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RESOURCE & ENVIRONMENTAL CONSULTANTS

Ecological Assessment of Henderson Creek

FEBRUARY 2000

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Prepared for

Waitakere City Council

February 2000

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1. Introduction

1.1 Background

Waitakere City Council wishes to prepare a Reserve Management Plan for Henderson Creek. Accordingly, the Council commissioned Kingett Mitchell & Associates (Kingett Mitchell) to undertake an ecological assessment of the flora and fauna of Henderson Creek in Waitakere City.

The main objective of this study was to determine the quality of the environment and the management needed to enhance and restore the ecological quality of reserves along Henderson Creek. This included identification of important areas of terrestrial and aquatic vegetation and faunal habitat, evaluation of the threats posed by weeds and other environmental variables, identification of areas that may benefit from restoration or revegetation, prioritisation of areas for improved management, and recommendation of appropriate revegetation and management methods.

1.2 Survey Area

The area surveyed encompasses riparian margins and public reserve land adjoining Henderson Creek from Alderman Drive (Cranwell Park) to the north-western motorway, a distance of approximately 3 linear kilometres (Fig. 1.1). Much of the riparian margin on the east bank of the creek is managed esplanade reserve, with well developed public access from adjoining streets and a walking track which extends its entire length. The west bank of the creek is less developed, although walking tracks extend along sections of the creek margin. Residential properties abut all reserve land on the east bank but land on the west bank is a mix of ongoing residential development (southern section) and used and abandoned and yet to be developed industrial blocks (northern section).

1.3 Scope of work

The scope of work for this assessment was derived from the brief provided by Waitakere City Council. In summary, key objectives of the survey were as follows.

1. Describe and map native and exotic vegetation.

2. Survey birds, reptiles and terrestrial invertebrates; establish species diversity and population estimates.

3. Survey fish and aquatic invertebrates; establish species diversity and population estimates; utilise Auckland Regional Council (ARC) diversity index for presentation.

4. Provide baseline data to enable future monitoring of ecosystem health and restoration progress.

5. Provide an assessment of major ecological processes affecting the site.

6. Identify a range of prioritised, general management options to protect and restore indigenous vegetation, faunal habitats, landscapes and stream quality of Henderson Creek.

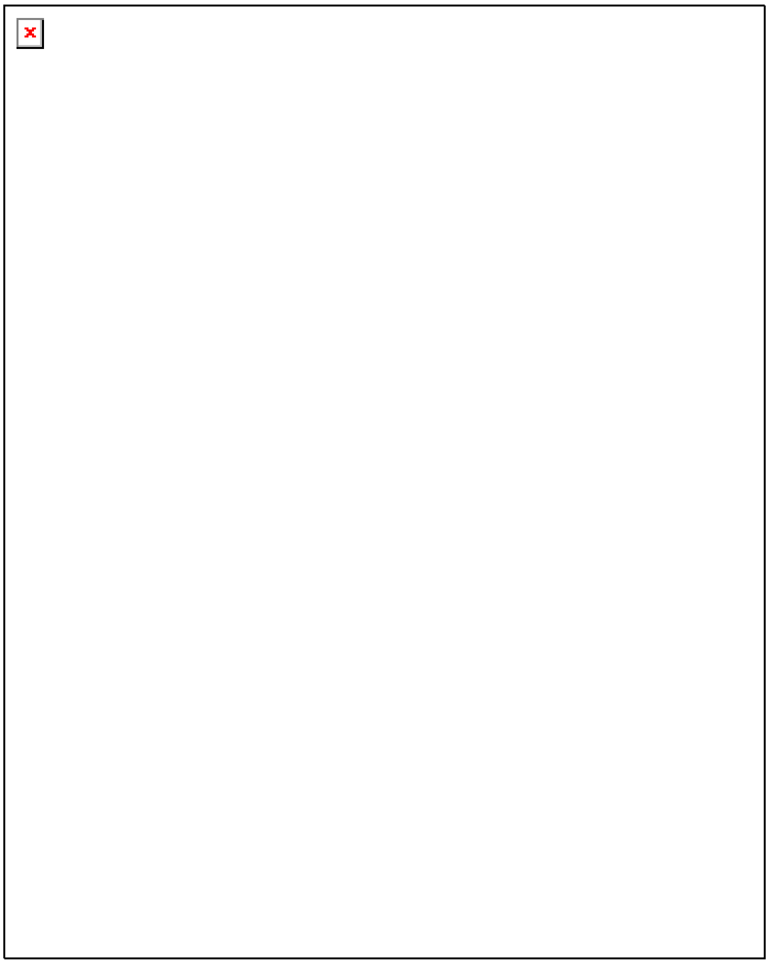


Fig. 1.1: Location of the Henderson Creek survey area.

2. Vegetation

2.1 General Description

Riparian margins in the upper reaches of the survey area, between Alderman Drive and the confluence of the Opanuku and Oratia Streams, are terrestrial-freshwater in character, with little or no intertidal vegetation. A sparse, fragmented fringe of saltmarsh sedges (primarily oioi and searush) in places along the waterline indicates some tidal influence is evident to the top of Henderson Creek. However, these species are more or less absent from the lower reaches of the Opanuku and Oratia Streams, although local tussocks of oioi occur around the waterline directly beneath the Mill Bridge in the Opanuku Stream. Vegetation surrounding the upper reaches of Henderson Creek and the lower reaches of Opanuku and Oratia Streams is diverse in composition. However overall, it may be characterised as modified secondary forest vegetation containing a predominance of exotic species, with small scattered remnants of indigenous coastal scrub and forest. Hence the area may be categorised within a single association for the purposes of mapping and management recommendations.

The middle reach of Henderson Creek, from Opanuku-Oratia confluence to Central Park Drive, contains a narrow, muddy intertidal zone of vegetation characteristic of the transition from a freshwater to an estuarine system, with the appearance of significant saltmarsh communities and scattered mangroves.

The lower reach of Henderson Creek from Central Park Drive to the northwestern motorway is estuarine, with substantial intertidal mangrove communities and local patches of saltmarsh. Evidence of major earthworks is apparent along the riparian margin including construction of an old road or sewer line along the west bank, and spoil encroachment, presumably from the development of the adjacent land blocks. Much of the low-lying area along the east bank is likely to have been wetland that has been filled in and developed, leaving only a narrow fringe of saltmarsh remaining along the waterline.

All vegetation within the survey area is highly modified and fragmented. Historical literature suggests repeated burning and/or clearance of the vegetation (Flude, 1977).

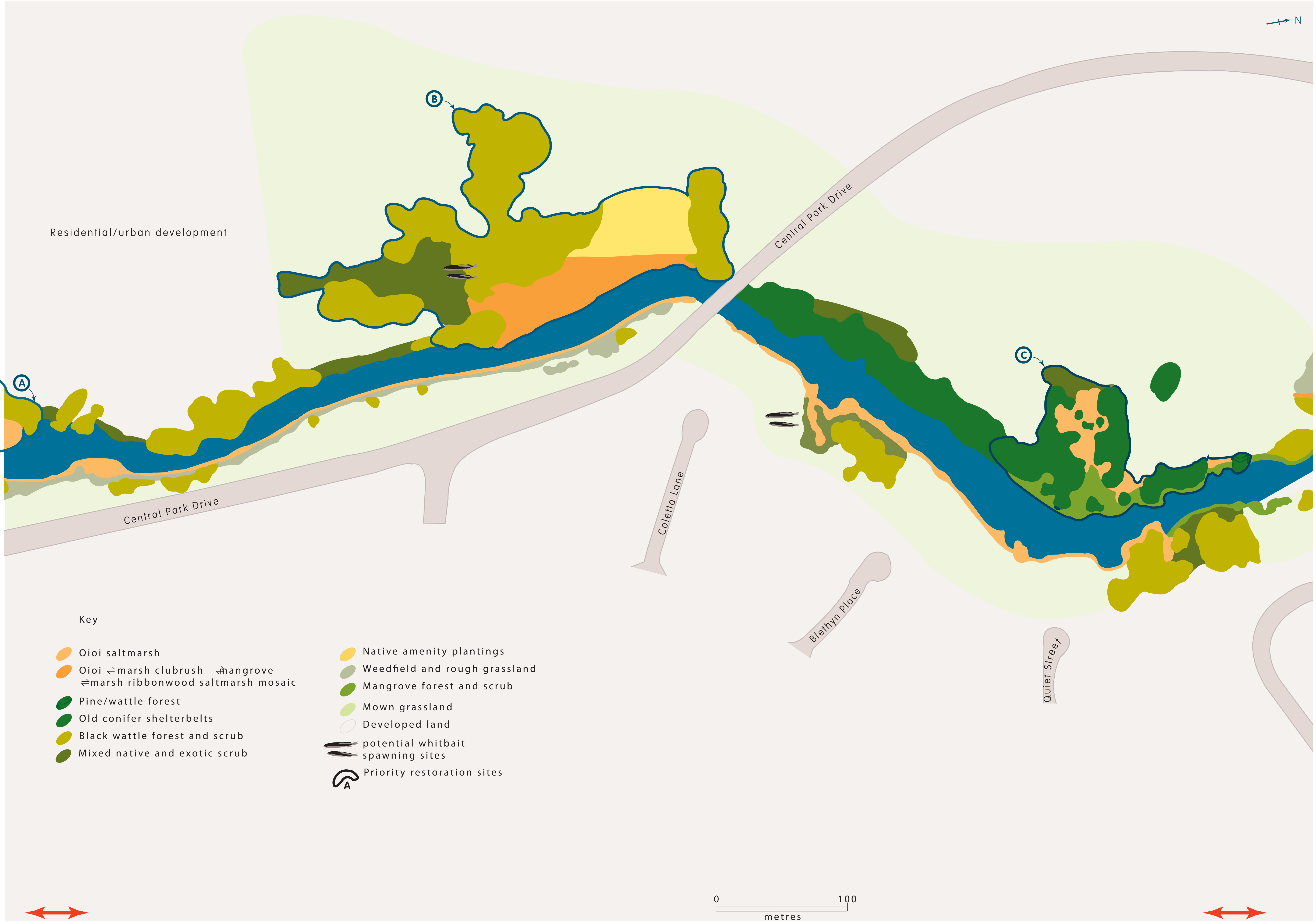
2.2 Vegetation Associations

Vegetation associations present within the survey area are mapped in Fig. 2.1 and each is described in the following sections.

Mixed forest, scrub and shrubland mosaic

Vegetation around the upper reaches of Henderson Creek and the confluence of the Oratia and Opanuku Streams comprises a mosaic of forest and shrubland, composed of an eclectic mix of native and exotic tree and shrub species. Crack willow, tree privet, pine, poplar and wattle locally dominate the forest canopy, interspersed with exotic canopy species such as oak, weeping willow, maple and various conifers, as well as occasional native trees including pohutukawa, puriri, totara, kauri, kahikatea and karaka. Wandering Jew frequently forms the ground cover beneath these stands, while bare, muddy banks are present where margins are exposed to severe scour.

N
Residential/urban development
Opanuku Stream
Ratanui Street
Alderman Drive
Cranwell Park
Sports Complex
Oratia Stream
A
Chilcote Road
Tui Glen Reserve
Residential/urban development
Central Park Drive
Residential/urban development
Key
Mixed forest scrub and shrubland mosiaand
Oioi saltmarsh
Black wattle forest and scrub
Mixed native and exotic scrub
Weedfield and rough grassland
Mown grass and
Developed land
Priority restoration sites
Potential whitebait spawning sites
A
0
100
metres


N
Residential/urban development
B
A
C
Central Park Drive
Central Park Drive
Coletta Lane
Blethyn Place
Quiet Street
Key
Oioi saltmarsh
Oioi ⇌marsh clubrush ⇌mangrove ⇌marsh ribbonwood saltmarsh mosaic
Pine/wattle forest
Old conifer shelterbelts
Black wattle forest and scrub
Mixed native and exotic scrub
Native amenity plantings
Weedfield and rough grassland
Mangrove forest and scrub
Mown grassland
Developed land
potential whitbait spawning sites
Priority restoration sites
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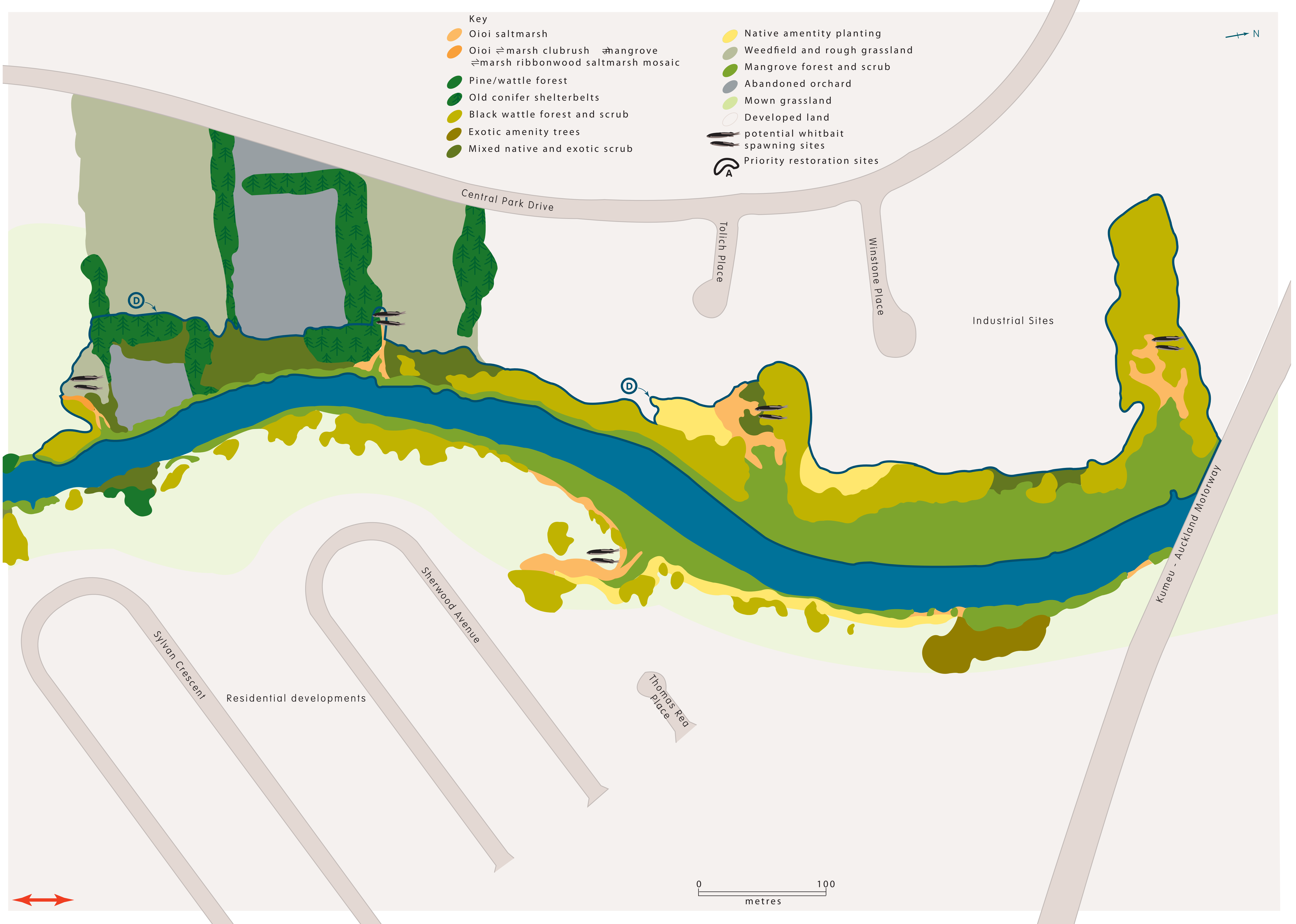
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Exotic amenity trees
Mixed native and exotic scrub
Native amentity planting
Weedfield and rough grassland
Mangrove forest and scrub
Abandoned orchard
Mown grassland
Developed land
potential whitbait spawning sites
Priority restoration sites
A
N
Central Park Drive
Tolich Place
Winstone Place
Industrial Sites
D
D
Kumeu - Auckland Motorway
Sylvan Crescent
Sherwood Avenue
Residential developments
Thomas Rea Place
0
100
metres

Small stands of tall kanuka scrub, and secondary forest remnants containing pohutukawa, kowhai, kahikatea, kauri and towai, occur throughout this reach, with a mixed understorey of native shrubs including mahoe, ponga, karamu, mapou and cabbage trees, and exotic species such as Chinese privet, gorse and black wattle. Local, dense swards of bamboo and eleagnus dominate short stretches of the stream bank.

Local areas of rough grassland and weed-field are present, with kikuyu forming dense swards interspersed with Japanese honeysuckle, great bindweed, cleavers and a variety of other weeds. Occasional amenity trees have been established in these areas. Chinese privet and shrubby crack willow saplings are common along the water margin, with scattered tutsan and pampas. Mist flower is common to locally abundant, with locally present ferns (predominantly kiokio and waterfern), and sedges (*Juncus gregiflorus, Cyperus ustulatus* and *Cyperus eragrostis*) along the water margin where no overhanging canopy is present. Weeds such as kahili ginger, yellow ginger, arum lily, elephant's ear, giant reed and montbretia occur in scattered clumps on the stream bank, in the open or in areas of light shade.

Short sections of stream bank are landscaped and maintained, with scattered amenity plantings of native shrubs, and a mixture of specimen trees. Small examples of remnant vegetation have been retained in some of these areas, such as in the Opanuku Stream below the mill bridge, with small clumps of shrubland containing kanuka, cabbage trees, ponga, karamu and flax, surrounded by mown grassland.

Black wattle forest and scrub

Black wattle forest and scrub dominates relatively extensive tracts of secondary forest and scrub along the true left bank in the lower reaches of Henderson Creek above the intertidal zone, and occurs in small patches elsewhere along the middle and lower reaches. Black wattle (to 10m tall), with occasional eucalyptus, macrocarpa and pine, form a semi-continuous canopy over a scrubby understorey of gorse, pampas, Chinese privet, mapou, karamu, ponga and local patches of bamboo. Occasional kanuka and cabbage trees are also present. Wandering Jew is abundant as a ground cover, with various herbaceous weeds including ivy, inkweed, montbretia and Japanese honeysuckle.

Mixed native and exotic scrub

Small patches of scrub occur along this reach, usually on the periphery of exotic forest and wetland areas. Kanuka forms a patchy canopy, interspersed with cabbage trees, ponga, Chinese privet, pampas, black wattle, gorse, karamu and mapou, scattered tree privet, and woolly nightshade. Japanese honeysuckle grows through the canopy in places, and local thickets of eleagnus and bamboo are also present.

Oioi saltmarsh and marsh clubrush - marsh ribbonwood - mangrove - oioi saltmarsh mosaic

Oioi dominates saltmarsh vegetation, interspersed with locally abundant searush, common *Baumea juncea* and scattered patches of giant umbrella sedge. Saltmarsh ribbonwood is scattered throughout this type, and is locally common, forming occasional patches of shrubland. Patches of saltmarsh herbs, grasses and sedges, including native bachelor's buttons, sea primrose, remuremu, arrow-grass, slender clubrush and saltmarsh rush, and exotic buck's horn plantain and hare's tail, are present in places around the margins of the saltmarsh, and are also interspersed through grassed areas along the intertidal margin, in hollows and low-lying areas.

Marsh clubrush is locally dominant in a few saltmarsh sites, occurring in less saline areas such as the lower reaches of small streams, and around the middle reaches of the survey area.

A zonation is evident in larger patches of saltmarsh, from estuarine mangrove forest, to oioi and searush in brackish water, to freshwater wetland species including flax, raupo, marsh clubrush and *Juncus effusus* in the upper reaches of the wetland. Weeds, particularly pampas, gorse and exotic grasses, become more prevalent as the saline influence declines, with often substantial infestations in the freshwater part of the wetlands.

Saltmarsh is patchily distributed along the middle and lower reaches of Henderson creek, frequently occurring in a narrow fringe along the landward side of mangrove stands, and around the mouths of small creeks and stormwater outflows. A comparatively extensive patch of oioi saltmarsh is present on the true left bank approximately 400m downstream from the Opanuku-Oratia confluence at the top of this reach. A smaller area of saltmarsh interspersed with raupo is also present around a stormwater inlet opposite. Approximately 100m further downstream is a mosaic of oioi saltmarsh, mangrove scrub, saltmarsh ribbonwood shrubland and swards of marsh clubrush.

Mangrove forest and scrub

Mangroves between 1m and 6m tall form a band of intertidal vegetation along both banks of Henderson Creek. Relatively tall, extensive patches of mangrove forest are present around the lower half of this reach, proceeding upstream to a narrow, discontinuous shrubby fringe. Individuals or small groups of mangrove seedlings are scattered through intertidal mudflats and saltmarsh along the middle reaches of Henderson Creek.

Weedfield and rough grassland

Patches of rank kikuyu grassland, interspersed with pampas, gorse, montbretia and occasional shrubby crack willow saplings, flax and native shrubs occur along the margins of Henderson Creek. Areas of rank grassland and weedfield also occur on hillslopes adjacent to Central Park. Japanese honeysuckle, jasmine, great bindweed and a mixture of herbaceous weeds including dock, yarrow, buttercup and exotic grasses are common to locally abundant.

Mown grassland

Areas of mown grassland are present along areas of creek margin, with local stands of amenity trees, including oak, maple, weeping willow, loquat, poplar and pine, interspersed with wattles.

Native amenity plantings

Indigenous coastal tree and shrub species, including cabbage trees, rewarewa, pohutukawa, flax, whau, manuka and ngaio, have been planted along a stretch of bank on the true right side of Henderson Creek. Plants are small but appear healthy and well-maintained. A number of weeds with the potential to smother plants, including kikuyu, Japanese honeysuckle, montbretia, great bindweed and cleavers are present, but are evidently regularly controlled.

Pine/wattle forest and mixed conifer stands

Forest stands adjacent to the Waitakere Stadium on the true left bank of Henderson Creek comprise a mixture of predominantly exotic species including radiata pine, maritime pine, black wattle, poplar, eucalyptus, oak, and macrocarpa. Chinese privet, wandering Jew, Japanese honeysuckle, pampas, blackberry, locally common *Gahnia xanthocarpa* and scattered flax comprises a dense understorey, with local stands of bamboo. Occasional seedlings of native trees have been planted in the understorey.

Abandoned orchard

An old, overgrown orchard containing pipfruit, stonefruit and citrus trees is present adjacent to Central Park, surrounded by shelterbelts of conifers. Fruit trees are interspersed with Chinese privet, pampas and areas of rank kikuyu grassland and weedfield.

2.3 Assessment of Significance

The significance of vegetation within the Henderson Creek intertidal and riparian zone was evaluated in the context of remaining natural areas in the Tamaki Ecological District, utilising the following criteria:

- Representativeness.
- Naturalness/intactness.
- Diversity.
- Rarity/special features.
- Buffering/connectivity.
- Size and shape.
- Long-term viability.
- Management input.

Representativeness and naturalness

Much of the vegetation within the survey area is highly modified, dominated by exotic species, and degraded by weeds and a history of intensive human landuse. In addition, parts of the area are managed to maintain their recreational and amenity values and have limited ecological value.

The riparian vegetation of Henderson Creek is in many ways typical of natural areas within the Tamaki Ecological District, which are characteristically small, modified, and isolated by the development of the surrounding land. Exotic plants often comprise a substantial or dominant component of terrestrial vegetation (Julian *et al.* 1998). This increases the relative significance of remnant areas of predominantly native vegetation, and of areas that can provide an ecological linkage between different habitat types. In particular, Julian *et al.* (1998) notes that while terrestrial coastal edge forest within the Tamaki Ecological District is generally degraded and dominated by exotic species, Henderson Creek is one of only two sites in the ecological district (and the only site on the Waitemata Harbour) that supports small remnants of healthy coastal broadleaf and coastal kauri forest (within the area described as mixed forest, scrub and shrubland mosaic in this report), and retains an intact coastal to inland vegetation sequence.

Substantial mangrove forest and scrub areas occur in the lower reaches of Henderson Creek, and several patches of saltmarsh are present that, although small, are of relatively good quality. In addition, a pattern of zonation from saline to freshwater vegetation is evident in many of these wetlands, from the seaward mudflats to the landward terrestrial edge. Estuarine wetlands are relatively well-represented in the Tamaki Ecological District, however the Henderson Creek wetlands are the only ones containing intact zonations from saltwater to freshwater vegetation, according to Julian *et al.* (1998). These habitats are of particular importance to native fish, which utilise such vegetation cover at the interface between salt water and freshwater to spawn. In addition, wetland habitats as a whole are nationally rare, with as little as 10 % remaining relative to their former (pre-European) extent due to drainage and land reclamation. Hence the protection and enhancement of wetland remnants is regarded as a priority.

Rarity and Diversity

No rare terrestrial flora or fauna is known from the survey area. The ecological diversity of the area as a whole is moderate, as it is in a transitional zone between estuarine and freshwater habitats.

Size, shape, buffering and connectivity

The quality of vegetated areas in the Henderson Creek survey area is poor in terms of its size and shape, as it is long, narrow, and poorly buffered. However, the area still forms an important connective link between the Waitemata Harbour and the forested Waitakere Ranges.

Long-term viability and management input

Henderson Creek requires active management to maintain long-term viability, including weed control, rubbish management, restoration of degraded areas and animal pest management. However, saltmarsh and estuarine vegetation is relatively resistant to weed invasion because of the specialised adaptations needed to survive in a saline environment, and are also less accessible to predators. Hence, restoration and maintenance of a healthy, intact, weed and predator free vegetation buffer is the key management requirement for these areas.

3. Aquatic Resources

3.1 Introduction

There are two components to the assessment of aquatic resources in Henderson Creek as it is a tidal system. These are the fresh water and estuarine areas of the creek.

3.2 Freshwater Quality

3.2.1 Introduction

This section of the report provides an overview of the water quality of the Opanuku and Oratia Streams. The quality of the freshwaters flowing into Henderson Creek is an important factor determining in part the overall ecological health of the aquatic ecosystem in the creek and also the perceived quality (aesthetics) of the creek.

3.2.2 Water Quality Information

There is a variety of water quality data for the Opanuku and Oratia Streams. The Auckland Regional Council (ARC) has monitored water quality in the Opanuku Stream for over 20 years. Auckland Regional Water Board (ARWB) (ARA 1982) reported on the water quality in the stream for the period 1977 – 1982. The early ARWB sampling was carried out at Candia Road. ARC (1993) reported monitoring data at this site for the period 1986 – 1991. Subsequent monitoring between 1993 and 1994 was reported by ARC (1995). The Oratia has been sampled as part of various investigations. Sampling was carried out in 1997 as part of a joint University of Auckland/Kingett Mitchell (Foundation for Research Science and Technology (FRST) (Kingett Mitchell (1999) study carried out in relation to microbial diversity in the Oratia Stream.

WCC have recently obtained further water quality data from the lower Opanuku and Oratia Streams. This work which is at the time of preparing this report being assessed as part of a component of the WCC Comprehensive Urban Stormwater Management Action Strategy.

Table 3.1 summarises ARC monitoring data for the period 1993-1999 for the Candia Road side on the Opanuku Stream. Table 3.2 provides a summary of data collected from the Oratia and the Opanuku in more recent sampling.

3.2.3 Conductivity

Conductivity is a measurement used to determine a number of applications related to water quality and provides an indication of the amount of dissolved solids in water. The measure provides information on the basic natural and man-made ionic changes in the stream water.

Table 3.1: Auckland Regional Council monthly water quality data from the Opanuku Stream monitoring site 1993-1999 (all units g/m^3 unless otherwise stated).

Parameter	Stream	No.	Mean	Median	Min	Max	Guidelines
Conductivity (mS/m)	Opanuku	58	14.31	14.15	10.1	28.4	NA
Suspended solids	Opanuku	58	-	4.6	0.6	29.0	110-175*
Turbidity	Opanuku	58	7.81	5.0	1.6	43.5	
Biological Oxygen Demand	Opanuku	58	1.24	1	1	5.3	NA
Dissolved Oxygen	Opanuku	57	9.55	9.55	1.7	11.9	6
Dissolved oxygen (%sat)	Opanuku	42	93.88	94	80	111	80-100
Nitrate/nitrite N	Opanuku	57	0.187	0.177	0.01	0.62	NA
Ammoniacal N	Opanuku	58	0.027	0.021	0.003	0.22	20-30**
Dissolved Reactive Phosphorus	Opanuku	56	0.015	0.012	0.005	0.04	NA
Total phosphorus	Opanuku	56	0.052	0.04	0.02	0.34	NA
pH (unitless)	Opanuku	58	-	7.4	6.8	7.8	6.5-9.0
Faecal coliforms (MPN)	Opanuku	57	-	800	49	54000	NLU

Note: Data provided by ARC Environment.
NA = no guideline available
* values taken from Rowe et al (1999) draft report.
** value taken from ANZECC (1992).

Changing conductivity can have a number of effects on waterways. These changes vary from having physiological effects on plants and animals to causing “mineral tastes” in drinking waters and corrosion or encrustation of metallic surfaces in direct contact with the water.

The conductivity of both the Opanuku and Oratia is relatively low and typical of rural streams in New Zealand (see Close & Davies-Colley 1990). Long-term conductivity data indicates that the conductivity varies through the year depending on stream flow and as such, is typically higher in summer when flows are lower.

New guidelines for nitrate and phosphorous for preventing undesirable biological growths are currently being drafted. These guidelines are site specific and require a detailed analysis of a streams hydrograph and water temperature record. Providing a guideline for nitrate and phosphorous are therefore beyond the scope of the current investigation.

3.2.4 pH

pH is a term used to indicate the alkalinity or acidity of water. At pH 7 the concentrations of H^+ and OH_- are the same and the water is referred to as being neutral. Below pH 7, the water is termed acidic and above pH 7 alkaline. Changes in pH can have effects on many chemical and biological processes in water. Most freshwater organisms prefer a pH range of 6.5-8.0. Outside of this range, the diversity of stream life can be reduced due to associated physiological stresses and also reproductive inhibition.

Changes in stream pH can result from natural processes and other inputs including wastewater discharges and rainfall (e.g., which may be acidic). pH also varies in water as function of natural processes and typically a diurnal fluctuation occurs as a result of the photosynthesis and respiration of aquatic plants. As a result, pH tends to increase in the afternoon in summer.

pH in the Opanuku Stream is typically near neutral but has varied between 6.7 and 7.8 at times. Recent sampling (Table 3.2) produced similar data for the Opanuku and Oratia.

3.2.5 Dissolved Oxygen and BOD_5

Dissolved oxygen (DO) is a critical factor in determining the overall quality of stream systems as oxygen is required for metabolism in aerobic organisms. Dissolved oxygen concentrations can fall in nutrient rich waters due to increased biological oxygen demand (the consumption of oxygen by decomposing organic matter), through chemical oxidation and decomposition. As dissolved oxygen concentrations in water drop, aquatic life can be put under stress. The lower the concentration, the greater the stress with organisms either having to move away or die. Healthy aquatic environments generally have a dissolved oxygen saturation of between 80-100%.

The summary of more recent ARC data for the Opanuku Stream presented in Table 3.2, shows that the DO concentration is typically high but has at times been recorded at low concentrations. Dissolved oxygen saturation has averaged 94%. This is similar to the % saturation data presented in earlier reports (ARC 1992, 1995). The saturation has occasionally been recorded below 80%. Table 3.2 also shows that in other spot sampling carried out during 1997 and 1999, the dissolved oxygen concentrations in the Oratia and Opanuku Streams have been relatively high.

Biological oxygen demand (BOD) is an important indicator of water quality. Elevated BOD levels can result in oxygen depletion. Data indicates that the Opanuku Stream waters contain relatively low concentrations ofBOD(~1 g/m^3). On a small number of occasions, the BOD concentrations were recorded up to 5 g/m^3. Examination of earlier data (e.g., ARC 1992, 1995), suggests that such excursions were infrequent.

Table 3.2: Recently collected water quality data for the lower Opanuku and Oratia Streams (all data g/m^3).

Stream	Sampling location	Sample	pH	Conductivity (mS/m)	DO (g/m^3)	*E. coli*	*TSS* (g/m3)	*Total Ammoniacal -N* (g N/m3)
Oratia	Henderson Shops	15.10.99	7.7	17.7	10.1	580	6	0.005
		10.11.99	7.2	16.8	8.4	2400	5	0.005
		19.11.99	7.3	16.7	9.1	2400	6	0.030
		11.11.97	NR	15.5	10.7	NR	4	0.030
Opanuku	Henderson Valley Road	19.10.99	7.7	13.2	10.6	200	21	0.005

Note: NR = no result.

3.2.6 Suspended Solids and Water Clarity

Suspended solids consist of any particulate matter suspended in the water column. They generally consist of a predominantly inorganic component consisting of silts, clays etc., and also an organic component of algae, zooplankton, bacteria and protozoa and detritus carried to the stream by overland runoff or by growth of organisms within the stream. This material contributes to the cloudiness or turbidity of the water. Waters with high suspended solids concentrations are generally obvious because of the muddy appearance.

There are a wide variety of factors affecting the concentrations of suspended solids in waterways. Local activities within the stream and erosion typically have the most significant local influence. Catchments or parts of catchments with erosion resistant geology and good cover of vegetation generally have low suspended solids concentrations in their waterways. Elevated concentrations of suspended solids have a wide range of potential effects in waterways including smothering of benthic fauna, effects on plant photosynthesis and aesthetic quality of the stream waters.

Data for the Opanuku Stream (Table 3.1) shows that the suspended solids concentration has had a median of 4.6 g/m^3 over the period 1993 to 1999. The concentrations have often been low indicating that the water has a relatively high clarity at times. Turbidity had a median value of 5.0 NTU over the same period. This suggests that the clarity may not as good as the suspended solids data suggests due to relatively high levels of fine particulates in the water. ARC (1995) indicates that the long term median turbidity in the Opanuku is 7 NTU; supporting the hypothesis that clarity is not that high. ARC (1995) provides data on black disc measurements taken in the Opanuku. Median Black Disc distances were 1.5 m. This compares with a median turbidity of 2.4 NTU and a Black Disc reading of 2.9 m in the Cascades Stream in the Waitakere ranges.

3.2.7 Ammonia

Ammonia is a reduced form of dissolved inorganic nitrogen most common in agricultural wastewaters and sewage. Ammonia can exert toxic effects on aquatic organisms as the un-ionised form is toxic. However under most conditions the un-ionised form makes up only a very small percentage of the total ammonia present. As such, the concentration of total ammonia has to become quite high before it exerts chronic or acute toxic effects. The United States Environmental Protection Agency (USEPA) (1998) chronic criteria at pH 7.0 is 3.08 g/m^3.

Table 3.1 shows that the median concentration of total ammonia in the Opanuku between 1993 and 1999 was 0.02 g/m^3. This median concentration is well below the USEPA chronic criteria. During this period, the highest concentration measured was 0.22 g/m^3. Historical data (ARC 1982, 1992, 1995) is similar. Concentrations measured in other sampling (refer Table 3.2) are also low.

3.2.8 Nitrate

ARC (1995) indicates that the median concentration of nitrate-N in the Opanuku Stream is 0.17 g/m^3. This concentration is low by comparison with other rural catchments in the region (ARC 1995) but elevated compared to streams draining bush catchments such as the Cascades Stream (median 0.022 g/m^3).

3.2.9 Phosphorus

Table 3.1 identifies that the median concentration of dissolved reactive phosphorus in the Opanuku Stream is 0.015 g/m^3. This concentration is similar to catchments such as the Cascades which have no agricultural influence. It is probable that sediment in suspension or within the stream bed influences the dissolved concentration of phosphorus.

Total phosphorus concentrations are higher than DRP as a result of the presence of phosphorus in suspended solids. As a result, the total phosphorus concentration in the Opanuku Stream is about twice that in the Cascades Stream. This is similar to the turbidity ratio in the two streams.

3.2.10 Metals

A range of trace elements are emitted in urban environments to the air, land and water. The three most common metal contaminants are copper lead and zinc because of their current or historical use in motor vehicles or other sources in urban environments. As a result these elements are commonly used as indicators of contaminants in aquatic environments.

Metals are not included in the ARC routine water quality monitoring at the Opanuku site. Sampling and testing for trace elements has been carried out on at least two occasions in the Opanuku or Oratia Streams. Table 3.3 shows that the concentration of lead has been relatively low and uniform in all samples (at 0.0007 g/m^3); zinc concentrations have also been relatively uniform with a median of 0.0014 g/m^3. Copper concentrations have been somewhat higher ranging from 0.0017 to 0.0665 g/m^3. Concentrations of all three metals are higher than those expected in bush and rural catchments not receiving stormwater runoff.

Concentrations of zinc were all lower that the USEPA chronic criteria for the protection of aquatic life (Table 3.4). Lead concentrations were similar to the criteria. Two of the copper concentrations were lower than the USEPA chronic criteria and two were higher (Table 3.4). It should be noted that the comparison is very conservative as the most appropriate manner to compare receiving water metal concentrations with the criteria is to measure the concentration of dissolved metals.

Table 3.3: Trace element concentrations in the lower Opanuku and Oratia Streams (all data g/m^3).

Stream	Sampling location	Sample	Cu	Pb	Zn
Oratia	Henderson Shops	15.10.99	0.0020	0.0007	0.012
		10.11.99	0.0665	0.0008	0.016
		19.11.99	0.0265	0.0008	0.017
Opanuku	Henderson Valley Road	19.10.99	0.0017	0.0005	0.010

Table 3.4: Summary of USEPA water quality guidelines for key metals (all data mg/m^3).

Parameter	USEPA (1986) Hardness = 25 g/m^3	
	Acute	**Chronic**
Copper	4.8	3.6
Lead	14	0.54
Zinc	36	33

3.2.11 Bacteria

A range of bacteria are present in fresh waters. These are derived from a wide variety of natural and man-made activities. Bacteriological indicators are generally used to indicate the risk of faecal contamination in waterways. The presence of faecal contamination is an indicator that a potential health risk exists for individuals exposed to the water. Faecal coliform bacteria generally occur in waterways as a result of domestic sewage seepage and overflows or non-point sources of human and animal waste.

Long term faecal coliform numbers in the Opanuku have been identified as 800/100 mL (Table 3.1) and this median is similar to that identified by ARC (1995). Recent sampling (on behalf of WCC) in 1999 found elevated numbers of E. coli in the Oratia stream.

Bacteriological indicators are generally used to indicate the risk of faecal contamination in waterways. While a number of different indicator organisms have been used in the past, *E. coli* is now the preferred indicator of fresh water microbial contamination (MfE 1999).

The acceptable running median of less than 126 *E. coli*/100mL is set for the safety of recreational users of fresh waters. 273 *E. coli/*100mL is the level prescribed as Alert Mode II which would require a sanitary survey to report on sources of contamination along with daily sampling.

Data collected recently by Kingett Mitchell and Associates in the Oratia Stream adjacent to the Henderson Creek shops indicates that e-coli levels are very high and exceed the new MfE guidelines for contact recreation.

3.2.12 Overview

The water quality information available for the Opanuku (at Candia Road) although well above Henderson Creek provides general information about the quality of fresh waters entering the creek. The following points can be made about the available data:

- pH was within the expected range for natural freshwaters.
- DO was at or near saturation.
- *E. coli* counts indicate significant levels of bacterial contamination.
- Metals concentrations were generally low but still indicative of contributions from sources such as stormwater runoff from roads. High concentrations of metals in stream sediments can reduce invertebrate species richness and can bio-accumulate in fish.

3.3 Freshwater Biological Resources

3.3.1 Habitat Quality in the Lower Oratia and Opanuku Streams

Benthic macroinvertebrate community structure and health are influenced by in-stream habitat and water quality (e.g., Stark 1993). To help with the interpretation of macroinvertebrate data, a range of other information such as in-stream habitat, channel characteristics, algae and riparian zone characteristics are utilised. Habitat characteristics assessed included water depth, substrate composition water velocity, algal cover, channel and riparian zone characteristics. Habitat data was collected according to the protocol described in Suren *et al* (1998) and involved sampling across 5 transects evenly spaced within the 100m long study reach in the Oratia and Opanuku Streams. Table 3.5 summarises the physical habitat conditions present at each site.

Table 3.5: Summary of habitat conditions at each site.

Site	W (m)	D (m)	Vel (m/s)	Channel Form
Opanuku	5	0.4	slow	pools/runs/riffles
Oratia	8	0.5	slow	pools/runs

The stream bed substrate at the site investigated on the Opanuku was dominated by large cobbles overlaid with silt. Downstream of Great North Road the stream bed is dominated by bed rock and silt. The stream bed substrate at the site investigated on the Oratia was dominated by bed-rock and silt. The substrate conditions in the lower reaches of these streams is likely to be limiting the diversity and abundance of the benthic invertebrate and fish communities, along with water quality.

Stream bank and channel heterogeneity and roughness which are key determinants of habitat quality and biological resources in urban streams was high at the Opanuku site and moderate at the Oratia site. Stream bank and channel heterogeneity in the Opanuku Stream downstream of Great North Road is reduced to ‘moderate’ levels and reflects the degree of impact that urban development has had on the riparian zone and stream banks.

Organic substrate provides habitat for invertebrates and fish as well as food for invertebrates. Coarse organic debris (woody matter etc.,) and submerged macrophytes were rare at the Opanuku and Oratia Stream sites. Low levels of coarse organic material and macrophyte cover is consistent with the flood prone nature of the lower Opanuku and Oratia Stream and reduced riparian vegetation.

3.3.2 Sampling Benthic Invertebrates

A single macroinvertebrate sample was collected from the Opanuku Stream from immediately upstream of Great North Road (see November 1999 data in Table 3.6) to provide a qualitative assessment of the species present at the site. The sample was collected from riffle/run habitat where diversity and density is considered to be the greatest (Pridmore & Roper 1985). The sample was collected from an area of stream that is consistent with the physical parameter range suggested by Stark (1993) and was comparable to a site on the Oratia Stream previously investigated by Kingett Mitchell (University of Auckland/Kingett Mitchell, Unpublished FRST research).

The sample was collected using a kick net technique by agitating the substrate for a period of 60 seconds. Macroinvertebrates that were dislodged were collected in a triangular sweep net (mesh 0.25 mm) positioned immediately downstream of the area of disturbance.

The sample was preserved in ethanol and the macroinvertebrates later identified and enumerated to a level that would allow the calculation of environmental quality indices.

The invertebrate data collected during the current investigation was added to data collected from various sites on the Opanuku and Oratia Streams in October 1999 and December 1997. This data serves as a useful comparison for data collected in the lower Opanuku as part of the current investigation.

As well as descriptive analysis, a range of ecological indices were employed in the examination of the macroinvertebrate data. These are summarised in the information box on the following page.

3.3.3 The Invertebrate Community of the Opanuku and Oratia Streams

Raw macroinvertebrate data collected from the lower Opanuku Stream site is summarised in Appendix B. A total of 933 invertebrates representing 11 taxa were collected from the streams. The invertebrate community was dominated by water and habitat tolerant taxa including chironomids, *Potamopyrgus* sp. (snail), oligochaete worms and shrimps (*Paratya* sp.).

The ‘health’ of a stream can be expressed as single numbers (indices values) which help describe features of the invertebrate community such as diversity (taxa number), total abundance, abundance of pollution sensitive taxa and community similarity. A range of indices values, calculated for the invertebrate community sampled at the lower Opanuku Stream site during the current investigation and from sites throughout the Opanuku and Oratia Streams in recent investigations are presented in Table 3.6 and Table 3.7.

Ecological Indices

Taxa Richness. This is simply a measure of the number of types of macroinvertebrates present in each sample. As a rule-of-thumb, the "richer" a community, the "healthier" the in-stream environment.

Abundance. Abundance measures the total number of macroinvertebrates found in each sample. Abundance is naturally highly variable but is also correlated with the health of the in-stream environment. In extremely degraded environments the total number of macroinvertebrates tends to be lower than in higher quality environments. However, this cannot be taken as a hard-and-fast rule, and depends to a large extent on the type of species in the community.

Macroinvertebrate Community Index. (MCI) (Stark 1985). This index is a measure of organic pollution within a stream. Taxa are allocated sensitivity scores between 1 and 10 based on their pollution tolerances. MCI scores can be used to describe the 'health' of a stream in the following manner. A score < 100 indicates gross enrichment, between 100 to 120 slight - moderate enrichment, and > 120 a pristine environment. MCI scores are calculated as:

Quantitative Macroinvertebrate Community Index (QMCI) (Stark 1985, 1993). The QMCI is based upon the relative sensitivity of the different invertebrate taxa to changes in water quality. The QMCI score represents a community-based index of environmental quality, with higher QMCI values indicating better environments. A score < 4 indicates probable severe pollution, between 5-6 indicates doubtful quality or possible mild pollution, and > 6 indicates clean water.

Urban Community Index (UCI) and Quantiative Community Index (QUCI) (Suren *et al* 1998). These indices were specifically developed for assessing invertebrate community health in urban stream habitats. UCI and QUCI scores are calculated in a similar manner to MCI and QMCI scores but use sensitivity scores for invertebrates that are relevant to urban stream water and habitat quality.

EPT (Ephemeroptera - Plecoptera - Trichoptera) Taxa Richness. EPT's are sensitive to changes in water and habitat quality. In general the number of EPT taxa correlates to water and habitat conditions and therefore provides a good indication of environmental quality.

EPT Ratio. The EPT Ratio is calculated by determining the proportion of the combined total abundance of ephemeroptera, plecoptera and trichoptera in a sample. Generally the higher the proportion of EPT's the better the quality of the habitat.

Margalef's Index. Margalef's Diversity Index is a measure of the evenness of a community (Winterbourn 1981) i.e., the extent to which all types of organisms are equally represented in the community. In general the more even the community the healthier it is.

% Dominant Taxa. This is a measure of the dominance of the single most abundant taxa. The dominance of a single taxa is a measure of the tolerance of an invertebrate community to degraded water and habitat quality and is expected to increase with reduced water and habitat quality.

Table 3.6: Summary of benthic invertebrate data collected from the Opanuku Stream.

	KMA October 1999			KMA November 1999
	Upper Opanuku	Middle Opanuku	Lower Opanuku	Lower Opanuku
Abundance	244	659	509	933
Taxa No.	23	15	10	11
EPT taxa No.	14	3	0	2
EPT ratio	0.8	0.0	0.0	0.0
MCI	122	79	72	78
QMCI	6.6	3.0	3.8	3.1
UCI	18.1	11.1	-4.8	7.5
QUCI	1.4	0.6	0.0	0.1
Margalefs	4.0	2.2	1.4	1.5
Dominant taxon	Mayfly	midge	snail	midge
% Dominant taxon	25	51	84	88

Table 3.7: Summary of benthic invertebrate data collected from Oratia Stream.

	KMA October 1999			KMA December 1997
	Upper Oratia	Middle Oratia	Lower Oratia	Lower Oratia
Abundance	226	154	428	492 ± 192*
Taxa No.	18	20	9	4 ± 2*
EPT taxa No.	8	10	2	4.0
EPT ratio	0.65	0.44	0.01	0.02 ± 0.01*
MCI	130	111	74	70 ± 2*
QMCI	7.0	5.3	3.3	3.1 ± 0*
UCI	16.8	18.3	8.3	6.5
QUCI	0.8	1.1	0.1	1.0
Margalefs	3.1	3.8	1.3	0.5
Dominant taxa	mayfly	beetle larvae	midge	midge
% Dominant taxon	30	23	45	80

Note: * denotes means ± 1 standard error.

The invertebrate data summarised in Table 3.6 and 3.7 shows that there is steady decline in invertebrate community health from the forested headwater sites downstream. Downstream changes in the invertebrate data collected in the Opanuku and Oratia Streams include:

- Increased invertebrate abundance.
- Decreased taxa richness, EPT taxa richness and EPT ratio scores.
- Decreased community indices (MCI, QMCI, UCI and QUCI) scores.
- Decreased diversity (Margalef’s).
- Shift from a mayfly to and chironomid dominated community.
- Increased % dominance scores.

These changes are related to a decline in riparian and in-stream habitat quality, as well as water quality, associated with the downstream progression from forested to horticultural to industrial to urban land uses. The cumulative effect of these changes is most pronounced in the lower sections of the Oratia and Opanuku Streams where the in-stream habitat and water quality is limiting the benthic invertebrate community. Benthic invertebrates are an important source of food for fish species, hence reductions in invertebrate diversity, abundance and changes to species composition limit the resources available to fish populations.

3.3.4 Fishery

A mixture of G-minnow traps and mini fyke nets were set overnight to assess native fish species at 4 locations within the lower Opanuku and Oratia Streams. Nets were set in pools close to the bank and concentrated in the section of streams that are influenced by the tide, where fish diversity and abundance can be expected to be highest. Captured fish were identified and returned to the water unharmed.

Fish Species Present

A total of 5 fish species were recorded during the current investigation. A New Zealand Freshwater Fish Database (NZFFD) search located 57 records from the Oratia Stream and 30 records for the Opanuku Stream. Nine species of fish and freshwater crustacea have been previously recorded in the Opanuku and Oratia Streams. These records (including those from the current investigation) are summarised in Tables 3.8 and 3.9.

Table 3.8: Summary of 'fish' species recorded in the Lower Opanuku Stream.

Species	Current Study	NZFFDB Record	Location
Longfinned eel	-	-	Anamata Stream (4 km upstream) McLeod Stream (3 km upstream) Parekura Stream (8 km upstream)
Shortfinned eel	√	√	Opanuku Stream (1 - 4 km upstream) Ananmata Stream (4 km upstream)
Common bully	-	√	Stoney Stream (7 km upstream) Opanuku Stream (4 km upstream)
Cran’s bully	-	√	Opanuku Stream (3 km upstream) McLeod Stream (3 km upstream) Parekura Stream (8 km upstream)
Banded kokopu	-	√	Anamata Stream (7 km upstream) Henderson Creek (5 km downstream) Waitoro Stream (3 km upstream)
Inanga	√	√	Estuary
Common smelt	-	√	Henderson Creek (5 km downstream)
Red finned bully	-	√	Opanuku Stream (3 – 4 km upstream)
Crayfish		√	Opanuku Stream (3 km upstream) Anamata Stream (4 km upstream) Waitoro Stream (3 km upstream) McLeod Stream (3 km upstream)
Yellow eyed mullet	√	-	Estuary

Data presented in Tables 3.8 and 3.9 show that the fish community in the Oratia and Opanuku Streams are similar. A majority of the NZFFDB records are for sites upstream of the area of interest to the current investigation. The NZFFDB records show that koura, short finned eel, long finned eel and Crans bully are widespread in the Opanuku Stream catchment. Short finned eel, common bully, and koura are widely distributed in the Oratia Stream

The lower Opanuku and Oratia Streams investigated as part of this study provide habitat for a range of native species including juvenile and adult eels, bullies and banded kokopu.

The lower reaches of these streams are also an important migratory pathway for diadromous (obligatory marine phase to life cycle) species such as eels, inanga and banded kokopu. A shallow section of bedrock stream bed on the Opanuku Stream approximately 500 m downstream of Alderman Drive appears to prevent the upstream migration of fish species without the ability to climb (includes common smelt and inanga). No such barrier exists in the lower reaches of the Oratia Stream and inanga and consequently common smelt are found several kilometres upstream.

Table 3.9: Summary of 'fish' species recorded in the Lower Oratia Stream.

Species	Current Study	NZFFDB Records	Location
Longfinned Eel	-	-	Potters Stream (8 km upstream) Oratia Stream (6 km - headwaters)
Shortfinned Eel	√	√	Hibernia Stream (7 km upstream) Bishop Stream (7 km upstream) Oratia Stream (2 – 6 km upstream)
Common bully	-	√	Hibernia Stream (7 km upstream) Bishop Stream (7 km upstream) Oratia Stream (2 km - headwaters)
Cran’s bully	-	-	Oratia Stream (2 km - headwaters)
Banded Kokopu	-	-	Hibernia Stream (7 km upstream) Oratia Stream headwaters
Inanga	√	-	Oratia Stream (0 – 6 km upstream)
Common Smelt	-	-	Oratia Stream (2 km upstream)
Red finned Bully	-	-	Oratia Stream (6 km upstream)
Torrent fish	-	-	Oratia Stream (6 km - headwaters)
Cockabully	√	-	Estuary
Crayfish		√	Hibernia Stream (7 km upstream) Bishop Stream (7 km upstream) Cantys Stream (8 km upstream) Oratia Stream (2 km - headwaters)
Goldfish	√	-	Lower reaches

Whitebait Spawning Habitat

The 'whitebait run' in New Zealand comprises the juveniles of the following species:

- Inanga (*Galaxias maculatus*).
- Banded kokopu (*Galaxias fasciatus*).
- Koaro (*Galaxias brevipinnis*).
- Giant kokopu (*Galaxias argenteus*).
- Short jawed kokopu (*Galaxias postvectis*).
- Common smelt (*Retropinna retropinna*).

Of these species, inanga, common smelt, and banded kokopu are known to spawn in estuarine (but still in freshwater) areas. Other species which make up the whitebait run have not been previously recorded in the Opanuku or Oratia Stream catchments.

Whitebait migrate from the sea in late winter early spring (August-October). These fish penetrate upstream to feed and grow throughout the summer. In late summer early autumn mature whitebait migrate downstream to the estuary to spawn. Spawning takes place amongst streambank vegetation near where the river is tidal freshwater. Spawning occurs on the peak of the spring tides. Larvae hatch on the spring tides the following month and are swept out to sea before returning as juvenile whitebait the following autumn.

A brief visual assessment of potential whitebait spawning sites indicated that there were a number of areas that have some potential as whitebait spawning habitat. Features of these areas include:

- Zone or interface between salt and freshwater.
- Plant species that are characteristic of such zones (e.g. *Carex, Fescue, Festura, Lotus* and *Paspallum*). Prime areas are where vegetation is protected from mowing and human disturbance.

These areas have been identified in Fig. 2.1.

3.3.5 Ecological Significance

3.3.5.1 Habitats

The riparian vegetation and in-stream habitat conditions in the lower Opanuku and Oratia streams have been highly modified by urban development. However the lower reaches of both streams continue to provide habitat for valuable aquatic biological resources.

3.3.5.2 Benthic Invertebrates

Despite the degraded nature of the benthic invertebrate community in the lower Opanuku and Oratia Streams the invertebrate community is a significant part of the health of the stream ecosystem including providing food for fish species.

3.3.5.3 Native Fish

The lower reaches of both streams provide habitat for juvenile and adult native fish species as well as been important migratory pathways for diadromous species. The tidal limits within several tributaries in the area appear to have some potential to support whitebait spawning. If this is shown to be the case this would significantly increase the ecological significance of the area in terms of its ability to sustain native fish populations.

3.4 Estuarine Resources

3.4.1 Introduction

Henderson Creek is principally intertidal, meaning that it comprises the zone where a freshwater body meets the tidal cycles and saline conditions of the sea. Estuaries are highly productive environments, as they trap sediment and concentrate nutrients carried downstream from the catchment area. Many native fish species also utilise the saline gradient extending up intertidal areas as a guide to suitable spawning sites.

The upper limit of salt-tolerant vascular plants such as mangroves, oioi and searush along the shoreline indicates the upper reaches of the estuarine area. Within Henderson Creek these plants extend from the estuary mouth (beyond the confluence of Henderson and Huruhuru Creeks, to Waitemata Harbour) upstream to Chilcott Road in Waitakere City (see Fig. 2.1a).

3.4.2 Habitats

Overview

The estuary and intertidal zone may be broadly subdivided into two regions, based upon shoreline vegetation. The lower estuary is fringed with dense stands of mangrove. South (upstream) of the Sherwood Avenue residential development (see Fig. 2.1c), mangroves are replaced by salt marsh species (predominantly oioi and searush), although occasional mangrove seedlings and stunted trees may be found almost to the limit of the intertidal zone. Extensive mud embankments visible at low tide throughout much of the study area.

Mangroves

Mangroves occur in tropical to warm temperate regions throughout the world. In New Zealand, mangroves are found on coastlines north of Opotiki (Chapman & Ronaldson 1958). Mangroves thrive on estuarine banks, as they are tolerant of freshwaters, but do not establish well on exposed shorelines (Levinton, 1995). Waitakere City is flanked by the Waitemata and Manukau Harbours, both of which are large, muddy, slow flushing harbours with extensive mangrove forests.

In Henderson Creek, mangrove swamps are best developed between the North-Western Motorway and Central Park Drive bridges. These mangroves possess a fairly typical estuarine fauna, with a variety of molluscs, worms and crustaceans. Pneumatophores are frequently covered with small barnacles (*Elminius modestus)* and other encrusting organisms, while populations of the mud snail *Amphibola crenata* are present in shaded areas.

In the lower estuary, where mangrove density is at its peak, a dense understorey of smaller mangroves and seedlings is present beneath the fully grown mangroves. This vigorous recruitment indicates a healthy mangrove population and optimal mangrove habitat.

Mangrove populations become progressively more sparse with distance upstream as the saline influence declines, giving way to saltmarsh, with only scattered seedlings and stunted mangrove trees south of Quiet St (Fig 2.1b).

Saltmarshes

Saltmarshes develop in saline areas where there is significant freshwater input, such as stream outflows, often forming a band along the landward margin of mangrove forests where surface water runoff and groundwater seepage dilutes the seawater.

Extensive salt marshes are present within Henderson Creek (saltmarsh composition is discussed previously in Section 2 of this report). The best example of a raised salt marsh in Waitakere City occurs within Henderson Creek just north of the north-western motorway, opposite the Concourse light industrial area (Hayward *et al.* 1999, Kingett Mitchell 1999), however this site was not included in the study area. Two significant stands of salt marsh were noted within the study area (see Priority Restoration Sites A & B in Fig 2.1a, 2.1b). Salt marsh vegetation in Henderson Creek extends upstream to the Chilcott Road residential development, although occasional, sparse clumps of oioi were noted in Opanuku Stream, directly beneath Alderman Drive.

Mud Flats and Embankments

The banks of Henderson Creek are lined at low tide by mud embankments and flats, reaching in excess of 1 m high in upper intertidal areas. These muddy habitats support high invertebrate populations, which provide an important food source for fish and shorebirds.

Sampling of the biota of mud embankments within the present study area was undertaken as part of a study of the effects of stormwater on estuarine environments for Waitakere City (Kingett Mitchell 1999). Samples recorded 19 species of invertebrates, but were dominated numerically by a small estuarine snail *Potamopyrgus estuarinus*, which was present in mud embankments and flats throughout the study area. A burrowing crab (*Helice crassa*) is another common component of this community, particularly adjacent to mangroves. Both these species are typically abundant on mud flats in brackish waters throughout New Zealand (Gunson 1983).

3.4.3 Ecological Values

General Assessment

The ecological significance of the estuarine and intertidal resources of Henderson Creek was evaluated with respect to several studies of these habitats undertaken in the last thirty years (Larcombe 1973, Knox 1983; Hayward *et al.* 1999; Kingett Mitchell 1999).

The most valuable ecological function of this and surrounding estuaries is as a depositional area for land-derived sediments, preventing them from being carried further into Waitemata Harbour. These nutrient rich tidal flats provide organic material for deposit-feeding invertebrates, and in turn for juvenile fish, and thus play an important role in the wider ecology of Waitemata Harbour (Larcombe 1973).

The intertidal margins of Henderson Creek have for the most part been heavily modified as a result of intensive urbanisation (Larcombe 1973). In several locations residential development has occurred nearly up to the edge of the channel, leaving only a very narrow buffering strip of saltmarsh vegetation (Fig. 2.1). Substantial areas of wetland have also been filled in and developed. Numerous outfalls discharge contaminant and debris-laden stormwater into Henderson Creek (Fig. 3.1). Anecdotal observations, along with informal discussion with local residents, suggest that the extent of the rubbish and debris visible along the banks of Henderson Creek is one of the major impediments to improving the amenity value of the area.

Benthic Macroinvertebrates

Overall, macroinvertebrate species diversity at the sites examined in Henderson Creek was relatively low in comparison to rural sites examined near Whenuapai and in Manukau Harbour (Kingett Mitchell 1999). Only 3 of the 19 polychaete species recovered from the rural sites were found adjacent to the stormwater outfalls examined within Henderson Creek (Fig. 3.1). Similarly, bivalve and crustacean diversity was also lower at these sites. The oligochaete fauna was, however richer at these sites, with 4 additional species recovered. The estuarine snail *Potamopyrgus estuarinus*, the most abundant member of the fauna within the Henderson Creek sites, was not recovered from any of the rural samples collected. However, this is more likely to be due to salinity differences rather than habitat quality.

Kingett Mitchell (1999) also examined macroinvertebrate populations in Huruhuru Creek, an adjacent tidal stream with a similar level of urbanisation and development to Henderson Creek. The two estuaries contained a biota of similar diversity, however the key difference between the Huruhuru and Henderson Creek sites was the complete absence of oligochaetes from Huruhuru sediments. Oligochaete worms often occur in areas of degraded estuarine sediments, and provide a broad indication of reduced habitat quality in Henderson Creek.

Henderson Creek estuary is of relatively low quality and diversity compared to other estuaries in the vicinity, which appears proportional to the degree of development surrounding it. However the area still has a sizeable invertebrate population, and hence still provides a significant resource to birds and fish.

Fig. 3.1: Stormwater outfall site (located adjacent to Priority Restoration Site A).

Sediment Quality

Estuaries have a naturally high sedimentation rate due to reduced wave action combined with high freshwater inputs. A consequence of the high depositional environment is that it can serve to trap into the substrate any contaminants liberated into this nutrient-rich environment (Morton & Miller 1968).

Kingett Mitchell (1999) examined contaminant concentrations in the sediments at several rural and urban estuarine sites within Waitakere City, including two sites adjacent to stormwater outfalls within the Henderson Creek study area (in the vicinity of Epping Esplanade Reserve). Overall sediment quality (in terms of three heavy metals examined) was poorer in urban sites than in rural estuarine sites. Concentrations of copper, zinc and lead at the Henderson Creek sites were marginally above the

Canadian guidelines (CCREM-ISQG) for marine sediment quality. This suggests that the elevated contaminant levels (likely due to input from contaminant-laden stormwater discharge) may have the potential to contribute to adverse effects on benthic fauna present in the creek sediments.

4. Avifauna

4.1 Field Investigation

A variety of methodologies were utilised to assess bird species inhabiting the environs of Henderson Creek; depending on the particular species and habitat these included:

- Standardised five minute transect counts (as specified by Dawson & Bull 1975).
- Fixed point scans to assess wetland and coastal bird populations.
- Taped luring for cryptic bird species.

Given the limitations (such as seasonal abundance and/or conspicuousness) of evaluating bird populations based on limited field data, existing information on the avifauna of the survey area was reviewed prior to the field investigation. Accordingly, the assessment of Henderson Creek avifauna relies also on existing literature on the populations within the Henderson Creek area, the wider Tamaki area and similar habitats throughout the region; and assessment of potential bird habitat types and resources comprising the Henderson Creek area.

4.2 Avifaunal Assemblages

A total of 23 terrestrial and aquatic bird species were detected within the various habitats comprising the Henderson Creek study area during the survey. Of these species, 2 were endemic (occur naturally and breed only in New Zealand), 9 were native (occur naturally in or self-introduced to New Zealand) and 12 were introduced (brought to New Zealand via human agency). A list of scientific names for all species noted in this section is provided in Appendix C.

Tui and grey warbler were the only endemic species recorded. Natives included silvereye, fantail, pukeko, spur-winged plover, white-faced heron, welcome swallow, black shag, little shag and grey duck, while introduced species comprised sparrow, chaffinch, greenfinch, goldfinch, blackbird, song thrush, myna, magpie, yellowhammer, starling, mallard and feral goose. None of the species detected have been assigned a priority rank by the Department of Conservation (Molloy & Davis 1994) in respect of threatened species which “require urgent assessment for conservation action”; such priority species are uncommon in urban environments.

Within the areas assessed by 5 minute counts, the relative abundance (level of detection) of bird species reflected habitat characteristics e.g., areas with older more diverse vegetation exhibited higher abundance and species diversity. Modified areas were dominated by common introduced passerine species. Native species were all in very low numbers with the exception of silvereye (self-introduced from Australia); silvereye have a ‘high’ relative abundance within the Tamaki Ecological District (Julian *et al*. 1998). Only one individual of each of the endemic species (tui and grey warbler) was detected; both species are ‘moderately’ abundant within the Tamaki Ecological District (*ibid.*). In both cases, these were found in areas of substantial (though not particularly diverse) native vegetation.

Scans of stream habitats detected nationally ‘common’ native species (grey duck and black shag); grey duck are considered ‘rare’ within the Tamaki Ecological District (*ibid.*). Native species (white-faced heron, spur-winged plover, welcome swallow and pukeko) were also detected; each species is considered of ‘moderate’ relative abundance within the Tamaki Ecological District (*ibid.*) excepting pukeko which are of ‘highly’ abundant. . Introduced species included mallard and feral goose.

Scans of saltmarsh/swamp areas north of Central Park Drive and mangroves areas south of the northwestern motorway were also undertaken; no bird species were detected. Given that the cryptic characteristics of the species that may potentially utilise such habitats (e.g., North Island fernbird and banded rail) often precludes their detection, ‘luring’ (using taped calls) was undertaken prior to and during dusk. No birds were detected; NI fernbird and banded rail are considered to be of ‘moderate’ and ‘rare’ relative abundance respectively within the Tamaki Ecological District (*ibid.*).

Surveys undertaken within the Henderson area as part of the Protected Natural Areas programme for the Tamaki Ecological District, and for the preparation of a reserve management plan for Tui Glen Reserve noted the presence of kingfisher, kereru (NZ pigeon), shinning cuckoo, eastern rosella, red-billed and black-backed gulls, rock pigeon and black swan. Of these, the only species of ‘low’ relative abundance within the Tamaki Ecological District is kereru.

Additional species undetected, but potentially utilising the study area, include dunnock, redpoll, California quail and little black shag.

4.3 Assessment of Significance

The abundance, species richness (i.e., the number of species) and composition (e.g., ratio of natives to exotics) of avifauna within the study area reflects the generally poor quality of the habitat in terms of provision of feeding, nesting and roosting resources. Despite this, the quality and diversity of specific areas does enable utilisation by significant numbers of birds (including some native species) compared to other urban environs. The predominance of highly modified areas and the presence of weeds and predators promotes the high proportion of introduced birds (both in terms of high numbers of individuals and species) and the paucity of endemic species.

In terms of provision of feeding, nesting etc., resources for bird species, key habitat requirements are vegetation diversity, structure and health. Accordingly the most significant bird habitats (actual and potential) within the study area are generally congruent with priority areas of vegetation identified in Fig. 2.1. With regard to habitat for terrestrial endemics, no significant areas of native scrub or forest exist within the study area.

Although not observed during the current survey, kereru have previously been recorded within the study area (i.e., Tui Glen; Landscape Architects 1995); this species is the only species detected that has been assigned a priority conservation rank (category B) by the Department of Conservation (Molloy & Davis 1994).

5. Lizards and Terrestrial Invertebrates

5.1 Field Investigation

5.1.1 Lizards

Survey technique followed that of Whitaker (1994) and involved assessment of likely lizard habitat using a three-point strategy.

1. Potential sites were scanned with binoculars (during the day) or spotlighted (at night) from a distance to detect active lizards.

2. The site was then approached cautiously, looking for any movement from disturbed lizards.

3. At the site, potential refuges were examined.

Refuges that were searched included under stones and logs, beneath loose bark or hanging vegetation, within cracks in clay banks, within accumulations of deep leaf litter and under dense ground vegetation. Gross estimates of lizard density are provided as the number of individuals seen or caught within a specified length of time. Notes were made on habitat quality such as presence of suitable refuges, food sources and habitat size and the presence of exotic predators.

5.1.2 Invertebrates

Terrestrial invertebrates are the most diverse and numerous group of organisms in terrestrial habitats. The range of microhabitats occupied and individual species' habits mean that a comprehensive survey of all invertebrate fauna was not possible within the timeframe of this survey. Indeed, the most comprehensive survey of beetles undertaken in New Zealand was in an urban area (Lynfield, Auckland) and that found nearly

1000 species of beetle over 15 years and estimated a total invertebrate fauna of greater than 3,400 species at that survey site.

The objective of this survey was confined to determining management priorities for the restoration of populations from past and present impacts and focuses on only a small fraction of the total insect fauna. Particular attention was given to ground-inhabiting invertebrate species, especially those which are flightless and therefore have few means of re-colonising habitats from which they have been extirpated. By comparison, flighted species are better equipped to re-colonise disturbed areas of land from adjacent forest fragments.

Assessment of invertebrate fauna concentrated on:

- Overall habitat quality.
- Diversity and representation of ground-dwelling fauna.
- Presence of invertebrate functional groups (size, feeding habit).

In each major habitat type invertebrates were sampled by searching, sweep netting and analysis of leaf litter and soil samples. The short duration of the survey did not warrant the use of pitfalls and intercept traps.

For ground-dwelling invertebrates, a subjective scale was used to categorise the relative abundance of various species:

Abundant present in large numbers in most suitable habitats.
Common present in moderate numbers in about half of suitable habitats.
Rare present in low numbers in few suitable habitats.

5.2 Assessment of Habitat Quality

5.2.1 General

Overall quality of riparian habitat for lizards and invertebrates along Henderson Creek is poor. Over the majority of its length, the creek's vegetation has been severely modified in the past through removal, burning (Flude 1977) and dumping of rubbish and spoil from earthworks. Remnant vegetation is severely fragmented and adventive weeds dominate in most existing forest patches. Five sites (see below; Areas A-E on Fig. 2.1) have been identified as potential habitat for lizards and invertebrates. The following section describes the habitat characteristics and specific features of Areas A-E as they relate to the presence of reptiles and invertebrates. .

5.2.2 East Bank of Henderson Creek

All areas along the east bank of Henderson Creek except that above Tui Glen (Fig. 2.1) has been modified in the recent past, although the remains of abundant privet stumps suggest that habitat quality prior to this was not particularly noteworthy. Much of the riparian margin on the landward side of the walking path is managed grassland that provides little or no suitable habitat for lizards and native invertebrates. Areas between the path and the creek have recently been cleared and re-planted. Most of these areas are currently unsuitable (although improvements could make it suitable) for native lizards or terrestrial invertebrates, primarily for three reasons:

1. **Immaturity of trees and shrubs**. Recent plantings do not provide sufficient shelter or food of fauna - this will improve as trees grow.

2. **Width of vegetation**. Sections of the riparian strip are only 1-2 trees wide, which although providing food for flighted, mobile invertebrates, will probably not allow build-up of leaf litter and refuges or provide safety from predators for lizards or flightless invertebrates. Some recent plantings and adjacent existing vegetation will eventually result in riparian vegetation up to 5m wide. If properly managed this may provide habitat for the aforementioned fauna, but the size of the areas are probably too small to support permanent, reproductively viable populations. Main users of these areas will most likely be flighted invertebrates and transient lizards. If linked to more substantial vegetation patches, these re-planted areas could serve as important corridors to aid in the natural dispersal of invertebrates and lizards from less disturbed and more species-rich habitats nearby.

3. **Lack of habitat complexity**. Ground-dwelling invertebrates and lizards require refuges such as logs, deep leaf litter and natural cavities in trees (such as those caused by rotting or splitting of timbers) as refuges and food supplies, all of which are absent from these sites.

Area E (see Fig. 2.1) encompasses an area of rank grass and scrub between the main walkway and the creek measuring 60m long by up to 20m wide. Privet trees have been recently removed and the site contains scattered patches of native shrubs such as mahoe, karamu and cabbage trees. This area has potential as suitable habitat in the future. Fallen logs left on-site provide good lizard and invertebrate habitat, as does the overgrown grassland. Further replanting of a diverse mix of canopy and understorey native plants and provision of refuges will make this area an important habitat for invertebrates and lizards and corridor for wildlife in general.

5.2.3 Southern End of Henderson Creek (East and West Banks)

Habitat complexity in the upper reaches of Henderson Creek is moderate, containing a relatively diverse native flora. Leaf litter and refuges such as fallen logs are sparse but this can be improved by a number of means (see following sections). Riparian width is moderate (approx 5-10m) but could be increased by retiring parts of adjacent managed grassland along the length of this section of creek (this has already been done in few locations in this area).

5.2.4 Central-Southern Margin of West Bank

The middle reaches of the survey area along the west bank of the creek support a mix of mainly exotic species with little canopy structure, leaf litter or refugia for fauna. Vegetation fragments are generally less than 5m wide and are dissected at frequent intervals to the water's edge by development from adjoining residential or industrial sections. All fragments comprise mostly immature Chinese privet with a few scattered tree ferns and native seedlings, and abundant weeds.

Recent development of residential properties has resulted in destruction of parts of the riparian vegetation, further reducing strip width and increasing opportunities for weeds, and smothering existing soil profiles with construction spoil which appears to be mostly poor quality clays.

5.2.5 Northern End of West Bank

This section comprises riparian margin below the Waitakere Stadium, adjoining disused apple orchards to the north and industrial blocks adjacent to the north-western motorway. This area supports the largest continuous strip of vegetation in the survey area (at least 600-700m long and up to 30m wide) and represents the highest quality habitat for lizards and invertebrates in the survey area.

The riparian strip directly below Waitakere Stadium is bisected longitudinally by a fitness track that splits the riparian vegetation into two separate strips approximately 5m in width, with few understorey plants, and poor leaf litter and refuges for ground-inhabiting fauna. Near the far northern edge of stadium boundary, the running track circumvents two small tributaries entering the creek and in doing so isolates a moderately-sized patch of regenerating scrub (Area C) between the track and the creek. This patch and the vegetation nearby provide ample opportunities for habitat protection an enhancement for lizards and invertebrates, especially if connected to the much larger disused forest and rank grasslands to the north.

Area D comprises a continuous strip of riparian vegetation at the foot of two disused orchards and offers the best habitat for native invertebrates and lizards. Key features include its size (at least 100 m long and 30 m wide), developed canopy structure (upper, middle and lower canopy), the presence of some native vegetation and proximity to a considerably larger area of disused land which may act as a reservoir or corridor for native wildlife from other areas. Riparian vegetation further to the north of this (below the industrial estate) is generally less than 5m wide and is dominated by exotic black wattle and pampas.

5.3 Lizard Fauna

Only two lizards were detected in the survey area. Both were copper skinks (*Cyclodina aenea*), a lizard common in urban Auckland and widespread throughout the North Island. Both were seen in rank grassland and blackberry adjoining area D.

Climatic conditions during search days were near perfect with little or no breeze and sunny weather. Climatic conditions were also favourable for night searching with damp ground and no wind. Many of the survey areas contained thick ground cover of rank grass or weeds and lizards may have been present but difficult to detect. Observation and searches of likely refuges in these areas detected no lizards. Overall, approximately 6 daylight hours and 1.5 night hours were spent searching for lizards.
Historic lizard fauna in the region probably comprised at least 13 species of lizards but successive habitat destruction has reduced this diversity to only three species of lizards now recorded from the central Auckland city area. Copper skinks are resilient to habitat change and parts of Henderson Creek (especially neighbouring residential back yards), including Area D where they were recorded in this survey, probably support healthy populations of them. Moko skinks (*Oligosoma moco*) and common green geckos (*Naultinus e. elegans*), two species also recorded from the central Auckland area, were not recorded at Henderson Creek and their 'absence' is probably due to both the history of high habitat disturbance and current lack of suitable native habitat.

5.4 Invertebrate Fauna

5.4.1 General

All inverterbrates recorded from the study sites are typical of those in Auckland urban areas; no species of national or regional conservation significance were found. Overall diversity of invertebrate fauna, in particular ground-dwelling species most vulnerable to habitat change, was poor and characteristic of an environment which has been severely modified, probably at frequent intervals, in the past.

5.4.2 Sites Sampled

Two sites were selected for sampling of terrestrial invertebrates following the assessment of habitat quality. These were the southern patch of mixed scrub/forest and the northern part of the west bank (Area D). Sites that were heavily modified or that supported immature replanted vegetation were not sampled. Past studies show that such sites are dominated by exotic invertebrate fauna; the majority of native invertebrate biodiversity (such as beetles; Kuschel 1990) is found in native forest patches rather than amenity plantings and managed grasslands.

Much of the sampling was undertaken in Area D because of its greater potential for supporting significant invertebrate fauna than the southern end of the creek. Brief surveys confirmed that invertebrate species found in Area D were also present at the southern end of the creek. General discussion of invertebrate fauna and management recommendations are equally applicable to forest fragments at the southern end of the creek as they are to Area D.

5.4.3 Diversity of Invertebrate Fauna

Generally, species diversity usually increases with increasing habitat complexity. For ground environments, variation in ground cover, micro-topography and refuges creates more niches which can be filled by a wider range of invertebrate species. Likewise, the presence of diverse flora in a layered canopy structure (e.g. ground cover, sub-canopy and canopy) is more capable of supporting a diverse arboreal invertebrate fauna than vegetation comprised of few species all the same height.

All invertebrate species collected from Henderson Creek were typical of Auckland urban habitats. No species are of significant conservation concern either at the national level or the regional level.

Diversity of terrestrial invertebrates at Henderson Creek in forest patches was fair (given the short duration of the survey) at the general taxonomic level (Order and Class; Appendix D), but there were some taxonomic groups noticeably absent from the sites surveyed. The absence of jumping bristletails (Class Archeaognatha) is puzzling as they are a nearly ubiquitous group in forest areas and are generalist feeders, eating a range of flora and decaying plant matter on the forest floor. Likewise, the apparent absence of centipedes (Class Chilopoda; ground-dwelling predators of other invertebrates) suggests that the diversity or abundance of their ground-dwelling prey may be insufficient to support large populations. Other noticeable absentees are the enormous range of large (> 10 mm body length), ground-dwelling beetles such as ground beetles (Carabidae), stag beetles (Lucanidae) and ground-dwelling cave and ground weta (Families Anostomstomatinae and Rhaphidophorinae) that are found in the nearby Waitakere Ranges and in great numbers on predator-free offshore islands. The absence of these species is certainly due to the high degree of historical habitat modification and presence of introduced predators.

Likewise, the distinct lack of widespread foraging damage to soft-leaved native shrubs suggests that scarab beetles (Genus *Costelytra* or *Odontria*), are either absent or present in only very low numbers in both re-planted areas on the east bank and at Area D and its surrounds. These flighted beetles can re-colonised disturbed sites from surrounding forest patches and may act as important pollinators for some native plants, but are vulnerable to introduced predators. Only the remains of a single individual were found at one site.

Sweep netting yielded 19 species of arboreal insect but this will be only a small sub-sample of that which is present because only the lower shrubs could be sampled.

Among ground-dwelling invertebrate collected were large numbers of some groups resilient to habitat disturbance, such as slaters (Order Isopoda), amphipod hoppers, proturans, springails (Order Collembola) and millipedes (Class Diplopoda;Table 5.1). Relative abundance of invertebrates listed in Table 5.1 for this study can be used to compare gross changes in invertebrate populations following management action (e.g. predator control).

The Auckland tree weta (*Hemideina thoracica*) was found in low numbers in Area D. Forage sign on shrubs along the southern banks indicated that tree weta were probably present there also, but night searching was not undertaken to confirm this. Tree weta or their feeding sign was found on only two native shrub species (karamu and hangehange). No sign or individuals were found on similar-sized exotic privet, wattle or other exotic shrub species.

Examination of feeding sign indicated that at least 75% of soft-leaved native shrubs in Area D were not being fed on by tree weta. Since only those shrubs that were abutting dead standing or fallen logs had tree weta on them and showed signs of tree weta foraging it is assumed that a lack of suitable refuges next to feed trees makes these trees inaccessible to the tree weta population. Planted shrubs along the east bank also showed no obvious sign of tree weta or beetle forage indicating that these fragments are inaccessible to or cannot support large populations of tree weta and scarab beetles.

5.4.4 Functional Diversity of Invertebrates

The presence or absence of some invertebrate groups from sites are good indicators of past or current levels of habitat modification and quality of existing habitat. In particular, invertebrates that are large and flightless, and therefore cannot readily re-colonised areas from which they have been removed, make excellent indicators of ecosystem health.

Forest areas at Henderson Creek are almost devoid of ground-dwelling, flightless beetles, arguably the most vulnerable group of invertebrates to habitat change and especially predation by introduced species such as rats. Also, intact, healthy forest ecosystems typically support a wide range of large (>10mm body length) invertebrates which contribute a substantial part of invertebrate biomass and provide food for a range of insectivorous native birds and reptiles.

The only large species found at Henderson Creek were one spider, one moth and the tree weta, despite intensive searching, indicating that habitats have been severely modified in the past, and / or the quality of habitat, including presence of introduced predators, may be insufficient for species to re-establish populations from local sources. Alternatively, habitats at Henderson Creek may currently be able to support some of these large ground-dwelling species but local sources may no longer exist from which individuals can naturally re-colonised Henderson Creek habitats.

Certainly, the presence of tree weta indicates that at least arboreal, large-bodied insects can survive in current habitats in the presence of introduced predators (see next section). Moreover, forest fragments may be suitable for many other, more vulnerable large invertebrate species including ground-dwelling species such as cave and ground weta and ground beetles. Re-introduction of invertebrates should be attempted (see next section) but sites will require predator control if many of these species are to survive and become established.

Table 5.1: Relative abundance of ground inhabiting invertebrate species at southern end and Area D.

Major taxonomic group	Common name	Relative abundance*
Order Protura	Proturans	Abundant
Order Collembola	Springtails	Abundant
Order Gastropoda	Snails (general)	Common
Class Isopoda	Porcellionid slaters	Abundant
Class Amphipoda	Amphipod hoppers	Abundant
Class Diplopoda	Millipedes	Abundant
Class Chilopoda	Centipedes	Rare
Order Opiliones	Harvestman spiders	Rare
Order Araneae	Ground spiders in general	Common
O. Coleoptera	Unidentified beetle	Common on trunks
	Scarabaeidae	Rare
	Carabidae	Rare
	Curculionidae	Rare
O. Orthoptera	Tree weta	Locally common

*see text for definition of abundance categories

6. Animal Pests

The presence of animal pests, such as cats, rats and possums, are likely to be a major variable influencing the diversity and abundance of terrestrial fauna populations, and the health and composition of vegetation. Animal pests are also a potentially serious impediment to the success of restoration efforts via their impact on planted vegetation and fauna populations.

Qualitative observations of terrestrial vertebrate pests during the course of survey work recorded any animals observed, along with signs such as droppings, scratch marks on trees, footprints and bones.

Six introduced mammalian predators of vegetation, lizards, invertebrates and/or other wildlife were recorded from the study area (Table 6.1). Although individuals of each species were not seen in all habitats, it is likely that all species preside in or visit all of the fragments and remnant vegetation patches throughout the survey area.

Table 6.1: Location and diversity of introduced mammalian predators.

Species	Evidence for presence	Location(s) recorded
Brushtail possum	3 individuals, droppings	Southern end & Area C
European rabbit	Droppings, tunnels	Southern end & all west bank
European hedgehog	Droppings	West side of southern end
Cat	2 individuals - domestic	East bank
Rat (prob. *Rattus rattus*)	Skull	Area C
Dog	Live animals - domestic	Throughout survey area

7. Management Issues and Recommendations

7.1 Introduction

The emphasis of this survey and its outputs is on improving the ecological health and viability of areas of riparian vegetation surrounding Henderson Creek. However, the report's recommendations also give consideration to the aesthetic and amenity values of the area, recognising its residential surroundings and associated diversity of uses. Management recommendations include:

- Protection of significant flora or vegetation associations.
- Prioritisation of potential sites for restoration and weed control.
- Habitat enhancement for fauna.
- Facilitation of the development of indigenous vegetation in areas currently dominated by exotic species.
- Monitoring requirements to evaluate the success of management strategies.

7.2 Revegetation

7.2.1 Introduction

Riparian enhancement of Henderson Creek will improve the value of the area as a connective link between the Waitakere Ranges and the coast. While the extent of riparian habitat surrounding Henderson Creek is limited, small vegetation fragments containing appropriate vegetation can act as regional linkages (ecological corridors) for the daily and seasonal movement of bird species, and facilitate natural dispersal and regeneration processes. Improved vegetation quality will also provide better protection against erosion and runoff, and can improve water quality and in-stream habitat.

The following section outlines principles approaches for the enhancement of riparian vegetation in Henderson Creek, both for priority sites, and to achieve the longer term goal of improving the natural values of the entire area.

7.2.2 Priority Areas for Vegetation Restoration

Four sites within the Henderson Creek survey area are identified as priority restoration areas (refer A-D on Fig. 2.1). These areas were selected because they contain:

- Vegetation associations of absolute or relative ecological significance.
- Habitats that contain or are potentially suitable for birds, invertebrates and aquatic fauna.

- An existing buffer of surrounding vegetation, or the capacity to establish one.

A further site, Area E, is also identified as a priority restoration site, however this is due to its suitability as lizard and invertebrate habitat, and contains no vegetation of particular significance. Table 7.1 ranks the value of sites within the Henderson Creek survey area on the basis of the above three characteristics. Areas A-D are described below.

Table 7.1: Prioritisation of riparian margin areas at Henderson Creek for vegetation restoration.

Location	Priority for restoration action
Area D	1 (Highest priority)
Area B	2
Area C	3
Area A	4
Lower reaches of Opunuku and Oratia streams/ upper reaches of Henderson Creek containing mixed forest, scrub and shrubland mosaic	5
Buffering vegetation for the small saltmarsh remnants around stormwater outflows along the east bank	6 (lowest priority)

A. Oioi saltmarsh remnant

Area A is recommended for restoration primarily because it contains a moderately large, intact patch of saltmarsh, which is a habitat of conservation value. It is poorly buffered, with gorse, pampas and abuts a recent housing development. The identified restoration priority for this area is to establish native terrestrial vegetation around the landward side of the saltmarsh. This will restore a complete vegetation sequence from estuarine to terrestrial vegetation, thus improving habitat diversity for fauna and providing a buffer to the wetland area. Flax, toetoe and *Carex* species would be suitable for planting around the wetland fringe, with a mixture of shrubs (such as manuka, kowhai, cabbage trees and small-leaved *Coprosma* species) along the bank, and taller trees a few metres back from the wetland margin.

B. Saltmarsh mosaic

Area B contains a moderately large, diverse example of saltmarsh vegetation, buffered on much of its landward margin by wattle forest and scrub. Watercourses draining the hillslopes behind this area flow into the saltmarsh and scrub, and may contain suitable whitebait spawning habitat. Priorities for this site include removal of pampas from within the saltmarsh, weed control and native re-vegetation within the surrounding exotic scrub and forest, and extension of a continuous vegetation buffer around the entire landward side of the saltmarsh margin (as described for

Area A). The establishment and retention of groundcovers such as rushes and sedges along the margins of small watercourses, particularly in the transitional zone between salt and freshwater, is recommended to maintaining and enhancing whitebait spawning habitat.

C. Waitakere Stadium saltmarsh and pine forest

Area C comprises relatively intact saltmarsh surrounded by pine/wattle forest, with local patches of indigenous scrub in the understorey. Vegetation is of moderate quality, with some weed invasion and evidence of previous disturbance, however the restoration potential is high. Priorities for management include removing weeds and undertaking enhancement planting of indigenous shrub species beneath the pine canopy to establish an intact vegetation buffer. Dead trees and fallen logs should be retained to provide habitat for reptiles and invertebrates, and native plants with fruit and flowers that are attractive to birds should be selected for enhancement planting. Canopy species (such as puriri, karaka and kohekohe) should be interspersed throughout the shrubs to provide a succession to indigenous forest when the pines are eventually removed.

D. Scrub, forest and intertidal vegetation mosaic

Area D comprises a mosaic of exotic forest, native and exotic scrub, saltmarsh and mangrove forest, forming a continuous band of riparian vegetation from below Waitakere Stadium to the northwestern motorway. Vegetation is of variable quality, and is primarily significant because of its extent and diversity. Of these, Area D is the highest priority for restoration as it provides the greatest overall habitat diversity and restoration potential. Management requirements will include:

- Removal of problem weeds (particularly wattle saplings and pampas) from wetland margins and understorey habitats prior to revegetation.
- Establishment of appropriate buffering vegetation, including sedges, flax and indigenous shrubs around wetland margins.
- Establishment of a diverse range of indigenous trees and shrubs in areas currently dominated by exotic species.
- Gradual replacement of exotic forest stands with native species. It may be desirable to leave a sparse canopy of exotic trees in order to provide perching sites for birds until native vegetation is well-established. Any trees felled should be left where they lie in order to provide nutrients for regenerating natives and to provide habitat and food for lizards and invertebrates. Some trees may also be poisoned and left standing to provide refuges for reptiles and invertebrates.

In the longer term, riparian enhancement of the wider Henderson Creek area is recommended to link significant habitats within the survey area, and to improve the quality of the area as an ecological corridor. This could also include relocation of the fitness trail away from the immediate margin of the creek to widen the effective riparian zone.

7.2.3 Weed control

Riparian vegetation of Henderson Creek is essentially exotic in character, as introduced species dominate most vegetation associations. Of the introduced species recorded within the survey area, a number are regarded as pests with the potential to threaten the existing ecological values or restoration potential of the site. The following section identifies key weed issues, management requirements and priorities within the Henderson Creek survey area.

- **Invasive canopy trees**

The main species comprising this group include crack willow, black wattle and tree privet. These species generally form mono-specific stands where they occur. The large trees provide stream bank stability, however willow and privet stands in particular cast heavy shade over the river margin. Some shade over the watercourse is important for regulating water temperature and controlling algal growth, however the dense canopies of these trees inhibit the development of an understorey or ground cover, providing little protection against runoff or scour.

Seedlings of these trees will either grow beneath a closed canopy (as for privet), or regenerate vigorously and abundantly in light gaps (as for willow and wattle). Both of these strategies enable these species to persist as canopy dominants, inhibiting succession of native tree and shrub species and reducing stand diversity.

Removal of invasive canopy species is recommended, however it should be noted that these trees provide erosion protection, particularly in the upper reaches of the survey area where banks are steep and the watercourse experiences intermittent high-velocity flows. Hence, revegetation should be undertaken in sites as or prior to removal of trees.

- **Serious environmental weeds**

A number of serious environmental weeds, including kahili ginger, Chinese privet, yellow ginger, eleagnus, giant reed, bamboo, pampas and wandering Jew are present in low abundances throughout the survey area, but are most common amongst the mixed forest, scrub and shrubland mosaic in the upper reaches of the survey area. These species form dense, impenetrable monocultures, gradually suppress and choke surrounding vegetation, and prevent seedling establishment and succession. This reduces the floristic, structural and habitat diversity of the vegetation. Of these species, kahili ginger and yellow ginger are of particular concern because of their ability to invade relatively undisturbed vegetation.

Removal of infestations of these weed species is a high priority due to their relatively low abundances, however it should be noted that substantial infestations of all these species are present upstream of the survey area, hence ongoing monitoring and control will be required.

- **Smothering plants**

This group includes kikuyu grass, Japanese honeysuckle, great bindweed, jasmine and ivy. These weeds are primarily of concern where they may smother low-stature or juvenile vegetation, and should be removed prior to restoration planting, and subsequently monitored and controlled until a continuous cover of native planted species has developed.

- **Weeds of stream margins**

Stream margins in the upper, freshwater reaches of the survey area are intermittently subjected to high-velocity flood flows, causing substantial erosion and scour, and facilitating the establishment of weeds such as mist flower and *Selaginella*. Control of weeds and revegetation of the water margin is problematic because of the regular disturbance by flooding, which washes away planted vegetation and encourages weed invasion. The key to achieving both these objectives is the establishment of desirable ground cover species that are robust enough to withstand scouring by floodwaters, tolerant of inundation, and dense enough to inhibit re-establishment of weeds, such as *Carex*, *Cyperus,* or *Bolboschoenus* species.

Low - growing mats of vegetation such as grasses and sedges should be planted at the water's edge, as these are more resistant to disturbance from high-velocity flows, protect the soil from scour, and can recolonise and stabilise collapsed or deposited sediments.

Kowhai is recommended for stream bank stabilisation, as it has a deep, wide - spreading root system, while its semi-deciduous foliage is so sparse that it does not inhibit the establishment of ground cover plants (Collier *et al.* 1995). Tree fuchsia is also recommended for the same reasons. Flax has neither a deep or wide - spreading root system, and hence is not suitable for planting at the immediate water's edge within areas of stream bank that are susceptible to overland flows (Collier *et al.* 1995).

7.2.4 Revegetation

Revegetation should aim to establish a continuous, healthy vegetation cover that will inhibit the re-establishment of weeds, increase the floristic, structural and habitat diversity of riparian vegetation, provide an effective buffer against runoff, and increase instream habitat quality and diversity.

The structure and composition of vegetation should be planned prior to undertaking planting. Fig. 7.1 shows an appropriate layout for riparian vegetation, in order to provide adequate shade and temperature regulation to the stream channel while providing adequate light for low-growing species to develop. Planting dense stands of trees and shrubs close to stream margins should be avoided as this produces excessive shading, which inhibits the development of a suitable ground cover (Collier *et al.* 1995).

Planting should be undertaken in blocks, as closely as possible (depending on species) in order to establish a continuous cover of vegetation. Vegetation structure should follow a multi-tiered approach, with vigorous, dense ground covers such as native sedges and native toetoe on the lower stream bank or wetland margin, flax, small trees and shrubs on the mid-bank, and larger tree species on the upper bank. Biodegradable artificial ground covers such as coconut matting can be utilised on steep banks to minimise erosion while permanent vegetation cover is established.

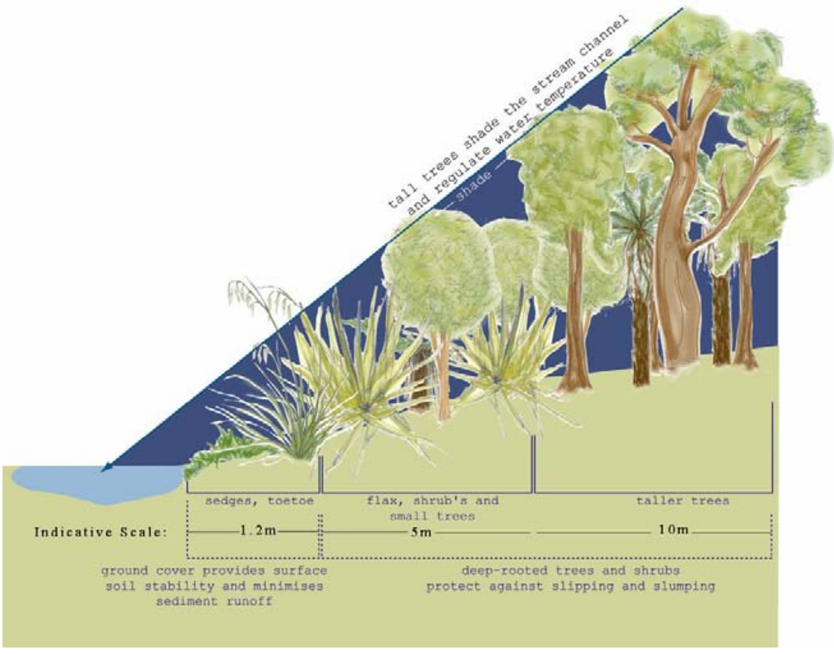

Fig. 7.1: Recommended structure for riparian revegetation.

7.2.5 Monitoring

Monitoring should be undertaken to evaluate the progress and success of revegetation programmes, and to identify ongoing maintenance and management requirements to ensure its success, such as replacement of dead plants, watering during drought periods, weed and predator control.

Monitoring sites should be selected following the development of a planting plan, and prior to planting. A single monitoring site is adequate for small restoration sites, while up to five plots may be required in Area D or other large sites. A monitoring site will comprise a permanent $10m^2$ plot within the restoration area. One corner of the plot should be pegged, but the plot should not be clearly marked, as this could potentially result in different treatment of the defined area. Vegetation cover within the plot should be described prior to planting, and a photo of the plot taken from the corner peg.

During planting, a record should be kept of numbers and species of plants established throughout the total restoration area. Seedlings should be tagged with stakes (labelled with species and planting date) to enable mortality to be recorded.

Subsequent monitoring of the site should be undertaken at three-monthly intervals for the first year, and at six-monthly intervals thereafter for the next five years. Monitoring should include an estimate of vegetation cover within the plot, and a photograph of the plot from the corner peg. Records of plant mortality, including species, date planted, and date when the death was noted should be kept for the entire site in small restoration areas, and from several monitoring plots in larger sites such as Area D. Any weed establishment observed should also be noted.

A brief report or record outlining results and management recommendations should be prepared from each monitoring survey, with a final report at the end of the five-year survey period, evaluating the success of restoration and determining requirements for ongoing monitoring and management.

7.3 Potential for Restoration of Lizard and Invertebrate Fauna

7.3.1 Prioritisation of sites

Table 7.2 ranks the habitat value of sites within the Henderson Creek survey area on the basis of resident biodiversity, habitat quality and future potential for restoration.

Table 7.2: Prioritisation of riparian margin areas at Henderson Creek for restoration of lizard and invertebrate faunas.

Location	Priority for restoration action
Area D south (below disused orchards; west bank)	1 (highest priority)
Area C (west bank)	2
Area D north (between Patch D south and motorway)	3
Southern end, including Oratia and Opanuku Streams	4
East bank from north-western motorway to Tui Glen	5
Central-southern end west bank	6 (lowest priority)

Restoration effort will have the greatest short and long-term gains and be most effective for the protection and enhancement of native lizard and terrestrial invertebrate populations if targeted at riparian vegetation along the northern end of the west bank of Henderson Creek.

7.3.2 Restoration Strategy

The following approaches are standard restoration and conservation practices that could be incorporated into a management strategy for the restoration of the lizard and invertebrate fauna of Henderson Creek.

Planning of public amenities

Planned future facilities may include an extension to the existing walking track in the vicinity of high priority sites on the west bank (north end). Placement of a new track should allow for the greatest possible area of continuous wildlife habitat. For example, instead of placing the track along the centre of existing or planned forest areas, tracks are better placed on one edge. For Area D and surrounding areas, the new track could run along the top of the small escarpment above the creek (instead of between the escarpment and the water as with other sections of the creek). This would provide an increased, unbroken width for wildlife habitat and increase views of the creek for the public. These tracks should be narrow and vegetation allowed to overhang from both sides to facilitate movement of lizard and invertebrate wildlife over tracks.

The disused blocks of land above Area D provide an exciting opportunity to expand restoration plans and reforest a sizeable area of land. Addition of all or part of these blocks to restoration plans would greatly increase the useable area for wildlife conservation. They would also provide such diverse opportunities as a recreational reserve and interpretative wildlife trail or an urban wildlife conservation area.

Habitat enhancement

Specific habitat needs for lizards and invertebrates will often be missing from areas undergoing restoration. Hollows in trees or other refuges for some animals may not naturally occur until some decades after initial pest control and replanting has been implemented. Simple solutions exist to provide for the habitat requirements of these species, thereby helping populations establish at an earlier stage of forest development than would occur naturally. Examples of aids include:

Weta boxes for tree weta, which provide refuge cavities and allow populations to exist in young forest. Boxes can be designed from natural materials making them inconspicuous to public, e.g., constructing lairs inside existing dead standing trees or strapping hollowed-out sections of tree trunk to existing live trees.

Gecko boxes work on the same principle as weta boxes, by providing refuges made of natural materials that mimic their natural refuges. Because geckos prefer warm, insulated refuges, gecko boxes could incorporate insulating material or even a small solar cell to provide warmth.

Skink refuges take a number of forms. Piles of coarse stones (mixed between 2cm and 20cm diameter) provide refuges for ground skinks and many invertebrates while excluding larger predators such as rats and cats. Fallen rotting logs are an essential element of forests which provide food and refuge for skinks, some geckos, and a huge range of invertebrates. Up to 50% of the exotic trees destined for control in restoration habitats should be cut down and trunks and major branches left on the forest floor to slowly decay. Fallen trees on slopes also accumulate leaf litter that would otherwise be washed into streams and thus provide additional habitats and seeding sources of smaller invertebrates. Dead standing trees are also valuable components of functioning forest ecosystems. Therefore, existing dead trees should be left, and some of the exotic trees (perhaps 1 out of every 5 trees) destined for removal could be ring-barked to leave them standing.

Establishment of ground cover, such as dense growths of low-growing ferns interspersed with vegetation-free open ground covered in leaf litter, provides excellent shelter and feeding grounds for skinks and large predacious invertebrates.

Re-introductions

Re-introductions of multiple missing components of invertebrate communities are easily achieved by re-seeding source habitats with leaf litter from more species-rich nearby habitats. Samples of leaf litter from a range of microhabitats (such as tree bases, deep litter aggregations, under rotten logs) contain an enormous range and number of macro and micro-invertebrates and can be carefully placed in similar prepared habitats at the receiving site. Samples should be transported in ‘breathable’ bags (e.g., muslin cloth) to prevent ‘sweating’ of samples and overheating and asphyxiation of animals inside.

A range of larger species can be re-introduced to the restoration areas, but many of these will require at least some predator control for populations to establish in release areas and expand. These include the following:

- **Tree weta**

Tree weta have a high intrinsic population growth rate and can be easily transferred from one site another. Their habitat needs, including a range of ground and arboreal refuges (logs, weta boxes, dead standing trees, tree hollows), are easily met, and their mostly arboreal habits make them less prone to predation by predominantly ground-foraging predators. Large populations of Auckland tree weta exist in the Waitakere ranges andcapture and translocation of up to even 50 of these for release at sites around Henderson Creek should only take a few nights' work. Alternatively, the existing weta populations at Area D and the southern end of the creek could be assessed and some individuals transferred to other parts of the creek.

- **Large ground invertebrates**

Invertebrates such as flightless ground beetles and weevils may be present but were not detected in the survey area. Re-seeding the area with locally sourced beetles will minimise genetic differences between possible resident and translocated populations. Successful establishment of large ground invertebrates will be dependent on suitable habitat at the release area and at least some control of predators such as possums, rats and hedgehogs.

- **Lizards**

Green geckos are arboreal and are found in forest fragments in other parts of Auckland. It may be 5-10 years before native vegetation is sufficiently established so that a green gecko translocation to Henderson Creek can take place. Moko skinks are a ground-dwelling diurnal species that should do well in the highlight environments of forest fragments. Control of predators, especially cats and rats, will be a pre-requisite to translocation of these or other ground-inhabiting fauna.

7.4 Avifauna Habitat Enhancement

Revegetation and predator control are the key strategies recommended to enhance avifaunal communities within the Henderson Creek area. Appropriate revegetation can increase the diversity, abundance and seasonal availability of food, and the availability of suitable nesting sites. This accordingly reduces competition for resources.

Attracting a greater diversity of bird species to the Henderson Creek area will enhance natural seed dispersal and the subsequent regeneration of native plant species. In particular, the kereru is a key species in regeneration processes as it is highly mobile and wide-ranging. Some larger fruited tree species such as karaka and miro may be entirely dependent on kereru for dispersal (Clout & Hay 1989).

Kereru utilises a variety of habitats and food types. Though predominantly frugivorous, it supplements its diet with foliage, buds and flowers. Planting of fruiting species such as karaka, tawa, taraire, puriri, miro, kohekohe, nikau, fuchsia, titoki, matai, pigeonwood and kahikatea may assist in attracting kereru and other frugivorous birds to the area in the long term, while establishing a diversity of fleshy-fruited shrubs and small trees will provide a more immediate food source, as well as being important for smaller birds, and for ensuring year-round food availability.

Planting of species such as kowhai, puriri, rewarewa, pohutukawa, fuchsia and flax will also act to encourage predominantly nectivorous birds such as tui. This species is known to commute long distances to access nectar sources. Restoration of invertebrates will also increase the chances of attracting and retaining populations of higher trophic level species such as morepork and smaller insectivores such as fantail, grey warbler and silver-eye.

Wetland Species

While the survey period for species such as fernbird and banded rail was limited, their apparent absence from saltmarsh and mangrove habitat in Henderson Creek is likely to be a function of species-specific requirements and poor habitat quality. Predator control and the establishment of vegetation around wetland margins to provide better shelter could facilitate the establishment of wetland bird species, potentially including these two species of conservation significance.

Banded rail are an endemic subspecies ‘threatened’ by wetland drainage, the reclamation of tidal estuaries, and grazing of riparian margins by stock (Bell 1986). The species is also vulnerable to predation by introduced mammals, especially mustelids. The subspecies is considered ‘locally common’ near the coast of the northern North Island (Heather & Robertson 1996) and is believed to breed on Traherne Island, adjacent to the northwestern motorway. They are most often found in mangrove forests, saltmarshes and rush-covered freshwater wetlands, and nest amongst thick grass or rushes.

North Island fernbird are a locally common endemic (Heather & Robertson 1996) that inhabit freshwater and tidal wetlands, especially reedbeds or pakihi with emergent scrub, and also occur in drier sparse scrub and bracken vegetation. This species is known to breed on Traherne Island.

7.5 Animal pest control

Area D is the priority site for undertaking predator control, as this site will benefit most and has the best chance of success. The location of Area D and its surrounds aids the effectiveness of predator control, as re-invasion pathways are reduced. Area D is bordered on two sides by significant barriers to pest re-invasion, namely the creek itself and the north-western motorway. Central Park Drive provides a barrier against pest re-invasion on the western and southern boundaries. Industrial developments adjacent to Area D provide a source of pests, especially rodents, but land-users could be approached to implement or support pest control measures on their land.

The isolation of Area D from residential properties means that cat visitation in this area is probably less than on the east bank and effective control and exclusion of cats may be more acceptable to ratepayers. Live trapping of cats could also highlight to residents the distances that their pets travel and the likely impacts they have on native fauna. If planned correctly, a cat trapping programme should have the support of landowners and provide valuable information to conservation managers on the habits of urban cats.

Existing technology can enable the safe and effective eradication of mammalian pests within the designated restoration area. Effective alternatives to kill trapping include the use of poison bait stations which are installed out of reach of public (especially children) and which dispense bait on-site without the target species being able to remove bait from the station and potentially scatter it over surrounding ground. Construction of a poison bait-station buffer zone around the restoration area will minimise re-invasion. A considerable body of scientific literature now exists to guide managers in planning the intensity and frequency of pest control programmes needed to give a defined conservation outcome or level of wildlife recovery.

7.6 Enhancement of In-stream Habitat Quality and Biological Resources

Catchment land use and stormwater inputs upstream play an important role in determining in-stream habitat quality. It is therefore recommended that the outputs from the current programme be integrated with the catchment management plans for the Oratia and Opanuku Streams.

Riparian enhancement that increases channel shading, reduces bank erosion and sediments, and increases organic matter inputs (provides food and cover for invertebrates and fish) will enhance in-stream habitat quality. Without significant changes to the catchment land use upstream riparian enhancement should, over time, maintain and possibly increase benthic invertebrate and fish community diversity and abundance within the area. It is therefore recommended that riparian enhancement be undertaken with a view to improving in-stream habitat quality.

Revegetation of creek margins in the lower reaches of Oratia and Opanuku Streams, and maintenance and enhancement of vegetation around drainage channels and small tributaries flowing into Henderson Creek will provide benefits to whitebait which possibly spawn in these areas. It is recommended that a more comprehensive investigation of the habitat in these areas is undertaken, with a view to undertaking a search for evidence of spawning in February and March. Areas which are identified as supporting whitebait spawning should be managed to enhance the available habitat, including improving fish access to these areas.

7.7 Management and Enhancement of Estuarine Resources

The main factors affecting the environmental quality of Henderson Creek's estuarine and intertidal areas relate to the effects of intense urbanisation, stormwater run-off and accumulation of man-made debris. This has been an issue in Henderson Creek for nearly 30 years (Larcombe 1973).

Undertaking a cleanup of rubbish and debris along the foreshore is the immediate priority to improve both habitat quality and amenity values of estuarine areas within Henderson Creek. This should include a programme to encourage responsible disposal of rubbish by local residents and members of the public.

Restoration of riparian vegetation along creek margins would stabilise stream banks and reduce inputs of contaminants associated with surface water runoff. Revegetation will also improve public perception of the area. Ideally, establishment of a substantial riparian buffer zone along the entire length of Henderson Creek would be desirable (i.e., at least 10 m wide, with 1-2 m of ground-covering vegetation along the water's edge). This may not be feasible at least in the short to medium term, because of limitations on resources and conflicts with other values and uses. However, development of riparian vegetation along short stretches of the creek margin will substantially improve localised inputs of surface water, and can hence contribute to overall water quality. This would be most effective if revegetation targets sections of stream adjacent to areas where surface water flows are likely to be high and have a greater contaminant loading, such as roads, parking lots and industrial sites.

As a longer term goal, improvements in stormwater treatment and reticulation could greatly reduce the discharge of stormwater-borne contaminants and smaller debris, enhancing water quality and potentially increasing biotic diversity. However this will require more wide-scale catchment management, and is outside the immediate scope of a management plan for Henderson Creek.

Sediment contamination may constrain improvements in biotic diversity within estuarine areas of Henderson Creek associated with better water quality. However dredging or treatment of sediment in this area is not recommended, as sediment disturbance would resuspend contaminants in the water column, with adverse effects on fish and wildlife. Over time, improvements in water quality will result in burial of contaminated sediment beneath cleaner sediment, eventually confining contaminants within anoxic mud layers, which are not utilised by estuarine biota.

8. Summary

For the most part, riparian vegetation and habitat of Henderson Creek is highly modified, dominated by exotic species, isolated by development of the surrounding land, and degraded by weeds and a history of intensive human landuse. Several examples of saltmarsh vegetation are present that, although small, are of relatively good quality, and the area contains examples coastal to inland vegetation sequences and salt to freshwater zonations that are now rare in the Tamaki Ecological District (Julian *et al.* 1998). No rare flora or fauna is known from the survey area, and the site is poor in terms of its size and shape, as it is long, narrow, and poorly buffered. However, the area still forms a connective link between the coastline and the forested Waitakere Ranges.

The quality of habitat along Henderson Creek is generally poor for birds due to predators, limited food resources, and lack of suitable nesting and roosting sites. Habitat for lizards and invertebrates is limited by the immaturity of planted trees and shrubs, the narrowness of much of the vegetation, and the lack of habitat complexity.

In-stream habitat conditions in the lower Opanuku and Oratia streams have been highly modified by urban development. However, the lower reaches of both streams continue to provide habitat for valuable aquatic biological resources and are an important migratory pathway for species such as eels, inanga and banded kokopu.

Key issues influencing the quality of estuarine areas in Henderson Creek include rubbish, contamination from stormwater systems and streambank erosion following clearance of riparian margins. Localised approaches including revegetation, collection of rubbish, and public education to encourage responsible use of the area will address these issues in part, however restoration of estuarine habitat quality also depends on management of the wider catchment area.

Riparian enhancement of Henderson Creek will improve the value of the area as a habitat for fauna and connective link between the Waitakere Ranges and the Waitemata Harbour. Improved vegetation quality will also provide better protection against erosion and runoff, and can improve water quality and instream habitat.

Four sites along Henderson Creek (Areas A-D) are identified as priority restoration areas, as they contain vegetation associations of ecological significance, habitats that contain or are potentially suitable for birds, invertebrates and aquatic fauna, and an existing buffer of surrounding vegetation, or the capacity to establish one. An additional site, Area E, is also identified as suitable for restoration of lizard and invertebrate habitat. Revegetation and predator control are the key components of restoration in these areas, while a range of measures including artificial aids to habitat enhancement and re-introductions are also proposed for improving lizard and invertebrate habitat.

Several potential whitebait spawning sites were identified in the lower reaches of Oratia and Opanuku Streams and around drainage channels and small tributaries flowing into Henderson Creek. A more comprehensive investigation of the habitat in these areas is recommended including a search for evidence of spawning in February and March.

Monitoring should be undertaken to evaluate the progress and success of revegetation programmes and to identify ongoing maintenance and management requirements to ensure its success. A five-year monitoring programme is recommended, with an evaluation at the end of this period to assess the success of restoration and determine further requirements for ongoing monitoring and management.

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Appendix C: Bird species detected in (or likely to utilise) Henderson Creek – local and national status.

Common Name	Taxonomic Name	Relative Abundance within Habitat in Tamaki Ecological District [1]	National Status [2]
Australian magpie	*Gymnorhina tibicen*	Moderate	Abundant introduction
Banded rail	*Rallus philippensis assimilis*	Rare	Locally common native
Blackbird	*Turdus merula*	High	Abundant introduction
Black-backed gull	*Larus dominicanus*	High	Abundant native
Black shag	*Phalacrocorax carbo*	Moderate	Common native
Black swan	*Cygnus atratus*	Low	Common introduction
Chaffinch	*Fringilla coelebs*	High	Abundant introduction
Eastern rosella	*Platycercus eximius*	Moderate	Locally common introd.
Fantail	*Rhididura fuliginose*	Moderate	Abundant native
Feral goose	*Anser anser*	Low	Common introduction
Goldfinch	*Carduelis carduelis*	High	Abundant introduction
Greenfinch	*Carduelis chloris*	Moderate	Common introduction
Grey duck	*Anas superciliosa*	Rare	Common native
Grey warbler	*Gerygone igata*	Moderate	Abundant endemic
House sparrow	*Passer domesticus*	High	Abundant introduction
Kingfisher	*Halcyon sancta*	Moderate	Abundant native
Little shag	*Phalacrocorax melanoleucos*	High	Common native
Mallard	*Anas platyrhynchos*	Moderate	Abundant introduction
Myna	*Acridotheres tristis*	High	Locally abundant introd.
NI fernbird	*Bowdleria punctata vealeae*	Moderate	Locally common endemic
NZ pigeon / kereru	*Hemiphaga novaeseelandiae*	Low	Common endemic
Pukeko	*Porphyrio porphyrio*	High	Abundant native
Rock pigeon	*Columba livia*		Common introduction
Silvereye	*Zosterops lateralis*	High	Abundant native
Song thrush	*Turdus philomelos*	High	Abundant introduction
Spur-winged plover	*Vanellus miles*	Moderate	Abundant native
Starling	*Sturnus vulgaris*	High	Abundant introduction
Tui	*Prosthemadera novaeseelandiae*	Moderate	Common endemic
Welcome swallow	*Hirundo tahitica*	Moderate	Abundant native
White-faced heron	*Ardea novaehollandiae*	Moderate	Abundant native
Yellowhammer	*Embreriza citrinella*	Moderate	Common introduction
Undetected			
Dunnock	*Prunella modularis*	High	Common introduction
California quail	*Callipepla californica brunnescens*	Low	Common introduction
Little black shag	*Phalacrocorax sulcirostris*		Locally common native
Redpoll	*Carduelis flammea*	High	Common introduction

Notes: 1 = Julian *et al*. 1998
2 = Heather & Robertson 1996

Appendix B: Terrestrial invertebrates detected at Henderson Creek

Major taxon	Minor Taxon	Name or number of species
Protura		1 sp.
Collembola		2 sp.
Gastropoda	Sigmurethra	Garden snail *Cantareus aspersus*
	Sigmurethra	1 sp.
Diplopoda	Sphaerotheriidae	1 sp.
Amphipoda		1 sp.
Isopoda	Porcellionidae	1 sp.
Opiliones	Phalangiidae	1 sp.
Araneae	Clubionidae	1 sp.
	Lycosidae	1 sp.
	Miturgidae	1 sp.
	Salticidae	3 sp.
Acari		1 sp.
Blattodea		1 sp.
Hymenoptera	Apidae	European honey-bee *Apis mellifera*
	Apidae	Bumblebee *Bombus spp.*
	Formicidae	Garden ant *Paratrechina vaga*
	Formicidae	3 sp.
	Vespulidae	German wasp *Vespula germanica*
Mantodea	Mantidae	New Zealand mantis *Orthodera novaezealandiae*
Diptera	Muscidae	1 sp.
	Tipulidae	1 sp.
		5 sp.
Lepidoptera		2 sp.
	Pieridae	White butterfly *Pieris rapae*
Orthoptera	Gryllidae	Black field cricket *Teleogryllus commodus*
	Anostostomatidae	Auckland tree weta *Hemideina thoracica*
	Acrididae	Shorthorned grasshopper spp.
Hemiptera	Cicadidae	Cicada spp.
Homoptera	Delphacidae	1 sp.
Coleoptera*	Scarabaeidae	1 sp. TO BE IDENTIFIED
	Carabidae	1 sp. TO BE IDENTIFIED
	Curculionidae	1 sp. TO BE IDENTIFIED
		2 sp. TO BE IDENTIFIED

* Beetles will be identified at Landcare Research by February-March 2000