Kingett Mitchell Ltd
RESOURCE & ENVIRONMENTAL CONSULTANTS

AQUATIC ECOLOGY AND STREAM MANAGEMENT GROUPS FOR URBAN STREAMS IN THE WELLINGTON REGION

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on behalf of

Wellington Regional Council

prepared by

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Executive Summary

This report presents the results of an investigation of Wellington urban and peri-urban streams from catchments within Wellington City, Porirua City, Lower and Upper Hutt City and the Kapiti Coast District Council. The ecology of each of these regulatory areas is included in separate sections of the report.

Sixty-one sites were sampled for aquatic macroinvertebrates and assessments of periphyton cover, instream habitat, riparian vegetation and bank erosion were also made. Five stream management groups were identified based on aquatic macroinvertebrate communities:

- Stream Management 1 (SM1) - Natural or forested.
- Stream Management 2 (SM2) - Natural semi-modified.
- Stream Management 3 (SM3) - Urban and rural modified.
- Stream Management 4 (SM4) - Urban modified.

SM1 is represented by the forested and unmodified upper catchments, SM2 by streams with either minor landuse modifications, or highly maintained stream sections within largely urbanised catchments (e.g., reserves). SM3 is represented by mid-catchment rural and urban large-sized streams, SM4 by urban modified streams and SM5 by lower catchment urbanised streams.

An environmental quality gradient was apparent with generally decreasing aquatic ecological condition from SM1 to SM3. Pollution sensitive ‘clean water’ type macroinvertebrate taxa dominated the benthic fauna in SM1 and SM2 streams while snails, worms and crustacean dominated the remaining steam groups in the Wellington region.

Recommended aquatic management of Wellington urban streams is based on the five stream types. Ecosystem objectives are recommended for each stream type along with suggested actions to achieve these objectives.

Table of Contents

List of Tables

List of Figures

Document Quality Assurance

This report has been prepared in accordance with Kingett Mitchell quality assurance procedures. All relevant quality control information in relation to biological and/or environmental data is identified within the document. The report has been reviewed and is approved for release as set out below.

	Name	**Signature**
Project Manager		
Project Reviewer		
Director approval for release		
Revision Status	**Description**	**Date**

1. Introduction

Urban waterways are the natural, modified and built freshwater systems existing in towns and cities. Increasing pressure on existing and currently unmodified waterways within the Wellington region is expected through growth and economic development. Amongst the major pressures placed on Wellington's waterways are steep with high catchment imperviousness and associated stormwater runoff, contaminated site leachate, wastewater overflows and industrial discharges. In addition, there is increasing pressure on the periphery of the City (peri-urban areas) as new subdivisions and development takes place.

A number of stream catchments occur within the boundaries of the Wellington Regional Council (WRC), Wellington City Council (WCC), Porirua City Council (PCC), Kapiti Coast District Council (KCDC), and Lower and Upper Hutt District Councils (LHCC and UPDC respectively). Little is known of the ecological health of many of these catchments particularly those that have undergone modification through urbanisation and other developments. Changes to landuse, has placed greater pressure on the ability of these streams to sustain their condition and health (i.e., ecological, water quality and habitat).

Increasing pressure by local communities, resource developments, land use changes and particularly stormwater discharges have focused attention on the health and condition of streams in the region. This attention has resulted in new policy and plans by the Regional and City Councils (e.g., 'Wet and Wild' plan by Wellington City Council 2002). These urban and semi-urban streams are often seen as important and attractive elements of the local landscape, as well as providing some essential services to communities.

This report presents an investigation of the ecological characteristics of several urban and peri-urban streams of the Wellington region. The investigation has occurred over two summer periods as a Phase I (Wellington and Porirua City streams) and Phase II (Hutt Valley and Kapiti Coast streams). The focus of the investigation has been an assessment of the ecological and habitat condition of the streams, and the development of an appropriate framework for stream management in the region.

2. Scope and Layout of Report

2.1 Objectives

The programme of work aimed to address the following key elements:

- What are the significant ecological characteristics of Wellington urban and peri-urban streams?

- How does the degree of development affect the ecological characteristics of the streams?
- What streams/locations require greater protection for ecology than other areas?
- What are appropriate ecological management objectives for the streams/catchments?

These questions have been addressed through the following programme of work:

a) An overview of the aquatic ecological resources of the urban and peri-urban streams of the Wellington region.

b) Collection of additional data and information from a range of urban and peri-urban streams. Rapid biological and habitat assessments were used.

c) Analysis of data to:

    1. Define the aquatic, habitat and riparian ecological characteristics of each stream catchment with reference to regional and national characteristics (e.g., inventories, commonness, rarity) and physical and chemical conditions.
    2. Define the stream categories in the region.
    3. Summarise stream type and characteristics to provide information for management evaluations (e.g., scarcity and frequency of occurrence of biota, diversity, priority setting, inventories and regional stream description).
    4. Assess information on catchment use, demand, development and future potential for development and rank streams/catchments to distinguish high valued streams from poorer quality habitats for management purposes.

d) Develop instream objectives for catchment management with recommendations for mitigation, enhancement and restoration as appropriate.

2.2 Layout of Report

Following the introductory sections (Sections 1-2), Section 3 presents a brief overview of the effects of urbanisation on freshwater ecosystems. This section serves to introduce some of the existing knowledge on urbanisation effects and some key concepts before the assessment of the Wellington urban streams is presented. Section 4 introduces the urban and peri-urban streams of the Wellington and Porirua City regions with some brief information on their location and landuse characteristics. Section 5-6 provides some background to the existing information known for the Wellington and Porirua streams, and Sections 6-9 presents an assessment of the ecology of Wellington and Porirua City streams, including hydrology and water quality.

Sections 10-11 provide the assessment of the Hutt Valley streams, and Kapiti Coast streams respectively, and key ecological characteristics of all streams sampled from the western Wellington region are discussed in Section 12.

Management of urban and peri-urban streams of Wellington is provided in Sections 13–15. Section 13 introduces stream Classification, while Section 14 provides an overview of some of the difficulties associated with stream restoration. Instream management objectives are introduced in section 15 while Section 16 provides Instream management objectives and guidance for Wellington urban and peri-urban streams. Concluding remarks are provided in Section 17.

3. Impacts of Urbanisation on Freshwater Ecosystems

3.1 Hydrology

Urbanisation leads to an increase in the area of impervious surfaces (e.g., roads, roofs and carparks) in a catchment and the development of drainage systems that rapidly transport rainwater run-off into waterways and decrease the infiltration of rainwater into underlying groundwater systems (Leopold 1968; Walsh et al. 2001). Consequently, surface water is quickly transported to nearby waterways. This rapid transportation of stormwater reduces groundwater retention and lowers the baseflow conditions for urbanised streams and increases flood peaks (Fig. 3.1) (Moscrip & Montgomerie 1997; Timperley & Kuschel 1999).

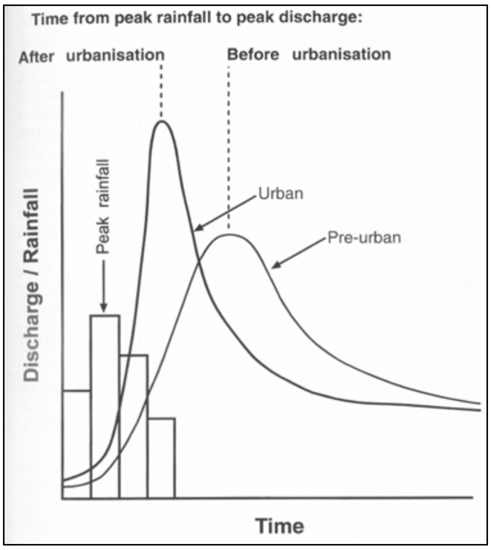

Fig. 3.1: Schematic diagram of changes to stream discharge following urbanisation.

The increased proportion of impervious surfaces in a catchment has been proposed as a general indicator of modifications to urban waterways. For example, the greater the degree of catchment imperviousness, the greater the impact on the stream biota (Schueler 1994; Arnold & Gibbons 1996). However, the efficiency of stormwater drainage systems must also be considered while investigating the efficiency of stormwater transport to nearby waterways (Leopold 1968; Walsh et al. 2001).

The conversion of natural catchments to predominantly urban systems leads to the modification of waterways using engineering solutions, which often do not incorporate the needs of the instream flora and fauna. The modification of urban waterways through channel straightening, culverting, introduction of concrete linings and the removal of instream and riparian vegetation increase the water removal efficiency from a catchment (Suren 2000). However, this modification can decrease the suitable habitat for aquatic invertebrates, fish and instream vegetation because the natural environment has been removed, baseflow conditions have been lowered and peak flows increased.

3.2 Riparian Vegetation

Urbanisation of river catchments also leads to the reduction of riparian vegetation (Timperley & Kuschel 1999), which increases the impacts from impervious surface run-off due to a reduction in the buffer zone between the land and stream environment (i.e., riparian zone) (LeBlanc et al. 1997). A reduction in a riparian strip also increases a streams direct exposure to sunlight, thereby increasing water temperatures and aquatic plant proliferation. Greater stream temperatures are often compounded by lower baseflows in relation to more impervious surfaces. Thus, elevated water temperature, which can be detrimental to aquatic life, can be a common feature of the urban stream environment.

3.3 Water Quality

Urbanisation and the associated impervious surface run-off may also complicate stream ecosystems by introducing contaminants and sediment created from urban and industrial activities. The contaminants can be deposited onto roads (e.g., Cu, Pb, Zn and PAH's), building roofs (e.g., trace metals) and other hard surfaces before being collected by run-off water in transit to nearby streams (Kingett Mitchell 2001).

Catchment imperviousness and the way in which stormwater networks are constructed are the primary determinants of stormwater quality and quantity entering waterways (Duncan 1995). Streams in urban environments often have elevated contaminant concentrations such as suspended sediment, nutrients and trace metals. However, the ultimate source of such pollutants is often overstated as the only impact on waterways, when the efficiency of pollutant transport to waterways may be equally important (Walsh et al. 2001). Therefore, the increased pollutant loading and transport efficiency constitutes impacts to urban waterways.

It is not surprising therefore, that urban stream flora and fauna show increased degradation with greater urbanisation and the macroinvertebrate fauna of urban waterways is often restricted when compared to non-urban watercourses in the same region (Davies & Hawkes 1981). Beavan et al. (2001) defined the urban river as a disturbed system with water quality problems, highly variable flow regime and modified physical habitat.

Until recently, few aquatic ecologists have turned their expertise to the urban stream environment (e.g., Suren 2000; Walsh 2000; Sonneman et al. 2001), because up until the last 20 years the primary value placed on urban waterways has been as drainage networks (PCE 2000, Walsh et al. 2001, Boothroyd 2001). This misconception of urban streams as simple conduits for the transport of stormwater off the land may explain the current paucity of suitable policy and management strategies for urban streams, and the focus on these waterways as conduits of human services (i.e., wastewater, stormwater removal).

4. Wellington City Urban and Peri-Urban Streams

4.1 Introduction

This section provides an introduction to the Wellington City streams with a brief outline of the major catchments, particularly those that have been the focus of this study. In particular, the Wellington City Council 'Wellington Wet and Wild: Bush and Streams Restoration Plan" (WCC 2002), has provided substantial background to the following catchment descriptions.

The WCC 'Wet and Wild' plan suggests five broad categories of stream catchments (Table 4.1). The 'Lost' streams category includes streams that have been fully piped or culverted, or those that have been significantly changed. These categories serve as a useful introduction to other streams of the Wellington region (e.g., Waiwhetu Stream, Horokiwi Stream, Korokoro Stream) and these are placed in the appropriate category based on landuse (Table 4.2).

4.2 Wilderness Streams

The 'wilderness' streams are those that are generally less accessible for study and use, and little information is available on their ecological and Instream values. The Oteranga Stream is heavily modified as a result of forest clearance, while the Waiariki Stream is significant for an uninterrupted altitudinal sequence from sea to montane. The Waipapa Stream is considered to be of high ecological significance.

Skerrets Creek and Wainuiomata Stream arise on the eastern slopes of the Wellington region and are predominantly native forest and/or scrub. For the purposes of the current ecological study, these two streams served as reference sites.

Table 4.1: Stream categories recognised by the 'Wet and Wild' Plan (WCC 2002).

Category	Stream catchments
Wilderness streams	Te Oterenga Stream; Waiariki Stream; other small southern streams
Rural streams	*Karori Stream (in rural area); Makara Stream; Ohariu Stream.*
Northern Streams	*Porirua Stream*
Urban streams	*Owhiro Stream; Kaiwharawhara Stream; Karori Stream (in urban area); Ngauranga Stream*.
'Lost' streams	Inner city streams, Te Aro, Mirimar Peninsula, Houghton Bay

Notes: Streams assessed as part of this current study are shown in italics.

4.3 Rural Streams

4.3.1 Lower Karori Stream

The larger Karori Stream catchment and its tributaries, with the exception of the upper reaches, has been repeatedly burnt and extensively grazed. There is a diverse native fishery in the catchment and is considered a high potential to increase the species and abundance of fish in the catchment.

4.3.2 Makara Stream

The Makara Stream and Ohariu Stream areas are both designated as having high ecological values (1984 Inventory of Biological Resources). The main Makara Stream runs through pasture with some scrub occurring above the valley flats. There is no significant indigenous vegetation along the stream and it is considered highly modified. Nevertheless, despite this modification and lack of stream edge vegetation, the Makara Stream is regarded of high ecological value and the most important of the rural/wilderness streams. It is considered that the Makara Stream and its estuary probably contain nearly all of the fish and invertebrate species found in this region of Wellington, including several species regarded as 'vulnerable' if no action is taken to sustain their populations.

4.3.3 Ohariu Stream

The Ohariu Stream is dominated by pasture landuse although there are scattered remnants of native bush. The Ohariu Stream and its tributaries rank alongside the Makara Stream and may contain some nationally rare fish species, and despite the lack of vegetated riparian zones for much of its length, the Ohariu Stream is important habitat for native fish. In particular, it shares an unmodified estuary with the Makara Stream, which forms a major unhindered passageway for the diadromous native fish.

Table 4.2 Landuse characteristics of selected study catchments in the Wellington region.

Landuse	Catchment (% of total catchment area)										
	Karori Stream	**Makara Stream**	**Mitchells Stream**	**Ngauranga Stream**	**Ohariu Stream**	**Owhiro Stream**	**Skerret Stream**	**Wainuiomata Stream**	**Waiwhetu Stream**	**Kaiwharawhara Stream**	**Porirua Stream**	**Kenepuru Stream**
Total area (ha)	3093	6117	504	923	1804	745	219	13374	1961	1682	3567	1299
Bare ground						1						
Gorse/manuka	43	20	4	10	3	42	13	32	30	14	9	13
Hardwood shrubs	7	3	26	9	1	22	7	5	2	19	5	5
Indigenous forest			6	1			75	39	4	7	1	2
Intermediate shrub	21	5	2	5		19		3	3	6	5	2
Mines and dumps			2			3						
Planted forest		3	3	1	3			3		2	3	
Pastoral	9	59	16	8	85	1		9		7	41	34
Grass	4	4	6	1	5	3		1	1	2	1	
Shrub	3	3	3	4	1	2	1	2	2	5	5	4
Urban	11		30	59	1	6	3	5	54	38	30	39
Urban open space	1	1	2	2			1	1	4	1	1	3

4.3.4 Northern Streams

The Porirua Stream catchment covers an extensive area of the northern city area, and include the tributaries: Kenepuru Stream, Mitchell's Stream). The stream catchment has been heavily modified with large areas of pasture (eastern catchments), and residential development. In addition, the mainstem of the stream retains little original riparian vegetation, and receives runoff from both motorway and railway for much of its length. The stream also passes through light industrial and commercial activity in the Tawa area. Parts of the catchment are subject to flooding and flow management regimes are in place. Below Tawa the stream has been heavily engineered, and runs through concrete channels towards the stream mouth.

4.4 Urban Streams

4.4.1 Owhiro Stream

The Owhiro Stream is heavily modified in its upper reaches due to partial culverting along Owhiro Road as it runs through Happy Valley, and the development of the southern landfill. Part of the stream runs through a tunnel within the landfill. There is little natural vegetation along the stream length, and there is the Owhiro Bay settlement towards the stream mouth.

4.4.2 Kaiwharawhara Stream

The Kaiwharawhara Stream and its tributaries drain an area of steep land from Ngaio in the north and the Karori Wildlife Sanctuary in the south. The catchment has been highly modified with some parts running through residential areas, and the lowermost reaches through industrial and commercial areas. Nevertheless, the stream retains some significant primary lowland forest remnants, large areas of advanced secondary growth, and reversion to pasture to scrub in the surrounding hills. In addition, the Ngaio Gorge area of steeply incised rock faces means that intrusions and building to the stream edge has been limited, and some of the natural values of the stream have been retained. Some parts of the stream are modified with the presence of two closed landfills, and the stream currently passes through a long culvert under one landfill site.

4.4.3 Ngauranga Stream

The Ngauranga Stream is heavily modified with presence of a quarry, freezing works, light industrial and commercial activity, and runoff from the adjacent motorway. Nevertheless, the stream has some areas of natural flow and bush regeneration.

4.4.4 Upper Karori Stream

The upper reaches of the Karori Stream are highly modified with the residential area of Karori and associated playing fields and commercial district. Parts of the headwater stream networks are piped and some have been engineered as concrete channels of straightened waterways.

5. Existing Water Quality and Ecological Data on Wellington Streams

5.1 Introduction

Only a few studies have investigated the water quality and ecology of streams of the Wellington area (e.g., Kingett Mitchell 2002a, 2002b, Strickland & Quarterman 2001, WRC 2000, 2001); and there is still much to be known of the interactions between the aquatic biota and the surrounding urban landuse. This section briefly summarises existing data on the water quality and ecology of streams in the Wellington region.

5.2 Regular Monitoring

Regular water quality monitoring is undertaken at a number of sites in the Wellington region, including a number of streams with urban influence (e.g., Kaiwharawhara, Porirua, Waiwhetu, Karori, and Owhiro Streams). WRC (2001) concluded that small urban sites with poor water quality included the Ngauranga, Waiwhetu and Karori Streams based on exceedances of WRC water quality guidelines. Streams within Wellington City (Makara, Ohariu, Karori, Owhiro, Kaiwharawhara and Ngauranga Streams) generally complied with WRC dissolved oxygen, pH, ammonia, and temperature guidelines (WRC 2001). Periphyton blooms were observed at least once at all but the lower Karori Stream, and up to four occasions in 15 visits in the Owhiro Stream

Regular assessments of macroinvertebrate communities as indicators of water quality provided a stronger signal of poor water quality with all Wellington City streams with possible (Karori Stream) – severe pollution (Ngauranga Stream). Severe pollution as indicated by macroinvertebrate communities was also evident in the Porirua Stream, although water quality monitoring did not show pollution problems. Additional water quality assessments of the Porirua Stream have been undertaken by Montgomery Watson and are discussed in Section 5.3.

WRC (2001) also concluded that poor water quality in the Kaiwharawhara, Ngauranga and Owhiro Streams was affected by a range of urban impacts including stormwater discharges, channelisation, and pollution incidents. However, results of monitoring of physical and chemical parameters present different signals from regular assessments of macroinvertebrate communities.

5.3 Water Quality

General

Information on the water quality of Wellington Streams is somewhat fragmented and few reports are available. The main sources of information on water quality of urban streams are from regular Council monitoring reports and synoptic surveys of urban streams:

- Sherriff & Wills 1996 (Nguaranga Stream).
- Aitken 1998 (Waiwhetu.
- Ward 1997 (Kaiwharawhara Stream). Stream).
- Pilotto et al. 1998 (Kaiwharawhara Stream).
- Montgomery Watson 2001 (Porirua Stream).
- Kingett Mitchell 2002a.

Williamson et al. (2001) provide a synthesis of existing information on the effects of urban stormwater in the Wellington region and most information presented here has been drawn from this review. Although the report was entitled stormwater, the authors acknowledge the difficulties in deciding what is 'stormwater' and what are other (usually illegal) point source discharges of spills. A similar difficulty is defining where stormwater conduits end, and where natural receiving waters commence. However, as many point source discharges occur to stormwater conduits, impacts are often difficult to separate. Furthermore, the summary concentrates on two main stream catchments where most information is available: Kaiwharawhara Stream and Waiwhetu Stream.

Nutrients and ammonia

Measurements of ammoniacal-N (NH_4-N), total phosphorus (Total P) and sulphate (SO_4) have been collected from Wellington Streams as part of regular monitoring or as part of synoptic surveys.

The Ngauranga, Kaiwharawhara, Karori, and Ohariu Streams all exhibit elevated levels of dissolved reactive phosphorus (DRP), while the Waiwhetu, Ngauranga, and lower Makara Streams were amongst several with high median levels of ammonia.

Median NH_4-N concentrations (0.26 g/m^3) in the Kaiwharawhara Stream did not breach the recommended guidelines for toxicity (0.32 g/m^3, 99% protection level, pristine ecosystems) for instream biota (ANZECC 2000), but did exceed the guidelines for growth of instream plants (0.02 g/m^3) on all three sampling occasions. Ward (1997) reported high ammonia levels below the disused Curtis Road landfill but these did not breach water quality guidelines. Very high concentrations of ammonia have also been found in a small tributary of the Ngaruagnga Stream below the disused Raroa landfill, but fall below ANZECC guideline levels in the mainstem of the stream.

Heavy metals in water column

Williamson et al. (2001) provided some evidence that concentrations of cadmium (Cd), zinc (Zn) and copper (Cu) in the water column of urban streams occasionally exceed water quality guidelines, the amount of data was too small to make statements representative of the Wellington region. High concentrations of cadmium were recorded in the water column of the Kaiwharawhara Stream, while levels of copper and zinc rarely exceeded water quality guidelines.

In one synoptic survey of Waiwhetu Stream the level of Cu and lead (Pb) were relatively high near the freshwater/saltwater interface. As these levels coincided with high turbidity, it may reflect the suspension of fine sediments by flow and density effects (Williamson et al. 2001), or the settling of fine particle in the low flow zone of the freshwater/saltwater interface. Total Manganese (Mn) concentrations in the Kaiwharawhara Stream did not exceed the recommended guidelines (1.9 g/m^3) for moderately disturbed ecosystems (ANZECC 2000).

Studies from the Kaiwharawhara Stream and Nguaranga Stream reported high concentrations of iron (Fe), in part due to landfill leachate, although there are no reports of iron-bacterial slimes affecting stream habitats in Wellington.

Heavy metals in sediments

Williamson et al. (2001) summarised the information on heavy metals in sediments of urban streams. Concentrations of heavy metals in the fine sediments (<63 m) from the Kaiwharawhara Stream were low, although were higher than found in a study of 15 Auckland streams. Interestingly, the Kaiwharawhara Stream exhibited high concentrations of heavy metals in relatively unurbanised and unindustrialised headwater areas, although the mainstem passes through an old landfill which may contribute some metal contamination. The main northern tributary also flows alongside the railway and which is probably a source for copper, lead and zinc (Williamson et al. 2001). Heavy metals increased markedly downstream of the area of light industrial activity in the lower Kaiwharawhara Stream and may represent past industrial activity or current contamination.

Heavy metal concentrations of sediments in the Inner City, Basin Reserve, Miramar and Waiwhetu Streams and drains were much higher than those found in fine sediments in Auckland streams. Sediment quality guidelines are frequently exceeded in Wellington streams to levels that may affect the stream biota (Williamson et al. 2001).

Other contamination

The most recent survey of contamination in Waiwhetu Stream has confirmed that significant contamination (scans for heavy metals and TPH) is confined to the stretch between the raceway and Hutt Park Bridge, with contamination down to 1 m below the streambed (Sheppard

& Goff 2001). Sheppard & Goff (2001) found a general diffusion of contamination away from the most heavily contaminated reach of stream, generally with decreasing contamination upstream and downstream of the raceway-Hutt Park bridge area. However, some local point sources of enrichment exist outside of the most heavily contaminated area of the stream. Two inferences were made from this recent study:

- A point source origin for contaminants via storm drains or direct dumping of waste.
- Remobilisation of contaminants by the incoming and outgoing tides, with reworking within the sediment (downstream) or within the water column (a non-point source upstream and downstream contamination).

Based upon maximum contamination depths for Pb and Zn, Sheppard & Goff (2001) estimated that some 29,000 m^3 of contaminated sediment in the lower Waiwhetu Stream. However, the most serious contaminants recorded were lead, zinc, barium, petroleum hydrocarbons, DDT and associated degradation products, and various poly-aromatic hydrocarbons (PAHs).

5.4 Hydrology

Few studies have focused on changes in flow regimes in Wellington urban and peri-urban streams. In a detailed analysis of flows in the Kaiwharawhara Stream, Ward (1997) found that, in keeping with evidence from urban streams in other New Zealand cities and overseas, the urban reaches had a greater frequency of smaller flood events, a lower baseflow, sharper flood peaks, and storms had a shorter lag time (e.g., Fig. 3.1).

In contrast, and as a consequence of modification by channelisation, roads and bridges flooding can be an issue in some Wellington streams. For example, the Waiwhetu Stream has a history of flooding in the lower reaches. The stream now retains a channel volume too small for even relatively small flood flows (Lew 1996).

5.5 Fisheries

Strickland & Quarterman (2001) have undertaken a recent review of the status of freshwater fish in the Wellington region. They found a total of 31 freshwater fish recorded in the New Zealand Freshwater Fish Database (NZFFD). Of these, 23 species were native fish, and only 4 of the native species were non-migratory.

In an investigation of inanga spawning habitats in the Wellington region, Taylor & Kelly (2001) identified three waterways (Wainuiuomata, Otaki Rivers, Makara Stream) with extensive areas of suitable vegetation for spawning. Several waterways were considered to offer potential for significant improvement for spawning while several catchments, including the Orongorongo River and Karori Stream were deemed unsuitable habitat.

5.6 Benthic Ecology

Comprehensive assessments of benthic ecology have been provided for the Kaiwharawhara (Kingett Mitchell 2002a) and Waiwhetu Stream (Kingett Mitchell 2002b). Overall, ecological health of the Kaiwharawhara Stream was moderate to good despite the landuse pressures (i.e., urbanisation, disused landfills).

The Kaiwharawhara Stream retains a relatively healthy habitat and Kingett Mitchell (2002a) concluded that this occurred as a result of the steep and entrenched nature of the catchment, which has minimised the effects related to sedimentation and channelisation often associated with urban stream systems. In addition, the generally high to good quality of riparian vegetation in reserves and parks are present within the catchment, which provide centres of biodiversity to aid restoration initiatives and rehabilitation. The Waiwhetu Stream retains a diverse aquatic fauna in the upper reaches, a moderately diverse aquatic fauna in the middle reaches and a degraded fauna in the lower contaminated reaches (Kingett Mitchell 2002b).

6. Assessment of the Ecology of Urban and Peri-urban Streams in the Wellington Region

6.1 Location of Wellington Stream Sites

Sixty-one sites were sampled within urban and peri-urban catchments (including reference streams) within the Wellington region (Fig. 6.1; Table 6.1 and Appendix 1). Sites were selected as representative of the variety of stream types in the region, with a number of sites being sampled within the same catchment to provide upper and lower catchment site information. Twenty-six Wellington City and Porirua sites were sampled between 10 March and 15 April 2003. Seventeen Hutt Valley and Kapiti Coast sites were sampled between 30 March 2004 and 1 April 2004. In addition, data was included from previous surveys of the Kaiwharawhara Stream (Kingett Mitchell 2002a) and Waiwhetu Stream (Kingett Mitchell 2002b), as the sampling methods used in each survey were similar.

Catchment area and landuse for each stream catchment has been provided by Wellington Regional Council and is shown in Table 6.1.

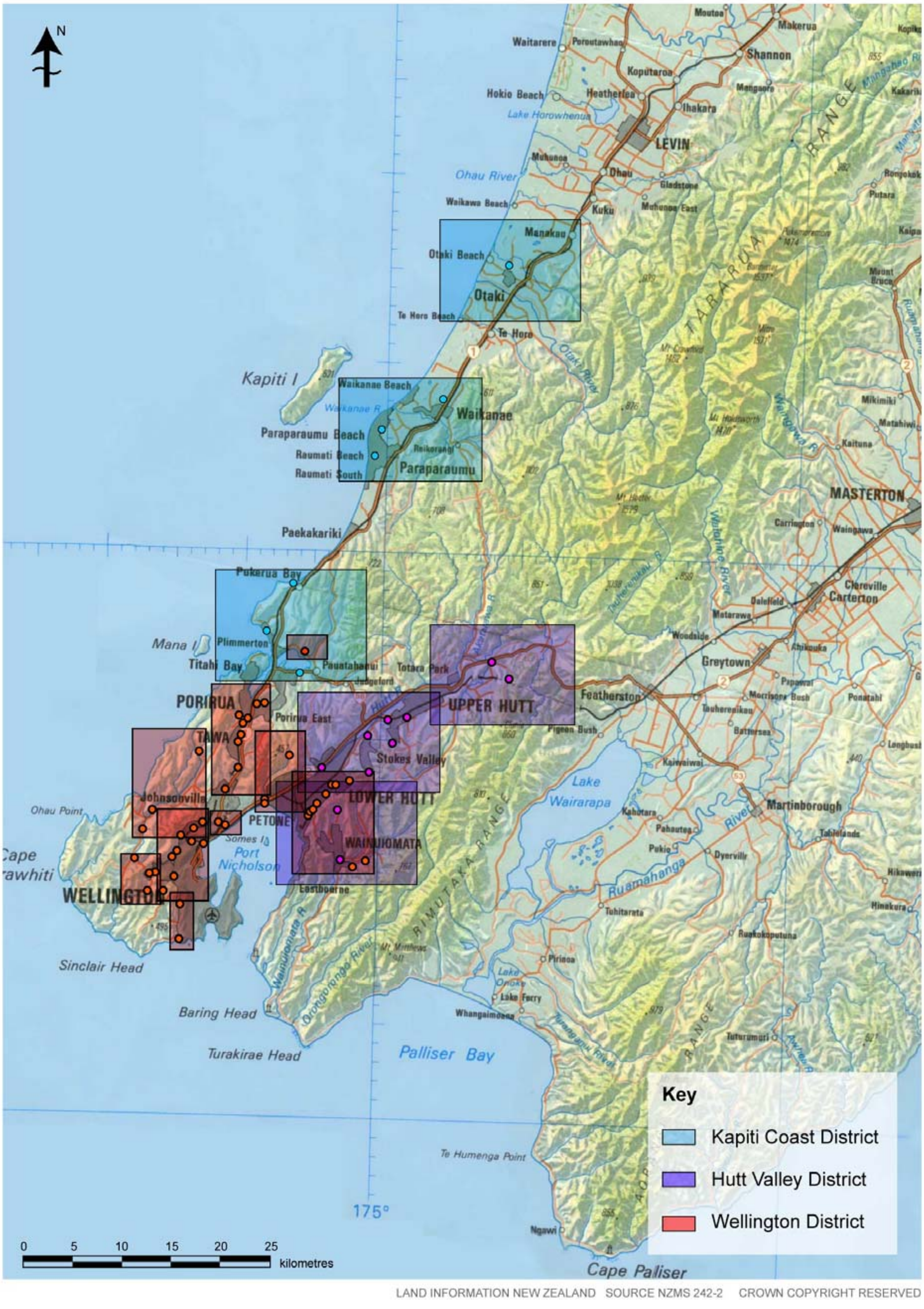

Fig. 6.1: Location of stream catchments and sites sampled within the Wellington region.

Table 6.1: Location and catchment characteristics of 61 stream sites surveyed in the Wellington region.

Stream	Site Code	NZMS Map Reference	Altitude (m above sea level)	Catchment area (ha)	Manuka /Gorse (%)	Hardwood – shrub (%)	Indigenous forest (%)	Shrub (%)	Planted exotic forest (%)	Pastoral (%)	Urban (%)	Urban open space (%)
Wellington City and Porirua Streams monitored in 2003												
Lower Porirua Stream	P1	R27 638 043	<10	3447.0	9.6	4.6	0.6	4.6	2.7	44.5	31.7	0.7
Lower Porirua Stream	P1A	R27 643 048	20	3216.9	9.6	4.8	0.6	4.8	2.3	44.8	31.1	0.7
Mid Porirua Stream	FS2	R27 638 043	20	3061.9	10.3	4.8	0.5	5.1	2.5	46.6	28.7	0.7
Mid Porirua Stream	P3	R27 636 032	40	3061.9	10.3	4.8	0.5	5.1	2.5	46.6	28.7	0.7
Mid Porirua Stream	P4	R27 633 025	40	2896.5	10.2	4.3	0.5	5.2	2.3	49.1	26.4	0.6
Upper Porirua Stream	P5	R27 633 000	60	1415.5	9.6	3.4	0.4	4.8	0.0	45.8	33.1	1.1
Upper Porirua Stream	P6	R27 620 979	80	161.8	3.1	1.7	0.0	2.7	0.0	0.0	92.5	0.0
Mitchell Stream	M1	R27 634 051	50	310.6	4.6	32.4	5.3	2.4	3.8	22.1	20.1	0.0
Mitchell Stream	M2	R27 643 048	20	412.8	6.1	42.7	2.6	3.2	5.1	24.6	5.4	0.0
Kenepuru Stream	Ken1	R27 652 062	10	1090.3	14.9	3.8	1.4	1.9	0.1	37.4	38.4	2.1
Kenepuru Stream	Ken2	R27 660 063	20	914.7	15.2	3.9	1.3	1.8	0.0	39.9	35.5	2.5
Horokiri Stream	HK1	R26 704 108	10	3163.6	13.8	4.8	3.3	7.4	17.4	53.2	0.0	0.0
Upper Karori Stream	KAR1	R27 549 898	160	281.4	7.3	12.2	0.0	6.5	0.0	2.3	69.1	1.6
Upper Karori Stream	KAR2	R27 543 897	160	414.0	10.3	11.8	0.0	8.1	2.6	1.7	62.1	2.5
Mid Karori Stream	KAR3	R27 541 880	100	731.7	21.1	16.1	0.0	11.1	1.5	1.9	45.8	1.7
Mid Makara Stream	MAK2	R27 528 912	20	2074.8	37.7	6.2	0.1	12.2	2.0	30.0	0.3	2.8
Upper Ohariu Stream	O1	R27 597 225	100	704.4	2.7	0.5	0.0	1.9	7.8	83.1	0.0	0.0
Mid Ohariu Stream	O2	R27 546 959	20	4810.2	8.2	0.5	0.2	2.8	4.1	79.8	0.4	0.0
Upper Ngauranga Stream	N1	R27 613 947	80	582.5	3.3	3.1	0.4	3.2	0.2	11.6	74.6	3.1
Lower Ngauranga Stream	N2	R27 620 944	20	881.3	9.0	9.4	1.7	4.6	0.2	8.5	63.6	2.1
Upper Owhiro Stream	OWH1	R27 574 867	100	71.7	0.0	7.5	0.0	2.1	0.0	0.0	88.7	1.7
Lower Owhiro Stream	OWH2	R27 573 833	20	883.7	35.9	20.2	0.0	20.7	0.0	1.1	16.1	0.5
Korimako Stream	KM1	R27 575 934	100	112.9	38.1	5.9	2.7	15.5	0.0	25.0	5.2	0.0
Lower Kaiwharawhara Stream	K1	R27 598 926	20	1673.9	14.0	19.3	7.2	6.2	2.9	6.7	40.8	1.1
Lower Kaiwharawhara Stream	K2	R27 586 928	40	1542.9	14.5	19.7	7.8	5.5	3.0	7.3	39.1	1.2
Mid Kaiwharawhara Stream	K3	R27 571 919	60	650.6	10.9	37.0	5.6	3.5	6.6	3.2	30.7	1.9
Mid Kaiwharawhara Stream	K4	R27 566 913	80	537.4	10.6	37.1	4.8	3.2	8.0	0.0	33.3	2.3
Upper Kaiwharawhara Stream	K5	R27 568 894	140	266.2	13.5	55.7	7.1	4.6	13.8	0.0	3.7	0.0
Upper Kaiwharawhara Stream	K6	R27 557 880	200	93.7	17.4	63.5	0.0	10.6	8.0	0.0	0.0	0.0
Upper Kaiwharawhara Tributary	KT1	R27 597 947	200	51.4	52.6	13.0	9.3	7.1	0.0	9.6	0.2	0.0

Stream	Site Code	NZMS Map Reference	Altitude (m above sea level)	Catchment area (ha)	Manuka /Gorse (%)	Hardwood – shrub (%)	Indigenous forest (%)	Shrub (%)	Planted exotic forest (%)	Pastoral (%)	Urban (%)	Urban open space (%)
Mid Kaiwharawhara Tributary	TRAIN	R27 588 941	100	177.3	10.5	3.4	12.1	0.3	0.0	0.1	71.4	2.2
Upper Korokoro Stream	KOR1	R27 685 012	140	268.0	34.8	9.3	4.7	12.8	8.6	29.4	0.0	0.0
Lower Korokoro Stream	KOR2	R27 660 969	20	1542.0	31.8	24.1	4.7	14.5	4.3	18.4	1.9	0.0
Lower Korokoro Stream	KOR3	R27 660 965	10	1573.0	31.2	24.3	4.6	14.7	4.2	18.0	2.6	0.0
Lower Waiwhetu Stream	W1	R27 704 953	10	1691.7	32.2	2.0	5.2	4.7	0.1	0.0	51.7	3.2
Lower Waiwhetu Stream	W2	R27 706 957	10	1598.4	30.7	1.9	5.5	4.6	0.1	0.0	53.7	2.7
Lower Waiwhetu Stream	W3	R27 709 959	20	1528.1	31.5	1.9	5.7	4.8	0.1	0.0	52.5	2.6
Mid Waiwhetu Stream	W4	R27 713 965	20	1419.3	30.7	2.1	5.4	4.8	0.1	0.0	53.4	2.4
Mid Waiwhetu Stream	W5	R27 722 974	20	978.2	38.5	2.7	7.8	5.9	0.2	0.0	41.6	1.7
Upper Waiwhetu Stream	W6	R27 728 983	20	815.5	41.3	2.9	9.0	6.1	0.2	0.0	37.5	1.5
Upper Waiwhetu Stream	W7	R27 732 983	20	768.8	42.5	3.1	9.5	6.1	0.2	0.0	35.9	1.3
Upper Waiwhetu Stream	W8	R27 746 987	40	174.0	58.8	3.5	24.6	3.4	0.8	0.0	8.7	0.1
Wainuiomata River	WC	R27 762 909	120	3535.7	2.1	3.7	93.3	0.6	0.0	0.1	0.2	0.0
Skerrets Creek	SC	R27 749 903	120		12.5	6.6	77.1	0.1	0.0	0.1	3.6	0.1
Hutt Valley and Kapiti Coast Streams monitored in 2004												
Duck Creek	DCL	R27 695 092	11	1015.0	7.7	0.5	3.1	1.3	13.5	50.2	18.8	4.6
Mangapouri Stream	MSO	S25 907 489	16	449.0	1.1	0.9	0.8	0.0	0.0	58.3	30.0	8.9
Wharemauku Stream	WSP	P26 771 303	<10	1323.0	1.6	4.5	2.0	0.8	1.6	59.1	28.3	1.2
Waimapehi Stream	WPB	R26 688 180	19	135.0	2.0	0.9	0.0	9.9	0.0	45.1	42.1	0.0
Airlie Road Stream	ARSL	R26 662 133	17	80.0	36.9	14.2	0.0	6.7	0.0	26.8	15.4	0.0
Kakariki Stream	KSW	R26 841 358	10	108.0	0.0	0.2	25.7	0.0	0.0	39.8	34.4	0.0
Tikotu Creek	TCG	R26 778 329	10	87.0	0.0	0.0	0.0	0.0	2.5	16.0	48.0	33.5
Speedys Stream	SP1	R27 717 999	17	1169.0	15.3	10.1	0.2	6.5	0.9	59.3	7.2	0.0
Stokes Valley Stream (upper)	SVU	R27 765 995	149	60.0	21.3	23.2	13.3	0.0	0.0	38.3	3.8	0.0
Stokes Valley Stream (lower)	SVL	R27 764 030	35	1040.0	54.2	3.6	8.0	1.4	0.1	0.9	30.9	0.8
Collins Stream (upper)	CSU	S27 907 085	195	366.0	10.8	20.9	67.7	0.6	0.0	0.0	0.0	0.0
Collins Stream (lower)	CSL	R26 890 102	102	499.0	32.4	6.0	12.6	1.4	40.0	2.3	5.0	0.3
Black Stream (upper)	BU	R27 733 958	104	109.0	48.2	2.5	22.0	2.9	0.0	23.2	1.2	0.0
Black Stream (lower)	BL	R27 736 910	90	1551.0	43.0	1.4	8.9	5.4	0.0	3.0	33.2	5.0
Pinehaven Stream	PHU	R27 789 023	159	103.0	39.9	11.5	1.7	1.4	37.4	0.0	5.7	0.0
Silverstream (upper)	SSU	R27 804 048	48	524.0	17.7	0.6	22.7	0.8	2.0	28.8	16.5	10.9
Silverstream (lower)	SSL	R27 784 046	41	487.0	22.4	1.0	9.9	0.8	22.9	0.0	39.6	1.5

6.2 Macroinvertebrate Communities

6.2.1 Collection

Benthic macroinvertebrates were collected at each site from substrates, epilithon and organic matter. Macroinvertebrate samples were collected using a standard triangular kick net (500 µm mesh) moving upstream through the study reach over a 1-2 minute period. Each available habitat was sampled in approximate proportion to its abundance within the stream reach by vigorously disturbing the habitat. All samples were preserved in 70% alcohol and returned to the laboratory for sorting and identification.

All invertebrates in each sample were enumerated and identified for each site. Where large numbers of some taxa occurred (i.e., Chironomidae, Oligochaeta, Mollusca), samples were sub-sampled using a sample-splitter or from a sorting tray divided into equal-sized quadrats. Taxa were identified where possible to genus using the keys of Winterbourn (1973), Chapman & Lewis (1976), Winterbourn et al. (2000) and additional available literature. Chironomidae, Oligochaeta and unidentifiable small or early macroinvertebrate instars were classified to Family level.

6.2.2 Biotic Indices

Species number and number of individuals collected from each sample was assessed for each site. The following ecological indices were calculated from this benthic macroinvertebrate data:

The proportion of **Ephemeroptera, Plecoptera** and **Trichoptera** taxa **(EPT)** present is calculated by determining the proportion of the combined total abundance of mayflies, stoneflies and caddisflies for each sample (Lenat 1988).

The caddisfly *Oxyethira albiceps* was removed during calculation of EPT scores due to its tolerance to pollution. EPT scores are sensitive to changes in water and habitat quality and give a good indication of the health of a stream. High EPT scores suggests high water and/or habitat quality, while low scores indicate low water and/or habitat quality.

Macroinvertebrate Community Indices. The Macroinvertebrate Community Index (MCI) (Stark 1985) and the Quantitative Macro Invertebrate community Index (QMCI) (Stark 1993) are based on scores assigned to each taxon, reflecting their sensitivity to pollution. Scores for all animals collected are then averaged to provide an estimate of the health of a site (Table 6.2). Higher index scores indicate higher stream health (Stark 1993). The MCI uses presence/absence data, while the QMCI is based on abundance data.

Table 6.2: Interpretation of MCI and QMCI values from Stony Riffles (from Boothroyd & Stark 2000).

Water Quality	MCI	QMCI
Clean Water	> 120	> 6
Doubtful quality or possible mild pollution	100 - 120	5 – 6
Probable moderate pollution	80 – 100	4 – 5
Probable severe enrichment	< 80	< 4

The MCI and QMCI were developed to assess the health of stony bottom streams, but have been adapted for streams elsewhere in New Zealand. Nonetheless, the output scores from soft bottomed, slow flowing streams need to be interpreted with care in order to draw sensible conclusions about habitat and water quality parameters.

The ecological indices used in this study (i.e., MCI, QMCI, EPT, taxa number and number of individuals) all assess different aspects of the state of the stream invertebrate community (the benthos). Each index in turn provides an estimate of the state or quality of a sampled site (i.e., MCI and QMCI assess *the level of pollution*; EPT estimates the *sensitive species component* of a community, while species number and number of individuals estimates *biodiversity and general condition* of a stream.

6.3 Instream Habitat

At each site, a representative stream reach ranging from 30 m to 50 m was selected to assess each streams environmental character. Five marked transects were spaced equally along the measured stream reach. Habitat was assessed using a modified Auckland Regional Council habitat assessment method (Maxted et al. 2000) and standard stream survey methods.

At each of the five transects, periphyton and macrophyte cover was estimated visually. Bankfull channel width was measured at the height of the active channel, wetted width was measured as the stream water width at the time of sampling, while channel slope was measured using an inclinometer.

Measurements of water temperature (^{o}C), dissolved oxygen (mg/L and % saturation), conductivity (µS/cm) and pH were undertaken mid-stream within each sample reach using field meters calibrated before each day of sampling.

Substrate characteristics were estimated at each transect as a percentage composition of 10 substrate types. The 10 substrate categories were clay/silt/sand (<2 mm diameter), small gravels (2-8 mm), medium gravels (8-32 mm), large gravels (32-64), small cobbles (64-128), large cobbles (128-256), boulders (>256 mm), bedrock and small and large wood. Artificial components of the streambed such as concrete linings and artificially placed boulders were included in this substrate assessment and assigned a >256 mm size-class.

6.4 Stream Bank Characteristics

Stream bank characteristics were measured at five equally spaced transects along each study reach. Measurements of bank height and length and horizontal depth of undercuts were taken from both true right and true left banks of each transect. Bank type was recorded as a percentage of the following categories: vertical, vertical with undercut, vertical with toe, steep (>45^{o}), gentle, composite, or with constructed concrete or gabions. Length of study reach with eroded or slumped banks was also recorded by walking along each reach and measuring the width of bank slumps and undercuts and expressing this as a percentage of reach length.

6.5 Riparian Vegetation

Riparian vegetation was assessed in the surveyed reaches to determine plant community composition and riparian buffer widths. At five equally spaced points along the study reach, vegetation type was recorded on both stream banks. On each bank, vegetation was sampled within a 5 m transect perpendicular to the stream. At 0, 1, 2, 5 and > 10 m intervals from the edge of the stream bank, the vegetation within five height tiers (0-0.5, 0.5–1.0, 1.0-2.0, 2.0-5.0 and >5.0 m) was recorded. The width of the riparian zone (distance from the top of the stream bank to the edge of zone or transition to managed landuse) was also estimated at each transect.

Eleven categories of vegetation were recorded for each sample point:

- NWS: Native woody species.
- EWS: Exotic woody species.
- NNS: Native non-woody species.
- ENS: Exotic non-woody species.
- F: Ferns.
- G: Grasses.
- NV: Non-vascular plants.
- ES: Exposed soil.
- R: Rock.
- LL: Leaf litter.
- Other: Concrete, rail irons etc.

Overall riparian vegetation was recorded as the percent occurrence of each vegetation category across all tiers and distance from the bank. Notes on dominant species were recorded as appropriate.

6.6 Treatment of Data

The macroinvertebrate assemblages at each site were classified by two-way indicator species analysis on abundance data using TWINSPAN (Hill 1979). The TWINSPAN classification of sites was terminated at level 3, after which the groupings were numerous and lacked ecological significance. The macroinvertebrate TWINSPAN groups were then used as the basis for all other analyses.

To assess whether samples collected from different sites and between clustered groups differed with respect to univariate community characteristics (i.e., individual community characteristics like MCI, QMCI, EPT, number of taxa, number of individuals and diversity), analysis of variance (ANOVA) was performed using SYSTAT (2000). Any statistical result with a P value (probability of difference) < 0.05 indicated there was a significant difference in that characteristic between clustered groups.

Patterns in taxa densities amongst invertebrate communities were analysed using non-metric multidimensional scaling (MDS) with Bray-Curtis dissimilarity coefficients based on abundance data. Relationships between environmental variables (incl. biotic indices) and MDS axis scores were investigated by correlation analysis.

7. Ecology of Urban Streams in Wellington City

7.1 Introduction

An NMDS ordination was also used to find natural groupings of sites based on macroinvertebrate taxa composition and abundance from sixteen sites within four highly urbanised catchments within Wellington City (excluding the Porirua Stream). The results of the NMDS are shown in Fig. 7.1.

Group I sites clearly separated in the ordination from Group V and VI sites, with some overlap with Stream Group III. The remaining groups are all clearly separated based on Stream Groups for the entire Wellington region.

7.2 Relationship with Habitat and Landuse Characteristics

Statistically significant correlations of environmental variables with NMDS axes are shown in Table 7.1. We have included landuse (as hectares) in this analysis to better understand the relationship of imperviousness (as urban area and urban open space) on macroinvertebrate communities.

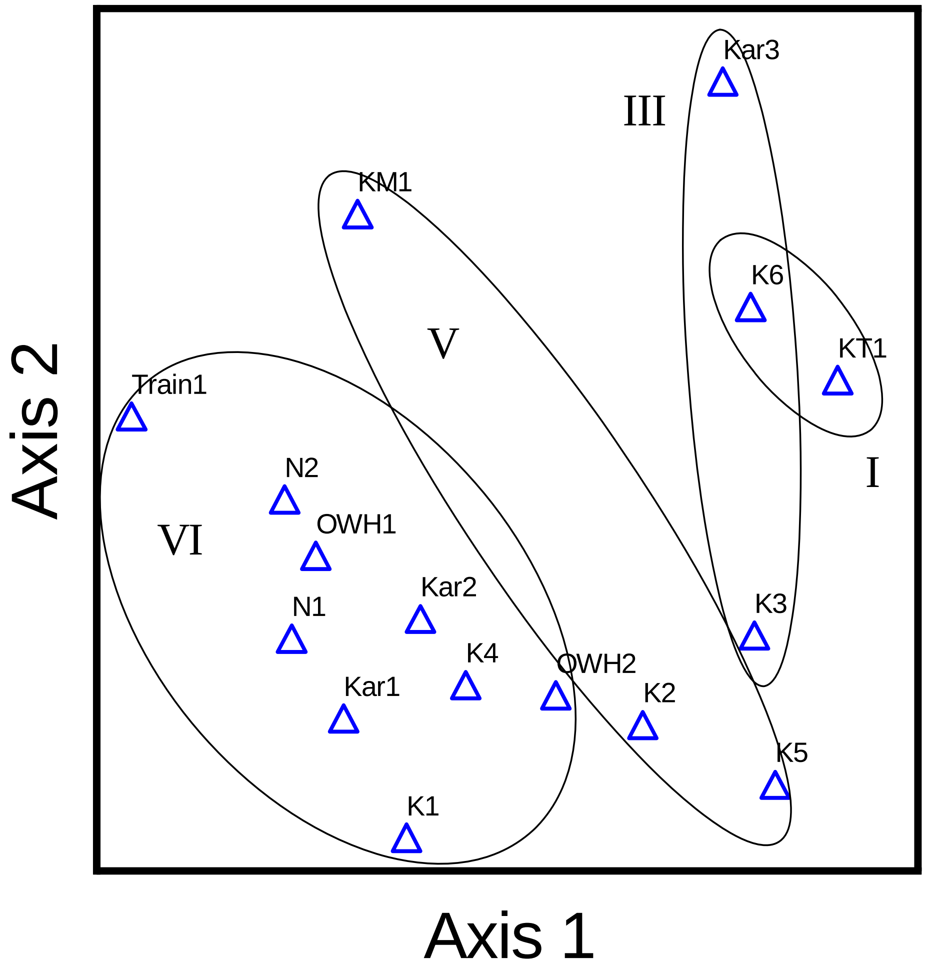

Fig. 7.1: Ordination (non-metric multidimensional scaling) of Wellington stream sites based on the invertebrate taxa and abundance. Ellipses show the Stream Groups for the Wellington region stream groups. See Table 7.1 for site locations.

Table 7.1: Correlation statistics for NMDS ordination axes (dimension) and habitat and landuse characteristics.

Attribute	Dimension 1	Dimension 2
Instream habitat		
Slope	**-0.67**	-0.03
Periphyton cover	**0.54**	-0.27
Riparian vegetation		
Riparian vegetation width	0.11	**-0.64**
Riparian native woody species	**-0.52**	-0.29
Riparian native non- woody species	-0.11	**-0.67**
Riparian exotic non-native woody species	**0.48**	0.32
Landuse		
Hardwood shrub (%)	0.09	**-0.65**
Exotic forest (%)	0.25	**-0.55**
Indigenous forest (%)	0.22	**0.70**

Macroinvertebrate communities of Stream Group I and III sites were correlated with greater slope and less periphyton cover, although periphyton cover was highly variable. Dimension 2 scores were correlated with decreasing riparian vegetation width and decreasing component of native non-woody vegetation in the riparian zone. To a lesser extent, sites with greater slope and less periphyton cover (Dimension 1, Table 7.1) exhibited riparian vegetation with high native woody species and low exotic non-woody species in the community.

The results show that the stream sites regarded as having a lower ecological condition (Stream Groups V and VI) are represented by a wider riparian vegetation buffer comprising a greater component of exotic woody and non-woody plants. Stream Group V and VI also exhibited a greater periphyton cover on the streambed compared to better quality sites(Stream Groups I and III) which can be characterised by having a narrow riparian margin but comprising greater native vegetation.

7.3 Stream Ecological Condition and Catchment Imperviousness

The amount of impervious cover (as tar sealed, concrete, compacted open ground) within a catchment has commonly been used as an indicator of urban pressure. Additional landuse indicators include housing density, population density, road density, and % urban land use. Drury et al. (2003) suggested the use of impervious cover, catchment landuse, daily traffic volume, number and volume of stormwater and treated wastewater overflows, stormwater treatment, extent of riparian vegetation, as indicators of urban pressures.

Similar to New Zealand and overseas studies on the effects of urbanisation on streams, the amount of impervious area within a catchment correlated highly with ecological condition of streams ($p=0.7$, Table 7.1, Fig. 7.2). Sites of lower ecological condition occurred where a greater percentage of the catchment is covered in hard impervious cover.

Most research shows that a decline in both species abundance and diversity begins at around 10% catchment imperviousness, but ranging from 5-20% (CWP 2003). For North Shore City streams, a decline in aquatic ecological condition is marked at 15-20% (Kingett Mitchell 2001), and 15% catchment imperviousness has been used as a limit for stormwater management aimed at protecting stream life (Heijs & Kettle 2003).

Although a decline in aquatic ecological condition is evident in Wellington urban streams following 5-10% imperviousness, the response is less severe, and the initial decline more variable (e.g., for MCI and EPT, Fig. 8.2). At higher urban landuse (i.e. > 60%) the decline in ecological condition in Wellington streams is much less marked than in Auckland streams, probably due to the topography of the region.

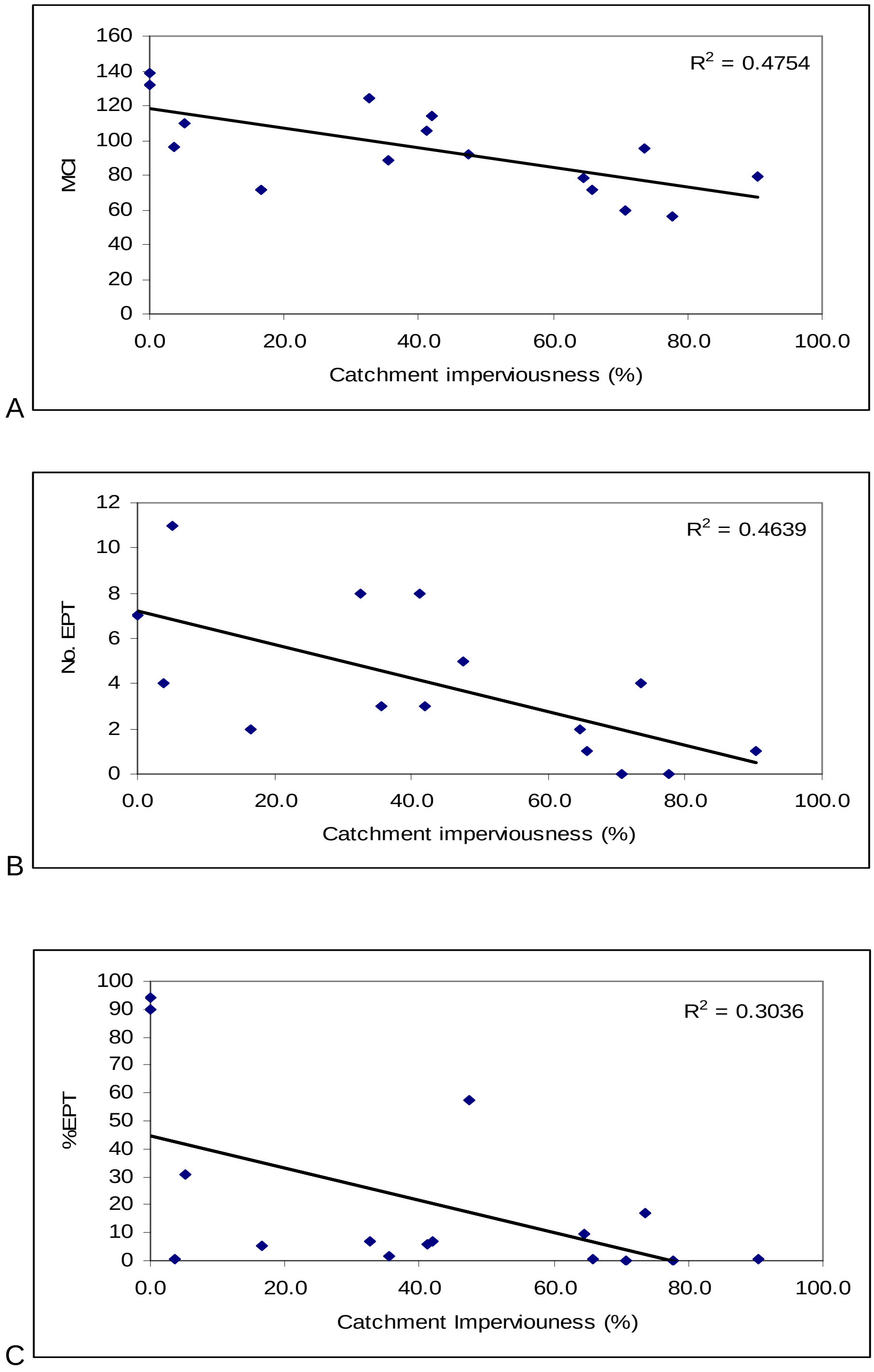

Fig. 7.2: **Relationship of catchment imperviousness with biotic indices A) MCI, B) No. of EPT, C) % EPT. Slope shows linear regression.**

8. Ecology of the Porirua River

8.1 Water Quality

Water quality of the Porirua Stream is regularly assessed as part of the Wellington Regional Council Baseline Freshwater Quality Monitoring Programme (WRC 2001). Despite the modified nature of the stream there were no exceedances of water quality criteria (temperature, dissolved oxygen, pH, ammonia, dissolved nutrients and turbidity) in 2000/2001 (WRC 2001). A specific study of sediment and water contamination of the Porirua Stream was undertaken in 2001 (Montgomery Watson 2001). Results suggested that:

- Heavy metals in sediments were highest downstream of the commercial/industrial zone between Linden and Bowland.
- Heavy metals in sediments were lower in the estuarine lower margins of the Porirua Stream, attributed to stormwater from Porirua being discharged directly to the Porirua Harbour.
- Organic constituents within sediments were generally below the ISQG-low guideline.
- Maximum levels of organic constituents occurred below the commercial/industrial zone between Linden and Bowland.
- ISQG-low guidelines for DDT and its breakdown products DDE and DDD were exceeded at all sites but was greatest in the Takapu Stream sediments.
- Heavy metals in the water column were elevated during rainfall events at several sites.
- No specific sources of heavy metal contamination in the water column were identified.

Publicly reported pollution incidents for the Porirua Stream catchment received by WRC from 1990 to 2001 were dominated by liquid waste and increased silt incidents (WRC 2001).

8.2 Instream Habitat

8.2.1 Water Quality

Table 8.1 shows the results of the water quality at each of the sites on the Porirua Stream sampled, and its tributaries. Dissolved oxygen (DO) levels were generally high (>8.55 g/m^3), and above recommended guidelines (>6 g/m^3, ANZECC 2000). Temperature approached the upper limits for some of the more temperature-sensitive macroinvertebrate taxa (e.g., stoneflies).

Table 8.1: Physico-chemical data Porirua sites.

Site	Temperature (°C)	Dissolved Oxygen (g/m^3)	Dissolved Oxygen (%)	pH	Conductivity (μS/cm)
P1	23.8	9.63	115.2	7.15	267
P1A	19.7	10.7	112	8.19	251.2
Mitchells 1 (M1)	15.3	8.55	85.3	7.47	249.4
Mitchells 2 (M2)	15.5	9.41	94.7	7.9	240
Kenepuru 1 (Ken1)	-	-	-	-	-
Kenepuru 2 (Ken2)	-	-	-	-	-

Notes: Physico-Chemical Parameters were not measured at all sites.

8.2.2 Channel Characteristics

Characteristics of the Porirua Stream channel are shown in Table 8.2. Clear differences were apparent between the sites. Particularly, Mitchell Stream was notably different to the other sites, as it was a smaller stream with a much narrower stream channel.

Percentage riparian cover (the amount of shade afforded to the stream) was substantial (>25%) at the two upstream sites of the tributaries (M1 and Ken2). Riparian cover at the remaining sites was sparse or non-existent. Periphyton cover, on the other hand, was greatest (>75%) at the less shaded sites (M2, P1 and P1A).

Table 8.2: Mean channel characteristics of Lower Porirua Stream and its tributaries.

Site	Velocity (m/s)	Water width (m)	Channel width (m)	Periphyton Cover (%)	Riparian Cover (%)	Riparian Width (m)
P1	0.18	12	12	75	0	10
P1A	0.4	4.5	4.5	90	0	5
Mitchells 1 (M1)	0.17	1.2	1.7	44	36	11
Mitchells 2 (M2)	0.16	1.3	1.5	80	11	5
Kenepuru 1 (Ken1)	0.07	3.5	4.5	9	10	3
Kenepuru 2 (Ken2)	0.12	4	4.6	-	50	10

8.2.3 Substrate Characteristics

The substrate of the Porirua Stream was dominated by gravels and cobbles (Table 8.3). There were some boulders present at several sites, including in the tributary Mitchells Stream, and in the mid-reaches of the Porirua Stream. Fine sediment (silt/sand) was present at most sites, but it was generally not a significant characteristic of the substrate.

Site Ken2 in the Kenepuru stream had several large willow trees growing in the riparian margin. This created several areas of the streambed that were covered entirely with willow root mats.

Table 8.3: Mean composition of substrate particles (%) at each Porirua Stream site.

Site	Silt/Sand (<2mm)	Gravels (2-32mm)	Cobbles (32-128mm)	Boulders (128-25mm)	Bedrock
P1	0	50	50	0	0
P1A	0	20	60	20	0
Mitchells 1 (M1)	0	59	36	5	0
Mitchells 2 (M2)	7	55	38	16	0
Kenepuru 1 (Ken1)	23	68	9	0	0
Kenepuru 2* (Ken2)	10	74	17	5	0

Note: *Up to 10% of the substrate was covered in willow root mats

8.3 Riparian Vegetation

The riparian vegetation of the lower reaches of the Porirua Stream mostly consisted of low growing grasses and herbaceous species. Sites P1 and P1A were bounded by the railway line and commercial properties, with an area of mown grass approaching the stream channel. Site P1 has intermittent trees providing some shade for the reach that have been planted for ornamental purposes. However, these trees are 5-10 m back from the stream edge, and offer little in the way of riparian cover.

The upper Mitchell Stream site (M1) had extensive riparian vegetation. This consisted of woody exotic species like gorse and blackberry, native woody species like mahoe, as well as smaller herbaceous plants. There was significant over head cover from several large *Eucalyptus* trees. The reach was shady, and the overhanging vegetation provides a heterogeneous habitat with moderate to high amounts of cover.

The lower site on Mitchell Stream (M2) was bounded by commercial properties and its riparian vegetation consisted primarily of grass and small herbaceous species. The reach was afforded a moderate degree of shading and cover by several willow and *Pittosporum* trees.

The downstream Kenepuru Stream Site Ken1 had a riparian zone in pasture land. Both banks had sparse areas vegetated by gorse, blackberry and other small woody species which provide some shade to the stream channel.

The upstream Kenepuru site (Ken2) had a wide, heavily vegetated riparian margin. Overhead shading was provided by mature pine and willow trees, and the ground was covered extensively by low growing herbaceous species.

8.4 Macroinvertebrate Community

8.4.1 Existing Information

The Porirua Stream is included in the Wellington Regional Council Baseline Freshwater Quality Monitoring Programme, and the macroinvertebrate community is sampled annually. Previous assessments of macroinvertebrate communities in the Lower Porirua Stream suggest generally low water quality (WRC 2001).

8.4.2 Diversity and Abundance

Macroinvertebrate fauna in the lower Porirua Stream and its tributaries is low in taxa richness. Fig. 8.1 shows that all sites had less than twenty macroinvertebrate taxa present. Abundances were variable, but were generally between 250 and 750 individuals per sample, with highest abundance at the Porirua Stream at Tawa. Highest taxa number occurred in the Lower Mitchells Stream and Porirua Stream at Tawa. Lowest taxa number occurred in the Lower Porirua and Lower Kenepuru Streams.

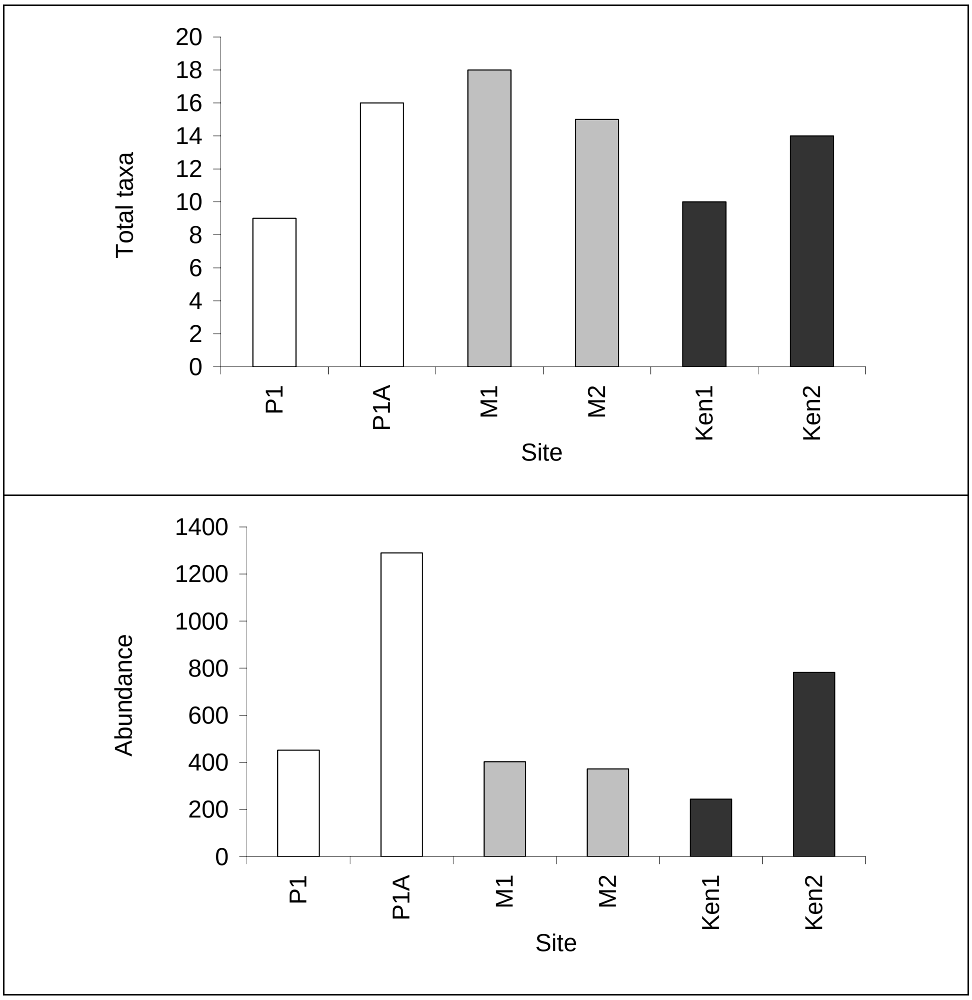

Fig. 8.1: Total taxa and total abundance of macroinvertebrates at sites on the Lower Porirua Stream and its tributaries.

Two tributary stream sites, M1 and Ken2 had Berger Parker scores greater than 0.5 (Fig. 8.2), indicating a higher degree of single taxa dominance with more than half the individuals dominated by the common snail *Potamopyrgus*.

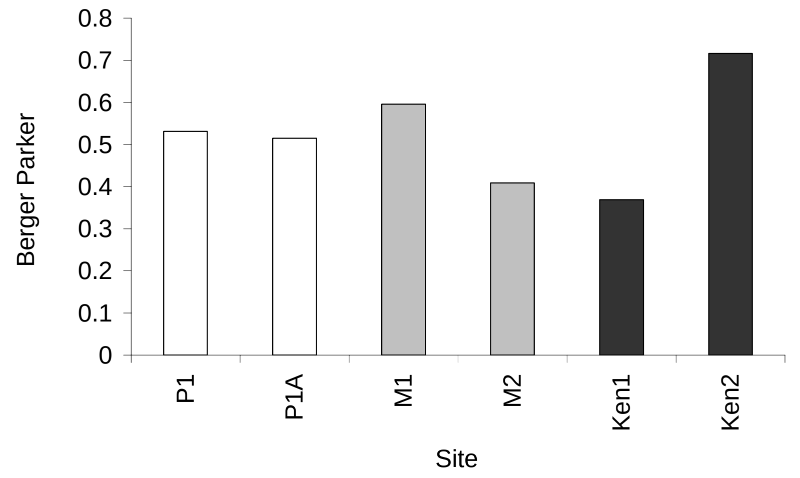

Fig. 8.2: Berger Parker index scores (indicating single taxa dominance) at all sites.

8.4.3 Community Composition

Molluscs (snails) were the dominant taxa at several sites (Fig. 8.3). Worms (Annelida) were more prevalent at Site P1, whilst Trichoptera (caddisflies) dominated Site M2. Ephemeroptera (mayflies) were absent from all sites with the exception of the mid-reaches of the Kenepuru Stream. Refer to Appendix 3 for full macroinvertebrate data for each site.

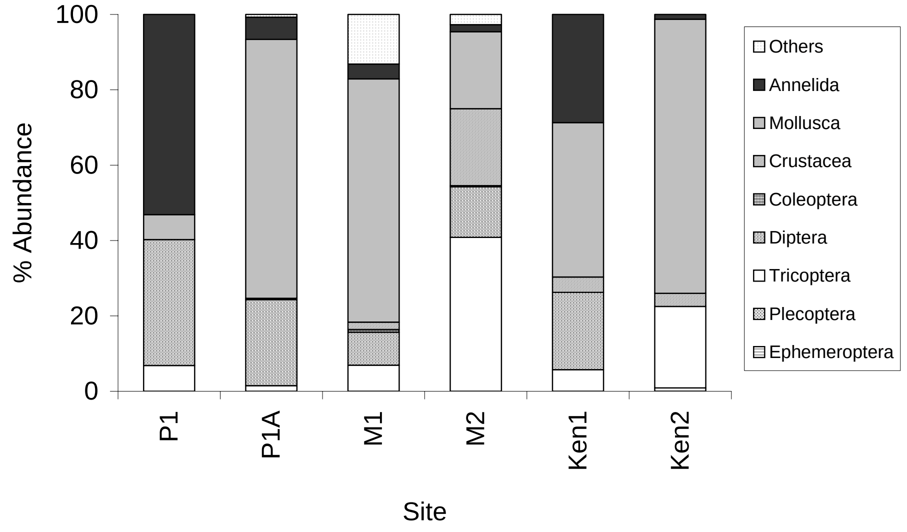

Fig. 8.3: Relative abundance of major invertebrate taxa groups at each site.

8.4.4 Quantitative Macroinvertebrate Community Index (QMCI)

The QMCI values ranged between 1.6 and 4.3 at Sites P1 and M1 respectively (Fig. 8.4, refer to Table 6.2). Mitchell Stream (M1 and M2) had marginally greater QMCI values than the two lower Porirua Stream sites (P1 and P1A) and Kenepuru Stream sites (Ken1 and Ken2). The QMCI values recorded for Porirua streams generally indicate moderate to severe organic enrichment (refer Table 6.2).

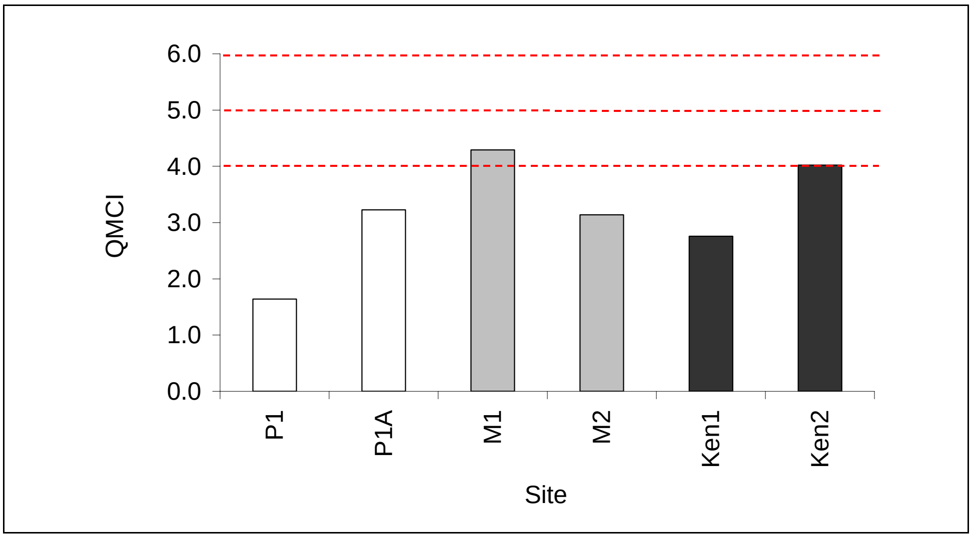

Fig. 8.4: QMCI values for the Lower Porirua Stream and tributaries.

8.5 Fish Communities

Six indigenous fish species were recorded from the lower Porirua Stream and its tributaries (Table 8.4). Eels *(Anguilla* sp.*)* and common bullies *(Gobiomorphus cotidianus)* were generally ubiquitous. Smelt *(Retropinna retropinna)* were present in large schools at Site P1A and M2. Of interest was the presence of giant kokopu *(Galaxias argenteus)* in the Upper Mitchells Stream. Giant kokopu are considered to be under Gradual Decline by DoC (Hitchmough 2002).

Table 8.4: Fish taxa recorded from the Lower Porirua Stream.

Scientific name	Common name	P1*	P1A	M1	M2	Ken1	Ken2
Anguilla sp.	Eel species		✓	✓	✓	✓	✓
Gobiomorphus cotidianus	Common bully		✓		✓	✓	✓
Gobiomorphus huttoni	Redfin bully		✓				
Galaxias maculatus	Inanga						✓
Galaxias argenteus	Giant kokopu			✓			
Retropinna retropinna	Smelt		✓		✓		

* Not fished.

8.6 Aquatic Characteristics of the Porirua Stream

8.6.1 Aquatic and Riparian Habitat

The Lower Porirua Stream was characterised by loose substrates comprising large and small cobbles, gravels and sands. This substrate provides a diverse habitat for macroinvertebrate fauna and periphyton.

The benefits of riparian vegetation are well known and documented: the riparian plants provide shade for the stream, which assist in lowering the instream temperatures. Riparian shade reduces incident light reaching the stream, thus reducing excessive periphyton growth. Riparian plants provide a buffer between the stream and existing landuse, and, in some cases, can provide a filter to prevent contaminated water from reaching the stream. Riparian plants also provide habitat for terrestrial insects, a proportion of which is known to fall into streams providing additional food for fish.

Site P1 and P1A have little riparian vegetation. The small tributaries, Mitchell Stream and Kenepuru Stream have extensive riparian vegetation in their upper reaches, but not in the lower reaches.

8.6.2 Macroinvertebrates

Macroinvertebrate communities in the Lower Porirua Stream exhibit low-moderate ecological values. The absence of many pollution-sensitive EPT macroinvertebrate taxa (mayflies, stoneflies, caddisflies), and the presence and dominance of many pollution-tolerant macroinvertebrate taxa suggests a poor quality habitat and environment.

MCI values indicate severe pollution and/or modification in some stream sections (e.g., Lower Porirua Stream, Lower Kenepuru Stream), with some improvements in the upper reaches of the respective tributaries (i.e., Upper Mitchells Stream, Upper Kenepuru Stream).

8.6.3 Fish Communities

A total of six indigenous fish species were recorded from the Lower Porirua Stream and its tributaries. No exotic fish taxa were recorded during the current survey. A search of the New Zealand Freshwater Fish Database (NZFFD) revealed that the following fish have been recorded from the Porirua Stream: longfin *(Anguilla dieffenbachii)* and shortfin eels *(Anguilla australis)*, giant kokopu, inanga, redfin and common bullies. The Porirua Stream is not ranked as an important system for migratory native fish and is not regarded as of high value (Strickland & Quarterman 2001).

The abundance of eels probably reflects the suitable habitat and food resources. Eels are very capable climbers and obstacles are less of a barrier to movement than for inanga. The aquatic fishery values of the Lower Porirua Stream reach are moderate and enhanced by the presence of giant kokopu.

8.7 Summary

The Lower reaches of the Porirua Stream have low-moderate aquatic ecological values. The habitat is variable and the lower reaches of the mainstem Porirua Stream in particular exhibit many of the characteristics of urban streams (i.e., channelisation, artificial substrates and banks, increased siltation, bank erosion, loss of habitat diversity and riparian vegetation).

The macroinvertebrate fauna is impoverished, with few of the invertebrate types that are generally indicative of better water quality present. However, some of these taxa are present in very large numbers and provide a food source for the fish.

The fishery values are enhanced by the presence of the giant kokopu, although it is noted that a single adult was recorded with no evidence of recruitment and younger juvenile stages.

Although not specifically investigated, there appear to be no significant physical barriers to fish migration in the Lower Porirua Stream. A low weir exists in the Lower Porirua Stream upstream of the area subjected to normal tidal variation. It is considered that this structure would present a barrier to upstream migration of whitebait at low water levels, but would not prevent migration at normal water levels (Taylor & Kelly 2001). The one exception is the Mitchells Stream where the stream runs through a large culvert under Kenepuru Road and hospital grounds (at least in part) and the presence of physical barriers within the culvert is unknown.

9. Ecology of Urban and Peri-urban Streams of the Hutt Valley

9.1 Instream Habitat

9.1.1 Water Quality

The DO concentrations recorded at Hutt Valley ranged between 9.64 g/m^3 at the lower Silverstream site and 10.9 g/m^3 at the upper Silverstream site (SSU). (Table 9.1). In general, DO concentrations and % saturation were high at Hutt Valley sites and above recommended guidelines (>6 g/m^3, ANZECC 2000).

The pH measured at Hutt Valley sites appeared circum-neutral, ranging between 7.03 and 7.43. The conductivity ranged between 72 µS/cm at the upper Collins Stream site (CSU) and 1300 µS/cm at Speedys Stream (SP1). The water temperature ranged between 10.7 ^{o}C at the upper Collins Stream site and 14.9 ^{o}C at the lower Stokes Valley site (SVL).

Table 9.1: A summary of physico-chemical parameters measured at the ten Hutt Valley sites.

Site	Dissolved oxygen (g/m^3)	Dissolved oxygen (%)	pH	Conductivity (µS/cm)	Temperature (^oC)
SP1	10.88	102	7.21	1300	12.5
SVU	10.35	96	7.34	101	11.6
SVL	10.19	102	7.03	134	14.9
CSU	10.71	96	7.35	72	10.7
CSL	10.78	100	7.16	78	12.2
BU	9.67	91	7.03	124	12.7
BL	10.11	96	7.18	129	12.2
PHU	10.30	94	7.35	148	11.4
SSU	10.90	101	7.26	157	11.9
SSL	9.64	93	7.43	162	13.7

9.1.2 Channel Characteristics

Characteristics of the Hutt Valley streams are shown in Table 9.2. The majority of the streams had moderate-slow flow velocities; the exceptions being Speedys Stream and Pinehaven Stream (PHU) which had velocities greater than 0.4 m/s. The Hutt Valley streams generally had narrow wetted widths and shallow depths (<0.4 m), the exceptions being Speedys Stream and the lower Black Stream (BL), which had widths exceeding 5.0 m. All Hutt Valley sites had a relatively higher percentage cover of periphyton (between 80-100%); with the only site with macrophytes present being the upper Silverstream site, which also had poor riparian cover. The lower sites generally had lower riparian cover, which coincided with increased stream widths but not necessarily a decrease in riparian width (Table 9.2).

Table 9.2: Mean channel characteristics recorded at the ten Hutt Valley sites.

Site	Velocity (m/s)	Water width (M)	Channel width (m)	Depth (m)	Periphyton Cover (%)	Macrophyte cover (%)	Riparian shade (%)	Riparian Width (m)
SP1	0.48	4.6	6.2	0.22	100	0	5	24.8
SVU	0.39	1.1	1.3	0.05	80	0	95	30.0
SVL	0.18	3.2	3.0	0.33	100	0	0	15.0
CSU	0.37	2.3	4.3	0.13	96	0	73	50.0
CSL	0.33	3.5	4.7	0.16	97	0	76	12.5
BU	0.25	1.2	1.1	0.13	100	0	34	11.9
BL	0.22	5.0	6.1	0.40	100	0	7	20.0
PHU	0.43	1.1	1.4	0.06	100	0	64	10.2
SSU	0.21	2.0	2.0	0.16	100	72	4	22.5
SSL	0.19	3.4	3.4	0.17	100	0	0	35.0

The upper sites in the upstream-downstream paired sites typically had a higher proportion of gentle sloping banks (Fig. 9.1). The urban and peri-urban streams had a higher proportion of concrete and wooden gabions and generally had steep or vertical stream banks.

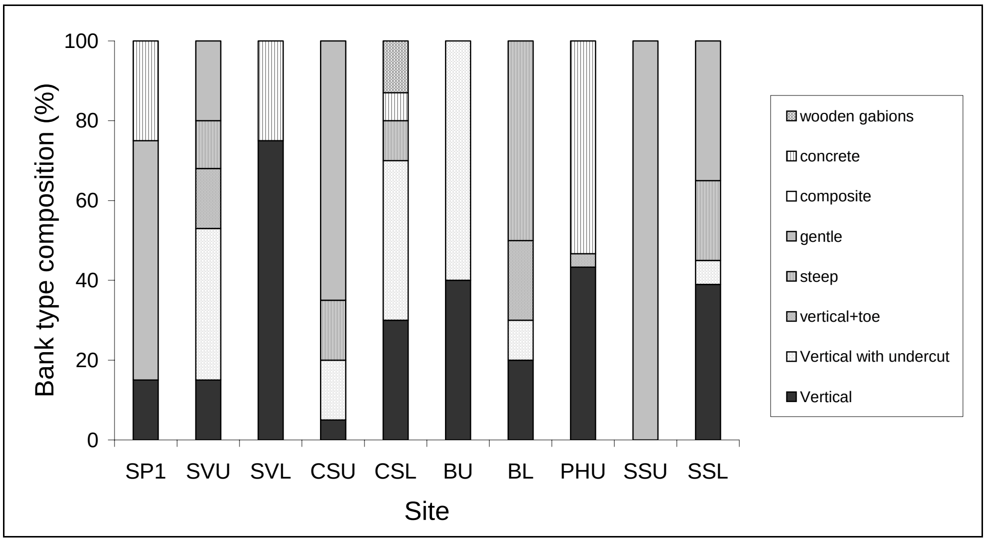

Fig. 9.1: The relative proportion (%) of stream bank type present at the ten Hutt Valley stream sites.

9.1.3 Substrate Characteristics

The sediment substrate at the Hutt Valley stream sites was generally made up of coarse material, with small cobbles (32-64 mm) being the predominant substrate size at nine of the ten sites (Fig. 9.2).

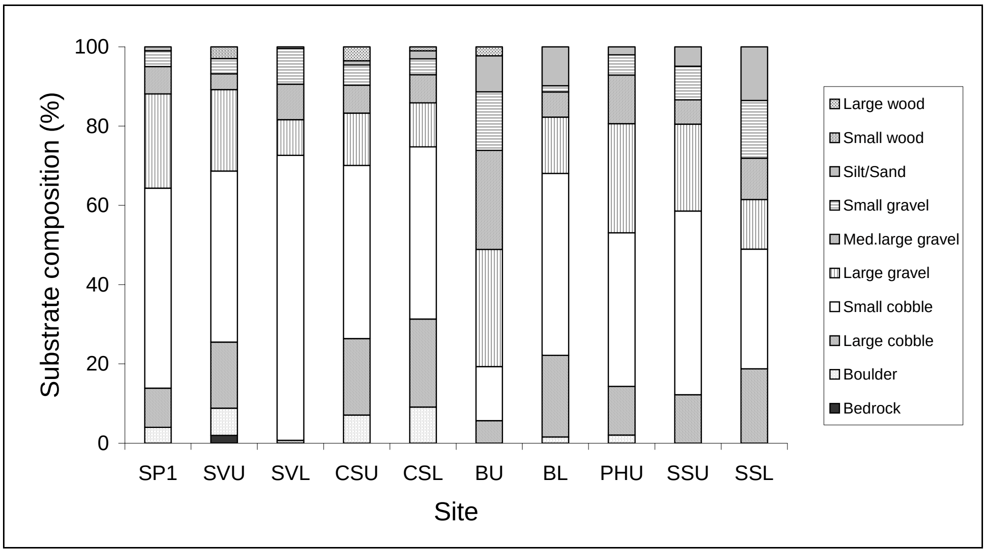

Fig. 9.2: The relative proportion (%) of each sediment size class at the ten Hutt Valley stream sites.

The exception was the upper Black Stream site (BU), where small to large gravels (2-32 mm) were the predominant substrate size (69%). Sand and silt made up a relatively low proportion of the substrate at all the Hutt Valley sites, with the lower Silverstream site (SSL) (14%) having the highest proportion. Boulders were present at six of the ten sites, but were most common at the upper and lower Collins Stream (CSL) (7.1% and 9.1%, respectively) and upper Stokes Valley Stream (SVU) (6.9%) sites.

9.1.4 Riparian Vegetation

The predominant riparian vegetation at six of the ten Hutt Valley stream sites was grass (>50%), with the lower Stokes Valley Stream, upper Black Stream and upper Silverstream sites consisting of greater than 90% grass riparian vegetation. The riparian vegetation at the upper Stokes Valley site was predominantly made up of native trees, while the upper Collins Stream site consisted of native trees (50%) and native shrub (50%) (Fig. 9.3).

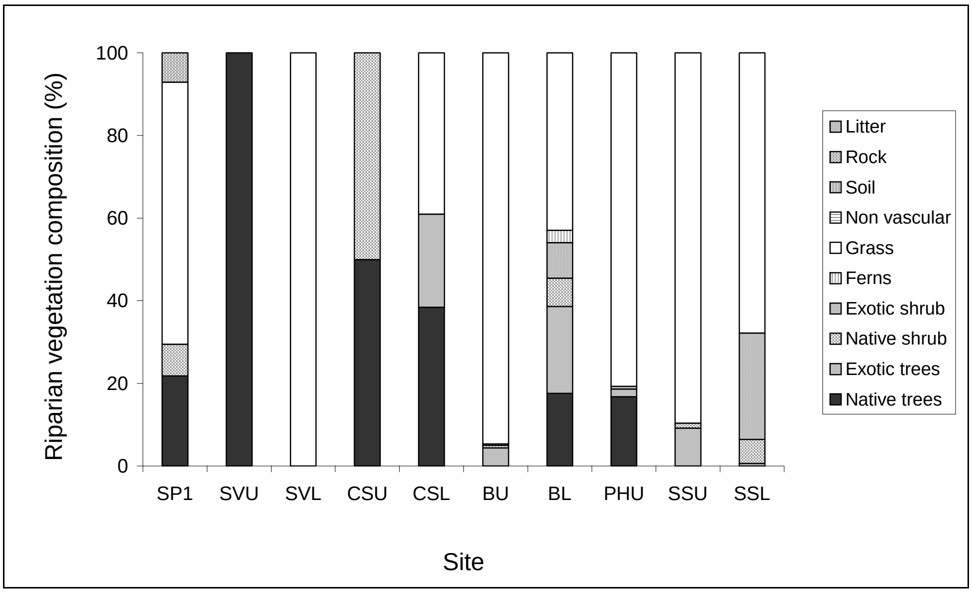

Fig. 9.3: The relative proportion (%) of each riparian vegetation class at the ten Hutt Valley stream sites.

The lower Collins Stream site had the second highest proportion of riparian trees (native 38%, exotic 23%) after the upper Stokes Valley Stream site. The biggest contrast between upstream-downstream paired sites occurred between the upper and lower Stokes Valley sites, where the upper site was entirely native trees compared with the lower site composed entirely of grass.

9.2 Macroinvertebrate Communities

9.2.1 Species Diversity and Abundance

A total of 91 macroinvertebrate taxa were identified from macroinvertebrate samples collected from 10 Hutt Valley urban and peri-urban streams. Taxa richness varied over a relatively narrow range between 19 at the upper Stokes Valley stream and 26 at Speedys Stream, upper Collins Stream, lower Collins Stream and lower Black Stream (Fig. 9.4).

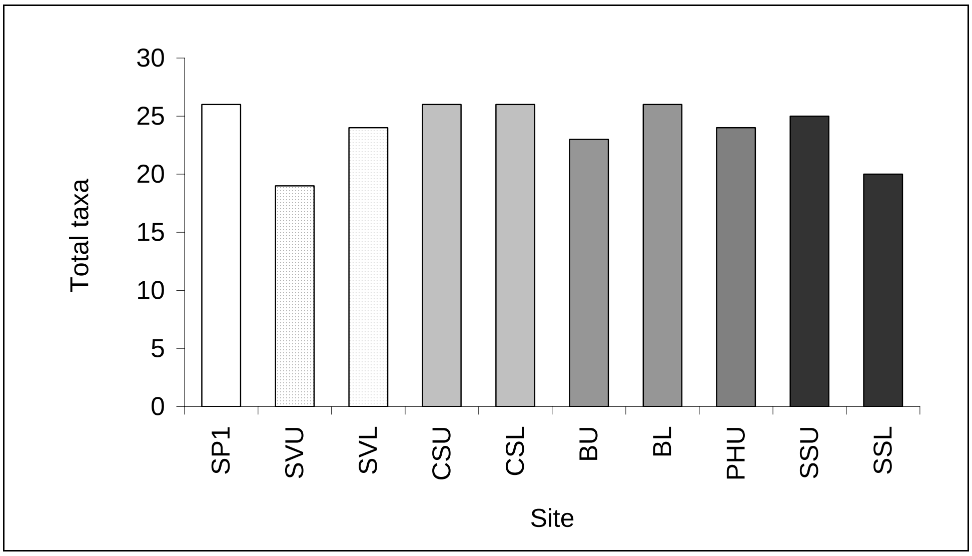

Fig. 9.4: Mean number of macroinvertebrate taxa collected from the ten Hutt Valley stream sites.

Invertebrate abundance ranged between 600 individuals at lower Black Stream and 2,900 individuals at upper Silverstream (Fig. 9.5).

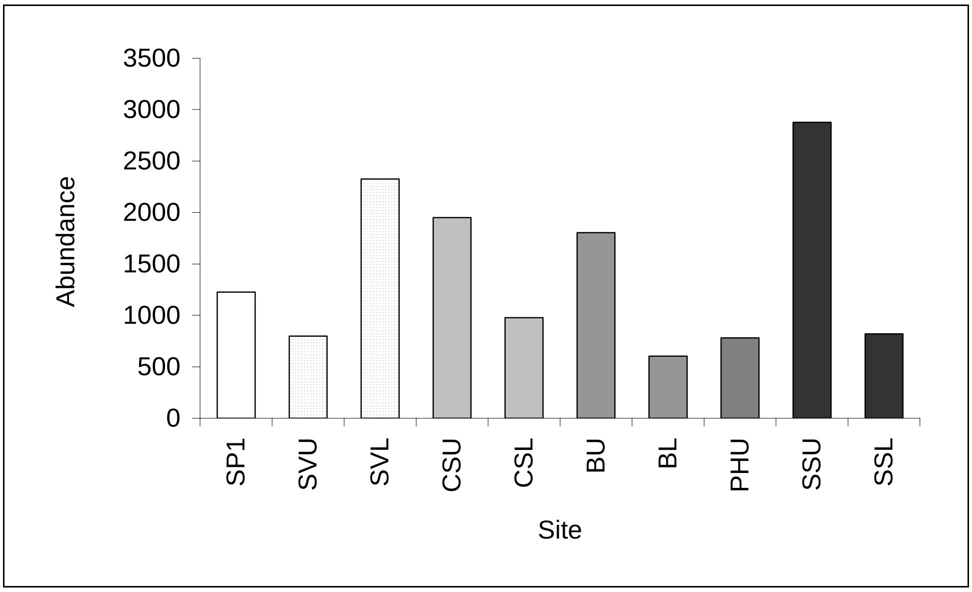

Fig. 9.5: Mean abundance of macroinvertebrate individuals collected from the ten Hutt Valley stream sites.

Macroinvertebrate abundance was lower at downstream sites relative to sites upstream of urban areas for three of the four upstream-downstream pairs. The exception was the upper and lower Stokes Valley Stream sites, where the lower site (2326 individuals) had a greater abundance than the upper site (798 individuals) (Fig. 9.5).

9.2.2 Community Composition

The macroinvertebrate community at Speedys Stream had the highest proportion of mayflies (82%) out of the Hutt Valley sites (Fig. 9.6). Refer to Appendix 3 for full macroinvertebrate data for each site.

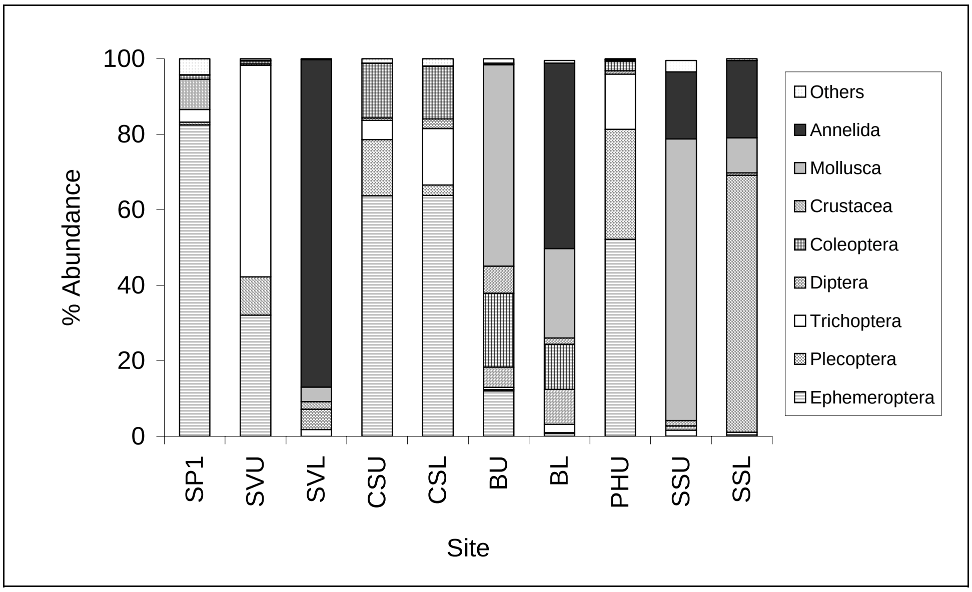

Fig. 9.6: The relative proportions (%) of the major macroinvertebrate taxonomic groups making up the community composition at the ten Hutt Valley stream sites.

The upper Stokes Valley site was dominated by caddisflies (56%), whereas the lower Stokes Valley site was dominated by annelid oligochaetes (87%). The upper and lower Collins stream sites had similar macroinvertebrate communities, with the only difference being that the upper site had a higher proportion of stoneflies (15%) and less caddisflies (5%) than the lower site (3% and 15%, respectively). The upper Black Stream site was dominated by molluscs (53%) and coleopterans (20%), with the lower site dominated by annelid oligochaetes (49%) and molluscs (24%). Both Black Stream sites had communities dominated by pollution tolerant taxa. The Pinehaven Stream site was dominated by EPT taxa (96%), with stoneflies making up a relatively large proportion (29%). The upper Silverstream site was dominated by molluscs (75%) and annelids (18%), whereas the lower Silverstream (SSL) site was dominated by dipterans (68%) and annelids (20%).

9.3 Biotic Indices

9.3.1 Quantitative Macroinvertebrate Community Index (QMCI)

The QMCI values at the ten Hutt Valley stream sites ranged between 1.3 at the lower Stokes Valley site and 8.8 at the upper Stokes Valley site (Fig. 9.7).

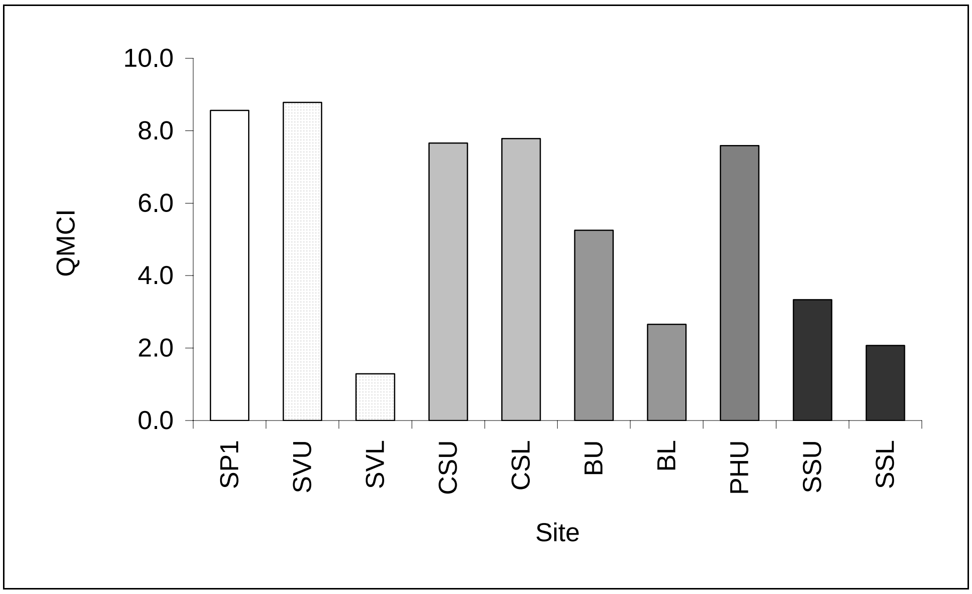

Fig. 9.7: Mean QMCI scores at the ten Hutt Valley Stream sites.

The upper site was located amongst native bush, whereas the lower site had poor riparian vegetation and a highly modified channel (see photographs in Appendix 2). Based on QMCI values, five of the ten Hutt Valley sites were inferred to have clean water (>6, Table 6.2), one site with possible mild pollution (4-5), and four sites with probable severe enrichment (<4). The QMCI values were lower at the downstream site for three of the four upstream-downstream pairs. The exception was the upper and lower Collins Stream sites, where the QMCI values were similar (7.7 and 7.8, respectively). The difference between the QMCI values at the upper and lower Black Stream sites (5.3 and 2.7, respectively) indicates a probable drop in water quality from mild pollution to probable severe enrichment. Although there was a decrease in the QMCI value between the upper and lower Silverstream sites (3.3 and 2.1, respectively), both sites were classified as showing probable organic enrichment (<4) (Fig. 9.7).

9.3.2 Number of EPT taxa and % EPT

The number of EPT taxa recorded at Hutt Valley sites ranged between 3 taxa at the lower Stokes Valley site and a relatively high 16 taxa at the lower and upper Stokes Valley sites (Fig. 9.8).

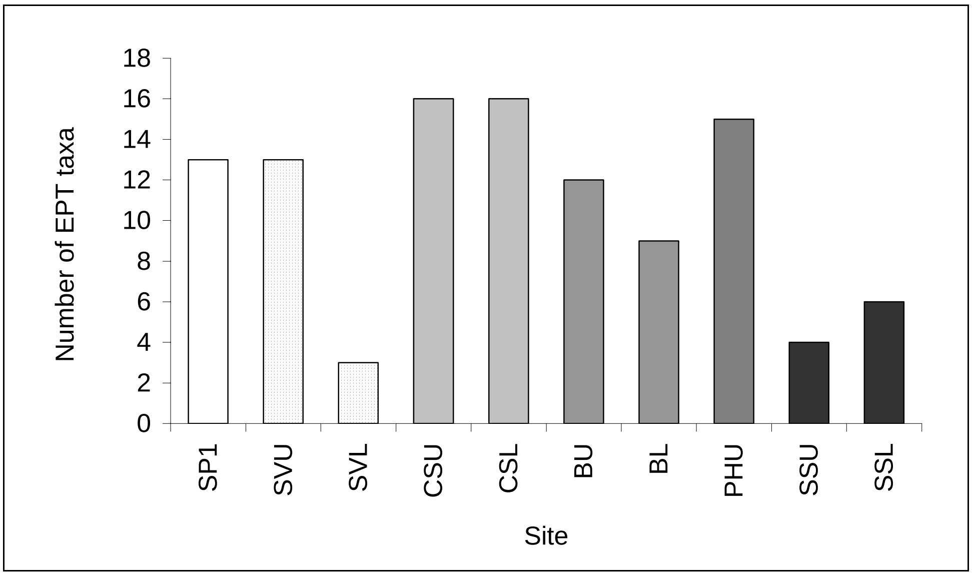

Fig. 9.8: **Mean number of EPT taxa recorded at the ten Hutt Valley stream sites.**

The proportion of EPT taxa making up the macroinvertebrate communities at Hutt Valley sites ranged between <1% at the lower Stokes Valley site and 98% at the upper Stokes Valley site (Fig. 9.9).

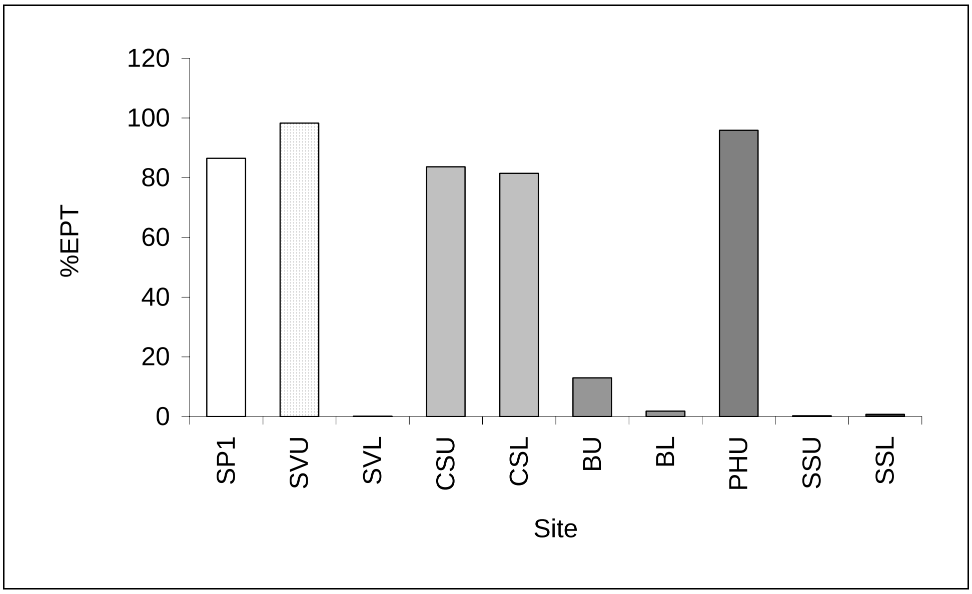

Fig. 9.9: **Mean proportion of EPT making up the community (%EPT) at the ten Hutt Valley stream sites.**

Five Hutt Valley sites including the upper Stokes Valley Stream, Pinehaven Stream, Speedys Stream, upper Collins Stream and lower Collins Stream had greater than 80% of the macroinvertebrate community made up by EPT taxa. Speedys Stream had the highest proportion of the community made up by mayflies (82%), with *Coloburiscus* and

Austroclima being the dominant taxa. The upper Stokes Valley site had the highest proportion of caddisflies (56%), with *Orthopsyche* being the dominant taxa. Although mayflies (52%) dominated the Pinehaven Stream community, the highest proportion of stoneflies (29%) occurred at this site, with *Taraperla* being the dominant stonefly taxa. Mayflies dominated the community at both the upper and lower Collins Stream sites (64% at both), with *Deleatidium* being the dominant mayfly taxa. The upper and lower Silverstream, upper and lower Black Stream, and lower Stokes Valley Stream sites had less than 15% of the community made up by EPT taxa.

9.4 Summary

The instream habitat at Hutt Valley sites was generally made up of coarse sediment substrates, which provided good macroinvertebrate habitat. The riparian vegetation was generally a mix of grass and/or native trees.

The Hutt Valley streams had relatively high and consistent species diversity across the ten sites, with upstream communities dominated by a high proportion of *Potamopyrgus* snails and EPT taxa, especially mayflies. This was reflected in the high biological index scores at upper sites.

Downstream urban and peri-urban sites generally had fewer sensitive EPT taxa and a higher proportion of tolerant oligochaetes and dipterans. Five sites had macroinvertebrate communities indicative of clean water. Four urban sites had macroinvertebrate communities indicative of severe organic enrichment. The biggest decline in water/habitat quality between upstream/downstream pairs occurred between the upper and lower Stokes Valley sites.

10. Ecology of Urban and Peri-urban Streams of the Kapiti Coast

10.1 Instream Habitat

10.1.1 Physico-chemical Parameters

The dissolved oxygen (DO) measured at Kapiti Coast sites ranged between a very low 1.42 g/m^3 and 14.8% saturation at Tikotu Creek (TCP) and 11.18 g/m^3 and 107% saturation at Airlie Road Stream (ARSL) (Table 10.1). If prolonged, it is likely that the low DO concentrations recorded at Tikotu Creek would restrict aquatic life.

The pH at all sites was circum-neutral, ranging between 6.74-7.89. The conductivity and water temperature were recorded within relatively narrow ranges, with the highest measurements recorded at the Airlie Road Stream site (conductivity, 537 µS/cm; water temperature, 14.3 ^{o}C). The lowest conductivity was recorded at Mangapouri Stream (MSO)

(163 µS/cm) with the lowest water temperature recorded at Kakariki Stream (KSW) (11.7 ^{o}C).

Table 10.1: A summary of physico-chemical parameters measured at the seven Kapiti Coast sites.

Site	Dissolved oxygen (g/m^3)	Dissolved oxygen (%)	pH	Conductivity (µS/cm)	Temperature (^{o}C)
DCL	9.72	97	7.24	179	-
MSO	8.86	82	7.09	163	11.9
WSP	7.55	73	7.03	231	13.5
WPB	10.24	97	7.46	391	12.6
ARSL	11.10	107	7.19	537	14.3
KSW	11.18	103	7.89	173	11.7
TCP	1.42	14.8	6.74	263	13.5

10.1.2 Channel Characteristics

Characteristics of the Kapiti Coast streams are shown in Table 10.2. The flow velocities recorded at Kapiti Coast streams were moderate-slow, ranging between 0.03 m/s at Tikotu Creek and 0.29 m/s at Waimapehi Stream (WPB). The streams were generally narrow and shallow, however Wharemauku Stream was 4.1 m wide and 0.51 m deep. Periphyton cover ranged between 0% at Tikotu Creek and Wharemauku Stream (WSP) and 80% at Duck Creek (DCL) (Table 10.2).

Table 10.2: A summary of the periphyton and macrophyte cover recorded at the seven Kapiti Coast sites.

Site	Velocity (m/s)	Water width (m)	Channel width (m)	Depth (m)	Periphyton Cover (%)	Macrophyte cover (%)	Riparian shade (%)	Riparian Width (m)
DCL	0.27	3.1	3.0	0.25	80	0	30	40.0
MSO	0.07	2.8	2.8	0.35	22	75	0	44.0
WSP	0.08	4.1	3.8	0.51	0	4	0	100.0
WPB	0.29	1.1	1.4	0.08	58	0	66	28.8
ARSL	0.03	1.2	1.2	0.05	77	1	17	30.0
KSW	0.24	1.7	1.9	0.08	33	2	40	50.0
TCP	0.03	3.0	3.0	0.40	0	20	3	20.0

Waimapehi Stream and Airlie Road Stream had over 50% periphyton cover, with Mangapouri Stream (22%) and Kakariki Stream (33%) having moderate cover. Macrophyte coverage ranged between 0% at Duck Creek and 75% at Mangapouri Stream. In general, streams had wide riparian vegetation zones, but provided moderate-poor channel shade (between 0 – 66% shade).

In general, the Kapiti Coast streams had steep or vertical stream banks that were either undercut or with toe (Fig. 10.1). Exceptions were the Airlie Road Stream site, which had concrete lined banks and the Kakariki Stream site, which had gentle sloping banks.

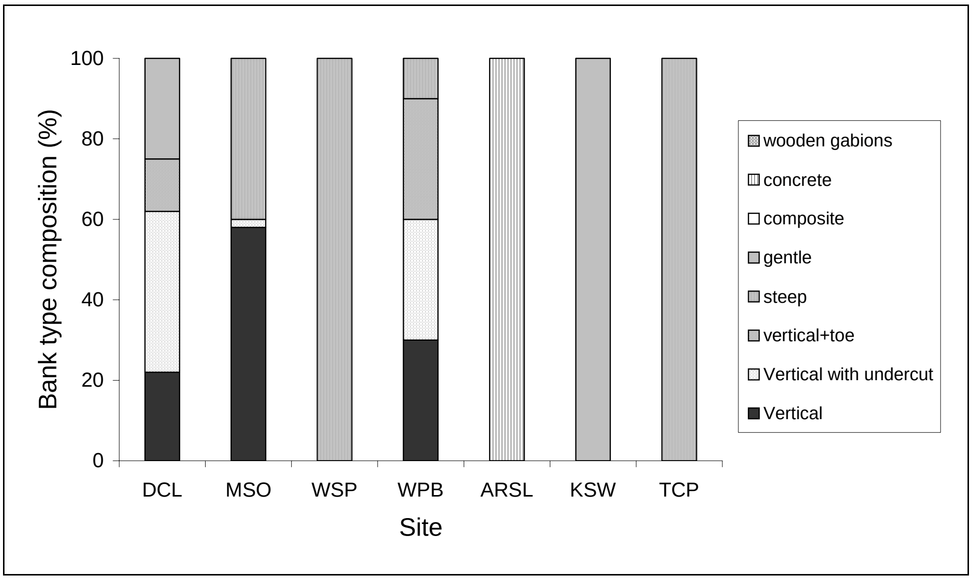

Fig. 10.1: The relative proportion (%) of stream bank type present at the seven Kapiti Coast stream sites.

10.1.3 Substrate Characteristics

Four of the seven Kapiti Coast sites were dominated by fine silt/sand sized particles (<2 mm), with the Tikotu Creek streambed made up almost entirely of silt/sand (98%) (Fig. 10.2). Those sites that were not dominated by fine substrates including Duck Creek, Waimapehi Stream and Kakariki Stream, were dominated by a mix of small cobbles and gravels.

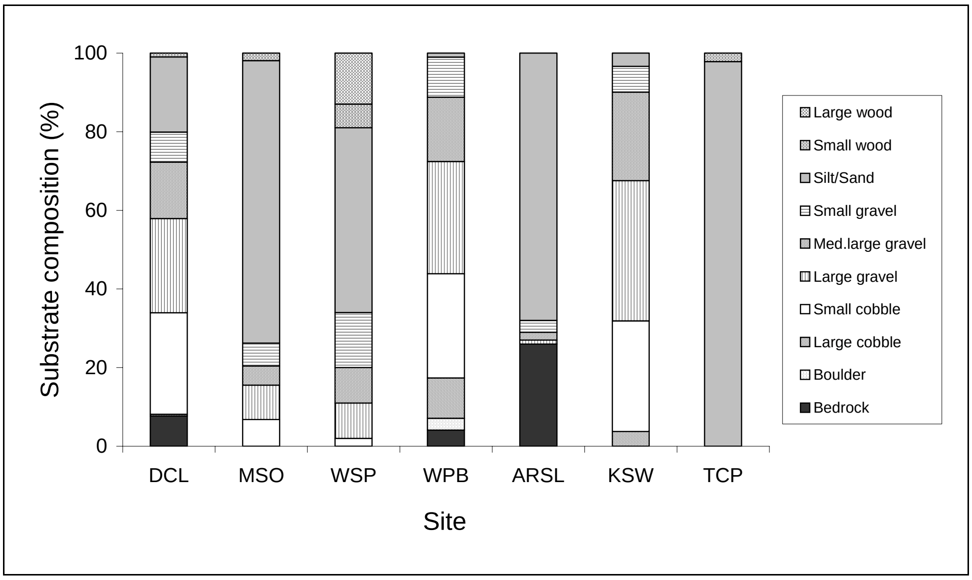

Fig. 10.2: The relative proportion (%) of each sediment size class at the seven Kapiti Coast stream sites.

10.1.4 Riparian Vegetation

The riparian vegetation recorded at the Kapiti Coast sites was predominantly made up of grass (up to 100%), with relatively small areas of native/exotic trees and exotic shrub. An exception was the Waimapehi Stream, which had 70% native tree riparian vegetation (Fig. 10.3).

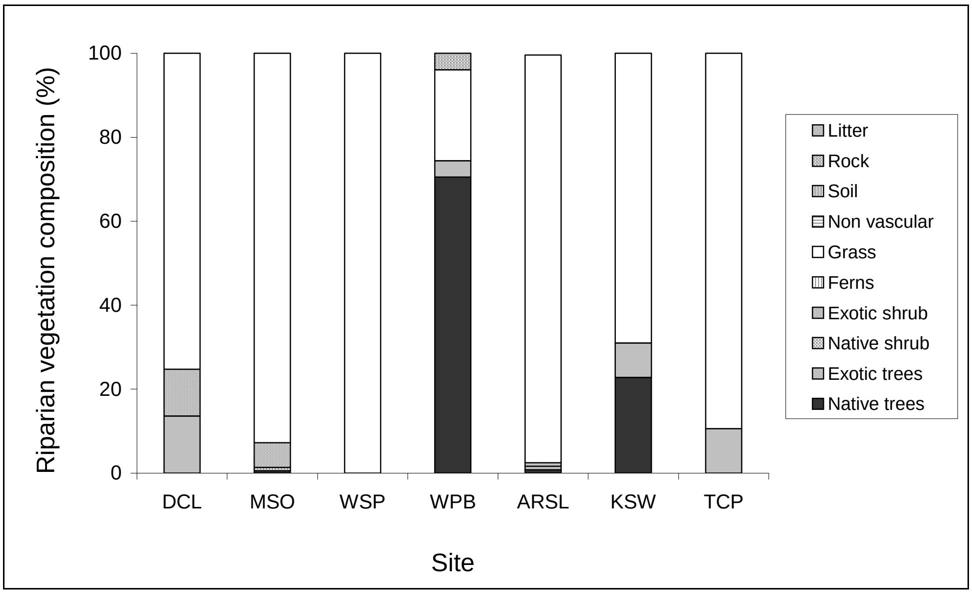

Fig. 10.3: The relative proportion (%) of each riparian vegetation class at the seven Kapiti Coast stream sites.

10.2 Macroinvertebrate Communities

10.2.1 Species Diversity and Abundance

Coast urban stream sites. Macroinvertebrate taxa richness ranged between 12 at Airlie Road Stream and 21 at Tikotu Creek, although five of the sites had between 18 and 21 taxa (Fig. 10.4).

Macroinvertebrate abundance varied over a relatively wide range between a low 54 individuals at Waimapehi Stream and 7275 individuals at Wharemauku Stream (Fig. 10.5).

10.2.2 Community Composition

The Kapiti Coast urban stream macroinvertebrate communities were generally dominated by taxa belonging to the dipteran, crustacean, mollusc and annelid groups (Fig. 10.6). The exception was Duck Creek, with coleopterans (23%), caddisflies (20%) and mayflies (15%), as well as annelids (16%) and molluscs (14%) making up the community.

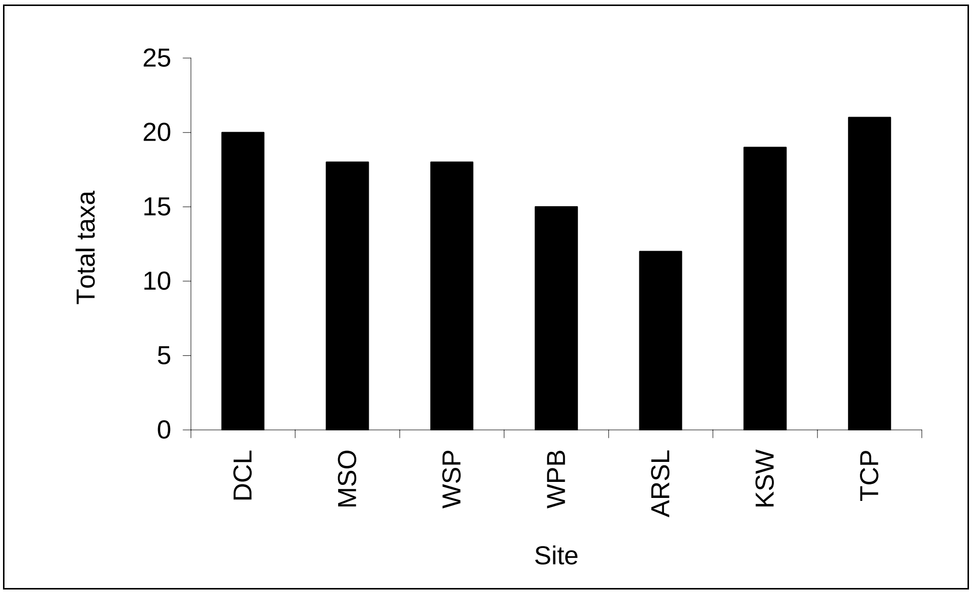

Fig. 10.4: Mean number of macroinvertebrate taxa and abundance recorded from the seven Kapiti Coast stream sites.

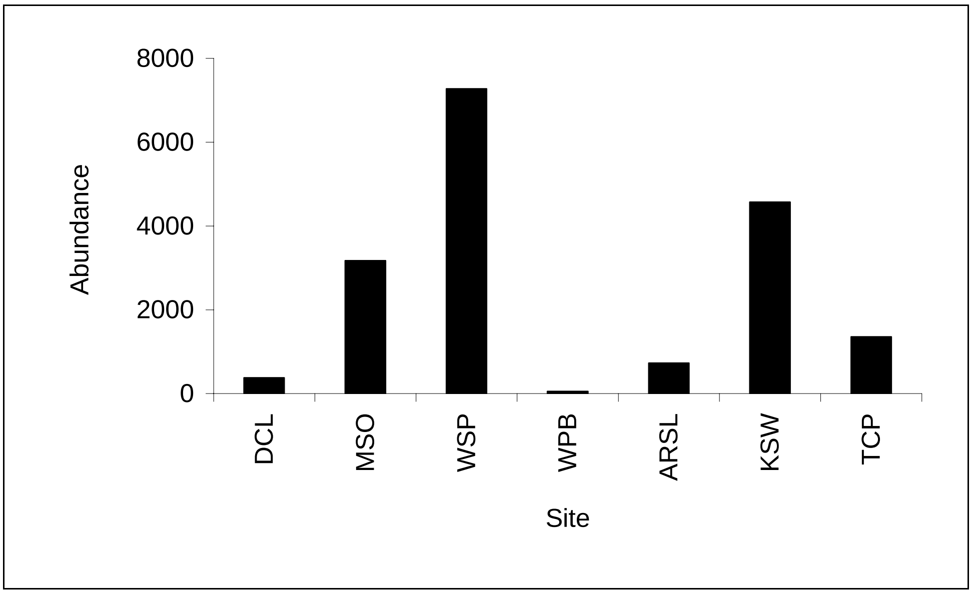

Fig. 10.5: Mean number of macroinvertebrate taxa and abundance recorded from the seven Kapiti Coast stream sites.

The Waimapehi Stream community, with only 54 individuals recorded, was also widely represented by most taxonomic groups, and was the only site with stoneflies (4%) recorded; however dipterans (56%) dominated the relatively low-abundance community with 30 individuals. The Mangapouri Stream and Wharemauku Stream sites were dominated by both crustaceans and molluscs, which in combination made up 95% and 100% of the communities, respectively.

The Airlie Road Stream site had relatively low taxonomic diversity, with molluscs (89%) dominating the community.

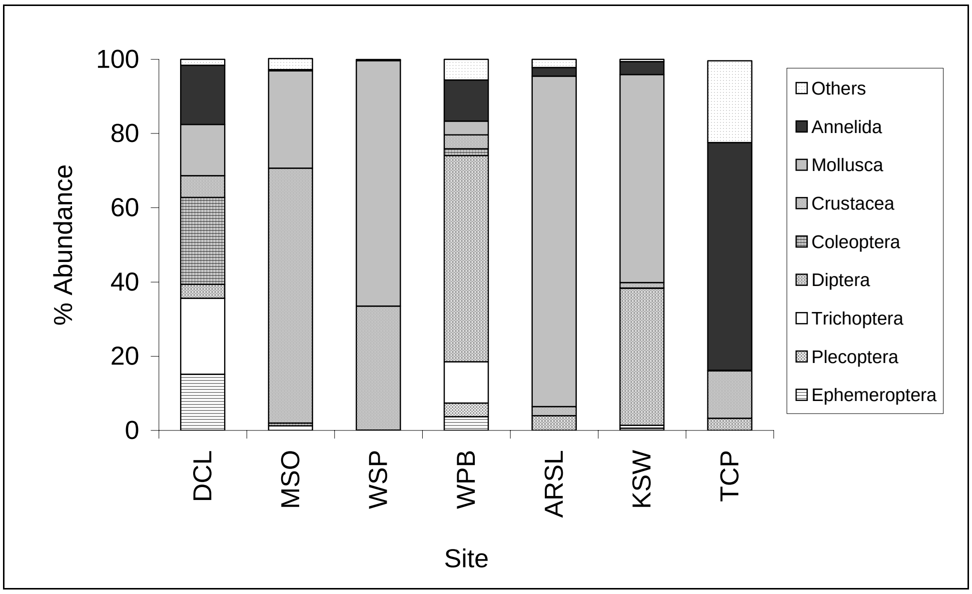

Fig. 10.6: The relative proportions (%) of the major macroinvertebrate groups making up the community composition at the seven Kapiti Coast stream sites.

The Kakariki Stream site had a high proportion of pollution tolerant molluscs (56%) and dipterans (37%), however, sensitive mayflies (1%) and caddisflies (1%) were present. The macroinvertebrate community at Tikotu Creek was dominated by typically pollution tolerant taxa including oligochaetes (61%), Platyhelminthes (flatworms) and Hirudinea (leeches) ("other" category, 21%) and crustaceans (13%).

10.3 Biotic Indices

10.3.1 Quantitative Macroinvertebrate Community Index (QMCI)

The QMCI value recorded at Duck Creek (QMCI 5.0) infers possible mild pollution (Fig. 10.7). The Mangapouri Stream and Wharemauku Stream QMCI values indicate probable moderate pollution (QMCI 4.5 and 4.3 respectively). The QMCI values recorded at Waimapehi Stream, Airlie Road Stream, Kakariki Stream and Tikotu Creek indicate probable severe enrichment (QMCI <4) (Fig. 10.7, refer Table 6.2).

The relatively low QMCI values recorded at the Kapiti Coast sites reflected the relatively high numbers of low scoring taxa such as the mollusc snails *Potamopyrgus* and *Physella*, chironomids (Orthocladiinae), ostracods, oligochaetes, flatworms and leeches numerically dominating the communities.

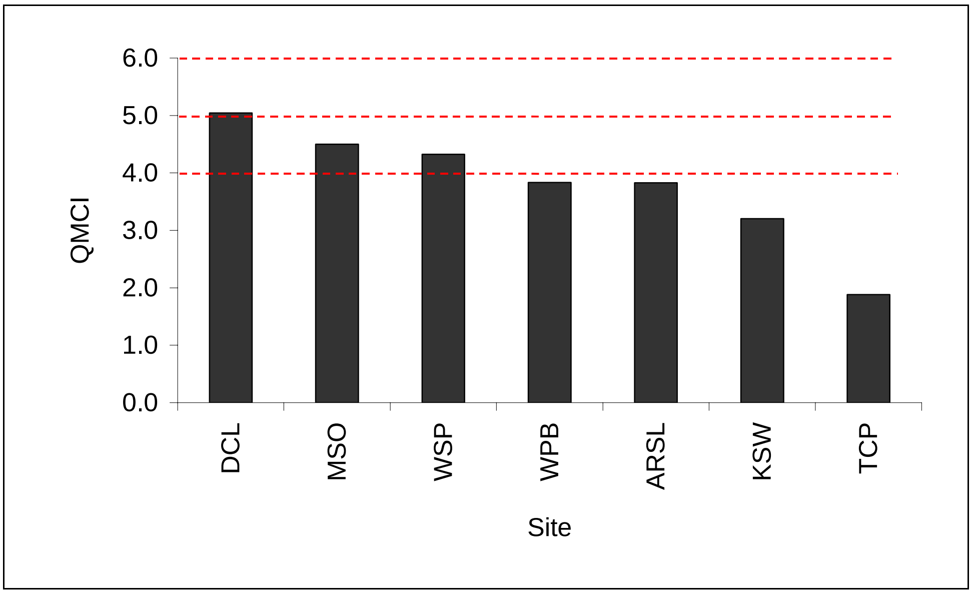

Fig. 10.7: Mean QMCI scores at the seven Kapiti Coast stream sites.

10.3.2 Number of EPT Taxa and % EPT

The number of sensitive EPT taxa ranged between no taxa at Airlie Road Stream and Tikotu Creek and 8 taxa at Duck Creek (Fig. 10.8).

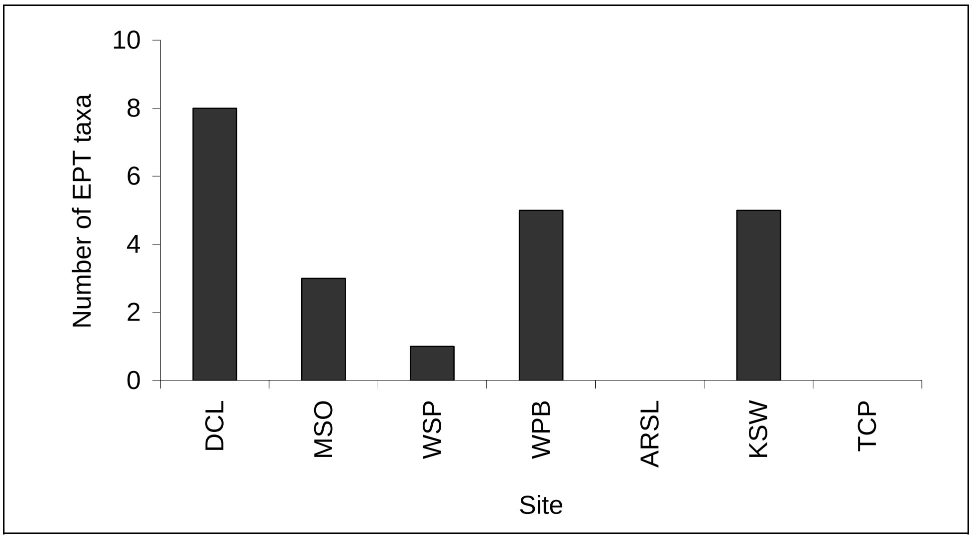

Fig. 10.8: Mean number of EPT taxa recorded at the seven Kapiti Coast stream sites.

The only Kapiti Coast sites with an appreciable number of sensitive EPT taxa making up the community were Duck Creek (36%) and Waimapehi Stream (19%), with all other sites having less than 2% of the community made up by EPT taxa (Fig. 10.9). Duck Creek had eight EPT taxa, five of which were caddisflies with *Triplectides* (14%) being the most abundant followed by *Pycnocentrodes* (4%), *Psilochorema* (2%), *Pycnocentria* (1%) and a single *Hudsonema* individual.

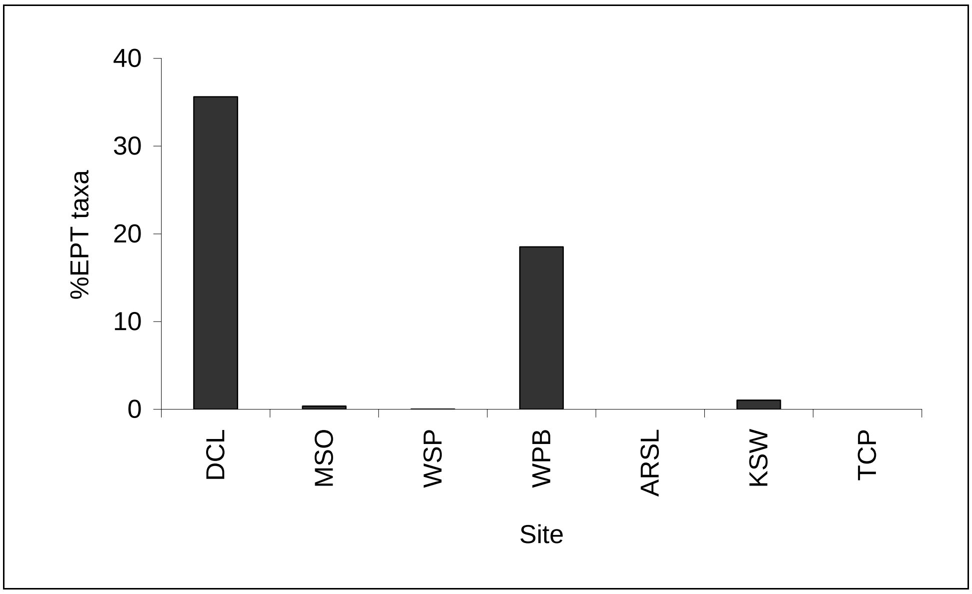

Fig. 10.9: Mean % of EPT taxa making up the macroinvertebrate community at the seven Kapiti Coast stream sites.

Mayflies recorded at Duck Creek included *Austroclima* (9%) and *Deleatidium* (6%), with a single *Zephlebia* individual. Waimapehi Stream had five EPT taxa, which included the caddisflies *Orthopysche* (9%) and *Psilochorema* (2%), mayflies *Coloburiscus* (2%) and *Zephlebia* (2%) and the only stonefly (*Spaniocerca*, 4%) found at any of the Kapiti Coast sites.

10.4 Summary

Physico-chemical parameters ranged between poor at Tikotu Creek and moderate-good at Airlie Road Stream and Kakariki Stream. The sediment substrates were generally made up of fine silt/sand and fine gravels supporting macrophyte growth. Exceptions were Duck Creek and Waimapehi, which had a higher proportion of larger cobbles, thus possibly explaining the relatively higher proportion of sensitive EPT taxa at these sites. Riparian vegetation was typically in grass with small patches of native/exotic trees and shrub.

The Kapiti Coast sites had moderate macroinvertebrate taxonomic richness, with sites typically overwhelmingly dominated by a few generally tolerant taxa including *Potamopyrgus* snails, dipterans, crustacean amphipods and oligochaetes. With the exception of Duck Creek and Waimapehi Stream, the Kapiti Coast sites generally had a low number of sensitive EPT taxa, and those recorded generally represented a very small proportion of the total community. This reflected the numerical dominance of the community by the generally tolerant taxa, which resulted in the QMCI scores indicating mild to severe organic enrichment at Kapiti Coast sites.

11. Ecology and Classification of Urban and Peri-urban Streams in the Wellington Region

11.1 Macroinvertebrate Communities

11.1.1 Classification

Seven macroinvertebrate communities comprising the 61 combined 2003 and 2004 stream sites were identified using TWINSPAN (Fig. 11.1). The seven Groups contained between 2 to 15 sites, and in general were classified along a gradient from diverse macroinvertebrate communities made up of relatively "clean water" taxa (high MCI scores) at Group 1 sites to low diversity communities containing pollution tolerant taxa (low MCI scores) at Group 7 sites.

Division one split Groups 1-3 (16 stream sites) from Groups 4-7 (45 sites) into four main groupings. Groups 1-3 sites were most commonly associated with the filter-feeding mayfly *Coloburiscus* (MCI score = 9) and the predatory stonefly *Stenoperla* (MCI = 10), while Groups 4-7 sites were most commonly associated with *Physella* snails (MCI = 3) and oligochaete worms (MCI = 1). A further division (Division 2) of the TWINSPAN analysis resulted in seven stream groupings. We investigated the seven groupings for relationships with habitat and other environmental factors to understand what environmental gradients existed amongst the sites.

In general the seven stream groupings can be described as follows:

- Group 1: Upper catchment, well-shaded, small, forested streams.
- Group 2: Upper catchment, open canopy, small open stream.
- Group 3: Mid-catchment, well-shaded, rural, small-moderate streams.
- Group 4: Mid-catchment, well-shaded, urban, moderate-sized stream.
- Group 5: Mid-lower catchment, rural or urban, moderate-sized streams.
- Group 6: Upper-lower catchment, urban, small-large streams.
- Group 7: Lower catchment, urban, moderate-large streams.

11.1.2 Species Diversity and Abundance

Invertebrate taxa richness and abundance differed significantly amongst the seven stream groups (ANOVA, $p<0.001$ and $p<0.01$, respectively).

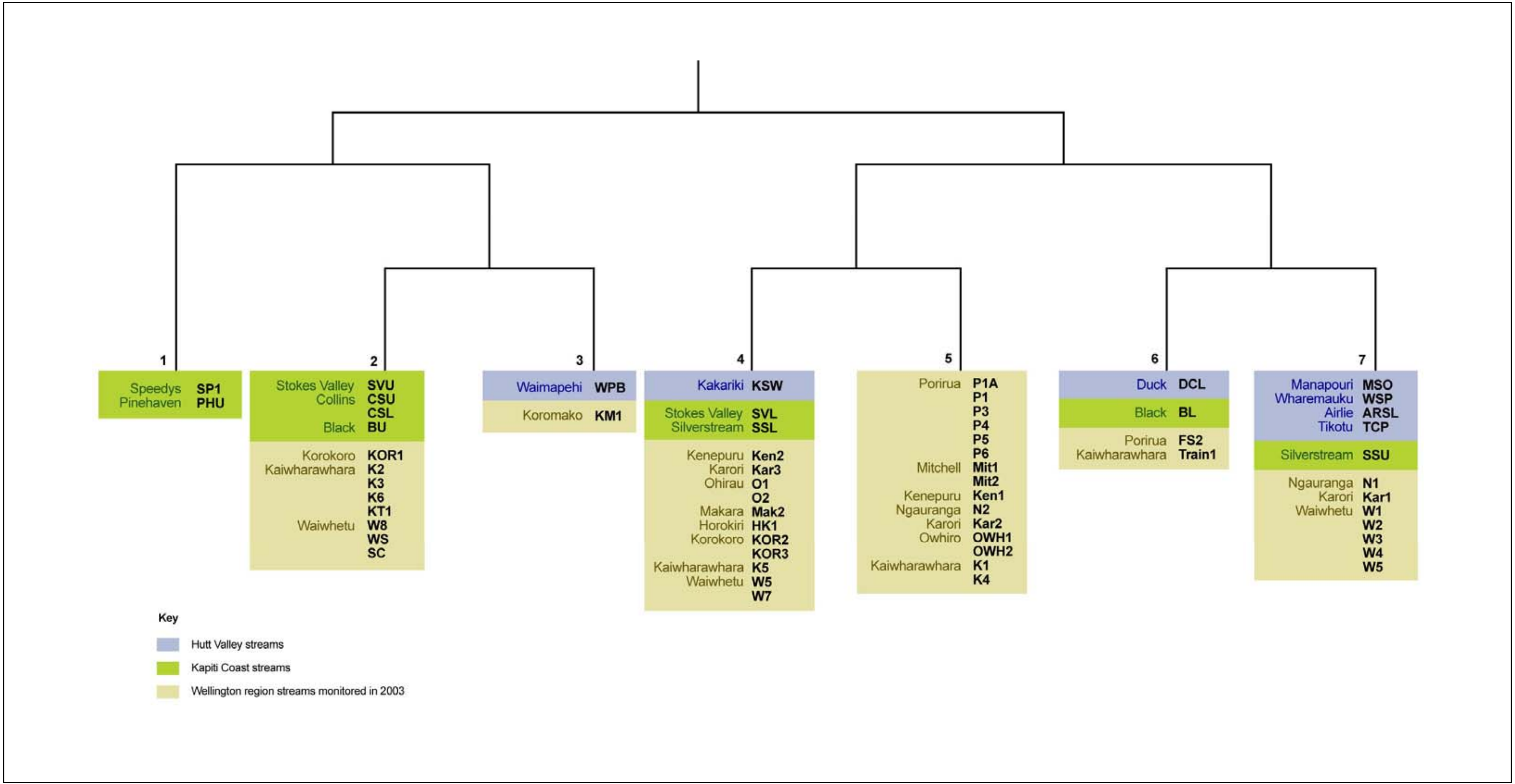

Fig. 11.1: TWINSPAN classification of 61 sites in the Wellington region.

There was an overall general decline in the mean taxon richness between Group 1 sites (23.0 ± 0.0[1] taxa) and Group 7 sites (12.0 ± 1.9 taxa) (Fig. 11.2). Group 7 sites had the greatest mean invertebrate densities (4,346 ± 1711 individuals), while Group 3 sites had the lowest (79 ± 25 individuals) (Fig.11.3).

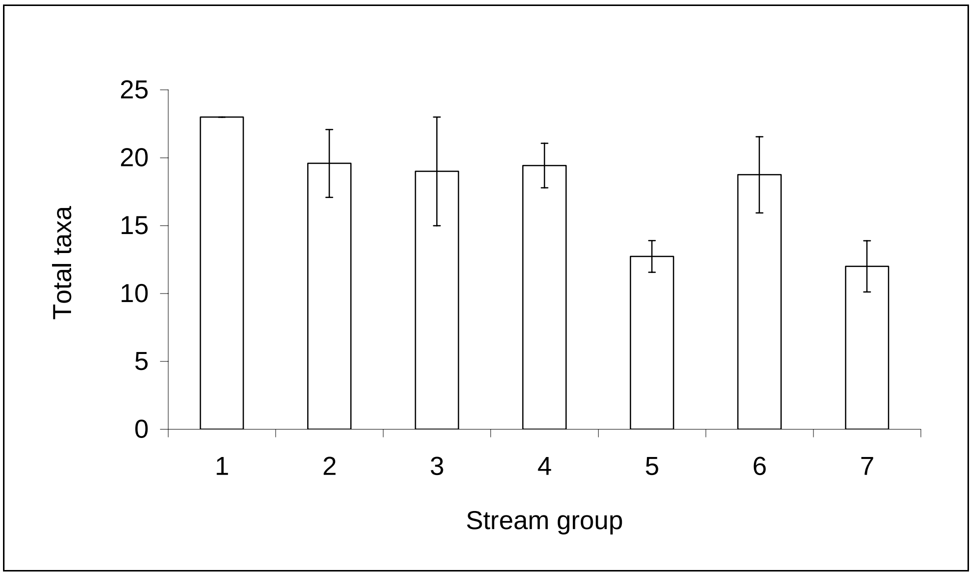

Fig. 11.2: Mean (± S.E.) number of macroinvertebrate taxa recorded from the seven stream groups identified in the Wellington region using TWINSPAN.

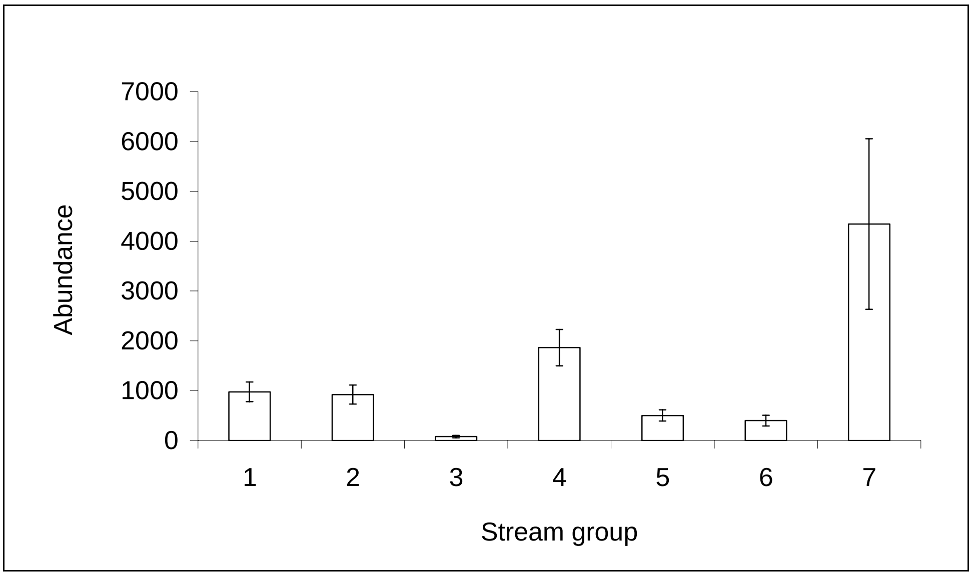

Fig. 11.3: Mean (± S.E.) abundance recorded from the seven stream groups identified in the Wellington region using TWINSPAN.

[1] All values are 1 standard error, unless noted otherwise.

11.1.3 Community Composition

There was a general shift in the macroinvertebrate community composition from those dominated by EPT taxa, especially mayflies, at Groups 1 and 2 sites, to an increasing relative abundance of more pollution-tolerant taxa, especially snails (Mollusca) and oligochaetes (Annelida), at Groups 6 and 7 sites (Fig. 11.4).

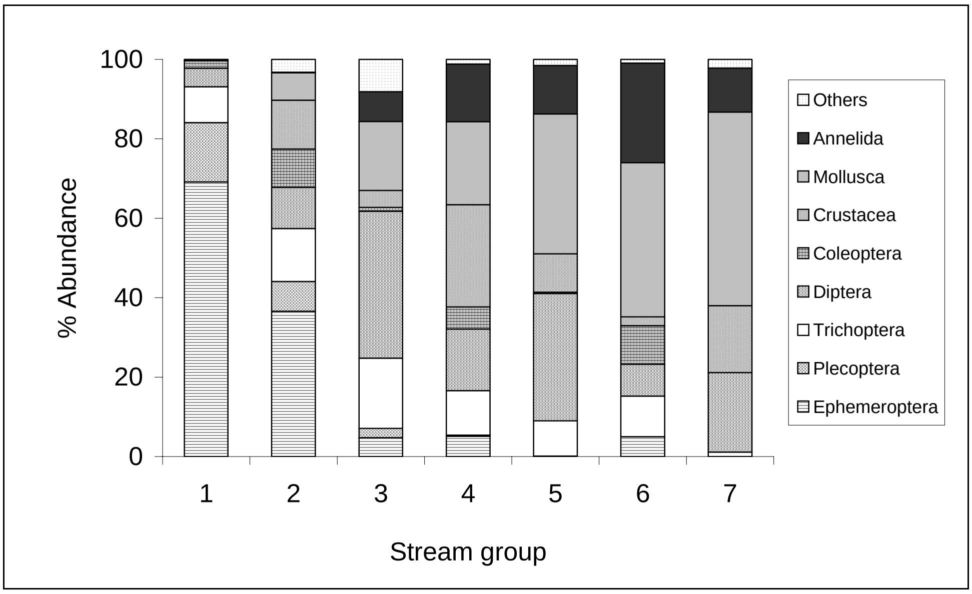

Fig. 11.4: Relative abundance of the major macroinvertebrate taxonomic groups recorded from the seven stream groups identified in the Wellington region using TWINSPAN.

Group 1 sites were dominated by Ephemeroptera (mayfly) taxa (69%), especially *Coloburiscus* and *Austroclima*. Plecoptera (stonefly) taxa were also common (15%) and included the presence of *Zelandobius* and *Taraperla*.

Group 2 sites were similarly dominated by EPT taxa but had a smaller proportion of mayflies (37%), stoneflies (7%) and trichopterans (caddisflies) (13%). Other common taxa (comprising 10% or more were coleopterans (especially elmid beetles), molluscs (mainly *Potamopyrgus*), and crustaceans (mainly amphipods).

Group 3 sites had low invertebrate densities overall and were dominated by dipterans (37%), especially chironomids. Molluscs were also relatively abundant (17%), especially the snail *Potamopyrgus*. Caddisflies comprised approximately 18% of the fauna, and were represented by a small number of individuals from numerous genera.

Group 4 sites were dominated by amphipod and ostracod crustaceans (26%). Molluscs (21%) also dominated the community, particularly

Potamopyrgus. Dipterans (16%), annelids (15%) and caddisflies (11%) were also relatively common.

Group 5 sites had relatively low taxon richness and were dominated by molluscs (35%), which included the snails *Physella* and *Potamopyrgus*. Dipterans were also relatively abundant (32%), mostly represented by chironomids. EPT taxa collectively comprised <10% of the fauna.

Group 6 sites were dominated by molluscs (39%), especially *Physella* and *Potamopyrgus* snails. Annelid worms were relatively abundant (25%), with coleopterans and caddisflies making up 10% each.

Group 7 sites contained the greatest proportion of pollution tolerant molluscs (49%). Dipterans and crustacean made up 37% of the community. As with Groups 5 and 6, *Potamopyrgus* and *Physella* were the most common molluscs, whilst ostracods and amphipods were abundant crustaceans.

11.1.4 Biotic Indices

Mean QMCI values were significantly different between groups ($p<0.001$) and showed a general decline between Group 1 and 7 (Fig. 11.5).

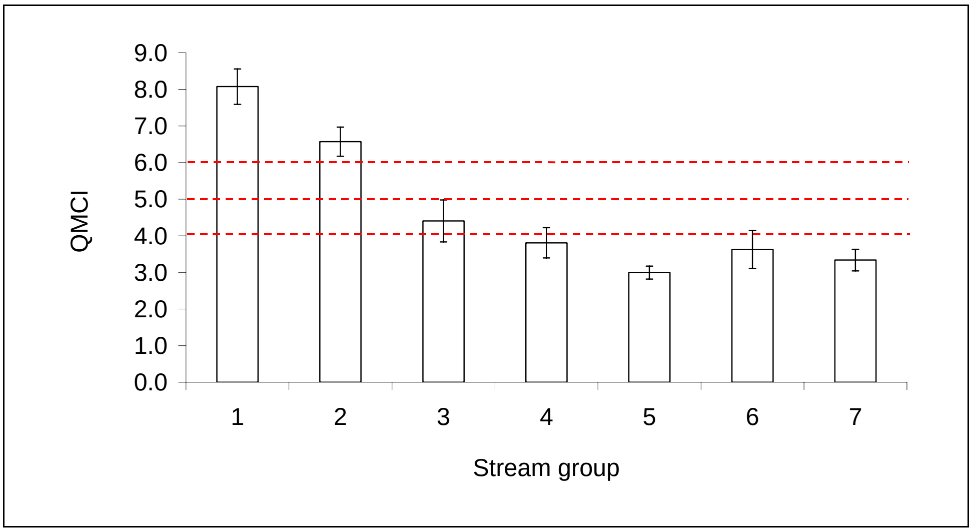

Fig. 11.5: Mean (± S.E.) QMCI scores recorded from the seven stream groups identified in the Wellington region using TWINSPAN.

The mean QMCI values for Group 1 and 2 sites were 8.1 (± 0.49) and 6.6 (± 0.40), respectively, and indicative of clean water (Table 6.2). The mean QMCI values for Group 3 sites were indicative of probable moderate pollution (4.4 ± 0.57), while Groups 4-7 QMCI values were indicative of probable severe pollution (QMCI < 4).

The mean number of sensitive EPT taxa recorded per site ranged between 13 (± 1.0) EPT taxa at Group 1 streams and 1 (± 0.4) EPT taxa at Group 7 streams (Fig. 11.6). There was a generally decreasing trend in the number of EPT taxa recorded between Groups 1 and 7.

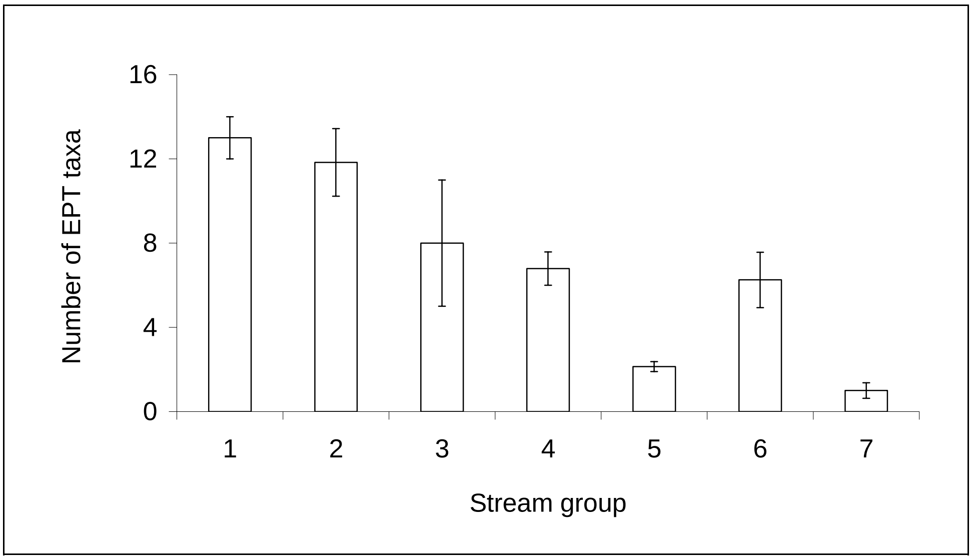

Fig. 11.6: **Mean (± S.E.) number of EPT taxa recorded from the seven stream groups identified in the Wellington region using TWINSPAN.**

Group 1 streams had the highest mean percentage of EPT taxa making up the community (93% ± 2.8), and comprised mainly of *Coloburiscus* and *Austroclima* mayflies (Figs. 11.7).

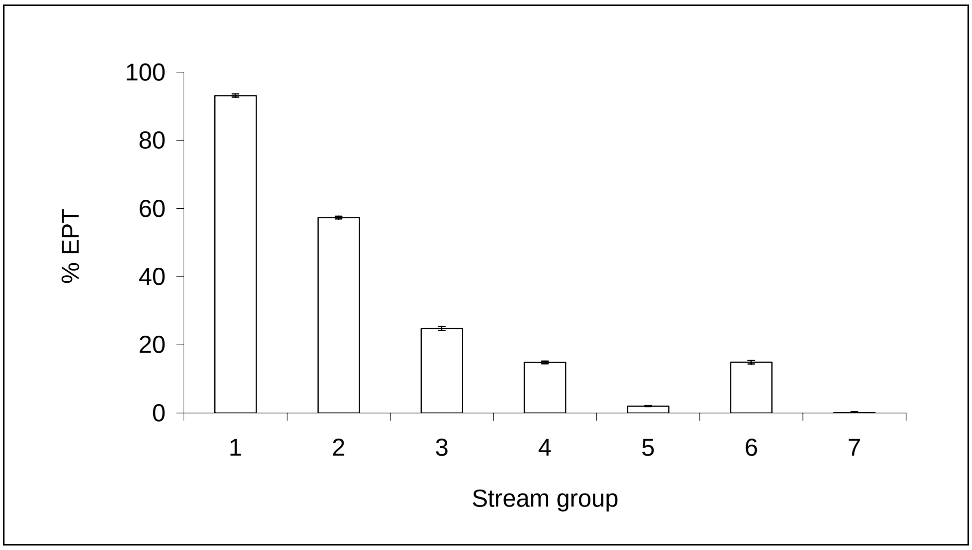

Fig. 11.7: **Mean (± S.E.) %EPT scores recorded from the seven stream groups identified in the Wellington region using TWINSPAN.**

Group 2 also had a relatively high proportion of EPT taxa (57% ± 10.2), which were generally numerically dominated by the mayflies Deleatidium and Coloburiscus. Other Groups had less than 11% of their communities made up by EPT taxa.

11.2 Instream Habitat

11.2.1 Differences in Instream Habitat

Substrate Characteristics

Although stream substrate composition was significantly different between the seven groups ($p<0.05$), most sites generally contained coarse sized particles >2 mm (Fig. 11.8). Stream Group 1 sites had the greatest proportion of small and large cobbles (56%), with Group 3 sites the greatest proportion of bedrock and boulders (27%). Group 4 stream sites had the greatest proportion of small, medium and large gravels (53%), whilst Group 5 and 6 sites had the greatest proportion of silt/sand (12% and 27% respectively). Woody debris made up no more than 10% of the substrate, with Group 2 sites having the greatest proportion with 7%.

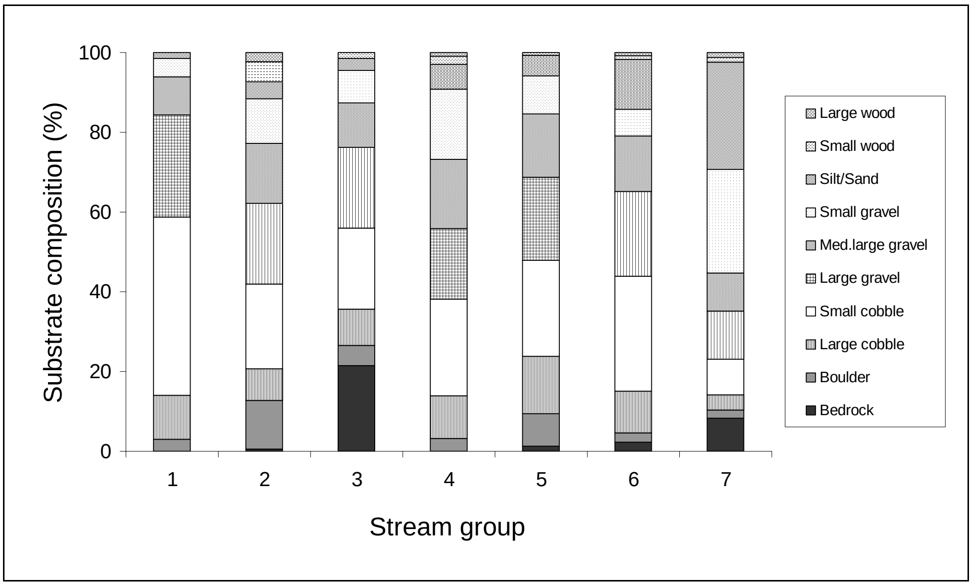

Fig.11.8: Relative abundance of various sediment size classes recorded from the seven TWINSPAN stream groups identified in the Wellington region.

Physico-chemical Characteristics

Water temperature differed significantly amongst stream groups ($p<0.01$). Groups 1-3 sites had mean temperatures ranging between 12.0 °C (± 0.6) and 13.4 °C (± 0.5), whilst means for Groups 4-7 sites were several degrees warmer ranging between 15.2 °C (± 1.9) and 17.1 °C (± 0.8) (Table 11.1).

Water pH differed significantly amongst stream groups ($p<0.01$), although the range was only between 6.60 (± 0.19) at Group 7 sites and 7.47 (± 0.12) at Group 5 sites. Dissolved oxygen concentrations were relatively high at all sites, ranging between 8.30 g/m^3 (± 0.76) at Group 7 sites and 10.59 g/m^3 (± 0.29) at Group 1 sites. Conductivity varied considerably between 141 µS/cm (± 17) at Group 2 sites and 724 µS/cm (± 576) at Group 1 sites. Neither dissolved oxygen nor conductivity differed significantly amongst stream groups ($p>0.05$).

Table 11.1: Mean physico-chemical characteristics of the seven TWINSPAN stream groups (S.E in brackets).

Stream Group	Temperature (°C)	DO (g/m^3)	DO (%)	pH	Conductivity (µS/cm)
1	12.0 (0.6)	10.59 (0.29)	98 (4)	7.28 (0.07)	724 (576)
2	13.4 (0.5)	10.42 (0.24)	100 (3)	6.97 (0.13)	141 (17)
3	12.1 (0.5)	9.32 (0.92)	87 (10)	7.13 (0.33)	294 (97)
4	15.3 (0.7)	9.40 (0.25)	95 (3)	7.21 (0.14)	173 (15)
5	17.1 (0.8)	9.34 (0.27)	95 (3)	7.47 (0.12)	236 (25)
6	15.2 (1.9)	9.60 (0.31)	96 (1)	7.13 (0.06)	153 (21)
7	15.4 (0.7)	8.30 (0.76)	83 (7)	6.60 (0.19)	342 (135)

Physical Habitat Characteristics

Water depth, overhead cover (% shade) and macrophyte cover all differed significantly amongst stream groups ($p<0.05$), although overhead cover showed the greatest variation amongst groups ($p<0.001$) (Table 11.2).

Table 11.2: Mean physical habitat characteristics of seven Wellington region stream groups (S.E in brackets).

Stream Group	Width (m)	Depth (m)	Velocity (m/s)	Shade (%)	Macrophyte cover (%)	Periphyton cover (%)
1	2.87 (1.73)	0.14 (0.08)	0.46 (0.03)	35 (30)	0 (0)	100 (0)
2	1.95 (0.36)	0.15 (0.02)	0.29 (0.03)	58 (11)	0 (0)	70 (9)
3	1.23 (0.11)	0.08 (0)	0.29 (0)	66 (0)	0 (0)	32 (26)
4	2.89 (0.31)	0.19 (0.02)	0.22 (0.02)	30 (9)	2 (2)	40 (9)
5	3.83 (0.74)	0.17 (0.02)	0.38 (0.17)	18 (5)	0 (0)	56 (8)
6	3.65 (0.82)	0.22 (0.07)	0.28 (0.02)	39 (21)	0 (0)	62 (17)
7	2.75 (0.32)	0.38 (0.08)	0.11 (0.02)	8 (3)	24 (10)	62 (12)

Shading was greatest amongst Groups 2 and 3 sites (58% ± 11 and 66% ±0, respectively) and least for Group 7 (8% ±3). Mean macrophyte cover was <1% for all stream groups except Groups 4 and 7, which had an average cover of 2% (±2) and 24% (±10), respectively. Stream channel width and velocity did not differ significantly amongst groups.

11.2.2 Instream Habitat Characteristics of Stream Groups

Group 1 stream sites had the highest proportion of small cobbles (45%) and large gravels (26%). Group 1 sites had the coolest water temperatures (12.0 °C ± 0.6), highest DO concentrations (10.59 g/m^3 ± 0.29) and highest conductivity (724 µS/cm ± 576). Streams were relatively shallow (mean 0.14 m ± 0.08) with the highest mean velocities (0.46 m/s ± 0.03). Shade cover was moderate at 35% (± 30), but had the highest periphyton cover (100% ± 0).

Group 2 stream sites had the highest proportion woody debris (7%), but moderate levels of inorganic sediment size classes compared with other groups. Group 2 sites had cool water temperatures (13.4 °C ± 0.5), high DO concentrations (10.42 g/m^3 ± 0.24) and relatively low conductivity (141 µS/cm ± 17). Streams were relatively narrow (1.95 m ± 0.36) and shallow (0.15 m ± 0.02) with moderate velocities (0.29 m/s ± 0.00). They were well shaded (58% ± 11) with high periphyton cover (70% ± 9).

Group 3 stream sites had the highest proportion of sediment substrate as Bedrock (22%). Large gravel (20%) and small cobbles (20%) also dominated the substrate. Group 3 sites were well shaded (66% ± 0) with cool water temperatures (12.1 °C ± 0.5) and low periphyton cover (32% ± 26). Streams were narrow (1.23 m ± 0.11) and shallow (0.08 m ± 0.00) with moderate velocities (0.29 m/s ± 0.00).

Group 4 stream sites were dominated by small cobbles (24%) and to a lesser extent, large gravel (18%), small gravel (18%) and medium-large gravel (17%). These sites had the highest proportion of medium-large gravel making up the substrate. Group 4 sites had warmer water temperatures (15.3 °C ± 0.7), below average shade (30% ± 9), macrophytes present (2% ± 2), but low periphyton coverage (40% ± 9).

Group 5 stream sites were dominated by small cobbles (24%), large gravel (21%) and a relatively high proportion of medium-large gravel (16%). Group 5 sites had the warmest temperatures (17.1 °C ± 0.8) and highest pH (7.47 ± 0.12). They were the widest streams (3.83 m ±0.74), had relatively high velocities (0.38 m/s ± 0.17), poor shade (18% ± 5) but moderate periphyton cover (56% ± 8).

Group 6 stream sites had an above average proportion of the substrate dominated by small cobbles (29%). Fine silt/sand (13%) made up an greater proportion of the substrate compared with sites in Groups 1-5. Group 6 sites had relatively warm water temperatures (15.2 °C ± 1.9) and low conductivity (153 µS/cm ± 21). They were relatively wide (3.65 m ± 0.82) and deep (0.22 m ± 0.07) with moderate stream velocities (0.28 m/s ± 0.02), shade (39% ± 21) and periphyton cover (62% ± 17).

Group 7 stream sites had the highest proportion of silt/sand (27%) and small gravel (26%) making up the substrate. Bedrock (9%) made up an above average proportion, whilst all other size classes were under represented. Group 7 sites had relatively warm water temperatures

(15.4 °C ± 0.7) with the lowest DO concentrations (8.3 g/m^3 ± 0.76) and pH (6.6 ± 0.19). They were the deepest streams (0.38 m ± 0.08) with the lowest velocities (0.11 m/s ± 0.02), had poor shade cover (8% ± 3) and had the greatest macrophyte growth (24% ± 10).

11.3 Riparian Vegetation

The relative abundance of different riparian vegetation types varied substantially amongst stream groups. Grass comprised a considerable proportion of the riparian zone for most groups, although the relative proportions differed significantly amongst stream groups (range of means, 17-72%). However, the riparian categories that showed the most significant variation between groups were the native trees, native shrubs and exotic trees (Fig. 11.9). Native trees were more common at Group 1-3 sites, whereas exotic trees were more common at Group 4-7 sites.

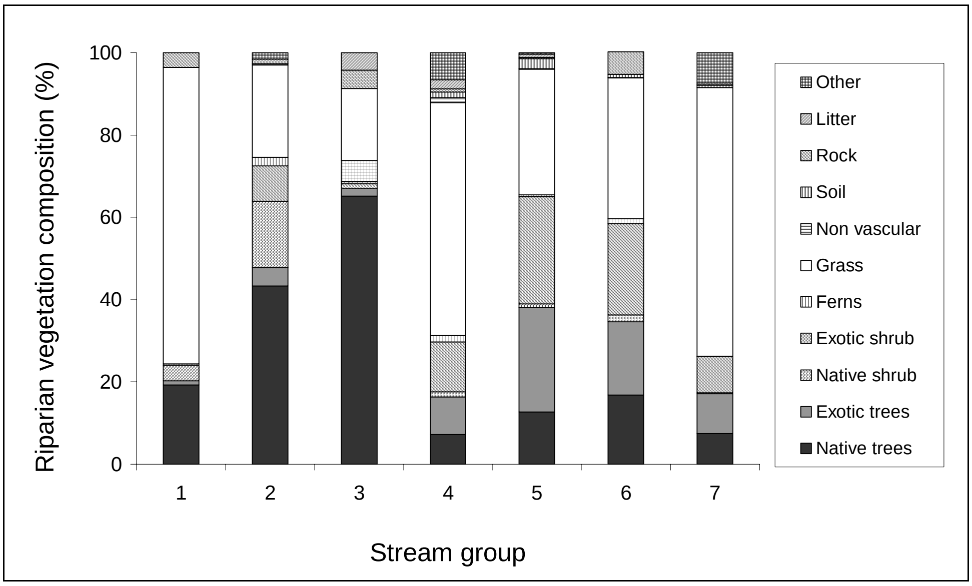

Fig.11.9: Relative abundance of riparian vegetation for seven stream groups in the Wellington region.

Group 1 sites had riparian vegetation dominated by grass with some native trees.

Group 2 vegetation comprised predominantly native trees and shrub with ferns and grass cover.

Group 3 sites had similar riparian vegetation to Group 2, but with a greater proportion of native trees making up the riparian vegetation.

Group 4 sites were characterised by a high proportion of grass and exotic shrub riparian vegetation.

Group 5 sites had a high proportion of exotic trees and shrubs.

Group 6 sites had mixed riparian vegetation consisting of native and exotic trees with native shrub.

Group 7 sites were dominated by mown grass but also consisted of native and exotic trees and native shrub.

11.4 Landuse

Landuse for each catchment and sites within catchments is provided in Table 11.3.

Table 11.3: Mean (range in brackets) landuse characteristics of 7 Stream Groups in the Wellington region.

	Stream Group						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Altitude (m ASL)	63 (10-115)	121 (40-200)	59 (18-100)	41 (10-140)	51 (10-160)	56 (16-100)	34 (0-160)
Catchment area (ha)	636 (103-1169)	668 (51-3536)	124 (113-135)	1369 (108-4810)	1365 (72-3447)	1451 (177-3062)	865 (80-1692)
Indigenous forest (%)	1 (0-2)	28 (0-93)	1 (0-3)	6 (0-25)	2 (0-7)	6 (1-12)	5 (0-23)
Shrub/Scrub (%)	45 (36-54)	48 (6-92)	39 (18-60)	41 (0-74)	30 (8-77)	25 (12-52)	27 (0-60)
Planted exotic forest (%)	19 (1-36)	6 (0-39)	0 (0-0)	6 (0-22)	2 (0-8)	4 (0-13)	0 (0-3)
Pastoral (%)	28 (0-57)	9 (0-34)	33 (25-41)	26 (0-83)	22 (0-49)	25 (0-50)	17 (0-59)
Urban (%)	6 (6-6)	8 (0-39)	23 (5-41)	19 (0-46)	41 (5-93)	37 (18-71)	44 (15-75)
Urban open space (%)	0 (0-0)	0 (0-2)	0 (0-0)	1 (0-3)	1 (0-3)	3 (1-5)	6 (0-34)
Other (%)	1 (0-2)	1 (0-8)	4 (0-8)	2 (0-9)	2 (0-10)	0 (0-1)	1 (0-2)

Note: Data is presented as a mean percentage of 5 transects with range in brackets. N = 5 (Group 1), 1 (Group 2), 3 (Group 3), 1 (Group 4), 9 (Group 5), 14 (Group 6), and 11 (Group 7).

Group 1 stream catchments were typically medium sized with landuse dominated by shrub/scrub (45%[2]), pastoral land (28%) and exotic forest (19%) with low instances of urban development (6%) and Indigenous forests (1%).

Group 2 stream catchments were typically at higher altitudes (121 m ASL) and of moderate size. Landuse was dominated by shrub/scrub (48%) and Indigenous forest (28%), with a low proportion of pastoral (9%) and urban developed (6%) areas.

Group 3 stream catchments were relatively small (124 ha) by comparison to other group catchments. The predominant landuse was in shrub/scrub

[2] All percentage and area values presented are the means for each group category.

(39%) and pastoral (33%) areas, with native and exotic forests uncommon (1% and 0%, respectively). Catchments in Group 3 had a moderate urban component (23%) to the landuse.

Group 4 stream catchments were typically large (1369 ha). The landuse was variable, with most categories represented; however shrub/scrub (41%), pastoral (26%) and urban (19%) areas dominated. Both exotic (6%) and native (6%) forests were represented in Group 4 catchments.

Group 5 stream catchments were large (1365 ha) with urban areas (41%) being the predominant landuse, followed by shrub/scrub (30%) and pastoral (22%) areas.

Group 6 stream catchments were generally the largest catchments (1451 ha). Urban areas dominated (37%), followed by shrub/scrub (25%) and pastoral (25%) areas. Indigenous (6%) and exotic forest (4%) areas also made up a proportion of the landuse. Urban open spaces (3%), albeit a small proportion, was represented in Group 6 catchments.

Group 7 stream catchments were of moderate size and lowest lying (34 m ASL) of the group catchments. They had the highest proportion of urban areas (44%) with urban open spaces making up 6%. A moderate proportion of the land was in shrub/scrub (27%), with relatively low instances of pastoral land (17%) and exotic forest (0%).

11.5 Macroinvertebrate – Habitat Relationships

The MDS ordination yielded a two-dimensional solution with a stress value of 0.21. Macroinvertebrate and habitat parameters that were significantly correlated ($p<0.05$) with axis scores are shown on Fig. 11.10. Macroinvertebrate indices were most strongly and positively associated with Axis 2 scores, especially QMCI values ($r_s = 0.93$). Biotic indicators (QMCI, %EPT & taxa richness) improved with increased shade, native riparian vegetation and larger substrate sizes (especially stream groups 1-3) along axis 2. Percent EPT also increased along axis 1 in association with native riparian shade, increased dissolved oxygen concentrations, and larger substrate sizes.

Stream Groups 1 and 2 sites are predominantly located in the upper and left area of the ordination, which indicates these sites are more associated with higher biotic index scores (QMCI, %EPT and taxa richness), greater stream velocity, greater percentage of native shrub riparian vegetation, shade and boulder substrates. Stream Groups 5-7 are generally located in the lower right section of the ordination and thus associated with finer substrates, increasing depth and less riparian vegetation (and increasing exposed soils). Stream Group 2 sites (only two sites) are located in the middle of the ordination and thus not showing strong relationships with the habitat and ecological parameters reported.

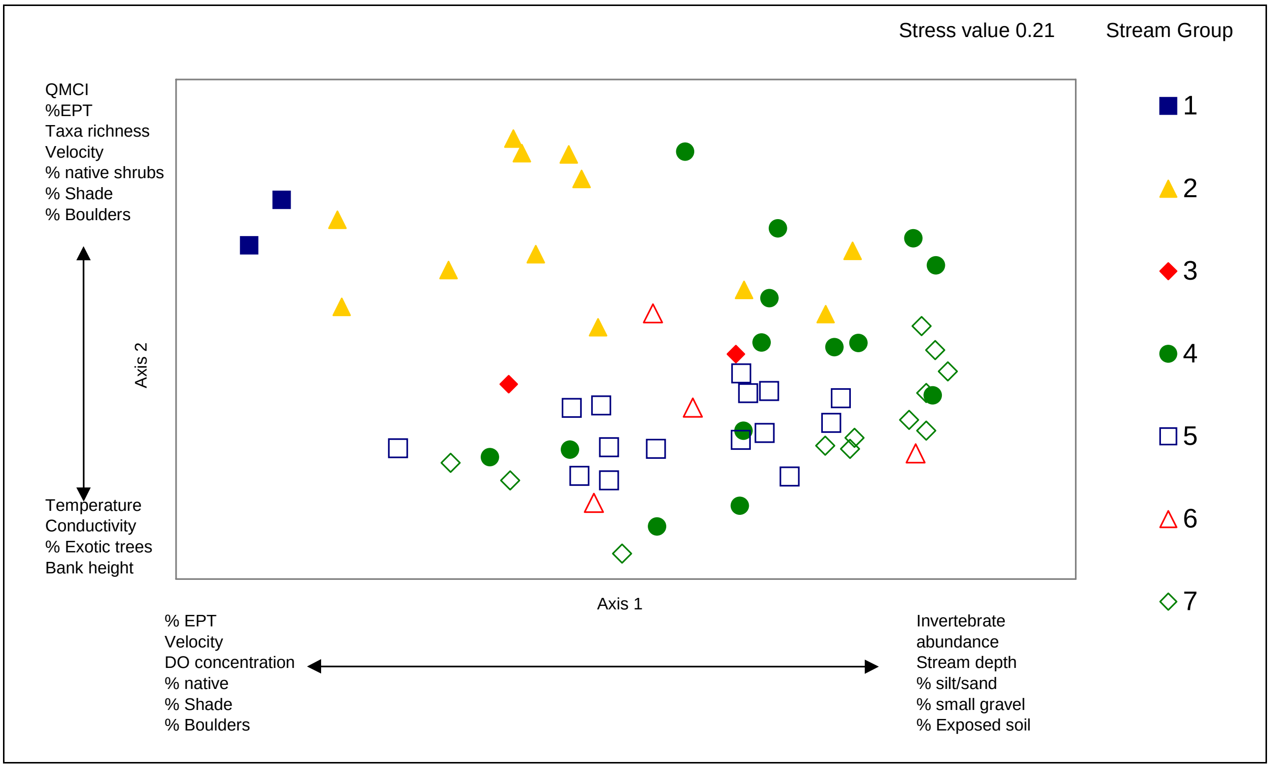

Fig. 11.10: An nMDS ordination of the 61 urban and peri-urban stream sites sampled in the Wellington region.

11.6 Summary

The results of the invertebrate analysis resulted in four site groupings at the Division 1 classification and seven groupings at Division 2 of a TWINSPAN classification. Analysis of the seven groupings suggests an environmental gradient reflected by improved macroinvertebrate communities in association with greater stream shade, velocity and rocky substrates and ma greater native component of the riparian vegetation. Although seven groups have been recognised by the classification, the similarity of several groups (e.g., Groups 4 and 5) suggests that a simpler classification will be equally effective and thus four groupings are likely to form a more practical and effective classification of Wellington urban streams.

12. Key Ecological Characteristics of Wellington Urban and Peri-urban Streams

12.1 Invertebrates

A total of 111 invertebrate taxa were identified from 61 urban and peri-urban stream sites in the Wellington region. Species diversity was moderate to high, although greatest diversity was found in sites with no or minimal urban development. With the exception of Stream Groups 1-3, all remaining sites were dominated by organisms tolerant of disturbance (i.e., worms, midges and snails).

Not surprisingly, highly modified urban and lowland floodplain streams were significantly different in the type and abundance of invertebrates compared to sites elsewhere in the Wellington region. By comparison, stream sites within low-lying peri-urban areas, or with particular characteristics (e.g., Site K5 below the reservoir, Site K2 in Ngaio Gorge, Site KM1 in Khandallah Park) were characterised by a greater relative abundance of amphipods, shrimps or koura, as well as caddisflies (Trichoptera).

Overall, the benthic fauna of the Wellington Streams was relatively high in species diversity (total taxa = 111; mean = 16) compared to sites in Auckland (e.g., Waitakere City: total taxa = 82; mean = 13, Kingett Mitchell 2000; North Shore City: total taxa = 57; mean = 10, Kingett Mitchell 2001; Auckland area: total taxa = 78; mean = 10, (Allibone et al. 2001).

Scarsbrook et al. (2000) found that 20 taxa was the average number of taxa expected for larger (i.e., mean annual flows vary from 0.8-567 m^3s^{-1}) non-urbanised rivers throughout New Zealand. The benthic fauna of the unmodified Wellington streams is consistent with those throughout New Zealand where insects (e.g., mayflies, caddisflies and stoneflies) are more abundant. However, species diversity and the type of taxa present in highly modified Wellington streams differ through the predominance of snails, midges and worms.

12.2 Instream and Riparian Habitat

Instream habitat varied throughout the Wellington streams. Lower catchment and lowland sites were generally wider, and substrates often contained a mixture of sand, gravels and cobbles. The overall lack of significant difference between substrate characteristics between sites probably reflects the large variation in habitat types within each stream type.

Riparian vegetation and stream bank characteristics also varied amongst sites, with the stream sites exhibiting lower ecological condition (as measured by macroinvertebrate biotic indices) characterised by riparian margins of grass and less native vegetation. In contrast, sites with higher ecological values were characterised by riparian margins with a greater native vegetation component.

For the Wellington City urban streams (Nearing, Kaiwharawhara, Owhiro and Karori Streams), stream sites regarded as lower ecological condition were represented by a wider riparian vegetation buffer comprising a greater component of exotic woody and non-woody plants, whilst stream sites with a higher ecological condition were characterised by having a narrow riparian margin but comprising greater native vegetation.

12.3 Urbanisation

An environmental gradient from better ecological quality to poorer ecological quality was associated with habitat characteristics present within seven stream clusters. These characteristics were also evident as a gradient of increasing urbanisation and stream modification.

As might be expected, urban catchment characteristics differed between the stream groups. Highly urbanised low-lying streams were characterised by increasing water depth, sand and gravel substrates, increasing macrophyte cover and with riparian margins increasingly grassed and characterised by less native vegetation and with poorer ecological condition.

The increased supply of stormwater from piped systems and storage ponds associated with urbanisation reduces the quality of water entering stream habitat (Moscrip & Montgomerie 1997; Timperley & Kuschel 1999). Reinforced channels offer little habitat for invertebrates to refuge during flood events (Suren 2000), although the biota of concrete channels recorded from Wellington streams (i.e., Waiwhetu and Karori Streams) was not significantly different from other stream/landuse modifications, unlike in Auckland where the low species diversity in the concrete lined channels has resulted in a separate management class (Kingett Mitchell 2001).

The small and short stream catchments of the Wellington region compare to those of Auckland and may also be a factor in reduced ecological condition and habitat suitability by increasing stormwater run-off impacts on the stream biota. Scheduler et al. (1999) suggested that negative impacts of stormwater run-off for stream biota can occur with as little as 15% of the catchment in urban landuse (i.e., impervious surfaces). In Wellington streams, although a decline in aquatic ecological condition occurs as urbanisation is initiated, the decline is less severe relative to urbanised streams in Auckland and some overseas examples.

Stormwater systems rapidly transport pollutants to nearby waterways after rain, which can also increase the sediment load in receiving water by streambed and bank scouring (Slender & Truman 1995). The highly variable rainfall conditions in the Wellington region can also contribute to the complexity of urban stream management with periods of low baseflow where the mixing of pollutants with stream water is minimal and sudden flash flooding during heavy rainfall.

12.4 Urban Stream Management Strategy and Instream Objectives

The development of an urban stream management strategy for Wellington will need to incorporate the key characteristics outlined above. Although impacts of urbanisation on stream ecology are apparent in Wellington and an environmental gradient from good quality to highly modified streams is apparent, some elements that characterise the Wellington streams will require a novel approach (e.g., urbanisation of upper catchments, steepness of catchments, lack of space and suitable land for stormwater treatment). Some of the difficulties in managing and re-mediating urban streams are discussed in the following section and the need for an development of instream objectives is discussed in Sections 11 and 12.

13. Summary

A total of 61 sites were sampled within streams of the Wellington region, with assessments of riparian vegetation, instream vegetation, bank stability and macroinvertebrate communities. Additional catchment development and landuse characteristics were collated from existing information available on Council GIS systems.

Although up to 7 groups were identified by Division 2 of the TWINSPAN analysis, the analysis in Section 11 shows similarity between several groupings such that four management groupings have been selected for stream management in the Wellington regions as follows:

- Stream Management 1 (SM1) - Natural or forested.
- Stream Management 2 (SM2) - Natural semi-modified.
- Stream Management 3 (SM3) - Urban and rural modified.
- Stream Management 4 (SM4) - Urban modified.

Overall, streams within the Wellington region have variable riparian and aquatic habitats. Highest water and habitat quality sites were present in the upper catchments in most cases (Stream Management Group 1), although moderate quality streams were evident in some mid-catchment sites. In contrast, the lowest water and habitat quality sites were within the lower floodplain sites (Management Group 4), which included the largest number of the sites sampled.

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Appendices

Appendix 1

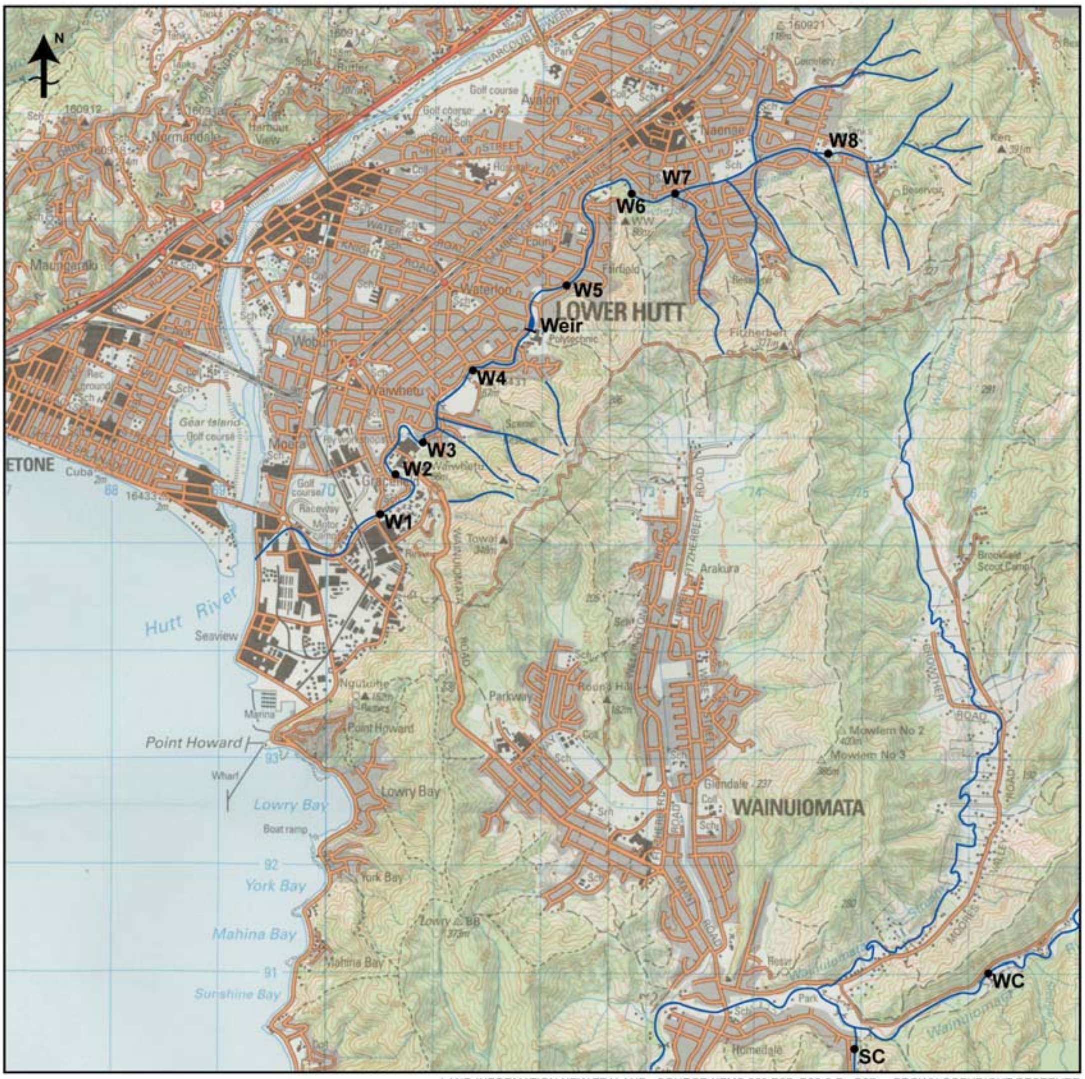
Site Locations

Appendix 1: Site Locations

Wellington and Porirua

Kaiwharawhara Tributary / Korimako Stream

Waiwhetu Stream



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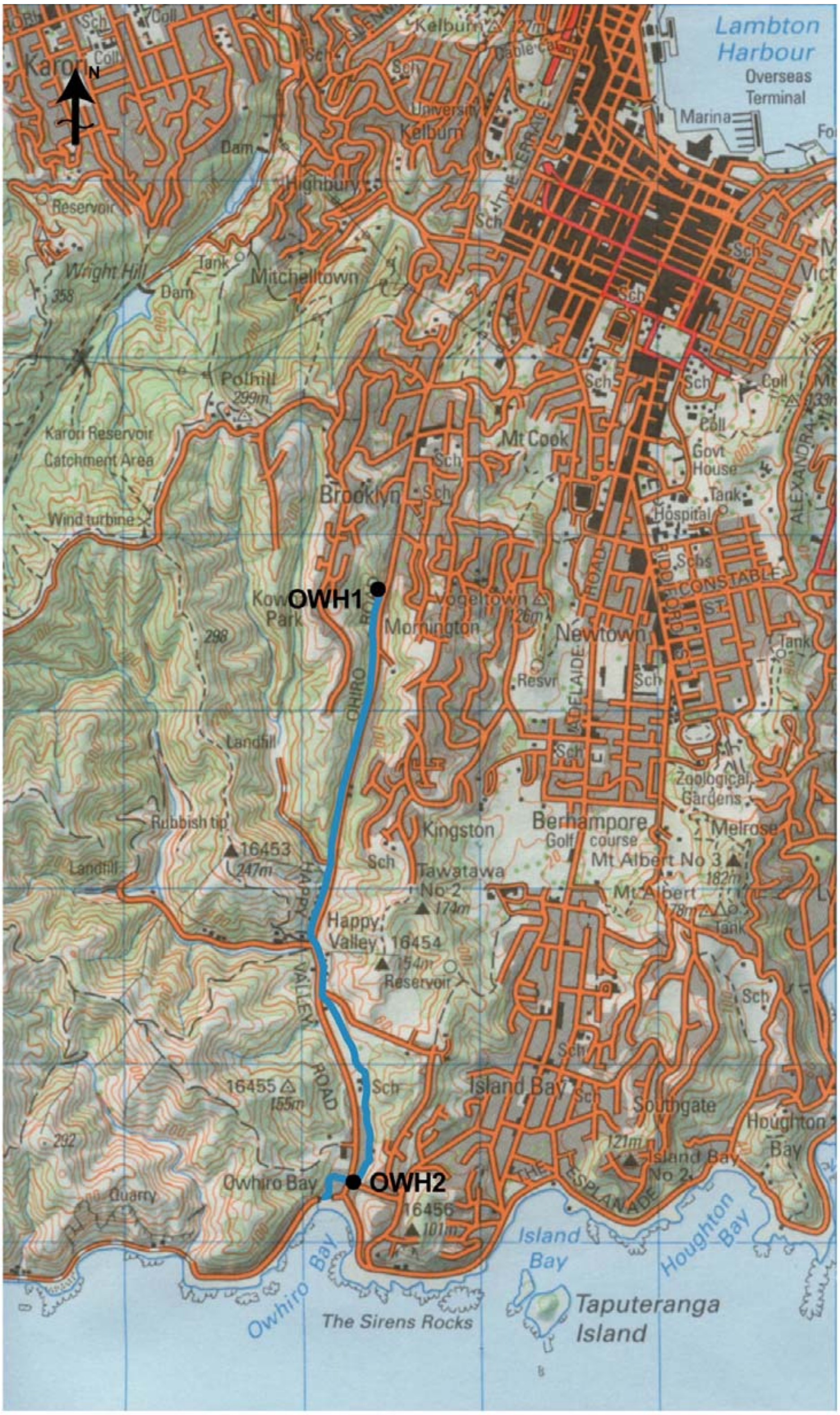
Owhiro Stream



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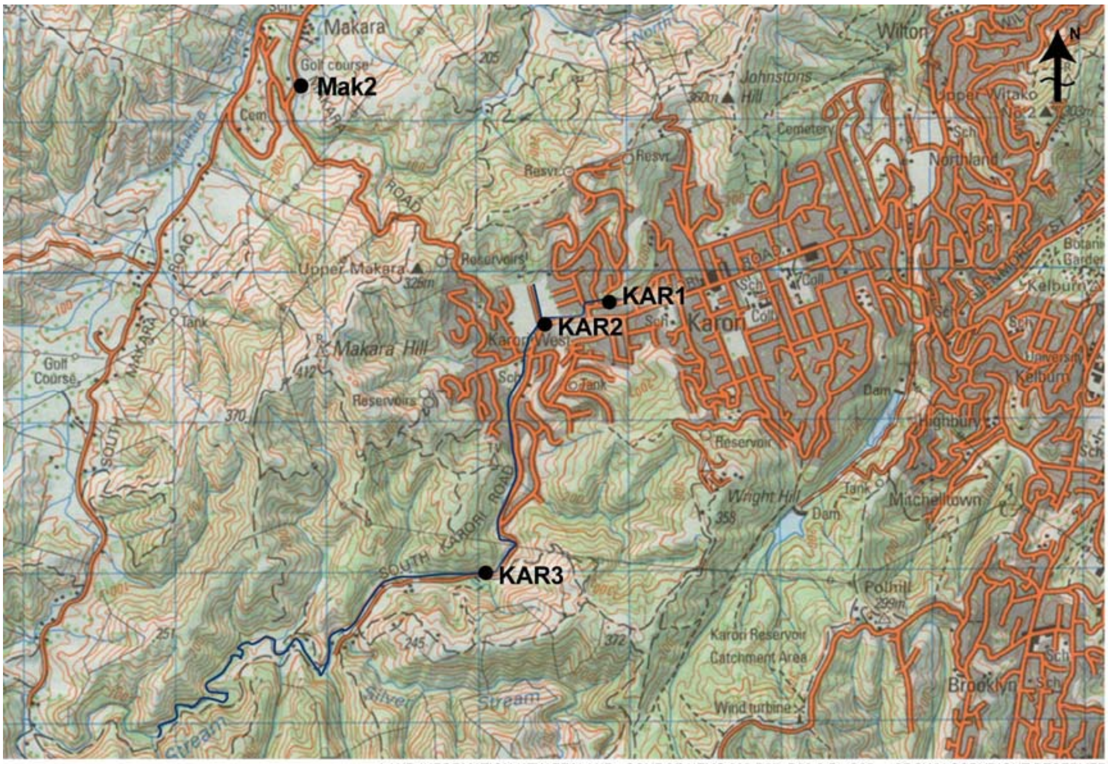
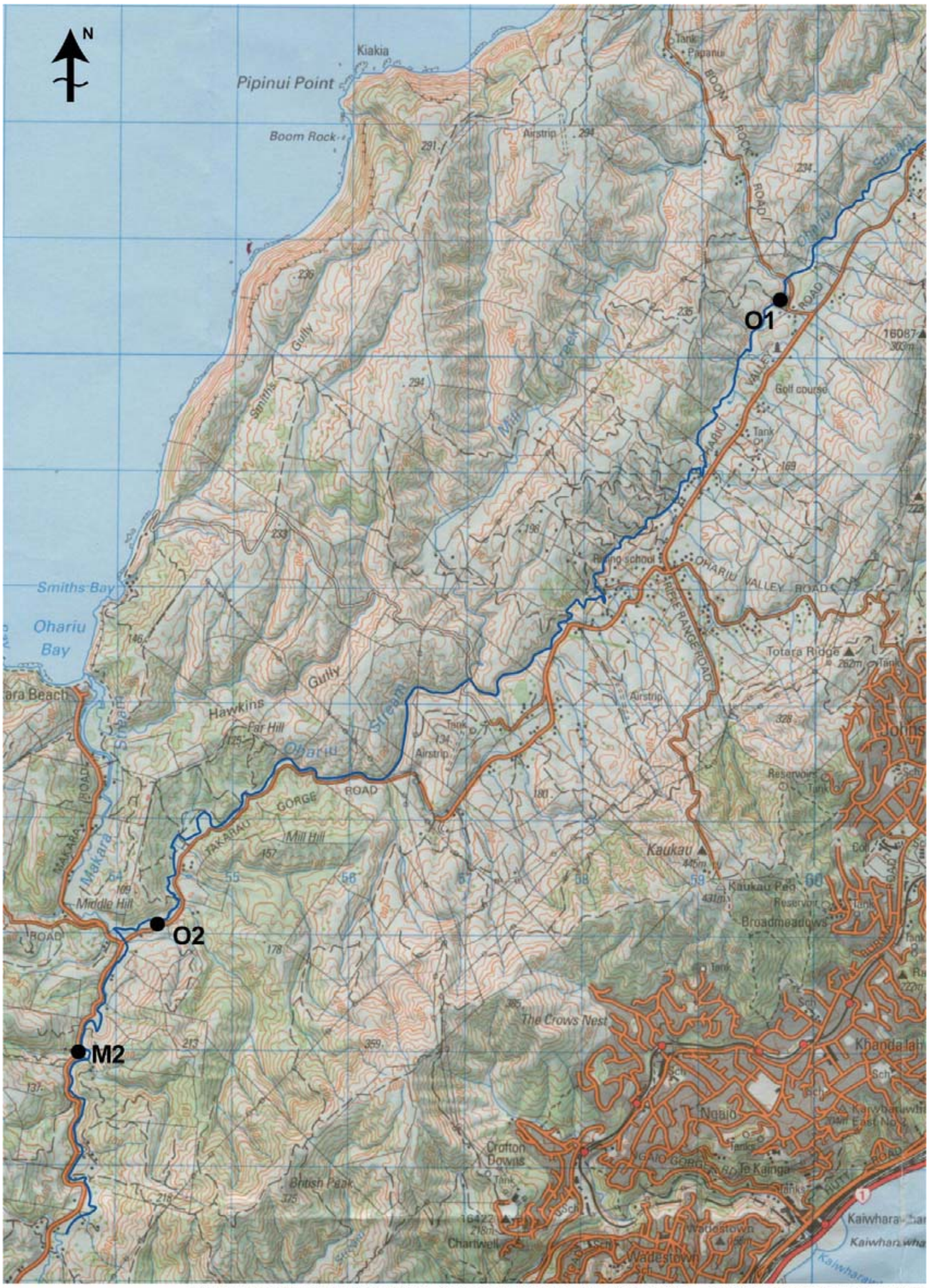
Makara Stream / Karori Stream



Ohariu Stream / Makara Stream



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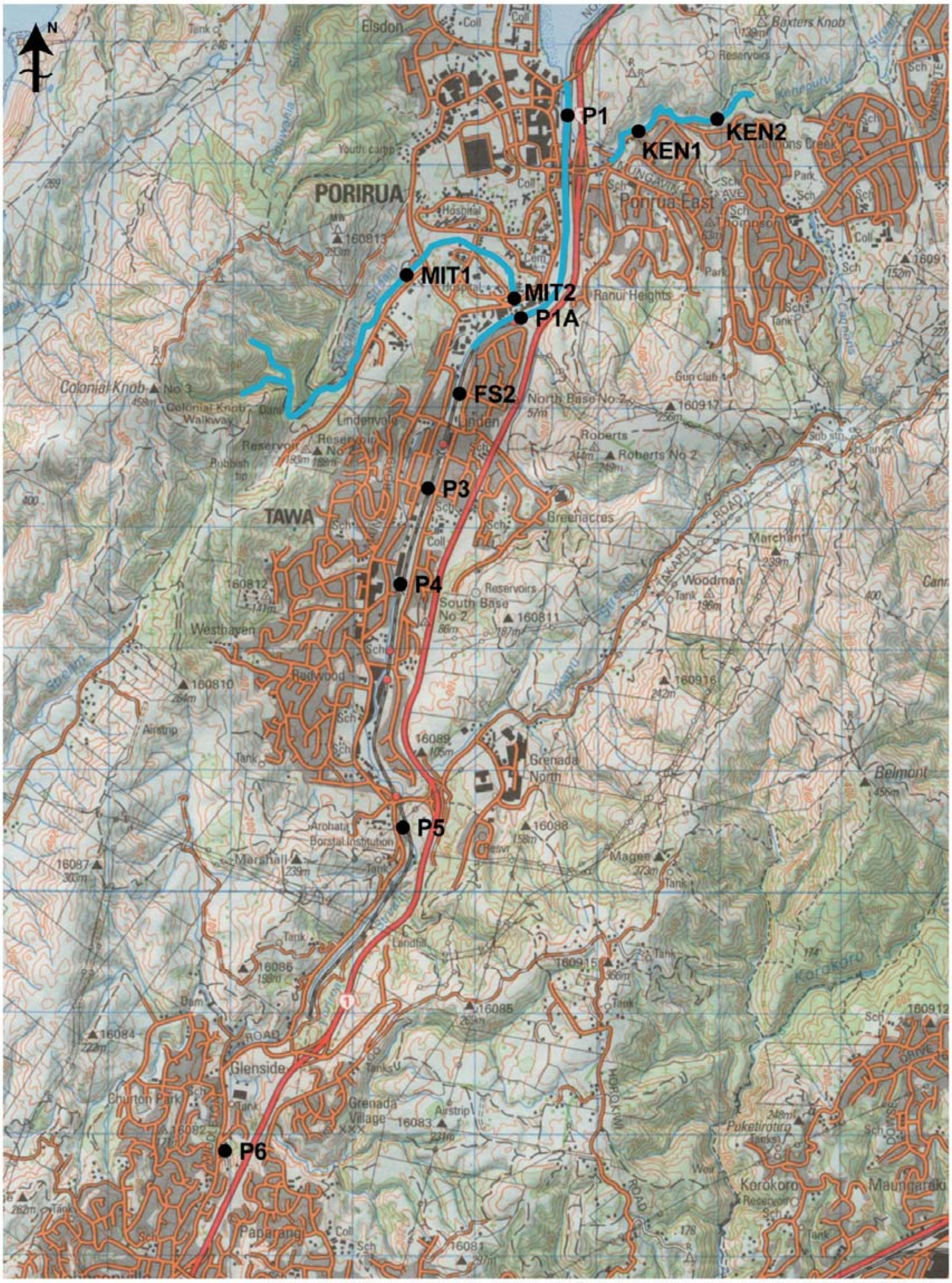
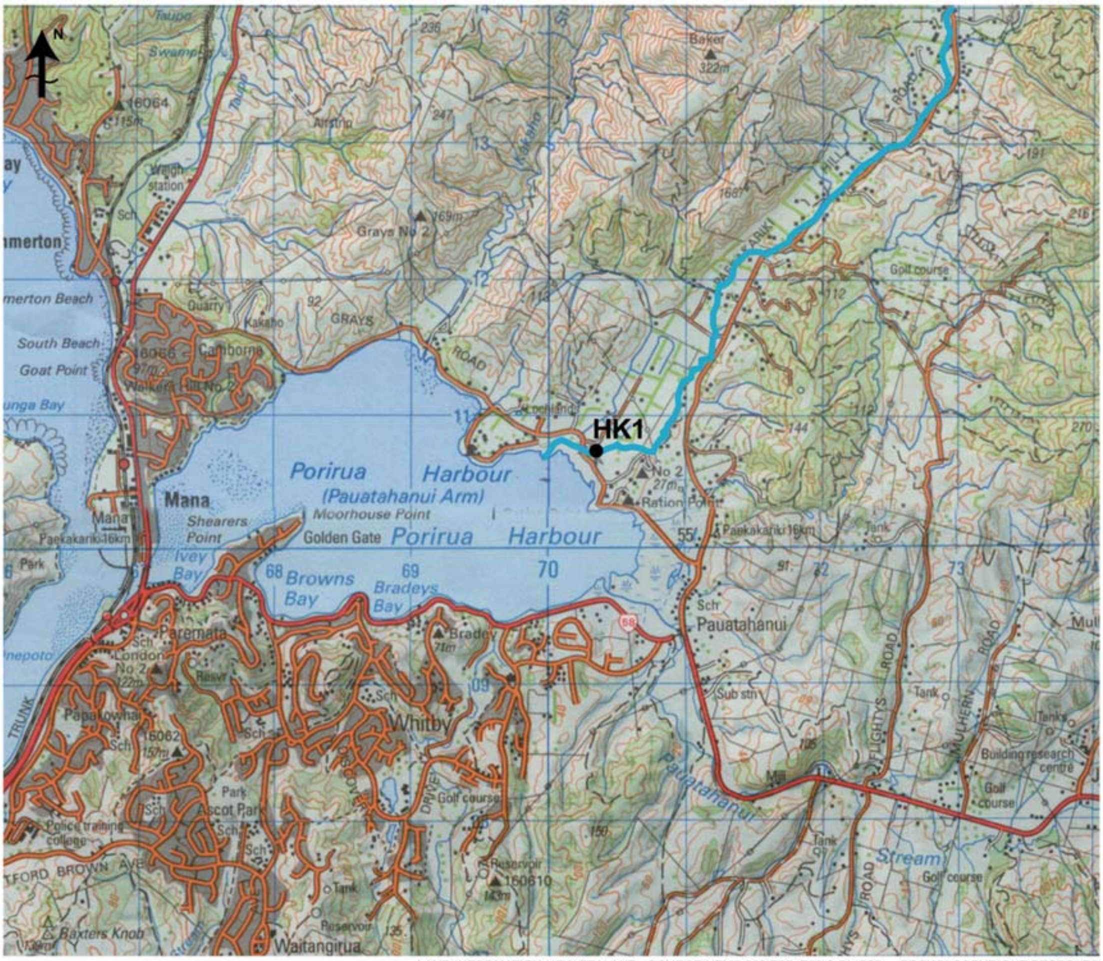
Ngauranga Stream

Ngauranga Stream

Kenepuru Stream / Porirua Stream / Mitchell Stream



Horokiri Stream



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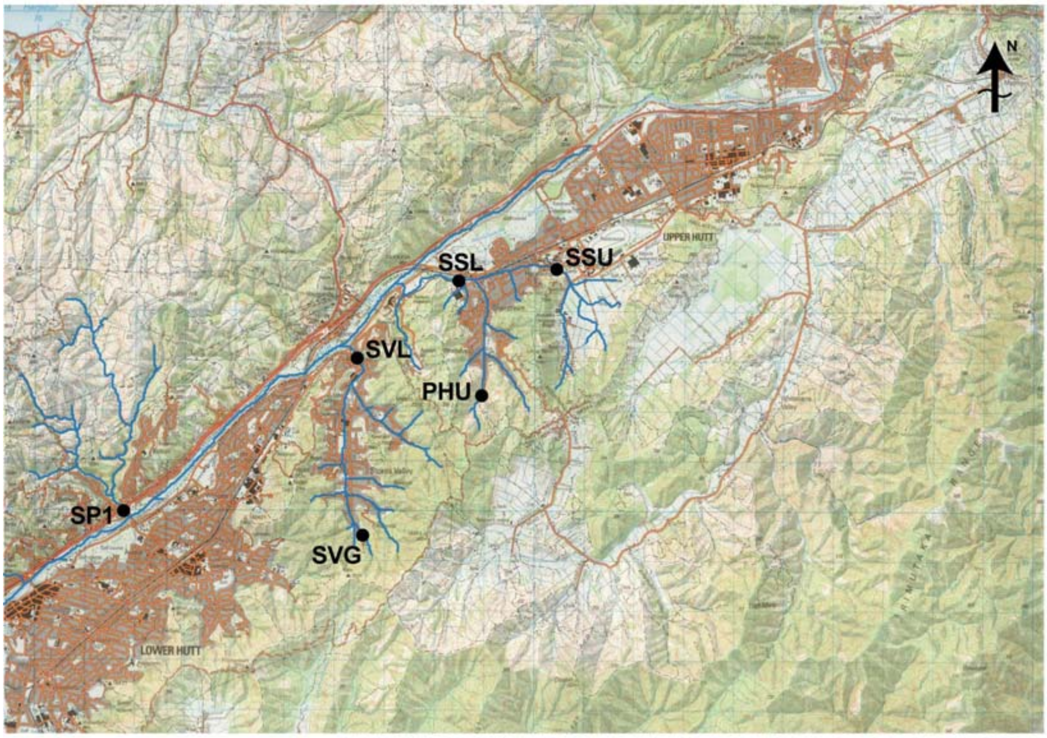
Hutt Valley

Stokes Valley Stream/Pinehaven Stream/Speedys Stream/Silverstream



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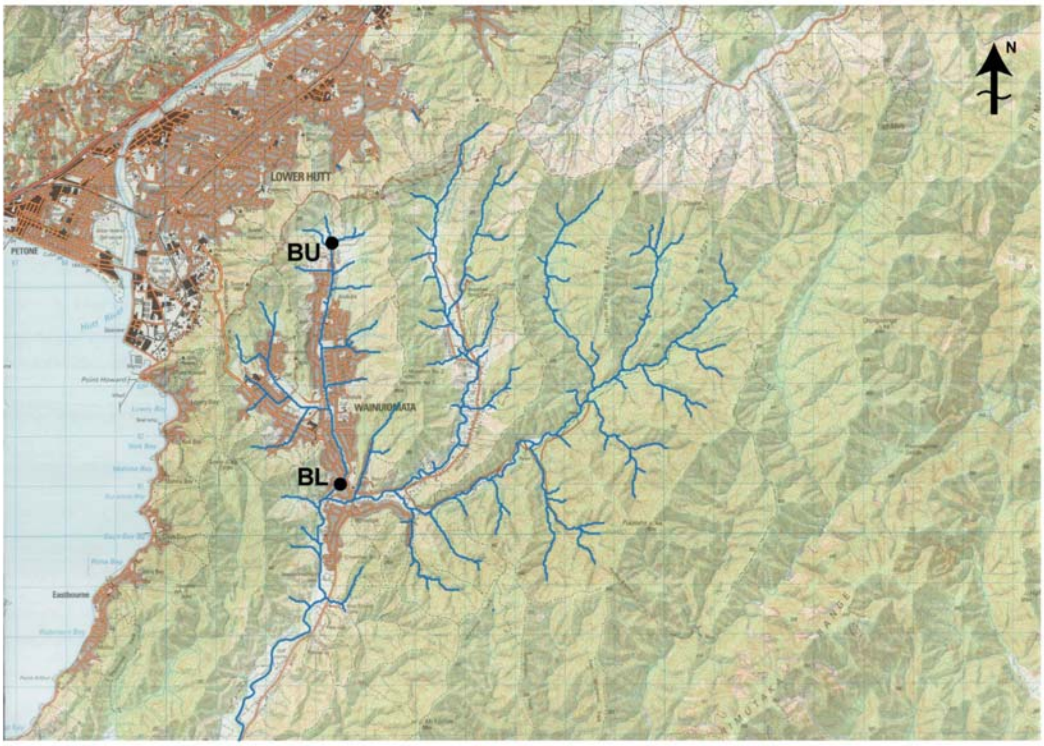
Black Stream



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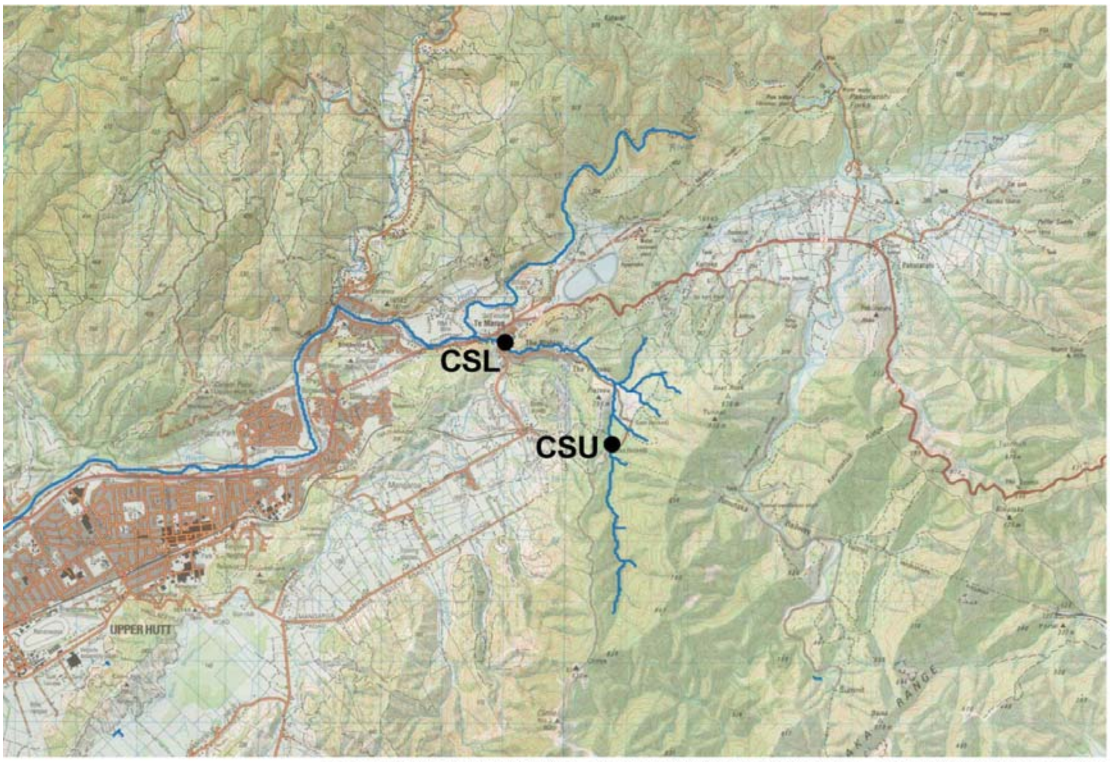
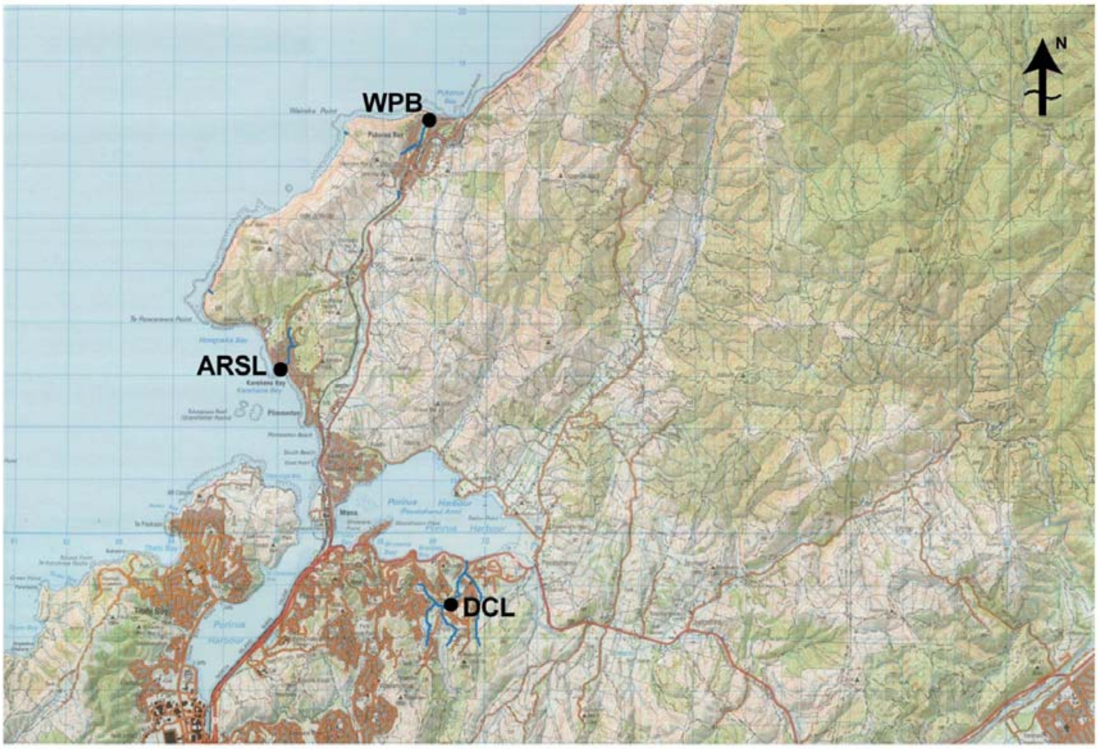
Collins Stream



Kapiti Coast

Airlie Road Stream/Waimapehi Stream/Duck Creek



Wharemauku Stream/Tikotu Creek/Kakariki Stream

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Mangapouri Stream

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Appendix 2

Hutt Valley and Kapiti Coast Stream Photos

Appendix 2: Site Photos

Hutt Valley Streams

Upper Stokes Valley Stream, upstream of main urban area. This site had a QMCI score of 8.8, the highest of all sites visited. Site **SVU**.

Lower Stokes Valley Stream, at downstream end of main urban area. This site had a QMCI of 1.3, the lowest of all sites visited. Site **SVL**.

Collins Stream Upper, within extensive native forest, upstream of The Plateau. Site **CSU**.

Collins Stream Lower, within residential area. Site **CSL**.

Black Stream Upper, within mainly farming landuse, Wainuiomata. Site **BU**.

Black Stream Lower, within urban area, downstream of Main Road. Site **BL**.

Silverstream Upper, beside Trentham Military Camp. Site **SSU**.

Silverstream Lower, below urban area. Site **SSL**.

Speedys Stream beside SH2. Includes a high proportion of native forest upstream in the catchment. Site **SP1**.

Pinehaven Stream, at the upstream end of the residential area, with a high proportion of native forest upstream. Site **PHU**.

Kapiti Coast Streams

Duck Creek, lower end of Whitby urban area. Site **DCL**.

Mangapouri Stream beside Convent Road, Otaki. Site **MSO**.

Wharemauku Stream, in Paraparaumu urban area. Site **WSP**.

Waimapehi Stream, Pukerua Bay. Site **WPB**.

Tikotu Creek, upstream of the golf course, within urban Paraparaumu. Site **TCP**.

Oily sheen on water surface of Tikotu Creek.

Airlie Stream Lower, within an urban park in Karehana Bay. Site **ARSL**.

Kakariki Stream, within a residential property in urban Waikanae. Site **KSW**.

Appendix 3

Raw Macroinvertebrate Data

Appendix 3: Macroinvertebrate Data

Wellington and Porirua Streams

Table 1

	FS2	HK1	K1	K2	K3	K4	K5	K6	KAR1	KAR2
Ephemeroptera										
Acanthophlebia								6		
Coloburiscus				1	1			72		
Deleatidium	1	6		2				68		
Zephlebia				2	3			60		3
Plecoptera										
Austroperla					1		1			
Stenoperla					1			14		
Zealandobius				2	5	1	4	134		
Trichoptera										
Aoteapsyche		92		10						
Hydrobiosella								22		
Hydrobiosis	2	6	1	34	1	1				
Oeconesidae			23	17	8					
Orthopysche						7	2			
Oxyethira	4	34		2			1			32
Psilochorema		12	16							
Pycnocentrodes		460								
Tiphobiosis					1					
Triplectides		5								
Megaloptera										
Archichauliodes	1	6	3	6	17	1	13	30		
Odonata										
Hemicordulia		1								
Hemiptera										
Sigara		2								
Coleoptera										
Elmidae	2	312						3		2
Ptilodactylidae								4		
Gyrinidae	8									
Diptera										
Aphrophila	6					1				
Austrosimulium		2			14		1			
Chironomus	5									
Limonia				54						1
Maoridiamesa				130						
Mischoderus						1				1
Muscidae									2	13
Orthocladiinae	2	78	512	180	7	371	38	4	226	128
Polypedilum										8
Psychodidae	2									
Tabanidae		1								
Tanypodinae	5		10					1		
Tanytarsini		1								8
Crustacea										
Amphipoda	5	20		688	220	116	1072		5	84
Ostracoda	2	304				132	128		2	2
Mollusca										
Physa	50	136		3		3	9		3	76
Potamopyrgus	200	408	1	66	15	1			1	3
Oligochaeta	200	52				34			5	
Total taxa	**16**	**20**	**8**	**15**	**13**	**12**	**11**	**12**	**7**	**13**
Abundance	**495**	**1938**	**570**	**1197**	**294**	**669**	**1271**	**418**	**244**	**361**
Berger Parker	**0.4**	**0.2**	**0.9**	**0.6**	**0.7**	**0.6**	**0.8**	**0.3**	**0.9**	**0.4**
MCI	**77.3**	**87.0**	**114.3**	**105.3**	**124.6**	**88.3**	**96.0**	**138.3**	**60.0**	**78.5**
QMCI	**2.7**	**4.2**	**2.5**	**4.4**	**5.1**	**2.8**	**4.7**	**6.6**	**2.1**	**3.1**
EPT taxa	**3**	**7**	**3**	**8**	**8**	**3**	**4**	**7**	**0**	**2**
%EPT	**1.4**	**31.7**	**7.0**	**5.8**	**7.1**	**1.3**	**0.6**	**90.0**	**0.0**	**9.7**

Table 2

	KAR3	KEN1	KEN2	KM1	KOR1	KOR2	KOR3	KT1	MAK2	MIT1
Ephemeroptera										
Acanthophlebia					1					
Ameletopsis					7					
Austroclima					104					
Coloburiscus				4	71	3		126	2	
Deleatidium	152		4	2	336	420	2	20	28	
Ichthybotus					3	1	1			
Neozephlebia			3		6					
Nesameletus	312				168				2	
Zephlebia					2			352		
Plecoptera										
Austroperla								118		
Spaniocerca				1						
Stenoperla					32					
Zealandobius					23	150	5			
Zealandoperla					21	2	1			
Trichoptera										
Aoteapsyche	136		155	2	208	960	18		140	8
Beraeoptera					5					
Costachorema	6				4					
Helicopsyche				1	36					
Hudsonema		3	5							
Hydrobiosella				4	16			158		
Hydrobiosis	11	1	2		29	24	3	2	2	1
Neurochorema						36				
Oeconesidae				2	1					
Olinga					68					
Oxyethira		10	1		8	390	29		24	9
Paraoxyethira						60	5			
Philorheithrus					7					
Plectrocnemia									2	
Polyplectropus			1	7	3	3	2			
Psilochorema					11	42		16	8	1
Pycnocentria				6						
Pycnocentrodes				1	7	300	12		128	
Triplectides			5				1			
Zelolessica				2	1					
Megaloptera										
Archichauliodes	34			1	60	270	12		6	52
Odonata										
Antipodochlora						1				1
Hemicordulia									1	
Coleoptera										
Elmidae	384				536	120	12		393	3
Hydraenidae					2					
Ptilodactylidae					3	1				
Diptera										
Aphrophila	2					42				1
Austrosimulium	3			6		3	2		3	1
Chironomus		10					1			
Empididae				1	4					
Limonia										2
Maoridiamesa	4				11	1				
Mischoderus	1									2
Muscidae	1				2	5	1		2	
Orthocladiinae		30		5	20	21	2	39	4	9
Paralimnophila										1
Polypedilum				6						

Table 2 (continued)

	KAR3	KEN1	KEN2	KM1	KOR1	KOR2	KOR3	KT1	MAK2	MIT1
Psychodidae				1						
Stratiomyidae					1					
Tabanidae	1					1	1			
Tanypodinae		10				1			11	19
Tanytarsini	9				6	72	1		3	
Tanytarsus					3					
Crustacea										
Amphipoda	6	10	2	5	25	1620	2500		440	
Isopoda										
Ostracoda			7		10	210	1		104	8
Paranephrops								1		
Mollusca										
Gyraulus									2	
Physa	2	10	7			4	5		36	2
Potamopyrgus	8	90	56	32	31	58	175	10	344	24
Sphaeriidae			2							
Oligochaeta	1	70	1	4	6	1	10		54	16
Platyhelminthes				1						
Nemertea				2			1			
Total taxa	**18**	**10**	**14**	**23**	**42**	**31**	**25**	**10**	**23**	**18**
Abundance	**1073**	**244**	**251**	**103**	**1904**	**4824**	**2803**	**842**	**1739**	**160**
Berger Parker	**0.4**	**0.4**	**0.6**	**0.3**	**0.3**	**0.3**	**0.9**	**0.4**	**0.3**	**0.3**
MCI	**92.2**	**68.0**	**91.4**	**110.4**	**130.7**	**100.0**	**87.2**	**132.0**	**96.5**	**88.9**
QMCI	**6.8**	**2.8**	**4.0**	**5.0**	**6.9**	**4.8**	**4.9**	**7.7**	**5.0**	**4.3**
EPT taxa	**5**	**3**	**8**	**11**	**27**	**13**	**11**	**7**	**9**	**4**
%EPT	**57.5**	**5.7**	**70.1**	**31.1**	**65.0**	**49.6**	**2.8**	**94.1**	**19.3**	**11.9**

Table 3

	MIT2	N1	N2	O1	O2	OWH1	OWH2	P1	P1A	P3
Ephemeroptera										
Coloburiscus					1					
Deleatidium				34	15					
Trichoptera										
Aoteapsyche				5	44		80			
Hydrobiosis					3			1	7	2
Olinga				7	1					
Oxyethira	152			64	28		13	30	12	50
Paraoxyethira				3						
Plectrocnemia					1					
Psilochorema			1	1	1					
Pycnocentrodes				72	32	2				
Megaloptera										
Archichauliodes	7				5	1	7		8	1
Odonata										
Xanthocnemis	3			11	4		1			
Hemiptera										
Microvelia					1					
Sigara				9						
Coleoptera										
Elmidae	1			12	8	1			4	
Gyrinidae										1
Diptera										
Aphrophila									1	
Austrosimulium				3	9		3			
Chironomus							2	10		
Ephydridae		1					1			
Eriopterini					1					
Hexatomini										1
Limonia	1					1	1			
Maoridiamesa	2		16				24		4	
Mischoderus	1					1	5		7	
Muscidae						9	8		1	
Orthocladiinae	42	132	68	1		88	420	130	28	
Paralimnophila									1	
Polypedilum							2			
Psychodidae						1				
Tanypodinae	4							100	1	
Tanytarsini					3		3			
Zelandotipula						2		10		
Lepidoptera										
Hygraula					2					
Crustacea										
Amphipoda	56		1	184	440	7	340			
Isopoda							1			
Ostracoda	7		1	168	16	6	16			
Paratya	13				8					
Mollusca										
Ferrissia			1		1	2			15	
Gyraulus					56					
Physa	4	8	24	16	16	240	160	10	28	40
Potamopyrgus	72	2	30	264	312	10	560	20	664	50
Oligochaeta	7	44	30	17	40	40	45	240	76	50
Hirudinea									1	
Platyhelminthes						3	1			
Total taxa	**15**	**5**	**9**	**17**	**26**	**17**	**22**	**9**	**16**	**8**
Abundance	**372**	**187**	**172**	**871**	**1049**	**419**	**1698**	**551**	**858**	**195**
Berger Parker	**0.4**	**0.7**	**0.4**	**0.3**	**0.4**	**0.6**	**0.3**	**0.4**	**0.8**	**0.3**
MCI	**81.3**	**56.0**	**71.1**	**88.2**	**101.5**	**78.8**	**71.8**	**64.4**	**77.5**	**77.1**
QMCI	**3.1**	**1.8**	**2.5**	**4.1**	**4.3**	**2.7**	**3.5**	**1.6**	**3.2**	**2.5**
EPT taxa	**1**	**0**	**1**	**7**	**9**	**1**	**2**	**2**	**2**	**2**
%EPT	**40.9**	**0.0**	**0.6**	**21.4**	**12.0**	**0.5**	**5.5**	**5.6**	**2.2**	**26.7**

Table 4

	P4	P5	P6	SC	Train1	W1	W2	W3	W4	W5
Ephemeroptera										
Acanthophlebia		1								
Coloburiscus				2						
Deleatidium				126						6
Zephlebia				14	4					1
Plecoptera										
Austroperla				2						2
Zealandobius				2						
Zealandoperla				2						
Trichoptera										
Aoteapsyche			1							
Hudsonema						1				
Hydrobiosis				6						17
Oeconesidae			3							
Oecetis					4					
Orthopysche				4	9					2
Oxyethira	60	2					800	30	112	
Plectrocnemia			1							
Psilochorema				4	2					
Tiphobiosis				2						
Megaloptera										
Archichauliodes		1		10						3
Odonata										
Austrolestes						1				
Ischnura										1
Xanthocnemis							22	4	360	6
Hemiptera										
Sigara									1	1
Coleoptera										
Elmidae	10									
Liodessus					1					1
Diptera										
Aphrophila					1					
Austrosimulium			1		11					
Chironomus	10					148	460			5
Limonia			1							
Maoridiamesa	10									
Mischoderus			9							
Molophilus			3							
Orthocladiinae	150	8	9		5	32	80		3	18
Paralimnophila			1							
Polypedilum			1	10		4				
Stratiomyidae					1					
Tanypodinae	30	8	1			4	44		4	
Zelandotipula			2							
Collembola			2							
Crustacea										
Amphipoda			18		1	1	1440	74	11936	3
Ostracoda	60									
Paratya							81	1		
Mollusca										
Lymnaea								24	4	
Physa	50	12	3		31			12	400	54
Potamopyrgus	20	6	19		2	144	8512	848	7040	204
Oligochaeta	80	1	1		39	18		58		936
Total taxa	**10**	**8**	**17**	**12**	**13**	**9**	**8**	**8**	**9**	**17**
Abundance	**480**	**39**	**76**	**184**	**111**	**353**	**11439**	**1051**	**19860**	**1264**
Berger Parker	**0.3**	**0.3**	**0.3**	**0.7**	**0.4**	**0.4**	**0.7**	**0.8**	**0.6**	**0.7**
MCI	**60.0**	**77.5**	**94.1**	**143.3**	**95.0**	**73.3**	**72.5**	**70.0**	**75.6**	**101.3**
QMCI	**2.4**	**3.8**	**4.0**	**7.5**	**3.1**	**2.4**	**3.9**	**3.8**	**4.6**	**1.8**
EPT taxa	**1**	**2**	**3**	**10**	**4**	**1**	**1**	**1**	**1**	**5**
%EPT	**12.5**	**7.7**	**6.6**	**89.1**	**17.1**	**0.3**	**7.0**	**2.9**	**0.6**	**2.2**

Table 5

	W6	W7	W8	WC
Ephemeroptera				
Acanthophlebia				3
Ameletopsis				1
Coloburiscus			10	1
Deleatidium		1	51	21
Nesameletus				52
Zephlebia			14	
Plecoptera				
Austroperla				5
Stenoperla			6	3
Zealandoperla				10
Trichoptera				
Costachorema				8
Hydrobiosis		3	12	5
Orthopysche			5	
Psilochorema		1	11	3
Tiphobiosis				15
Megaloptera				
Archichauliodes			9	38
Odonata				
Xanthocnemis	5			
Coleoptera				
Elmidae				116
Ptilodactylidae			1	
Diptera				
Aphrophila				1
Austrosimulium			2	
Limonia			2	2
Maoridiamesa				54
Orthocladiinae	280	512	48	30
Polypedilum		8	3	
Tanytarsus			6	
Crustacea				
Amphipoda		5	4	
Ostracoda			9	
Paranephrops			2	
Mollusca				
Physa	140	4		
Potamopyrgus	2912	18	38	3
Oligochaeta	256	27		3
Total taxa	**5**	**9**	**19**	**21**
Abundance	**3593**	**579**	**234**	**375**
Berger Parker	**1**	**1**	**0**	**0**
MCI	**60**	**87**	**117**	**132**
QMCI	**4**	**2**	**5**	**6**
EPT taxa		**3**	**7**	**12**
%EPT		**1**	**47**	**34**

Hutt Valley and Kapiti Coast Streams

Table 6

	DCL	MSO	WSP	WPB	ARSL	KSW	TCP
Ephemeroptera							
Austroclima sepia	32		1				
Coloburiscus				1			
Deleatidium	24					28	
Zephlebia	1			1			
Plecoptera							
Spaniocerca				2			
Trichoptera							
Costachorema						1	
Hudsonema	1						
Hydrobiosis						3	
Oecetis		1					
Orthopysche				5			
Oxyethira		28				16	
Psilochorema	8			1		16	
Pycnocentria	2						
Pycnocentrodes	14						
Triplectides	52	11					
Megaloptera							
Archichauliodes	3					1	
Odonata							
Antipodochlora							1
Austrolestes		2	1				11
Xanthocnemis		80	3				4
Hemiptera							
Anisops							16
Diaprepocris			1				
Microvelia			1				
Sigara		2	1				40
Coleoptera							
Dytiscidae							1
Elmidae	88		1			2	
Ptilodactylidae				1			
Diptera							
Austrosimulium		20		9		24	
Chironomus							2
Empididae	1					1	
Ephydridae			2				
Eriopterini	2						
Muscidae				2			2
Orthocladiinae	7	4		7	12	1664	36
Paralimnophila			1				
Polypedilum				8	7		
Psychodidae				4	10		2
Tanypodinae	4						
Tanytarsini							2
Acarina	2	1		3	2	10	3
Crustacea							
Amphipoda	20	2048	2400	2		56	1
Copepoda					10		12
Cladocera		1					
Isopoda					2		
Ostracoda		128	16		6	10	160
Paratya	2	2	15				
Mollusca							
Lymnaeidae							1
Physella		320	13		8	1	1
Potamopyrgus	52	512	4800	2	640	2560	
Sphaeriidae			1			1	
Oligochaeta	60	10	16	6	17	160	832
Hirudinea		2	1			16	80
Platyhelminthes					13		140
Nemertea	1	1	1		1	1	5
Total taxa	**20**	**18**	**18**	**15**	**12**	**19**	**21**
Abundance	**376**	**3173**	**7275**	**54**	**728**	**4571**	**1356**
Berger Parker	**23.4**	**64.5**	**66.0**	**16.7**	**87.9**	**56.0**	**61.4**
MCI	**110.0**	**77.8**	**90.0**	**101.3**	**63.3**	**85.3**	**72.4**
QMCI	**5.0**	**4.5**	**4.3**	**3.8**	**3.8**	**3.2**	**1.9**
EPT taxa	**8**	**3**	**1**	**5**	**0**	**5**	**0**
%EPT	**35.6**	**0.4**	**0.0**	**18.5**	**0.0**	**1.1**	**0.0**

Table 7

	SP1	SVU	SVL	CSU	CSL	BU	BL	PHU	SSU	SSL
Ephemeroptera										
Acanthophlebia		3		20	3			2		
Ameletopsis		2		4				1		
Austroclima jollyae	32							50		
Austroclima sepia	288	1		1				96		
Coloburiscus	680	216		48	32	24	2	110		1
Deleatidium		15		1152	576	192	1			2
Neozephlebia	11				1			48		
Nesameletus				16	12					
Oniscigaster				1						
Siphlaenigma								100		
Zephlebia		19		1		1	2		2	
Plecoptera										
Acroperla								1		
Austroperla		56		40	4	3				
Nesoperla								16		
Spaniocerca							1			
Spaniocercoides								10		
Stenoperla		5		96	4	2				
Taraperla	1							160		
Zealandobius	8	18		144	1			40		
Zealandoperla		2		10	18	1				
Trichoptera										
Aoteapsyche					8					
Beraeoptera					1					
Confluens	14									
Costachorema						1				
Hudsonema								1	1	
Hydrobiosella	5	12		5	2					
Hydrobiosis					4	5				1
Kokiria								1		
Neurochorema		3					1			
Oeconesidae	1									
Olinga	1			40	128	1		112		
Orthopysche	8	432		52						
Oxyethira			40				8		40	3
Paraoxyethira			1							
Polyplectropus						1				
Psilochorema				2	2	2	2			1
Pycnocentrella	4									
Pycnocentria	8					1	1			
Pycnocentrodes					1					
Triplectides			1				1		4	1
Megaloptera										
Archichauliodes	48		1	12	16					1
Odonata										
Xanthocnemis							3		40	
Hemiptera										
Microvelia									1	
Sigara									2	
Coleoptera										
Dytiscidae	14							16		
Elmidae		5		272	128	352	72		1	
Hydraenidae				10	8	1		1		
Liodessus								3		
Ptilodactylidae	4	1	1	1						

Table 7 (continued)

	SP1	SVU	SVL	CSU	CSL	BU	BL	PHU	SSU	SSL
Diptera										
Aphrophila	20		2		3					
Austrosimulium					8	1	4		4	4
Ceratopogonidae									1	
Chironomus			1							
Culicidae			1							
Dolichopodidae	3									
Empididae			1				1			
Ephydridae	2							1		
Eriopterini		2	2	5	4	96	2			
Hexatomini		1								
Lobodiamesa	1									
Maoridiamesa	1									
Molophilus	2									
Muscidae			1				1		1	8
Nothodixa	38									
Orthocladiinae			110	2	3		44		22	536
Paradixa			1							
Paralimnophila							1		2	
Podonominae	25							3		
Polypedilum			1	2	7				2	8
Psychodidae			2							
Tanypodinae	6		1				1	3		2
Tanytarsini			2	4			2			
Lepidoptera										
Hygraula								2		
Acarina			4	10	3	20	3		3	
Crustacea										
Amphipoda		1	40		1	128	3			5
Cladocera								2		
Ostracoda			5			1	7		40	
Mollusca										
Ferrissia										1
Lymnaeidae									32	
Physella			3			2	7		192	2
Glyptophysa	1									
Potamopyrgus		4	88			960	136		1920	72
Sphaeriidae								1	2	1
Oligochaeta			2016	1		8	296			168
Eiseniella									512	
Hirudinea						1			48	1
Platyhelminthes									3	2
Nemertea			1				1		2	
Bryozoa									1	
Total taxa	**26**	**19**	**24**	**26**	**26**	**23**	**26**	**24**	**25**	**20**
Abundance	**1226**	**798**	**2326**	**1951**	**978**	**1804**	**603**	**780**	**2878**	**820**
Berger Parker	**55.5**	**54.1**	**86.7**	**59.0**	**58.9**	**53.2**	**49.1**	**20.5**	**66.7**	**65.4**
MCI	**128**	**153**	**75**	**146**	**135**	**128**	**99**	**133**	**77**	**85**
QMCI	**8.6**	**8.8**	**1.3**	**7.7**	**7.8**	**5.3**	**2.7**	**7.6**	**3.3**	**2.1**
EPT taxa	**13**	**13**	**3**	**16**	**16**	**12**	**9**	**15**	**4**	**6**
%EPT	**86.5**	**98.2**	**0.1**	**83.6**	**81.5**	**13.0**	**1.8**	**95.9**	**0.2**	**0.7**