The distribution of fish in the urban gully system streams of Hamilton City

CBER Contract Report 48

Client report prepared for
Environment Waikato and Hamilton City Council

By

Brenda M.T.A. Aldridge
Brendan J. Hicks

Giant kokopu (*Galaxias argenteus*; 220 mm length) from the Hamilton City peri-urban area.

Centre for Biodiversity and Ecology Research
Department of Biological Sciences
School of Science and Engineering
The University of Waikato
Private Bag 3105
Hamilton, New Zealand

2 October 2006

Email: b.hicks@waikato.ac.nz

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

CBER University of Waikato
Centre for Biodiversity and Ecology Research

Table of contents

List of tables

Page

List of figures

List of appendices

Abstract

The distribution of fish in the urban gully system streams of Hamilton City was investigated using various methods of fishing. Fishing methods used in the city wide survey included trap netting using Gee minnow and fyke nets, electric fishing, and spotlighting at selected sites. Water quality and habitat parameters were assessed at each of the sites to add information to in-stream freshwater fish assemblages (i.e., preferred habitat). Culverts were assessed downstream of all sites because, native freshwater fish of New Zealand are largely migratory, having both freshwater and marine life histories. Freshwater fish migrate between habitats, therefore barriers to swimming fish passage may determine the presence of fish species at inland sites. Pest fish were less common than native fish in this survey, although they represent a greater proportion of the fish caught, because the small pest fish mosquitofish are prolific breeders and were present in very high numbers at a few sites. This study has shown that some urban streams can support diverse fish assemblages where water quality and habitat conditions permit. Threatened species were found to be present in streams previously thought of as supporting little stream life with low fish habitat or biodiversity value. The need for restoration and management of these streams is vital if the diversity and distribution of native fish is to be maintained.

1.0 Introduction

The distribution of fish in Hamilton's urban centres is poorly known; this research aims to overcome this lack of knowledge through information gathering via fishing within Hamilton City. The research was performed in collaboration with the Environment Waikato (EW), Hamilton City Council (HCC), and the Department of Conservation (DOC).

The four main objectives of this research were to:

- Fish sites to fill in gaps in data as perceived from NIWA's New Zealand Freshwater Fish Database (NZFFD).
- Determine the distribution and presence of giant kokopu and longfin eel, which are listed as a threatened species by DOC.
- Address the distribution of fish in green-field areas that are to be developed in the future or are being developed at present.
- Document the presence and location of any pest fish.

The fish assemblages are expected to resemble those of a habitat modified from the impact of urbanisation. Urbanisation has a wide range of effects on stream ecosystems through '…clearing of vegetation, compaction of soil, and ditching, draining, piping and ultimately covering land with impermeable surfaces…' (Roy *et al.*, 2005). The land changes associated with urbanisation have many effects on freshwater environments, such as, altering instream storm flow, base flow hydrology, channel morphology and erosion, and increased sediment and nutrient contamination, all of which can affect fish assemblage composition (Roy *et al.*, 2005).

While it has been found that urbanisation has an effect on freshwaters within urban development, there have been limited studies on the impact of urbanisation on fish populations. The research conducted by Morgan and Cushman (2005) found that in one catchment 'abundance in highly urbanized sites was only slightly lower than the least-urbanized sites'. While this was the case for one catchment studied, the other catchment studied showed opposite result. This suggests that the effect of urbanisation on fish assemblages may be catchment specific, and depends on the tolerance of the species present as well as their preferred habitat.

Our research follows that of Wilding (1998), who analysed many parameters of streams within and surrounding Hamilton to indicate the state of health of Hamilton's urban streams. This research involved sampling water quality, habitat quality, invertebrates, and fish. Wilding noted the degraded nature of Hamilton streams, 'In many respects, the Hamilton City waterways represent typical degraded lowland streams' (Wilding, 1998). Wilding (1998) found that eels were predominant in the Hamilton streams and that black mudfish were present in swampy streams close to Hamilton. Wilding (1998) noted that the only record of giant kokopu was in the Rotokauri area. A study of Auckland streams found banded kokopu were able to survive in urban streams, but only where adequate riparian vegetation was present (Wilding, 1998).

Habitat appeared to be the limiting factor for fish, and Wilding (1998) speculated that thermal stress might also prevent some species from inhabiting the Hamilton streams, though vegetation would decrease the effect of temperature extremes. Habitat limitations on in-stream fish

assemblages could be overcome to a degree through the restoration effort of riparian vegetation that is being undertaken (Clarkson and McQueen, 2004).

Because many of New Zealand's native fish are migratory, access to sites will determine their presence and abundance. Therefore all culverts from a survey site downstream to the Waikato River were assessed to determine swimming fish access to survey sites. All of the migratory fish present in the streams would have entered the freshwater environment (the Waikato River) at Port Waikato. Eels, giant and banded kokopu, and inanga are lowland fish that are often found in headwater streams due to their ability to climb and therefore overcome barriers (either natural or man made), that may provide a barrier to swimming fish species. Bullies, torrentfish, and smelt comprise the remainder of the lowland native fish species which that have been found in the urban gully system streams in Hamilton (Table 1). Bullies may be sea run or have land-locked populations (McDowall, 1978). Many of the migrating fish that are found in New Zealand streams can also have land locked populations. Torrentfish live in fast flowing waters and are migratory. Unlike some of the other native fish they do not have the ability to climb so are restricted to easily accessible lowland habitats. All of these fish (Table 1) occur in lowland freshwater stream habitats in New Zealand, such as those that are now affected by urban development.

Table 1: Common and scientific names of fish that were caught during this survey of Hamilton City streams.

Common name	Scientific name
Native fish	
Longfin eel	*Anguilla dieffenbachii*
Shortfin eel	*Anguilla australis*
Whitebait	Juvenile *Galaxias* spp.
Banded Kokopu	*Galaxias fasciatus*
Giant Kokopu	*Galaxias argenteus*
Inanga	*Galaxias maculatus*
Common smelt	*Retropinna retropinna*
Common bullies	*Gobiomorphus cotidianus*
Torrentfish	*Cheimarrichthys fosteri*
Introduced fish	
Mosquitofish	*Gambusia affinis*
Brown trout	*Salmo trutta*
Rainbow trout	*Oncorhynchus mykiss*
Koi carp	*Cyprinus carpio*
Brown bullhead catfish	*Ameiurus nebulosus*

2.0 Methods

2.1 Fish Survey Sites

The survey sites for this research were selected in collaboration with Environment Waikato staff. The sites were chosen within gully systems to represent gaps that exist within the New Zealand Freshwater Fish Database (NZFFD). A wide range of habitats and catchments were sampled to determine the distribution of fish within the urban gully system streams in Hamilton City.

A total of 41 sites (Table 2 and Figure 1) were sampled within the urban and peri-urban streams of Hamilton from December 2005 to March 2006. Habitat and fish were assessed at each site; macroinvertebrate samples were also collected at many of the sites by Environment Waikato staff. These sites were located within the four main catchments of Hamilton city including two sites in Waitawhiriwhiri catchment, three sites in the Mangaonua catchment, ten sites in the Mangakotukutuku catchment, and ten sites in the Kirikiriroa catchment. Three sites within the Te Awa O Katapaki catchment, eight sites in Rotoukari catchment, two sites at Gibbons Creek, one site in the stream behind the Waikato hospital, one site in Fairfield and one site in the Bankwood area were also sampled (Figure 2). Some of the sites coincided with Environment Waikato's REMS (Regional Ecological Monitoring of Streams) sites. Sites in green-field areas were selected to provide a comparison with fully urbanised sites.

At each site five Gee minnow trap nets were set overnight. The nets had a mesh size of 5 mm and were baited with cat biscuits held in small punctured plastic containers. Fyke nets with a mesh size of 25 mm were set in those streams that had deep enough pools to house the nets. The nets were generally set over a 50 m reach unless there were not enough suitable habitats to accommodate the nets within that reach. In each stream section a representative reach was sampled including pool, run, riffle and backwater habitats. Fyke nets were set adjacent to areas considered to offer good fish habitat (i.e., those with in-stream cover). A stand-down period of approximately one week was adhered to following substantial rain events. Captured fish were identified and their total length was measured. Where identification could not be performed in the field, fish were bought back to the laboratory or photos were taken for later identification. Galaxiid species that could not be positively identified to species were collectively called whitebait (*Galaxias* spp.).

Table 2: Description of the 41 sites sampled by Gee minnow nets, fyke nets, spotlighting and electric fishing during the summer of 2005 and 2006. TR = true right, TL = true left (looking downstream).

Site	Catchment	Location description	Date	Time	Reach	NZ map grid	
				NZST	length (m)	E	N
M1	Mangakotukutuku	Sandford TR tributary	6/12/2005	10.00	50	2712751	6374066
M2	Mangakotukutuku	Sandford mid tributary	7/12/2005	7.36	50	2712231	6373913
M3	Mangakotukutuku	Sandford TL tributary	7/12/2005	8.17	50	2712235	6373926
M4	Mangakotukutuku	Sandford kokopu tributary	13/12/2005	10.30	50	2712236	6374178
M5	Mangakotukutuku	Below Peacockes Rd	13/12/2005	10.00	100	2712550	6374441
M6	Mangakotukutuku	Malabar St tributary	13/12/2005	9.15	50	2712640	6373733
M7	Mangakotukutuku	Pelorous St	13/12/2005	8.30	100	2712184	6372905
M8	Mangakotukutuku	TR tributary pasture	14/12/2005	9.00	50	2713210	6373473
M9	Mangakotukutuku	Acacia	21/12/2005	8.30	50	2712223	6372022
M10	Mangakotukutuku	Saxbys Rd	22/12/2005	8.10	50	2710928	6372869
K1	Kirikiriroa	Tauhara St	2/01/2006	9.40	50	2709514	6381687
K2	Kirikiriroa	Glen Lynn Rd	2/01/2006	10.40	50	2710250	6381720
K3	Kirikiriroa	Chedworth TL branch	17/01/2006	10.15	50	2711226	6381356
K4	Kirikiriroa	Chedworth TR branch	17/01/2006	9.15	50	2711223	6381362
K5	Kirikiriroa	Tramway Rd	17/01/2006	12.40	50	2712315	6381065
K6 u/s	Kirikiriroa	Thomas Rd	2/01/2006	12.50	50	2711106	6383232
K6 d/s	Kirikiriroa	Thomas Rd	27/12/2005	12.40	50	2711108	6383218
K7	Kirikiriroa	Coltswald Rd	17/01/2006	12.20	50	2711328	6382404
k8	Kirikiriroa	Tauhara park main branch	27/12/2005	11.30	50	2710288	6381903
K9	Kirikiriroa	Tauhara park high EC	27/12/2005	11.20	50	2710246	6381922
K10	Kirikiriroa	Mangati park	17/01/2006	11.05	50	2710753	6382107
T1	Rotokauri	Rotokauri Rd	27/02/2006	12.30	50	2706427	6379403
T3	Rotokauri	Duck Rd	2/03/2006	12.15	50	2702543	6381305
T4	Rotokauri	Te Kowhai Rd	1/03/2006	13.25	50	2702065	6382426
T5	Rotokauri	Exelby Rd	27/02/2006	13.05	50	2704524	6380532
T6	Rotokauri	Te Kowhai Rd	1/03/2006	14.00	50	2704741	6382341
T7	Rotokauri	Ruffell Rd	3/03/2006	11.05	50	2705533	6383325
T8	Rotokauri	Horitu Rd	3/03/2006	11.40	50	2704351	6386562
Mn1	Mangaonua	above culvert	9/01/2006	11.00	10	2715690	6375746
Mn2	Mangaonua	TL tributary	9/01/2006	11.20	50	2715741	6375765
Mn3	Mangaonua	TR tributary	9/01/2006	10.35	50	2715690	6375739
S1	Te Awa O Katapaki	River Rd golf course	10/01/2006	15.50	50	2706727	6384425
S2	Te Awa O Katapaki	Sylvester Rd	10/01/2006	14.00	50	2708416	6383454
S3	Te Awa O Katapaki	Tuirangi St	10/01/2006	13.30	50	2708605	6383764
W1	Waitawhiriwhiri	Edgecumbe St	13/12/2005	13.00	50	2710146	6378492
W2	Waitawhiriwhiri	Upstream	13/12/2005	13.50	50	2708124	6377130
P1	Hamilton East	Gibbons creek	13/02/2006	15.45	50	2711696	6376986
P2	Hamilton East	Gibbons creek	13/02/2006	14.45	50	2712102	6377333
F1	Fairfield	Airedale Rd	17/01/2006	13.15	50	2709972	6378958
H1	Hospital	Hospital stream	23/12/2005	8.55	50	2711426	6375305
B2	Bankwood	McNicol Rd	9/01/2006	14.45	50	2710467	6379571

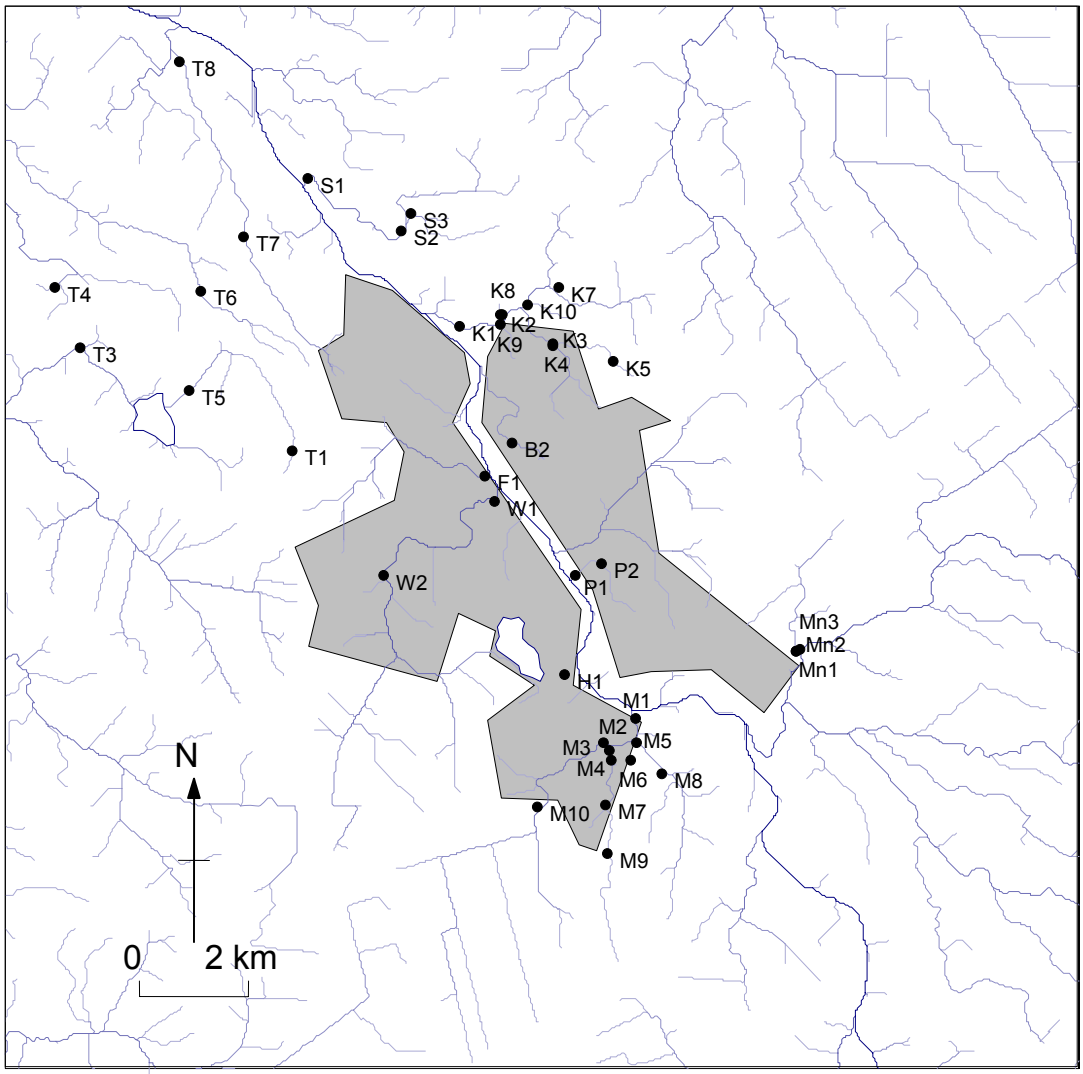

Figure 1: Map of the surveyed sites in Hamilton City and its peri-urban surroundings (Compiled with Fish Database Assistant, NIWA).

2.2 Water Quality and Habitat Assessment

When the trap nets were set, a Field Assessment Form (Appendix 1) was completed as detailed in the Environment Waikato 'REMS' monitoring guidelines (Collier & Kelly, 2005). These forms provide information of the quality of the water and habitat at each of the sites. Water and habitat quality parameters were obtained at each site, including measurements of dissolved oxygen, temperature, conductivity, pH, bottom substrate, stream width, velocity, depth, instream structures that may provide habitat, riparian vegetation, and the surrounding land use. The GPS co-ordinates were recorded at each of the sites assessed. Photos of each of the sites were taken at the same time as the field assessment forms were completed.

Dissolved oxygen was measured using the YSI Model 55 meter calibrated before each use. Measurements were recorded as percentage saturation and mg/l. Conductivity was measured

using the YSI Model 30 conductivity meter. Specific conductivity, i.e., standardised to 25ºC, was recorded in µS/cm. Temperature was also measured using the conductivity meter. Stream width and depth were measured using a meter ruler or tape measure, while velocity was estimated into ranges (<0.1, 0.1-0.3, >0.3 m/s).

Measurements and sampling were conducted during normal stream flows (in the absence of rain) in December 2005 to March 2006. Soft or hard bottomed Field Assessment Form's (Collier & Kelly, 2005), were completed at some of the site's by Environment Waikato staff. The forms were completed in collaboration with sampling of the macroinveterbrate data, as required by the REMS guidelines

2.3 Culvert Assessments

To identify limitations to upstream fish migration, the position of culverts downstream of all of the sites were identified from a road map which. Culvert assessments were performed using forms provided by Environment Waikato. Part of a stream section was also walked to check for confluences or any other culvert or structure not shown on road maps that may affect the assemblages of the fish species in the streams. Photos were taken at both the inlet and outlet of the culvert. At each culvert the length of the culvert and the diameter were measured, the culvert type was recorded as well as the barrier potential the culvert posed to fish passage.

2.4 Other Fishing Methods

Once all identified sites had been trapped and culverts downstream had been assessed, sites were identified to be electric fished or spotlighted. Relatively narrow and shallow sites with clear to slightly colored water were spotlighted and electric fished. Spotlighting was usually completed before electric fishing, because electric fishing has a greater impact on the fish. Spotlighting was performed on fine nights, with a low moon. Red filtered lights were used and a minimum of two people spotlighted a reach for safety. The approach to the stream was done as quietly as possible; there was then a stand down period of 5-10 minutes to allow fish that may have been startled by the approach, to return to their normal foraging habits. Fish were visually spotted using a battery powered torch, with the beam covered in red cellophane. Fish visually spotted were usually netted using a fine meshed dip net for species identification and length estimation. Where there was an abundance of fish of the same species, one fish was caught to determine the species. A 50-100 m reach was spotlighted (the actual reach was measured), and the time taken to spotlight a reach was recorded, along with fish numbers where possible and approximate size (actual size recorded if fish were caught).

Electric fishing was performed using a back-pack electric fishing machine (NIWA Instrument Systems EFM300) used by an experienced operator. A 50 m reach was fished; the reach length and width, and the time taken to fish the reach were recorded at each site. Caught fish were temporarily held in a bucket of water until processed. Processing the fish involved anesthetising the active fish using laboratory grade benzocaine before measuring the fish to the nearest millimeter on a measure board.

Location, species presence, and water quality parameters were entered into the NZFFD, making the data publicly available.

3.0 Results

Forty-one sites were selected to represent urban and peri-urban environments within Hamilton city, and to show variation within and between inner city catchments. Two catchments were extensively fished. These were the Mangakotukutuku and the Kirikiriroa catchments. Fishing was conducted in small sections of a number of streams.

Thirteen fish species were caught in the study, eight of which were native and five of which were introduced (Table 1). The most widely distributed fish were shortfin eels, which occurred at 56% of the 41 sites (Figure 2), which combines the fish caught by all sampling methods, i.e., trapping, spotlighting, and electric fishing. Longfin eel and Mosquitofish were also widely distributed. All of the fish caught during this survey were predominant at lowland sites.

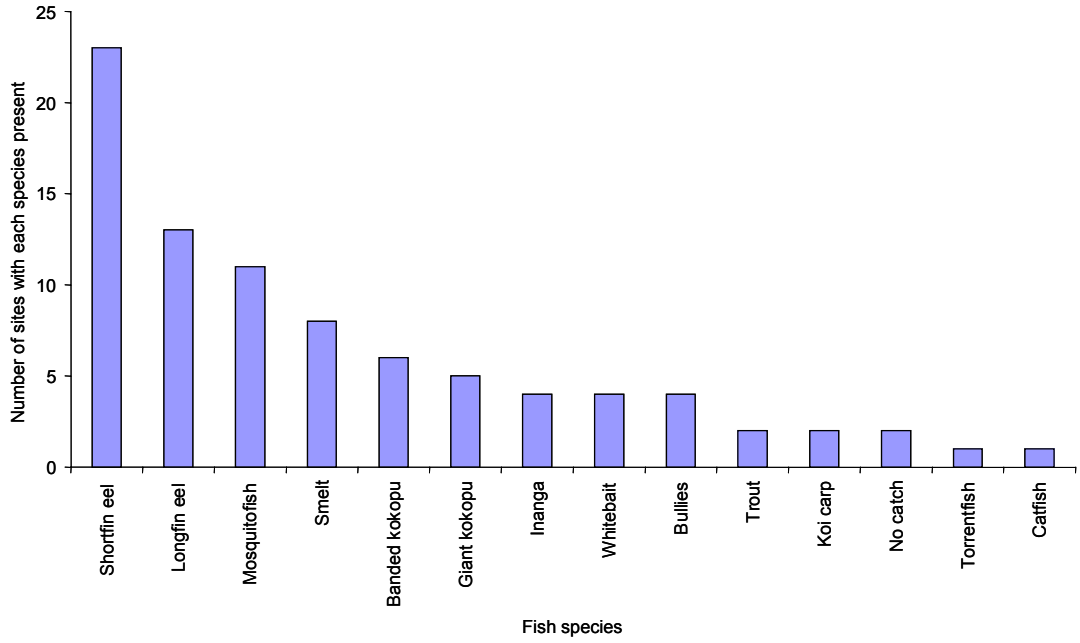

Figure 2: Distribution of fish among the 41 surveyed sites in Hamilton City streams.

3.1 Water Quality

Water quality measurements were conducted at each of the 41 sites (Table 3). Several sites had low dissolved oxygen (e.g., T3), or high conductivity (e.g., K9) indicating contamination from unknown sources.

Table 3: Physical characteristics of the Hamilton City streams sampled including in-stream and riparian data**.**

Site	Active width (m)	Stream width (m)	Stream depth (m)	Surface velocity (m/s)	Shading	Riparian status	Fenced sides	Temperature (°C)	DO (%)	DO mg/L	Conductivity (µS/cm)	Turbidity	pH
M1	1.80	1.00	0.30	0.1-0.3	partly	parkland	none	16.3	77	7.6	193	slight	7.7
M2	3.00	2.50	0.40	0.1-0.3	partly	parkland	none	16.5	75	7.3	172.4	slight	7.3
M3	2.50	2.00	0.75	0.1-0.3	partly	parkland	none	16.6	83	79.4	206	high	6.9
M4	1.00	0.80	0.30	0.1-0.3	significant	parkland	none	17.1	96	9.3	182	clear	7.6
M5	4.50	1.80	0.30	0.1-0.3	partly	parkland	none	18.4	101	9.5	193	slight	7.4
M6	1.50	0.50	0.05	0.1-0.3	significant	parkland	none	17.4	85	8.1	205	clear	7.6
M7	2.00	1.50	0.20	0.1-0.3	partly	parkland	none	18.3	91	8.6	189	clear	7.7
M8	2.50	1.75	0.80	0.1-0.3	significant	native forest	none	19	59	5.5	211	clear	7.4
M9	0.30	0.25	0.15	0.1-0.3	partly	retired grass	partial	20.5	47	4.2	179	clear	7.4
M10	2.50	1.50	0.35	0.1-0.3	partly	retired grass	both	17	63	6.1	224	slight	6.4
K1	2.00	1.30	0.40	0.1-0.3	partly	retired grass	none	17.1	74	7.2	172	slight	7.7
K2	0.90	0.75	0.15	0.1-0.3	partly	parkland	none	17.8	89	8.5	167	clear	7.5
K3	2.10	1.80	0.60	0.1-0.3	partly	parkland	none	15.6	84	8.3	162	high	6.9
K4	1.00	0.80	0.20	0.1-0.3	partly	parkland	none	15.3	79	7.9	229	high	7.4
K5	1.20	0.90	0.15	0.1-0.3	partly	parkland	none	22.8	76	6.5	284	slight	6.6
K6 us	3.00	1.60	0.60	0.1-0.3	partly	parkland	none	18.1	53	5	227	slight	7.1
K6 ds	0.40	0.35	0.20	0.1-0.3	open	retired grass	none	18.3	73	7.3	254	clear	7.4
K7	5.60	1.10	0.10	<0.1	significant	parkland	none	16.2	58	5.8	316	clear	7.4
K8	1.50	1.40	~1.0	0.1-0.3	partly	parkland	none	16.7	72	7	215	high	7.5
K9	0.80	0.40	0.15	0.1-0.3	partly	parkland	none	19.9	56	5.1	673	clear	7.8
K10	0.75	0.60	0.15	0.1-0.3	partly	parkland	none	16.3	75	7.4	306	clear	6.9
T1	1.40	1.20	0.15	<0.1	open	pasture	partial	18.7	122	11	123	clear	7.1
T3	3.00	2.00	0.20	0.1-0.3	open	retired grass	partial	18.6	48	4.8	197	clear	6.9
T4	1.20	0.80	0.30	<0.1	open	pasture	partial	16.9	80	7.4	211	clear	7.1
T5	1.70	1.35	0.30	0.1-0.3	partly	retired grass	both	16.2	85	8.5	181	clear	6.9
T6	1.50	1.30	0.30	<0.1	open	pasture	partial	21.6	98	8.4	227	high	6.8
T7	2.20	1.20	0.20	0.1-0.3	open	pasture	partial	18.4	98	9.3	266	clear	7.1
T8	2.50	2.10	0.40	0.1-0.3	open	pasture	none	17.5	109	10.4	229	clear	7.2
Mn1	7.00	7.00	0.90	0.1-0.3	partly	pasture	none	16.5	84	8.2	206	high	7.4
Mn2	6.00	6.00	>1	0.1-0.3	partly	pasture	none	17.3	88	8.5	202	high	7.5
Mn3	1.50	1.40	0.35	0.1-0.3	partly	pasture	none	16.3	81	8	206	high	7.5
S1	2.00	1.80	0.20	0.1-0.3	significant	native shrub	none	19.5	93	8.6	252	high	6.8
S2	1.20	1.00	0.50	0.1-0.3	partly	retired grass	none	18.6	75	7	302	high	6.4
S3	2.50	1.80	~0.55	<0.1	open	parkland	none	24	64	5.2	234	high	6.4
W1	5.00	4.00	0.50	0.1-0.3	partly	parkland	none	19.7	93	8.4	208	high	7.3
W2	1.50	1.30	0.25	0.1-0.3	open	parkland	both	22.6	104	9.1	198	high	6.6
P1	1.60	1.50	0.40	0.1-0.3	partly	parkland	none	18.8	98	9.1	190	slight	6.9
P2	1.80	1.50	0.25	0.1-0.3	significant	parkland	none	17.6	83	8	219	clear	6.9
F1	1.40	1.10	0.20	0.1-0.3	partly	parkland	none	16.6	85	8.4	179	clear	7.4
H1	0.60	0.45	0.15	0.1-0.3	open	parkland	none	17.6	93	8.8	161	clear	7.6
B2	1.20	1.10	0.15	0.1-0.3	partly	native shrub	none	19.3	96	8.9	181	clear	7.4
Mean	2.14	1.57	0.32					18.1	81	9.44	216		7.2

The active channel width for a site is the estimated width of the stream at bankfull discharge, while the stream width is the width of the water. The maximum value for active and stream width was 7 m, while the minimum is 0.3 m and 0.25 m for active and stream width respectively. This indicates that a wide range of different stream sizes were analysed during this work. The stream depth varied from very shallow (0.1 m) to a depth of greater than 1 m. When the water depth at a site approached 1 m the actual depth could not be measured as it was too dangerous for the surveyor to gain access to the stream. Streams were usually sampled at normal flow generally yielding results between 0.1-0.3 m/s or <0.1 m/s. The canopy cover of the stream at most sites was partly shaded, and the stream was often not fenced. Temperatures ranged from 16.2 to 24ºC with an average of 18.1ºC. Dissolved oxygen values were usually high with an average of 81% and 9.44 mg/L, however, at some sites the dissolved oxygen was low, approaching 50% saturation and some sites were super saturated with values above 100%. Conductivity had an average value of 216 µS/cm. Water clarity varied from clear to highly turbid in the surveyed sites. The pH ranged from 6.4 to 7.8 with an average value of 7.2.

3.2 Habitat

The bottom substrate present at each of the sites was determined through visual observation of the stream reach, and by determining the fraction of each sediment size in a hand grab sample. Most of the streambed sediment composition was dominated by fine particle size (mud and sand), which is indicative of low gradient, slow flowing stream systems. Some streams had larger sediment sizes (cobbles and boulders). In the city streams, these were often artificial, and had been placed in these environments to stop erosion and scour and to create riffles (Table 4).

The substrate compaction at most of the sites was negligible (Table 5). Large wood is an important structural component in streams providing substrate for invertebrates and habitat for fish. Most of the streams had a significant amount of wood in the stream ranging from 5 to 50%. Coarse detritus levels within most of the streams also ranged from 5 to 50%, but in some of the streams there was <5% coarse detritus present. Fine detritus was present in some of the streams but usually at low levels, i.e., <5%. Filamentous algae and macrophytes had low abundances in the surveyed stream sites.

3.3 Fishing

Gee minnow traps were set at all 41 survey sites, yielding a total fish catch of 495 fish over 19 trapping nights (Table 6). Five nets were usually set over a 50 m reach, but at some sites there was insufficient habitat so the traps were either set over 100 m, or less than five traps were set. Traps were set once at all sites, except sites M1and M2 where traps were set twice because wet weather on the first sample night resulted in no catch. At each site, traps were set to sample representative habitats of the stream (run, riffle and pool).

Table 4: Substrate composition for each of the streams sampled.

Site	Mud	Sand	Fine gravel	Coarse gravel	Cobble	Boulder	Bedrock
M1	10	50	15	15	10		
M2	10	60	15	15			
M3	40	50	5		5		
M4	10	80	5	5			
M5	10	80	5	5			
M6	5	85	5		5		
M7	5	50	20	20	5		
M8	45	40	5	10			
M9	50	50					
M10	20	60	10	10			
K1	10	75	5	5	5		
K2	10	80	5	5			
K3	30	50	5	5	10		
K4	80	20					
K5	60	40					
K6 u/s	90	10					
K6 d/s	10	70	10	10			
K7	100						
K8	40	40	10	10			
K9	5	60	15	15	5		
K10	20	60	10	10			
T1	90	10					
T3	100						
T4	30	60	5	5			
T5		10	5	5	20	20	40
T6	60	40					
T7	10	40	20	20	10		
T8	10	60	15	15			
Mn1	10	80	5	5			
Mn2	10	80	5	5			
Mn3	10	80	5	5			
S1	10	70	5	5	10		
S2	10	60	10	10	10		
S3	80	10	5	5			
W1	15	80	5				
W2	Concrete Gobi blocks on the stream bed						
P1		50	15	15	20		
P2		50	15	15	20		
F1	10	20	5	5	20	40	
H1		60	20	20			
B2		10	20	30	40		

Table 5: Substrate, wood, algae, detritus and macrophytes for each of the sites. X indicates the condition for each variable and site.

Site	Compaction		Large Wood			Coarse detritus		Fine detritus			Filamentous algae		Macrophytes	
	none	mod	<5%	5-50%	>50%	<5%	5-50%	<5%	5-50%	>50%	<5%	5-50%	<5%	5-50%
M1		X	X				X		X		X		x	
M2	x		X				X		X		X		x	
M3	x			X			X		X		X		x	
M4		X		X			X	X			X		X	
M5	x			X			X	X			X		x	
M6	x			X			X		X		X		x	
M7		X		X			X	X				X	x	
M8	x			X			X		X		X			x
M9	X			X			X		X		X			x
M10		X		X			X	X			X		x	
K1	X			X			X	X			X		x	
K2	X			X			X	X			X		x	
K3	X			X			X		X		X			x
K4	X			X			X		X	X	X		x	
K5	X			X			X		X		X			x
K6 u	X				X		X		X		X			x
K6 d		X		X		X		X				X		x
K7	X			X			X			X	X		x	
K8	X			X			X	X			X		x	
K9	X		X				X	X			X		x	
K10	X			X			X		X		X		x	
T1	X		X				X		X			X		x
T3	X		X			X		X				X		x
T4	X		X				X	X			X			x
T5				X		X		X				X	x	
T6	X		X				X		X		X			x
T7	X		X			X		X				X	x	
T8		X	X				X	X				X		x
Mn1	X			X		X		X			X		x	
Mn2	X			X		X		X				X	x	
Mn3	X			X			X	X			X		x	
S1	X			X			X	X			X		x	
S2	X			X		X		X			X		x	
S3		X	X				X			X	X			x
W1	x		X				X		X		X		x	
W2							X				X			
P1		X		X			X	X			X		x	
P2		X		X		X		X			X		x	
F1	X		X				X		X		X		x	
H1		X		X			X	X			X		x	
B2	X		X			X		X			X		x	

Table 6: Fish caught using Gee minnow traps, including the date and time set and collected.

Site	FFDB card	Traps in (NZST)		Traps out (NZST)		Number of fish caught											
		Date	Time (h)	Date	Time (h)	Longfin eel	Shortfin eel	Banded kokopu	Inanga	Whitebait	Common smelt	Mosquitofish	Common bullies	Torrentfish	Total	No. of traps set	No. of empty traps
M1	21764	5.12.05	13	6.12.05	8										0	5	5
M1	21764	13.12.05	11	14.12.05	7.1					4		1			5	6	3
M2	21769	5.12.05	13	6.12.05	8.4										0	5	5
M2	21769	6.12.05	8.3	7.12.05	7.4										0	5	5
M3	21771	6.12.05	10	7.12.05	8.2										0	5	5
M4	21773	12.12.05	12.45	13.12.05	10.3			1							1	3	2
M5	21803	12.12.05	13.05	13.12.05	9.3	3				1	1			3	8	6	1
M6	21805	12.12.05	13.15	13.12.05	9										0	3	3
M7	21808	12.12.05	14	13.12.05	8										0	5	5
M8	21810	14.12.05	9	15.12.05	8										0	6	6
M 9	21814	21.12.05	8.3	22.12.05	8	2									2	5	4
M10	21767	22.12.05	8.1	23.12.05	8.3										0	5	5
K1	21742	2.01.06	9.4	3.01.06	7.5					1					1	5	4
K2	21747	2.01.06	10.4	3.12.06	8.5		2								2	5	3
K3	21750	16.01.06	9.25	17.01.06	10		1				3				4	5	1
K4	21752	16.01.06	9	17.01.06	9.15		4				1				5	5	1
K5	21754	17.01.06	12.4	18.01.06	7.15										0	5	5
K6 u/s	21758	2.01.06	12.5	3.01.06	9.3							14			14	5	1
K6 d/s	21757	27.12.05	12.4	28.12.05	10							58			58	5	1
K7	21759	16.01.06	10.3	17.01.06	12.2										0	5	5
K8	21760	27.12.05	11.3	28.12.05	9.35										0	5	5
K9	21762	27.12.05	11.2	28.12.05	9.3										0	5	5
K10	21744	17.01.06	11.05	18.01.06	8						2				2	5	4
T1	22106	27.02.06	12.3	28.02.06	12.15							270			270	5	0
T3	22107	2.03.06	12.15	28.02.06	13.5		1					2			3	5	4
T4	22109	1.03.06	13.25	2.03.06	11.45							13			13	5	2
T5	22110	27.02.06	13.05	28.02.06	13			5	1						6	5	3
T6	22112	1.03.06	14	2.03.06	12.1		20					1			21	5	1
T7	22113	3.03.06	11.05	3.02.06	11.1										0	5	5
T8	22114	3.03.06	11.4	3.03.06	11.4				24			1			25	5	2
Mn 1	21815	9.01.06	11	10.01.06	10								3		3	5	3
Mn 2	21817	9.01.06	11.2	10.01.06	10.4										0	5	5
Mn 3	21819	9.01.06	10.35	10.01.06	9.3								2		2	5	3
S1	22101	10.01.06	15.5	11.01.06	9.2								1		1	5	4
S2	22102	10.01.06	14	11.01.06	8.45										0	5	5
S3	22104	10.01.06	13.3	11.01.06	7.5							27			27	4	0
W1	22115	13.12.05	13	14.12.05	9.5		1								1	6	5
W2	22116	13.12.05	13.5	14.12.05	10.1		2								2	5	3
P1	21822	13.02.06	15.45	14.02.06	10.05			2		8		6	3		19	5	3
P2	21823	13.02.06	14.45	14.02.06	9.45										0	5	5
F1	21739	17.01.06	13.15	18.01.06	8.45										0	5	5
H1	21741	22.12.05	9.18	23.12.05	8.55										0	5	5
B2	21737	9.01.06	14.45	10.01.06	13										0	5	5
Total						5	31	8	25	14	7	393	9	3	495		

At eighteen of the sites no fish were caught using the Gee minnow traps, but some had a high abundance of 270 mosquitofish , e.g., site T1, which is a farm drain with minimal cover and slow water flow on Rotokauri Road. Fifty eight mosquitofish were caught at K6 d/s on Thomas Road. Where mosquitofish were caught in high numbers, no other fish species were caught. At site T6, a farm drain than runs through pasture in the Te Rapa/Rotokauri catchment, 20 shortfin eels were caught over 50 m, providing evidence of the high productivity of some of these sites. Of interest is the presence of 24 inanga at site T8 in the Te Rapa catchment, located off Horitiu Road. This site was accessible to the Waikato River.

A single baited fyke net was set at every site where the depth of the water was greater than 1 m. The water had to be greater than this depth for the fyke net to be set correctly in the water. In all fyke nets, either the longfin or the shortfin eel were caught, and at site K8 both species were found to co-exist (Table 7). The other species caught in the fyke net were too large to be caught in the Gee minnow nets. The threatened species giant kokopu were caught at two of the 13 sites where fyke nets were set. The remainder of the catch consisted of two introduced species the brown trout, and catfish which is classified as a pest fish.

Table 7: Fish caught using fyke nets, including the date and time set and collected.

		Nets in (NZST)		Nets out (NZST)							
Site	FFDB card	Date	Time (h)	Date	Time (h)	Longfin eel	Giant kokopu	Shortfin eel	Brown trout	Catfish	Total
M2	21770	5.12.05	13.00	6.12.05	8.00	2					2
M3	21772	5.12.05	13.00	6.12.05	8.40	1					1
M8	21812	14.12.05	9.00	15.12.05	8.00	1					1
M10	21768	22.12.05	8.10	23.12.05	8.30	3	2				5
K1	21743	2.01.06	9.40	3.01.06	7.50	2			1		3
K3	21751	16.01.06	9.25	17.01.06	10.00			1			1
K4	21753	16.01.06	9.00	17.01.06	9.15			1			1
K8	21761	27.12.05	11.30	28.12.05	9.35	1		1			2
T3	22108	2.03.06	12.15	28.02.06	13.50			8		1	9
T5	22111	27.02.06	13.05	28.02.06	13.00	1					1
Mn1	21816	9.01.06	11.00	10.01.06	10.00	3					3
Mn 2	21818	9.01.06	11.20	10.01.06	10.40	5					5
S2	22103	10.01.06	14.00	11.01.06	8.45		3	3			6
Totals						19	5	14	1	1	40

Spotlighting was conducted at sites that were shallow, narrow, and had clear water, so that the whole stream could be visually assessed. Where possible, the catch was recorded in absolute numbers. If this was not possible, the abundance of the fish was in relative abundance (Table 8). The length of the fished reach was measured using GPS where a clear reading was possible. Length was approximated where a stable GPS reading could not be obtained. Introduced fish were only seen at one of the sites, and were present at this site during flood where the stream received significant input from the Waikato River. All other fish seen were native; this could be due to the nocturnal feeding nature of many native fresh water fish. A complete list of fish seen at spotlighting sites is given in Appendix 2.

Table 8: Fish visually seen while spotlighting using a red filter.
a=abundant (>10), c=common (6-10), o=occasional (2-5), r=rare (1).

Site	FFDB card	Reach length (m)	Longfin eel	Shortfin eel	Banded kokopu	Inanga	Giant kokopu	Smelt	Trout
M1	21765	75		o(2)				a	
M4	21774	50		r(1)	o(3)				
M6	21806	105		o(4)	r(1)				
M7	21809	105		o(4)				c	
M8	21811	80			c		r(1)		
K2	21748	50		o		o		c	
K2 u/s	21749	200		c	o(2)	o	r(1)	o	
K5	21755	50		r(1)					
K10	21745	80				c		a	
Mn3	21820	30						a	
S1	22105	55						c	o(2)
P1	21324	20					o(3)		
P2	21824	40		r(1)					
F1	21740	40		o(3)					
B2	21738	95	o(3)	r(1)					

Electric fishing involves passing an electric current through the water column to stun and attract fish to the surface waters. At each of the sites, only one sweep was completed using the backpack operated electric fishing machine. The absolute time of fishing was recorded (Table 9). The length of the fished reach was measured using a tape measure; width and depth measurements were taken at five different points along the fished reach and averaged. The area was calculated using the measured data. Shortfin eels were caught at all of the sites, while the other species caught were only found at 1-3 of the 10 sites surveyed (Table 9).

Table 9: Fish caught using an electric fishing backpack, including date, time of fishing, and general stream characteristics.

Site	FFDB card	NZST time start	NZST time finish	Date	Length (m)	Area (m^2)	Average width (m)	Average depth (m)	Mosquitofish	Inanga	Smelt	Longfin eel	Shortfin eel	Koi carp	Banded kokopu	Total
M1	21766	10.46	11.35	6/12/2005	30	64	2.14	0.29	1	1	8	9	5			24
M4	21775	12.34	12.53	23/01/2006	37	27	0.74	0.18					3		1	4
M5	21804	13.45	14.15	23/01/2006	65	94	1.44	0.64					5	2		7
M6	21807	15.12	15.34	23/01/2006	65	94	1.44	0.66					5		1	6
M8	21813	11.00	11.33	7/01/2006	39	60	1.53	0.51				1	4			5
K5	21756	9.00	9.46	31/01/2006	48	72	1.5	0.65					10			10
K9	21763	11.50	12.05	31/01/2006	51	72	1.42	0.51					3			3
K10	21746	10.32	10.52	31/01/2006	41	72	1.75	0.5	2		5		6			13
Mn3	21821	10.15	10.54	23/01/2006	29	50	1.75	0.25			7		5			12
P2	21825	13.00	13.21	7/01/2006	40	62	1.54	0.38					5			5
Total									3	1	20	10	51	2	2	89

When all fishing methods were combined, a total of 636 fish (not including abundance classes during spotlighting) were caught or observed in this study (Table 10). In addition to the three methods of fishing, fish that were visually seen when setting or collecting nets are also recorded in Table 10. These include an unidentified eel at H1, the stream that runs through Graham Park behind the hospital, a shortfin eel at S3 on Tuirangi Street, and a koi carp at Mn1 in the Mangaonua catchment. No fish were caught or observed at two of the survey sites (K7, and T7). Shortfin eels were caught at the greatest number of sites in the Hamilton urban environment. The threatened species giant kokopu and longfin eels were recorded at five and 13 sites respectively. Lengths of fish caught by electrofishing, Gee minnow trapping, and fyke netting is given in Appendix 3.

The Mangakotukutuku and Kirikiriroa catchments had similar fishing effort. Longfin eels were recorded at seven of the 10 sites sampled within the Mangakotukutuku catchment, and their abundance within this catchment represents 59% of the total longfin eels caught. Longfin eels were common in the Mangaonua catchment (eight were caught at three sites), but were uncommon at all other sites (three were caught in the Kirikiriroa catchment). Three giant kokopu each were caught in the Mangakotukutuku, Te Awa O Katapaki and Gibbons creek at Parana Park catchments. The tenth and final giant kokopu record was from the Kirikiriroa catchment. Torrentfish were only caught in the Mangakotukutuku catchment and banded kokopu were present at more sites and in greater frequencies in this catchment than any other. Smelt were slightly more common in the Kirikiriroa catchment, while inanga were found in similar abundances for both catchments. The Mangakotukutuku catchment contained 33% of the total native fish caught and represented 24% of the sample sites, while 18% of the total native fish were caught in the Kirikiriroa catchment, which represented 27% of the sample sites.

The pest fish species mosquitofish, koi carp, and catfish were recorded at 11, two, and one site respectively. Trout were recorded at two sites. During this survey, a total of 403 pest fish were caught, 396 (or 98%) of these were mosquitofish and these were dominant in the Te Rapa/ Rotokauri catchment (287). Mosquitofish were also common in the Kirikiriroa catchment, while only one was caught in the Mangakotukutuku catchment. Two koi carp were caught in the Mangakotukutuku catchment and one was seen in the Mangaonua catchment. One trout was caught in the Kirikiriroa catchment and two in the Te Awa O Katapaki catchment. No pest fish were caught in the Waitawhiriwhiri, Fairfield, Hospital, and Bankwood catchments.

The catch in nets may be greater than the numbers noted because many of the fish caught together had natural predator and prey relationships, especially where larger eels were present. There was evidence of this relationship at two sites; M5 below Peacockes Road and M8 a peri-urban site located on Dixon Road. At site M5 three longfin eel was caught in a Gee minnow net, and while processing one of the eels regurgitated three whitebait fish. However, this is not direct evidence of predation in the trap, as there is no way of knowing how long the eel had been in the trap, or whether the whitebait had been taken before the eel entered the trap. At site M8, one longfin eel was caught in a fyke net, along with the carapace of a koura (fresh water crayfish). This is definite evidence of predation in the traps. Therefore predation in traps might have reduced apparent catch rates.

Koura (freshwater crayfish, *Paranephrops planifrons*) were identified at four sites during this survey: M1, M6, M8, and Mn3.

3.4 Culvert Assessments

Culvert assessments were performed downstream of all of the survey sites (Table 11) to determine access to the upstream sites. Culverts were almost always present where a road crossed the stream. The type of culvert, length, width, and material it was constructed from were recorded. Pictures of both the inlet and outlet were taken. The severity to passage was determined mainly from the downstream outlet of a culvert which is an obstacle that fish migrating upstream have to overcome. Factors that determine the severity of passage are: whether or not a pipe is perched, undercut, or long with fast flow that is not disrupted or broken by objects (i.e., riffles). The high abundance of eels in the urban environment is probably partially due to their ability to overcome culvert barriers. Of the 47 culverts assessed, 27 were considered to have no effect on passage upstream, six provided a problem at low flows only, and 13 provided a problem at most flows. The severity of passage restriction was not recorded at one of the surveyed sites (Table 11). Assessing the barrier that culverts pose to fish passage is important as it indicates the likely composition of fish species present at a site.

Table 10: Tally of the fish caught using Gee minnow nets, fyke nets, spotlighting, and electric fishing. =Fish abundances are as follows; a=abundant (>10), c=common (6-10), o=occasional (2-5), r=rare (1).

Site	Number of fish													Percent at each site
	Longfin eel	Shortfin eel	Banded kokopu	Inanga	Whitebait	Common smelt	Mosquitfish	Common bullies	Torrentfish	Giant kokopu	Trout	Koi carp	Catfish	
M1	9	11		1	4	a	1							4.2
M2	2													0.3
M3	1													0.2
M4		4	5											1.4
M5	3	5			1	1			3			2		2.3
M6		9	2											1.7
M7		4				c								0.6
M8	2	4	c							1				1.1
M 9	2													0.3
M10	3									2				0.8
K1	2				1						1			0.6
K2		4	2	o		c				1				1.1
K3		2				3								0.8
K4		5				1								0.9
K5		11												1.7
K6 u/s							14							2.2
K6 d/s							58							9
K7														0
K8	1	1												0.3
K9		3												0.5
K10		6		c		a	2							1.2
T1							270							42.1
T3		10					2						1	2
T4							13							2
T5	1		5	1										1.1
T6		20					1							3.3
T7														0
T8				24			1							3.9
Mn 1	3							3				* 1		0.9
Mn 2	5													0.8
Mn 3		5				a		2						1.1
S1								1			2			0.2
S2		3								3				0.9
S3		* 1					27							4.5
W1		1												0.2
W2		2												0.3
P1			2		8		6	3		3				3.4
P2		6												0.9
F1		3												0.5
H1														0.2
B2	3	1												0.6
Total	37	120	14	26	14	5	396	9	3	10	3	3	1	100
No. of sites	13	23	6	5	4	8	11	4	1	5	2	2	1	

Table 11: The 47 culverts that were assessed downstream of all of the sample sites (ND = no data).

Site	Date	NZ Map grid E	NZ Map grid N	Type	Length (m)	Diameter (m)	Inlet	Outlet	Severity of passage impedance	Flow
Waterford Rd - M1	6/12/2005	2712751	6374066	pipe	50	2.5	flat	pool	none	normal
Malabar street - M6	13/12/2005	2712640	6373733	pipe	9.5	0.6	flat	perched	most flows	normal
Pelorus street - M7	13/12/2005	2712184	6372905	pipe	36	1.8	pool	pool	none	normal
Splitt Avenue - M7	13/12/2005	2712193	6373348	pipe	>50	1.8	flat	flat	none	normal
Waterford & Cromwell M	20/12/2005	2712816	6373636	pipe		0.4		perched	most flows	normal
Corner Dixon & Ohaupo M	20/12/2005	2712330	6372672	pipe	55	0.6	pool	flat	low flows	normal
Corner Ohaupo & Dixon M	20/12/2005	2712291	6372632	pipe		1.2		perched	ND	
Ohaupo Rd M	20/12/2005	2711121	6373504	pipe	27	3	flat	flat	none	high
Saxbys Rd M	20/12/2005	2711080	6373046	box	18	3	flat	perched	most flows	high
River Rd - K	24/01/2006	2709137	6381909	arch	10	-	flat	flat	none	normal
Hukanui (Mangati Park) K	17/01/2006	2710628	6382031	pipe	20	3.5	flat	flat	none	normal
Glenn Lynn Ave K	2/01/2006	2710404	6381584	pipe	17	1.5	flat	perched	most flows	normal
Park - K2	2/01/2006	2710250	6381720	pipe	8	1.2	flat	flat	none	normal
Tramway Rd - K5	18/01/2006	2712336	6381023	pipe	18	0.8	flat	perched	most flows	normal
Crosby Rd - K5	18/01/2006	2712302	6381087	pipe	23	0.75	flat	pool	none	normal
Stoneleigh Rd - K5	13/02/2006	2712113	6381342	pipe	16	1.7	flat	flat	none	normal
Park off Stoneleigh Rd - K5	13/02/2006	2712158	6381332	pipe	2	0.8	flat	perched	most flows	normal
Rotokauri Rd - T1	20/02/2006	2706439	6379426	pipe	16	1.2	flat	flat	none	normal
Duck Rd - T3	20/02/2006	2702543	6381314	arch	5	5	flat	pool	none	normal
Te Kowhai Rd - T4	20/02/2006	2702059	6382423	pipe	12	1.5	pooled	flat	none	normal
Te Kowhai Rd - T6	20/02/2006	2704742	6382301	pipe	8	1	pooled	flat	none	normal
Ruffel Rd - T7	20/02/2006	2705542	6383315	box	11	2.2	flat	pool	none	normal
Exelby Rd - T5	27/02/2006	2704524	6380532	pipe	15	1.5	flat	perched	most flows	normal
Horitu Rd - T8	3/03/2006	2704351	6386562	pipe	11	2.7	flat	flat	none	normal
Washer Rd T	3/03/2006	2704179	6386826	arch	6	3	flat		none	normal
Cambridge Rd - Mn1	24/01/2006	2715375	6374751	box	9	4	flat	flat	none	high
Morrinsville Rd - Mn1	9/01/2006	2715649	6375779	pipe	46	1.3	flat	flat	none	normal
Matangi Rd - Mn3	9/01/2006	2715692	6375723	arch	11	3.5	flat	perched	low flows	normal
Magellan rise S	10/01/2006	2708521	6383626	box	25	2.5	flat	flat	none	normal
River Rd - S1	11/01/2006	2706732	6384459	pipe	48	2.4	pool	perched	low flows	normal
Sylvester rd - S2	10/01/2006	2708431	6383464	pipe	8	1.1	flat	flat	none	normal
Turangi st - S3	10/01/2006	2708701	6383821	box	27	2.5	flat	flat	most flows	normal
Lincoln Rd - W	19/02/2006	2708400	6377757	pipe	35	2	flat	flat	none	normal
Train tracks Forestview W	19/02/2006	2709703	6378404	pipe *2	11	1.7	flat	pool	none	normal
Waitoa - W	1/03/2006	2709061	6377652	box	42	2	perch	flat riffle	low flows	
Ulster St - W	1/03/2006	2709619	6378370	pipe	20	2.5, 5	flat	perched	most flows	normal
Victoria St - W1	13/12/2005	2710146	6378492	arch box	32	5.5	perch	perched	most flows	
No. 9, Whyte St P	30/01/2006	2712111	6377506	pipe	5	0.7	flat	flat	none	normal
No 9 a & b Whyte St P	30/01/2006	2712120	6377478	pipe	16	1	flat	perched	low flows	normal
Whyte Rd P	30/01/2006	2712144	6377453	pipe	22	0.8	flat	pool	none	normal
River\Memorial Drive - P2	30/01/2006	2711697	6377009	-	>100	0.8	flat	flat	none	normal
Awatere Rd - F1	13/02/2006	2709892	6378985	pipe	27	1	flat	perched	low flows	normal
Graham Park (hospital) H	22/12/2005	2711426	6375305	pipe	13	0.5	flat	perched	most flows	high
Cobham Rd - H1	23/12/2005	2711490	6375449	pipe	>50	0.7	flat	perched	most flows	normal
Wymer Rd - B2	14/02/2006	2710020	6380611	pipe	19	0.8	pool	perched	most flows	normal
River Rd - B2	14/02/2006	2709997	6380730	pipe	50	1.2	flat	flat	none	normal

3.6 Catchment and Site Summaries

3.6.1 Mangakotukutuku Catchment

The Mangakotukutuku catchment is located south of Hamilton city and includes the suburbs of Melville and Glenview. The area is represented by a large gully system, and some of the surrounding land use has recently been and is still being urbanised. The headwaters of the catchment are generally in pasture. The water colour at some of the sites is very brown, which is due to peat staining in upper reaches and high sediment loads in lower reaches. The riparian vegetation in this catchment was largely intact but was often represented by introduced ground cover species (e.g., wandering willie or *Tradescantia*, Figure 3)

Figure 3: Site M1 located within the Mangakotukutuku catchment off Peacockes Road in Sandford Park.

Ten sites were surveyed in this catchment, and nine culverts were assessed. The culverts generally allowed fish access to the sites, but four of the culverts provided a problem to fish access at most flows. These were: the perched culvert at Malabar Street (M6), the corner of Ohaupo Road and Dixon Street, Peacockes Road, and Saxbys Road. All of the sites located above these culverts had only eels or banded or giant kokopu present, reflecting their climbing ability or possibly habitat quality. Eels were present at all of the sites, banded kokopu at three of sites and giant kokopu at two sites. Smelt and other fish that are unable to overcome culvert barriers were only found in the lower reaches of the catchment, close to the Waikato River. Inanga, smelt, koi carp, and mosquitofish were found at lower elevations close to the Waikato River, with koi carp and torrentfish being restricted to below the Peacocks Road culvert (Figure 4).

There was only one previous record from the NZFFD for this catchment (M7 on Pelorous Street). A previous record for this site found the following fish present: mosquitofish, inanga, banded kokopu, smelt, shortfin eel, and longfin eel. During this survey only shortfin eel and smelt were present. This site was also assessed in 1998 by Wilding who also found shortfin eels. Wilding

(1998) also electric fished a site on Peacockes Road and caught longfin eels, shortfin eels, common smelt, and mosquitofish. This site was upstream from the Peacockes Road

Access to the upstream sites was partially prevented by a perched and undercut culvert under Peacockes Road. This provides a partial barrier to fish passage at most flows, however when the Waikato River level is high, fish may access the upstream sites. Site M1, the true right tributary of the stream in Sandford park is located downstream of M8 (peri-urban site). Access appears to be good to M1 where fish with limited climbing ability are present (smelt and mosquitofish). The access to M8 is probably restricted as only climbing species are present; longfin and shortfin eels, banded kokopu and giant kokopu, however, the presence of these species may reflect habitat quality. Only one culvert was assessed between these two sites and access was available, however, other barriers could have been missed.

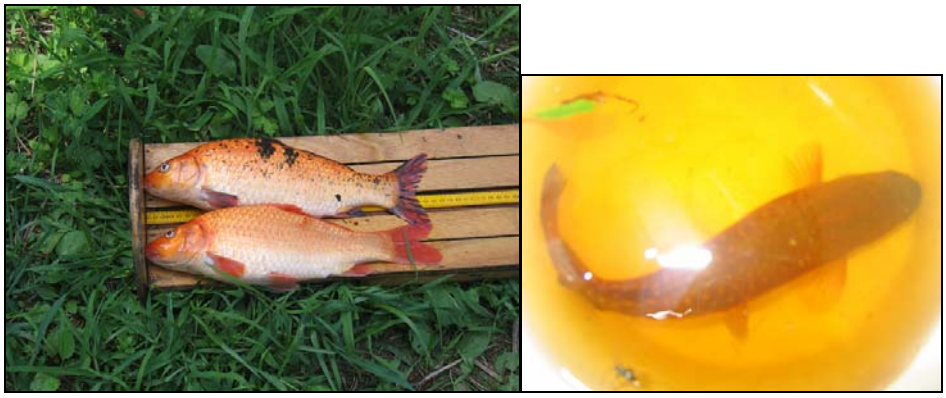

Figure 4: Koi carp caught below Peacockes Road (M5) on the left, and giant kokopu caught at M10 on Saxbys Road on the right.

3.6.2 Kirikiriroa Catchment

The Kirikiriroa catchment is located north east of Hamilton City, and is represented mainly by the Chartwell area. Urbanisation is quite well established in this catchment. Like the Mangakotukutuku catchment, 10 sites were also surveyed. The riparian vegetation was less intact than in the Mangakotukutuku catchment (in general), having a lot of exposed bank, which could lead to an increase in the stream silt levels. The riparian vegetation is characterised by introduced low growing plants with scattered exotic trees (Figure 5).

Figure 5: Photo of a typical Kirikiriroa catchment stream (K2).

Three of the culverts provide access problems at most flows. The sites above these culverts contain only those species that are able to overcome culvert access problems. Kokopu were visually seen at K2; including several banded kokopu and a giant kokopu. Shortfin eels were more common in this catchment than longfin eels (which were more common in the Mangakotukutuku catchment), which may indicate that habitat and possibly water quality are better in the Mangakotukutuku catchment. Mosquitofish were the only fish caught at site K6 and were present in high numbers. There was no catch with any of the fishing methods at site K7; this site had low DO, high conductivity, and dries up later in summer.

Many previous fish records existed within the Kirikiriroa catchment and were sourced from the NZFFD. K1, the site on Tauhara Street, had not previously been fished. This site was downstream of all other sites, and a longfin eel, brown trout and whitebait were caught in traps. K2 in the park off Glen Lynn Road had previous been fished and the following fish were found; shortfin eel, inanga, banded kokopu, giant kokopu, and unidentified eel. During this survey all of these species were again identified. K9, a small tributary stream in Tauhara Park with an extremely high conductivity value of 673 µS/cm, had not been previously fished, during this survey shortfin eels were caught close to the confluence of a larger branch of the stream. Further upstream a strong chemical smell was noted and a dead shortfin eel was seen in the stream, K8 the larger stream which drained K9, was also sampled. Upstream of K8 smelt had previously been caught (NZFFD), but during this survey only shortfin and longfin eels were captured.

There were no previous NZFFD records for K3, K4, K6, K7 or K10. However, records downstream of the confluence of sites K3 and K4 indicated smelt, shortfin, longfin, and unidentified eels and giant kokopu were present, and during this survey shortfin eels and smelt were trapped at both sites. At K5, on Tramway Road, upstream of K4, only shortfin eels were caught during this survey. Two culverts between sites K4 and K5 provided a barrier to upstream passage these were located in a park off Stoneleigh Road and under Tramway Road.

3.6.3 Te Rapa/Rotokauri Sites

The Te Rapa/Rotokauri sites were located on the north-western side of Hamilton City. Some of the sites fall within the jurisdiction of the Waikato District Council, but were assessed to gain knowledge of the complete system. Seven sites were assessed in a new area that is proposed to undergo subdivision in the near future. All of the sites were surrounded by pasture. Pasture was therefore the main riparian vegetation of the streams and most of the streams were highly modified (Figure 6).

Figure 6: Te Rapa/Rotokauri sites were mainly modified/unmodified farm drains that ran through pasture - like the one shown on the left. The site on the right is T5 and was highly incised with bedrock base and riparian vegetation.

Figure 7: Catfish caught in the fyke net at T3. Eight shortfin eels were also caught in the net.

The stream at site T5 was located on the road edge of Exelby Road and drained into Lake Rotokauri. This site was of considerable better quality than any of the other streams in this area. At T5, five juvenile banded kokopu were caught and one longfin eel. Giant kokopu were earlier captured in the drain section of this stream (Champion *et al*. 2001). The other sites were dominated by shortfin eels. Mosquitofish were present in high numbers at two of the sites, and a catfish was caught at T3 (Figure 7). Site T8, which was close to the Waikato River, had significant numbers of inanga. All culverts provided access to swimming fish except the perched culvert on Exelby Road, upstream of T5.

There were no records of freshwater fish (on the NZFFD) caught in the Te Rapa/Rotokauri catchment. However, fishing was conducted in this catchment in 2001 by BECA Carter Hollings and Ferner Ltd (Champion *et al*, 2001) as part of the Rotokauri structure plan phase one report. Eleven sites were fished using many different methods including; multi-panel gill nets, fine mesh fyke net, Gee minnow traps, electric fishing, observation, and log overturn. Shortfin eels were found to be common within this catchment. Many introduced fish including, rudd, catfish and brown trout were caught in Horseshoe Lake along with common bully and one longfin eel. At the site on Rotokauri Road which coincides with T1, Champion *et al* (2001) caught shortfin eels and rudd both of which were highly abundant. During this survey, only mosquitofish were caught, and in very high abundance. The other sites sampled during the BECA survey do not directly correlate with our survey sites. Fish caught within the catchment during this survey include the species noted above plus, juvenile banded kokopu, inanga and a longfin eel. The banded kokopu caught during this survey were in their juvenile form and it is possible that some could have been giant kokopu due to the difficulty in differentiating between the two at the juvenile life stage.

3.6.4 Mangaonua Catchment

The Mangaonua Catchment is on the north-eastern side of Hamilton City; all sites were located off Matangi Road (Figure 8). Three sites were chosen, two of the sites had deep water and access was a problem while the third site, on the true right side of the stream was much shallower, and as a result was electric fished and spotlighted. Downstream access to the sampling sites was adequate, and the catch included longfin and shortfin eels, bullies (which were only caught in two other catchments during this study) and smelt.

Figure 8: Mn3, Matangi Road. All of the sites sampled in the Mangaonua catchment were in close proximity to each other. The riparian vegetation for all sites was a mixture of weed, pasture and willow trees.

There are two previous records from the NZFFD for site Mn3, the true right branch of the stream. These were old records which indicated the presence of common bully, smelt and mosquitofish. There were many other NZFFD records for this catchment both upstream and downstream of the

sample sites. During this survey shortfin eels, smelt and bullies were present at Mn3. Bullies and longfin eels were trap netted at Mn1 below the confluence of the two streams and a koi carp was observed when setting nets. At Mn2, the left branch of the stream, longfin eels were caught. The presence of the swimming fish smelt and koi carp indicate that access to this cluster of sites is good. This is reinforced by the culverts assessed downstream of the sites which provide no barrier to swimming fish or were a barrier only at low flows.

3.6.5 Te Awa O Katapaki Catchment

This catchment is located north of Hamilton and is the catchment adjacent to the Kirikiriroa catchment. The catchment is undergoing significant urbanisation and development at the moment, the site in Figure 9 was located on the edge of a major development. The culverts in this catchment have little to no impact on the fish access to the survey sites.

Figure 9: Site photo of the second survey site (S2) in the Te Awa O Katapaki catchment.

All sites were quite different in nature. The uppermost site S3 has recently had works undertaken on it has and riparian areas have been replanted. The water is shallow, the flow is slow, and there is no instream or overhead cover which resulted in a high spot temperature value of 24ºC. Mosquitofish and tadpoles were dominant. Downstream at site S2, depth and flow rate increased, three giant kokopu were caught at this site (Figure 10). Site S1, had good riparian cover, with good access and in close proximity to the Waikato River.

Figure 10: Three giant kokopu caught in the fyke net at S2.

There are many recent fishing records for the Te Awa O Katapaki catchment in the NZFFD, and because of this limited fishing effort was applied to the stream during this survey. At S1, previous records showed that shortfin eels, common bully and smelt were present. During this survey, bullies and trout were caught and observed, respectively. At S2 located on Sylvester Road, previous records reveal the following fish were caught; shortfin eels, common bully, smelt and inanga. During this survey giant kokopu and shortfin eels were caught. There were no previous NZFFD records for S3. During this survey, mosquitofish were found to be present, and shortfin eels were also observed when the silt in the culvert under Tuirangi Street was cleared by council staff. All culverts surveyed within this catchment provided access to swimming fish. 'The presence of smelt in the stream, right up to Site 5, indicates that the River Road culvert is not restricting 'swimming fish' passage' (Kessels, 2004) (Kessels Site 5 is located upstream of S2). This was also noted by Hicks *et al* (2001) during a study of the catchment. There were no previous records of giant kokopu in this catchment, and their occurrence was unexpected given the apparent degraded nature of many parts of the stream. Hicks *et al* (2001) noted that fish of high conservation value, such as giant or banded kokopu (*Galaxias argenteus* or *G. fasciatus*) were not found during the 2001 survey, and stated that this was predictable given the warm, unshaded nature of the stream. The discovery of giant kokopu in this catchment in January of 2006 may be attributed to the establishment of vegetation upstream of the site or the time of the survey, and indicates that even apparently degraded sites can harbour species of high conservation value when some suitable habitat occurs.

3.6.6 Waitawhiriwhiri Catchment

Only two sites were assessed within the Waitawhiriwhiri catchment because there are existing records for the stream, and the culvert where the stream enters the Waikato River is perched by 0.5 m which prevents fish access except when river flow is high. The stream contains iron floc. 'Upon entering well-oxygenated streams, dissolved iron readily oxidizes and in high concentrations forms iron floc, which is a visible orange 'growth' (Wilding, 1998). The stream has little riparian cover and the bottom is composed of gobi concrete blocks (Figure 11). The stream appears to be severely degraded and only shortfin eels were present.

Figure 11: Waitawhiriwhiri catchment section of the stream, with minimal riparian cover, concrete bottom and iron flocculation.

There are many previous records of fish in the Waitawhiriwhiri catchment in the NZFFD including; smelt, rudd (*Scardinius evythrophthalmus*), koi carp, goldfish, shortfin eels, unidentified eels, common bully, and catfish. The barrier at the confluence of the Waitawhiriwhiri Stream and the Waikato River, is obviously overcome at certain times of the year when the river is in flood to allow fish migration upstream. The low diversity of fish species in this catchment is expected due to the degraded nature of the stream. Waitawhiriwhiri catchment represents a particularly inhospitable environment for fish for several reasons including severe iron floc deposits (Wilding, 1998), concrete Gobi mats lining the stream bottom for several hundred meters, and minimal to no riparian vegetation upstream.

3.6.7 Gibbons Creek at Parana Park/Seeley's Gully Sites

These two sites represent a small catchment within the city in the Hamilton East area. Parana Park is located between the Waikato River and River Road, the stream in the park has a narrow riparian margin. The second site is upstream several hundred meters, above where the stream is diverted through a 200 m long concrete pipe which has both natural stream and storm water input. The artificial change to the hydrology of the stream poses a major problem for migratory fish. While fish diversity and abundance was high in Parana Park; having whitebait, bullies, banded and giant kokopu, only shortfin eels were found upstream. The low diversity upstream may also be due to the extensive iron floc (Figure 12).

Figure 12: P2 located in Seeley's Gully; note the orange iron flocculation and rubbish visible on the stream bottom.

One previous 1985 NZFFD record (record number 4566, card number 5092, NZ map grid easting 2714100, northing 6379300) in the peri-urban headwaters of Gibbons Creek had abundant black mudfish (*Neochanna diversus*). The records from this study show that there are many fish species present in Parana Park, while further upstream barriers to fish migration or the lack of suitable habitat seem to limit distribution to only shortfin eels at Seeley's Gully. The decrease in species richness can be attributed to the effects of urbanisation particularly the effects of storm water input and piping of stream water (Roy *et al.*, 2005).

3.6.8 Fairfield Site

One site was surveyed in this small tributary in the Fairfield area. The site was located off Airedale Road, below the Fairfield Bridge. From the river to the first culvert is a 100-150 m reach of stream, almost half of which is constantly affected by Waikato River backwash. The actual stream is highly modified, with the bottom consisting of large concrete rubble. The riparian vegetation is dominated by bamboo. The culvert just upstream from the site may provide a barrier in low flows. The inlet to the culvert has native riparian vegetation with clear water.

There were no previous records for this small tributary of the Waikato River. Only shortfin eels were found during this survey. Other fish (such as koi carp and smelt) were present close to the confluence with the Waikato River but were considered to be present in backwater of the Waikato River, so were excluded from the results.

Figure 13: Highly modified Fairfield site F1.

3.6.9 Hospital Stream Site

The access to H1, the hospital stream site located in Graham Park was severely limited by the vertical concrete drop structure at the Waikato River (Figure 14) which provides a barrier to fish access at most flows. Just upstream the stream flow is piped through a 0.7 m diameter pipe under Cobham Road (for approximately 50-100 m). No fish were caught in this stream, but an unidentified eel was seen when trap nets were set.

Figure 14: Hospital stream (H1). One side had weed dominated riparian cover, while the other had recently been sprayed. The picture on the right is the outlet from this stream to the Waikato River; note the perched nature of the culvert.

Several NZFFD records for the sampled section of this stream exist. These previous records reveal the presence of the following species; shortfin and unidentified eels, inanga, and banded kokopu. One unidentified eel was observed during this survey, the limited catch is probably due to the barrier to migration represented by the culvert at the confluence of the Waikato River.

3.6.10 Bankwood Site

The Bankwood stream site B2, had clear water with a cobble gravel bottom (Figure 15). There was partial instream coverage by riparian vegetation. One of the culverts downstream of the site provided access problems at most flows. Only eels were recorded at B2; most were longfin eels ranging from 300 to 850 mm. The lack of other fish species could be due to the high biomass of eel.

Figure 15: Bankwood Stream section showing with good water clarity and a cobble/gravel bottom.

Previous NZFFD records reveal that longfin, shortfin and unidentified eels have previously been caught or observed within this catchment. An extensive electric fishing survey undertaken by

NIWA on the 17th and 18th of January 2006 resulted in the following species being caught; giant kokopu, longfin eels, and shortfin eels.

4.0 Discussion

4.1 Water Quality

The water quality in the Hamilton urban gully streams was widely varied. Average water temperature was 18.1ºC but reached a maximum at 24ºC at site S3 located in the Te Awa O Katapaki Esplanade on Tuirangi Road. High water temperatures were associated with a lack of riparian cover and slow moving water.

Six of the 41 survey sites had dissolved oxygen levels of less than 60 %; two of these sites only had shortfin eels, and one site only contained mosquitofish. However one site, M9, had a longfin eel, and site M8 with a DO of 59 % contained both longfin and shortfin eels as well as inanga and a giant kokopu. There were four sites (K7, K10, S2 and K9) with conductivity higher than 300 µS/cm. One site, K7 also had low dissolved oxygen levels, and no fish were caught. Shortfin eels, smelt, and gambusia were caught at K10 (Mangati Park), and giant kokopu were caught at S2 (below Sylvester Road). Site K9 in Tauhara Park had a conductivity greater than 600 µS/cm; shortfin eels were present here.

It does not appear that one water quality parameter is a single determinant of stream health or habitat value for fish. Shading of the stream is important as it regulates temperature, and provides instream habitat and substrate for both fish and macroinveterbrate. Riparian vegetation also provides allochthonous input and a further food source in the form of terrestrial invertebrate input. Hicks (1997) found that terrestrial taxa can be significant in the diet of longfin eels and banded kokopu in the Waikato. There were six sites with significant riparian cover surveyed; these were M4, M6, M8, K7, S1, and P2. Shortfin eels were caught at four of these sites, banded kokopu at two sites, longfin eels at one site, a bully and trout were present at site S1 (River Road golf course).

4.2 Habitat Quality

The substrate of the urban streams surveyed is indicative of most lowland streams. Water flow is usually quite slow which is reflected by the fine composition of the stream bottom (i.e. mud and sand sized grains). Seven sites had 100% fine material in the mud and sand grain size fraction. These sites were located in two catchments Kirikiriroa (K4, K5, K6 u/s, K7) and Te Rapa/Rotokauri (T1, T3, T6). These sites were dominated by two species; shortfin eel and mosquitofish, at K4 one smelt was present. Although larger sediment sizes do exist, those in the cobble size fraction are often artificial. Cobbles may be added to stabilise parts of the stream bed, to create riffles for natural stream habitat. Survey site T3 has a significant amount of bedrock this may be because the stream has been artificially deepened to the bedrock base. Natural gravel substrates were present at M1 and B2.

Many of the streams surveyed had an average amount of coarse detritus and wood in the surveyed stream section. These are both determinants of stream habitat complexity and indicate that there is input from the terrestrial environment which is retained in the stream. Coarse detritus also provides a food source for many invertebrates. Wood provides in-stream structure that can be utilised by many stream organisms either directly as substrate or indirectly through using the pools that are created behind such structures (providing habitat for fish, and refuge from predators, or flow in high flowing systems). Wood and fine or coarse detritus were present in abundances >50 % at sites with slow water flow and low dissolved oxygen levels. At these sites the fish diversity was low and dominated by species tolerant of degraded environments such as mosquitofish and shortfin eels.

It has been documented that lowland streams often lack significant periphyton communities because the waterways are generally choked with macrophytes (Harding *et al.*, 2004). However, in the streams sampled during this survey, macrophytes were usually absent. The presence of macrophytes might be expected if high conductivity levels resulted from nutrient input in these streams. Macrophyte growth in open urban streams is probably limited by high water turbidity and high flows from storm water runoff.

Filamentous algae were usually not present in the streams in the urban environment. While filamentous algae is usually found associated with larger sediments on the stream bottom it was also found attached to other substrates in the stream such as wood, macrophytes and foliage from riparian vegetation that has been submerged. Filamentous algae were found at eight of the survey sites were the canopy was open or partly shaded, and all sites had clear water except for site Mn2 which was highly turbid. Algae were present on stable substrate that allowed attachment, in relatively shallow water which had limited cover from riparian vegetation allowing sun light penetration.

4.3 Fishing

The distribution of fish in the Hamilton urban gully streams was found to be quite diverse. Thirteen different species of fish were present in differing abundance's in the streams. Of these only five were introduced fish, and three of those were pest fish. The introduced fish that were found included; koi carp, brown trout, rainbow trout, mosquitofish and one catfish. All introduced fish except mosquitofish were found in relatively low abundance. Of particular interest was the presence of native threatened fish species such as the giant kokopu and the longfin eel. Giant kokopu were found at five of the sites, and longfin eel at 13 of the sites. Many of the native fish caught in the survey are migratory species, which migrate upstream to small inland tributaries to spend their adult life. Eels are a migratory fish which migrate as elvers to spend adult life in freshwater streams before migration to spawning grounds off the coast of Tonga.

Inanga, banded kokopu, koaro, shortjaw kokopu, giant kokopu, and smelt, are part of the whitebait run. All of this group except smelt, belong to a group of fish called the galaxiids, and all but short jaw kokopu and koaro have been found in Hamilton streams (short jaw kokopu and koaro are upland species). Galaxiids migrate into freshwater from August to November. These fish spawn in freshwater, and the young travel downstream to the ocean. They spend some time

before migrating into freshwater as whitebait in early spring, to spend there adult life in inland streams and rivers.

Shortfin eels were found at a greater number of sites in the urban environment than any other fish species. This is probably a reflection of their ability to overcome barriers in the form of culverts, and because they inhabit lowland areas such as around Hamilton city. The shortfin eel has a more lowland in distribution than the longfin eel (McDowall, 1990). Shortfin eels are able to live in-stream sections with little cover, and high nutrient input as suggested by Hicks and McCaughan (1997) who studied the effect of land use on eel production and fish abundance. They found that there is an increase in eel biomass in pasture streams, especially shortfin eel, attributed to the increased light, inorganic nitrogen, water temperatures, and instream primary productivity associated with the removal of forest cover (Hicks and McCaughan, 1997) which are also characteristics of urban stream sections.

4.3.1 Gee Minnow Traps

Gee minnow traps were set at all of the 41 sites and yielded a total of 500 fish. Many of these fish caught were mosquitofish (78 %), which were trapped at 24% of the sites using this method (overall they were caught at 27% of the sites). Shortfin eel were caught in the next highest numbers; they accounted for 7% of the total fish catch and were trapped at 20% of the survey sites using Gee minnow traps (overall they were caught at 56% of the sites).

Where mosquitofish were caught they were either caught in low abundance along with other fish, or they were caught in very high abundances and were the only fish present. While it has been suggested that mosquitofish compete and displace native fish there is evidence that they live in degraded systems and in doing so fill an available niche (Ling, 2004). This research supports this view as mosquitofish were caught in high numbers in degraded systems. Mosquitofish are aggressive in tank studies but more research is needed to determine their effect on native fish (Ling, 2004).

All other fish caught in the Gee minnow traps were caught in low abundance except at site T8 where 24 inanga were caught. These were abundant due to the close proximity to the Waikato River, and many could be caught in the traps due to their small size. Fish caught in Gee minnow traps were usually juvenile or small adults.

4.3.2 Fyke Nets

Fish were also trapped in fyke nets that were set overnight. Fyke nets were set at 13 sites and five different species of fish were caught; longfin eels, shortfin eels, giant kokopu, brown trout, and catfish. Eels were caught at all of the sites a fyke net was set. Longfin eels represent 48% of the catch in the fyke nets; shortfin eels represent 35% of the catch, giant kokopu 13%, and trout and catfish 2% each. This suggests that eels are much more common than is shown by the Gee minnow data.

4.3.3 Spotlighting

Fifteen of the 41 survey sites were spotlighted. Spotlighting is a useful method of determining fish presence and abundance as it is less costly in terms of time and monetary costs; it is also less

stressful on fish. A study conducted by McCullough and Hicks (2002) suggested that spotlight counts for population estimates of banded kokopu were 64% of the population estimates. McCullough and Hicks (2002) also suggested that dusk to about 1000 h NZST in summer was the best time to spotlight (this coincides with the spotlighting that was undertaken as part of this survey). Spotlighting and electric fishing have the advantage over trapping that certain life stages are not eliminated. Eels appeared to be under represented by spotlighting; as they were recorded as not present at sites where they had been previously caught (i.e. at M8 one longfin eel was caught in a fyke net).

4.3.4 Electric Fishing

Ten sites were electric fished, all sites except two coinciding with sites that were evaluated by spotlighting. Electric fishing has become a common method for assessing instream fish dynamics. This method is often used by contractors (Kessels, 2004; Champion *et al*, 2001) it was also the method of fishing used by Wilding (1998) when surveying the state of the Hamilton streams. Electric fishing provides a quantitative value for fish populations unlike other methods that may be used. Eels were caught at all electric fishing sites, even where they were not observed during spotlighting. Eels were observed to flip their tail out of the water when first stunned revealing their presence to the person surveying the stream. All species observed when spotlighting were also caught at those same sites while electric fishing except the giant kokopu observed when spotlighting at site M8 (however, the water was deep in places at M8 and the bottom composed of fine sediment that caused the stream to become highly turbid when agitated and therefore parts were not fished). Fish were usually caught in lower abundances, this may be because a smaller reach is assessed when electric fishing.

It appears that all fishing methods preferentially reveal different fish species or life stages. Gee minnow traps catch small or juvenile fish, whereas fyke nets can be used to catch adult and very large fish. Spotlighting reveals nocturnal fish and often in high abundances, but eels are often missed, and electric fishing appears to reveal most fish species (except possibly giant kokopu, although they have been caught using this method (Champion *et al*, 2001)). All methods have advantages and disadvantages, while electric fishing appears to capture most fish it is a costly method which can not be used in deep waters, or where substrate is uneven, and is dangerous. Spotlighting is relatively cheap but appears to under represent some species, such as eel. Fish caught in traps and nets is restricted to the mesh and opening sizes, but traps and nets are easy to deploy in environments where the other two methods can not be used. Used together these methods yield a picture of the presence and relative abundance of fish species at a site.

Wilding (1998) found that the sites at Edgecumbe and Peacockes Roads were the only sites that supported native fish other than eels during his electric fishing survey. Banded kokopu were only recorded at one site outside Hamilton City. The findings of the present survey expand on the fisheries data found during the 1998 survey. This is probably due to the increase in sample sites, in particular small side streams, and the fact that many different fishing methods were used. This research has increased the information of the distribution of fish in Hamilton City's urban gully stream systems, and when used in conjunction with other information including that held in the NZFFD an overall picture of the state of the Hamilton gully system streams can be gained. This study provides a snap shot of the fish assemblages in the Hamilton gully system streams, it does not take into consideration seasonal or long term changes. The study also has limited

applicability between catchments as sampling effort was not applied consistently and there was no replication of sample sites.

5.0 Conclusion

In-stream assemblages in urban environments can be diverse and can provide valuable biodiversity despite the highly modified setting. This survey has found a wide range of native fish in Hamilton urban streams including galaxiids, some of which are threatened, such as the giant kokopu. Bullies and torrentfish were found to be uncommon in the small urban streams surveyed. Many of the fish recorded during this survey appear to persist in small tributary streams that are shaded by riparian vegetation. The effect of storm water input to many of these small streams needs further assessment. The Mangakotukutuku catchment had a diverse assemblage of native species including the only torrentfish, as well as species of conservation value. Within this catchment M5 and M8 had a high diversity of species. K2, located within the Kirikiriroa catchment and, P1 in Parana Park, were sites outside of the Mangakotukutuku catchment with particularly high natural fish diversity. Pest fish had low abundances in the Mangakotukutuku and Mangaonua catchments, were moderately abundant in the Kirikiriroa, Te Awa O Katapaki catchments, as well as Parana Park, and were highly abundant in the Te Rapa/Rotokauri catchment, especially site T1. Culverts may play a role in limiting pest fish spread and careful consideration needs to be given to ways of facilitating passage for native fish but not pest fish.

6.0 Acknowledgements

This study was jointly funded by the Environment Waikato (EW), and Hamilton City Council (HCC), logistical support was provided from the University of Waikato and the Department of Conservation (DoC), this report was originally submitted for BIOL-555-06Y Special Topic. We are especially grateful to, Kevin Collier, Johlene Kelly, Megan Wood, Michael Lake, Bruno David, and Alex Ring. Additional support, study site selection, and literature was provided by EW, HCC and DOC. We also thank Jody Richardson and NIWA for the NZFFD cards for the Bankwood stream.

7.0 References

Champion, P., S. Parkyn, B. Chisnall. 2001. *Rotokauri structure plan - ecological assessment. NIWA Client Report BCH01201*. Unpublished report prepared for Beca Carter Hollings and Ferner Ltd. National Institute of Water and Atmosphere Ltd, Hamilton.

Clarkson, B.D., McQueen, J.J. 2004. *Ecological Restoration in Hamilton City, North Island, New Zealand.* 16th International Conference, Society for ecological Restoration, Victoria, Canada.

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

Harding, J., Mosley, P., Pearson, C., Sorrell. B. 2004. *Freshwaters of New Zealand*. New Zealand Hydrological Society Inc. Christchurch, New Zealand.

Hicks, B.J. 1997. *Food webs in forest and pasture streams in the Waikato region, New Zealand: a study based on analyses of stable isotopes of carbon and nitrogen, and fish gut contents*. New Zealand Journal of Marine and Freshwater Research 31: 651-664

Hicks, B.J., Barrier, R.F.G. 1996. *Habitat requirements of black mudfish (Neochanna diversus) in the Waikato region, North Island, New Zealand*. New Zealand Journal of Marine and Freshwater Research 30: 135-151

Hicks, B.J., McCaughan, H.M.C. 1997. *Land use, associated eel production, and abundance of fish and crayfish in streams in Waikato, New Zealand*. New Zealand Journal of Marine and Freshwater Research 31: 635-650

Hicks, B.J., Reynolds, G.B., Laboyrie, J.L., Hill, C.D.H. 2001. *Ecological and physical characteristics of the Te Awa O Katapaki Stream, Flagstaff, Waikato.* CBER Contract Report Number 13, Hamilton, New Zealand.

Ling, N. 2004. *Gambusia in New Zealand: really bad or just misunderstood?* New Zealand Journal of Marine and Freshwater Research 38: 473-480

Kessels, G. 2004. *Hamilton City Council; Ecological investigations of the Te Awa O Katapaki Stream and Catchment*. New Zealand. Kessels and associates Limited

McDowall, 1978. New Zealand Freshwater Fishes; a guide and natural history. Auckland, New Zealand. Heinemann Educational Books (NZ) Ltd.

McCullough, C.D., Hicks, B.J. 2002. *Estimating the abundance of banded kokopu (Galaxias fasciatus Gray) in small streams by nocturnal counts under spotlight illumination*. New Zealand Natural Sciences 27:1-14

Morgan, R.P., Cushman, S.F. 2005. *Urbanization effects on stream fish assemblages in Maryland, USA.* The North American Benthological Society 24(3): 643-655.

Roy, A.H., Freeman, M.C., Wenger, S.J., Ensign, W.E., Meyer, J.L. 2005. *Investigating hydrologic alteration of fish assemblages shifts in urbanizing streams*. The North American Benthological Society 24(3): 656-678

Wilding, T.K. 1998. *The state of Hamilton streams*. Environment Waikato, Hamilton.

Appendix 1. Field Assessment Form as detailed in the Environment Waikato 'REMS' monitoring guidelines (Collier & Kelly, 2005) that was used in this survey.

FIELD ASSESSMENT COVER FORM: (100m reach)
WADEABLE HARD-BOTTOMED AND SOFT-BOTTOMED STREAMS

STREAM NAME:		**ASSESSOR:**	
SITE NUMBER:	**SAMPLE NUMBER:**	**DATE:**	**TIME (NZST):**

GPS COORDINATES: **Downstream end of reach - Easting –** **Northing –**
Upstream end of reach - Easting – **Northing –**

CHANNEL FEATURES

Canopy Cover:

Open Partly shaded Significantly shaded

Fencing:

None or ineffective
One side or partial on both sides
Complete on both sides

INSTREAM HYDRAULIC CONDITIONS

Estimated or measured reach average conditions:

Stream width _____ m
Stream depth _____ m
Surface velocity _____ m/sec

WATER QUALITY

Temperature: _____ ºC Conductivity: _____ mS/m
Dissolved Oxygen: _____ % _____ mg/L
Turbidity: Clear Slightly turbid Highly turbid Stained Other_____

ALGAE

Cover on stones or other stable substrates
absent
slippery (to touch)
obvious (clearly visible by eye)
abundant (filamentous algae present)
very abundant (filamentous algae common)
Estimated %age of reach area covered by filamentous algae (exclude algae on macrophytes):
_____%

MACROPHYTES

Indicate the DOMINANT type:

rooted emergent rooted submerged
rooted floating free floating
floating algae

Estimated %age of reach volume (area x depth) occupied by macrophytes:
_____%

INORGANIC SUBSTRATE

Compaction
assorted sizes tightly packed &/or overlapping
moderately packed with some overlap
mostly a loose assortment with little overlap
no packing / loose assortment easily moved.

Embeddedness
<5% gravel-boulder particles covered by fine sediment
5-24% covered by fine sediment
25-49% covered by fine sediment
50-75% covered by fine sediment
>75% covered by fine sediment

% Surficial size composition

Substrate type	Diameter	Percentage
Bedrock	-	
Boulder	> 256mm	
Cobble	>64-256mm	
Gravel	>2-64mm	
Sand	>0.06-2mm	
Silt	0.004-0.06mm	
Clay	<0.004mm	

NB: sand/silt/clay categories can be combined

ORGANIC SUBSTRATE (% cover - need not sum to 100)

Large wood (>10 cm diameter): _____%
Detritus (small wood, sticks, leaves etc > 1 mm): _____%
Muck/mud (fine organic matter < 1 mm): _____%

HABITAT TYPES SAMPLED (% of effort)

Stones: _____% Riffles: _____%
Wood: _____%
Macrophytes: _____%
Edges: _____% Runs: _____%

COMMENTS

NO. INVERTEBRATES RETURNED TO STREAM

Koura: _____ Shrimps: _____
Crabs: _____ Mussels: _____
Others (specify) _____

Species of mussel (tick)

Hyridella	*Cucumerunio*
PICTURE	*PICTURE*

Appendix 2. Fish counted by spotlighting at night using a red filter in Hamilton City streams in 2006. v.a= very abundant (>20) a=abundant (10-20), c=common (6-10), o=occasional (2-5), r=rare (1).

			GPS start		GPS finish		Fished length		Number or	Length
Site	Location	Date	E	N	E	N	(m)	Species	occurence	(mm)
B2	Reece's gully	16-Jan	2710416	6379579	2710508	6379565	93	longfin eel	3	320-350
								shortfin eel	1	400
K2	Glen Lynn Ave	16-Jan	2710225	6381765	2710250	6381720	51	shortfin eel	c	
								smelt	a	
								inanga	c	
K2	Glen Lynn Ave	16-Jan	2710404	6381584	2710250	6381720	205	inanga	c	
u/s								smelt	c	
								shortfin eel	a	
								giant kokopu	3	100-180
K10	Mangati Park	16-Jan	2710736	6382089	2710816	6382107	82	smelt	v.a	
								inanga	a	
								shortfin eel	c	
M8	Dixon Rd	17-Jan	2713288	6373466	2713232	6373529	84	banded kokopu	a	
								koura	a	
								giant kokopu	1	300
M6	Malabar Rd	17-Jan	2712569	6373657	2712640	6373733	104	banded kokopu	1	
								shortfin eel	4	350
M1	Waterford Rd	17-Jan	2712719	6374136	2712739	6374066	73	shortfin eel	2	
								smelt	v.a	
M7	Pelorus St	17-Jan	2712245	6372976	2712174	6372900	104	smelt	a	
								shortfin eel	4	
M4	Small trib at Bader St	14-Feb					~50	banded kokopu	3	150
								shortfin eel	1	550
Mn3	Matangi Rd	14-Feb					30	smelt	v.a	
P2	Selly's gully	14-Feb					40	shortfin eel	1	450
K5	Tramway Rd	14-Feb					48	shortfin eel	1	650
S3	River Rd Golf course	15-Feb					55	trout	2	400
								smelt	a	
F1	Airedale Rd	15-Feb					40	shortfin eel	3	300-600

Appendix 3. Lengths of fish caught by Gee minnow trapping (gmn), electrofishing (efm), and fyke netting (fyke) in Hamilton City streams from December 2005 to March 2006.

Site	Catchment	Location description	Habitat	Method	Species	Length (mm)
M1	Mangakotukutuku	Sandford TR tributary	pool	gmn	*Galaxias* spp.	75
M1	Mangakotukutuku	Sandford TR tributary	pool	gmn	*Galaxias* spp.	83
M1	Mangakotukutuku	Sandford TR tributary	pool	gmn	*Galaxias* spp.	65
M1	Mangakotukutuku	Sandford TR tributary	pool	gmn	mosquitofish	23
M1	Mangakotukutuku	Sandford TR tributary	run	gmn	*Galaxias* spp.	60
M1	Mangakotukutuku	Sandford TR tributary		efm	mosquitofish	26
M1	Mangakotukutuku	Sandford TR tributary		efm	koura	
M1	Mangakotukutuku	Sandford TR tributary		efm	koura	
M1	Mangakotukutuku	Sandford TR tributary		efm	inanga	75
M1	Mangakotukutuku	Sandford TR tributary		efm	common smelt	109
M1	Mangakotukutuku	Sandford TR tributary		efm	common smelt	111
M1	Mangakotukutuku	Sandford TR tributary		efm	common smelt	105
M1	Mangakotukutuku	Sandford TR tributary		efm	common smelt	114
M1	Mangakotukutuku	Sandford TR tributary		efm	common smelt	109
M1	Mangakotukutuku	Sandford TR tributary		efm	common smelt	105
M1	Mangakotukutuku	Sandford TR tributary		efm	common smelt	104
M1	Mangakotukutuku	Sandford TR tributary		efm	common smelt	66
M1	Mangakotukutuku	Sandford TR tributary		efm	shortfin eel	360
M1	Mangakotukutuku	Sandford TR tributary		efm	shortfin eel	230
M1	Mangakotukutuku	Sandford TR tributary		efm	shortfin eel	115
M1	Mangakotukutuku	Sandford TR tributary		efm	shortfin eel	114
M1	Mangakotukutuku	Sandford TR tributary		efm	shortfin eel	97
M1	Mangakotukutuku	Sandford TR tributary		efm	longfin eel	440
M1	Mangakotukutuku	Sandford TR tributary		efm	longfin eel	635
M1	Mangakotukutuku	Sandford TR tributary		efm	longfin eel	350
M1	Mangakotukutuku	Sandford TR tributary		efm	longfin eel	315
M1	Mangakotukutuku	Sandford TR tributary		efm	longfin eel	370
M1	Mangakotukutuku	Sandford TR tributary		efm	longfin eel	1020
M1	Mangakotukutuku	Sandford TR tributary		efm	longfin eel	510
M1	Mangakotukutuku	Sandford TR tributary		efm	longfin eel	355
M1	Mangakotukutuku	Sandford TR tributary		efm	longfin eel	240
M2	Mangakotukutuku	Sandford mid tributary	pool	gmn	inanga	76
M2	Mangakotukutuku	Sandford mid tributary	pool	fyke	longfin eel	1010
M2	Mangakotukutuku	Sandford mid tributary	pool	fyke	longfin eel	810
M3	Mangakotukutuku	Sandford TL tributary		gmn	no catch	
M3	Mangakotukutuku	Sandford TL tributary	pool	fyke	longfin eel	540
M4	Mangakotukutuku	Sandford kokopu tributary	pool	gmn	banded kokopu	150
M4	Mangakotukutuku	Sandford kokopu tributary		efm	banded kokopu	120
M4	Mangakotukutuku	Sandford kokopu tributary		efm	shortfin eel	478
M4	Mangakotukutuku	Sandford kokopu tributary		efm	shortfin eel	515
M4	Mangakotukutuku	Sandford kokopu tributary		efm	shortfin eel	297
M5	Mangakotukutuku	Below Peacockes Rd	run	gmn	longfin eel	340
M5	Mangakotukutuku	Below Peacockes Rd	pool	gmn	longfin eel	340
M5	Mangakotukutuku	Below Peacockes Rd	pool	gmn	torrentfish	112
M5	Mangakotukutuku	Below Peacockes Rd	fast run	gmn	torrentfish	103
M5	Mangakotukutuku	Below Peacockes Rd	pool	gmn	torrentfish	88
M5	Mangakotukutuku	Below Peacockes Rd	pool	gmn	common smelt	76
M5	Mangakotukutuku	Below Peacockes Rd	pool	gmn	*Galaxias* spp.	60
M5	Mangakotukutuku	Below Peacockes Rd	pool	gmn	longfin eel	380
M5	Mangakotukutuku	Below Peacockes Rd		efm	shortfin eel	470
M5	Mangakotukutuku	Below Peacockes Rd		efm	shortfin eel	500
M5	Mangakotukutuku	Below Peacockes Rd		efm	shortfin eel	271
M5	Mangakotukutuku	Below Peacockes Rd		efm	shortfin eel	340
M5	Mangakotukutuku	Below Peacockes Rd		efm	shortfin eel	310
M5	Mangakotukutuku	Below Peacockes Rd		efm	koi carp	329
M5	Mangakotukutuku	Below Peacockes Rd		efm	koi carp	311
M6	Mangakotukutuku	Malabar St tributary		gmn	no catch	
M6	Mangakotukutuku	Malabar St tributary		efm	banded kokopu	188
M6	Mangakotukutuku	Malabar St tributary		efm	shortfin eel	816
M6	Mangakotukutuku	Malabar St tributary		efm	shortfin eel	813
M6	Mangakotukutuku	Malabar St tributary		efm	shortfin eel	432
M6	Mangakotukutuku	Malabar St tributary		efm	shortfin eel	342

Site	Catchment	Location description	Habitat	Method	Species	Length (mm)
M6	Mangakotukutuku	Malabar St tributary		efm	shortfin eel	242
M6	Mangakotukutuku	Malabar St tributary		efm	koura	30
M7	Mangakotukutuku	Pelorous St		gmn	no catch	
M8	Mangakotukutuku	TR tributary pasture		gmn	no catch	
M8	Mangakotukutuku	TR tributary pasture	run	fyke	longfin eel	470
M8	Mangakotukutuku	TR tributary pasture		efm	koura	33
M8	Mangakotukutuku	TR tributary pasture		efm	koura	25
M8	Mangakotukutuku	TR tributary pasture		efm	longfin eel	507
M8	Mangakotukutuku	TR tributary pasture		efm	shortfin eel	347
M8	Mangakotukutuku	TR tributary pasture		efm	shortfin eel	85
M8	Mangakotukutuku	TR tributary pasture		efm	shortfin eel	255
M8	Mangakotukutuku	TR tributary pasture		efm	shortfin eel	216
M9	Mangakotukutuku	Acacia	pool	gmn	longfin eel	290
M9	Mangakotukutuku	Acacia	pool	gmn	longfin eel	230
M10	Mangakotukutuku	Saxbys Rd		gmn	no catch	
M10	Mangakotukutuku	Saxbys Rd	pool under shade	fyke	longfin eel	680
M10	Mangakotukutuku	Saxbys Rd	pool under shade	fyke	longfin eel	520
M10	Mangakotukutuku	Saxbys Rd	pool under shade	fyke	longfin eel	430
M10	Mangakotukutuku	Saxbys Rd	pool under shade	fyke	giant kokopu	220
M10	Mangakotukutuku	Saxbys Rd	pool under shade	fyke	giant kokopu	260
K1	Kirikiriroa	Tauhara St	deep run	gmn	*Galaxias* spp.	71
K1	Kirikiriroa	Tauhara St	run under shade	fyke	longfin eel	590
K1	Kirikiriroa	Tauhara St	run under shade	fyke	longfin eel	890
K1	Kirikiriroa	Tauhara St	run under shade	fyke	brown trout	310
K2	Kirikiriroa	Glen Lynn Rd	pool	gmn	shortfin eel	350
K2	Kirikiriroa	Glen Lynn Rd	pool	gmn	shortfin eel	310
K3	Kirikiriroa	Chedworth TL branch	pool	gmn	shortfin eel	310
K3	Kirikiriroa	Chedworth TL branch	run	gmn	common smelt	82
K3	Kirikiriroa	Chedworth TL branch	run	gmn	common smelt	85
K3	Kirikiriroa	Chedworth TL branch	pool	gmn	common smelt	70
K3	Kirikiriroa	Chedworth TL branch	run	fyke	shortfin eel	570
K4	Kirikiriroa	Chedworth TR branch	run	gmn	shortfin eel	80
K4	Kirikiriroa	Chedworth TR branch	pool	gmn	common smelt	130
K4	Kirikiriroa	Chedworth TR branch	pool	gmn	shortfin eel	160
K4	Kirikiriroa	Chedworth TR branch	pool	gmn	shortfin eel	430
K4	Kirikiriroa	Chedworth TR branch	pool	gmn	shortfin eel	310
K4	Kirikiriroa	Chedworth TR branch	pool	fyke	shortfin eel	590
K5	Kirikiriroa	Tramway Rd		gmn	no catch	
K5	Kirikiriroa	Tramway Rd		efm	shortfin eel	690
K5	Kirikiriroa	Tramway Rd		efm	shortfin eel	560
K5	Kirikiriroa	Tramway Rd		efm	shortfin eel	420
K5	Kirikiriroa	Tramway Rd		efm	shortfin eel	340
K5	Kirikiriroa	Tramway Rd		efm	shortfin eel	1010
K5	Kirikiriroa	Tramway Rd		efm	shortfin eel	560
K5	Kirikiriroa	Tramway Rd		efm	shortfin eel	760
K5	Kirikiriroa	Tramway Rd		efm	shortfin eel	420
K5	Kirikiriroa	Tramway Rd		efm	shortfin eel	320
K5	Kirikiriroa	Tramway Rd		efm	shortfin eel	567
K6 u/s	Kirikiriroa	Thomas Rd	pool	gmn	mosquitofish	24
K6 u/s	Kirikiriroa	Thomas Rd	pool	gmn	mosquitofish	24
K6 u/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	50
K6 u/s	Kirikiriroa	Thomas Rd	stagnant pool	gmn	mosquitofish	27.4
K6 u/s	Kirikiriroa	Thomas Rd	stagnant pool	gmn	mosquitofish	27.4
K6 u/s	Kirikiriroa	Thomas Rd	stagnant pool	gmn	mosquitofish	27.4
K6 u/s	Kirikiriroa	Thomas Rd	stagnant pool	gmn	mosquitofish	27.4
K6 u/s	Kirikiriroa	Thomas Rd	stagnant pool	gmn	mosquitofish	27.4
K6 u/s	Kirikiriroa	Thomas Rd	stagnant pool	gmn	mosquitofish	27.4
K6 u/s	Kirikiriroa	Thomas Rd	stagnant pool	gmn	mosquitofish	27.4
K6 u/s	Kirikiriroa	Thomas Rd	stagnant pool	gmn	mosquitofish	27.4
K6 u/s	Kirikiriroa	Thomas Rd	stagnant pool	gmn	mosquitofish	27.4
K6 u/s	Kirikiriroa	Thomas Rd	pool	gmn	mosquitofish	81
K6 u/s	Kirikiriroa	Thomas Rd	pool	gmn	mosquitofish	29

Site	Catchment	Location description	Habitat	Method	Species	Length (mm)
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	33
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	39
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	42
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	19
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	21
K6 d/s	Kirikiriroa	Thomas Rd	run	gmn	mosquitofish	39
K6 d/s	Kirikiriroa	Thomas Rd	pool	gmn	mosquitofish	41
K7	Kirikiriroa	Coltswald Rd		gmn	no catch	
k8	Kirikiriroa	Tauhara park main branch		gmn	no catch	
k8	Kirikiriroa	Tauhara park main branch	run	fyke	shortfin eel	650
k8	Kirikiriroa	Tauhara park main branch	run	fyke	longfin eel	550

Site	Catchment	Location description	Habitat	Method	Species	Length (mm)
K9	Kirikiriroa	Tauhara park high EC		gmn	no catch	
K9	Kirikiriroa	Tauhara park high EC		efm	shortfin eel	595
K9	Kirikiriroa	Tauhara park high EC		efm	shortfin eel	463
K9	Kirikiriroa	Tauhara park high EC		efm	shortfin eel	136
K9	Kirikiriroa	Tauhara Park high EC			shortfin eel	600
K10	Kirikiriroa	Mangati park	pool	gmn	common smelt	62
K10	Kirikiriroa	Mangati park	pool	gmn	common smelt	61
K10	Kirikiriroa	Mangati park		efm	common smelt	72
K10	Kirikiriroa	Mangati park		efm	common smelt	52
K10	Kirikiriroa	Mangati park		efm	common smelt	53
K10	Kirikiriroa	Mangati park		efm	common smelt	56
K10	Kirikiriroa	Mangati park		efm	common smelt	55
K10	Kirikiriroa	Mangati park		efm	mosquitofish	45
K10	Kirikiriroa	Mangati park		efm	mosquitofish	42
K10	Kirikiriroa	Mangati park		efm	shortfin eel	618
K10	Kirikiriroa	Mangati park		efm	shortfin eel	460
K10	Kirikiriroa	Mangati park		efm	shortfin eel	660
K10	Kirikiriroa	Mangati park		efm	shortfin eel	310
K10	Kirikiriroa	Mangati park		efm	shortfin eel	360
K10	Kirikiriroa	Mangati park		efm	shortfin eel	590
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35

Site	Catchment	Location description	Habitat	Method	Species	Length (mm)
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	pool	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	run	gmn	mosquitofish	20
T1	Rotokauri	Rotokauri Rd	run	gmn	mosquitofish	20
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35

Site	Catchment	Location description	Habitat	Method	Species	Length (mm)
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35

Site	Catchment	Location description	Habitat	Method	Species	Length (mm)
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35

Site	Catchment	Location description	Habitat	Method	Species	Length (mm)
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T1	Rotokauri	Rotokauri Rd	narrow run	gmn	mosquitofish	35
T3	Rotokauri	Duck Rd	run/pool	gmn	shortfin eel	340
T3	Rotokauri	Duck Rd	run/pool	gmn	mosquitofish	32
T3	Rotokauri	Duck Rd	run/pool	gmn	mosquitofish	32
T3	Rotokauri	Duck Rd	run	fyke	catfish	235
T3	Rotokauri	Duck Rd	run	fyke	shortfin eel	460
T3	Rotokauri	Duck Rd	run	fyke	shortfin eel	740
T3	Rotokauri	Duck Rd	run	fyke	shortfin eel	550
T3	Rotokauri	Duck Rd	run	fyke	shortfin eel	560
T3	Rotokauri	Duck Rd	run	fyke	shortfin eel	430
T3	Rotokauri	Duck Rd	run	fyke	shortfin eel	330
T3	Rotokauri	Duck Rd	run	fyke	shortfin eel	470
T3	Rotokauri	Duck Rd	run	fyke	shortfin eel	420
T4	Rotokauri	Te Kowhai Rd	run	gmn	mosquitofish	20
T4	Rotokauri	Te Kowhai Rd	run	gmn	mosquitofish	20
T4	Rotokauri	Te Kowhai Rd	run	gmn	mosquitofish	20
T4	Rotokauri	Te Kowhai Rd	run	gmn	mosquitofish	20
T4	Rotokauri	Te Kowhai Rd	run	gmn	mosquitofish	20
T4	Rotokauri	Te Kowhai Rd	run	gmn	mosquitofish	38

Site	Catchment	Location description	Habitat	Method	Species	Length (mm)
T4	Rotokauri	Te Kowhai Rd	pool	gmn	mosquitofish	25
T4	Rotokauri	Te Kowhai Rd	pool	gmn	mosquitofish	25
T4	Rotokauri	Te Kowhai Rd	pool	gmn	mosquitofish	25
T4	Rotokauri	Te Kowhai Rd	pool	gmn	mosquitofish	25
T4	Rotokauri	Te Kowhai Rd	pool	gmn	mosquitofish	25
T4	Rotokauri	Te Kowhai Rd	pool	gmn	mosquitofish	25
T4	Rotokauri	Te Kowhai Rd	pool	gmn	mosquitofish	25
T5	Rotokauri	Exelby Rd	pool	gmn	banded kokopu	50
T5	Rotokauri	Exelby Rd	pool	gmn	banded kokopu	55
T5	Rotokauri	Exelby Rd	pool	gmn	banded kokopu	68
T5	Rotokauri	Exelby Rd	pool	gmn	banded kokopu	56
T5	Rotokauri	Exelby Rd	pool	gmn	banded kokopu	62
T5	Rotokauri	Exelby Rd	pool	gmn	inanga	45
T5	Rotokauri	Exelby Rd	pool	fyke	longfin eel	700
T6	Rotokauri	Te Kowhai Rd	run	gmn	shortfin eel	290
T6	Rotokauri	Te Kowhai Rd	run	gmn	shortfin eel	315
T6	Rotokauri	Te Kowhai Rd	run	gmn	shortfin eel	390
T6	Rotokauri	Te Kowhai Rd	run	gmn	shortfin eel	120
T6	Rotokauri	Te Kowhai Rd	run	gmn	mosquitofish	24
T6	Rotokauri	Te Kowhai Rd	run	gmn	shortfin eel	250
T6	Rotokauri	Te Kowhai Rd	run	gmn	shortfin eel	250
T6	Rotokauri	Te Kowhai Rd	run	gmn	shortfin eel	250
T6	Rotokauri	Te Kowhai Rd	run	gmn	shortfin eel	250
T6	Rotokauri	Te Kowhai Rd	run	gmn	shortfin eel	250
T6	Rotokauri	Te Kowhai Rd	run	gmn	shortfin eel	250
T6	Rotokauri	Te Kowhai Rd	pool with macrophytes	gmn	shortfin eel	264.5
T6	Rotokauri	Te Kowhai Rd	pool with macrophytes	gmn	shortfin eel	264.5
T6	Rotokauri	Te Kowhai Rd	pool with macrophytes	gmn	shortfin eel	264.5
T6	Rotokauri	Te Kowhai Rd	pool with macrophytes	gmn	shortfin eel	264.5
T6	Rotokauri	Te Kowhai Rd	pool with macrophytes	gmn	shortfin eel	264.5
T6	Rotokauri	Te Kowhai Rd	pool with macrophytes	gmn	shortfin eel	264.5
T6	Rotokauri	Te Kowhai Rd	pool with macrophytes	gmn	shortfin eel	264.5
T6	Rotokauri	Te Kowhai Rd	pool with macrophytes	gmn	shortfin eel	264.5
T6	Rotokauri	Te Kowhai Rd	pool with macrophytes	gmn	shortfin eel	264.5
T6	Rotokauri	Te Kowhai Rd	pool with macrophytes	gmn	shortfin eel	264.5
T7	Rotokauri	Ruffell Rd		gmn	no catch	
T8	Rotokauri	Horitu Rd	pool	gmn	mosquitofish	35
T8	Rotokauri	Horitiu Rd	pool	gmn	inanga	60.4
T8	Rotokauri	Horitiu Rd	pool	gmn	inanga	60.4
T8	Rotokauri	Horitiu Rd	pool	gmn	inanga	60.4
T8	Rotokauri	Horitiu Rd	pool	gmn	inanga	60.4
T8	Rotokauri	Horitiu Rd	pool	gmn	inanga	60.4
T8	Rotokauri	Horitiu Rd	pool	gmn	inanga	60.4
T8	Rotokauri	Horitiu Rd	pool	gmn	inanga	60.4
T8	Rotokauri	Horitiu Rd	pool	gmn	inanga	60.4
T8	Rotokauri	Horitiu Rd	pool	gmn	inanga	60.4
T8	Rotokauri	Horitiu Rd	pool	gmn	inanga	60.4
T8	Rotokauri	Horitiu Rd	pool	gmn	inanga	60.4
T8	Rotokauri	Horitiu Rd	pool	gmn	inanga	60.4
T8	Rotokauri	Horitiu Rd	pool	gmn	inanga	60.4
T8	Rotokauri	Horitiu Rd	pool	gmn	inanga	60.4
T8	Rotokauri	Horitiu Rd	pool	gmn	inanga	60.4
T8	Rotokauri	Horitiu Rd	pool	gmn	inanga	60.4
T8	Rotokauri	Horitiu Rd	fast run	gmn	inanga	54.6
T8	Rotokauri	Horitiu Rd	fast run	gmn	inanga	54.6
T8	Rotokauri	Horitiu Rd	fast run	gmn	inanga	54.6
T8	Rotokauri	Horitiu Rd	fast run	gmn	inanga	54.6
T8	Rotokauri	Horitiu Rd	fast run	gmn	inanga	54.6
T8	Rotokauri	Horitiu Rd	pool	gmn	inanga	58
T8	Rotokauri	Horitiu Rd	pool	gmn	inanga	58
T8	Rotokauri	Horitiu Rd	pool	gmn	inanga	58
T8	Rotokauri	Horitiu Rd	pool	gmn	inanga	58

Site	Catchment	Location description	Habitat	Method	Species	Length (mm)
T8	Rotokauri	Horitiu Rd	pool	gmn	inanga	58
T8	Rotokauri	Horitiu Rd	pool	gmn	inanga	58
T8	Rotokauri	Horitiu Rd	pool	gmn	inanga	58
T8	Rotokauri	Horitiu Rd	pool	gmn	inanga	58
Mn1	Mangaonua	Above culvert	pool	gmn	common bully	46
Mn1	Mangaonua	Above culvert	pool	gmn	common bully	41
Mn1	Mangaonua	Above culvert	run	gmn	common bully	68
Mn1	Mangaonua	Above culvert	run	fyke	longfin eel	550
Mn1	Mangaonua	Above culvert	run	fyke	longfin eel	470
Mn1	Mangaonua	Above culvert	run	fyke	longfin eel	530
Mn2	Mangaonua	TL tributary		gmn	no catch	
Mn2	Mangaonua	TL tributary	deep pool	fyke	longfin eel	480
Mn2	Mangaonua	TL tributary	deep pool	fyke	longfin eel	470
Mn2	Mangaonua	TL tributary	deep pool	fyke	longfin eel	440
Mn2	Mangaonua	TL tributary	deep pool	fyke	longfin eel	520
Mn2	Mangaonua	TL tributary	deep pool	fyke	longfin eel	540
Mn2	Mangaonua	TL tributary	deep pool	fyke	longfin eel	430
Mn3	Mangaonua	TR tributary	run	gmn	common bully	45
Mn3	Mangaonua	TR tributary	run	gmn	common bully	46
Mn3	Mangaonua	TR tributary		efm	common smelt	86
Mn3	Mangaonua	TR tributary		efm	common smelt	54
Mn3	Mangaonua	TR tributary		efm	common smelt	73
Mn3	Mangaonua	TR tributary		efm	common smelt	80
Mn3	Mangaonua	TR tributary		efm	common smelt	79
Mn3	Mangaonua	TR tributary		efm	common smelt	68
Mn3	Mangaonua	TR tributary		efm	common smelt	75
Mn3	Mangaonua	TR tributary		efm	koura	40
Mn3	Mangaonua	TR tributary		efm	koura	25
Mn3	Mangaonua	TR tributary		efm	koura	26
Mn3	Mangaonua	TR tributary		efm	shortfin eel	690
Mn3	Mangaonua	TR tributary		efm	shortfin eel	394
Mn3	Mangaonua	TR tributary		efm	shortfin eel	390
Mn3	Mangaonua	TR tributary		efm	shortfin eel	531
Mn3	Mangaonua	TR tributary		efm	shortfin eel	110
S1	Te Awa O Katipaki	River Rd golf course	pool	gmn	common bully	74
S2	Te Awa O Katipaki	Sylvester Rd		gmn	no catch	
S2	Te Awa O Katipaki	Sylvester Rd	run	fyke	shortfin eel	630
S2	Te Awa O Katipaki	Sylvester Rd	run	fyke	shortfin eel	710
S2	Te Awa O Katipaki	Sylvester Rd	run	fyke	shortfin eel	650
S2	Te Awa O Katipaki	Sylvester Rd	run	fyke	giant kokopu	155
S2	Te Awa O Katipaki	Sylvester Rd	run	fyke	giant kokopu	213
S2	Te Awa O Katipaki	Sylvester Rd	run	fyke	giant kokopu	208
S3	Te Awa O Katipaki	Tuirangi St	run	gmn	mosquitofish	25
S3	Te Awa O Katipaki	Tuirangi St	run	gmn	mosquitofish	25
S3	Te Awa O Katipaki	Tuirangi St	run	gmn	mosquitofish	25
S3	Te Awa O Katipaki	Tuirangi St	pool	gmn	mosquitofish	46
S3	Te Awa O Katipaki	Tuirangi St	pool	gmn	mosquitofish	46
S3	Te Awa O Katipaki	Tuirangi St	pool	gmn	mosquitofish	46
S3	Te Awa O Katipaki	Tuirangi St	pool	gmn	mosquitofish	46
S3	Te Awa O Katipaki	Tuirangi St	pool	gmn	mosquitofish	46
S3	Te Awa O Katipaki	Tuirangi St	pool	gmn	mosquitofish	26
S3	Te Awa O Katipaki	Tuirangi St	pool	gmn	mosquitofish	26
S3	Te Awa O Katipaki	Tuirangi St	pool	gmn	mosquitofish	26
S3	Te Awa O Katipaki	Tuirangi St	pool	gmn	mosquitofish	26
S3	Te Awa O Katipaki	Tuirangi St	pool	gmn	mosquitofish	26
S3	Te Awa O Katipaki	Tuirangi St	pool	gmn	mosquitofish	26
S3	Te Awa O Katipaki	Tuirangi St	pool	gmn	mosquitofish	26
S3	Te Awa O Katipaki	Tuirangi St	pool	gmn	mosquitofish	26
S3	Te Awa O Katipaki	Tuirangi St	pool	gmn	mosquitofish	26
S3	Te Awa O Katipaki	Tuirangi St	pool	gmn	mosquitofish	26
S3	Te Awa O Katipaki	Tuirangi St	pool	gmn	mosquitofish	26
S3	Te Awa O Katipaki	Tuirangi St	pool	gmn	mosquitofish	26

Site	Catchment	Location description	Habitat	Method	Species	Length (mm)
S3	Te Awa O Katipaki	Tuirangi St	pool	gmn	mosquitofish	46
S3	Te Awa O Katipaki	Tuirangi St	pool	gmn	mosquitofish	20
S3	Te Awa O Katipaki	Tuirangi St	pool	gmn	mosquitofish	20
S3	Te Awa O Katipaki	Tuirangi St	pool	gmn	mosquitofish	20
S3	Te Awa O Katipaki	Tuirangi St	pool	gmn	mosquitofish	20
S3	Te Awa O Katipaki	Tuirangi St	pool	gmn	mosquitofish	20
S3	Te Awa O Katipaki	Tuirangi St	pool	gmn	mosquitofish	20
S3	Te Awa O Katipaki	Tuirangi St	pool	gmn	tadpole	36
W1	Waitawhiriwhiri	Edgecumbe St	run	gmn	shortfin eel	300
W2	Waitawhiriwhiri	Upstream	pool	gmn	shortfin eel	370
W2	Waitawhiriwhiri	Upstream	pool	gmn	shortfin eel	350
P1	Hamilton East	Gibbons Creek	run	gmn	common bully	
P1	Hamilton East	Gibbons Creek	run	gmn	common bully	
P1	Hamilton East	Gibbons Creek	run	gmn	common bully	
P1	Hamilton East	Gibbons Creek	run	gmn	mosquitofish	34
P1	Hamilton East	Gibbons Creek	run	gmn	mosquitofish	34
P1	Hamilton East	Gibbons Creek	run	gmn	mosquitofish	34
P1	Hamilton East	Gibbons Creek	run	gmn	mosquitofish	34
P1	Hamilton East	Gibbons Creek	run	gmn	*Galaxias* spp.	54.3
P1	Hamilton East	Gibbons Creek	run	gmn	*Galaxias* spp.	54.3
P1	Hamilton East	Gibbons Creek	run	gmn	*Galaxias* spp.	54.3
P1	Hamilton East	Gibbons Creek	run	gmn	*Galaxias* spp.	54.3
P1	Hamilton East	Gibbons Creek	run	gmn	banded kokopu	63
P1	Hamilton East	Gibbons Creek	run	gmn	banded kokopu	65
P1	Hamilton East	Gibbons Creek	run	gmn	mosquitofish	24
P1	Hamilton East	Gibbons Creek	run	gmn	mosquitofish	24
P1	Hamilton East	Gibbons Creek	run	gmn	*Galaxias* spp.	55
P1	Hamilton East	Gibbons Creek	run	gmn	*Galaxias* spp.	45
P1	Hamilton East	Gibbons Creek	run	gmn	*Galaxias* spp.	35
P1	Hamilton East	Gibbons Creek	run	gmn	*Galaxias* spp.	32
P2	Hamilton East	Gibbons Creek		gmn	no catch	
P2	Hamilton East	Gibbons Creek		efm	shortfin eel	510
P2	Hamilton East	Gibbons Creek		efm	shortfin eel	823
P2	Hamilton East	Gibbons Creek		efm	shortfin eel	320
P2	Hamilton East	Gibbons Creek		efm	shortfin eel	255
P2	Hamilton East	Gibbons Creek		efm	shortfin eel	423
F1	Fairfield	Airedale Rd		gmn	no catch	
H1	Hospital	Hospital stream		gmn	no catch	
B2	Bankwood	McNicol Rd		gmn	no catch	