report

April 2014

Mangere River Fish Study

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1.0 Introduction

1.1 Background

The Mangere River catchment covers an area of 82 km^2 and is located approximately 12 km west of Whangarei (Figure 1).

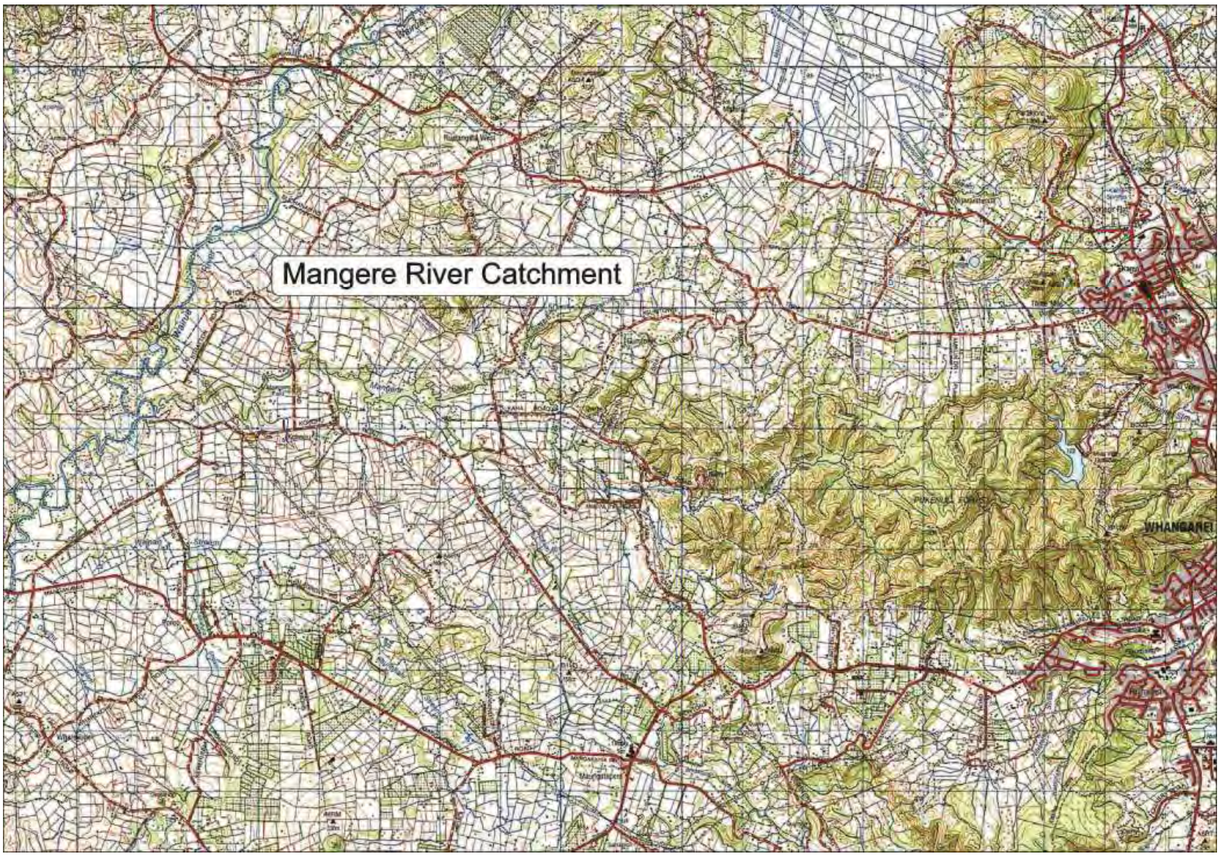


Figure 1: Mangere River catchment location.

DairyNZ and Northland Regional Council (NRC) are currently working together to improve the water quality of the Mangere River. NRC prepared a report on the Mangere Catchment water quality in 2011 including describing the river's catchment, rainfall, groundwater, geology, land use, existing resource consents, hydrology, habitat quality, periphyton and macroinvertebrates (NRC 2011). Fish populations were not surveyed or described in NRC (2011) and the lack of information on fish was identified as a gap that needs to be addressed in order to assist with setting water quality and quantity limits for the river.

The aims of this assessment are to:

- Collate and review existing fish data for the Mangere River catchment.
- Undertake surveys of in-stream and riparian habitat, dissolved oxygen, benthic invertebrates, fish and fish barriers in Summer and Spring 2013.
- Assess and describe the current fish population.
- Identify potential catchment actions for improving native fish diversity and density.

1.2 Study Tasks

The tasks identified in the scope agreed with DairyNZ and NRC were:

- Review the New Zealand Freshwater Fish Database (NZFFDB) to provide an historical perspective.
- Assessments of up to 15 representative sites throughout the catchment.
- Fish survey methodologies to include electric fishing and/or netting (fyke and minnow traps) and/or spot-lighting in line with the New Zealand Freshwater Fish Sampling Protocols (draft protocols – March 2013).
- Assessment of in-stream and riparian habitat condition at appropriately located sampling sites using an approved protocol with data to be linked in with an extensive survey of riparian condition in the catchment being undertaken by DairyNZ.
- Semi-quantitative macroinvertebrate sampling.
- Automated diurnal oxygen and temperature profile (24 hr per site at up to 6 sites) with appropriate Quality Assurance.
- Mapping of significant physical barriers to fish passage.

The purpose of this report is to collate and summarise the key results from the Summer and Spring 2013 surveys and make recommendations for improving native fish diversity and abundance. Section 2 sets out the study methods, Section 3 briefly reviews the existing water quality and ecology information for the Mangere River and Section 4 summarises the key findings of the Summer and Spring 2013 surveys and Section 5 provides recommendations for improving native fish diversity and density in the Mangere River catchment.

2.0 Methodology

2.1 New Zealand Freshwater Fish Database Search

A search of the New Zealand Freshwater Fish Database and review of the Wairua River fish population study recently undertaken by NIWA was carried out in January 2014 to describe the native fish population in the wider Wairua River catchment.

2.2 Survey Sites and Timing

Fish populations can be influenced by a wide range of factors including:

- In-stream and riparian habitat quality.
- Water quality.
- Distance from the sea.
- Dams, weirs and waterfalls.
- Fishing pressure.
- Season.

These factors can in turn be influenced by a complex range of interacting factors such as climate, geology, land use, land management practises and economic conditions.

NRC monitored water quality monthly at 6 sites in the Mangere Catchment since July 2007 (NRC 2011). The Mangere Catchment land use geology and climate are also described in NRC (2011). DairyNZ are currently assessing riparian habitat within the catchment.

Catchment information contained within NRC (2011) along with information provided by NRC (e.g. weir locations) was used along with information gathered during the catchment visit on 20th March 2013 to select sites. The sampling sites are shown on Figure 2 and presented in Table 1.

The Summer 2013 survey was undertaken between 26th March – 28th March 2013. The Spring 2013 survey was undertaken between 12th November – 14th November 2013.

2.3 Fish

The fish survey methodologies used in the current study were electric fishing, spotlighting and trapping and netting (Table 1). Water depth or poor water clarity prevented electric fishing and spotlighting at some sites. Two survey methods were used at each site where conditions and time allowed.

Sampling was undertaken in accordance with the draft New Zealand Freshwater Fish Sampling Protocols (Joy et al 2013) and involved surveying 150 m long reaches. Sites were surveyed using single pass electric fishing or setting 6 standard baited commercial eel fyke nets with plastic 20 mm diameter excluders fitted between the second and last net compartment and 12 unbaited minnow traps (collapsible mesh design with 4 mm mesh size). Mudfish were surveyed during the Spring 2013 at 4 sites using the methodology recommended in Ling *et al* (2009).

2.4 Habitat

Riparian and in-stream habitat conditions was assessed at all main stem and tributary sites during the Summer and Spring surveys using Protocol P2b, P2c and P2d from Stream Habitat Assessment Protocols for wadeable rivers and streams of New Zealand (Harding *et al* 2009). A detailed photographic record of habitat conditions was also made at each site during each survey. Component P2b, P2c and P2d involved the collection of the following:

- Wetted width, maximum pool and mean riffle water depth.
- Meso habitat length.
- Riffle water velocity.
- Run, riffle and pool bank full channel shape, wetted width channel shape.
- Riffle, run and pool percent substrate composition, embeddedness, compactness, scour and deposition zones, organic matter and fish habitat.
- Riparian zone characteristics – channel shading, buffer width, buffer intactness, vegetation composition, bank stability, livestock access, denitrification potential, land slope, ground cover and soil drainage.

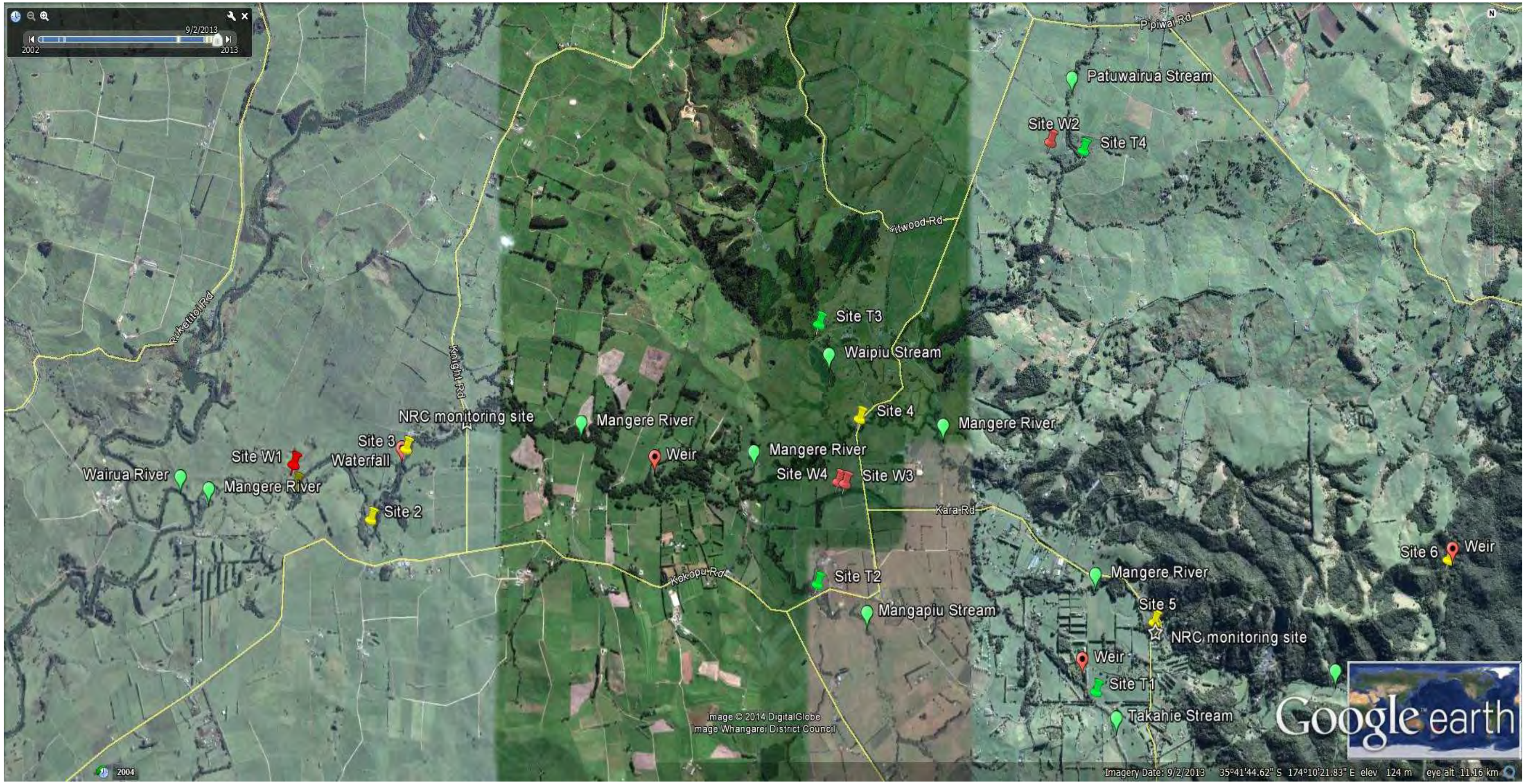


Figure 2: Survey site locations.

Table 1: Fish survey site summary.

Site Code	Location	Type	Sampling Method	Survey Timing
Site 1	Lower Mangere River, downstream of falls	Main stem	Fyke nets and mesh minnow traps, EFM*	Summer and Spring
Site 2	Lower Mangere River, downstream of falls	Main stem	Fyke nets and mesh minnow traps	Summer and Spring
Site 3	Lower Mangere River, upstream of falls	Main stem	Fyke nets and mesh minnow traps	Summer and Spring
Site 4	Middle Mangere River, Kokopu Road Bridge.	*Main* stem	Fyke nets and mesh minnow traps	Summer and Spring
Site 5	Upper Mangere River, Kara Road Bridge.	Main stem	EFM	Summer and Spring
Site 6	Upper Mangere River, Pukenui Forest.	Main stem	EFM, spotlighting*	Summer and Spring
Site T1	Unnamed upper river tributary, McKinlay Road Bridge.	Tributary	Fyke nets and mesh minnow traps	Summer and Spring
Site T2	Mangapiu Stream, upper tributary, Kokopu Road Bridge.	Tributary	Fyke nets and mesh minnow traps	Summer and Spring
Site T3	Waipui Stream middle reach tributary, Roydon Road Bridge.	Tributary	Fyke nets and mesh minnow traps	Summer and Spring
Site T4	Patuwairua Stream, middle reach tributary.	Tributary	Fyke nets and mesh minnow traps	Summer and Spring
Site W1	Lower river wetland off Knight Road.	Wetland	Fine mesh wire traps	Spring
Site W3	Middle river wetland off Kokopu Road.	Wetland	Fine mesh wire traps	Spring
Site W4	Middle river wetland off Kokopu Road.	Wetland	Fine mesh wire traps	Spring
Site W2	Upper river wetland off Kokopu Road.	Wetland	Fine mesh wire traps	Spring

Note: * method only used in the Spring survey.

2.5 Macroinvertebrates

A single macroinvertebrate sample was collected from main stem and tributary sites during the Summer and Spring surveys. Protocol C1 was used for hard bottom sites and Protocol C2 was used for soft bottom sites (Stark *et al* 2001). Samples were preserved and processed using Protocol P3 – full count with subsampling. The following indices were calculated and used to assess macroinvertebrate community health, habitat and water quality.

Taxa Number. This is a measure of the overall health of the benthic macroinvertebrate community and habitat and water quality. Generally the higher the taxa number the healthier the waterway. The number of taxa present at a site can be highly variable and can respond to a large number of factors and can therefore fluctuate widely depending on sampling effort (Stark and Maxted 2007).

Abundance. This is another measure of the overall health of the benthic macroinvertebrate community and habitat and water quality. Generally the higher the abundance of water and habitat sensitive taxa the healthier the waterway.

Macroinvertebrate Community Index (MCI). The MCI is used for measuring stream health and in particular organic enrichment. Individual taxon scores range from 1 – insensitive to 10 – highly sensitive. Community MCI scores typically range from < 80 – poor or probable severe pollution to > 120 – excellent or clean water (Stark and Maxted 2007). Hard bottom MCI taxa scores were used at hard bottom sites and soft bottom MCI scores were used at soft bottom sites.

EPT Taxa Number. This is another measure of the overall health of the benthic macroinvertebrate community and habitat and water quality. A benthic macroinvertebrate community that has a higher number of water and habitat sensitive taxa from the groups – ephemeroptera (mayflies), plecoptera (stoneflies) and trichoptera (caddisflies) (EPT) indicates a healthier waterway.

%EPT. This is another measure of the overall health of the benthic macroinvertebrate community and habitat and water quality. A benthic macroinvertebrate community that has a higher percentage of water and habitat sensitive taxa from the EPT groups indicates a healthier waterway.

2.6 Dissolved Oxygen Sampling

Calibrated dissolved oxygen data sondes, supplied by NRC were deployed for approximately 24 hours at Site 1, Site 3, Site 4, Site 5, Site 6 and Site T2 during the Summer survey.

2.7 Mapping of Fish Barriers

The NRC database of potential fish barriers (weirs and dams) and visual inspection during the fish surveys were used to assess the potential of barrier to prevent fish passage.

3.0 Mangere River Catchment

The Mangere River is a low lying, low gradient river characterised by an incised ‘U shaped’ channel with low water velocity. The mean river flow recorded at Knights Road Bridge in the lower river is approximately 1.5 m^3/s while the minimum flow is 46 L/s. NRC (2011) describes the Mangere River as a perennial river with higher flows occurring between June and October.

The river’s source is the Mangere Stream within the Pukenui Forest just west of Whangarei. The Mangere Stream is joined by several cobble and bedrock dominated tributaries (Patuwairua and Waipui Streams) in the higher water yielding northern volcanic geology and several much smaller soft bed streams from the much lower water yielding sandstone dominated geology in the southern portion of the catchment (Mangapiu Stream).

The Mangere River catchment is dominated by exotic grassland grazed by dry stock and dairy cattle (76.4% of catchment land use). The remaining catchment land uses comprise indigenous vegetation cover (21.9%), forestry (0.6%) and other (1.7%) (NRC 2007). There are 19 dairy farms within the catchment with 13 of these located in the gentle sandstone country in the southern portion of the catchment (NRC 2011). NRC (2011) reported that there are 14 resource consents to discharge animal waste to either land or water, 11 resource consents to discharge sewage to land and 11 active water takes within the catchment. One of the water take consents on the Mangapiu Stream allows the consent holder to dam water within an on-stream dam.

The Mangere River had the poorest water quality in the Northland Region in 2006 and 2007 with elevated nutrient concentrations, low water clarity and high bacteria counts (NRC 2011). Following recent treatment system upgrades on 17 of the 19 dairy farms within the catchment water quality has improved with total phosphorus and total nitrogen decreasing in both the Mangapiu Stream and lower Mangere River and an improvement in bacteria levels, water clarity and turbidity (NRC 2011).

NRC (2011) reported an improvement in stream channel stability between 2004 – 2008 and also improved habitat quality in 2010 despite a decline in stream bed composition and diversity. The Macroinvertebrate Community Index (MCI) scores recorded at Knights Road since 2000 has placed the river in the ‘moderate – severe’ pollution water quality class. There appears to have been a decline in %EPT and MCI scores around 2004 – 2005 with just a slight improvement in scores between 2005 and 2010. The MCI score at Knights Bridge (between Sites 3 and 4) in 2011 was 80 (cut off between moderate and poor water quality categories) and placed the site 11th worst out of the 37 state of the environment sites monitored by NRC across the region (Pohe 2011).

One of the dominant features of the Mangere River are the Mangere Falls in the lower reaches, located between Site 2 and Site 3 (Figure 3). The falls are a major barrier for fish and prevent upstream migration for all but the strongest climbers such as elvers. Large numbers of elvers are seen attempting to climb the falls in January each year (Bruce Savill pers. com.).

A weir near the downstream boundary of the Pukenui Forest (immediately downstream of Site 6) is also likely to prevent upstream passage for non climbing species (Figure 2 and Figure 4).

Figure 3: View of the Mangere Falls in late March 2013.

Figure 4: View of the Mangere Stream weir in Pukenui Forest.

4.0 Summer 2013 Survey Results

4.1 River Flow

The Summer 2013 survey was undertaken after a significant drought in Northland. The minimum flow at Knights Road during the drought was 67 L/s recorded on 12th March 2013 and had an estimated return period of approximately 9 years (Dale Hansen, NRC hydrology Group Manager, pers. com.). The lowest recorded flow in the Mangere River at Knights Road is 48 L/s recorded on 30th March 2010 and had an estimated return period of approximately 44 years.

The southern tributaries (Mangapiu Stream, Site T1 and unnamed McKinlay Road tributary, Site T2) that were assessed during the surveys appear to be intermittent while the northern tributaries (Patuwairua Stream, Site T3 and Waipui Stream, Site T4) are perennial.

4.2 In-stream and Riparian Habitat

A summary of the in-stream and riparian habitat data recorded during the Summer 2013 survey is presented in Table 2 and Table 3.

A view of each of the main stem study sites is shown in Figure 5. A view of each of the tributary study sites is shown in Figure 6.

Site 1.

Site 2.

Site 3.

Site 4.

Site 5.

Site 6.

Figure 5: View of main stem study sites surveyed in Summer 2013.

Site T1.

Site T2.

Site T3.

Site T4.

Figure 6: View of tributary study sites surveyed in Summer 2013.

Table 2: Stream habitat characteristics.

	Site 6	Site 5	Site 4	Site 3	Site 2	Site 1	Site T1	Site T2	Site T3	Site T4
Site length (m)	100	100	100	100	100	100	100	100	100	100
Wetted width (m)	5.4	4.5	3.5	12.5	5.4	12.5	0.4	2.0	2.0	1.5
Maximum pool depth (m)	0.80	0.32	1.5	0.60	0.60	> 1.0	0.35	0.50	1.0	0.6
Mean riffle depth (m)	0.19	0.19	0.50	0.21	0.13	0.18	0.08	0.20	0.19	0.07
% Riffle, % run, % pool	Ri 10, P 90	Ri 15, Ru 45, P 40	P 100	Ri 12, Ru 15; P 63	Ri 5, P 95	Ri 30, P 70	Ri 5, P 95	P 100	P 100	Ri 5, Ru 13, P 82
Riffle, run, pool channel	U	U	U	U	U	U	U	U	U	U
Mean riffle velocity (m/s)	0.63	0.63	0.40	0.40	0.60	0.60	0	0	0	0.60
Riffle % substrate size classes	G 50, C 50	G 100	NA	Be 100	G 40, C 40, B 20	G 25, C 25, B 50	G 100	Si 100	NA	G 25, C 50, B 25
Run % substrate size classes	G 50, C 50	G 100	Si 100	Be 100	Si 10, G 20, C 40, B 30	NR	Si 100	Si 100	NA	G 10, C 60, B 30
Pool % substrate size classes	Si 10, G 50, C 40	Si 50, G 50	Si 100	Be 100	G 40, C 40, B 20	C 40, B 40, Si 20	Si `100	Si 100	Si 100	Si 50, B 50
% embeddedness	30	20	NA	NA	35	30	50	NA	100	23
Substrate compactness	low	low	NA	NA	moderate	high	low	NA	NA	low
% deposition & scouring	67	47	100	100	33	50	50	100	100	33
% organic matter	A 52, W 50	W 27	M 80, A 10, W 40	M 17, W 5	M 1, W 27	M 35, W 18	W 10	A 80, W 60	M 100, W 10	W 27

Note: Riffle velocity is the mean of 3 velocity readings, NR = Not recorded, NA = Not applicable, Ri = riffle, Ru = run, P = pool, Si = silt, G = gravel, C = cobble, B = boulder, BE = bedrock, % embeddedness, % deposition, % macrophytes (M), % algae (A) and % woody debris and leaves (W) is expressed as the mean of scores from a riffle, run and pool with the survey reach.

Table 3: In-stream and riparian habitat conditions.

	Site 6	Site 5	Site 4	Site 3	Site 2	Site 1	Site T1	Site T2	Site T3	Site T4
% obstructions to flow	7	20	40	63	35	50	0	60	50	30
% bank cover	67	7	40	100	33	50	0	33	100	17
Channel shading	5	4	3	5	1	2	2.5	5	2	4
Buffer width	2	4	4	2	2	2	3.5	4	1	2
Buffer Intactness	3	5	4	2.5	2	1.5	3.5	4.5	1	2
Vegetation composition	3	4.5	2	2.5	1	1.3	3	4	1	2.5
Bank stability	3	2	1	5	2	2	1	1	1	3
Livestock access	2	5	1	2.5	2	1	4.5	3	1	1.5
Soil denitrification potential	3	3	1	1	1	1.5	1	2	2	2
Land slope	1	1	1	3	1	1.5	1	1	1	1
Ground cover (buffer zone)	3	3	3	2.5	2	3.5	2	1.5	1.5	2
Soil drainage	3	2	4	2	3	3	3	3	1	2
Rills/channels	3	4.5	3	3	3	3	3.5	3.5	3	3

Note: % obstructions to flow and % bank cover are a measure of fish habitat and are presented as the mean score for a riffle, run and pool within the study reach.

Riparian habitat scores are the mean of true right and true left bank scores for the entire study reach.

4.3 Water Quality

Fish Survey Site Physico-chemical Results

The physico-chemical spot measurement results from the Summer 2013 survey are presented in Table 4. These water quality results indicate that river water temperature at all sites except Site T3 is likely to remain below levels that are harmful to fish. Water clarity exceeded 1 m at all main stem sites and also at Site T4. Dissolved oxygen (DO) levels exceeded 80 % at all sites except Sites T1 and T2 where 43% and 24% dissolved oxygen saturation was recorded – well below the level that is harmful for fish (Table 4). The proposed National Environmental Standards express dissolved oxygen as a concentration limit. DO concentrations are also presented in Table 4.

Dissolved Oxygen Results

In 2000 a 24-hour study of the Mangere River by NRC found DO concentrations showed an increasing downstream trend of greater variability (NRC, 2002). The furthest downstream site in the study (Knights Road) exhibited DO concentrations well below commonly cited guidelines for the protection of aquatic ecosystems (80% saturation). NRC concluded the low DO concentrations downstream were the result of the numerous farm dairy effluent discharges within the catchment, and diffuse agricultural runoff.

YSI data sondes were deployed at Sites 1, 3, 4, 5 and 6 to monitor DO and temperature at five sites on the Mangere River following a period of extended low flow (Figure 7). The sites sampled were:

- Site 6: the most upstream site with predominantly native vegetation upstream.
- Site 5: 4 km downstream from Site 6 where there is some influence from dry stock farming.
- Site 4: mid-catchment approximately10 km from Site 6 where there is a greater potential effect from dairy farming and other land uses.
- Site 3: lower catchment approximately 16 km downstream from Site 6 where there is a greater potential effect from dairy farming and other land uses.
- Site 1: lower catchment approximately 18 km downstream from Site 6 where there is a greatest potential effect from dairy farming and other land uses.

The sondes were deployed for a minimum of 19.5 hr and a maximum of 26.5 hr, as shown in Table 5. A summary of the continuous temperature and DO data is presented in Table 6. Continuous DO saturation data is presented in Figure 7.

Table 4: Physico chemical water quality and water clarity results.

	Site 6	Site 5	Site 4	Site 3	Site 2	Site 1	Site T1	Site T2	Site T3	Site T4
Date/time	28 March 5 pm	28 March 11 am	26 March 5.30 pm	26 March 3 pm	26 March 1 pm	26 March 11 am	28 March 9.30 am	28 March 11 am	28 March 4 pm	28 March 2 pm
Temperature (°C)	14.4	15.4	15.6	16.6	17.2	16.3	13.8	13.2	20.0	15.9
DO (% saturation)	94	90	97	92	95	98	43	24	91	103
DO (mg/L)	9.6	9.0	9.6	8.9	9.1	9.6	4.4	2.5	8.3	10.2
pH	7.4	7.4	7.6	7.4	7.6	7.8	7.1	7	7.2	7.6
Conductivity (uS/cm)	128	138	150	155	156	155	NR	216	167	99
Clarity (m)	> 1	> 1	> 1	> 1	> 1	> 1	0.68	0.32	0.75	> 1

Table 5: Data sonde deployment schedule.

Site	Description	Monitoring Period
Site 6	Control	6:45pm 27 Mar 2013 – 3:30pm 28 Mar 2013
Site 5	4 km downstream of Site 6	6:00pm 26 Mar 2013 – 3:45pm 27 Mar 2013
Site 4	10 km downstream of Site 6	3:45pm 26 Mar 2013 – 6:15pm 27 Mar 2013
Site 3	16 km downstream of Site 6	7:30pm 25 Mar 2013 – 3:00pm 26 Mar 2013
Site 1	18 km downstream of Site 6	5:30pm 25 Mar 2013 – 2:45pm 26 Mar 2013

During the assessment period temperatures were coolest at Site 6, warmest at Site 1, and similar at Site 3, Site 4 and Site 5. DO was assessed as DO saturation due to the differences in temperature across the sites.

DO saturation at Sites 5 and 6 was similar following the peak period of oxygen production by primary producers during daylight hours, and the difference between the maximum and minimum saturation was similar also; 6 % and 7 %, respectively. Site 5 exhibited a slightly lower (approximately 1 – 2 %) DO saturation throughout the hours of darkness compared with Site 6; this is indicative of a higher oxygen demand in the Mangere River at Site 5.

A similar pattern was evident between Site 5 and Site 4, but to a greater extent – a greater daytime oxygen production at Site 4 results in a higher DO saturation than at the two upstream sites, but a greater oxygen demand at Site 4 resulted in a DO sag of 3 % compared with Site 5 at 7:00 - 7:30 am. The difference between the maximum and minimum DO saturation (15 %) between Site 5 and Site 4 was also more marked than at the upstream sites.

This trend is further continued at Site 3 where DO saturation at the end of the daylight hours is greater than at all upstream sites, but then decreased markedly at night, reaching a minimum level of 76.6 % at 8:00 am. The difference between the maximum and minimum DO saturation at Site 3 was the greatest for all of the sites (22 %). Finally, Site 1 showed the highest DO saturation of all sites but less relative oxygen demand compared with Site 3. Hence, the minimum DO saturation observed is 91.4 % at 5:45 am and the difference between the maximum and minimum DO saturation is improved also (15 %).

The trend in DO saturation in the Mangere River at the sites investigated is entirely consistent with the pattern of land use and physical characteristics of the catchment. Both DO production and DO demand increases downstream due mainly to the activity of primary producers, which are more abundant downstream due to increases in nutrient inputs and more favourable habitat conditions.

Over the period of the assessment, DO saturation fell below the 80 % guideline that is commonly cited as a requirement for fish (Hay *et al*., 2006) only at Site 3. DO concentrations did not fall below 5 g/m^3, which is considered the absolute minimum non-lethal stress level to maintain for fish at all times (BCME, 2007), on any occasion. The BCME 30-day mean DO 'non-production of impairment' guideline for fish (not early life stages) is 8 g/m^3, which was maintained at all sites except Site 3.

Based on this assessment the DO status of the Mangere River means it is able to support fish throughout most of the main stem. At Site 3 DO did not meet the guideline but fish were recorded at the site (see Table 9). DO guidelines were satisfied, 2 Km downstream at Site 1.

Table 6: Summary of data sonde results.

Site	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% saturation)
Site 6	13.9 (13.6, 14.3)	9.28 (9.22, 9.71)	90.0 (88.9, 94.6)
Site 5	15.4 (14.9, 16.1)	8.87 (8.65, 9.36)	89.0 (86.9, 93.6)
Site 4	15.0 (14.3, 15.3)	9.06 (8.47, 9.81)	89.9 (82.9, 97.9)
Site 3	14.9 (14.5, 16.1)	8.38 (7.80, 9.75)	82.8 (76.6, 98.3)
Site 1	16.8 (15.7, 18.1)	9.08 (9.00, 10.1)	93.7 (91.4, 107)

Note: Data presented as median (minimum, maximum).

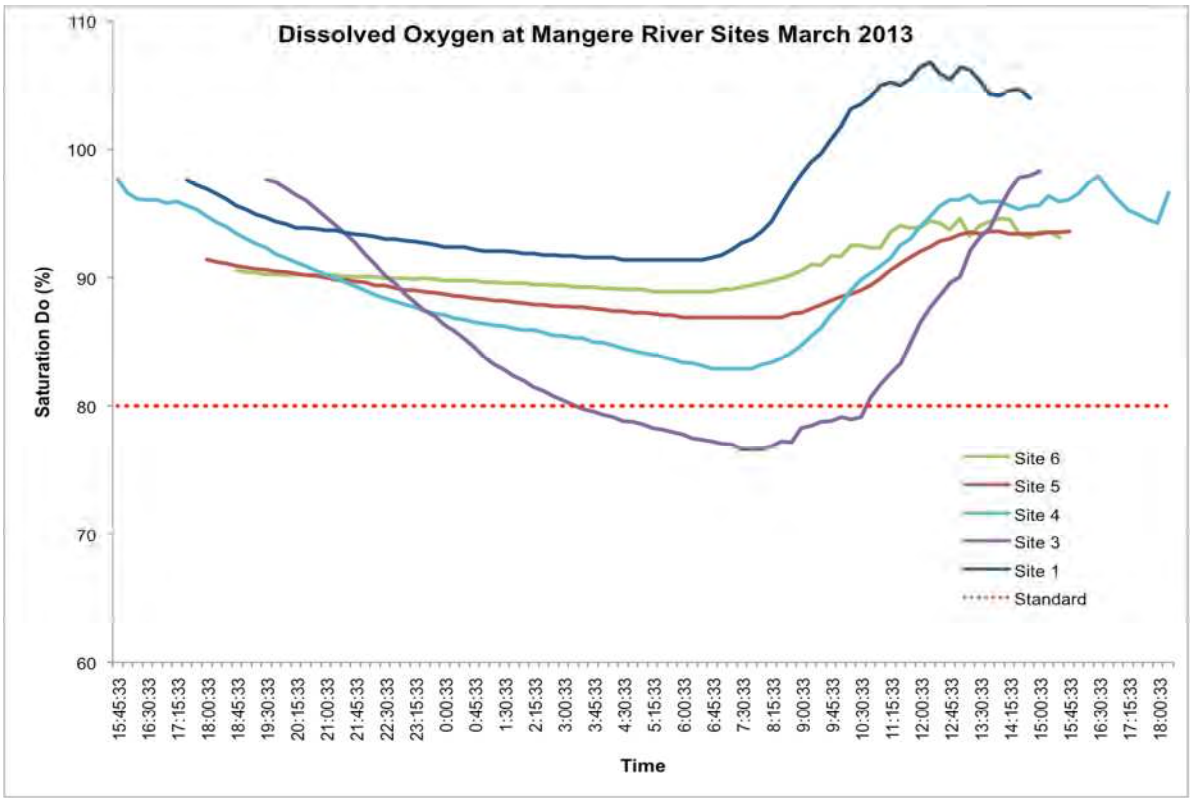


Figure 7: Summer 2013 data sonde dissolved oxygen results.

4.4 Benthic Invertebrates

The MCI quality classes are presented in Table 7. A summary of the benthic macroinvertebrate survey results for the Summer 2013 survey are presented in Table 8.

Table 7: MCI quality classes.

Quality Class	MCI
Excellent	>120
Good	100 - 119
Fair	80 - 99
Poor	< 80

The key findings from the Summer survey were:

- The only site with an MCI score within the 'excellent' water quality class was Site 6 on the edge of the Pukenui Forest.
- The MCI score dropped by 8 points to 113 ('good' water quality class) at Site 5 located downstream of a dry stock farm and several lifestyle blocks and where stock have access to the stream.
- The MCI score dropped by 23 points to 90 ('fair' water quality class) at Site 4, a soft bed section located downstream of dry stock, lifestyle and dairy farms.
- The MCI score increased by 7 points to 97 at Site 3, 5 points at Site 2 and 3 points at Site 1 and indicate improved water quality in the lower reaches downstream of Site 3 and the majority of the dairy farms within the catchment.
- MCI scores were very low in the 2 southern tributaries with a score of 23 at Site T1 and 53 at Site T2. MCI scores were higher (98) in both the northern tributaries (Sites T3 and T4).
- Overall the benthic invertebrate indices showed a marked drop in water quality between Site 6 and Site 5 and a slight improvement downstream of Site 3 and very poor water quality in the southern tributaries (Sites T1 and T2).
- Except at Sites 3, T1 and T2 the range and abundance of benthic invertebrates appeared to be suitable for supporting a healthy fish population.
- Koura were recorded at Sites 1, 3, 4, 5, 6 and T4.

Table 8: Benthic macroinvertebrate indices scores.

	Site 6*	Site 5*	Site 4#	Site 3*	Site 2*	Site 1*	Site T1#	Site T2#	Site T3#	Site T4*
Taxa Number	19	9	7	7	8	11	4	12	11	12
EPT taxa Number	10	5	3	5	5	5	0	1	4	7
Abundance	303	345	1,227	103	1,035	2,689	35	3,635	175	431
%EPT	27	81	1	90	96	15	0	0	21	87
MCI	121	113	90	97	103	106	23	53	98	98

Note: * hard bottom MCI taxa scores used to calculate site MCI score.

soft bottom MCI taxa scores used to calculate site MCI score.

4.5 Fish

The NZFFDB has a 4 records for the Mangere River. The species recorded in the Mangere River in 1986 in a survey by Northland Fish and Game and in 1992 in a survey by DoC were:

- Longfin eel
- Shortfin eel
- Common bully
- Crans bully
- Koura

The NZFFDB has 185 records for the Wairoa River including records upstream of the Wairua River Falls. NIWA (2012) reported the following species from the Wairoa River catchment:

- Common bully
- Crans bully
- Redfin bully
- Longfin eel
- Shortfin eel
- Inanga
- Torrentfish
- Banded kokopu
- Shortjaw kokopu
- Koaro
- Common smelt
- Black mudfish
- Lamprey
- Grey mullet
- Yelloweye mullet
- Koura
- Perch
- Rudd
- Brown bullhead catfish
- Goldfish
- Mosquitofish
- Brown trout
- Rainbow trout

NIWA (2000) reported that the only diadromous fish species recorded upstream of the Wairua Falls were longfin and shortfin eels. The species recorded in the Wairua River, upstream of the Wairua River Falls, are:

- Common bully
- Crans bully
- Longfin eel
- Shortfin eel
- Black mudfish
- Catfish
- Goldfish
- Mosquitofish
- Brown trout
- Rainbow trout
- Koura

Mr Savill, a landowner near the Mangere Falls, reported that he has seen adult eels, catfish and trout in the reach downstream of the Mangere Falls and that the lower river is fished on a regular basis by commercial eel fishermen.

The fish abundance and size range estimates recorded in the Summer 2013 survey are presented in Table 9. The key findings from the Summer 2013 fish survey were:

- All species recorded have previously been recorded in the Wairua River upstream of the Wairua Falls.
- The most abundant and widely distributed species was common bully.
- Crans bully were limited to Site 6.
- The eel population was dominated by a low density of large longfin eels.
- No galaxiids were recorded.
- Mosquitofish were recorded at Site 1, T2 and T3.
- A single medium sized brown trout was recorded at Site 5 and trout were also observed rising at Site 1 downstream of the falls.

Overall the Summer survey results indicate that the fish population, upstream of the Mangere River Falls is dominated by common bully and to a lesser extent eels. Eels are diadromous and need to migrate to sea to breed. Whilst the Mangere River Falls is a significant barrier the size range of shortfin eels at Sites 5 and 6, well upstream of the falls, indicates that recruitment is occurring regularly albeit by a very small number of individuals. The lack of shortfin eels at the sites in the lower river (Sites 1 and 2) downstream of the Mangere River Falls is somewhat surprising given the, typically, more lowland distribution of shortfin eels. The river water temperatures recorded during the data sonde survey were below shortfin elvers preferred water temperature of 26.9 °C reported by Richardson *et al* (1994).

Longfin eels were recorded at all sites except Site 6 in the upper Mangere River and Site 3, immediately upstream of the falls. The lack of longfin eels at Site 3 is not surprising given the bedrock nature of the site and the lack of suitable cover for eels. The size range of longfin eels captured throughout the catchment was heavily skewed towards larger fish and suggests that longfin eel recruitment over the Mangere River Falls maybe more sporadic. It is not known whether commercial eel fisherman occasionally release eels, captured downstream of the Mangere River Falls, upstream. The river water temperatures recorded during the data sonde survey were below longfin elvers preferred water temperature of 24.4 °C reported by Richardson *et al* (1994).

Common bully were by far the most abundant and widespread species caught during the Summer survey and were recorded at all sites except the northern tributary Sites T1 (Takahie Stream) and T2 (Mangapiu Stream). Common bully are a non diadromous species and their recruitment is therefore not affected by the Mangere River Falls. The river water temperatures recorded during the data sonde survey were below common bullies preferred water temperature of 20.2 °C reported by Richardson *et al* (1994).

Crans bully was limited to Site 6 on the edge of the Pukenui Forest that has the best habitat and water quality of all the sites surveyed. Crans bully's preferred water temperature is 21 °C (Richardson *et al* 1994).

The pest fish Gambusia (Mosquitofish) were recorded in the lower Mangere River at Site 1 and in the northern Waipui Stream (Site T3) and southern Mangapiu Stream (Site T2). Mosquitofish are very tolerant of high water temperatures and low dissolved oxygen levels and can therefore exploit streams with very poor water quality. The presence of Mosquitofish at Sites 1, T2 and T3 is indicative of high water temperature and poor habitat at these sites.

The presence of trout downstream of the falls is expected given the population that exists in the Wairua River. The single brown trout captured at Site 5 will have been released into the upper river by Fish and Game Northland in an attempt to establish a fishery and trout fishing opportunities close to Whangarei. Trout are only occasionally released into the Mangere River and no releases have occurred for a long time (Nathan Burkepile, Northland Fish and Game pers. com.). The trout population in the Mangere River is likely to be limited by the amount and quality of in-stream adult habitat and high river water temperature in the middle section of the river.

Koura were recorded in the upper and middle reaches of the main stem of the Mangere River (Sites 3 – 6) and in the northern Patuwairua Stream (Site T4) and southern Takahie Stream (Site T1). Koura prefer habitat with plenty of in-stream and bankside cover and so the lack of Koura at the tributary Sites T1, T2 and T3 that had poor habitat is unsurprising.

Table 9: Fish species abundance and size range (mm) recorded at each site.

Common Name	Site 6*	Site 5*	Site 4#	Site 3#	Site 2#	Site 1#	Site T1#	Site T2#	Site T3#	Site T4#
Shortfin eel[+Δ]	R (100 – 600)	C (360 – 550)								
Longfin eel[+Δ]		R (550 – 600)	R (650 – 750)		R (460 – 810 mm)	C (450 – 610)	R (700 – 750)	R (650)	R (650 – 900)	R (650 – 1,000)
Common bully[Δ]	A (10 – 70)	A (20 – 55)	VA 15 – 70)	A (15 – 65)	VA (15 – 75 mm)	A (15 – 60)			C (50 – 100)	A (20 – 100)
Crans bully[Δ]	R (70)									
Mosquitofish						C (15 – 30)		A (20 – 50)	R (20)	
Brown trout		R (260)				Obs. (400)				
Koura[Δ]	C (70)	C (25 – 80)	R (70 – 80)	R (60 – 70)		R (50)				C (60 – 85)

Note: VA = Very abundant ≥ 35, A = Abundant 20 - 34, C = Common 5 – 19, R = Rare ≤ 5. * = electric fished, # = minnow traps and fyke nets. Obs = observed, Δ = native species, + = diadromous species.

5.0 Spring 2013 Survey Results

5.1 River Flow

The Spring survey was undertaken during a sustained period of settled weather and low river flows. The Mangere River flow on the days of the survey was approximately 450 L/s (Figure 8).

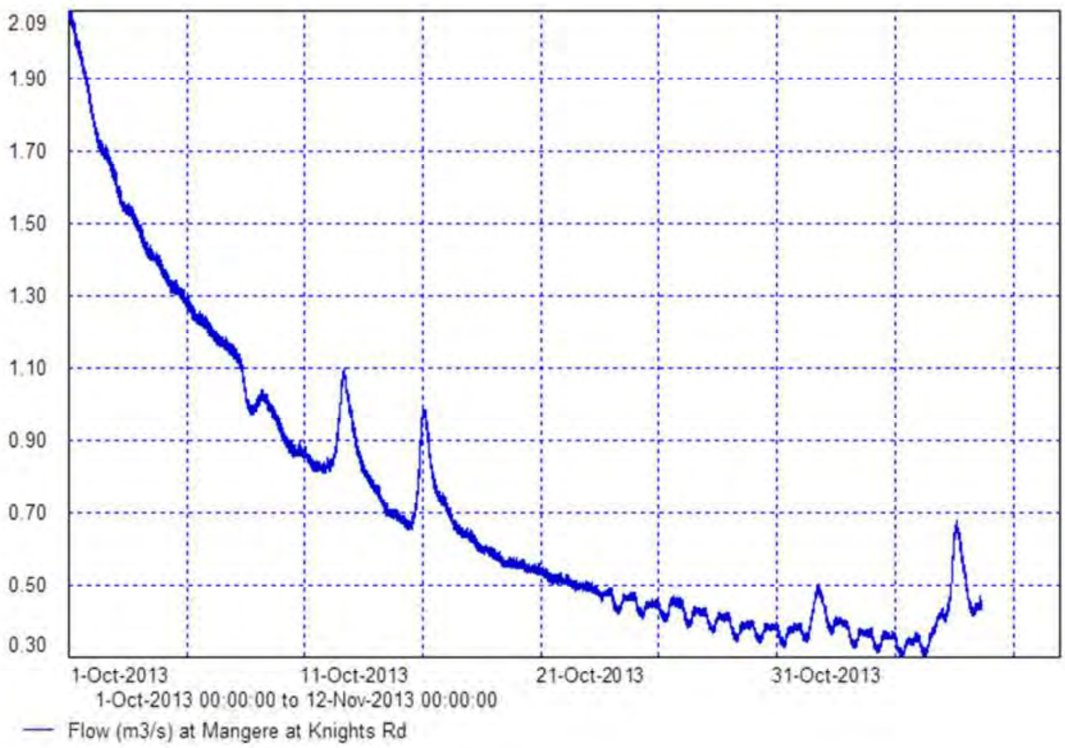


Figure 8: Mangere River flow at Knights Road Bridge prior to the Spring survey.

5.2 In-stream and Riparian Habitat

A summary of the in-stream and riparian habitat data recorded during the Spring 2013 survey is presented in Table 10 and Table 11.

A view of each of the main stem study sites is shown in Figure 9. A view of each of the tributary study sites is shown in Figure 10 and a view of each of the wetland mudfish study sites is shown in Figure 11.

Site 1.

Site 2.

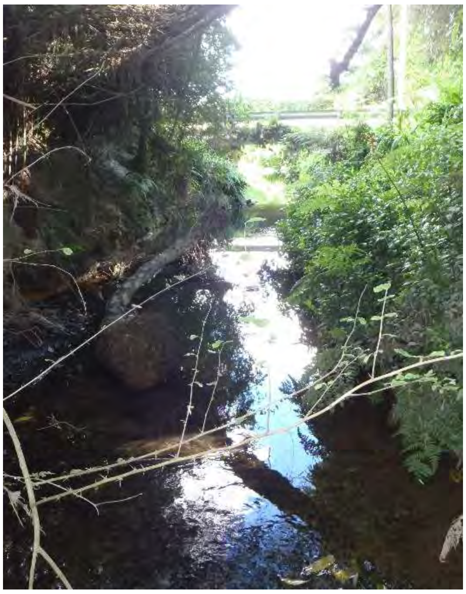
Site 3.

Site 4.

Site 5.

Site 6.

Figure 9: View of main stem study sites surveyed in Spring 2013.



Site T1.

Site T2.

Site T3.

Site T4.

Figure 10: View of tributary study sites surveyed in Spring 2013.

Site W1.

Site W2.

Site W3.

Site W4.

Figure 11: View of wetland mudfish study sites surveyed in Spring 2013.

5.3 Water Quality

Physico-chemical Results

The physico-chemical results from the Spring 2013 survey are presented in Table 12. These water quality results indicate that river water temperature was below the preferred level of the species present at the time of the survey. Dissolved oxygen levels exceeded 80% at all sites except Sites T1 and T2. Dissolved oxygen levels at Sites T1 and T2 were below the level that can be harmful to fish (Table 12). The pH was within the range that is suitable for fish.

Table 10: Stream habitat characteristics.

	Site 6	Site 5	Site 4	Site 3	Site 2	Site 1	Site T1	Site T2	Site T3	Site T4
Site length (m)	100	100	100	100	100	100	100	100	100	100
Wetted riffle/run width (m)	5.4	4.5	5	18	8	12.5	0.4	2.0	1.75	2
Maximum pool depth (m)	0.80	0.32	1.5	0.60	0.60	> 1.0	0.35	0.50	1.0	0.6
% Riffle, % run, % pool	Ri 10, P 90	Ri 15, Ru 45, P 40	P 100	Ri 12, Ru 15; P 63	Ri 15, P 85	Ri 30, P 70	Ri 5, P 95	P 100	P 100	Ri 5, Ru 13, P 82
Riffle, run, pool channel	U	U	U	U	U	U	U	U	U	U
Riffle % substrate size classes	G 50, C 50	G 100	NA	Be 100	G 40, C 40, B 20	G 25, C 25, B 50	G 100	Si 100	C 20, Gr 80	G 25, C 50, B 25
Run % substrate size classes	G 50, C 50	G 100	Si 100	Be 100	Si 10, G 20, C 40, B 30	NR	Si 100	Si 100	Si 100	G 10, C 60, B 30
Pool % substrate size classes	Si 10, G 50, C 40	Si 50, G 50	Si 100	Be 100	G 40, C 40, B 20	C 40, B 40, Si 20	Si `100	Si 100	Si 100	Si 50, B 50
% embeddedness	30	20	NA	NA	35	30	50	NA	100	23
Substrate compactness	low	low	NA	NA	moderate	high	low	NA	NA	low
% deposition & scouring	67	47	100	100	33	50	50	100	100	33
% organic matter	W 50	W 27	M 80, A 10, W 40	W 10	M 1, W 17	A 80, W 18	W 10	M 50, W 80	M 45, A 27, W 13	W 50

Note: NR = Not recorded, NA = Not applicable, Ri = riffle, Ru = run, P = pool, Si = silt, G = gravel, C = cobble, B = boulder, BE = bedrock, % embeddedness, % deposition, % macrophytes (M), % algae (A) and % woody debris and leaves (W) is expressed as the mean of scores from a riffle, run and pool with the survey reach.

Table 11: In-stream and riparian habitat conditions.

	Site 6	Site 5	Site 4	Site 3	Site 2	Site 1	Site T1	Site T2	Site T3	Site T4
% obstructions to flow	7	20	40	63	35	50	0	65	50	40
% bank cover	67	7	40	100	33	50	0	33	67	85
Channel shading	5	4	3	5	1	2	2.5	5	2	4
Buffer width	2	4	4	2	2	2	3.5	4	1	2
Buffer Intactness	3	5	4	2.5	2	1.5	3.5	4.5	1	2
Vegetation composition	3	4.5	2	2.5	1	1.3	3	4	1	2.5
Bank stability	3	2	1	5	2	2	1	1	1	3
Livestock access	2	5	1	2.5	2	1	4.5	3	1	1.5
Soil denitrification potential	3	3	1	1	1	1.5	1	2	2	2
Land slope	1	1	1	3	1	1.5	1	1	1	1
Ground cover (buffer zone)	3	3	3	2.5	2	3.5	2	1.5	1.5	2
Soil drainage	3	2	4	2	3	3	3	3	1	2
Rills/channels	3	4.5	3	3	3	3	3.5	3.5	3	3

Note: % obstructions to flow and % bank cover are a measure of fish habitat and are presented as the mean score for a riffle, run and pool within the study reach.

Riparian habitat scores are the mean of true right and true left bank scores for the entire study reach.

Table 12: Physico chemical water quality results.

	Site 6	Site 5	Site 4	Site 3	Site 2	Site 1	Site T1	Site T2	Site T3	Site T4
Date/time	14 Nov 3.30 pm	14 Nov 5 pm	14 Nov 10 am	13 Nov 9 am	13 Nov 10.30 am	13 Nov 1 pm	14 Nov 4.30 pm	14 Nov 4 pm	14 Nov 11.30 am	14 Nov 1 pm
Temperature (°C)	14.2	NR	NR	15.3	15.6	16.4	15.3	16.7	15.8	15.4
Dissolved oxygen (% saturation)	99	NR	NR	85	98	106	56	69	99	102
pH	7.7	7.4	7.7	7.4	7.6	7.9	6.8	6.9	7.4	7.6
Conductivity (uS/cm)	101	138	101	101	108	109	123	155	101	82

5.4 Benthic Invertebrates

The key findings from the Spring survey were:

- No sites had an MCI score within the ‘excellent’ water quality class. The highest MCI score (102 – ‘good’ water quality class) was recorded at Site 6, as it was in the Spring 2013 survey.
- MCI scores were higher at all sites, except Site T2 compared to the MCI score reported for the Knights Bridge site by Pohe (2011).
- MCI scores increased at 3 out of the 4 tributary sites in Spring compared to Summer 2013.
- MCI scores decreased at 5 out of the 6 Mangere River sites in Spring compared to Summer 2013.
- The MCI score dropped by 4 points to 98 (‘fair’ water quality class) at Site 5 located downstream of a dry stock farm and several lifestyle blocks and where stock have access to the stream.
- The MCI score dropped by 2 points between Site 5 and Site 4. This compares to a by 23 point decline in MCI scores between Site 5 and Site 4 in Summer 2013.
- The MCI score dropped by 3 points from 96 to 93 (‘fair’ water quality class) between Site 4 and Site 3. This compares to a 7 point increase between Site 4 and Site 3 in Summer 2013.
- The MCI score remained steady between Site 3 and Site 2 and dropped by 2 points from 93 to 91 (‘fair’ water quality class) between Site 2 and Site 1. This compares to a 5 point increase between Site 3 and Site 2 and 3 point increase between Site 2 and Site 1 in Spring 2013 and is reflective of the different low conditions prior to each of the surveys.
- MCI scores were higher in the 2 southern tributaries in Spring 2013 compared to Summer 2013 with a score of 81 at Site T1 (23 in Summer 2013) and 59 at Site T2 (56 in Summer 2013).
- MCI scores were lower at Site T3 (96) and higher at Site T4 (105) compared to Summer 2013 (MCI = 98).
- Overall the MCI scores indicated a steady and gradual decline in water quality down the catchment with the greatest decrease occurring between Site 6 and Site 5 and poor invertebrate community health in the northern tributaries.
- The other biological indices (taxa number, %EPT and abundance) indicated a drop in water quality between the upper and mid catchment sites and improved water quality between the mid and lower catchment sites.
- Freshwater crabs were recorded at Site 4 and Site T4.
- Koura were recorded at Sites 1, 3, 5, 6, T1 and T3.
- The range and abundance of benthic invertebrates appeared to be suitable for supporting a healthy fish population at all sites, except Site 3 where there was low abundance owing to the bedrock substrate.

Table 13: Benthic macroinvertebrate indices scores.

	Site 6*	Site 5*	Site 4#	Site 3*	Site 2*	Site 1*	Site T1#	Site T2#	Site T3#	Site T4*
Taxa Number	28	25	18	15	22	21	20	29	27	19
EPT taxa Number	12	10	7	8	10	9	3	4	11	10
Abundance	3,311	1,989	685	199	1,368	1,191	2,009	3,410	2,702	1,380
%EPT	49	5	14	70	67	76	<1	9	14	80
MCI	103	98	96	93	93	91	81	59	96	105

Note: * hard bottom MCI taxa scores used to calculate site MCI score.

soft bottom MCI taxa scores used to calculate site MCI score.

5.5 Fish

The fish abundance and size range estimates recorded in the Spring 2013 survey are presented in Table 14. The key findings from the Spring 2013 fish survey were:

- All species recorded have previously been recorded in the Wairua River upstream of the Wairua Falls.
- The most abundant and widely distributed species was common bully.
- The eel population is dominated by a low density of large longfin eels.
- No galaxiids were recorded.
- No trout were recorded.
- No mudfish were recorded.
- The species assemblage at each site in Spring 2013 was similar to Summer 2013.
- The size of common bully was lower in Spring compared to Summer 2013.

Overall the Spring survey results were similar to the Summer survey results and indicated that the fish population, upstream of the Mangere River Falls is dominated by eels and common bully.

The size range of longfin eels captured in Spring 2013 was much less heavily skewed towards larger fish and suggests that longfin eel recruitment over the Mangere River Falls may occur more regularly than the Spring survey results alone would suggest.

Common bully were by far the most abundant and widespread species caught during the Spring survey. The size range of common bully captured in Spring was skewed towards the smaller size classes and reflects the annual breeding cycle with the Spring survey occurring closer to spawning than the Summer survey.

Table 14: Fish species abundance and size range (mm) recorded at each site.

Common Name	Site 6*	Site 5*	Site 4#	Site 3#	Site 2#	Site 1#	Site T1#	Site T2#	Site T3#	Site T4#
Shortfin eel$^{+\Delta}$										
Longfin eel$^{+\Delta}$	C (250 – 650)	A (80 – 1,100)			C (200 - 700)	C (A) (400 - 550)			R (600 – 850)	R (1,000)
Common bully$^{\Delta}$	VA (15 – 60)	C (40 - 70)	C (15 – 50)	C 15 – 80)	C (15 – 35)	A (A) (15 – 45)	R (15)		C (25 - 40)	VA (15 - 70)
Crans bully$^{\Delta}$	R (50)					R (R) (30 – 45)				R (60 – 70)
Mosquitofish								R (20)		
Brown trout										
Koura$^{\Delta}$	A (40 - 50)			R (50)		R (C) (55)	R (60)		R (30)	

Note: VA = Very abundant ≥ 35, A = Abundant 20 - 34, C = Common 6 – 19, R = Rare ≤ 5. * = electric fished, # = minnow traps and fyke nets.
Δ = native species, + = diadromous species. Counts in brackets at Site 1 are for electric fishing survey.

6.0 Catchment Management to Assist Native Fish Communities

6.1 Background

Before an assessment of the possible interventions to improve native fish diversity and density within the Mangere River Catchment can be made it is important to understand what type of fish community exists within the river and what key factors are influencing the community.

NIWA (2012) reported that shortfin eel, longfin eel, crans bully, common bully have been captured throughout the Wairoa River catchment, including upstream of the Wairua Falls and Wairua Power Station. Juvenile banded kokopu were common amongst fish observed using the fish pass and mussel spat rope at the Wairua Falls Power Station in 2012 Williams et al (2013). It is therefore likely that banded kokopu are able to access the lower Mangere River downstream of the falls. There are also anecdotal records from the 1960's of banded kokopu occurring in the Mangere River in the Pukenui Forest (Manning 2001, WDC 2009). There is only a single record of koaro, a strong climber, from the Awakino Stream, downstream of the falls and the only records for banded kokopu and shortjaw kokopu are also from below the Wairua River Falls and Wairua Power Station. Based on the NZFFDB records and the results of the Mangere River study koaro and shortjaw kokopu are not expected from the Mangere River.

The most significant influences on native fish community diversity and density in New Zealand are distance from the sea, elevation and physical habitat (Jowett and Richardson 2003 and 2005). Other important variables known to influence native fish communities are the geographic location of the site, stream width, and the percentage of native vegetation cover and farming land use in the catchment (Jowett and Richardson 2003). Water quality and barriers to fish passage including dams and waterfalls can also exert strong influences on native fish communities.

6.2 Mangere River Fish Community Water Quality and Habitat Requirements

The Mangere River is well inland with the confluence of the Mangere and Wairua Rivers approximately 70 Km inland from the northern tip of the Kaipara Harbour. The elevation of study sites ranged from approximately 80 m above sea level at Site 1 in the lower river to 140 m above sea level at Site 6 in the upper river. The Mangere River Catchment is characterised by moderate elevations with generally gentle stream gradients. The upper main stem and northern tributaries have higher gradients with a mix of riffle, run and pool habitat and cobble or gravel dominated bed substrates. This habitat is preferred by a range of native fish including bullies, elvers and galaxiids. The soft marine tertiary sediments in the middle section of the main stem and southern tributaries are highly erodible. The main stem and southern tributaries, through its middle reaches have cut a deeply incised and meandering, gently graded, U shape channel with a high proportion of silty pool habitat preferred by adult eels and common bully. The volcanic geology in the low gradient lower river (downstream of Knights Road) has created cobble and gravel dominated riffle sections preferred by bullies, elvers, juvenile trout and galaxiids interspersed by bedrock sections that do not provide good fish habitat and deeper silty pools preferred by adult eels and adult trout for cover.

The Wairua River Falls and Wairua Power Station exert a strong influence on the native fish community of the Wairua and Mangere Rivers with only fish with strong climbing abilities such as elvers able to climb the falls and dam. The Mangere River Falls is also a significant barrier to fish preventing all but the strongest climbers from accessing the river upstream. The natural and artificial barriers in the Mangere and Wairua Rivers strongly influence the native fish community by preventing passage of some species and altering the recruitment of other species such as eels.

Richardson and Jowett (2005) identified 12 commonly occurring fish communities using records from the NZFFDB and the environmental variables associated with each category. The upper Mangere River falls within the 'modified bush stream' category capable of supporting eels, crans bully and galaxiids as described in Richardson and Jowett (2005). The middle and lower reaches of the main stem and southern and northern tributaries fall within the 'inland low gradient' category which Richardson and Jowett (2005) described as been most suited to bully communities. The results of the current study confirmed this with common bully been by far the most widely distributed and abundant species.

Based on the all of the available information about the fish community and barriers within the Wairoa River catchment it appears likely that the Mangere River habitat is naturally suited to common bully, crans bully, eels and koura. The Wairua and Mangere Falls are natural barriers to fish. It would be possible to increase the distribution and abundance of fish throughout the catchment by implementing a trap and transfer programme or improving access by installing a fish pass at the falls. Trap and transfer programmes and fish passes are very costly to build and operate and given that the falls are natural such interventions are not recommended. As a result any interventions, such as undertaking riparian planting, are not expected to increase the diversity of the current fish community within the Mangere River catchment and instead interventions should be focused on improving fish density as discussed below.

6.3 Improving Fish Density

The question then is can the current water quality or habitat in the Mangere River be altered to increase common bully, crans bully, longfin eel, shortfin eel and koura density and, if so, what and where should the improvements be carried out. Habitat is more commonly the factor that limits fish density (Richardson and Jowett 2005) and this is likely to be the situation throughout most of the Mangere River catchment. Options for increasing fish diversity and density through improved water and habitat quality are discussed below.

Water Quality

Water quality and in particular very low dissolved oxygen levels is likely to be limiting the fish community in the northern tributaries. Actions to improve water quality in these tributaries should be a priority. Actions include fencing stock out of water ways and planting the riparian margin with species that can filter sediment and nutrients stabilise the stream banks and increase channel shading. It is recommended that these actions be undertaken along the full length of the northern tributaries including fencing stock out from beneath the areas of mature totara (e.g. the Mangapiu Stream, immediately downstream of Kokopu Road) where shading and stock have destabilised banks and increased sediment inputs. The level of stream bank and channel shading is so high in some of these areas, where mature totara are growing, that there may be a need to selectively and carefully remove some trees to increase light levels to allow an understory to become established. Improving the water quality within the northern tributaries is expected to increase the diversity and abundance of the current fish community. The poor water quality within the northern tributaries appears to, in part, be related to the very low flows that occur in these streams. Water quality typically decreases during extended periods of low flow. It is therefore recommended that options for increasing the flow in the northern tributaries, such as reducing water takes, be investigated.

The MCI scores indicate a fall in water and habitat quality between Site 6 and Site 5. The land use between Site 5 and Site 6 comprises a dry stock property and various lifestyle blocks and the river is largely unfenced. The high water and habitat quality within the Pukenui Forest could be extended downstream by linking the native vegetation within the forest with the mature totara that characterises the riparian zone in the middle reaches of the river. This linkage would be achieved by working with NRC and the landowners to fence and plant the riparian margin between Site 5 and Site 6.

River banks throughout the middle and lower catchment are unstable, particularly in sections where the river has cut a deep U shaped channel and where the erosive forces during high river flows result in slumping (see Site 2, Figure 5). Fencing and planting these sections with plant species capable of reducing erosion such as flaxes and sedges will reduce sediment inputs and improve water quality.

Habitat Quality

Adult longfin eels and koura prefer habitat that provides plenty of in-stream and bankside cover. Fencing and planting riparian margins is a common and proven method of improving habitat quality for fish. It is recommended that stock be fenced out of all waterways and that riparian planting be carried out to increase stream bank stability and increase stream bank cover. This could be achieved by planting plants such as carex that provide a thick grassy sword that bind stream bank sediments and overhang the stream margins and create undercut banks.

Adult longfin eels and koura use log jams and large woody debris as cover. Selecting and planting trees that, overtime, provide this large woody debris would be a way of increasing adult longfin eel and koura habitat.

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Report Signature Page

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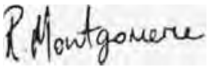

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