic benthic macro-invertebrate fauna throughout 13 of the 15 water bodies are in poor to fair condition with limited sensitive taxa present within the benthos of those streams.

4.5. Water Quality

While water quality is important to aquatic biology, the measurement of chemical water quality was under taken by BECA, (2011) we summarised in this following section, that work prior to our ecological interpretation of the quality conditions and values.

4.5.1. Background Water Quality Monitoring

Monitoring of water quality in the western half of the Wellington region has been carried out by GWRC since 1987. From 2003, that monitoring frequency increased to annually as required under Rivers State of Environment (RSOE) reporting. Of the 55 sites monitored, three are located in close proximity to the Project proposed Expressway alignment: Ngarara Stream, Waikanae River, and Whareroa Stream tributary. Mazengarb Drain was originally monitored but has recently been removed from RSOE reporting (2009).

Method 25 of the Regional Policy Statement (GWRC, 2009), seeks the improvement of water quality of seven water bodies within the Kāpiti District; which include two within this study area, the Waikanae River Estuary and the Mazengarb Drain. The municipal waste water for Paraparaumu, Raumati and Waikanae townships currently discharge into the Mazengarb Drain via the WWTP Drain (a small tributary of the Waikanae River). Prior to 2002 waste water was also discharged to the Ngarara Stream via the Black Drain (Perrie & Cockeram, 2010).

Table 10 summarises GWRC data collected in the Ngarara and Mazengarb Streams where they did not meet minimum stream health guidelines (MFE, 2000). It is notable that these two monitoring sites were the lowest ranked and provided the worst quality of GWRC's 55 monitored sites from 1997 to 2003. The full results of the water quality monitoring are attached in Appendix 30.B.

Table 14 Streams monitored by Greater Wellington Regional Council and the water quality parameters exceeded between 1997 and 2003.

Site Name	Parameter Exceeded	Guideline Value	Median Value above recommended guidelines (n=25) and % of time exceedence recorded
Ngarara Stream at Field Way	Dissolved Oxygen	≥ 80% RMA 1991 Third Schedule	38.8% below threshold 100% of times sampled
	Visual Clarity – Black Disc	1.6m MFE (1994)	.37m Below threshold 100% of times sampled
	Total organic carbon		12.1mg/L
	Ammoniacal Nitrogen	≥ 0.021 exceeded 97.3% of samples	1.3mg/L Exceedance 97.3% of samples.

Site Name	Parameter Exceeded	Guideline Value	Median Value above recommended guidelines (n=25) and % of time exceedence recorded
	Total Phosphorus	0.033 mg/L	Exceedance 100% of samples
	Macroinvertebrate Community Index	MCI 80.1	Fair (2010)
Mazengarb Stream	Dissolved Oxygen	≥ 80% RMA 1991 Third Schedule	63.6%
	Visual Clarity – Black Disc	1.6m MFE (1994)	.36m Below threshold 100% of times sampled
	Total organic carbon	9.6mg/L	9.6mg/L
	Ammoniacal Nitrogen	≥ 0.021 exceeded 91.8% of samples exceeded	.310mg/L Exceedance 91.8% of samples
	Total Nitrogen	0.614 mg/L.	4.39mg/L Exceedance 95% of samples.
	Total Phosphorus	0.033 mg/L.	Exceedance 100% of samples

4.5.2. Grab Sample Results

The following section summarises water quality grab sampling carried out by BECA in 2011. They cover two types of sampling, baseflow analysis of water quality carried out by ELS and analysed by BECA (Table 17), and first flush sampling of streams during rainfall events carried out by Boffa Miskell (Table 17).

Base Flow and Rain Event Sampling

Six of the 15 watercourses traversed by the proposed Expressway were sampled during normal flows and during heavy rainfall events. These six were selected to be representative of the range of waterways potentially affected by the alignment. Detail of the sampling undertaken is contained within Section 5.2 of Technical Report 24, Volume 3 (Baseline Water and Sediment Quality Investigation Report). Table 15 summarises these results, highlighting water quality measures that exceeded accepted guidelines.

Table 15 Summary of the Water Quality Parameters/Contaminants at elevated levels within six representative streams (BECA, 2011)

Watercourse	General Water Quality (BECA Sampling)	Base Flow Water Quality Exceedances	Stormwater Quality Exceedances
Whareroa	Poor *	Nutrients, TSS, turbidity, water quality, bacterial counts	
Wharemauku	Poor		DO, E Coli, aluminium (acid soluble), copper (dissolved) zinc (dissolved)
Mazengarb Drain	Poor	Boron, nutrients, suspended solids, BOD	DO, E Coli, aluminium (acid soluble), copper (dissolved) zinc (dissolved)
Waikanae River	Good	Dissolved reactive phosphorus	E Coli, aluminium (acid soluble),
Waimeha	Fair	Nutrients	E Coli,
Ngarara Stream[1]	Poor	Ph, dissolved oxygen, nutrients, suspended solids, turbidity, bacterial counts, aluminium	

[1] Streams in the Ngarara Stream catchment only (does not include Waimeha Stream)

As part of the ecological description of each stream sampling reach, three water quality metrics were also recorded: pH, Turbidity (or clarity), and Total Suspended Sediments (TSS). All samples were taken during base flows (low flow periods), following periods of dry weather. Table 16 summarises the results.

Table 16 Event Sampling of water quality (Ph, Turbidity and TSS)

	pH	Turbidity (NTU)	TSS (g/m3)
Hadfield Kowhai Stream	7.70	0.20	5.33
Paetawa Stream	6.98	5.73	14.00
Smithfield Drain	6.37	21.63	151.00
Kakariki Stream	7.90	6.80	40.33
Ngarara Creek	6.99	377.00	129.33
Waimeha Stream	6.82	3.70	35.67
Waikanae River	6.98	5.73	14.00
Muaupoko Stream	7.80	23.10	17.33
Mazengarb (WWTP)	7.87	5.03	6.33
Mazengarb Stream	7.89	5.43	14.33

	pH	Turbidity (NTU)	TSS (g/m3)
Wharemauku Stream	7.80	24.77	24.00
Lower Drain 7	7.78	467.50	35.67
Upper Drain 7	6.46	15.00	82.33
Whareroa Drain	3.27	622.00	130
Whareroa Tributary	9.71	65.70	84.00

In terms of ecological health, a pH level of between 6 and 9 is considered acceptable with an excellent range being 6.5-7.5. (Niwa, 2011). Levels that exceed these values are likely to have ecological irregularities. 11 sites had pH levels compatible to most NZ stream life, four were satisfactory. One site (Whareroa Drain) had highly acidic readings (<3.5). The Smithfield Drain, and the Upper Drain 7 had moderately acidic readings.. One site, Whareroa Tributary had alkaline readings.

Turbidity and TSS at elevated levels can have adverse effects on stream ecology, flora and fauna. As a general rule, base levels of both metrics should be below 5 NTU (Nephelometric Turbidity Units) and 5(g/m3), but can be tolerated at levels of up to 25NTU or greater (banded kokopu) for long periods of time (Rowe et al 2004). These levels of TSS can increase to several hundred or even thousands during rainfall events, and if they are of short duration most species can also tolerate or evade such infrequent and short sedimentation episodes.

It is notable that all sites sampled during base flows exceeded 5(g/m3). Many of the streams sampled had levels of suspended sediments that greatly exceeded the “acceptable” limits including Smithfield Drain, Ngarara Creek, upper Drain 7, and Whareroa Drain. Six streams had NTU readings below or at the 5 NTU level (illustrating that NTU and TSS are not always correlated in a linear equal ratio way). Three streams had NTU levels that were above the 25 NTU level at low flow. Generally the waterways of the Project are high in suspended sediments at base flows.

Summary of Water Quality Results

Nutrients

Baseline sampling shows that nutrient levels, as indicated by Total Nitrogen and Total Phosphorus, were elevated, that is, above the ANZECC 2000 guideline values at five of the six sampled waterbodies.

Nutrient levels are important in freshwater systems because at raised levels they lead to excessive growth of plants, many of which can be unwanted organisms (e.g. algae). Over a longer time period changed nutrient levels cause changes in the food web of a freshwater ecosystem and can affect plants, animals, communities and habitats (Niwa, 2011).

The results obtained suggest that nutrient enrichment is a major issue in the lower reaches of streams generally within the sample area.

Heavy Metals

The following streams had raised heavy metal contaminants: the Ngarara and Mazengarb in base flows and the Wharemauku and the Mazengarb in stormwater flushes (BECA, 2011). The elements Aluminium, Copper, Zinc and Boron were found to be raised above (ANZECC 2000) guidelines.

Dissolved fractions represent a greater risk than the total in terms of ecological impacts as it relates to the more bio-available metal fraction. Therefore, poor water quality and risk of toxicity effects on aquatic organisms is better highlighted by exceedances of dissolved metals in relation to guideline values.

Turbidity

None of the streams had baseline levels of suspended sediments that are biologically acceptable (i.e they are raised) in the long term. This is most likely a result of the low gradient and the surrounding land uses.

Stormwater

Stormwater sampling highlighted the water quality shows issues in most sampled streams with raised levels of heavy metals, dissolved oxygen, and E Coli (Technical Report 24, Volume 3).

Combined these factors suggest that many of the streams along the proposed Expressway alignment currently present challenging environments for indigenous flora and fauna, and will favour the presence of species of both plant, invertebrate and fish that are highly tolerant of high contamination levels, poor water quality, and poor clarity.

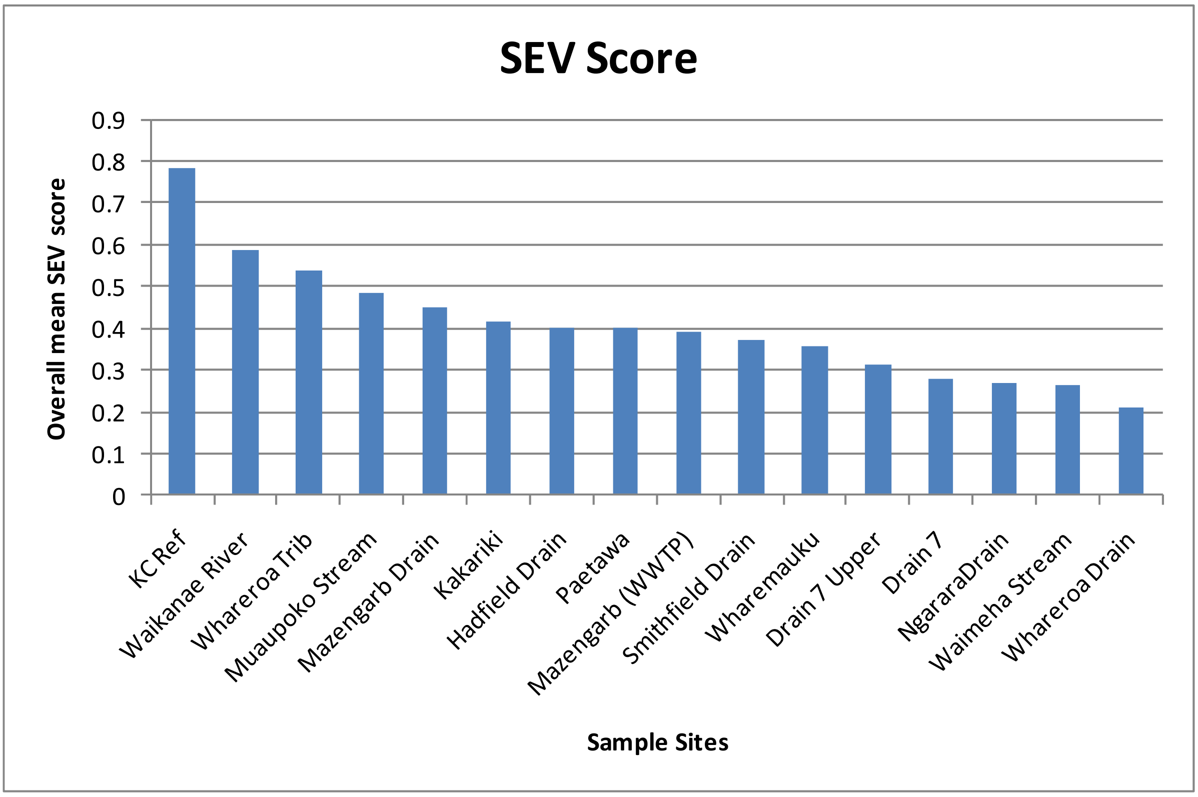
4.6. Stream Ecological Valuation (Sev)

4.6.1. Summary of Results

SEV scores across the sampled sites ranged from 0.21 at Whareroa Drain to 0.78 at the Reference Site. The major factor influencing the SEV scores for most streams sampled is the absence of effective riparian margins. Riparian vegetation and fencing has many functions including: year round shade, organic material addition, stream bank stability decreases flood damage and increases water quality

The SEV results are ranked and shown in Figure 12. The raw scores are provided in Appendix 30.I.

Figure 12 Calculated total SEV scores (reference site = KC Ref)



Only three streams have values greater than 0.5, Whareroa Tributary (0.54) and Waikanae River (0.66) and the reference site. It is notable that the Waikanae River does not score as well as the SEV reference.

Based on the results of the SEV sampling, all the other streams other than the Whareroa Tributary and the Waikanae River potentially affected by the proposed Expressway could be considered to be ecologically compromised to some degree. Most notably, nine of the remaining 13 streams score lower than 4.0, and three score below 3.0 (Whareroa Drain, Drain 7, and Ngarara Creek). These are exceptionally low functional scores based on our knowledge of waterbodies in the Wellington Region.

Factors Influencing Sev Scores

Table 15 summarises the four principal SEV factors (hydraulic function, biogeochemical functioning, habitat provision and biodiversity function).

Table 17 SEV factors at each reach which drive the overall SEV score.

	Hydraulic function mean score	Biogeochemical function mean score	Habitat provision function mean score	Biodiversity function mean score	Overall mean SEV score (maximum value 1)
Whareroa Tributary	0.750	0.510	0.255	0.532	0.544
Whareroa Drain	0.263	0.371	0.263	0.179	0.283
Drain 7 (Lower)	0.388	0.355	0.503	0.275	0.362
Drain 7 (Upper)	0.416	0.338	0.155	0.216	0.304
Wharemauku Stream	0.538	0.400	0.369	0.425	0.437
Mazengarb Stream	0.495	0.309	0.523	0.271	0.373
Mazengarb Drain (WWTP)	0.219	0.526	0.508	0.296	0.389
Muaupoko Stream	0.475	0.403	0.710	0.486	0.480
Waikanae River	0.900	0.365	0.860	0.779	0.664
Waimeha Stream	0.325	0.316	0.440	0.346	0.341
Ngarara Creek	0.486	0.228	0.314	0.179	0.291
Kakariki Stream	0.625	0.352	0.488	0.418	0.454
Smithfield Drain	0.451	0.395	0.344	0.309	0.381
Paetawa Drain	0.540	0.489	0.547	0.417	0.491
Hadfield / Kowhai	0.406	0.477	0.239	0.340	0.395
Reference	0.888	0.668	0.965	0.763	0.783

Only the Waikanae River had functional scores that approach the reference site. In all other waterways there was a low (<.55) and varied response.

The most inconsistent scoring noted within the Waikanae River, which scored below average (0.365) in biogeochemical functioning, but high in all other scores – this has driven the overall SEV score down to 0.665.

Overall, these scores suggest a range of factors are responsible for the poor ecological value of most of these streams, including issues with hydraulic flows, stream structure, water quality, habitat diversity and quality, riparian cover, and associated low biodiversity.

5. Evaluation of Systems, Habitats and Biota

5.1. Introduction

Freshwater ecosystems, habitats and species have been evaluated against a number of recognised benchmarks. The statutory benchmark is set out in the Greater Wellington Regional Freshwater Plan (operative 17th Dec 1999). However, evaluations by comparisons of species and community have also been done to assess the ecological importance of the waterways within the wider study area. This is important in setting priorities for protection and mitigation. Data collected for GWRC's 'State of the Environment' monitoring is used to form these comparative evaluations.

5.2. Statutory Context

The Greater Wellington Regional Freshwater Plan seeks to recognise waterways of significance to the Region. It includes appendices that list river mouths (Plan Appendix 1); wetlands lakes and rivers (and their margins) which have a high degree on natural character (Plan Appendix 2); and River Corridors, which includes the river bed (Plan Appendix 10) and Water Bodies with Nationally Threatened Indigenous Fish Recorded in the Catchment and Nationally Threatened Indigenous Aquatic Plants (Plan Appendix 3)

Table 18 Values recognised in the GWRC Freshwater Plan

Regionally significant in terms of Ecology	Ecologically Significant River Mouths (Appendix 1)	Nationally Threatened Indigenous Fish (Appendix 3)	Recreational Values (Appendix5)	Managed for Water Supply Purposes (Appendix 6)	Needing Enhancement (Appendix 7)	Important River Corridor (Appendix 10)
Hadfield Kowhai Stream						
Paetawa Drain						
Smithfield Drain						
Kakariki Stream					√	
Ngarara Creek					√	
Waimeha Stream	√					
Waikanae River		√	√	√		√
Muaupoko Stream		√				
Mazengarb (WWTP)					√	
Mazengarb Drain/Stream					√	
Wharemauku Stream		√				
Lower Drain 7						
Upper Drain 7						
Whareroa Drain		√				
Whareroa Tributary		√				

From an ecological perspective "needing enhancement" is not a current and existing value nor is recreational values, nor water supply purposes. Recreational value can even be deleterious to some ecological values. The aspects considered in the Plan that are of greatest ecological relevance are the presence of threatened species and importance for corridor function. The river mouth aspect, while important also, are all distant from the Project. Considering these relevant ecological factors, there are five Rivers with ecologically important values recognised by the Plan.

5.3. Sensitivity and Tolerances

Presence in general of Ephemeroptera, Plecoptera and Trichoptera (EPT) is indicative of good water quality and aquatic habitat, and through that of better quality freshwater habitat. Generally the assemblages in the Project waterways have low to very low EPT representation both in terms of taxa and abundance. The MCI and QMCI scores presented in Table 19 are an indicator of community tolerance and show that the macroinvertebrate fauna represent poor to fair water quality habitats with limited sensitive taxa. Only the Waikanae River had assemblages well represented by EPT and higher rating MCI species.

These scores indicate that the macro-invertebrate fauna present in the streams potentially affected by the proposed Expressway Alignment are dominated by robust and tolerant species able to persist in streams with significant water quality issues. The only exception is the Waikanae River which contains a diverse EPT assemblage, including a number of sensitive species that need good water quality to persist.

Table 19 Summary of MCI and SQMCI scores for sampled sites

Site/stream	MCI	QMCI	Tolerance
Hadfields Kowhai Stream	Fair	Fair	High
Paetawa Drain	Fair	Fair	High
Kakariki Stream	Fair	Fair	High
Smithfield Drain	Poor	Poor	High
Ngarara Creek	Poor	Fair	High
Waimeha Stream	Poor	Fair	High
Waikanae River	Good	Excellent	Low
Muaupoko Stream	Fair	Fair	High
Mazengarb (WWTP)	Poor	Poor	High
Mazengarb Stream	Poor	Fair	High
Wharemauku	Fair	Poor	High
Lower Drain 7	Poor	Fair	High
Upper Drain 7	Poor	Poor	High
Whareroa Drain and Trib	Poor	Poor	High

Ecological Significance / Ecological Characteristics

Two primary methods have been used to test the regional value of the reaches and streams affected by the proposal. The fish Index of Biotic integrity (IBI) has been calculated for the sites sampled and compared to the general condition of other waterways in the Region (**Appendix 30.D**).

A comparison has also been made of how the %EPT, QMCI and MCI values rank relative to the data on these same factors published by GWRC as part of their SOE programme (Perrie, 2008).

There are no comparative metrics for the physical habitat. However, the SEV outputs are compared in relation to the reference site and the site.

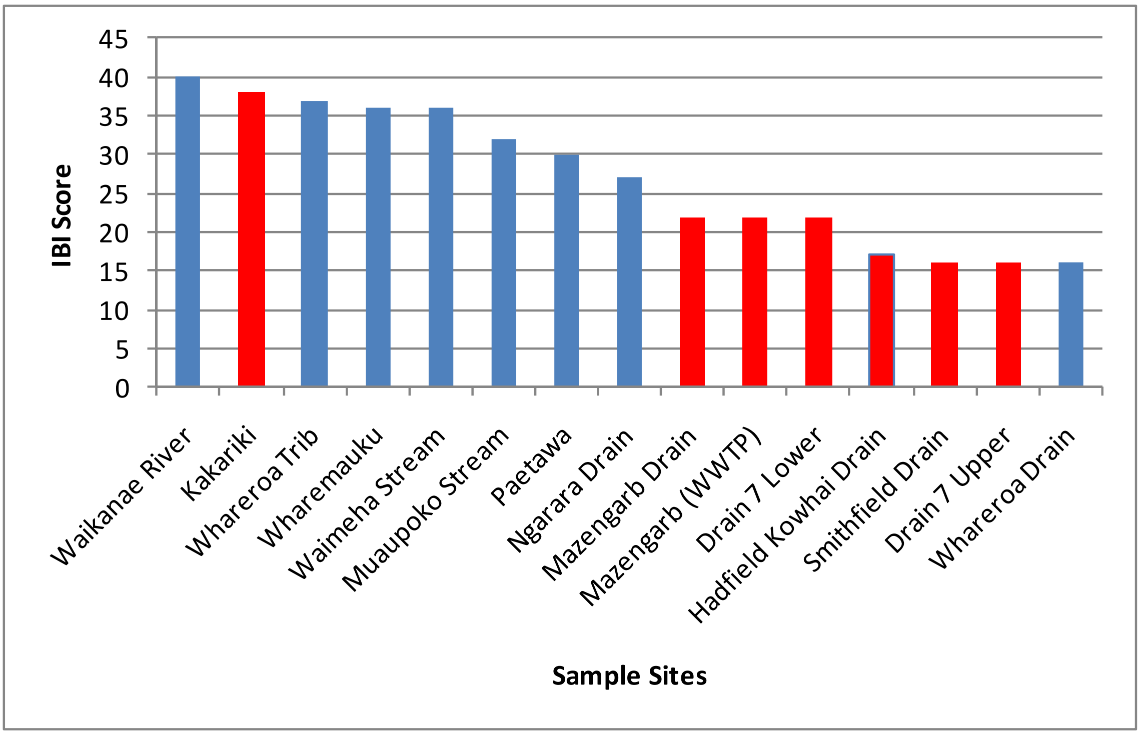
Fish Communities

An IBI score was calculated for each site based on the presence/absence of fish taxa from the freshwater fish database and set against the Regional background. The regional background was developed by calculating the IBI for 99 streams in the Region (Appendix 30.D) using the model developed by the Centre for Freshwater Ecosystem Modelling and Management, Massey University (Joy 2009).

The IBI scores for the surveyed sites of the Project area are shown ranked in

. The scores ranged from 18 to 56.

Figure 13 Summary of Integrated Biodiversity Index (IBI) scores for sampled sites.



Blue = Freshwater Fish Database Records Red = BML Sampling

The score from the Waikanae River and the Kakariki is an average of the IBI scores found on the database.

Following the IBI methodology these scores give rise to the following Regional IBI rating (Table 20).

Table 20 IBI Wellington Regional Rating (adapted from Joy, 2005)

Site	Rating
Hadfield	Poor
Paetawa	Fair
Smithfield Drain	Very poor
Kakariki	Good
Smith Drain Trib of Ngarara	Very Poor
Waimeha Stream	Fair
Waikanae River	Good
Muaupoko Stream	Fair
Mazengarb (WWTP)	Poor
Mazengarb Stream	Poor
Wharemauku Stream	Fair
Drain 7 Lower	Very Poor
Drain 7 Upper	Very Poor
Whareroa Drain	Very Poor
Whareroa Tributary	Good

The regional modelling included 19 records from the Waikanae River and its tributaries. Of these 19 records, five were indicative of "poor", six "fair", five "good", two "very good" and one was "excellent" fish communities.

Of the full suite of waterway sites in the region, only seven stream sites returned an excellent IBI score (scores of > 50). In terms of fish assemblages the Waikanae River occasionally measured as very good and is a very important system on the west coast of the Wellington Region.

It is of interest that more than a third of the sites sampled rated 'very poor' – the lowest rating possible. Many streams of better quality further up the catchment may rate only as "fair" or "good", as streams become less important in terms of fish taxa richness the higher up the catchment. The IBI analysis does not distinguish well the natural decline in species richness occurring in headwaters.

The fish diversity and health of the lower catchment streams are vital to enable the migratory species passage to breeding grounds throughout their life cycles.

Threatened Fish Species

Records and databases and our sampling shows that threatened fish species were caught have been recorded from 12 of the waterbodies traversed by the proposed Expressway Alignment. Typically long fin eel were sampled in the lower reaches and directly affected areas. Red fin bully, banded kokopu and inanga were found at three sites, but were not common throughout.

Table 21 Fish sampled within survey sites at risk and declining regionally

Site Name	Threatened fish species (Alibone et al 2010)
Hadfield Kowhai Stream	long fin eel
Paetawa Drain	Banded kokopu, long fin eel,
Kakariki Stream	long fin eel
Ngarara Creek	long fin eel,
Waikanae River	long fin eel, red fin bully
Muaupoko Stream	long fin eel
Mazengarb (WWTP)	long fin eel
Mazengarb Drain	long fin eel
Wharemauku Stream	long fin eel, giant kokopu*
Lower Drain 7	long fin eel, Inanga,
Whareroa Drain	long fin eel,
Whareroa Tributary	long fin eel,

"At Risk" (Townsend et al 2008) "Declining" (Alibone et al 2010) * based on a survey undertaken by DOC,1999).

The Regional Policy Statement, and the Regional Freshwater Plan, refer to these streams as "significant" as they provide "spawning habitat", and "provide habitat for indigenous fish species within the catchment". Therefore they are of importance (in accordance with Policies 17, 23 and 42).

Aquatic Macro-Invertebrate Fauna – Regional Comparisons

The Greater Wellington Regional Council State of the Environment (SOE) publication 2007/2008[5] has been used to place the sampled stream sites into a Regional context. This SOE reporting programme reports on a variety of water quality and macro-invertebrate sampling outcomes for 58 sites measured annually around the Wellington Region.

A summary of Regional means of the chosen metric is provided below in Table 22 and they are compared with the average values for each metric of each of the Project's streams.

Table 22 Regional Means for selected metrics

	QMCI	MCI	Richness	%EPT
MacKays To Peka Peka Results				
Hadfield Kowhai Stream	4.7	77	15	13
Paetawa Drain	4.4	87	15	20
Smithfield	2.7	70	18	6
Kakariki Stream	4.5	77	19	21

[5] Annual freshwater quality monitoring report for the Wellington region, 2007/08. GW/EMI-G-08/161. October 2008 Welling Regional Council Publication.

Ngarara Drain	4.3	75	11	9
Waimeha	4.7	77	15	13
Waikanae	6.4	115	33	55
Muaupoko	4.2	88	24	6
Ngarara Creek	1.7	4	5	0
Mazengarb Stream	4.8	69	13	8
Wharemauku Stream	3.7	90	28	25
Lower Drain 7	3.1	60	11	9
Upper Drain 7	2.5	73	11	9
Whareroa Drain	3.7	78	14	19
Whareroa Trib	4.3	96	30	30
GWRC Results				
Regional Mean 2007/2008	**5.55**	**106.26**	**20.05**	**43.2%**
Survey site Rating Relative to Regional Means	Generally Below	Well Below	Generally Below	Well Below (<half the value)

In regard to all SOE metrics, benthic invertebrate fauna values for the sampled streams are generally below the Regional averages. In regard to QMCI, the Project sites are distributed from 1.7 to 6.4, with all but one sites score below in the regional average of 5.55.

The Project sites are generally in the lower 3rd in terms of taxa richness although the Waikanae, Wharemauku and Muaupoko score well. Percentage EPT ranking and MCI scores are well below the regional means, at about half the regional value, with the exception of the Waikanae River.

In summary, the Waikanae River is the only water body along the proposed Expressway alignment that rated above the regional mean over all four of these measures. The rest are below or well below the Regional average condition.

5.4. Water Quality

The water quality data (BECA, 2011) illustrates that waterways within traversed by or downstream of the proposed Expressway alignment are characteristic of lowland waterways draining predominantly agricultural land use with elevated nutrient concentrations, some elevated bacteriological counts and low toxicant concentrations. BECA found noticeable differences in results – relative to the land use within each catchment.

Key findings from this work programme are as follows:

All metal and organic contaminant concentrations in the bed sediment samples collected from the sites sampled in the major watercourses along the proposed Expressway alignment extent were below the corresponding guideline value.

- The water quality at the sampling location in the Wharemauku Stream was 'poor' due to mixed pastoral, residential and commercial land use activities in the upstream drainage area. The base and high flow waters had elevated nutrient concentrations, ammonical-nitrogen, and dissolved and total zinc relative to the corresponding guideline trigger values.
- The base flow and stormwater quality at the Mazengarb Drain sampling point was 'poor' with elevated nutrients, ammonical-nitrogen, suspended solids, organic matter, copper and zinc. This site is impacted by urban land use, as well as the discharges from the 'eastern' tributary of the Otaihanga Landfill.
- The Kakariki Stream water quality west of SH1 was 'poor' with elevated nutrient concentrations, suspended solids and bacterial counts.
- The Waimeha Stream had generally good water quality however there were some slightly elevated nutrient concentrations and suspended solids in some of the waters sampled.
- The water quality of the base flow waters in the Waikanae River and Hadfield Drain/Te Kowhai Stream was generally good with most indicators and contaminant concentrations within the limits of the corresponding guideline values. During high flow conditions, the water quality in the Hadfield Drain/Te Kowhai Stream was then 'poor' due to elevated suspended solids, ammonical-nitrogen, nutrients and bacterial counts. This is most likely due to stormwater runoff from agricultural land use activities in the predominantly rural upstream drainage catchment.

5.5. Regional Condition and Value Conclusion

Aquatic habitat sampling undertaken as part of the MacKays to Peka Peka Expressway Project and regional and historical data demonstrate that overall the streams of the MacKays to Peka Peka area support robust fauna that are generally tolerant of organic water pollution and contaminants and are indicative of poor quality lowland aquatic habitat.

This is a result of long term nutrient enrichment, background of contamination from land management practices and frequent or extensive channel modifications. The absence of systematic data collection over a long time means that it is not possible to identify any trends in fauna communities or condition of the physical environment.

Maintaining the diversity in the lower reaches of the Waikanae system is of very high ecological value and importance at the Regional scale. In terms of aquatic habitat most waterbodies studied here are not maintaining a "good" habitat condition for aquatic biota.

At a Regional scale, the aquatic fauna and physical habitat of the Hadfield/Kowhai, Waimeha, Waikanae (but not the Waikanae River), Wharemauku and Whareroa catchments streams are already considered to be degraded.

Taking the evaluations from each of the subunits i.e. macroinvertebrate studies, PHA, threatened species, SEV function, then "averaging" these scores a final "value" judgement was made with results shown in Table 23;

Only the Waikanae scores consistently above the medium value and only that waterway (of those studied) is regionally significant. Two of the other waterways can be considered of moderate value but the majority of the waterways are of generally low value (regionally).

Table 23 Tabulated summary of Aquatic Ecological Value

Regionally significant in terms of Ecology	PHA	(SEV)	Fish	Threatened Fish * Present	Aquatic invertebrates	Compilation result
Hadfield Kowhai Stream	L	L	L	Y	L	L
Paetawa Drain	L	L	L	Y	L	L
Smithfield Drain	L	L	L	Y	L	L
Kakariki Stream	L	L	L	Y	M	L
Ngarara Creek	L	L	L	Y	L	L
Waimeha Stream	L	L	L	Y	L	L
Waikanae River	H	M	M	Y	H	H
Muaupoko Stream	M	L	L/M	Y	M	L/M
Mazengarb (WWTS)	L	L	L	Y	L	L
Mazengarb Stream	L	L	L	Y	L	L
Wharemauku	L	L	M	Y	M	M
Lower Drain 7	L	L	L	Y	L	L
Upper Drain 7	L	L	L	Y	L	L
Whareroa Drain	L	L	L	Y	L	L
Whareroa Trib	M	L	M/L	Y	M	M

* Adapted from Strickland & Quarterman, (2001)

Table conclusion: Regionally significant in terms of Aquatic Ecology: Waikanae River

6. Discussion – Aspects Related to the Potential Adverse Aquatic Effects

The following discussion provides some context to the components of the freshwater aquatic environment that are important to their health and functioning and which will need to be considered where works enter, divert, armour or channelize existing streams. This section is intended to assist in assessing potential effects, determining appropriate mitigation, and guiding ongoing management and monitoring. This document is not the assessment of aquatic effects. It covers the following matters:

- Fish Passage (culverts)
- Stream Habitat (armouring and diversion)
  - Stream velocities
  - Stream Depth
  - Stream habitat
  - Stream substrate
- Riparian vegetation (restoration opportunities)

6.1. Fish Passage

6.1.1. Issues

Many indigenous freshwater fish are migratory and must spend part of their lifecycle in the sea (diadromous). They require streams and rivers that are relatively unmodified from the mouth to the headwaters. If passage along a stream is prevented, populations of some species upstream of the barrier will eventually die out. The Freshwater Fisheries Regulations (1983) require that passage must be provided for indigenous fish.

At any stream diversion within intermittent and perennial streams, the design of stream works needs to not only consider fish passage but must match velocities with the original stream to ensure resident fish can maintain themselves in the new channel and utilise the habitat.

Also each fish has different climbing and burst swimming abilities and so the species of resident fish must be known to ensure the design caters to these requirements.

There is a well established toolbox for design ARC TP131 (Boubee, et al, 2000) (and installation of fish friendly culverts and these can ensure fish passage is maintained under most circumstances. In addition there is a range of methods for creating or maintaining habitat within culverts that can offset some of the effects of lost habitat.

6.2. Diversions and Rock Armouring

Significant diversions are scheduled within the proposed Expressway alignment (around 1km) with the original stream beds reclaimed. With careful design it can be possible to emulate, and most importantly, improve the original physical habitat conditions of the original channel. The following discussion highlights key issues with regard to diversion formation and design and current knowledge of the requirements.

6.2.1. Habitat diversity – Run/Riffle/Pool

Habitat types within the alignment are currently made up of pool, deep slow run with occasional riffle habitat (apart from the Waikanae River where riffle habitat is most dominant). Jowett & Richardson (1995) state the preferred habitat of a range of native species which are also common in the Project area (Table 24). This indicates the type of habitat to be built into the diversion reaches.

Table 24 Percentage of fish by habitat type (Jowett & Richardson, 1995)

	% in riffle	% in run
Long-fin eel	77.7	23.9
Short finned eel	76.1	22.3
Upland bully	43.6	56.4
Common bully	59.1	40.9
Redfinned bully	63.1	36.9

6.2.2. Depths of Water

Depths and velocities influence species preference and acceptance of habitats. Generally native fish are thought to prefer shallow water (0.3M) over deeper water. However, it is generally accepted that due to the high level of modification of the lower reaches of rivers and streams along with access and predation issues, the data available on their distribution patterns is thought to be skewed towards the limitations of their environment rather than their preference.

Jowett and Richardson (2006) surveyed are wide range of habitats and discovered that native fish are found in a range of depths including from 0.05 to 0.67 m depth (but this does not consider lakes). They found that the distribution of native fish with water depth varied between species (Table 25). Blue gilled bullies and torrent fish were more common in deeper water (0.25-0.5 m), whereas half or more of the short finned eels, upland bullies, and common river galaxias occurred in water < 0.125 m deep. We note that the Jowett and Richardson (1995) survey sampling did not include koaro, banded kokopu, short jawed kokopu, giant kokopu and some of the other fishes relevant to the waterways traversed by the MacKays to Peka Peka Expressway.

Table 25 Distribution by percentage abundance of fish species across water depths.

	Depth (m)			
Species	**<0.125**	**0.125-0.25**	**0.25-0.5**	**>0.5**
Longfinned eel	37.0	35.9	20.6	6.5
Shortfinned eel	53.2	25.7	17.3	3.9
Torrentfish	16.1	37.6	39.4	6.9
Upland bully	56.6	28.1	8.2	7.1
Redfinned bully	36.7	43.4	15.1	4.7
Bluegilled bully	13.8	45.8	35.2	5.2
Common river galaxias	50.0	30.1	13.7	6.2

Common bully	44.6	30.1	14.5	10.8
Average of all species	**38.5%**	**34.6%**	**20.5%**	**6.5%**

As the most occupied depth profiles listed in Table 25 are within the same range as the waterways traversed by the MacKays to Peka Peka waterways, any stream diversion adhering to the profile naturally found will be, in terms of habitat, acceptable to all fish species.

6.2.3. Substrate Sizes

Substrate sizes and the spaces between substrates provide for, and even govern, the species suited to the habitat. Eel and lamprey prefer the softer substrates such as silts, sands and gravels, bullies are found in abundance in small to middle sized cobbles, galaxids in larger cobbles and often in boulder – cobble habitat. Koaro and banded kokopu are often in bed rock or solid bottom pools and boulder chute habitat. Table 26 illustrates some measured "preferences" by Jowett and Richardson (1995).

Table 26 Fish preference for substrate as percentage distribution across substrate sizes (Jowett & Richardson 1995).

	Substrate size (mm)			
Species	**<32**	**32 - 46**	**64-128**	**>128**
Longfinned eel	7.3	37.4	30.4	24.9
Shortfinned eel	77.7	15.0	5.7	1.6
Torrentfish	45.6	36.7	13.6	4.2
Upland bully	13.5	53.1	26.7	6.7
Redfinned bully	0.0	24.6	27.8	47.6
Bluegilled bully	0.7	81.1	11.8	6.5
Common river galaxias	39.9	15.9	44.2	NS
Common bully	63.0	25.2	0.0	11.8
All above species	**38.1**	**38.9**	**13.7**	**9.3**

Throughout the Project area, the substrate is dominated by fine silt, sand and with gravels (<32mm, 32-46mm), and the species most commonly sampled along the proposed Expressway Alignment, concur with the above findings. Any diversions and streambed construction should remain consist with the local ecology.

6.2.4. Stream Velocities

The forth component of habitat preference water velocity. Fish especially, but also aquatic macro-invertebrates and aquatic plant life have tolerances to particular flows as well as preferences. Species swimming abilities and species "preference" flows have been researched and modelled by a number of NIWA researchers. Native fish species have differing abilities to cope with deferent velocities, some velocities are preferred others result in avoidance behaviours, some can only be passed through short bursts of extreme energy, some can be passed through sustained swimming. Native fish are typically found in velocities under 0.3ms-1 but of course can be found in velocities much higher than this where there is refugia or sub habitats out of “central” flow. All these factors must be considered, (especially flood conditions) when replacing a natural stream channel with a culvert.

6.3. Riparian Vegetation

Currently the majority of the streams lengths within the proposed Expressway designation lack riparian vegetation other than rank grasses and exotic weeds. Many of the waterbodies sampled still allow unrestricted stock access. Riparian cover provides a wide range of benefits for aquatic habitat.

- It reduces daily and seasonal temperature fluctuations including summer peaks which can be debilitating for some species.
- Native riparian trees, shrubs and tussocks have evolved fast growing, strong and fibrous root systems which stabilise stream banks reducing stream bank erosion.
- They also reduce flood flow velocities when streams overtop their banks and flow across adjacent terraces. This also reduces erosion.
- A forest canopy contributes organic matter, leaves and small branches, for detritus feeders as well as terrestrial insects which provide food for carnivorous fish and macro-invertebrates.
- Branches and trees that fall into the stream provide snags and create debris dams which are extremely important habitats and refugia for stream fauna.
- Appropriate riparian vegetation provides spawning habitat for several species of native fish and breeding corridor areas for adult EPT and Diptera invertebrate fauna.

Re-vegetation of these streams with appropriate species can therefore provide significant ecological benefits and should form a component of the mitigation package for this Project.

6.4. Sediment Discharge to Freshwater

6.4.1. Introduction

Sediment discharge into waterways is an issue mainly during construction, when silt and soils from areas of open earthworks can be carried into waterways during rain events. Once the earthworks are completed and stabilised, sediment should not reach the waterways except perhaps in extreme rain events or if ground cover is again disturbed.

6.4.2. General Adverse Effects

Some sediment discharge into all streams is both natural and necessary to supply food and to act as a medium for detritivore species and macrophytes and as food for net caddisflies. Too much sediment however, can create adverse and undesirable effects.

Too much sediment in solution (causing cloudy water) restricts periphyton growth (i.e. plant biomass, and, thereby, the food reservoirs for herbivores (including invertebrates, fish and water fowl (Briggs

1980)); it gets into, and interferes with, fish and invertebrate gills; and makes prey acquisition difficult for visual hunters. The realisation of such effects however, requires weeks of sustained heavy suspended sediment. Short-term, non-lethal effects include reach evacuation (by fish) and increased downstream drift of invertebrates, or a “close up shop” approach by Crustacea.

Prolonged periods of high suspended sediment levels can also change the physical properties of the habitat because turbid waters rise in temperature more quickly and to higher levels than clear water; also sediment increases nutrient status and smothers spawning gravels.

Too much sediment falling out of suspension and settling for too long causes coating of the substrate which, if heavy enough, kills periphyton (the grazers’ food base), hides organic resource, smothers sessile or poor moving invertebrate species (killing them) and eventually fills interstitial spaces (reducing the habitat depth available). Long term it is this sedimentation of the between cobble space and surface that radically changes a hard substrate community and removes most of the EPT taxa replacing them with worms, midges and detrital species.

6.4.3. Guidelines and Trigger Levels

The Australia-New Zealand Environment Conservation Council (ANZECC) Guidelines (2000) have no set criteria for turbidity, because sediment itself is both a necessity and a pollutant, and different systems require and tolerate different levels and at different frequencies. New Zealand data (ANZECC) suggests that as a first trigger (i.e. a change from unmodified to slightly modified) an NTU reading of 5.6 should be used and TSS of approximately 6mg/L. Above this reading, a river may be considered as modified. There is, however, no trigger point that reflects either adverse effects or sure harm.

In New Zealand some Regional Councils have adopted a trigger NTU of 25 based on levels needed to protect some native fish. This is based on research such as Vinyard & Yaun (1996), Dorgeloh (1995), Rowe & Dean (1998) and Richardson et al (2001). These researchers showed that banded kokopu’s upstream migration can be disturbed by NTU greater than 20 (22 gm-3).In contrast other native fish (koaro and common bully) do not avoid waters, or decrease feeding rates, with NTU as high as 300 (340 gm-3) (this relates to base flows).

The figure of around 20-25 NTU should be considered a “warning” level (dependent on initial stream condition – (i.e. the background turbidity), rather than a “damaging” level. The data gathered by BECA, August, 2001 through the current assessment process show that the streams studied have mean ranges of NTU between 0.6 and 17.6. with only 3 sites over 5NTU.

When considering the effect of much higher short term sediment pulses associated with rainfall events, Rowe et al (2002, 2004) tested suspended solid concentrations up to 10,000 NTU on a range of fish and failed to cause mortality. A range of other experiments (Rowe and Graynoth 2002, Barrett et al 1922, Vinyard & Yaun 1996, Dorgeloh 1995, James et al 2002) have explored raised sediment (NTU) effects – in all cases high sediments (>1000 NTU) in suspension are not (in the short term) significantly adverse. In summary adverse effects can occur where there is:

- A high NTU (>20-25 for migratory banded kokopu) over extended periods of time or
- A 20% or more increase on the back ground average, or

Each metric in this list is a proportional increase that is not scientifically proven but currently considered to be a sufficient change from a normal situation that indicates the potential for a change in state of habitat or biota.

6.5. Stormwater Discharge to Freshwater

6.5.1. Introduction

Road surfaces contribute considerably larger pollutant loads compared with other land uses. In many studies, correlations have been made between the amount of pollutants generated and the road traffic volume (Wong et al 2000).

Surface water/storm water run-off from roads may contain litter and litter breakdown chemicals (nicotine, plastics etc), heavy metals (cadmium, chromium, copper, nickel, lead and zinc), Polyaromatic hydrocarbons (PAH), oils, surfactants and cause changes to the pH.

In ecological terms, the issue is that the introduction of new contaminants or raised levels of existing contaminants may adversely affect the benthic communities, whether through toxic effects (acute or chronic) with flow-on effects to the food chain, or through reduction in habitat quality (i.e. changing oxygen availability, changing the pH), or they may result in chemical barrier to species migration.

Currently in most of the catchments there is a nutrient issue and in some cases issues related to Boron, zinc, aluminium (BECA, August, 2011). This is especially the case in the more urbanised catchments (Wharemauku, Mazengarb). The adverse effects on aquatic ecology of road runoff have been relatively poorly studied; however, urbanisation and impervious surfaces (of which roading is a major contributor) has been reasonably-well studied, especially in the UK and USA (e.g. Barrett et al 1995, Chadwick et al 2006, May et al 199, Maxted & Scoggins 2004, Paul & Meyer 2001, Barbec et al 2002).

Over the long term chronic, and eventually acute, toxicity eventually lead to serious ecological consequences. These include: a simplification of the fauna and flora; development of a pattern of annual or seasonal issues such as algal blooms; occurrence of mosquito population explosions etc;

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Appendix 30.A

Glossary of Terms

Appendices

APPENDIX 30.A: GLOSSARY OF TERMS

Biometric A biological measure typically a number describing a quantum of a feature or features or a score or index value.

EPT An abbreviation for Ephemeroptera, Plecoptera and Trichoptera (mayfly, stonefly and caddisfly). Taxa most sensitive to water pollution

FFDB Fresh Water Fish Data Base

GWRC Greater Wellington Regional Council

IBI Index of Biological Integrity

Macroinvertebrate. An aquatic invertebrate above "micro".

MCI A biometric – an index score – "Macroinvertebrate Community Indices". A summation of scores allocated to various taxa based on their measured sensitivity to water organic contaminants.

MWWT Mazengarb at Waste Water Treatment Station

NTU Nephelometric Turbidity Unit – A measure of how much light reflects from particulates in a column of water.

PHA Abbreviation for Physical Habitat Analysis and term used to describe aspects of the aquatic habitat involving the bank, substrate, water and riparian condition.

QMCI A biometric –an index scare – "Quantitative Macroinvertebrate Community Indices" a measure of the influence of each taxa based on its numerical abundance in the community on the "sensitivity score" (the MCI).

Riparian Edges immediately along the banks of a waterway. The riparian zone is that 3 Dimensional area adjacent that directly interacts with the waterway (eg shades it or drops material into it).

RPS Regional Policy Statement

SEV Stream Evaluation system. A system devised to regulate data collection and allow through formulae to establish a range of biological values relating to stream habitat function, condition etc.

SOE State Owned Enterprise

SQMCI Semi Quantitative Macro Invertebrate Community Indice

Substrate The ground or floor material of a water course (typically rocky, gravelly, sandy or muddy).

Taxa richness The number of identifiably different “species”.

Taxa A less discriminate word for species. Taxa may also mean genera, sub-species etc.

TSS Total Suspended Solids

Turbidity A measure of the amount of suspended matter in the water column. Turbidity is often considered to be how “dirty” the water is and looks. It is a different measure from clarity and from direct measures of suspended solids. There is a strong correlation between turbidity and suspended solids up to around 350 NTU.

WWP Wastewater Plant

WWTP Wastewater Treatment Plant

Appendix 30.B

GWRC Freshwater Monitoring Results

APPENDIX 30.B: GWRC FRESHWATER MONITORING RESULTS

Water Quality Index grades for RSoE sites monitored at monthly intervals by GWRC over July 1997 to July 2003, based on compliance with guideline values.

Rank	Site No.	Site Name	Guideline Compliance (Median Values)						REC
			DO	Clarity	FC	NO_3-N	Amm. N	DRP	
Very Good Water Quality									
1	FB47	Waiohine R at Gorge	✓	✓	✓	✓	✓	✓	CX/H/HS/IF
2	FB03	Otaki R at Pukehinau	✓	✓	✓	✓	✓	✓	CW/H/HS/IF
3	FB36	Ruamahanga R at Mt Bruce	✓	✓	✓	✓	✓	✓	CX/H/HS/IF
4	FB22	Hutt R at Te Marua Water Intake	✓	✓	✓	✓	✓	✓	CX/H/HS/IF
5	FB01	Waitohu S at Water Supply Intake	✓	✓	✓	✓	✓	✓	CW/H/HS/IF
6	FB35	Orongorongo R at Orongo. Stn	✓	✓	✓	✓	✓	✓	CW/H/HS/IF
7	FB31	Wainuiomata R at Manuka Track	✓	✓	✓	✓	✓	✓	CW/L/HS/IF
8	FB04	Otaki R at Mouth	✓	✓	✓	✓	✓	✓	CW/H/HS/IF
9	FB51	Tauherenikau R at Websters	✓	✓	✓	✓	✓	✓	CW/H/HS/IF
10	FB45	Waingawa R at South Rd	✓	✓	✓	✓	✓	✓	CX/H/HS/IF
11	FB26	Pakuratahi R 50m d/s Farm Ck	✓	✓	✓	✓	✓	✓	CX/H/HS/IF
12	FB37	Ruamahanga R at Dble Bridges	✓	✓	✓	✓	✓	✓	CX/H/HS/P
13	FB29	Akatarawa R u/s Hutt R confl.	✓	✓	✓	✓	✓	✓	CW/L/HS/IF
14	FB50	Huangarua R at Ponatahi Br	✓	✓	✓	✓	✓	✓	CD/L/SS/P
Good Water Quality									
15	FB06	Waikanae R at Reikorangi Br	✓	✓	×	✓	✓	✓	CW/L/HS/IF
16	FB25	Hutt R u/s of Melling Br	✓	✓	×	✓	✓	✓	CW/L/HS/IF
17	FB24	Hutt R opp. Manor Park G.C.	✓	✓	×	✓	✓	✓	CW/H/HS/IF
18	FB32	Wainuiomata R at L. Wood Pk	✓	✓	×	✓	✓	✓	CW/L/HS/IF
19	FB23	Hutt R at Birchville Canoe Club	✓	✓	×	✓	✓	✓	CW/H/HS/IF
20	FB10	Horokiri S at Ongly	✓	✓	×	✓	✓	✓	CW/L/HS/P
21	FB44	Waipoua R at Colombo Rd Br	✓	✓	✓	×	✓	✓	CW/L/HS/P
22	FB11	Pauatahanui S at Elmwood Br	✓	✓	×	✓	✓	✓	CW/L/HS/P
23	FB38	Ruamahanga R at Te Ore Ore	✓	×	✓	✓	✓	✓	CW/L/SS/P
24	FB15	Makara S u/s Ohariu Stream	✓	✓	×	✓	✓	✓	CW/L/HS/P
25	FB48	Waiohine R at Bicknells	✓	✓	✓	✓	✓	×	CW/H/HS/P
Fair Water Quality									
26	FB27	Mangaroa R at Kalcoolies Cnr	✓	×	×	✓	✓	✓	CW/L/HS/P
27	FB39	Ruamahanga R at Gladstone Br	✓	×	✓	✓	✓	×	CW/L/SS/P
28	FB40	Ruamahanga R at Waihenga Br	✓	×	✓	✓	✓	×	CW/L/SS/P
29	FB16	Makara S at Kennels	✓	×	×	✓	✓	✓	CW/L/HS/P
30	FB12	Porirua S at Glenside	✓	✓	×	×	✓	✓	CW/L/HS/U
31	FB13	Porirua S at Wall Pk	✓	✓	×	×	✓	✓	WW/L/HS/U
32	FB42	Whangaehu R at Waihi	✓	×	✓	✓	✓	×	CW/L/SS/P
33	FB08	Waikanae R at Oxbow Boat Ramp	✓	×	×	✓	✓	✓	CW/L/HS/IF
34	FB14	Ohariu S 50m u/s Makara Stream	✓	×	×	✓	✓	×	CW/L/HS/P
35	FB18	Karori S d/s Sth Makara Stream	✓	✓	×	×	✓	×	CW/L/HS/U
36	FB20	Kaiwharawhara S at Ngaio Gorge	✓	✓	×	×	✓	×	CW/L/HS/U
37	FB17	Karori S at Makara Peak	✓	✓	×	×	✓	×	CW/L/HS/U
38	FB46	Taueru R at Gladstone	✓	×	×	×	✓	✓	CD/L/SS/P
39	FB19	Owhiro S at Mouth	✓	×	×	×	✓	✓	CW/L/HS/U
Poor Water Quality									
40	FB34	Wainuiomata R u/s of White Br	✓	×	×	×	✓	×	CW/L/HS/IF
41	FB41	Kopuaranga S at Stewarts	✓	×	×	×	✓	×	CW/L/SS/P
42	FB33	Wainuiomata R at Golf Course	✓	✓	×	×	×	×	CW/L/HS/IF
43	FB43	Whangaehu R 250 u/s confl.	✓	×	×	×	✓	×	CD/L/SS/P
44	FB02	Waitohu S at Norfolk Cres	✓	×	×	×	×	✓	CW/L/HS/P
45	FB05	Mangaone S at Sims Rd Br	×	×	×	✓	×	✓	WW/L/AL/P
46	FB49	Mangatarere R at SH2	✓	✓	×	×	×	×	CW/L/HS/P
47	FB28	Mangaroa R at Te Marua	✓	✓	×	×	×	×	CW/L/HS/P
48	FB21	Ngauranga S 400m u/s Mouth	✓	✓	×	×	×	×	CW/L/HS/U
49	FB30	Waiwhetu S at Wainui Hill Br	×	×	×	×	×	✓	WW/L/HS/U
50	FB07	Ngarara S at Field Way	×	×	×	×	×	×	WW/L/AL/P
51	FB09	Mazengarb Drn u/s Waikanae R	×	×	×	×	×	×	WD/L/M/U

Appendix 30.C

Pha & Stream Morphological Date

APPENDIX 30.C PHA & STREAM MORPHOLOGICAL DATE

Scores out of 20

Final grade out of a possible 1

Habitat Parameter/Site r	KC Ref	Mazengar	Hadfields	Upper Dra	Smithfield	Whareroa Trib
1.Aquatic Habitat Abund	18	12	10	0	14	15
2. Aquatic Habitat Divers	18	6	10	0	5	6
3.Hydrologic Heterogene	18	6	5	1	4	11
6.Channel Shade	16	19	10	1	1	5
7. Riparian Vegetation In	16	6	6	4	8	4
H (sum/140)	0.86	0.49	0.41	0.06	0.32	0.41
Mean of reference sites	0.86					
Mean of Albany referenc	0.86					
Mean of Papakura refere	0.91					
Vphyshab	1	**0.569767**	**0.476744**	**0.069767**	**0.372093**	**0.476744**

Habitat Parameter/Site r	KC Ref 1	Wharmau	Paetawa D	Kakariki	Ngarara D	Waimeha	Whareroa	Drain 7	Mazengar	Muapoku	Waikanae
1.Aquatic Habitat Abund	18	9	2	8	9	11	1	1	15	10	17
2. Aquatic Habitat Divers	18	7	2	4	7	9	2	2	14	9	15
3.Hydrologic Heterogene	18	3	2	3	6	6	2	13	5	5	8
6.Channel Shade	16	3	8	3	9	0	2	1	8	10	9
7. Riparian Vegetation In	16	4	2	8	4	4	0	10	6	4	8
H (sum/100)	0.86	0.26	0.16	0.26	0.35	0.3	0.07	0.27	0.48	0.38	0.57
Mean of reference sites	0.86										
Mean of Albany referenc	0.86										
Mean of Papakura refere	0.91										
Vphyshab	1	**0.302326**	**0.186047**	**0.302326**	**0.406977**	**0.348837**	**0.081395**	**0.313953**	**0.55814**	**0.44186**	**0.662791**

Appendix 30.D

Ibi Base Analysis

APPENDIX 30.D IBI BASE ANALYSIS

Index of Biological Integrity - Wellington Region : Fish
Centre for Freshwater Ecosystem Modelling and Management, Massey University

Site	IBI score	Rating
Akatarawa River	48	Very Good
Taepiro Stream	48	Very Good
Kahikatea Stream	18	Poor
Waiorua Stream	22	Poor
Waiorua Stream	26	Poor
Te Kahuoterangi Stream	16	Very Poor
Te Rere Stream	16	Very Poor
Maraetakaroro Stream	22	Poor
Unnamed wetland	16	Very Poor
Wharekohu Stream	18	Poor
Kaiwharawhara Stream	20	Poor
Te Mimiorakopa Stream	26	Poor
Muaupoko Stream	30	Fair
Taupo Swamp	36	Fair
Korokoro Stream	36	Fair
Bull Stream	42	Good
Waikanae River tributary	40	Good
Waikanae River tributary	48	Very Good
Waikanae River	36	Fair
Horokiri Stream tributary	32	Fair
Waikanae River	42	Good
Waikanae River	48	Very Good
Horokiri Stream tributary	30	Fair
Wainui Stream	20	Poor
Waikanae River	26	Poor
Waikanae River	26	Poor
Horokiri Stream	56	Excellent
Horokiri Stream	52	Excellent
Horokiri Stream	56	Excellent
Horokiri Stream tributary	56	Excellent
Horokiri Stream tributary	38	Good
Horokiri Stream tributary	46	Good
Horokiri Stream tributary	50	Very Good
Waimeha Stream	32	Fair
Horokiri Stream	42	Good
Horokiri Stream tributary	22	Poor
Horokiri Stream	34	Fair
Horokiri Stream	42	Good
Horokiri Stream	46	Good
Horokiri Stream	34	Fair
Wainui Stream tributary	26	Poor
Maungakotukutuku Stream	48	Very Good
Maungakotukutuku Stream	48	Very Good
Waikanae River	40	Good

Waikanae River	24	Poor
Ngatiawa River	22	Poor
Reikorangi Stream	28	Poor
Waikanae River	40	Good
Waikanae River	28	Poor
Waikanae River	34	Fair
Waikanae River	28	Poor
Waikanae River	34	Fair
Waikanae River	36	Fair
Waikanae River	30	Fair
Waikanae River	56	Excellent
Ngarara Stream	38	Good
Waimeha Stream	36	Fair
Ngarara Stream	28	Poor
Ngarara Stream tributary	28	Poor
Ngarara Stream	28	Poor
Ngarara Stream	22	Poor
Waikanae River	40	Good
Unnamed wetland	16	Very Poor
Unnamed pond	18	Poor
Tui Stream	36	Fair
Taupo Stream	20	Poor
Whakatikei River tributary	48	Very Good
Bull Stream	28	Poor
Wainui Stream	40	Good
Wharemauku Stream tributary	36	Fair
Taupo Stream tributary	18	Poor
Taupo Swamp	18	Poor
Taupo Swamp	18	Poor
Taupo Stream	18	Poor
Taupo Stream	28	Poor
Lake Onoke	0	No Natives
Wainuiomata River	36	Fair
Lake Onoke	42	Good
Wainuiomata River	32	Fair
Lake Onoke	26	Poor
Lake Kohangatera	14	Very Poor
Mukamukaiti Stream	26	Poor
Mukamuka Stream	18	Poor
Ohau River	50	Very Good
Ōtaki River	36	Fair
Mangahao River tributary	44	Good
Mangahao River	36	Fair
Mangatangi Stream	48	Very Good
Ōtaki River tributary	32	Fair
Ōtaki River tributary	34	Fair
Ōtaki River tributary	20	Poor
Mangaore Stream	44	Good
Waikawa Stream	42	Good
Ohau River	50	Very Good
Makorokio Stream	52	Excellent
Lake Papiatonga tributary	26	Poor
Mangatainoka River tributary	40	Good
Mangatainoka River	48	Very Good
Tramway Creek	32	Fair
Mangaone Stream	24	Poor

Mangaone Stream	30	Fair
Mangaone Stream	26	Poor
Unnamed wetland	24	Poor
Unnamed wetland	22	Poor
Unnamed wetland	24	Poor
Unnamed wetland	16	Very Poor
Mangaore Stream tributary	34	Fair
Mangaore Stream	34	Fair
Waikawa Stream	44	Good
Waiti Stream	48	Very Good
Makahika Stream	40	Good
Ohau River	44	Good
Makorokio Stream	56	Excellent
Paetawa	30	Fair
Drain 7 Wharemauku	22	Poor
Whareroa Stream @ QE 2 Park	16	Very Poor
Wharemauku	28	Poor
Mazengarb Stream	22	Poor
Mazengarb (WWTS)	22	Poor
Muaupoko Stream	32	Fair
Waikanae Proposed Bridge	30	Fair
Ngarara Nga Manu	36	Fair
Ngarara Drain	16	Very Poor
Waimeha	14	Very Poor
Hadfield Drain / Te Kowhai	18	Poor
Kakariki at Nga Manu	36	Fair
Ngarara Drain	16	Very Poor
Drain 7 Upper	16	Very Poor
Smithfield Drain	16	Very Poor
Whareroa Trib Waterfall Rd	26	Poor

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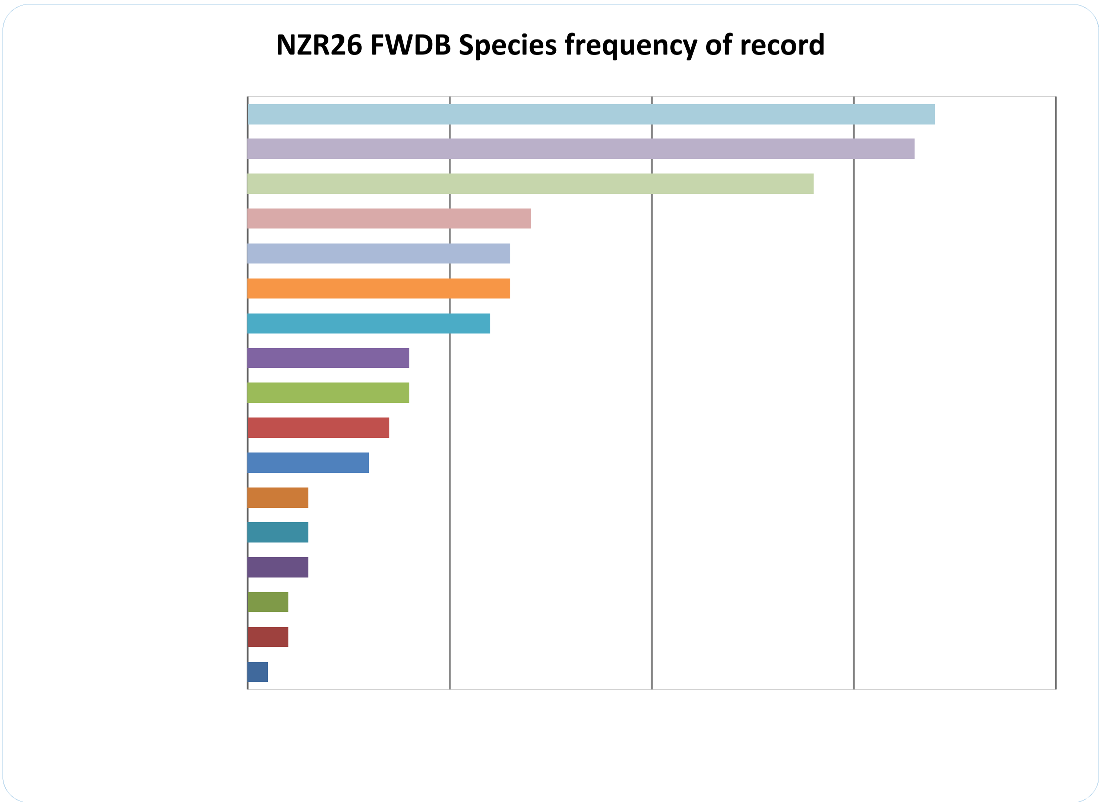

NZR26 FWDB Species frequency of record

Appendix 30.E

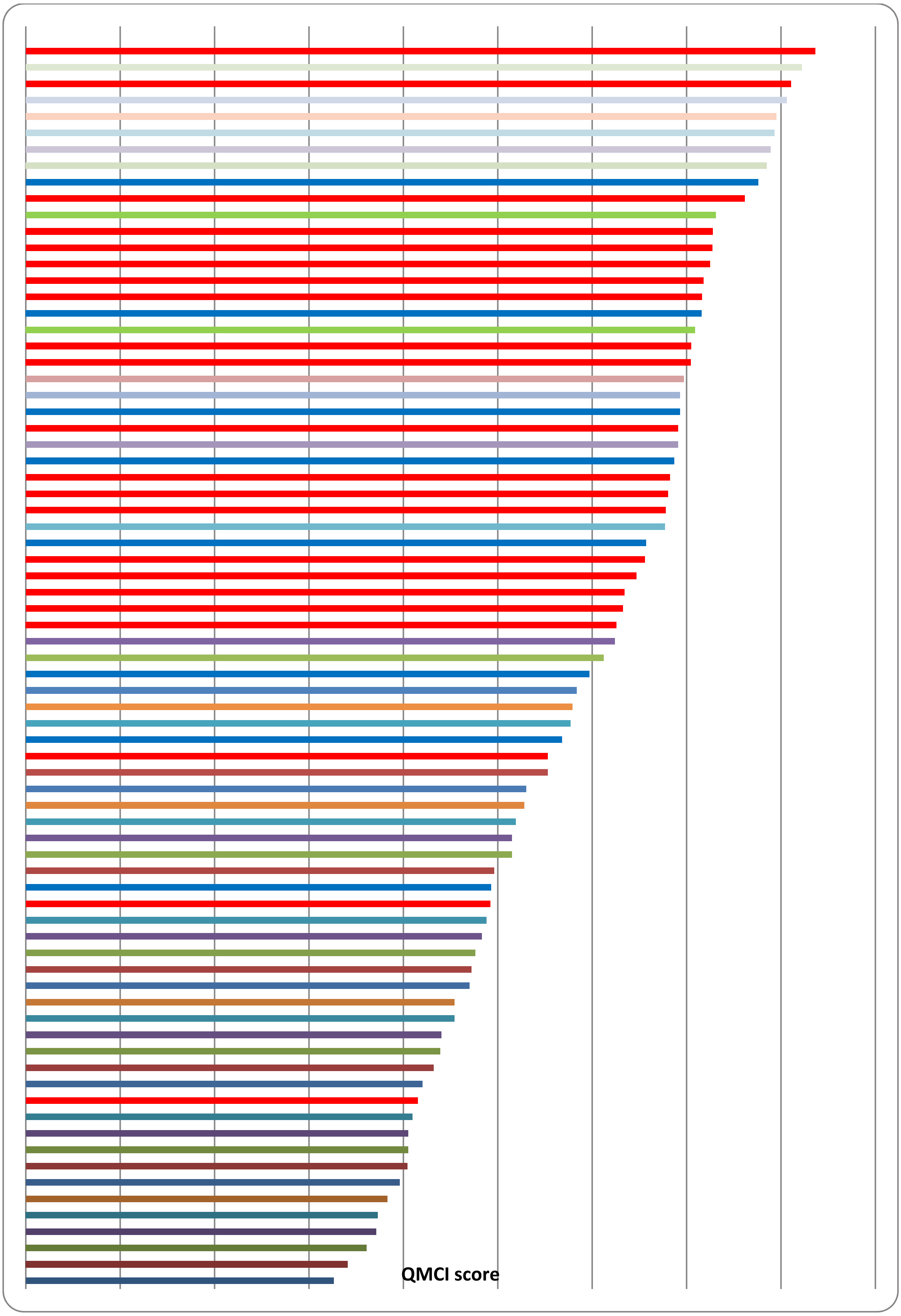
Regional Rivers Macroinvertebrate Metrics

APPENDIX 30.E REGIONAL RIVERS MACROINVERTEBRATE METRICS

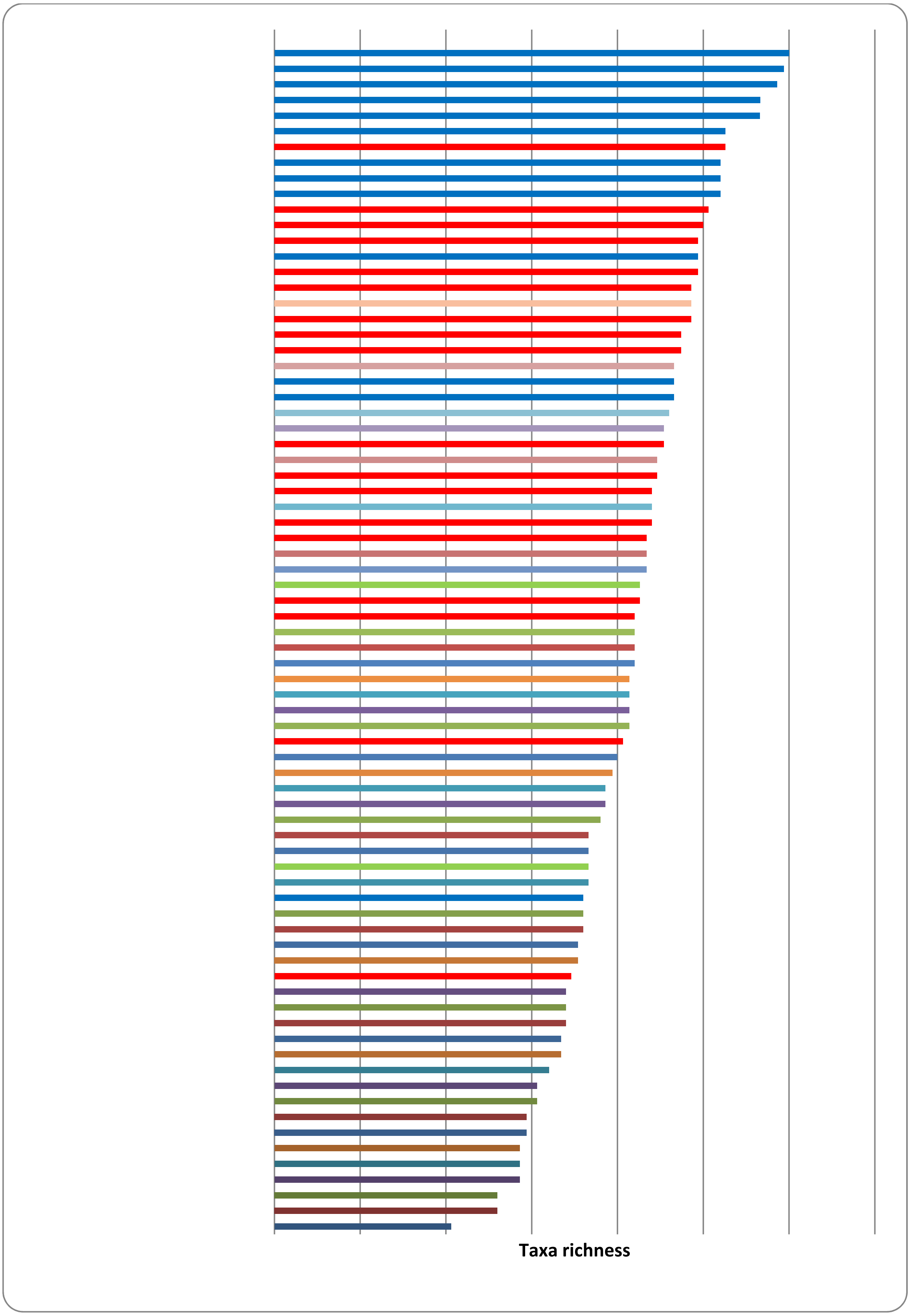
Macroinvertebrate data from Regional Council (Perrie 2008)

GWRC - Regional Biometrics				
	QMCI (2009)	Taxa richness (2009)	%EPT (2009)	MCI (2007)
Site Name	Mean QMCI	Mean taxa richness	mean %EPT	Mean MCI
Mangapouri S at Rahui Rd	4.05	20.33	9.0%	87.1
Mangapouri S at Bennetts Rd	4.54	13	7.0%	70
Waitohu S at Forest Pk	8.22	28.33	90.3%	138.2
Waitohu S at Norfolk Cres	4.72	14.7	0.0%	101.4
Ōtaki R at Pukehinau	7.76	17.3	95.0%	124.1
Ōtaki R at Mouth	5.15	18	37.5%	110
Mangaone S at Sims Rd Br	4.7	16.7	0.0%	60.6
Ngarara S at Field Way	4.76	10.3	1.8%	74.2
Waikanae R at Mangaone Walkway	7.95	23	86.0%	139.6
Waikanae R at Greenaway Rd	5.97	22.7	51.0%	118.2
Whareroa S at Waterfall Rd	6.24	28.3	56.0%	114.6
Whareroa S at QE Park	4.83	18	8.0%	74.6
Horokiri S at Snodgrass	7.09	18.3	75.8%	112.1
Pauatahanui S at Elmwood Br	7.31	21.3	11.8%	91.3
Porirua S at Glenside	3.26	21.7	9.5%	91.1
Porirua S at Wall Park (Milk Depot)	2.9	14.3	1.9%	92.8
Makara S at Kennels	4.4	17.7	10.4%	95.7
Karori S at Makara Peak	4.05	20.7	29.3%	87.6
Kaiwharawhara S at Ngaio Gorge	3.41	21	5.5%	94.7
Hutt R at Te Marua Intake Site	7.93	22.7	89.8%	143.5
Hutt R opp. Manor Park G.C.	4.93	19.3	41.0%	104.3
Hutt R at Boulcott	4.39	18.3	31.8%	99
Pakuratahi R 50m d/s Farm Ck	6.77	25.3	84.0%	129
Mangaroa R at Te Marua	4.88	22.3	56.0%	112.7
Akatarawa R at Hutt confl.	6.93	23.3	81.0%	124.3
Whakatikei R at Riverstone	6.91	23.3	70.0%	120.5
Waiwhetu S at Wainui Hill Br	3.83	7.7	0.0%	82.4
Wainuiomata R at Manuka Track	7.16	29.7	79.0%	133.5
Wainuiomata R u/s of White Br	3.61	19.7	27.0%	96.4
Orongorongo R at Orongorongo Stn	6.57	14.3	51.0%	99.6
Ruamahanga R at McLays	8.06	20.7	87.6%	149.3
Ruamahanga R at Te Ore Ore	6.87	15.3	68.0%	112.7
Ruamahanga R at Gladstone Br	5.68	15.3	23.5%	109.1
Ruamahanga R at Pukio	5.28	14.7	26.4%	108.7
Mataikona Trib at Sugar Loaf Rd	5.79	30	80.0%	124
Taueru R at Castlehill	5.15	22	66.0%	125.8
Taueru R at Gladstone	4.15	24.7	9.4%	88.7
Kopuaranga R at Stewarts	4.54	26.3	45.4%	107.7
Whangaehu R 250m u/s confl.	3.73	16.7	3.0%	61.3
Waipoua R at Colombo Rd Br	4.96	26	56.4%	108.9
Waingawa R at South Rd	6.34	17.7	54.0%	120.9
Whareama R at Gauge	3.96	14.3	2.0%	71.8
Motuwaireka S at Headwaters	6.97	26	63.5%	127.9
Totara S at Stronvar	5.3	21.3	63.0%	96.6
Parkvale Trib at Lowes Res.	5.19	18.3	19.0%	101.4
Parkvale S at Weir	3.71	17	4.4%	88.6
Waiohine R at Gorge	7.89	18.3	92.0%	136.8

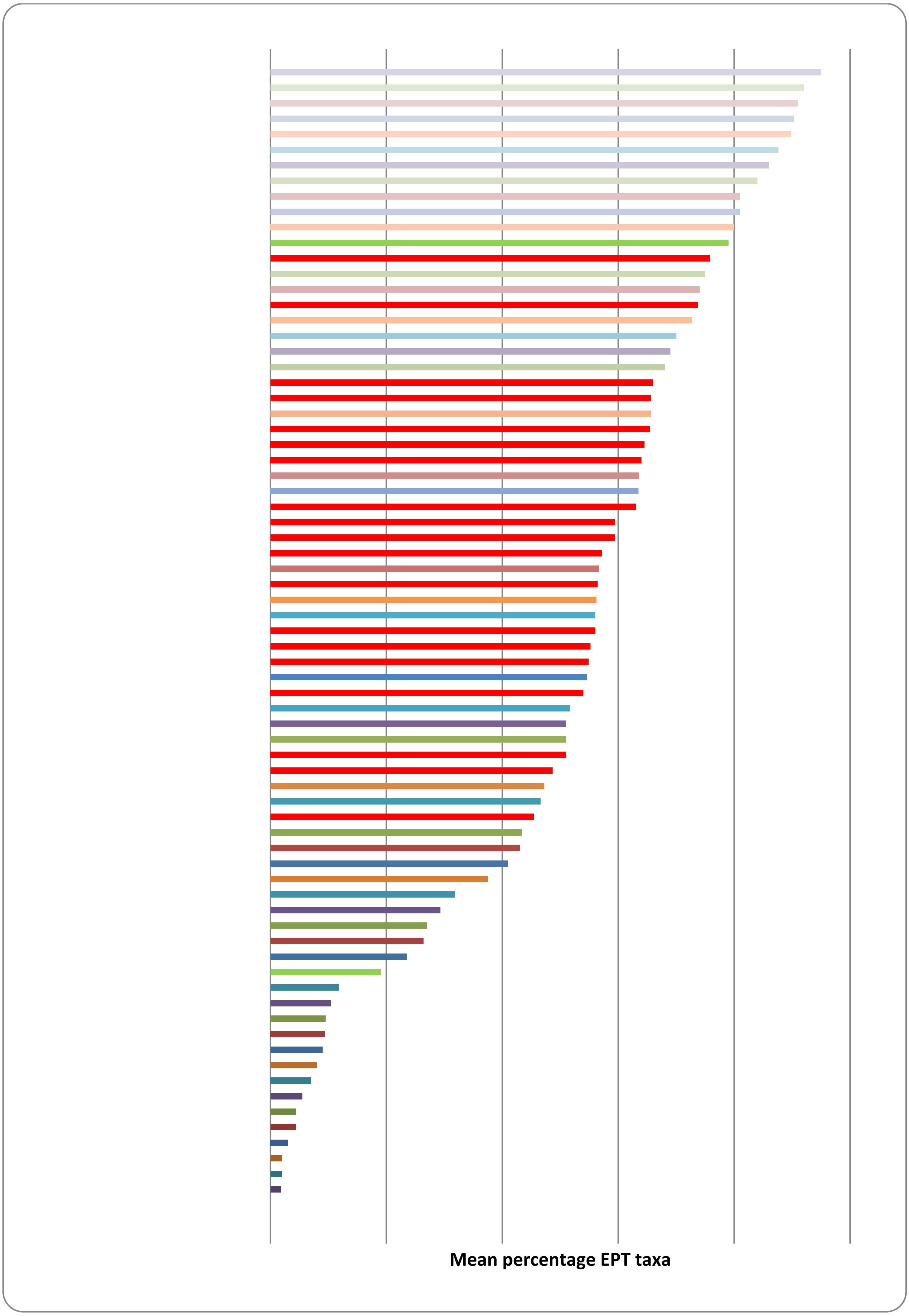
Waiohine R at Bicknell's	7.18	13	74.0%	106
Beef Ck at Headwaters	7.85	29.3	81.0%	132.6
Mangatarere S at SH	5.53	19.3	43.0%	105.8
Huangarua R at Ponatahi Br	4.2	24.3	51.0%	104.3
Tauanui R at Whakatomotomo Rd	5.77	26.3	69.0%	119.3
Awhea R at Tora Rd	4.32	16	0.0%	85.8
Coles Ck Trib at Lagoon Hill Rd	4.04	21	4.4%	107.8
Tauherenikau R at Websters	6.12	17	46.6%	109.7
Waiorongomai R at Forest Pk	6.93	20.7	91.0%	116
Mean	**5.54875**	**20.05**	**43.21%**	**106.26**
Median	**5.235**	**20.01**	**46.00%**	**107.75**



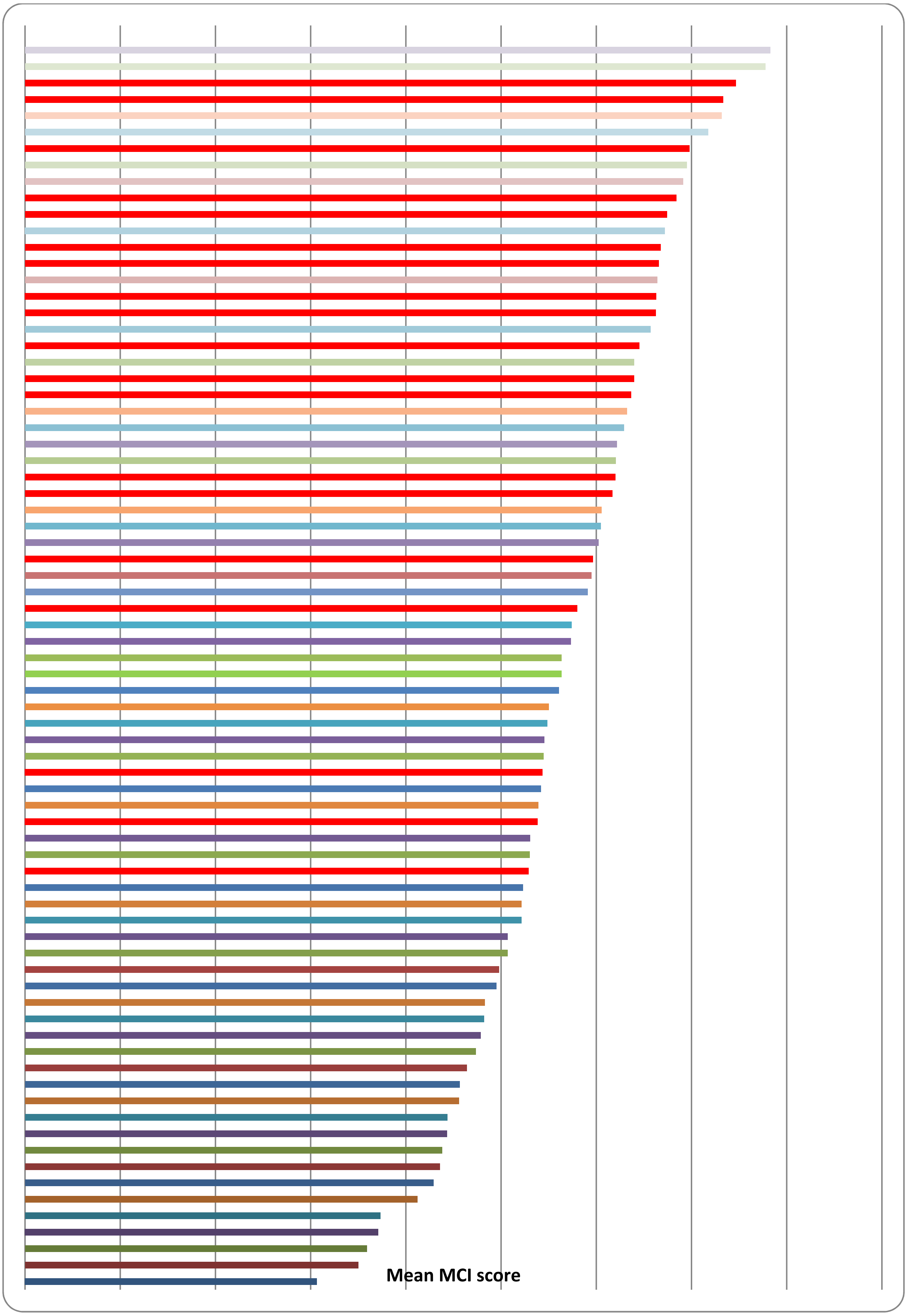
Mean Regional QMCI measures



Mean Regional taxa richness



Mean Regional % EPT



Mean Regional MCI

Appendix 30.F

Fish Survey Results

APPENDIX 30.F FISH SURVEY RESULTS

SUMMARY RESULTS

Habitat	# taxa	Total # Fish
Hadfields Kowhai Stream	2	25
Paetawa Drain	3	71
Smithfield Drain	3	7
Kakariki Stream	4	30
Ngarara Creek	2	12
Waimeha Stream	2	11
Waikanae River	5	42
Muaupoko Stream	5	46
Mazengarb WWTP	3	90
Mazengarb Stream	3	34
Wharemauku	4	31
Drain 7 Lower	3	60
Drain 7 Upper	3	7
Whareroa Drain	2	10
Whareroa Tributary	3	12

SITE RESTULTS

Site Code 1 : Whareroa Stream Tributary											
Reach	1	2	3	4	5	6	7	8	9	10	
SPECIES	Run	Run/pool	Run	run/pool	Run	Run	Run	Run	Run	Run	SUM
Longfin eel											0
Shortfin eel											0
Koaro											0
Banded Kokopu											0
Giant Kokopu											0
Inanga											0
Redfin bully											0
Common bully											0
Brown Trout											0
Smelt											0
Flounder											0
Whitebait (sp. unknown)											0
Elver (sp. unknown)											0
Eel (sp. unknown)											0
Verified Taxa	0	0	0	0	0	0	0	0	0	0	0
SUM all fish	0	0	0	0	0	0	0	0	0	0	0

Site Code 2 : Whareroa Drain

Reach	1	2	3	4	5	6	7	8	9	10	
SPECIES	Run	Run/pool	Run	run/pool	Run	Run	Run	Run	Run	Run	SUM
Longfin eel	2				1	2	1				6
Shortfin eel				1							1
Koaro											0
Banded Kokopu											0
Giant Kokopu											0
Inanga											0
Redfin bully											0
Common bully											0
Brown Trout											0
Smelt											0
Flounder											0
Whitebait (sp. unknown)											0
Elver (sp. unknown)							2				2
Eel (sp. unknown)										1	1
Verified Taxa	1	0	0	1	1	1	1	0	0	0	2

SUM all fish	2	0	0	1	1	2	3	0	0	1	10

Site Code 3 : Drain 7 Lower

Reach	1	2	3	4	5	6	7	8	9	10	
SPECIES	Run	Run/pool	Run	run/pool	Run	Run	Run	Run	Run	Run	SUM
Longfin eel											0
Shortfin eel											0
Koaro											0
Banded Kokopu											0
Giant Kokopu											0
Inanga											0
Redfin bully											0
Common bully											0
Brown Trout											0
Smelt											0
Flounder											0
Whitebait (sp. unknown)											0
Elver (sp. unknown)											0
Eel (sp. unknown)											0
Verified Taxa	0	0	0	0	0	0	0	0	0	0	0
SUM all fish	0	0	0	0	0	0	0	0	0	0	0

Site Code 4: Drain 7 Upper

Reach	1	2	3	4	5	6	7	8	9	10	
SPECIES	Run	Run/pool	Run	run/pool	Run	Run	Run	Run	Run	Run	SUM
Longfin eel											0
Shortfin eel											0
Koaro											0
Banded Kokopu											0
Giant Kokopu											0
Inanga											0
Redfin bully											0
Common bully											0
Brown Trout											0
Smelt											0
Flounder											0
Whitebait (sp. unknown)											0
Elver (sp. unknown)											0
Eel (sp. unknown)			1		1		1				3
Verified Taxa	0	0	0	0	0	0	0	0	0	0	0
SUM all fish	0	0	1	0	1	0	1	0	0	0	3

Site Code Drain 5a: Wharemauku

Reach	1	2	3	4	5	6	7	8	9	10	
SPECIES	Run	Run/pool	Run	run/pool	Run	Run	Run	Run	Run	Run	SUM
Longfin eel	2				1						3
Shortfin eel		1	1	1		2					5
Koaro											0
Banded Kokopu											0
Giant Kokopu											0
Inanga	1			13							14
Redfin bully											0
Common bully											0
Brown Trout											0
Smelt											0
Flounder											0
Whitebait (sp. unknown)			30		3						33
Elver (sp. unknown)					3	1					4
Eel (sp. unknown)				1							1
Verified Taxa	2	1	1	2	1	1	0	0	0	0	3
SUM all fish	3	1	31	15	7	3	0	0	0	0	60

Site Code 5b: Wharemauku Stream

Reach	1	2	3	4	5	6	7	8	9	10	
SPECIES	Run	Run/pool	Run	run/pool	Run	Run	Run	Run	Run	Run	SUM
Longfin eel	2	1	2	1	1	2	4	3			16
Shortfin eel			1					1			2
Koaro											0

Banded Kokopu											0
Giant Kokopu											0
Inanga								1	1		2
Redfin bully											0
Common bully	1				3		1				5
Brown Trout											0
Smelt											0
Flounder											0
Whitebait (sp. unknown)											0
Elver (sp. unknown)				1			5				6
Eel (sp. unknown)											0
Verified Taxa	2	1	2	1	2	1	2	3	1	0	4
SUM all fish	3	1	3	2	4	2	10	5	1	0	31

Site Code 6: Mazengarb Stream

Reach	1	2	3	4	5	6	7	8	9	10	
SPECIES	Run	Run/pool	Run	run/pool	Run	Run	Run	Run	Run	Run	SUM
Longfin eel			1					1			2
Shortfin eel			1				2				3
Koaro											0
Banded Kokopu											0
Giant Kokopu											0
Inanga											0
Redfin bully											0
Common bully	1				4	5		1			11
Brown Trout											0
Smelt											0
Flounder											0
Whitebait (sp. unknown)											0
Elver (sp. unknown)	3	3	3	2		2	3	2			18
Eel (sp. unknown)											0
Verified Taxa	1	0	2	0	1	1	1	2	0	0	3
SUM all fish	4	3	5	2	4	7	5	4	0	0	34

Site Code 7: Mazengarb Stream (WWTS)

Reach	1	2	3	4	5	6	7	8	9	10	
SPECIES	Run	Run/pool	Run	run/pool	Run	Run	Run	Run	Run	Run	SUM
Longfin eel	3	4		3	3	2					15
Shortfin eel	12		12	18	13	6					61
Koaro											0
Banded Kokopu											0
Giant Kokopu											0
Inanga											0
Redfin bully											0
Common bully				1							1
Brown Trout											0
Smelt											0
Flounder											0
Whitebait (sp. unknown)											0
Elver (sp. unknown)	4	3				6					13
Eel (sp. unknown)											0
Verified Taxa	2	1	1	3	2	2	0	0	0	0	3
SUM all fish	19	7	12	22	16	14	0	0	0	0	90

Site Code 8: Muaupoko Stream

Reach	1	2	3	4	5	6	7	8	9	10	
SPECIES	Run	Run/pool	Run	run/pool	Run	Run	Run	Run	Run	Run	SUM
Longfin eel	1										1
Shortfin eel		2					1				3
Koaro											0
Banded Kokopu											0
Giant Kokopu											0
Inanga		14					3	6			23
Redfin bully											0
Common bully			1	1							2
Brown Trout											0
Smelt		3	1	3	1						8
Flounder											0
Whitebait (sp. unknown)											0

Elver (sp. unknown)	3			1	3			2			9
Eel (sp. unknown)											0
COUNT (Verified Taxa)	1	3	2	2	1	0	2	1	0	0	5
SUM all fish	4	19	2	5	4	0	4	8	0	0	46

Site Code 9: Waikanae River

Reach	1	2	3	4	5	6	7	8	9	10	
SPECIES	Run	Run/pool	Run	run/pool	Run	Run	Run	Run	Run	Run	SUM
Longfin eel						1					1
Shortfin eel	1	3	2	1	2		1				10
Koaro											0
Banded Kokopu											0
Giant Kokopu											0
Inanga				3							3
Redfin bully		1	1				1				3
Common bully		6	1	1	1						9
Brown Trout											0
Smelt											0
Flounder			2								2
Whitebait (sp. unknown)	1										1
Elver (sp. unknown)		1			3	2	2				8
Eel (sp. unknown)											0
Verified Taxa	1	3	4	3	2	1	2	0	0	0	6
SUM all fish	2	11	6	5	6	3	4	0	0	0	37

Site Code 10: Waimeha

Reach	1	2	3	4	5	6	7	8	9	10	
SPECIES	Run	Run/pool	Run	run/pool	Run	Run	Run	Run	Run	Run	SUM
Longfin eel											0
Shortfin eel						1					1
Koaro											0
Banded Kokopu											0
Giant Kokopu											0
Inanga											0
Redfin bully											0
Common bully								1			1
Brown Trout											0
Smelt											0
Flounder											0
Whitebait (sp. unknown)											0
Elver (sp. unknown)			3			1	3	2			9
Eel (sp. unknown)											0
Verified Taxa	0	0	0	0	0	1	0	1	0	0	2
SUM all fish	0	0	3	0	0	2	3	3	0	0	11

Site Code 11: Ngarara Drain

Reach	1	2	3	4	5	6	7	8	9	10	
SPECIES	Run	Run/pool	Run	run/pool	Run	Run	Run	Run	Run	Run	SUM
Longfin eel						1					1
Shortfin eel							1				1
Koaro											0
Banded Kokopu											0
Giant Kokopu											0
Inanga											0
Redfin bully											0
Common bully											0
Brown Trout											0
Smelt											0
Flounder											0
Whitebait (sp. unknown)											0
Elver (sp. unknown)					2		2			2	6
Eel (sp. unknown)		1				3					4
Verified Taxa	0	0	0	0	0	1	1	0	0	0	2
SUM all fish	0	1	0	0	2	4	3	0	0	2	12

Site Code 12: Kakariki

Reach	1	2	3	4	5	6	7	8	9	10	
SPECIES	Run	Run/pool	Run	run/pool	Run	Run	Run	Run	Run	Run	SUM

Longfin eel		1							1		2
Shortfin eel						1					1
Koaro											0
Banded Kokopu											0
Giant Kokopu											0
Inanga											0
Redfin bully											0
Common bully					1			2			3
Brown Trout											0
Smelt				1	5	3	4		3		16
Flounder											0
Whitebait (sp. unknown)		1									1
Elver (sp. unknown)	2	2	1	2							7
Eel (sp. unknown)											0
Verified Taxa	0	1	0	1	2	2	1	1	2	0	4
SUM all fish	2	4	1	3	6	4	4	2	4	0	30

Site Code 13: Smithfield Drain

Reach	1	2	3	4	5	6	7	8	9	10	
SPECIES	Run	Run/pool	Run	run/pool	Run	Run	Run	Run	Run	Run	SUM
Longfin eel										2	2
Shortfin eel				1							1
Koaro											0
Banded Kokopu											0
Giant Kokopu											0
Inanga											0
Redfin bully											0
Common bully											0
Brown Trout											0
Smelt											0
Flounder											0
Whitebait (sp. unknown)											0
Elver (sp. unknown)											0
Eel (sp. unknown)				1					2	1	4
Verified Taxa	0	0	0	1	0	0	0	0	0	1	2
SUM all fish	0	0	0	2	0	0	0	0	2	3	7

Site Code 14: Paetawa

Reach	1	2	3	4	5	6	7	8	9	10	
SPECIES	Run	Run/pool	Run	run/pool	Run	Run	Run	Run	Run	Run	SUM
Longfin eel	2			2	2	1		1			8
Shortfin eel											0
Koaro											0
Banded Kokopu	6						1				7
Giant Kokopu											0
Inanga											0
Redfin bully											0
Common bully											0
Brown Trout											0
Smelt	1	1	6								8
Flounder											0
Whitebait (sp. unknown)											0
Elver (sp. unknown)			3	3	8	3	3	5	3	8	36
Eel (sp. unknown)											0
Verified Taxa	3	1	1	1	1	1	1	1	0	0	3
SUM all fish	9	1	9	5	10	4	4	6	3	8	59

Site Code 15 : Hadfield Drain

Reach	1	2	3	4	5	6	7	8	9	10	
SPECIES	Run	Run/pool	Run	run/pool	Run	Run	Run	Run	Run	Run	SUM
Longfin eel											0
Shortfin eel		1									1
Koaro											0
Banded Kokopu	1	2		1	1	3		5	8		21
Giant Kokopu											0
Inanga											0
Redfin bully											0
Common bully											0
Brown Trout											0

Smelt										0
Flounder										0
Whitebait (sp. unknown)										0
Elver (sp. unknown)								2		2
Eel (sp. unknown)				1						1
Verified Taxa	1	2	0	1	1	1	0	1	1	0	2
SUM all fish	1	3	0	2	1	3	0	5	10	0	25

Appendix 30.G

Macroinvertebrate Data

APPENDIX 30.G MACROINVERTEBRATE DATA

Job Number	W09181E			W09181E			W09181E			W09181E			W09181E		
Stream	1. Whareroa Trib			2. Whareroa Drain			3. Drain 7 Wharemauku			4. Upper Drain 7			5. Wharemauku		
Site Code															
Field Staff										MCP/BR					
Sampling protocol/effort:	3 kicks per site.			3 kicks per site.			3 kicks per site.			3 kicks per site.			3 kicks per site.		
Date Collected	16-Dec-10			16-Dec-10			2-Dec-10			13-Apr-11			2-Dec-10		
Last heavy Rain (> 15mm)	13-Dec-10			13-Dec-10			20-Oct-10			5-Apr-11			20-Oct-10		
Easting				1745908.89			1745927.99			1745928.18			1745933.86		
Northing				405642.21			405506.91			405506.82			405452.97		
Alt (m)				6			3			5			3		
Distance from Sea (km)				3.2			2.02			1.42			2.45		
Average Wetted Width (m)				1.8			1.5			2			2.2		
Average Channel Depth (m)				0.3			12			0.55			23		
Average Velocity (m/s)				0			0.3			0			0.3		
Dom Rip Hab				Rough Pasture			Willows			Rough Pasture			Grassland		
Dom Land Use				Pasture			Pasture			Abandoned			Reserve		
Source				Ryder			Ryder			Ryder			Ryder		
Form of data				Full Count			Full Count			Full Count			Full Count		
Sub Samples	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Ephemeroptera															
Acanthophlebia															
Amelotopsis															
Arachnocolus															
Atalophlebioides															
Austroclima													18	12	24
Austronella															
Coloburiscus															
Deleatidium	135	260	305											6	18
Ichthybotus		1											1		
Isothraulus															
Mauiulus															
Neozephlebia															
Nesameletus															
Oniscigaster															
Rallidens															
Siphlaenigma															
Tepakia															
Zephlebia sp															
Trichoptera															
Alloecentrella															
Aoteapsyche					1										
Beraeoptera															
Confluens															
Conuxia															
Costachorema															
Cryptobiosella															
Diplectrona															
Ecnomina															
Ecnomidae															
Edpercivalia															
Helicopsyche															
Hudsonema sp	1	2	3												
Hydrobiosella															
Hydrobiosis sp.		3	2												
Hydrochorema	1	1													
Kokiria															
Neurochorema															
Oecetis															
Oeconesidae	17														
Olinga															
Orthopsyche															
Oxyethira													204	552	1146
Paroxyethira															
Philorheithrus															
Plectrocnemia															
Polyplectropus															
Psilochorema													1	1	1
Pycnocentrella															

Pycnocentria		1													
Pycnocentrodes													1		
Rakiura															
Synchorema															
Tiphobiosis															
Triplectides		2		28	38	10	4			2		4		12	2
Triplectidina															
Zelandoptila															
Zelolessica															
Plecoptera															
Acroperla															
Austroperla	1														
Cristaperla															
Halticoperla															
Megaleptoperla															
Nesoperla															
Spaniocerca															
Spaniocercoides															
Stenoperla															
Taraperla															
Zelandobius															
Zelandoperla															
Hemiptera															
Anisops															
Diaprepocoris															
Microvelia															
Saldidae															
Sigara										22	3	14	1		1
Coleoptera															
Antiporus															
Berosus															
Copelatus															
Dytiscidae						1								1	4
Elmidae	1	11	10											420	396
Enochrus															
Homeodytes															
Hydraenidae															
Hydrophilidae					3	2								1	
Liodessus															
Onychohydrus															
Podaena															
Ptilodactylidae															
Rhantus															
Scirtidae															
Staphylinidae															
Odonata															
Aeshna															
Anisoptera					2										
Antipodochlora															
Austrolestes															
Hemianax															
Hemicordulia															
Ischnura															
Procordulia															
Uropetala															
Xanthocnemis	4			7	33	4	3			1		3			
Neuroptera															
Kempynus															
Diptera															
Aphrophila		1				1	1		1				108	24	114
Austrosimulium	56	52	345												
Calopsectra															
Ceratopogonidae															
Chironomidae															
Chironomus					4	2	282	30	132	69	31	211	101 4	306	96
Corynoneura															
Cryptochironomus															
Culex				260	11	14									
Culicidae															
Diptera indet.															
Dixidae															
Dolichopodidae															
Empididae															6

Ephydridae															
Eriopterini		1	1												
Harrisius															
Hexatomini	4	12	15											1	
Limnophora															
Limonia															
Lobodiamesa															
Maoridiamesa															
Mischoderus		1	3											1	4
Molophilus															
Muscidae			1			3								1	2
Nannochorista															
Neocurupira															
Neolimnia															
Neoscatella															
Nothodixa															
Orthocladiinae	8	56	21	1		7	6	6	12	1			126	90	114
Parochlus															
Paradixa										2			6	18	96
Paralimnophila															
Paucispinigera															
Pelecorhyncidae															
Peritheates															
Podonominae										2		3			
Polypedilum						19									
Psychodidae															
Scatella															
Sciomyzidae															
Stratiomyidae			1												
Syrphidae															
Tabanidae					9	13									
Tanypodinae	27						396	48	114	7	2	27	84		12
Tanytarsini															
Tanytarsus															
Thaumaleidae															
Tipulidae															
Zelandotipula															
Megaleptopera															
Archichauliodes		5	3										12	1	5
Lepidoptera															
Hygraula															
Collembola															
Crustacea															
Amphipoda				10	9	1									
Cladocera															
Copepoda															
Halicarcinus															
Helice															
Isopoda															
Mysidae															
Ostracoda	135	90	135				72	6	18	253	32	440	198	120	102
Paracalliope	2354	855	1030										114	180	582
Paraleptamphopus															
Paranephrops															
Paranthura															
Paratya	1												12	30	6
Tanaidacea	34	90	80												
Acarina															
Arachnida															
Dolomedes															
Mollusca															
Gundlachia = Ferrissia															
Glyptophysa = Physastra															
Gyraulus															
Hyridella															
Latia															
Lymnaeidae															
Melanopsis															
Physa = Physella	32	35	60				1					1	7	12	
Potamopyrgus	1554	3285	4810					54	18				4218	4212	7620
Sphaeriidae	39	10	19					66	6				7		
Bryozoa															

Hirudinea	22	15	30												
Nematoda															
Nematomorpha															
Nemertea															
Oligochaeta	134	60	255				16	6	30	4	1	16	12	12	294
Platyhelminthes															
Polychaeta															
Rhabdocoela															
Tardigrada															
COELENTERATA															
Hydra															

Job Number	W09181E			W09181E			W09181E			W09181E			W09181E		
Stream	6. Mazengarb Stream			7. Mazengarb at Waste Water			8. Muaupoko Stream			9. Waikanae			10. Waimeha		
Site Code															
Field Staff															
Sampling protocol/effort:	3 kicks per site.			3 kicks per site.			3 kicks per site.			3 kicks per site.			3 kicks per site.		
Date Collected	3-Dec-10			3-Dec-10			3-Dec-10			3-Dec-10			9-Dec-10		
Last heavy Rain (> 15mm)	20-Oct-10			20-Oct-10			20-Oct-10			20-Oct-10			20-Oct-10		
Easting	1755351.13			405341.43			1750139			1750139			1752040		
Northing	405351.13			175010.86			405241			405239.7			405204		
Alt (m)	6			6			2			2			2		
Distance from Sea (km)	2.65			2.43			2.02			1.9			1.3		
Average Wetted Width (m)	1.8			3.6			2.1			27			4.4		
Average Channel Depth (m)	30			60			45			50			50		
Average Velocity (m/s)	0.25			0.5			0.37			0.95			0.25		
Dom Rip Hab	Designation			Short Pasture & Rushes			Rough Pasture			Short Pasture & Rushes			Short Pasture		
Dom Land Use	Grazing			Grazing			Grazing			Grazing			Grazing		
Source	Ryder			Ryder			Ryder			JS			Ryder		
Form of data	Full Count			Full Count			Full Count			Full count			Full Count		
Sub Samples	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Ephemeroptera															
Acanthophlebia															
Amelotopsis															
Arachnocolus															
Atalophlebioides															
Austroclima															
Austronella															
Coloburiscus										1	10	6			
Deleatidium								51		125	1040	1036			
Ichthybotus															
Isothraulus															
Mauiulus															
Neozephlebia															
Nesameletus											1	1			
Oniscigaster															
Rallidens															
Siphlaenigma															
Tepakia															
Zephlebia sp															
Trichoptera															
Alloecentrella															
Aoteapsyche										3	5	18			
Beraeoptera															
Confluens											139	51			
Conuxia															
Costachorema															
Cryptobiosella															
Diplectrona															
Ecnomina															
Ecnomidae															
Edpercivalia															
Helicopsyche										7	6	44			
Hudsonema sp															
Hydrobiosella															
Hydrobiosis sp.								1		3	9	2			
Hydrochorema															
Kokiria															
Neurochorema							3	8	4			2			
Oecetis															
Oeconesidae															
Olinga										49	212	113			
Orthopsyche															
Oxyethira										2	2		10		
Paroxyethira															
Philorheithrus															
Plectrocnemia										7	6				
Polyplectropus													1	2	
Psilochorema								1		10		13			
Pycnocentrella															

Pycnocentria											33				
Pycnocentrodes								106		247	432	769			
Rakiura															
Synchorema															
Tiphobiosis															
Triplectides	1	1					2	4	11	1					
Triplectidina															
Zelandoptila															
Zelolessica															
Plecoptera															
Acroperla															
Austroperla															
Cristaperla															
Halticoperla															
Megaleptoperla												1			
Nesoperla															
Spaniocerca															
Spaniocercoides															
Stenoperla															
Taraperla															
Zelandobius											2	4			
Zelandoperla												3			
Hemiptera															
Anisops															
Diaprepocoris															
Microvelia															
Saldidae															
Sigara													40		
Coleoptera															
Antiporus															
Berosus															
Copelatus															
Dytiscidae															
Elmidae	432						3	57		347	176	777			
Enochrus															
Homeodytes															
Hydraenidae															
Hydrophilidae															
Liodessus															
Onychohydrus															
Podaena															
Ptilodactylidae															
Rhantus															
Scirtidae															
Staphylinidae															
Odonata															
Aeshna															
Anisoptera									1						
Antipodochlora															
Austrolestes															
Hemianax															
Hemicordulia															
Ischnura															
Procordulia															
Uropetala															
Xanthocnemis													26		
Neuroptera															
Kempynus															
Diptera															
Aphrophila										5	11	10			
Austrosimulium								25			5	4			
Calopsectra															
Ceratopogonidae															
Chironomidae															
Chironomus	13	9	5	50	66	526	9		99	4	10		4		1
Corynoneura															
Cryptochironomus															
Culex															
Culicidae															
Diptera indet.															
Dixidae															
Dolichopodidae															
Empididae															
Ephydridae															

Eriopterini								5		4	12	8			
Harrisius															
Hexatomini															
Limnophora															
Limonia				1											
Lobodiamesa															
Maoridiamesa															
Mischoderus								1							
Molophilus	1	1	2												
Muscidae											1				
Nannochorista															
Neocurupira															
Neolimnia															
Neoscatella															
Nothodixa															
Orthocladiinae	31	4	3	82	4	350		13			15	4	2		2
Parochlus															
Paradixa									3				2		
Paralimnophila								2							
Paucispinigera															
Pelecorhyncidae															
Peritheates															
Podonominae															
Polypedilum													3	3	4
Psychodidae															
Scatella															
Sciomyzidae															
Stratiomyidae															
Syrphidae															
Tabanidae												4			
Tanypodinae	4	1					1		5	21	9		3	1	1
Tanytarsini											10	2			
Tanytarsus															
Thaumaleidae															
Tipulidae															
Zelandotipula															
Megaleptopera															
Archichauliodes								2							
Lepidoptera															
Hygraula															
Collembola	1	1													
Crustacea															
Amphipoda								1	3						
Cladocera															
Copepoda															
Halicarcinus															
Helice															
Isopoda															
Mysidae															
Ostracoda	85	38	19						1				139	45	21
Paracalliope	199	614	352				7	48	362				2832	3544	762
Paraleptamphopus															
Paranephrops															
Paranthura															
Paratya							22	21	33	4	15			5	2
Tanaidacea															
Acarina										1					
Arachnida															
Dolomedes															
Mollusca															
Gundlachia = Ferrissia															
Glyptophysa = Physastra															
Gyraulus															
Hyridella															
Latia															
Lymnaeidae													1	2	6
Melanopsis															
Physa = Physella	23	4	3												
Potamopyrgus	58	38	11				92	979	241	39	20	537	968	382	328
Sphaeriidae	1						9	8	19				8	8	12
Bryozoa															
Hirudinea				104	14	15				1					
Nematoda															

Nematomorpha															
Nemertea															
Oligochaeta	5	8	7	2	4	2	2	10	6			3			
Platyhelminthes															
Polychaeta															
Rhabdocoela															
Tardigrada															
COELENTERATA															
Hydra															

Job Number	W09181E			W09181E			W09181E			W09181E			W09181E		
Stream	11. Ngarara Drain			12. Kakariki			13. Smithfield Drain			14. Paetawa			15. Hadfield Drain		
Site Code															
Field Staff															
Sampling protocol/effort:	3 kicks per site.			3 kicks per site.			3 kicks per site.			3 kicks per site.			3 kicks per site.		
Date Collected	9-Dec-10			9-Dec-10			13-Apr-10			12-Dec-10			11-Feb-11		
Last heavy Rain (> 15mm)	20-Oct-10			20-Oct-10			5-Apr-11			20-Oct-10			21-Jan-11		
Easting	1750249.57			1750249.57			1750602.85			405351			1750515		
Northing	405141.03			405141.03			405340.34			1750050			405017		
Alt (m)	7			7			6			8			8		
Distance from Sea (km)	1.54			2.04			1.73			2.9			3.1		
Average Wetted Width (m)	1.6			1.5			1.2			1.8			1.3		
Average Channel Depth (m)	0.15			0.3			0.3			0.15			0.3		
Average Velocity (m/s)	0.25			0.45			0			0			0		
Dom Rip Hab	Blackberry/rough pasture			Blackberry			Grazed Pasture			Scrub			Rough Pasture		
Dom Land Use	Grazing			Riparian			Pasture			Grazing			Pasture		
Source	Ryder			Ryder			Ryder			Ryder			Ryder		
Form of data	Full Count			Full Count			Full Count			Full Count			Full Count		
Sub Samples	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Ephemeroptera															
Acanthophlebia															
Amelotopsis															
Arachnocolus															
Atalophlebioides															
Austroclima															
Austronella															
Coloburiscus															
Deleatidium													15	6	12
Ichthybotus															
Isothraulus															
Mauiulus															
Neozephlebia															
Nesameletus															
Oniscigaster															
Rallidens															
Siphlaenigma															
Tepakia															
Zephlebia sp															
Trichoptera															
Alloecentrella															
Aoteapsyche															
Beraeoptera															
Confluens															
Conuxia															
Costachorema															
Cryptobiosella															
Diplectrona															
Ecnomina															
Ecnomidae															
Edpercivalia															
Helicopsyche															
Hudsonema sp															
Hydrobiosella															
Hydrobiosis sp.					11	5									
Hydrochorema															
Kokiria															
Neurochorema													1		

Oecetis															
Oeconesidae														3	2
Olinga										1	5	8			
Orthopsyche															
Oxyethira															
Paroxyethira															
Philorheithrus															
Plectrocnemia											1	1			
Polyplectropus	1					1									
Psilochorema					1										
Pycnocentrella															
Pycnocentria															
Pycnocentrodes															
Rakiura															
Synchorema															
Tiphobiosis															
Triplectides				8	13	7					3	1			
Triplectidina								1							
Zelandoptila															
Zelolessica															
Plecoptera															
Acroperla															
Austroperla															
Cristaperla															
Halticoperla															
Megaleptoperla															
Nesoperla															
Spaniocerca															
Spaniocercoides															
Stenoperla															
Taraperla															
Zelandobius															
Zelandoperla															
Hemiptera															
Anisops															
Diaprepocoris															
Microvelia															
Saldidae															
Sigara								1							
Coleoptera															
Antiporus															
Berosus															
Copelatus															
Dytiscidae						1			1						
Elmidae														1	1
Enochrus															
Homeodytes															
Hydraenidae															
Hydrophilidae							1	1							
Liodessus															
Onychohydrus															
Podaena															
Ptilodactylidae															
Rhantus															
Scirtidae															
Staphylinidae															
Odonata															
Aeshna															
Anisoptera															
Antipodochlora															
Austrolestes															
Hemianax															
Hemicordulia															
Ischnura															
Procordulia															
Uropetala															
Xanthocnemis	2	12			1			3	2	1	18	1	1	5	4
Neuroptera															
Kempynus															
Diptera															
Aphrophila															
Austrosimulium				45	408	798				1	3	15	3	1	
Calopsectra															
Ceratopogonidae									8						

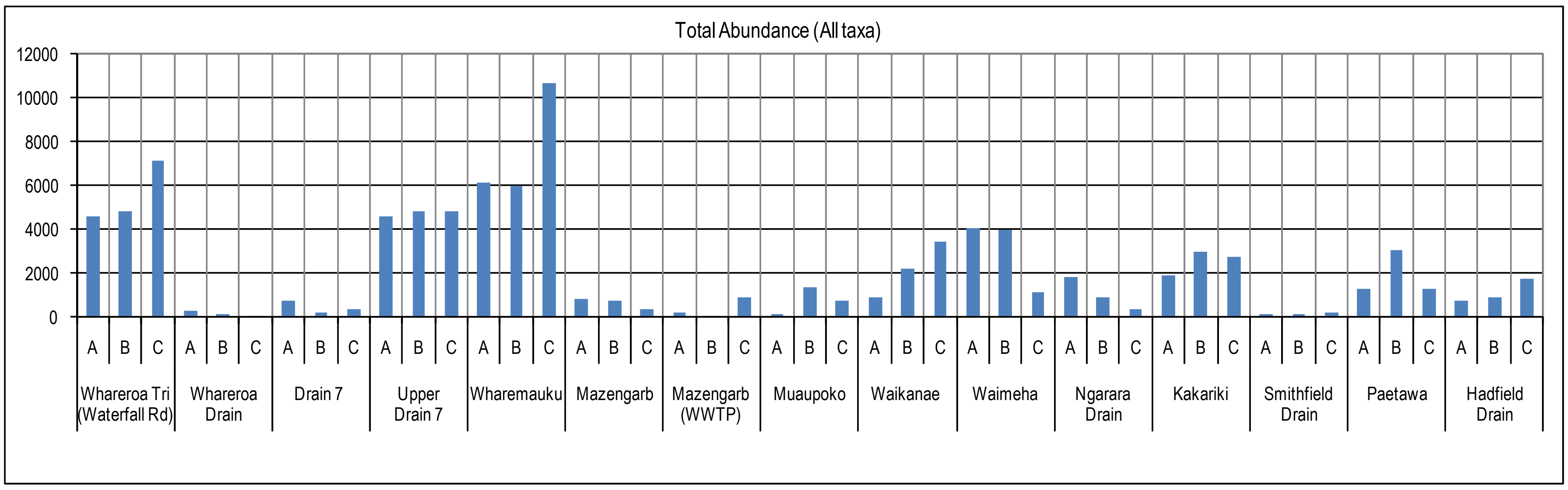
Chironomidae															
Chironomus						1	34	26	81			1			1
Corynoneura													19	5	142
Cryptochironomus															
Culex	2							9	2						
Culicidae															
Diptera indet.															
Dixidae															
Dolichopodidae															
Empididae															
Ephydridae															
Eriopterini															
Harrisius															
Hexatomini														1	1
Limnophora															
Limonia															
Lobodiamesa															
Maoridiamesa															
Mischoderus															
Molophilus				1	1	1							1		
Muscidae															
Nannochorista															
Neocurupira															
Neolimnia															
Neoscatella															
Nothodixa															
Orthocladiinae	1			9	51	63		3	9		1	9		2	1
Parochlus															
Paradixa				2	5	6		1	1					2	1
Paralimnophila											1		6	9	2
Paucispinigera															
Pelecorhyncidae															
Peritheates															
Podonominae															
Polypedilum				20	119	97							2	1	4
Psychodidae						1									1
Scatella															
Sciomyzidae															
Stratiomyidae															
Syrphidae															
Tabanidae										4					
Tanypodinae	5	33	3				12	12	45				2	5	8
Tanytarsini									36					1	
Tanytarsus														1	
Thaumaleidae															
Tipulidae															
Zelandotipula	2													1	
Megaleptopera															
Archichauliodes														2	
Lepidoptera															
Hygraula															
Collembola															
Crustacea															
Amphipoda				10	9	1				340	944	810			
Cladocera															
Copepoda															
Halicarcinus															
Helice															
Isopoda															
Mysidae															
Ostracoda	81	192	156	7		1	50	57	30	10	4	97	151	132	102
Paracalliope	138 8	552	102	169 6	228 6	168 0	3	1	1				555	710	143 5
Paraleptamphopus															
Paranephrops															
Paranthura															
Paratya															
Tanaidacea															
Acarina									1						
Arachnida															
Dolomedes															
Mollusca															
Gundlachia = Ferrissia															
Glyptophysa = Physastra															

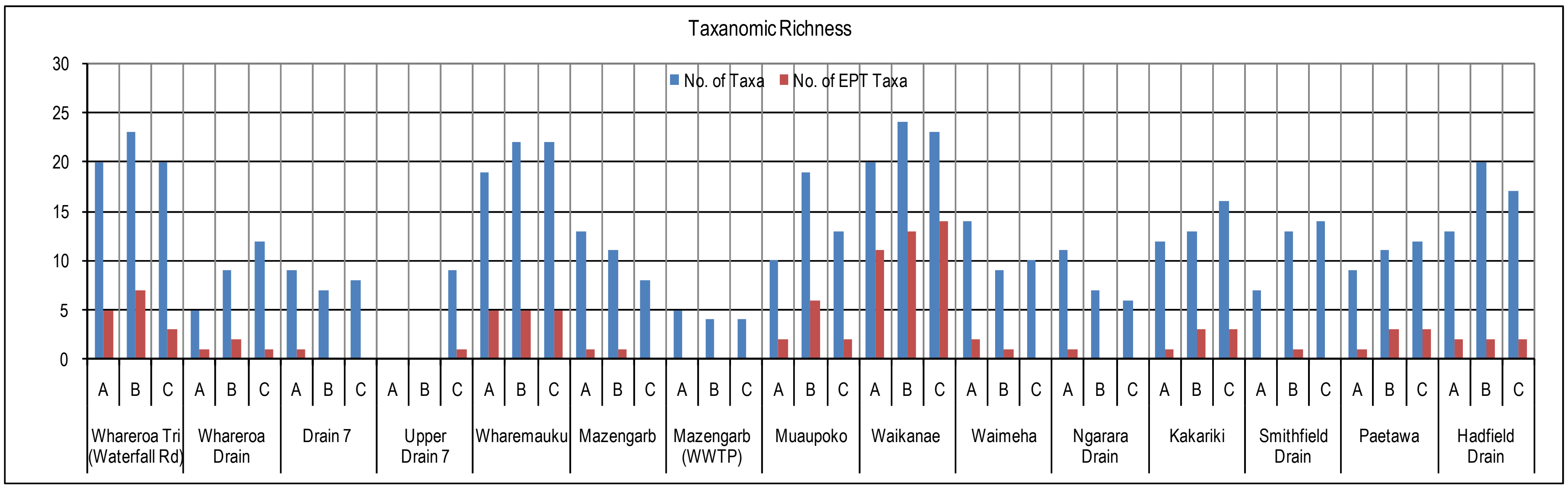
Gyraulus															
Hyridella															
Latia															
Lymnaeidae								1							
Melanopsis															
Physa = Physella										1	1				
Potamopyrgus	315	81	90	76	86	65				952	2100	294	20	15	20
Sphaeriidae	14	24	36	2						1		6			
Bryozoa															
Hirudinea							2	21	13						
Nematoda															
Nematomorpha															
Nemertea															
Oligochaeta	11	21	3	8	8	2	3		20			10	3	11	4
Platyhelminthes															
Polychaeta															
Rhabdocoela															
Tardigrada															
COELENTERATA															
Hydra															

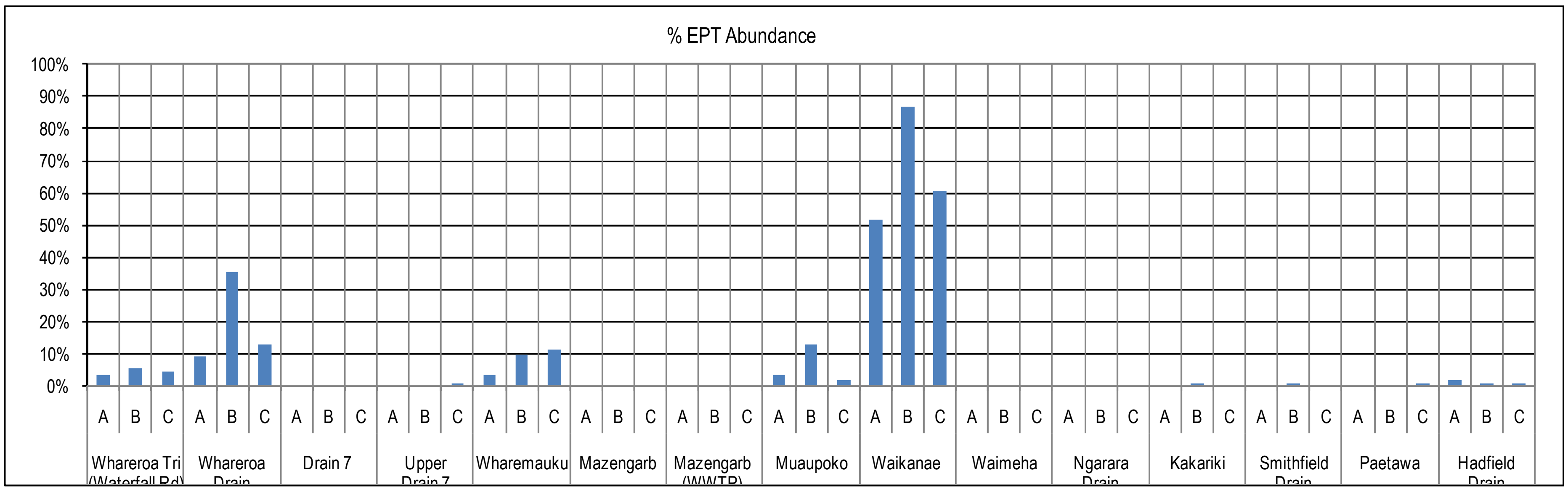
Appendix 30.H

Macro-Invertebrate Analysis (Detail)

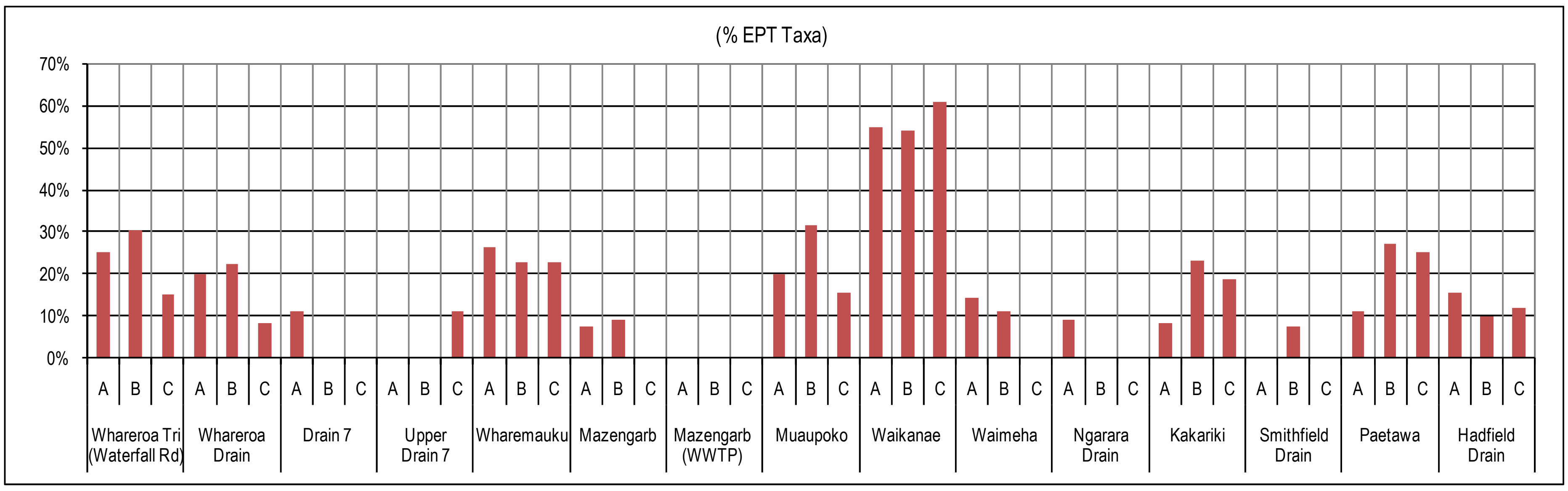
APPENDIX 30.H MACRO-INVERTEBRATE ANALYSIS (DETAIL)



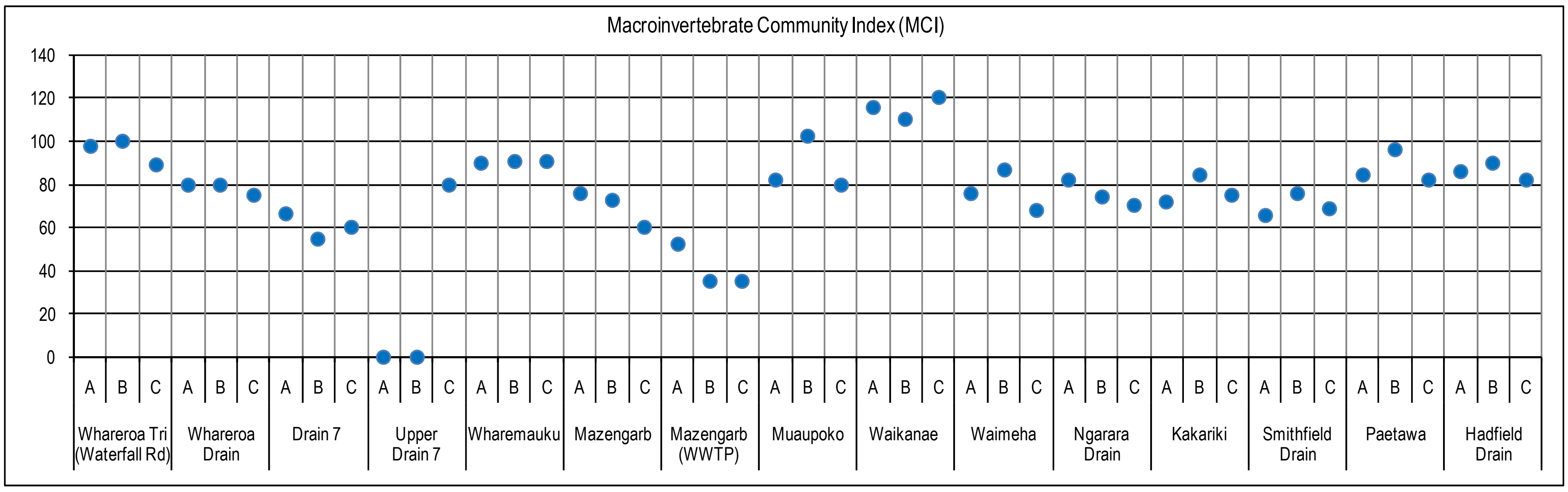


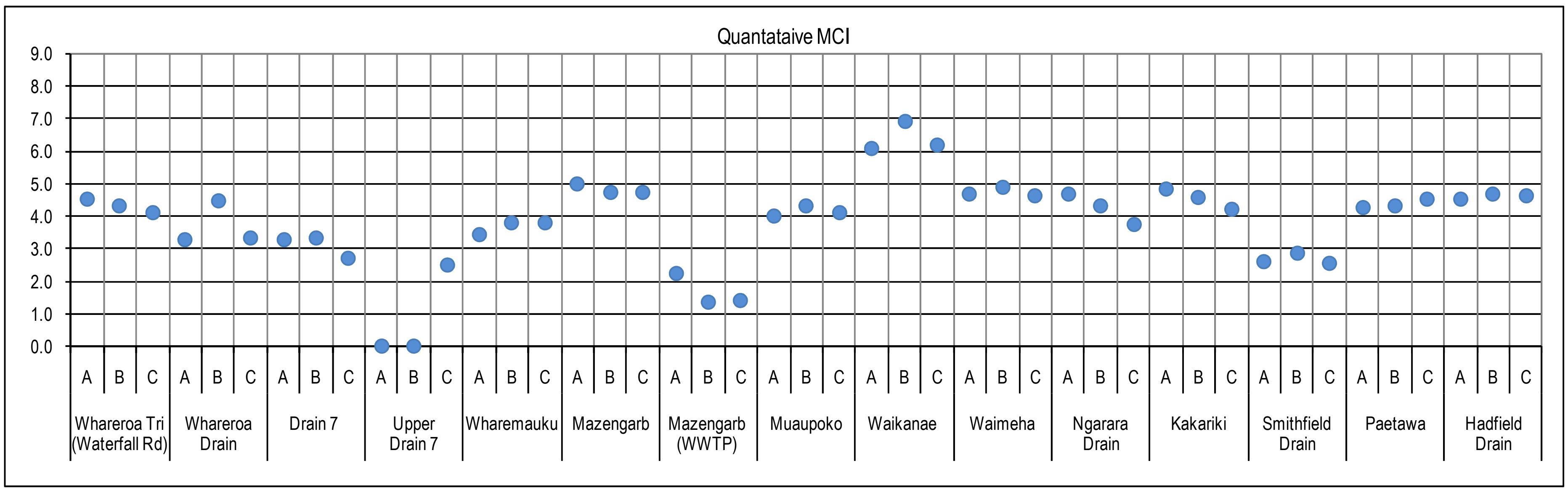


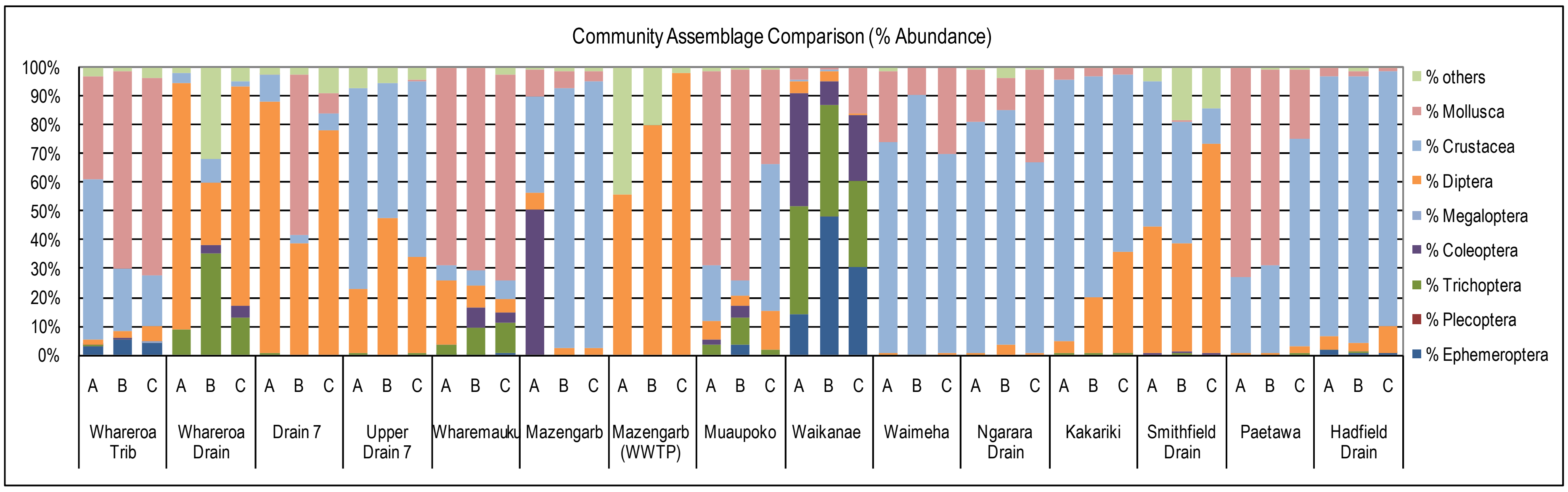
% EPT Abundance
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Whareroa Tri (Waterfall Rd)
Whareroa Drain
Drain 7
Upper Drain 7
Wharemauku
Mazengarb
Mazengarb (WWTP)
Muaupoko
Waikanae
Waimeha
Ngarara Drain
Kakariki
Smithfield Drain
Paetawa
Hadfield Drain

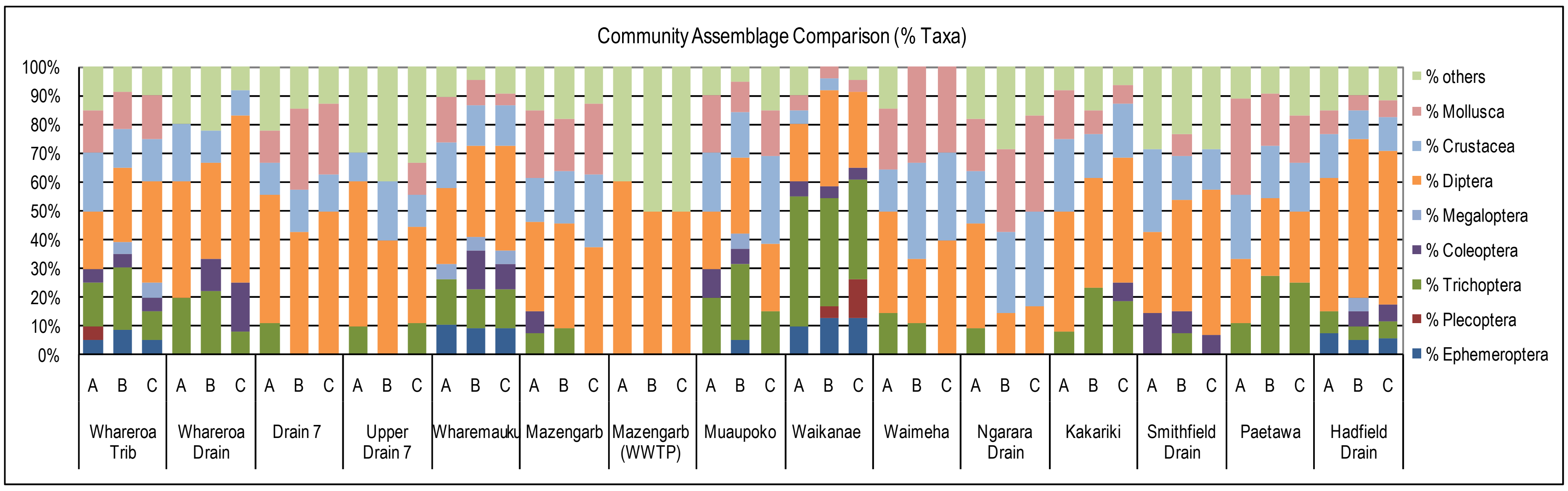


(% EPT Taxa)
70%
60%
50%
40%
30%
20%
10%
0%
Whareroa Tri (Waterfall Rd)
Whareroa Drain
Drain 7
Upper Drain 7
Wharemauku
Mazengarb
Mazengarb (WWTP)
Muaupoko
Waikanae
Waimeha
Ngarara Drain
Kakariki
Smithfield Drain
Paetawa
Hadfield Drain


Macroinvertebrate Community Index (MCI)
140
120
100
80
60
40
20
0
A B C
Whareroa Tri (Waterfall Rd)
Whareroa Drain
Drain 7
Upper Drain 7
Wharemauku
Mazengarb
Mazengarb (WWTP)
Muaupoko
Waikanae
Waimeha
Ngarara Drain
Kakariki
Smithfield Drain
Paetawa
Hadfield Drain


Quantataive MCI
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
A B C
Whareroa Tri (Waterfall Rd)
Whareroa Drain
Drain 7
Upper Drain 7
Wharemauku
Mazengarb
Mazengarb (WWTP)
Muaupoko
Waikanae
Waimeha
Ngarara Drain
Kakariki
Smithfield Drain
Paetawa
Hadfield Drain


Community Assemblage Comparison (% Abundance)
% others
% Mollusca
% Crustacea
% Diptera
% Megaloptera
% Coleoptera
% Trichoptera
% Plecoptera
% Ephemeroptera
Whareroa Trib
Whareroa Drain
Drain 7
Upper Drain 7
Wharemauku
Mazengarb
Mazengarb (WWTP)
Muaupoko
Waikanae
Waimeha
Ngarara Drain
Kakariki
Smithfield Drain
Paetawa
Hadfield Drain


Community Assemblage Comparison (% Taxa)
% others
% Mollusca
% Crustacea
% Diptera
% Megaloptera
% Coleoptera
% Trichoptera
% Plecoptera
% Ephemeroptera
Whareroa Trib
Whareroa Drain
Drain 7
Upper Drain 7
Wharemauku
Mazengarb
Mazengarb (WWTP)
Muaupoko
Waikanae
Waimeha
Ngarara Drain
Kakariki
Smithfield Drain
Paetawa
Hadfield Drain

Appendix 30.I

Sev Scores and Calculation Sheets

APPENDIX 30.I SEV SCORES AND CALCULATION SHEETS

Stream	Reference Site	Current (SEVi-C & SEVm-C)	Potential (SEVi-P)	Impact Culvert (SEVi-I)	Impact Armour (SEVi-I)	Impact Diversion (SEVi-I)	Mitigate Potential Culvert (SEVm-P)	Mitigate Potential Armour (SEVm-P)	Mitigate Potential Divert (SEVm-P)	ECR CULVERT	ECR ARMOUR	ECR DIVERT
Whareroa Tributary	0.783	0.544	0.612	0.451	0.475	0.000	0.612	0.612	0.762	3.519	3.012	1.205
Whareroa Drain	0.783	0.283	0.390	0.225	0.256	0.000	0.390	0.390	0.575	2.305	1.863	1.019
Drain 7 (Lower)	0.783	0.362	0.485	0.236	0.360	0.000	0.485	0.485	0.673	3.034	1.517	1.080
Drain 7 (Upper)	0.783	0.304	0.537	0.345	0.384	0.000	0.537	0.537	0.652	1.234	0.989	1.237
Wharemauku Stream	0.783	0.437	0.537	0.371	0.402	0.000	0.537	0.537	0.568	2.490	2.022	1.417
Mazengarb Stream	0.783	0.373	0.494	0.326	0.395	0.000	0.494	0.494	0.580	2.079	1.220	1.277
Mazengarb Drain (WWTP)	0.783	0.389	0.500	0.307	0.379	0.000	0.500	0.500	0.581	2.613	1.641	1.291
Muaupoku Stream	0.783	0.480	0.619	0.388	0.478	0.000	0.619	0.619	0.677	2.500	1.522	1.370
Waikanae River	0.783	0.664	0.712	0.446	0.551	0.000	0.712	0.712	0.784	8.296	5.014	1.363
Waimeha Stream	0.783	0.341	0.424	0.223	0.362	0.000	0.424	0.424	0.644	3.641	1.122	0.988
Ngarara Creek	0.783	0.291	0.441	0.274	0.380	0.000	0.441	0.441	0.673	1.672	0.612	0.984
Kakariki Stream	0.783	0.454	0.523	0.358	0.448	0.000	0.523	0.523	0.716	3.597	1.634	1.095
Smithfield Drain	0.783	0.381	0.456	0.293	0.297	0.000	0.456	0.456	0.747	3.259	3.189	0.915
Paetawa Drain	0.783	0.491	0.594	0.366	0.480	0.000	0.594	0.594	0.650	3.333	1.659	1.369
Hadfield / Kowhai	0.783	0.395	0.575	0.282	0.349	0.000	0.575	0.575	0.657	2.444	1.890	1.313

Function category	Function	Worksheet #	Variable (code)	KC Ref 1	Hadfields Drain/Kowhai	Paetawa Drain	Smithfield Drain	Kakariki
		1	Vbed	1.00	1.00	0.54	0.50	0.50
		2	Verosn	1.00	0.70	1.00	0.20	0.70
		30	Vimper	1.00	0.50	1.00	0.30	1.00
Hydraulic	**NFR**		=	**1.00**	**0.43**	**0.77**	**0.11**	**0.60**
		14	Vfpwidth	1.00	0.00	0.70	1.00	0.40
		3	Vfreq	0.10	0.40	0.40	0.80	0.40
Hydraulic	**CFP**		=	**0.55**	**0.20**	**0.55**	**0.90**	**0.40**
		4	Vbarr	1.00	0.00	0.30	0.30	1.00
		31	Vcatch	1.00	1.00	1.00	1.00	1.00
Hydraulic	**CSM**		=	**1.00**	**0.00**	**0.30**	**0.30**	**1.00**
		1	Vbed	1.00	1.00	0.54	0.50	0.50
Hydraulic	**CGW**		=	**1.00**	**1.00**	**0.54**	**0.50**	**0.50**
			Hydraulic function mean score	**0.89**	**0.41**	**0.54**	**0.45**	**0.63**
		18	Vshade	0.94	0.51	0.95	0.01	0.70
		15	Vdepth	1.00	0.80	0.70	0.80	0.80
		22	Vveloc	0.90	0.90	1.00	1.00	1.00
		21	Vlength	0.40	0.80	0.40	0.80	0.40
biogeochemical	**WTC**		=	**0.85**	**0.67**	**0.83**	**0.44**	**0.72**
		5	Vdod	1.00	0.51	0.25	0.04	0.15
biogeochemical	**DOM**		=	**1.00**	**0.51**	**0.25**	**0.04**	**0.15**
		19	Vcanop	0.85	0.54	0.06	0.00	0.20
		20	Vdecid	0.94	0.45	0.00	0.00	0.50
biogeochemical	**OMI**		=	**0.45**	**0.42**	**0.06**	**0.00**	**0.15**
		23	Vtrans	0.10	1.00	1.00	1.00	1.00
		24	Vretain	0.02	1.00	0.40	1.00	0.30
biogeochemical	**IPR**		=	**0.00**	**1.00**	**0.40**	**1.00**	**0.30**
		16	Vsurf	1.00	0.10	0.80	0.06	0.30
biogeochemical	**DOP**		=	**1.00**	**0.10**	**0.80**	**0.06**	**0.30**
		14	Vfpwidth	1.00	0.00	0.70	1.00	0.40
		6	Vrough	1.00	0.10	0.70	0.70	0.70
		3	Vfreq	0.10	0.40	0.40	0.80	0.40
biogeochemical	**FPR**		=	**0.70**	**0.17**	**0.60**	**0.83**	**0.50**
			Biogeochemical function mean score	**0.67**	**0.48**	**0.49**	**0.39**	**0.35**
		9	Vgalspwn	1.00	0.00	1.00	1.00	0.00
		10	Vgalqual	1.00	0.25	0.25	0.75	0.75
		17	Vgobspwn	1.00	0.10	0.80	0.10	0.80
habitat provision	**FSH**		=	**1.00**	**0.05**	**0.53**	**0.43**	**0.40**
		7	Vphyshab	1.00	0.48	0.19	0.37	0.30
		8	Vwatqual	0.72	0.26	0.90	0.00	0.70
		30	Vimper	1.00	0.50	1.00	0.30	1.00
habitat provision	**HAF**		=	**0.93**	**0.43**	**0.57**	**0.26**	**0.58**
			Habitat provision function mean score	**0.97**	**0.24**	**0.55**	**0.34**	**0.49**
		28	Vfish	0.60	0.30	0.50	0.30	0.60
Biodiversity	**FFI**		=	**0.60**	**0.30**	**0.50**	**0.30**	**0.60**
		25	Vmci	0.70	0.30	0.30	0.10	0.10

		26	Vept	1.00	0.40	0.22	0.10	0.11
Biodiversity	**IFI**		=	**0.85**	**0.35**	**0.26**	**0.10**	**0.11**
		29	Vvert	0.60	0.30	0.50	0.30	0.60
		27	Vinvert	1.00	0.59	0.52	0.64	0.40
Biodiversity	**ABI**		=	**0.80**	**0.44**	**0.51**	**0.47**	**0.50**
		11	Vripcond	0.60	0.10	0.10	0.30	0.30
		12	Vripconn	1.00	0.20	1.00	0.80	1.00
		13	Vripar	0.80	0.50	0.10	0.00	0.10
Biodiversity	**RVI**		=	**0.80**	**0.27**	**0.40**	**0.37**	**0.47**
			Biodiversity function mean score	**0.76**	**0.34**	**0.42**	**0.31**	**0.42**
Sum of scores (maximum value 16)				**12.54**	**6.33**	**7.86**	**6.10**	**7.26**
Overall mean SEV score (maximum value 1)				**0.783**	**0.395**	**0.491**	**0.381**	**0.454**

Function category	**Function**	**Worksheet #**	**Variable (code)**	**Ngarara Drain**	**Waimeha**	**Waikanae**	**Muaupoku Stream**	
		1	Vbed	0.50	0.50	1.00	0.70	
		2	Verosn	0.20	0.70	1.00	0.70	
		30	Vimper	0.70	1.00	1.00	1.00	
Hydraulic	**NFR**		=	**0.25**	**0.60**	**1.00**	**0.70**	
		14	Vfpwidth	0.00	0.00	0.40	0.00	
		3	Vfreq	0.40	0.40	0.80	0.40	
Hydraulic	**CFP**		=	**0.20**	**0.20**	**0.60**	**0.20**	
		4	Vbarr	1.00	0.00	1.00	0.30	
		31	Vcatch	1.00	1.00	1.00	1.00	
Hydraulic	**CSM**		=	**1.00**	**0.00**	**1.00**	**0.30**	
		1	Vbed	0.50	0.50	1.00	0.70	
Hydraulic	**CGW**		=	**0.50**	**0.50**	**1.00**	**0.70**	
			Hydraulic function mean score	**0.49**	**0.33**	**0.90**	**0.48**	
		18	Vshade	0.10	0.20	0.11	0.40	
		15	Vdepth	0.60	1.00	1.00	1.00	
		22	Vveloc	1.00	1.00	0.90	1.00	
		21	Vlength	0.40	0.40	0.40	0.40	
biogeochemical	**WTC**		=	**0.38**	**0.50**	**0.44**	**0.60**	
		5	Vdod	0.00	0.20	1.00	1.00	
biogeochemical	**DOM**		=	**0.00**	**0.20**	**1.00**	**1.00**	
		19	Vcanop	0.18	0.10	0.07	0.32	
		20	Vdecid	0.12	0.80	1.00	0.05	
biogeochemical	**OMI**		=	**0.17**	**0.06**	**0.03**	**0.31**	
		23	Vtrans	0.10	1.00	0.10	0.10	
		24	Vretain	0.20	0.20	0.04	0.02	
biogeochemical	**IPR**		=	**0.15**	**0.20**	**0.00**	**0.00**	
		16	Vsurf	0.30	0.80	0.18	0.13	
biogeochemical	**DOP**		=	**0.30**	**0.80**	**0.18**	**0.13**	
		14	Vfpwidth	0.00	0.00	0.40	0.00	

		6	Vrough	0.70	0.01	0.40	0.70	
		3	Vfreq	0.40	0.40	0.80	0.40	
biogeochemical	**FPR**		=	**0.37**	**0.14**	**0.53**	**0.37**	
			Biogeochemical function mean score	**0.23**	**0.32**	**0.36**	**0.40**	
		9	Vgalspwn	0.00	0.25	1.00	1.00	
		10	Vgalqual	0.25	0.25	1.00	0.75	
		17	Vgobspwn	0.10	0.80	1.00	1.00	
habitat provision	**FSH**		=	**0.05**	**0.43**	**1.00**	**0.88**	
		7	Vphyshab	0.41	0.35	0.66	0.44	
		8	Vwatqual	0.50	0.10	0.56	0.30	
		30	Vimper	1.00	1.00	1.00	1.00	
habitat provision	**HAF**		=	**0.58**	**0.45**	**0.72**	**0.55**	
			Habitat provision function mean score	**0.31**	**0.44**	**0.86**	**0.71**	
		28	Vfish	0.20	0.50	0.50	0.53	
Biodiversity	**FFI**		=	**0.20**	**0.50**	**0.50**	**0.53**	
		25	Vmci	0.10	0.10	1.00	0.30	
		26	Vept	0.10	0.00	1.00	0.54	
Biodiversity	**IFI**		=	**0.10**	**0.05**	**1.00**	**0.42**	
		29	Vvert	0.20	0.50	0.50	0.53	
		27	Vinvert	0.10	0.10	1.00	0.72	
Biodiversity	**ABI**		=	**0.15**	**0.30**	**0.75**	**0.63**	
		11	Vripcond	0.10	0.60	0.60	0.10	
		12	Vripconn	0.50	0.50	1.00	0.80	
		13	Vripar	0.20	0.50	1.00	0.20	
Biodiversity	**RVI**		=	**0.27**	**0.53**	**0.87**	**0.37**	
			Biodiversity function mean score	**0.18**	**0.35**	**0.78**	**0.49**	
Sum of scores (maximum value 16)				**4.66**	**5.46**	**10.63**	**7.68**	
Overall mean SEV score (maximum value 1)				**0.291**	**0.341**	**0.664**	**0.480**	
Function category	**Function**	**Worksheet #**	**Variable (code)**	**Mazengarb (WWTP)**	**Mazengarb Stream**	**Wharmauku**	**Upper Drain 7**	
		1	Vbed	0.50	0.52	0.10	0.50	
		2	Verosn	0.20	1.00	1.00	0.20	
		30	Vimper	0.50	1.00	1.00	0.90	
Hydraulic	**NFR**		=	**0.18**	**0.76**	**0.55**	**0.32**	
		14	Vfpwidth	0.00	0.70	0.00	1.00	
		3	Vfreq	0.40	0.10	1.00	0.10	
Hydraulic	**CFP**		=	**0.20**	**0.40**	**0.50**	**0.55**	
		4	Vbarr	0.00	0.30	1.00	0.30	
		31	Vcatch	1.00	1.00	1.00	1.00	

Hydraulic	**CSM**		**=**	**0.00**	**0.30**	**1.00**	**0.30**	
		1	Vbed	0.50	0.52	0.10	0.50	
Hydraulic	**CGW**		**=**	**0.50**	**0.52**	**0.10**	**0.50**	
			Hydraulic function mean score	**0.22**	**0.50**	**0.54**	**0.42**	
		18	Vshade	1.00	0.27	0.30	0.09	
		15	Vdepth	0.80	1.00	0.80	1.00	
		22	Vveloc	0.80	0.90	1.00	1.00	
		21	Vlength	0.40	0.40	0.40	0.80	
biogeochemical	**WTC**		**=**	**0.83**	**0.52**	**0.52**	**0.51**	
		5	Vdod	0.70	0.29	0.32	0.00	
biogeochemical	**DOM**		**=**	**0.70**	**0.29**	**0.32**	**0.00**	
		19	Vcanop	0.99	0.44	0.30	0.04	
		20	Vdecid	0.40	0.30	0.00	0.27	
biogeochemical	**OMI**		**=**	**0.79**	**0.37**	**0.30**	**0.03**	
		23	Vtrans	0.40	0.10	0.70	1.00	
		24	Vretain	1.00	0.02	0.20	1.00	
biogeochemical	**IPR**		**=**	**0.40**	**0.00**	**0.14**	**1.00**	
		16	Vsurf	0.16	0.17	0.70	0.06	
biogeochemical	**DOP**		**=**	**0.16**	**0.17**	**0.70**	**0.06**	
		14	Vfpwidth	0.00	0.70	0.00	1.00	
		6	Vrough	0.40	0.70	0.28	0.16	
		3	Vfreq	0.40	0.10	1.00	0.10	
biogeochemical	**FPR**		**=**	**0.27**	**0.50**	**0.43**	**0.42**	
			Biogeochemical function mean score	**0.53**	**0.31**	**0.40**	**0.34**	
		9	Vgalspwn	0.00	0.00	0.50	0.00	
		10	Vgalqual	0.25	0.75	0.75	0.25	
		17	Vgobspwn	1.00	1.00	0.10	0.10	
habitat provision	**FSH**		**=**	**0.50**	**0.50**	**0.24**	**0.05**	
		7	Vphyshab	0.57	0.56	0.30	0.07	
		8	Vwatqual	0.42	0.07	0.40	0.00	
		30	Vimper	0.50	1.00	1.00	0.90	
habitat provision	**HAF**		**=**	**0.52**	**0.55**	**0.50**	**0.26**	
			Habitat provision function mean score	**0.51**	**0.52**	**0.37**	**0.15**	
		28	Vfish	0.37	0.37	0.47	0.30	
Biodiversity	**FFI**		**=**	**0.37**	**0.37**	**0.47**	**0.30**	
		25	Vmci	0.00	0.10	0.30	0.00	
		26	Vept	0.00	0.00	0.67	0.09	
Biodiversity	**IFI**		**=**	**0.00**	**0.05**	**0.48**	**0.05**	
		29	Vvert	0.37	0.37	0.47	0.30	
		27	Vinvert	0.00	0.10	0.84	0.14	
Biodiversity	**ABI**		**=**	**0.18**	**0.23**	**0.65**	**0.22**	
		11	Vripcond	0.10	0.30	0.30	0.60	

		12	Vripconn	0.80	0.80	0.00	0.20	
		13	Vripar	1.00	0.20	0.00	0.10	
Biodiversity	**RVI**		**=**	**0.63**	**0.43**	**0.10**	**0.30**	
			Biodiversity function mean score	**0.30**	**0.27**	**0.43**	**0.22**	
Sum of scores (maximum value 16)				**6.23**	**5.96**	**6.99**	**4.87**	
Overall mean SEV score (maximum value 1)				**0.389**	**0.373**	**0.437**	**0.304**	
Function category	**Function**	**Worksheet #**	**Variable (code)**	**KC Ref 1**	**Drain 7**	**Whareroa Drain**	**Whareroa Trib**	
		1	Vbed	1.00	0.50	0.50	0.50	
		2	Verosn	1.00	0.20	0.20	0.70	
		30	Vimper	1.00	1.00	1.00	1.00	
Hydraulic	**NFR**		**=**	**1.00**	**0.35**	**0.35**	**0.60**	
		14	Vfpwidth	1.00	0.00	0.00	1.00	
		3	Vfreq	0.10	0.80	0.40	0.80	
Hydraulic	**CFP**		**=**	**0.55**	**0.40**	**0.20**	**0.90**	
		4	Vbarr	1.00	0.30	0.00	1.00	
		31	Vcatch	1.00	1.00	1.00	1.00	
Hydraulic	**CSM**		**=**	**1.00**	**0.30**	**0.00**	**1.00**	
		1	Vbed	1.00	0.50	0.50	0.50	
Hydraulic	**CGW**		**=**	**1.00**	**0.50**	**0.50**	**0.50**	
			Hydraulic function mean score	**0.89**	**0.39**	**0.26**	**0.75**	
		18	Vshade	0.94	0.55	0.45	0.06	
		15	Vdepth	1.00	0.70	0.80	1.00	
		22	Vveloc	0.90	0.80	1.00	0.90	
		21	Vlength	0.40	0.40	0.40	0.40	
biogeochemical	**WTC**		**=**	**0.85**	**0.59**	**0.59**	**0.41**	
		5	Vdod	1.00	0.28	0.10	0.31	
biogeochemical	**DOM**		**=**	**1.00**	**0.28**	**0.10**	**0.31**	
		19	Vcanop	0.85	0.50	0.10	0.12	
		20	Vdecid	0.94	0.10	0.20	0.08	
biogeochemical	**OMI**		**=**	**0.45**	**0.48**	**0.09**	**0.12**	
		23	Vtrans	0.10	0.70	1.00	1.00	
		24	Vretain	0.02	0.20	0.20	1.00	
biogeochemical	**IPR**		**=**	**0.00**	**0.14**	**0.20**	**1.00**	
		16	Vsurf	1.00	0.20	1.00	0.49	
biogeochemical	**DOP**		**=**	**1.00**	**0.20**	**1.00**	**0.49**	
		14	Vfpwidth	1.00	0.00	0.00	1.00	
		6	Vrough	1.00	0.55	0.34	0.40	
		3	Vfreq	0.10	0.80	0.40	0.80	
biogeochemical	**FPR**		**=**	**0.70**	**0.45**	**0.25**	**0.73**	
			Biogeochemical function mean	**0.67**	**0.36**	**0.37**	**0.51**	

			score					
		9	Vgalspwn	1.00	0.00	1.00	0.50	
		10	Vgalqual	1.00	0.25	0.25	0.75	
		17	Vgobspwn	1.00	1.00	0.10	0.10	
habitat provision	**FSH**		**=**	**1.00**	**0.50**	**0.18**	**0.24**	
		7	Vphyshab	1.00	0.31	0.10	0.48	
		8	Vwatqual	0.72	0.40	0.20	0.04	
		30	Vimper	1.00	1.00	1.00	0.10	
habitat provision	**HAF**		**=**	**0.93**	**0.51**	**0.35**	**0.27**	
			Habitat provision function mean score	**0.97**	**0.50**	**0.26**	**0.26**	
		28	Vfish	0.60	0.20	0.27	0.43	
Biodiversity	**FFI**		**=**	**0.60**	**0.20**	**0.27**	**0.43**	
		25	Vmci	0.70	0.10	0.3	0.70	
		26	Vept	1.00	0.20	0.10	0.80	
Biodiversity	**IFI**		**=**	**0.85**	**0.15**	**0.20**	**0.75**	
		29	Vvert	0.60	0.30	0.20	0.43	
		27	Vinvert	1.00	0.40	0.10	0.86	
Biodiversity	**ABI**		**=**	**0.80**	**0.35**	**0.15**	**0.65**	
		11	Vripcond	0.60	0.10	0.10	0.30	
		12	Vripconn	1.00	1.00	0.20	0.50	
		13	Vripar	0.80	0.10	0.00	0.10	
Biodiversity	**RVI**		**=**	**0.80**	**0.40**	**0.10**	**0.30**	
			Biodiversity function mean score	**0.76**	**0.28**	**0.18**	**0.53**	
Sum of scores (maximum value 16)				**12.54**	**5.79**	**4.52**	**8.70**	
Overall mean SEV score (maximum value 1)				**0.783**	**0.362**	**0.283**	**0.544**	

Appendix 30.J

Bml Field Study Water Quality Results

APPENDIX 30.J BML FIELD STUDY WATER QUALITY RESULTS

	Temp (oC)	pH	Turbidity (NTU)	TSS (g/m3)	DO (ppm)
Hadfield Kowhai Stream	21.00	7.74	0.60	5.00	1.33
	21.00	7.69	0.00	6.00	1.49
	21.00	7.67	0.00	5.00	0.19
Paetawa Drain	15.40	7.33	10.10	16.00	7.65
	15.20	6.87	3.40	12.00	7.12
	15.20	6.73	3.70	14.00	6.64
Smithfield Drain	17.40	6.43	22.40	137.00	0.39
	17.40	6.35	23.80	170.00	0.38
	17.40	6.34	18.70	146.00	0.37
Kakariki Stream	13.80	8.04	6.70	39.00	7.41
	13.80	7.88	6.80	39.00	7.22
	13.80	7.79	6.90	43.00	7.20
Ngarara Drain	14.60	7.30	377.00	121.00	9.52
	14.60	7.05	1,897.00	126.00	5.90
	14.60	6.62	2,365.00	141.00	5.09
Waimeha Stream	15.00	7.15	4.20	35.00	10.69
	15.00	6.72	2.90	37.00	9.62
	15.00	6.59	4.00	35.00	9.61
Waikanae Stream	15.40	7.33	10.10	16.00	7.65
	15.20	6.87	3.40	12.00	7.12
	15.20	6.73	3.70	14.00	6.64
Muaupoko Stream	23.30	7.79	23.30	16.00	7.33
	23.00	7.80	23.00	19.00	7.28
	23.00	7.80	23.00	17.00	7.28
Mazengarb (WWTP)	27.20	7.88	6.00	6.00	6.40
	27.20	7.88	6.30	7.00	6.43
	27.10	7.86	2.80	6.00	6.87
Mazengarb Stream	26.90	7.88	6.00	13.00	2.50
	26.90	7.89	5.00	16.00	1.88
	26.90	7.89	5.30	14.00	2.19
Wharemauku Stream	23.00	7.82	21.00	24.00	7.26
	23.00	7.80	30.00		7.28
	23.00	7.79	23.30		7.33
Lower Drain 7	23.10	7.73	207.00	38.00	5.17
	22.60	7.79	728.00	36.00	4.92
	23.10	7.81		33.00	4.30
Upper Drain 7	15.40	7.00	14.80	81.00	0.41
	15.50	6.37	15.60	84.00	0.41

	15.60	6.00	14.60	82.00	0.35
Whareroa Drain	15.90	4.02	2328.00	141	4.89
	15.60	3.63	644.00	117	2.42
	15.60	2.15	600.00	132	2.15
Whareroa Trib	9.60	9.88	108.70	114.00	0.07
	9.30	9.75	3.70	66.00	0.10
	9.40	9.49	22.70	72.00	0.07