Technical Report 31

Ecological Technical Report 5: Marine Habitat and Species - Description & Values

NZ TRANSPORT AGENCY
WAKA KOTAHI

MacKays to Peka Peka Expressway

Revision History

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A	Sharon De Luca		8 August 2011
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on behalf of	Boffa Miskell Ltd		

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1. Introduction

This report describes the results of the marine ecological field investigations undertaken adjacent to the proposed MacKays to Peka Peka Expressway (the “Project”) in May-June 2011. This technical report is one of a series of reports prepared for the NZ Transport Agency that report on ecological investigations undertaken as part of the Project.

The ecological investigations associated with the Project included describing and mapping the values of ecological systems that occur along this route, as well as describing the distribution and abundance of native flora and fauna within or in close proximity to the Project footprint. From this work the potential environmental effects of both the construction and ongoing operation of the proposed road will be assessed in the Ecological Impact Assessment (Technical Report 26, Volume 3), and measures to mitigate potential or actual adverse effects be developed.

There are not anticipated to be any direct effects on marine ecological values due to construction or operation of the Project, as the proposed Expressway Alignment occurs at some distance from marine environments. However, potential indirect effects may occur due to the discharge of runoff, during both construction and operation phases, to streams and rivers that discharge to the marine environment. Thus, in developing the methodology to investigate the marine ecology associated with the Project and surrounding area, the following potential effects were considered:

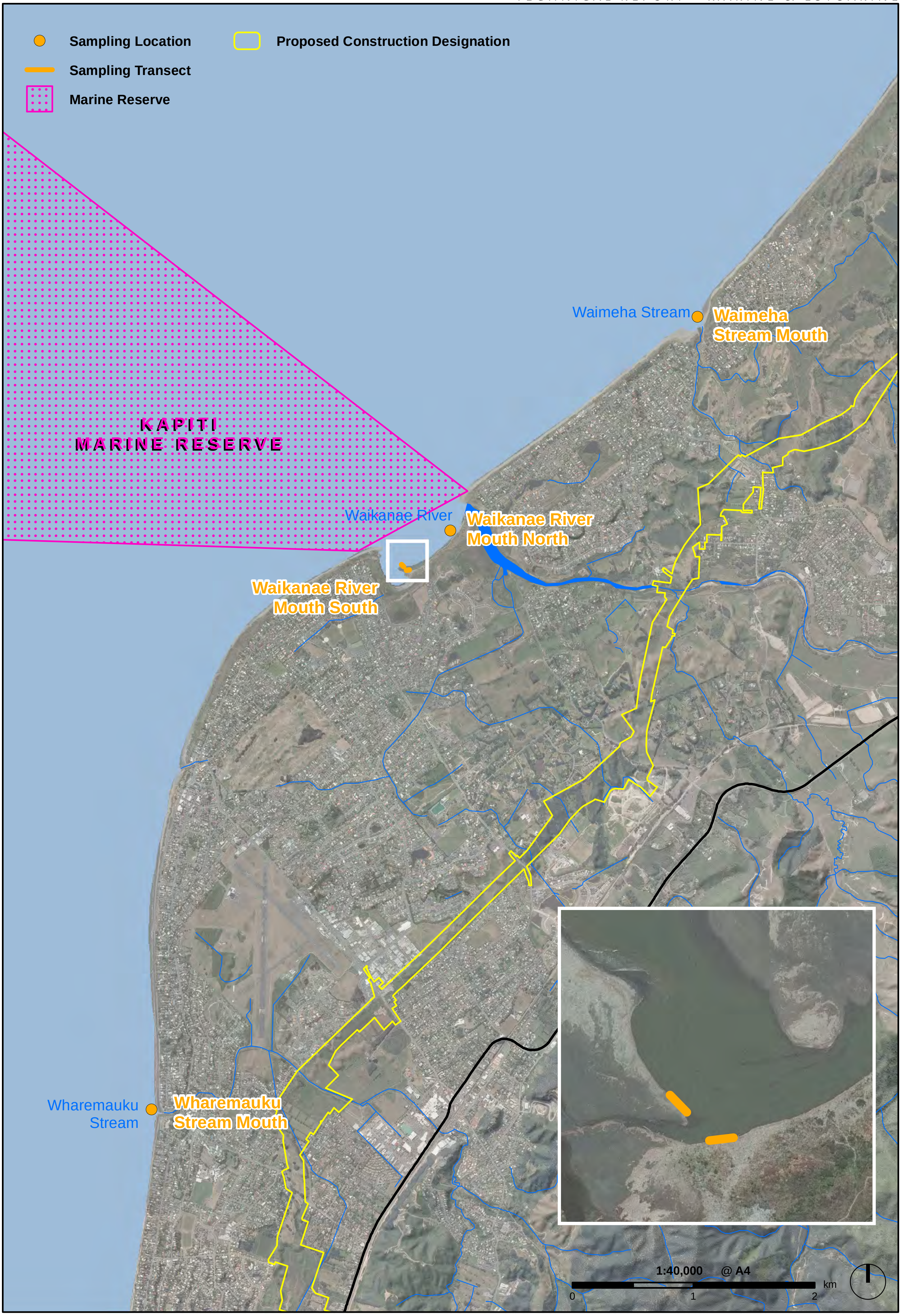
- Discharge of sediment laden stream and river water to estuaries and open beaches;
- Discharge of road runoff contaminants via stream and rivers to the estuaries and open beaches;
- Impact on food resources for birds and fish within the Waikanae Estuary and the Wharemauku and Waimeha Stream mouths as a result of Project earthworks within the catchment area.

The results of the marine ecology investigations presented here provide the baseline study which will inform the subsequent EcIA for the Project. Consequently, the objectives of the marine ecology survey were:

- To characterise the immediate marine/estuarine receiving environments and identify habitat that may be affected due to the Project;
- To identify the dominant intertidal invertebrate community assemblages;
- To determine the presence of significant marine/estuarine habitats and species;
- To characterise baseline estuarine surface sediment quality.

2. Habitat context

The proposed Expressway Alignment occurs within the Foxton Ecological District (ED). The coastal component of the ED has been described by McEwen (1987) as comprising extensive sand-dunes, several estuaries, wetlands, dune lagoons and a few coastal swamp forest remnants containing nikau, pukatea and kahikatea. Three estuaries have been identified as being potentially affected by construction and operational phase stormwater discharges to streams/rivers from the Project: Ngarara Estuary (Waimeha Stream), Waikanae Estuary (Waikanae River), Wharemauku Estuary (Wharemauku Stream) (Figure 1).



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2.1. Waimeha Stream mouth (Ngarara Estuary)

Waimeha Stream is a small, spring-fed stream originating from the outskirts of the Waikanae township that becomes the Ngarara Estuary at the stream mouth. The catchment area consists mainly of pastureland. Water quality from previous studies showed characteristics of typical lowland waterways influenced by agricultural run-off (elevated nutrient levels and low toxicant concentrations) (Technical Report 24, Volume 3). Robertson & Stevens (2007), in their study of Kāpiti Coast marine environments, considered water quality in the stream and estuary to be moderate. However, when the mouth of the stream blocks, estuarine water quality is likely to decline.

The stream mouth is modified, with channelisation and construction of an esplanade strip. In 1920 the stream was re-directed to discharge across the beach and provide another white-baiting stream (Todd et al., n.d). A string of small lakes occupies where the river once ran and is now an artificial estuary.

Ngarara Estuary is a narrow (5-10 m) and shallow (0.5 m) tidal river mouth estuary. Estuarine habitat diversity is low due to upstream modifications, regular modification of the beach channel and lagoon (in order to protect coastal residential property), lack of salt marsh vegetation and high abundance of weeds (Robertson & Stevens 2007).

The sand-flats are a feeding area for coastal and shore birds including black-backed and red-billed gulls, Caspian terns and pied stilts. The relative close proximity to the Waikanae Estuary suggests that a number of other species are likely to visit periodically (Todd et al., n.d).

The Waimeha Stream mouth and estuary is a popular site for recreational activities, which increases both the demand for development and consequently threats to the ecosystem.

2.2. Waikanae Estuary

The Waikanae River originates from the western base of the Tararua Ranges where the habitat is largely native bush (Todd et al., n.d). The Waikanae River has good water quality, reflecting the forest and pastoral landuse in the catchment. As the stream migrates towards the coast it passes through the Reikorangi Basin where tributaries feed into the river. As the river nears the coast it runs through the urban areas of Waikanae and Otaihanga, feeding into the estuary and mixing with the tidal seawater. Water quality in the estuary is reduced due to the discharge of treated wastewater via the Mazengarb Drain (Robertson & Stevens 2007). Occasionally the mouth of the river becomes partially blocked, which may result in reduced water quality until the blockage is cleared.

The estuary is a tidal river mouth estuary and covers approximately 80 ha (Todd et al., n.d) and contains a variety of habitats including tidal mudflats, vegetated sandflats, sand-dunes, two tidal lagoons and saltmarsh (McConkey & Bell, 2005; Robertson & Stevens, 2007). The estuary is approximately 1.5km long, 40-50m wide and average water depth is 1-3 m. The intertidal sand flats (comprising 50% of the estuary) sandflats providing important habitat for native fish, as well as a feeding resource for a variety of resident and migratory (national and international) bird species. For these reasons the Waikanae Estuary Scientific Reserve was established in 1978 and is cared for by the Department of Conservation (DoC) (McConkey & Bell, 2005), which considers the significant estuary environment within the reserve as having high ecological value (DOC 2010).

The intertidal area within the Waikanae Estuary below mean high water spring is within the Kāpiti Marine Reserve, which was established in 1992. The Marine Reserve links the Waikanae Estuary Scientific Reserve and the Kāpiti Island Nature Reserve. The reserve incorporates a distribution overlap of species of cool temperature southern waters and warm temperate northern waters resulting in a mixture of northern and southern species. The reserve is also unique as it contacts four distinct habitat zones in close proximity. The habitat zone identified around the Waikanae River mouth is characterised as partly sheltered shallow sand habitat (Department of Conservation, 1998).

Pressure is being exerted on the estuary habitats and fauna due to increasing urban development, human recreational activities, introduction of mammalian predators and the spread of exotic plant species (particularly around the estuary margins as a result of urban development). Consequently, an extensive indigenous flora restoration programme is being undertaken by DOC, Kāpiti Coast District Council, Greater Wellington Regional Council and Waikanae Estuary Care Group.

2.3. Wharemauku Estuary

Wharemauku Stream originates behind Raumati and continues through the Kaitawa Reserve (the outskirts of Paraparaumu), with the stream discharging onto the sandflats along the open coast of Raumati Beach. The lower reaches of the stream are modified through channelisation, wooden walls, and adjacent roading and residential land use. Wharemauku Estuary is a shallow, small tidal river mouth estuary that is approximately 3-5m wide. The margins of the estuary are highly modified with sea walls and houses located on the foredunes (Robertson & Stevens 2007). Estuarine habitat diversity is low given the historic and ongoing modifications and the lack of salt marsh vegetation and tidal flats.

Land-use within the catchment includes pastoral and residential, with some land remaining in scrub and forest. Gravel extraction also occurs within the catchment. These activities and land cover types have resulted in poor stream water quality conditions primarily relating to elevated concentrations of faecal contaminants and nitrogen. Water quality assessments undertaken by the

Project team[1] specifically for the Project determined that the recorded levels of dissolved zinc and aluminium may be exerting a toxic effect on freshwater organisms (Bibby, R. 2011). However, the estuary is well flushed and is unlikely to suffer adverse effects from poor stream water quality (Robertson & Stevens 2007).

The Wharemauku Stream differs from the Waikanae and Waimeha streams due to intense urban development and modifications altering the natural stream movement. Hard engineering structures, such as retaining walls and barriers, constrain and alter the natural path of the stream. These structures impede the natural migration paths of several fish species (Todd et al., n.d).

3. Methods

3.1. Intertidal field investigations

The objectives of the intertidal field investigations were to:

- Characterise the immediate marine/estuarine receiving environments and identify habitats that may be affected by the Project;
- Identify the dominant intertidal invertebrate community assemblages;
- Determine the presence of significant habitats and threatened species;
- Collect baseline sediment quality data.

Intertidal estuarine sampling was based on the Estuarine Environmental Assessment and Monitoring National Protocol (Cawthron Institute, 2002). A total of four sites were surveyed (see Figure 1: Location of Sampling Sites) comprising: one site at the Waimeha Stream mouth (Ngarara Estuary), two sites (north and south) at the Waikanae Estuary, and one site at the Wharemauku Stream mouth. Sampling and assessment of the sites were undertaken on 31st May and 1st June 2011, during fine weather conditions and within two hours either side of low tide (approximately 15:20 pm on 31st May 2011 and 15:56 pm on 1st June 2011).

At each of the Waimeha, Waikanae North and Wharemauku sites, a 50 m x 30 m grid (subdivided into 10 15 m x 10 m smaller grids, identified as A to J) was established using GIS prior to entering the field. The 10 smaller grids (A to J) were then subdivided into six 5 m x 5 m grids (identified as 1 to 6). Sampling was undertaken at one of the randomly selected 5 m x 5 m grids (1 to 6) within each 15 m x 10 m grid (A to J) (Figure 2).

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

The following analyses were undertaken for each of these sites:

- To assess infaunal abundance and diversity a sediment core (haphazardly placed) was collected from each site using a 13 cm diameter × 10 cm deep (area = 1,327 cm3) PVC tube. The tube had a tapered leading edge and a metal handle on the top to facilitate penetration. Individual tubes were manually driven into the sediment, removed with core intact and the contents bagged. Samples were processed at each site by washing the contents of each sample through a 0.5 mm sieve using seawater from the estuaries. All material retained on the sieve were carefully removed and placed into a labelled plastic container, preserved in 60-70% ethanol. Cawthron Institute invertebrate experts processed the samples, extracting and identifying the macrofauna present.
- A 0.50 m x 0.50 m (0.25 m2) quadrat was used to sample epifauna (surface dwelling) and macroalgae. The quadrat was haphazardly placed at each site approximately 0.5 m from which cores were taken. All organisms occurring within the quadrat were identified to species level and counted. Macroalgal cover was estimated on the basis that a 5 x 5 cm area equates to 1 % cover. Crab/worm holes at the sediment surface were also counted.
- A redox discontinuity layer (RDL) sample was collected to assess the sediment anoxic layer at each site. A 60 mm diameter PVC cylinder was driven into the sediment to a depth of 8-10 cm and capped before extracting the cylinder. After collection, the core was cut in half lengthways and the depth of the start of the anoxic sediment layer measured using a 30 cm ruler where present (generally visible as a dark black (anoxic) zone, relative to lighter oxygenated sediment).
- A surface sediment (top 2 cm) sample was collected for contaminant and sediment grain size analyses. Using a garden trowel, the sediment samples from grids A to E (shown on Figure 2) were combined to form a composite sample, as were samples from F to J. The two composite samples were each divided in half, with one half of each being sent to Hill Laboratories for analysis of copper, lead, zinc, high molecular weight polycyclic aromatic hydrocarbons (HMW PAHs), and total organic carbon (TOC) and the other half sent to Cawthron Institute for sediment grain size analyses.

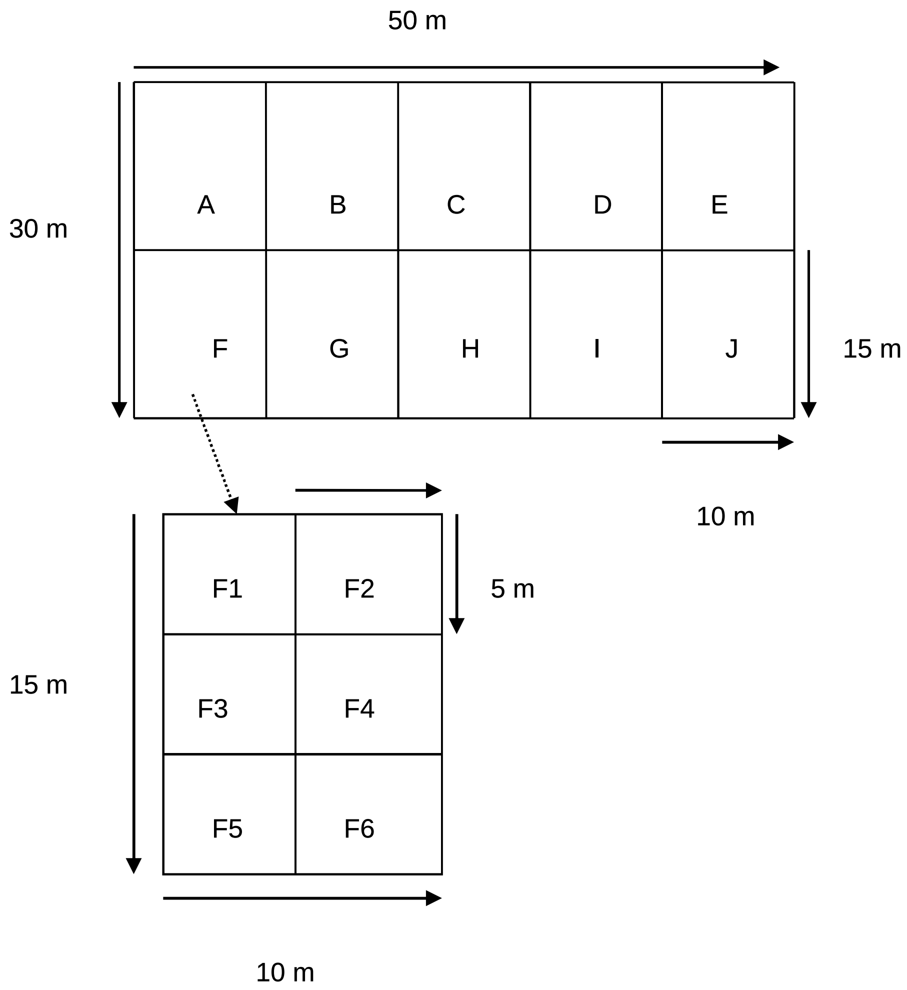

Figure 2: Schematic showing intertidal experimental design.

The Waikanae South site required a different sampling design due to the intertidal area being narrow and naturally constrained. At this site, two 25m transects were established in the narrow area of intertidal sediment adjacent to the southern side of the Waikanae River low tide channel, each side of a small drainage channel leading to the Waikanae River (see inset in Figure 1). Samples were collected a 5 m intervals along the two transects, totalling ten sampling locations. GPS co-ordinates were marked for each location and noted in a waterproof notebook. Sample collection at each of the ten locations followed the same protocol as the other sites.

Thus, a total of 40 sites were sampled (10 each at Waimeha, Waikanae North, Waikanae South and Wharemauku).

3.2. Assessment of ecological value

Marine ecological values are described in this report as being low, moderate or high. Table 1 lists the characteristics which have been used to assess the predominant ecological values of parts of the marine environment within the Project area, based on a weight of evidence approach. Not all characteristics listed within each ecological value category need to be present in order to assess ecological value. Consideration of low, moderate and high benthic invertebrate species richness and diversity is based on expert judgment and experience.

Table 1: Characteristics of estuarine site with low, moderate and high ecological values

Ecological value	Characteristics
LOW	§ Benthic invertebrate community degraded with low species richness and diversity. § Benthic invertebrate community dominated by organic enrichment tolerant and mud tolerant organisms with few/no sensitive taxa present. § Marine sediments dominated by smaller grain sizes. § Shallow depth of oxygenated surface sediment. § Elevated contaminant concentrations in surface sediment, above ISQG-high or ARC-red effects threshold concentrations[2]. § Invasive, opportunistic and disturbance tolerant species dominant. § Habitat highly modified.
MODERATE	§ Benthic invertebrate community typically with moderate species richness and diversity. § Benthic invertebrate community has both (organic enrichment and mud) tolerant and sensitive taxa present. § Marine sediments typically comprise approximately 50-70% smaller grain sizes. § Depth of oxygenated surface sediment typically >0.5 cm. § Contaminant concentrations in surface sediment generally below ISQG-high or ARC-red effects threshold concentrations. § Few invasive opportunistic and disturbance tolerant species present. § Habitat modification limited.

[2] ANZECC (2000) Interim Sediment Quality Guideline (ISQG) High contaminant threshold concentrations or Auckland Regional Council's Environmental Response Criteria Red contaminant threshold concentrations (Auckland Regional Council, 2004).

Ecological value	Characteristics
HIGH	§ Benthic invertebrate community typically highly diverse with high species richness. § Benthic invertebrate community contains many taxa that are sensitive to organic enrichment and mud. § Marine sediments typically comprise <50% smaller grain sizes. § Depth of oxygenated surface sediment typically >1.0 cm. § Contaminant concentrations in surface sediment rarely exceed low effects threshold concentrations. § Habitat largely unmodified.

4. Results and discussion

Photos of each of the sites sampled and representative intertidal benthic sediment are provided in Appendix 31.A. Detailed site descriptions are provided in Appendix 31.B.

4.1. Sediment quality

4.1.1. Intertidal sediment grain size

At all sites sampled, the average proportion of surface sediment grain size was dominated (>70%) by fine sand (Figure 3, Table 2), with the Waimeha Stream mouth having the highest proportion (84%). Approximately 95-99% of the sediment at all four sites fell within the medium to very fine sand range (Figure 3, Table 2). Silt and clay was negligible at all sites (<2%). These results are consistent with those of Cawthron (2006) for Wharemauku Stream mouth and Waikanae River mouth.

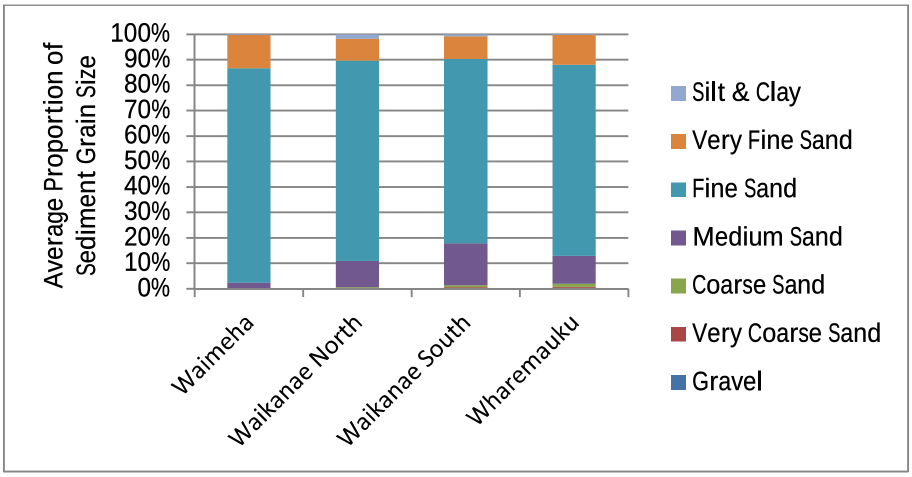

Figure 3: Intertidal surface sediment grain size composition

Table 2: Mean intertidal surface sediment grain size

	Gravel	Very Coarse Sand	Coarse Sand	Medium Sand	Fine Sand	Very Fine Sand	Silt & Clay
	>2mm	<2mm->1mm	<1mm->500um	<500um->250um	<250um->125um	<125um->63um	<63um
Waimeha	0	0	0.1	2.25	84.3	13.1	0.4
Waikanae North	0.1	0.1	0.5	10.3	78.7	8.6	1.9
Waikanae South	0.3	0.3	0.8	16.6	72.3	9.0	0.9
Wharemauku	0.4	0.5	1.2	11.1	75.1	11.7	0.3

4.1.2.Intertidal sediment contaminants

The concentration of common stormwater contaminants (copper, lead, zinc and HMW PAHs) was compared against the former Auckland Regional Council (ARC) Environmental Response Criteria (ERC) and the Australian and New Zealand Environment and Conservation Council (ANZECC) Interim Sediment Quality Guidelines (ISQG) (refer to Appendix 31.C for trigger levels).

The results indicated that contaminant concentrations at all intertidal sites sampled were significantly below ERC and ISQG low effects thresholds (Table 3). Of the four sites, sediment collected from the Waikanae North site had the highest concentration of zinc (47 mg/kg dw), lead (9.3 mg/kg dw) and copper levels (7.4 mg/kg dw) (Table 3). The other three sites had similar concentrations of contaminants, all being at very low levels. Thus overall, stormwater contaminant concentrations in surficial sediment are low at all four sites. These results are similar to those reported by Cawthron (2006) for Wharemauku Stream mouth and Waikanae Stream mouth (Waikanae South).

Table 3: Intertidal sediment quality data

	Waimeha	Waikanae North	Waikanae South	Wharemauku	ARC ERC Green	ISQG Low
Copper (mg/kg dry wt)	3.3	7.4	3.3	3.2	<19	65.0
Lead (mg/kg dry wt)	4.1	9.3	3.9	3.9	<30	50.0
Zinc (mg/kg dry wt)	26.5	47.0	25.0	26.5	<124	200.0
HMW PAHs (mg/kg dry wt)	0.12	0.06	0.10	0.15	<0.66	1.7

4.2. Redox discontinuity layer (depth of start of anoxic sediment)

Anoxic sediment depth levels at both the Waikanae North and South sites ranged between 0-7 cm, with an average depth of 2.9 cm and 3.8 cm respectively. No anoxic layer depth was recorded at the Waimeha or Wharemauku sites.

4.3. Marine invertebrates

4.3.1. Epifauna

None of the quadrats at the four sites surveyed contained epifauna, as shown by the photographs in Appendix 31.B. Waimeha and Wharemauku are high energy, exposed sandy beaches, which are typically characterised by low abundance and diversity of intertidal marine invertebrates. In comparison, the Waikanae North and South sites are relatively more sheltered and are influenced by freshwater more than the Waimeha and Wharemauku sites. As such, though not found during this survey, epifauna such as mud crabs and small gastropods are likely to be present within the Waikanae estuary.

4.4. Macroalgae

Macroalgae was not observed at any of the four sites surveyed. As stated above, two of the survey sites (Wharemauku and Waimeha Stream mouth) are high-energy, exposed sandy habitats which are typically unsuitable for macroalgae settlement. Both sites at the Waikanae River mouth were also unsuitable for macroalgae settlement due to freshwater influence and likely periodic high velocity flows during storm events.

4.4.1. Infaunal community composition

Analysis of core sediment samples revealed that the benthic fauna communities at the four sample locations were dominated by amphipods (Figure 4, Figure 5, Table 4). *Lysianassidae* (amphipoda) was the species most dominant in samples collected from Waimeha Stream mouth, where as the freshwater amphipod *Paracorophium* sp. was most abundant taxa at the Wharemauku Stream, Waikanae North and South. The sample taken from Waikanae North was the only site to reveal a second group of taxa, gastropods (the estuarine snail, *Potamopyrgus estuarinus*), in relatively high abundance (Figure 4, Figure 5, Table 4). Polychaetes, isopods and bivalves were represented in low abundance throughout all sites (Table 4).

Based on the existing research information there were two sensitive species detected in the survey. The bivalve *Paphies australis* (pipi) are sensitive to sediment deposition and have a strong sand preference. This species was detected at Waikanae North and South. The amphipod

Phoxocephalidae sp. was detected at the mouth of the Waimeha Stream and is sensitive to organic enrichment. Of the other species that there is information on tolerance to organic enrichment and mud, all are indifferent, tolerant or opportunistic (see Appendix 31.D). .

The infaunal invertebrate data clearly separates the two high energy exposed sandy beach sites (Waimeha and Wharemauku) and the two more sheltered estuarine sites (Waikanae North and South). Waimeha and Wharemauku infaunal communities are characterised by relatively low taxa diversity and average abundance of dominant taxa compared to the Waikanae sites (Figure 4, Figure 5).

Table 4: Average abundance of dominant intertidal taxa

	Waimeha	Waikanae North	Waikanae South	Wharemauku
Gastropods	0.1	152.9	1.4	0.0
Bivalves	0.0	1.2	0.4	0.0
Polychaetes	0.2	19.9	8.4	1.0
Isopods	0.3	0.1	14.2	0.1
Amphipods	4.7	285.0	104.2	16.1
Other	0.2	8.4	0.9	0.2
TOTAL	5.5	467.5	129.5	17.4

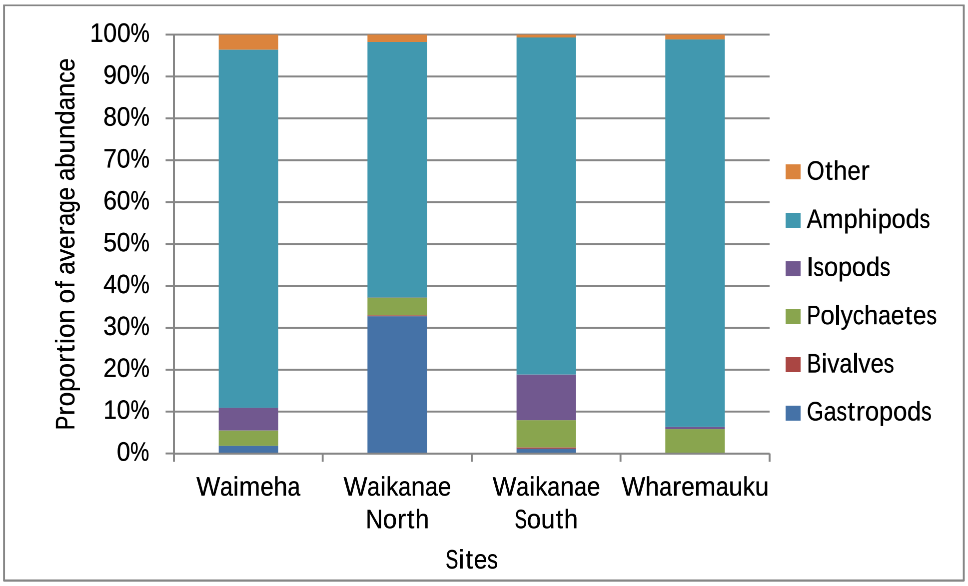

Figure 4: Proportion of average abundance of dominant intertidal taxa

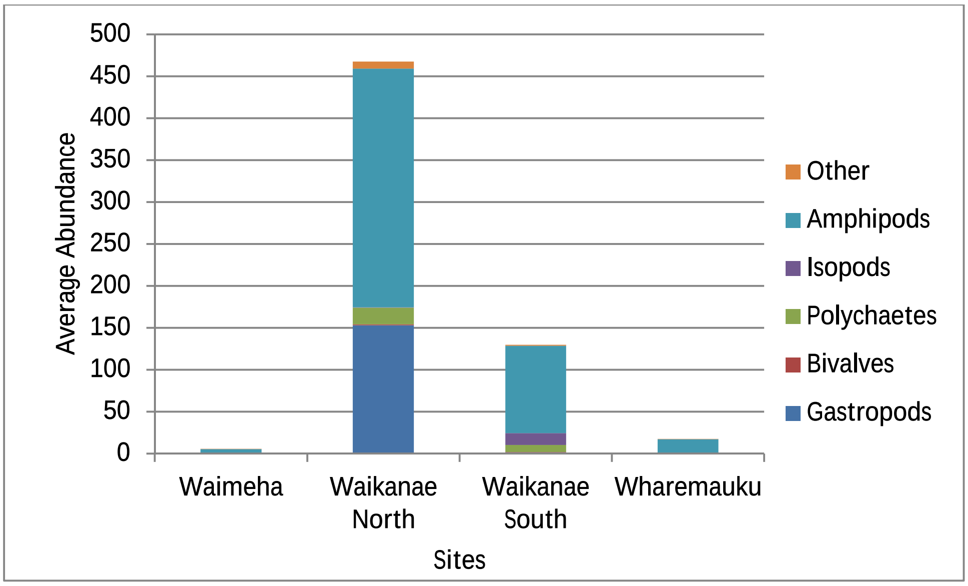

Figure 5: Average abundance of dominant intertidal taxa

Average species richness was highest at Waikanae North (approximately 10), followed by Waikanae South (approximately 6 species), whereas Waimeha and Wharemauku both had less than 2 taxa present per core on average (Figure 6).

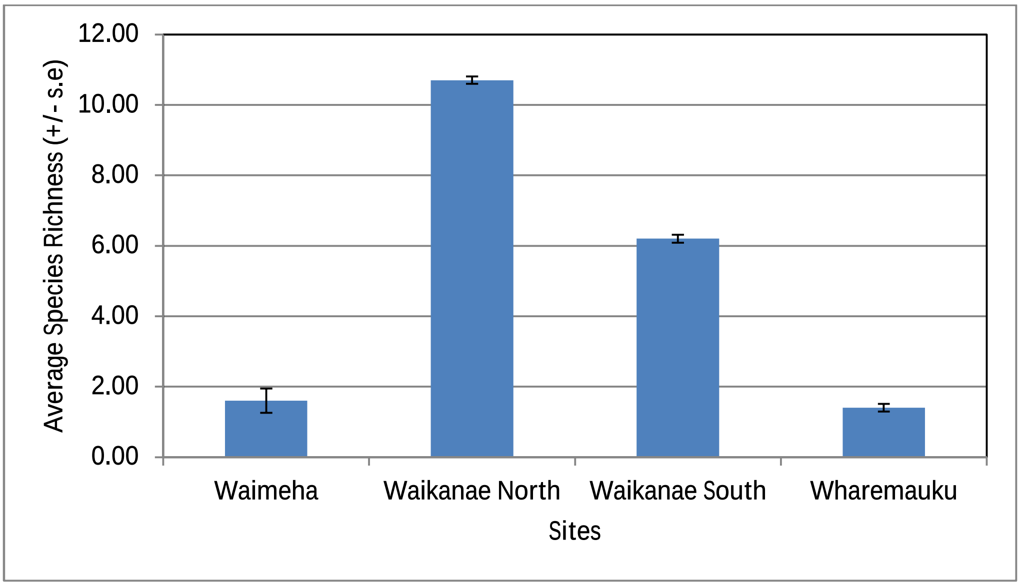

Figure 6: Average species richness

The average Shannon-Wiener Diversity Index ranged between 0.29 and 0.98 across the 40 samples collected at the four sites indicating low species richness and low evenness (Figure 7). Average Shannon-Wiener Diversity Index was highest at the Waikanae North site (0.98) and lowest at the Waimeha site (0.29) (Figure 7)

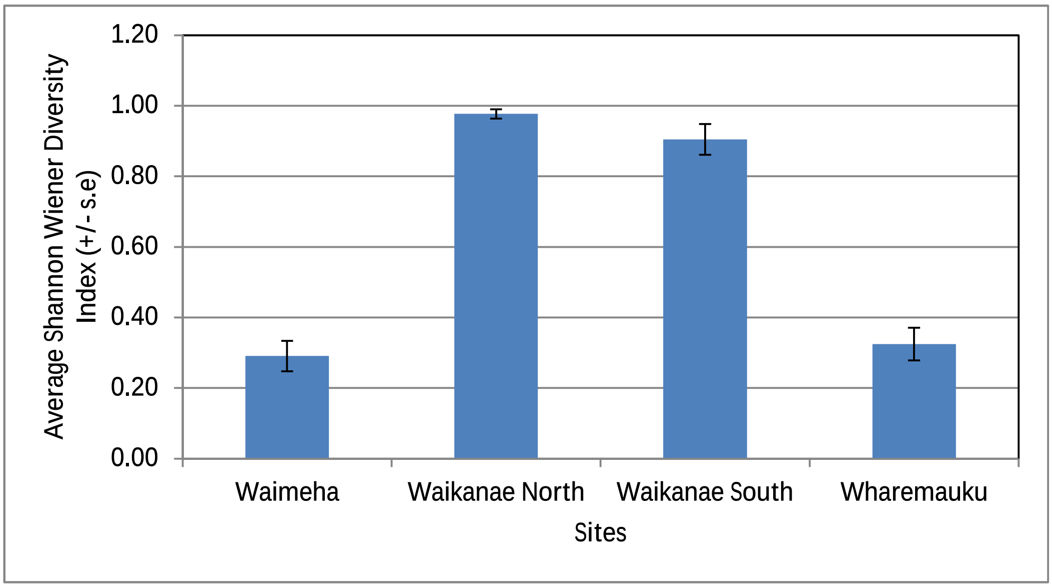

Figure 7: Average Shannon Wiener Diversity Index

Cawthron (2006) detected a range of amphipods, polychaetes and gastropods in the Waikanae Estuary. The invertebrate community composition was similar to that detected for the Project, with the community being dominated by the gastropod *Potamopyrgus* sp., polychaete worms *Scoleocolepides benhami* and *Scolelepis* sp., and the estuarine amphipod *Paracorphium* sp. Average species richness detected by Cawthron (2006) was 7.5, which is similar to that presented in Figure 6 above.

The infaunal invertebrate assemblages at the sites surveyed are considered to be typical for the habitat types and similar to previous surveys (Cawthron, 2006).

5. Assessment of ecological value

The patterns in the data collected reflect the environment from which they were collected: open sandy beaches and sheltered estuaries.

The common ecological characteristics of the open sandy beach sites of Waimeha and Wharemauku sites are contained in Table 5 below.

Table 5: Ecological Features Common to Waimeha (Ngarara) and Wharemauku Estuaries

	Ecological Features
Sediment Grain Size	Dominated by fine sand grain size.
Sediment Quality	Contaminant concentrations in sediment significantly below guideline values.
Redox Discontinuity Layer	No anoxic sediment discernable.
Surface Macroalgae	No macroalgae present.
Epifauna	No epifauna present.
Infaunal Invertebrates	Low diversity and abundance of invertebrates, which is typical and expected in the mobile sands of an exposed beach and does not reflect a degraded habitat in this case. Shannon Wiener Diversity below 0.4.
Sensitive Invertebrates	No known sensitive invertebrate species detected.
Habitat Modification	Moderate degree of modification of the marine habitat, including channelisation, management of stream/river mouths, and periodic realignment of the Waimeha Stream drainage channel through the sandflats directly out to sea.

These features when considered together indicate high ecological values at Waimeha and Wharemauku Stream mouths.

The two Waikanae Estuary sites were similar to the Waimeha and Wharemauku sites in terms of being dominated by the sand grain size, having low concentrations of contaminants and no epifauna or macroalgae present, but with additional common features (Table 6).

Table 6: Ecological Features Common to Waikanae Estuary

	Ecological Features
Sediment Grain Size	Dominated by fine sand grain size.
Sediment Quality	Contaminant concentrations in sediment significantly below guideline values.
Redox Discontinuity Layer	Depth of anoxic sediment on average 2-4 cm.
Surface Macroalgae	No macroalgae present.
Epifauna	No epifauna present.
Infaunal Invertebrates	Invertebrate assemblage dominated by a high abundance of amphipods and gastropods. Shannon Wiener Diversity just below 1.
Sensitive Invertebrates	Sensitive invertebrate species detected e.g. including pipi.
Habitat Modification	Largely unmodified habitat.

Given these characteristics it is considered that the marine habitat within the Waikanae Estuary also has high ecological values.

6. Conclusions

- All of the three marine habitats studied have high ecological values.
- Waimeha and Wharemauku Streams discharge to high energy, open sandy beaches, affording significant and rapid dilution and removal of any stormwater discharges.
- The Waikanae Estuary is lower energy and has more potential to accumulate sediment and associated contaminants. Therefore, it is particularly important to ensure that construction and operational phase stormwater discharged to the Waikanae River from the Project is treated to a high standard to protect the ecological values of the estuary and the adjacent marine reserve.

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Appendix 31.A

Photos of Sample Sites and Intertidal Benthic Sediment

Appendix 31.A: Photos of Sample Sites and Intertidal Benthic Sediment

Plate 1: Waimeha Stream mouth.

Plate 2: Intertidal benthic sediment at Waimeha Stream mouth.

Plate 3: Waikanae (North) River site.

Plate 4: Intertidal benthic sediment at Waikanae (North) River site.

Plate 5: Waikanae (South) River mouth.

Plate 6: Intertidal benthic sediment at Waikanae (South) River mouth.

Plate 7: Wharemauku Stream mouth.

Plate 8: Intertidal benthic sediment at Wharemauku Stream mouth.

Appendix 31.B

Detailed Site Descriptions

Appendix 31.B: Detailed Site Descriptions

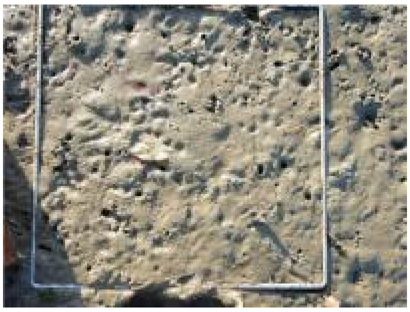
Waimeha Stream mouth

Site name and description	Image
Site W1A1 § Consisted of sandy mud and firm sand for surface sediment characteristics. § Notable debris of bark and a small amount of shell fragments. § No sediment anoxic layer present. § No macroalgae, epifauna or crab holes present.	
Site W1B4 § Surficial sediment was relatively featureless apart from few fragments of ground-up shells and bark within firm sand. § No sediment anoxic layer present. § No macroalgae, epifauna or crab holes present.	
Site W1C1 § Consisted of fine sand. § No sediment anoxic layer present. § No macroalgae, epifauna or crab holes present.	
Site W1D5 § Surficial sediment consisted of muddy sand. § No sediment anoxic layer present. § No macroalgae, epifauna or crab holes present.	No image available
Site W1E1 § Featureless firm sand. § No sediment anoxic layer was present. § No macroalgae or epifauna in sample quadrat. § No crab holes present.	

Site name and description	Image
Site W1F6 § Surficial sediment contained firm sand and small amounts of bark debris and shell fragments. § No sediment anoxic layer. § No macroalgae or epifauna. § No crab holes were present.	
Site W1G4 § Surficial sediment firm. § Quadrat was featureless with no sediment anoxic layer present. § No macroalgae or epifauna. § No crab holes were present.	No image available
Site W1H2 § Firm sand with a small scattering of shell fragments and bark debris. § No sediment anoxic layer present. § No macroalgae or epifauna. § No crab holes present.	
Site W1I3 § Surficial sediment predominantly firm sand with patches of muddy sand. § No sediment anoxic layer. § No macroalgae or epifauna. § No crab holes present.	
Site W1J3 § Muddy sand with very fine traces of bark debris present in small surface puddles. § No sediment anoxic layer present. § No macroalgae or epifauna present. § No crab holes were present.	

Waikanae North

Site name and description	Image
Site PA5 § Surficial layer with a consistency of liquidised mud. § Sediment anoxic layer was approximately 4 cm below the surface sediment. § No macroalgae, epifauna or crab holes.	
Site PB3 § Thick surface layer of jellified mud, gelatinous to the touch. § Some leaf debris. § The sediment anoxic layer was approximately 2.5 cm in depth from the surface sediment. § No macroalgae, epifauna or crab holes.	
Site PC5 § Characterised by a thick surface layer of gelatinous mud. § Leaf debris was also present § Sediment anoxic layer was measured at 3.5 cm deep. § No macroalgae, epifauna or crab holes.	
Site PD1 § Surficial sediment comprised of muddy sand and some leaf debris. § Colouration of the anoxic sediment core showed the whole sample to be dark in colour. § No macroalgae or epifauna were present. § Sixteen crab holes were present.	

Site name and description	Image
Site PE4 § Surficial sediment consisted of gelatinous mud and leaf debris. § Sediment anoxic layer measured 4 cm in depth (this measurement was difficult to determine as the sample was extremely viscous and would not hold the shape of the extracting tube). § No macroalgae, epifauna or crab holes. (Due to the nature of the surficial sediment crab holes were difficult to determine as any indent made was quickly recovered by the jelly-like sediment).	
Site PF6 § Comprised of muddy sand and a small amount of leaf litter. § Sediment anoxic layer was 5 cm from the surface sediment. § No macroalgae or epifauna present. § Forty five crab holes present.	
Site PG1 § Comprised of muddy sand and a small amount of leaf litter. § Sediment anoxic layer was 6 cm from the surface sediment. § No macroalgae or epifauna present. § Twenty four crab holes present.	
Site PH1 § Comprised of muddy sand and a small amount of leaf litter. § Sediment anoxic layer was 5 cm. § No macroalgae or epifauna present. § Twenty one crab holes present.	

Site name and description	Image
Site PI3 § Comprised of muddy sand with a minimal amount of clay texture and a small amount of leaf litter. § Sediment anoxic layer was 3 cm from the surface sediment. § No macroalgae or epifauna present. § Forty two crab holes present.	
Site PJ6 § Comprised of muddy sand with a minimal amount of clay texture and a small amount of leaf litter. § Sediment anoxic layer was 7 cm from the surface sediment. § No macroalgae or epifauna present. § Thirty four crab holes were present.	

Waikanae South

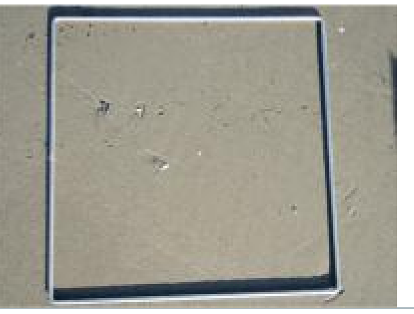
Site name and description	Image
Site W2A § Surficial sediment consisted of firm sand with small amounts of shell fragments and fine bark debris. § Sediment anoxic layer was approximately 6 cm below the sediment surface. § No macroalgae, epifauna or crab holes were present within the sample quadrat. (Core samples were difficult to take from this area as a large tree had been washed up and buried within the sample area. Several attempts were needed to find somewhere that allowed the corer to penetrate deep enough for an appropriate sample size).	

Site name and description	Image
Site W2B § Surficial sediment was predominantly muddy sand with some bark debris present. § Sediment anoxic layer was 3 cm deep and very light in colour making it quite hard to distinguish on site. Black lines were visibly noticeable on the surface within the sample quadrat § No macroalgae, epifauna or crab holes.	
Site W2C § Typified by firm sand with muddy patches and lots of bark debris. § Sediment anoxic layer was approximately 5 cm below the sediment surface. § No macroalgae, epifauna or crab holes.	
Site W2D § Surficial sediment comprised of muddy sand with scatterings of bark debris. § Sediment anoxic layer was 8.5 cm deep. § No macroalgae, epifauna or crab holes.	
Site W2E § Characterised by muddy sand § Sediment anoxic layer measured 2 cm below the sediment surface. § No macroalgae, epifauna or crab holes.	
Site W2F § Surficial sediment comprised of muddy sand with small rocks (<20 cm) scattered throughout. § Sediment anoxic layer measured 3 cm below the surface sediment. (Two samples were taken of the sediment anoxic layer as the original sample did not yield a clear	

Site name and description	Image
representation to determine the level of anoxic sediment). § No macroalgae, epifauna or crab holes.	
Site W2G § Surficial sediment was characterised by firm sand. § Sediment anoxic layer of 1.5 cm below the surface sediment. § No macroalgae or epifauna. § One crab hole was noted.	
Site W2H § Comprised of fine sand with small patches of muddy sand and two *Paphies subtriangulata* shells. § Sediment anoxic layer was 5 cm deep and very distinct. § No macroalgae, epifauna or crab holes.	
Site W2I § Characteristics were fine, muddy sand. § Two shells of *Mactra discors* (Trough shell) were present on the surface. § Sediment anoxic layer was 4 cm below the surface sediment. § No macroalgae, epifauna or crab holes.	
Site W2J § Surficial sediment was muddy sand with multiple surface tracks from snails and one shell of *Paphies subtriangulata*. § No sediment anoxic layer was present. § No macroalgae, epifauna or crab holes.	

Wharemauku

Site name and description	Image
Site RA3 § Surficial sediment was firm sand consisting of a few broken *Paphies subtriangulata* shells on the surface. § No sediment anoxic layer present. § No macroalgae, epifauna or crab holes present.	
Site RB3 § Surficial sediment was relatively featureless with firm sand consisting of a few broken *Paphies subtriangulata* shells on the surface. § No sediment anoxic layer present. § No macroalgae, epifauna or crab holes.	
Site RC4 § Characterised by compact, hard surficial sediment. § No sediment anoxic layer present. § No macroalgae, epifauna or crab holes present.	
Site RD3 § Surficial sediment was firm sand consisting of a few broken *Paphies subtriangulata* shells on the surface. § No sediment anoxic layer present. § No macroalgae, epifauna or crab holes.	
Site RE4 § Surficial sediment was firm sand consisting of a few broken *Paphies subtriangulata* shells on the surface. § No sediment anoxic layer present. § No macroalgae, epifauna or crab holes.	

Site name and description	Image
Site RJ4 § Surficial sediment was firm sand consisting of *Paphies subtriangulata* shell fragments on the surface. § No sediment anoxic layer present. § No macroalgae, epifauna or crab holes.	
Site RH2 § Surficial sediment consisted of fine sand and shell fragments. § No sediment anoxic layer present. § No macroalgae, epifauna or crab holes.	
Site RG5 § Surficial sediment consisted of fine sand and shell fragments. § No sediment anoxic layer present. § No macroalgae, epifauna or crab holes present.	
Site RF6 § Surficial sediment consisted of fine sand and patches of sandy mud. § *Paphies subtriangulata* shell fragments present. § No sediment anoxic layer present. § No macroalgae, epifauna or crab holes.	
Site RI5 § Surficial sediment consisted of fine sand and patches of sandy mud. § *Paphies subtriangulata* and *Mactra discors* shell fragments present. § No sediment anoxic layer. § No macroalgae or epifauna. § Two crab holes were present.	

Appendix 31.C

Contaminant Trigger Levels

Appendix 31.C: Contaminant Trigger Levels

Concentrations of copper, lead, zinc and high molecular weight polycyclic aromatic hydrocarbons (HMW-PAHs) are compared against Auckland Regional Councils (ARC) Environmental Response Criteria (ERC) (ARC, 2004), whereas mercury, DDT and dieldrin are compared against Australian and New Zealand Environment and Conservation Council (ANZECC, 2000) Interim Sediment Quality Guidelines (ISQG). The table below provides the trigger and threshold limits for both the ARC ERC and ISQG.

ARC ERC thresholds were developed based on ANZECC (2000) ISQG and other internationally recognised sediment quality guidelines. Contaminant concentrations in the green range indicate that the biology of the site is unlikely to be impacted, whereas the amber range indicates possible impact and the red range indicates probable impact.

Contaminant	ARC ERC Green	ARC ERC Amber	ARC ERC Red	ISQG-Low	ISQG-High
Copper	<19	19-34	>34	65	270
Lead	<30	30-50	>50	50	220
Zinc	<124	124-150	>150	200	410
HMW-PAHs	<0.66	0.66-1.7	>1.7	1.7	9.6

Appendix 31.D

Known Tolerance of Invertebrates to Organic Enrichment and Deposition of Mud

Appendix 31.D: Known Tolerance of Invertebrates to Organic Enrichment and Deposition of Mud

Sources: NIWA Website, Wikipedia, Robertson & Stephens (2009) and Nicholls et al. (2009)

Tolerance Scales: enrichment (based on Borja et al., 2000) and mud (based on Gibbs & Hewitt, 2004; Norkko et al., 2001) and on authors own experience.

Group and Species		Tolerance to Organic Enrichment	Tolerance to Mud	Site Present at	Details
Nemertea	*Nemertea sp.1, 2, 3, 4*	Tolerant	Prefers some mud	Waikanae N Waikanae S	Ribbon or Proboscis Worms, mostly solitary, predatory, free-living animals. Intolerant of anoxic conditions. Optimum mud range 55-60%, but distribution between 0-95%.
Polychaeta	*Capitella capitata*	Opportunistic and Anoxia Tolerant	Prefers some mud but not high percentage	Waikanae N	A blood red capitellid polychaete which is very pollution tolerant. Common in sulphide rich anoxic sediments. Optimum range 10-15% or 20-40% mud, distribution range 0-95% mud, based on *Heteromastus filiformis.*
	Glyceridae	Indifferent	Prefers some mud but not high percentage	Wharemauku	Glyceridae (blood worms) are predators and scavengers. They are typically large, and are highly mobile throughout the sediment down to depths of 15 cm. They are distinguished by having four jaws on a long eversible pharynx. Intolerant of anoxic conditions. Often present in muddy conditions. Intolerant of low salinity.
	Heteromastus filiformis	Opportunistic	Prefers some mud but not high percentage	Waikanae N	Small sized capitellid polychaete. A sub-surface, deposit-feeder that lives throughout the sediment to depths of 15cm, and prefers a sandy-muddy substrate. Despite being a capitellid, *Hetromastus* is not opportunistic and does not show a preference for areas of high organic enrichment as other

Group and Species		Tolerance to Organic Enrichment	Tolerance to Mud	Site Present at	Details
					members of this polychaete group do. Relatively tolerant of sedimentation and not very mobile. Optimum range 10-15% or 20-40% mud, distribution range 0-95% mud.
	Nicon aestuariensis	Tolerant	Prefers mud	Waikanae N Waikanae S	A nereid (ragworm) that is tolerant of freshwater and is a surface deposit-feeding omnivore. Prefers to live in moderate to high mud content sediments. Optimum range 55-60% or 35-55% mud, distribution range 0-100% mud.
	Scolecolepides benhami	Tolerant	Strong mud preference	Waikanae N Waikanae S	A surface deposit feeder. Is rarely absent in sandy/mud estuaries, often occurring in a dense zone high on the shore, although large adults tend to occur further down towards low water mark. Prefers low-moderate mud content (<50% mud). A close relative, the larger *Scolecolepides freemani* occurs upstream in some rivers, usually in sticky mud in near freshwater conditions. Optimum range 25-30% mud, distribution range 0-60% mud.
Oligochaete	*Oligochaete sp.*	NA	Strong mud preference	Waimeha Waikanae N Waikanae S	Segmented worms - deposit feeders. Classified as very pollution tolerant by AMBI (Borja et al. 2000) but a review of literature suggests that there are some less tolerant species. Many oligochaete species prefer sand and then mud. Tolerant of depth of sedimentation and time exposed. Optimum range 95-100% mud, distribution range 0-100% mud.
Gastropod	*Potamopyrgus estuarinus*	Tolerant	Prefers mud.	Waikanae N Waikanae S	Endemic to NZ. Small estuarine snail, requiring brackish conditions for survival. Feeds on decomposing animal and plant matter, bacteria and algae. Intolerant of anoxic surface muds. Tolerant of muds and organic enrichment.

Group	Species	Tolerance to Organic Enrichment	Tolerance to Mud	Site Present at	Details
Bivalvia	*Paphies australis*	NA	Strong sand preference as adult. Sand or mud as juvenile	Waikanae N Waikanae S	This pipi is endemic to NZ. Pipi are tolerant of moderate wave action, and commonly inhabit coarse shell sand substrata in bays and at the mouths of estuaries where silt has been removed by waves and currents. They have a broad tidal range, occurring intertidally and subtidally in high-current harbour channels to water depths of at least 7m. Prefer sandy substrates. Highly mobile suspension feeders. Intolerant of depth of sediment deposition. Adults optimum range 0-5% mud, distribution 0-5% mud. Juveniles often found in muddier sediment.
	Halicarcinus whitei	NA	NA	Waikanae N	A species of pillbox crab. Lives in intertidal and subtidal sheltered sandy environments.
Crustacea	*Macrophthalmus hirtipes*	NA	Prefers mud, but not high percentage	Waikanae N	The stalk-eyed mud crab is endemic to NZ and prefers waterlogged areas at the mid to low water level. Makes extensive burrows in the mud. Tolerates moderate mud levels. This crab does not tolerate brackish or fresh water (<4ppt). Like the tunnelling mud crab, it feeds from the nutritious mud. Optimum range 45-50% mud, distribution range 0-95% mud.
	Mysidacea sp.1	Indifferent	NA	Waikanae N Waikanae S	Mysidacea is a group of small, shrimp-like creatures. They are sometimes referred to as opossum shrimps. Wherever mysids occur, whether in salt or fresh water, they are often very abundant and form an important part of the normal diet of many fishes.

Group and Species	Tolerance to Organic Enrichment	Tolerance to Mud	Site Present at	Details
Paracorophium sp.	Indifferent	Strong mud preference	Waikanae N Waikanae S Wharemauku	A tube-dwelling corophioid amphipod. Two species in NZ, *P. excavatum* and *P. lucasi*. Both are endemic to NZ. *P. lucasi* occurs on both sides of the North Island, but also in the Nelson area. *P. excavatum* has been found mainly in east coast habitats of both the South and North Islands. Sensitive to metals. Also very strong mud preference. Optimum range 95-100% mud, distribution range 40-100% mud. Often present in estuaries with regularly low salinity conditions.
Phoxocephalidae sp.	Sensitive		Waimeha	A family of amphipods.