

Ecological study of Hickford Park and coastal walkway route options

2012

ERI report number: 005

Prepared for the New Plymouth District Council

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Contents

Executive Summary

An ecological study of Hickford Park, (New Plymouth) was conducted by the Environmental Research Institute, University of Waikato, for the New Plymouth District Council. The main ecological features of the park were mapped and described and recommendations were made for the future management of the site. Hickford Park encompasses significant wetland habitat (Waipu Lagoons and oxidation ponds), sections of planted native species, an extensive duneland system, exotic plantation forest, grazed pasture, sports playing fields and the recently completed Taranaki Velodrome. The Waipu Lagoons represent a rare coastal lagoon ecosystem type in Taranaki, and host a diverse range of native wetland flora and fauna. The acclaimed coastal walkway currently extends half way through Hickford Park to St Andrews Drive. The environmental impacts of several proposed routes for the extension of the coastal walkway through the remainder of the park to Bell Block beach were assessed and recommendations made for the preferred route from an ecological perspective. In summary:

- Indigenous vegetation and habitats of indigenous fauna should not be disturbed if an alternative option is available. Possible ecological impacts of the walkway development may include removal of native vegetation, impact on dune system, alteration to land contours and slope, soil disturbance and sediment input to waterways.
- Construction of the coastal walkway along the originally proposed route option (1.1) would require both vegetation removal and re-contouring and would result in a decrease or degradation of natural dune habitat.
- Route option 1.2 appears to be the most feasible option, as the Waitara sewer line has previously been installed in the same location and no vegetation removal would be required.
- Route options 1.2, 1.3 and the proposed walkway links, provide an opportunity to enhance the public's appreciation of the ecology within Hickford Park.
- In all cases, the ecological effects of the preferred walkway route should be offset via enhancement and restoration plantings.

1 Introduction

The award-winning Coastal Walkway forms an extensive sea-edge path currently spanning from Port Taranaki to Hickford Park, Bell Block. The New Plymouth District Council is currently planning the future extension of the Coastal Walkway towards Waitara, and as part of this project, the walkway is required to be extended through Hickford Park to link with Bell Block beach.

Hickford Park is a large, council managed, coastal reserve, spanning from the New Plymouth Golf Club to the Mangati Stream in Bell Block. The reserve contains a number of recreational features including the Coastal Walkway and other walkway networks, the Taranaki Velodrome and the Sports Park with a number of playing fields. A large portion of the park is also under grazed pasture and managed by a neighbouring farmer. Ecological features within the park include an active dune system, the Waipu Lagoons, artificial wetlands in the oxidation ponds, planted natives and plantation forest.

The 2009 Coastal Walkway development plan indicated that the walkway be extended to Bell Block beach along the coastal zone. In 2011, an alternative route was proposed as part of the Sports Park Management Plan, whereby the walkway would extend inland through the sports park region of Hickford Park. This second route was supported by submissions from both Forest and Bird and the Bell Blocks Residents Society. However, several residents objected to this route, primarily concerned with a loss of privacy to Parkvue Drive homes in close proximity to the walkway. These residents proposed a third alternative route, which extends along the coast before coming inland, avoiding the sand dune system.

2 Objectives

In June 2012, the New Plymouth District Council commissioned the Environmental Research Institute, University of Waikato, to undertake an ecological study of Hickford Park as part of the walkway extension drafting process. The main purpose of the study was to assess the ecological values within the park, thus assisting the Council with park management and planning of the Coastal Walkway extension. The main objectives of the study were to:

- Identify and map the ecological features within Hickford Park.
- Undertake an ecological impact assessment of the three proposed Coastal Walkway route options.
- For each proposed route, identify the potential ecological impacts and propose mitigation techniques to reduce or eliminate such impacts.

3 Methodology

The majority of the data in this report was collected during a rapid qualitative vegetation survey of Hickford Park, conducted between the 12th and 16th of June, 2012. This primarily involved the description and mapping of ecological features. Field sketch maps were later digitised in CorelDRAW X4 2008. In addition, three permanent vegetation monitoring quadrats were established at the Waipu Lagoons. Ten inked tracking tunnels were also deployed for three nights at various locations within Hickford Park, to determine the presence of native and/or pest animals.

3.1 Vegetation assessment

A permanent i-Tree quadrat (quadrat area: 168.6 m^2, quadrat radius: 7.315 m) was established in the eastern sector of the riparian vegetation which surrounds the Waipu Lagoons, following the Urban Forest Effects (UFORE) protocols outlined by Nowak et al. (2003). Developed by the United States Forest Service and other collaborators, i-Tree is designed to quantify the value of urban forest fragments in terms of ecosystem services. Ultimately, it is intended that this method will provide an internationally recognised standard that enables direct comparison between cities worldwide (for more information see www.ufore.org and www.itreetools.org). The i-tree method includes collecting data on tree parameters such as stem diameter, crown height and width, dieback and canopy light exposure for each individual tree in the plot. Species contributions to the shrub and ground tiers are also quantified and a general site description made. To enable the accurate relocation of quadrats in the future, the quadrat centre was marked with a metal peg, GPS coordinates were recorded, and three trees were marked with numbered metal tree tags (a sketch map made showing the trees bearing and distance to the centre of the quadrat enables accurate relocation (Appendix 2). In 2010, the i-Tree method was also used to survey vegetation within Huatoki (three quadrats) and Ratapihipihi (four quadrats) scenic reserves in New Plymouth; and more recently, four i-Tree quadrats were also established at Barrett Domain.

In addition to the i-Tree quadrat, two wetland monitoring quadrats (4 m^2) were installed within flax and reedland, on the Waipu Lagoon margins. Quadrats were established using the National Wetland Monitoring System protocols outlined by Clarkson et al. (2003). The overall ecological condition of the wetland is compared against an assumed natural state, such as pre-settlement. It is scored using five indicators to reflect the extent and impact of the modification. The indicators relate to the major threats known to damage wetlands and are based on changes in hydrology, soil and nutrients, ecosystem intactness, native animal dominance and native plant dominance (Clarkson 2010). GPS coordinates of quadrats were noted and position in relation to a permanent ground peg sketched to allow accurate relocation in the future (Appendix 3).

The purpose of installing these permanent quadrats is to provide quantitative baseline data on vegetation structure and composition and allow for future monitoring of changes in vegetation. The use of i-Tree and national wetland monitoring protocols makes the data readily comparable with sites elsewhere in New Zealand.

3.2 Animal tracking

Inked tracking tunnels are a useful, non-invasive means of confirming species presence at sites. Individuals walk through the tunnels and across the inked pad positioned in the centre of the tunnel, leaving tracks which can later be identified. Although the presence of rodents at the site could be assumed without tracking tunnels, it was hoped that geckos or skinks (potentially at the site) could be persuaded to also enter the tunnels. A total of 10 tracking tunnels were installed around Hickford Park; two were located at the Waipu lagoons, four were located in the sand dunes accessed of Mangati Road, two were located amongst debris on the dune-beach interface at Bell Block Beach and also at the western border of Hickford Park, and a further two were installed in flax-land along the existing walkway route. Canned pear and apple coated in honey was used as the attractant, as recommended by Watts et al. (2010) for gecko and skink tracking. Once deployed in the field, tracking tunnels were monitored daily for three days (Figure 1).

Figure 1: Inked racking tunnels deployed at Hickford Park within the beach-vegetation interface (left) and active dunes near Mangati Road, Bell Block Beach (right).

4 Results: Ecological values

The vegetation of Hickford Park can be loosely divided into seven main types; pasture, parkland, native and mixed planted stands, duneland, wetland and exotic plantation. A comprehensive vascular species list for the Hickford Park area is provided in Appendix 1. This list was compiled from observations made by A.P Druce (1964-1973) and C.C Ogle (2004) for the Waipu Lagoons, in combination with species noted in Hickford Park area by E.J Coleman et al. (2010), and R.J Bylsma and J.T Efford (present survey). A total of 170 vascular species have been identified within the park, of these, 76 (44.5%) were indigenous species and 91 (54.5%) were exotic species. Of the indigenous species recorded, two have threatened distributions (de Lange 2009). Tainui (*Pomaderris apetala*), although planted at Hickford Park, is considered Nationally Critical and water brome (*Amphibromus fluitans*), reported in the Park by A.P Druce (1964-1973), is classified as Nationally Endangered (de Lange 2009).

The main ecological features of Hickford Park were mapped (Figure 2 and Figure 3) and are described in Sections 4.1-4.8. Data from the permanent vegetation monitoring quadrats are provided in Appendix 2 and 3. An enlargement of the ecological value maps are also provided in Appendix 5.

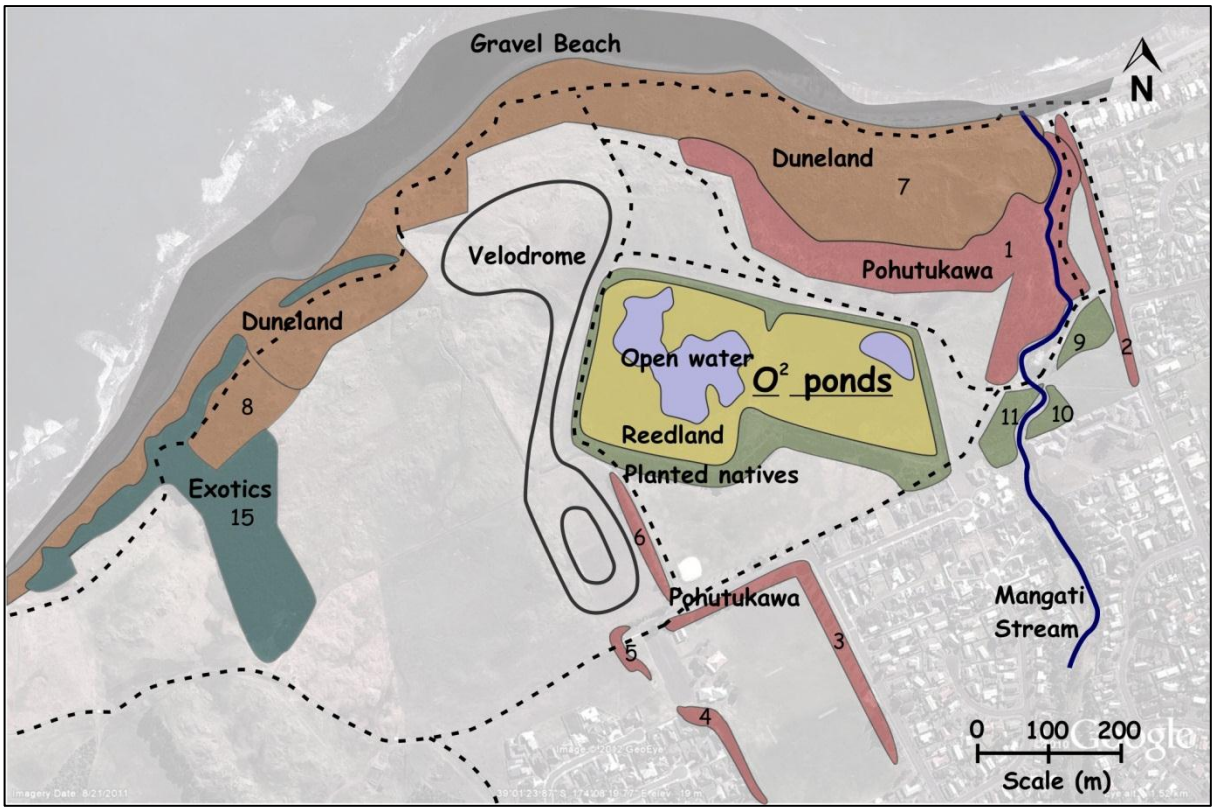

Figure 2: Map showing the ecological features within the eastern sector of Hickford Park. See text for detailed description of features.

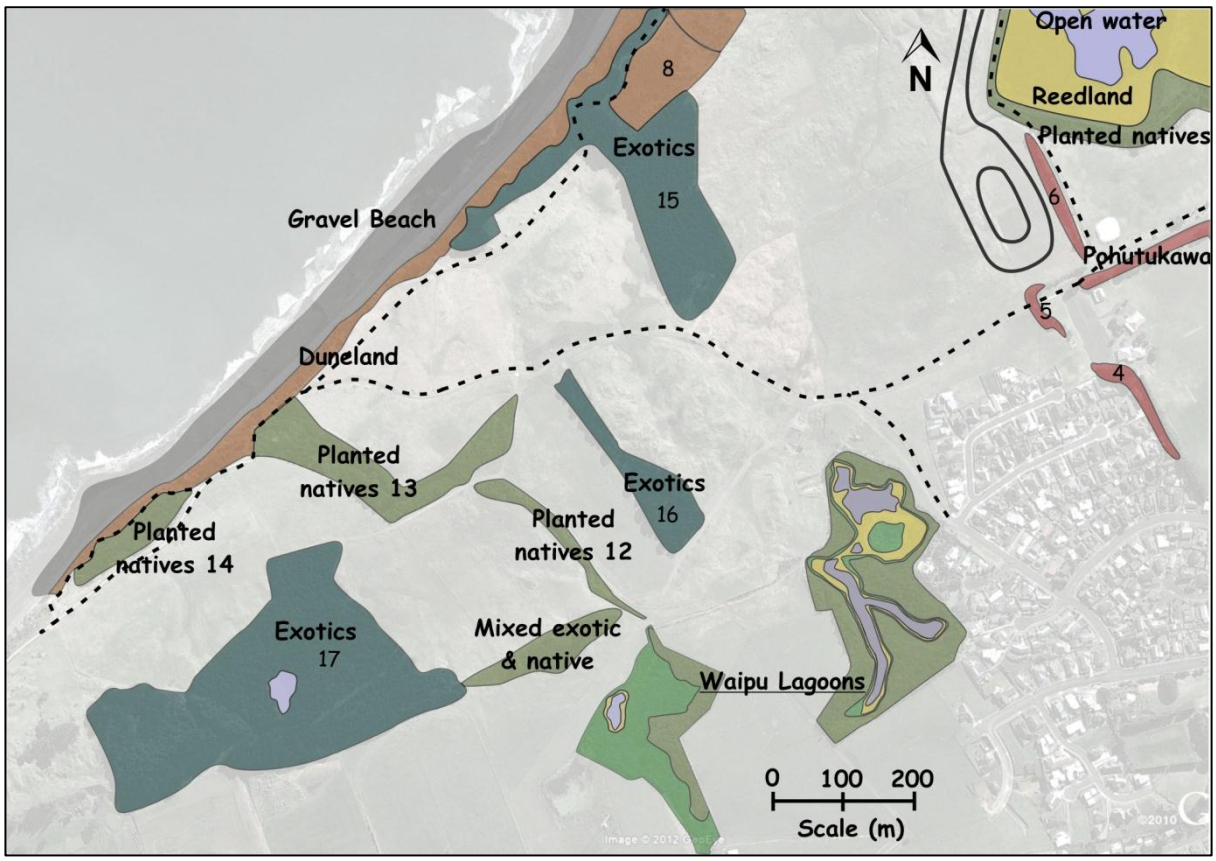

Figure 3: Map showing the ecological features within the western sector of Hickford Park. See text for detailed description of features.

4.1 Waipu Lagoons

The Waipu Lagoons (Figure 4) are a series of three irregularly shaped, natural coastal lagoons (lakelets) with a combined open water area of approximately 2 ha. The lagoons and surrounding vegetation cover approximately 8 ha, and provide valuable habitat to native wildlife. The Waipu Lagoons represent a rare ecosystem type, as coastal lagoons are no longer common in the Taranaki Region. In 1986, the Department of Lands and Survey listed the wetlands as Protected Natural Areas in recognition of their high ecological values (Bayfield & Benson 1986). Based on the National Wetland Monitoring protocols, we suggest the Waipu Lagoons have a Condition Index score of 20.66/25, indicating a wetland with only a minor degree of modification from the original state (See Appendix 3).

Although spring fed (with no stream water input), anthropogenic nutrient sources in the vicinity of the lagoons include grazed pasture and housing/urban developments. Native dominated vegetation which fringes the lagoons would act to buffer nutrient inputs, however nutrient levels are likely to be well above historical levels; coastal lagoons naturally have very low fertility (Ogle 2003). Although the lagoons are fully fenced, there was some evidence (pugging and hoof prints) that stock had previously entered the vegetated area which surrounds the eastern lagoon. Exotic water birds such as black swan

and Canada geese, which are common on the lagoons, may also contribute to the addition of nutrients as they tend to feed on the surrounding pasture and later return to the lagoons to roost (Ogle 2003).

The presence of various mammalian pests (e.g. domestic/and feral cats, hedgehogs, mice, rats and mustelids) at the lagoons would also considerably impact the native wildlife, increasing competition for food and habitat resources and also predation. A number of ground nesting bird species are suspected to use the lagoons (e.g. the endangered Australasian bittern *Botaurus poiciloptilus*), these species are likely to be most vulnerable.

Native vegetation which fringed the margins of the lagoons was dominated either by reedland, flaxland or mixed natives. Reedland was present in the littoral zone, while flax dominated the interface between the reedland and mixed native vegetation (Figure 5). Smaller areas, dominated by native sedges, were also present within the interface zone. The main vegetation types at the lagoon were mapped (Figure 4) and are described below. For ease of vegetation descriptions, the lagoons have been numbered from 1 to 3.

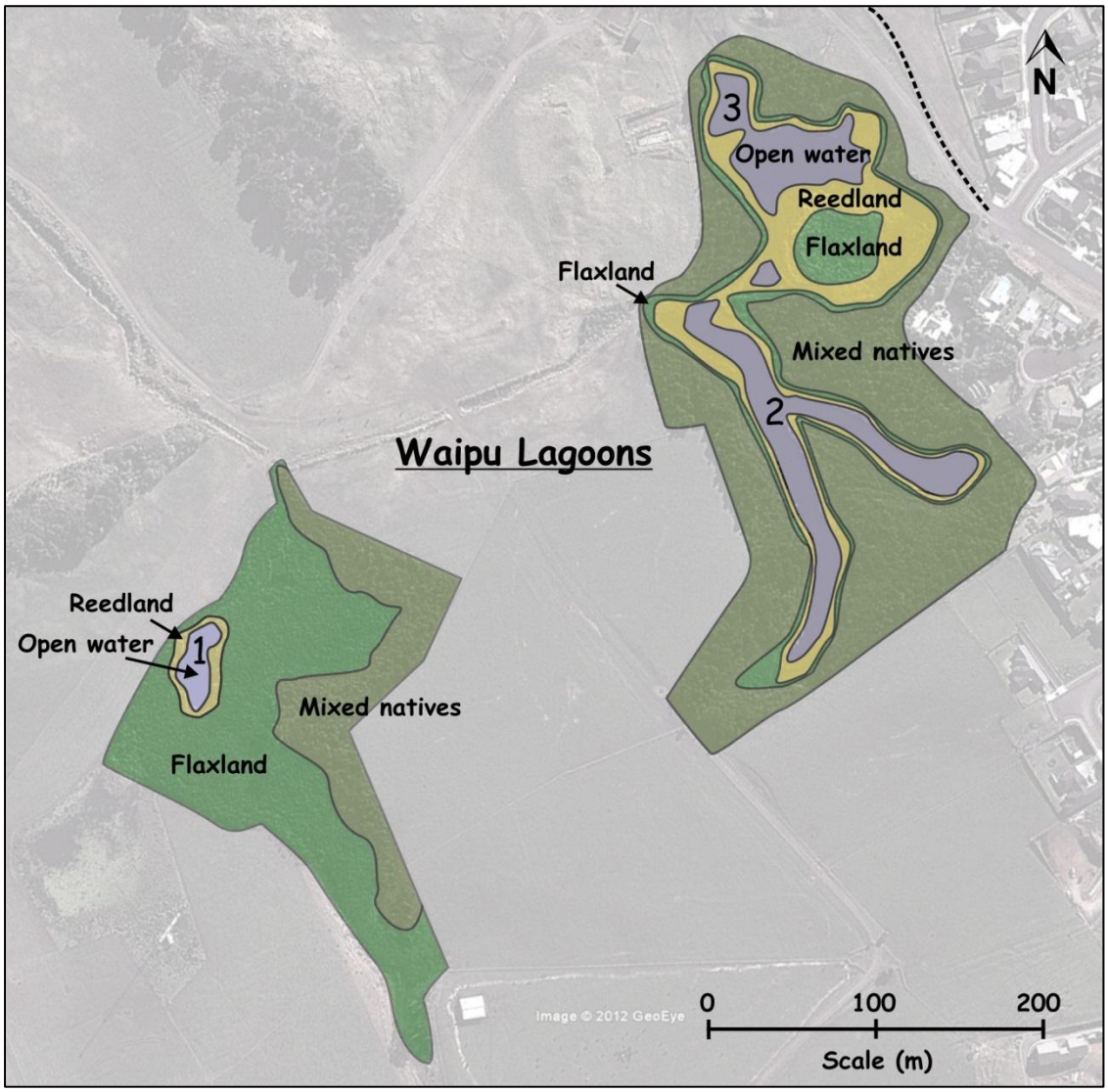

Figure 4: Map showing the vegetation zones within the Waipu lagoons. See text for vegetation descriptions.

4.1.1 Reedland

Reedland vegetation was dominated by raupo (*Typha orientalis*) up to 2 metres tall. At the time of this survey all raupo displayed natural winter die back. In some areas of deeper water, kuta (*Eleocharis sphacelata*) was also common. Other species present within the littoral vegetation were sharp spike sedge (*Eleocharis acuta*), grass-leaved rush (*Juncus planifolius*), *Carex secta*, *Carex virgata*, *Baumea rubiginosa*, *Isachne globosa*, coastal cutty grass (*Cyperus ustulatus*), water fern (*Azolla filiculoides*) and several *Isolepis* species (*I. distigmatosa*, *I. inundata*, *I. prolifer*).

4.1.2 Flaxland

Flaxland vegetation dominated by flax (*Phormium tenax*) up to 2 metres in height was present on the lagoon margins between the reedland and surrounding riparian forest. Of the three broad vegetation types identified for the lagoons, flaxland was the most extensive, particularly around lagoon 1, having a total area of nearly 2 ha. Scattered emergent cabbage tree (*Cordyline australis*) individuals were also common, particularly around the eastern two lagoons (2 and 3). Other species that were common growing beneath and amongst the flax were karamu (*Coprosma robusta*), kawakawa (*Macropiper excelsum*), taupata (*Coprosma repens*), toetoe (*Austroderia toetoe*), kiokio (*Blechnum novae-zelandiae*) and swamp kiokio (*Blechnum minus*). Exotic species included pampas (*Cortaderia selloana*) and arum lily (*Zantedeschia aethiopica*).

4.1.3 Mixed natives

On drier ground at the peripherals of the lagoons, cabbage tree, silver fern (*Cyathea dealbata*) and mamaku (*Cyathea medullaris*) become more common above flaxland species. With increasing distance from the lagoon margins, coastal/lowland tree species (some planted) pohutukawa (*Metrosideros excelsa*), ngaio (*Myoporum laetum*), coastal banksia (*Banksia integrifolia*) and mahoe (*Melicytus ramiflorus*) became more dominant and formed a continuous canopy up to 10 metres in height. Whau (*Entelea arborescens*) and coastal shrub daisy (*Olearia solandri*) were also present. It is not known whether or not the coastal shrub daisy was planted at the lagoons in the past, but it is now naturally regenerating. The understory was predominantly native with kawakawa being the most common; other species included karamu, mahoe, regenerating karaka juveniles (*Corynocarpus laevigatus*), hangehange (*Geniostoma rupestre*), houpara (*Pseudopanax lessonii*) and fireweed *Haloragis erecta*). Ferns hanging spleenwort (*Asplenium flaccidum*) and shining spleenwort (*Asplenium oblongifolium*) were also common. The understory contained a number of exotic species such as arum lily (*Zantedeschia aethiopica*), plectranthus (*Plectranthus ciliatus*), wandering jew (*Tradescantia fluminenis*), fatsia (*Fatsia japonica*) and flowering cherry (*Prunus* sp.). Exotic species were more common in the eastern sector which surrounded lagoons 2 and 3. Here, the vegetation is bounded by houses, and these have provided a number of garden escapes. A grove of puriri (*Vitex lucens*) at the east of lagoon 2 (bordered by Ludlow Place residents) had recently been heavily pruned

(Figure 5b); the increased light levels in the understory coupled with disturbance has allowed weeds species to proliferate. Nearby, large coastal banksia had also undergone a recent pruning. Between lagoon 2 and 3, a labelled Pa harekeke (planted flax cultivars used for Maori weaving) is also present.

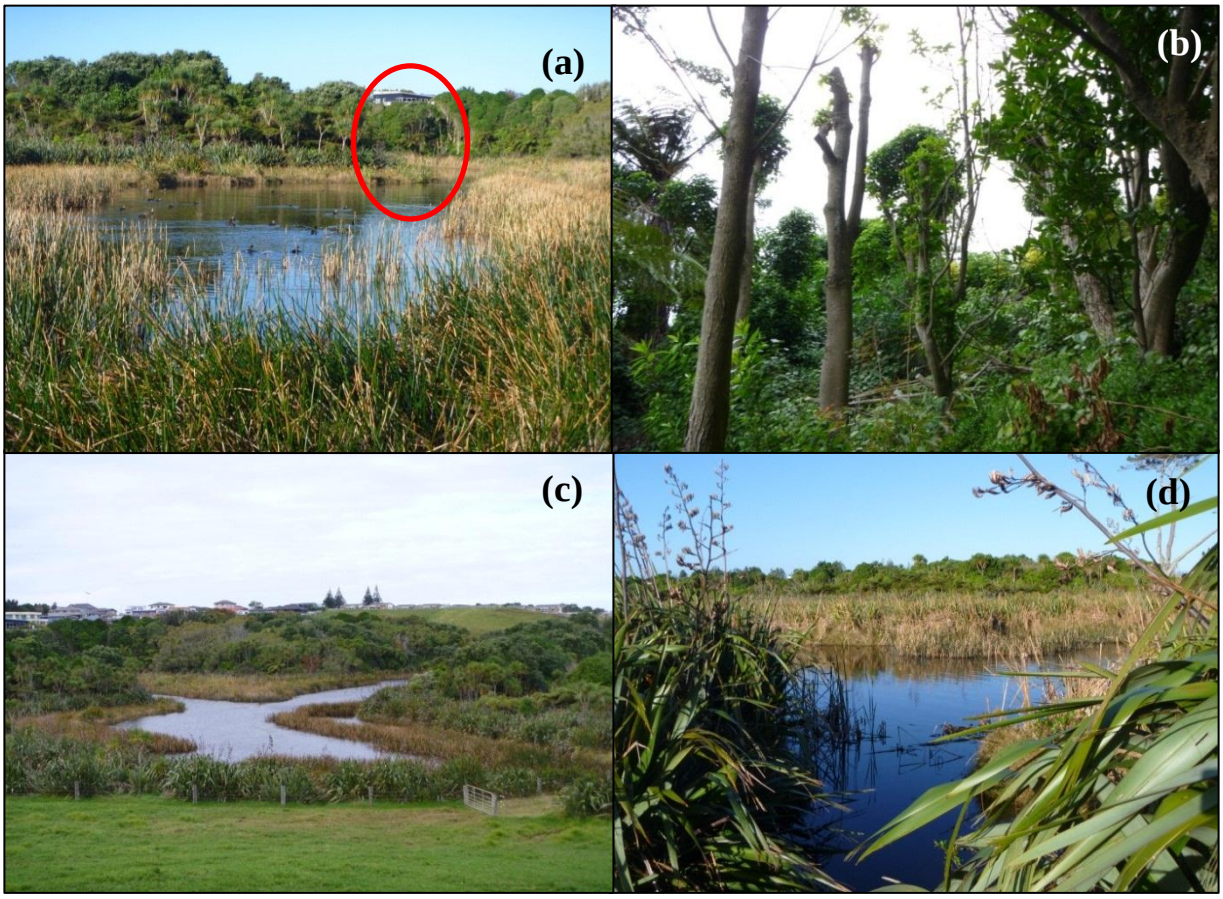

Figure 5: Waipu Lagoons and surrounding vegetation showing area of pruned puriri **(a,b)** and vegetation transition from reedland to flaxland then mixed natives **(c, d)**.

4.2 Oxidation ponds

The oxidation ponds (disused) provide an artificial wetland habitat for a vast number of bird species. Reedland is the dominant vegetation type within the oxidation ponds; however the surrounding man-made embankments have been planted with an array of native species. The location of vegetation types around and within the oxidation ponds are shown on Figure 2.

4.2.1 Reedland

The western pond had a large area of open water, surrounded by reedland (Figure 6). Open water was frequently used by water fowl, and the nationally sparse New Zealand dabchick (*Poliocephalus rufopectus*) has been recorded here (see Section 4.8.1). The eastern pond was predominantly vegetated with reedland, with only a small area of open water present in the north-eastern sector. Reedland vegetation included a mosaic of raupo, kuta, kuawa (*Schoenoplectus tabernaemontani*) and giant rush (*Juncus pallidus*).

4.2.2 Planted natives

Embankments which surround the oxidation ponds were primarily vegetated with planted natives, however the natural arrival of some shrubs and native ferns had also occurred. Fern species included swamp kiokio, kiokio, shining spleenwort and stunted mamaku. Vegetation on the northern and eastern embankments was dominated by flax and cabbage tree which overtopped exotics including Yorkshire fog (*Holcus lanatus*), dandelion (*Taraxacum officinale*) and kikuya grass (*Pennisetum clandestinum*). Vegetation on the southern edge was more diverse and occupied a much broader zone, screening the ponds from the softball playing fields. On the wetland margin, pasture grasses and exotic weeds (including kikuya, umbrella sedge, willow weed and Mercer grass (*Paspalum distichum*)) mixed with the native rush and reed species. Vegetation south of the embankment included a band of planted ngaio which adjoined a stand of mixed planted natives dominated by pohutukawa. Here, pohutukawa overtopped a native understory of mostly kawakwa, taupata and karo, with native spinach (*Tetragonia implexicoma*) common on the ground. Several large gum (*Eucalyptus* sp.) and pine (*Pinus radiata*) trees were also present. Planted natives along the western embankment consisted of an intermittent canopy of ngaio and pohutukawa over flax, karo, kawakawa and tuapata, the majority of which had naturally regenerated. In several open areas, gorse (*Ulex europaeus*) had also established.

Figure 6: Vegetation within and surrounding the oxidation ponds.

4.3 Mangati Stream

The Mangati Stream (Figure 7) on the eastern border of Hickford Park has a small, industrialised/urbanised catchment, with over 10% of its 1st and 2nd order tributaries having been subject to modification since 2001. The Mangati Stream has also been identified as having very poor water quality (Taranaki Regional Council 2010). In the past, several pollution incidents (primarily the result of industrial discharges) have occurred, two of which involved major fish kills. In response to

this, the Taranaki Regional Council now require special licencing for discharges into the stream and have implemented the Mangati Stream Catchment Resource Consents Monitoring Programme, to ensure compliance and monitor water quality and biota. Since this programme started, the Mangati Stream has seen a number of improvements in water quality (Taranaki Regional Council 2010). Fish species recorded within Mangati stream are provided in Section 5.7.2 of this report.

Vegetation along the streamside within Hickford Park was predominantly exotic grasses (e.g., kikuya, and Mercer grass) and flax. However localised patches of montbretia (*Crocosmia* x *crocosmiiflora*) and floating sweet grass (*Glyceria maxima*) were also present. Further from the stream, planted pohutukawa overtopped pasture grasses. Small areas of stream side erosion were also evident along the channel, particularly in the area located behind the boxing club.

Figure 7: Mangati Stream mouth (left) and area of streamside dominated by exotic grasses (right).

4.4 Sand dune vegetation

4.4.1 Duneland (7)

Hickford Park comprises a dune system which increases in size and height in the eastern region of the park; sand dunes west of Mangati Road were noted to be rapidly eroding during the 1970's (Taranaki Catchment Commission 1988). Active dunes had no soil profile, were unstable, highly drained and contained low levels of nutrients (Coleman et al. 2010). Active dunes were vegetated in a mosaic of both native and exotic species; however areas of open sand were common, particularly in the eastern most region near the Mangati road beach access, where foot traffic is also assumed to be the greatest (Figure 8). Dunes were dominated by exotic marram grass (*Ammophila arenaria*) and native knobby club rush (*Isolepis nodosa*), with patches of exotics such as yellow tree lupin (*Lupinus arboreus*), boxthorn (*Lycium ferocissimum*), inkweed (*Phytolacca octandra*) and ice plant (*Carpobrotus edulis*) also common. Small, localised areas of native sand sedge (*Carex pumila*) were present on the edges of tracks or recently disturbed/active sites.

Consolidated duneland, present along the western sector of coastline hosted an array of native and exotic species (Figure 8). Native species included wind-shorn taupata, karo, ngaio and small-leaved pohuehue (*Muelenbeckia complexa*). Pohuehue (*Muelenbeckia australis*) was also present, scrambling throughout the dune vegetation and also amongst debris and driftwood on the vegetation-beach interface. Marram grass and knobby club rush were common on the vegetation-beach interface, and also throughout the wider dune vegetation. A large number of exotics had also established amongst the dune vegetation including those listed for active dunes as well as kikuya grass, yorkshire fog, broad-leaved fleabane (*Conzya albida*), sheep's sorrel and dandelion.

Figure 8: Active dune system with un-vegetated areas and pampas invasion (left) and interface between dune vegetation and stoney beach (right).

4.4.2 Duneland (8)

This vegetation unit occupied a concave open area of approximately 0.6 ha, situated behind the fore dunes and adjacent to plantation forest. Knobby club rush and flax up to 1.5 metres tall dominated this area. Other species included scattered individuals of karo, taupata and small-leaved pohuehue. The exotic species, blackberry, gorse, yellow tree lupin and pampus, were also abundant; blackberry formed very dense thickets in some areas (Figure 9). Although this area had no open water, localised areas dominated by moss were common. This unit is ecologically significant because it is the only un-grazed area of back dune within the park that has not been subject to high levels of planting.

Figure 9: Knobby club rush and flax land (left) and area dominated by blackberry (right).

4.5 Pohutukawa

4.5.1 Planted pohutukawa (1)

This vegetation unit covered an area of approximately 1 ha. Variably spaced, planted pohutukawa and Kermadec Island pohutukawa (*M. kermadecensis*) overtopped exotics including kikuya grass, buttercup (*Ranunculus acris*) and narrow leaved plantain (*Plantago laceolata*). Pohutukawa were generally less than 8 metres tall and did not form a continuous canopy (Figure 10). Other less common tree species included coastal banksia, and cabbage tree. It has been suggested that planting a monoculture of pohutukawa may slow the rate at which a diverse community will develop, compared to other nurse species; however taupata, kohuhu and coastal banksia were seen regenerating directly beneath the young pohutukawa here. More regeneration and recruitment is expected as this stand develops and gives rise to a continuous canopy. Although pohutukawa here are below the species natural southern limit, over time it is expected this stand will develop into a small pohutukawa forest, and will increasingly provide a significant resource to native wildlife and have considerable ecological and aesthetic value.

A thin band of vegetation between the existing path (walkway option 2.1) and Mangati road was dominated by both cabbage tree and pohutukawa, over flax, taupata and karaka. This zone of vegetation was predominantly native, however a number of exotic species were present included coastal banksia, woolly nightshade (*Solanum mauritianum*), brush wattle (*Paraserianthes lophantha*) and flowering cherry (*Prunus*). Montbretia also formed dense swards along the margins of the Mangati Stream.

4.5.2 Planted pohutukawa (2)

This vegetation unit comprised of a thin, road side band of vegetation approximately 3 m wide, spanning 500 metres, and screening Hickford Park from Mangati Road traffic. Pohutukawa was the dominant tree species in this planting, along with cabbage tree, taupata, flax and karo; most of which were naturally regenerating.

4.5.3 Planted pohutukawa (3,4,5,6)

These pohutukawa dominated stands were small, isolated and bordered park and farmland. Stand number 3 bordered the Hickford Park fields on the Smeaton Road and Saint Andrews Drive boundaries. The stand was comprised of widely spaced trees over-topping mowed grass. Stands 4, 5 and 6 were also dominated by pohutukawa, however had other canopy natives and naturally regenerating understories. Stand 4 comprised a thin densely vegetated strip and canopy height reached approximately 10 metres. Other species that were present here included karo, taupata and mahoe. Stand 5 was comparable in both structure and composition to stand 4. Stand 6 was approximately 200 metres by 2 metres wide and ran adjacent to a shallow drain on the western boundary of the softball field (Figure 10). Pohutukawa was the dominant species along with cabbage tree, taupata, kawakawa and karo Scattered pampas was also present.

Figure 10: Planted pohutukawa on back dune (a, b), and pohutukawa stand 6 (c) and 3 (d).

4.6 Planted natives

4.6.1 Planted natives (9)

This vegetation unit located along the boxing club road was dominated by cabbage tree and pohutukawa (approximately 6 metre tall) over flax. Other tree and shrub species present included brush wattle, taupata, karaka and karo. Natural regeneration of karaka, taupata and karo was occurring. A small depression situated in the south eastern region included exotic species such as buttercup and kikuya grass; however on the margins of this depression were dominated by natives flax, mamaku and taupata.

4.6.2 Planted natives (10)

This unit comprised a small wetland dominated by raupo, however exotic floating sweet grass had invaded the margins. The riparian zones along the Mangati streamside and on the margins of the wetland here were dominated by a mosaic of flax and cabbage tree.

4.6.3 Planted natives (11)

Karaka was the dominant canopy species in the south-western corner of this vegetation unit, replaced by pohutukawa elsewhere. Canopy height ranged from 6 to 10 metres. The understory was generally sparse; however vegetation became denser on the peripherals. Understory species included silver fern, taupata, kawakawa and arum lily.

4.6.4 Planted natives (12)

This unit comprised of a narrow fenced drain which linked the Waipu lagoons with the vegetation unit "Planted natives 13" and the coast (Figure 11). The drains length was approximately 500 metres. Planted flax was common on the drain edges, as were the native sedges *Carex virgata* and *Carex secta*. The exotic umbrella sedge was also common here along with a mixture of grasses such as kikuya, Mercer grass and yorkshire fog.

Figure 11: Drain showing planted flax along drain edge.

4.6.5 Planted natives (13)

This patch of planted natives covered approximately 1.9 ha and had variable species composition (Figure 12). A shallow vegetated drain linked this stand with the Waipu Lagoons. In places this drain had large amounts on umbrella sedge growing along the margins. Near the coast, flax land was the dominant vegetation type within this unit, with scattered kawakawa and taupata also present. A band of coastal banksia, ngaio and pohutukawa were also present near the lookout platform in the north west of the stand. South of this the vegetation was predominantly ngaio with emergent coastal banksia

and pine (both *P. radiata* and Norfolk pine). Beneath these and on the stand margins, kawakawa and flax were common. Where this stand runs parallel to the coastline, vegetation was predominantly flaxland with emergent cabbage tree; cabbage trees became taller and intermixed with pohutukawa in the south-west and ngaio was also present.

Figure 12: Planted natives 13. View from lookout platform (left) and southern section of stand (right).

4.6.6 Planted natives (14)

This vegetation unit was dominated by a mixture of native species and coastal banksia (Figure 13). This stand had a canopy height between 3-5 metres; the vegetation was wind-shorn and shorter on the seaward side. Flax and mountain flax (*Phormium cookianum*) were both present on the vegetation peripherals, particularly on the seaward side. Common canopy species included karo, ngaio, banksia, pohutukawa and tainui. Understory species included taupata, kawakawa and houpara. Exotic blackberry and yellow tree lupin were present on the margins.

Figure 13: Mixed exotic and native stand (circled on left). Seaward side of stand showing flax on the peripherals (right).

4.6.7 Mixed exotic and native

This vegetation unit was approximately 0.5 ha in extent and occupied a small hummock along the southern boundary of Hickford Park. Vegetation was open with scattered individuals of Norfolk Pine and *Pinus radiata*. Other species included gorse, boxthorn, pampas and coastal banksia. The south eastern sector of this unit was more densely vegetated with pohutukawa, coastal banksia and ngaio forming an almost continuous canopy.

4.7 Exotic dominated stands

4.7.1 Exotics (15)

This vegetation unit covered approximately 3.5 ha and linked up with the dune vegetation. The dominant species present were pine and Lawson's cypress (*Chamaecyparis lawsoniana*). A lesser number of Norfolk pines were also present, particularly in the south-western quarter where some had been recently planted in a small clearing. Similar to unit 16, the understory was sparse under the exotics and the majority of shrub species were present on the well-lit peripherals. Common native shrub species were kawakawa, taupata, karo and native spinach. Other exotic species, also most common on stand margins, included blackberry, gorse, kikuya grass, Yorkshire fog and inkweed. The native leather leaf fern (*Pyrrosia eleagnifolia*) was growing epiphytically on a number of the pine and cypress trees.

4.7.2 Exotics (16)

This vegetation unit was approximately 1.2 ha in extent and was surrounded by pasture. The dominant species was mature Lawson's cypress, however gum trees (*Eucalyptus* spp.) and Norfolk pine were also present (Figure 14). The understory was fairly sparse, however there was some regeneration of native shrubs occurring, particularly karo and taupata. Although the perimeter of this vegetation unit was fenced the understory on the margins of the stand had been heavily browsed by stock. Stand margins also hosted a number exotic species such as blackberry, gorse and woolly nightshade. Similar to vegetation unit "exotics 15", the native spinach was common (Figure 14).

Figure 14: Native spinach growing beneath exotic plantation stand (left), and absence of understory below exotics (right).

4.7.3 Exotics (17)

This vegetation unit was the largest single unit of plantation forest in the park, and covered approximately 8.5 ha. A number of informal tracks run throughout this stand. The dominant tree species was Lawson's cypress. Similar to the previously described exotic stands, the understory was sparse, partially owing to the densely shading canopy and slowly decomposing litter beneath. Understory species were limited to the stand peripherals and along track boundaries where light levels were higher. Native marginal vegetation included tuapata, karo, ngaio, large leaved pohuehue, silver fern, kawakawa and cabbage tree. Native ferns, hanging spleenwort and leather leaf fern were present growing epiphytically on the cypress trees. Exotic weed species were also common on vegetation margins and along the track edges and included blackberry, inkweed, woolly nightshade, boxthorn and yellow tree lupin. An area with a developed understory was present in the south-eastern quarter, and comprised tainui, ngaio, akeake (*Dodonaea viscosa* var.), taupata, kawakawa, woolly nightshade and coastal banksia; during this field survey, six tui's were noted in a single coastal banksia tree at this location.

Figure 15: Small wetland within planted exotic stand.

This vegetation unit also encompasses a small wetland area of approximately 150 m^2. In the riparian zone surrounding this, a small number of whau were present, but the remainder was dominated by exotics including Mercer grass, kikuyu grass and willow weed (*Persicaria maculosa*). Vegetation within the littoral zone also included clumps of *Isolepis* spp. (Figure 15).

4.8 Fauna

4.8.1 Bird life

Hickford Park provides a range of habitats (e.g., wetlands, native and exotic plantings, dune land) supporting a number of native and introduced bird species. A record of birds recorded at the Waipu Lagoons and oxidation ponds has been provided by Barry Hartley (The Ornithological Society of New Zealand, Taranaki representative). His list was compiled from 109 (oxidation ponds) and 9 (Waipu lagoons) visits to the sites, made between November 1999 and December 2011 (Table 1). In this period, a total of 32 bird species were recorded at the Waipu Lagoons and 48 bird species were recorded at the oxidation ponds. Combined lists have a number of notable features, such as the presence of the New Zealand dabchick (*Poliocephalus rufopectus*), which has a conservation ranking of nationally sparse (Hitchmough 2002). The grey teal and Australasian coot (although the latter not recorded by Barry Hartley) are both also naturally uncommon in the Taranaki Region, and both have been recorded within Hickford Park (Bayfield and Benson 1986).

The nationally endangered Australasian bittern (*Botaurus poiciloptilus*) has also previously been recorded at the Waipu Lagoons by Bayfield and Benson (1986), and occasionally one has also been seen along the nearby Waiongana River (Barry Hartley pers. com.). The Australasian bittern is recognised as a nationally endangered species due to its small and rapidly declining populations (IUCN 2012), largely a result of a loss and degradation of suitable wetland habitats. The Australasian bittern is considered a potential indicator of the health of wetlands and the status of birds within them because its presence is likely to depend on healthy fish stocks and water regimes and predator-free habitats (Gilbert et al. 2007; Polak 2007; O'Donnell 2011). The species has only been recorded at a few other locations within the Taranaki region, including Barrett Domain and vegetated farm ponds near Inglewood (Bayfield and Benson 1986).

Table 1: Bird species recorded at the Waipu Lagoons and oxidation ponds, Hickford Park, by Barry Hartley (The Ornithological Society of New Zealand, Taranaki representative) between 1999 and 2011.

Bird species		+ indicates presence	
Common name	**Scientific name**	**Waipu lagoons**	**Oxidation ponds**
Australasian harrier	*Circus approximans*	+	+
Australasian shoveler	*Anas rhynchotis*	+	+
Australian magpie	*Gymnorthina tibicen*	+	+
Banded dotterel	*Charadrius bicintus*		+
Bar-tailed godwit	*Limosa lapponica*		+
Black fronted dotterel	*Charadrius melanops*		+
Black shag	*Phalacrocorax carbo*	+	+
Black swan	*Cygnus atratus*	+	+
Black-backed gull	*Larus dominicanus*	+	+
Blackbird	*Turdus merula*	+	+
Canadian goose	*Branta canadensis*	+	+
Cattle egret	*Bubulucus ibis*		+
Chaffinch	*Fringilla celebs*	+	+
Fantail	*Rhipidura fuliginosa*	+	+
Feral pigeon	*Columba livia*	+	+
Goldfinch	*Carduelis carduelis*	+	+
Greenfinch	*Carduelis chloris*	+	+
Grey duck	*Anus superciliosa*	+	+
Grey teal	*Anus gracilis*		+
Grey warbler	*Gerygone igata*		+
House sparrow	*Passer domesticus*	+	+
King fisher	*Halcyon sancta*		+
Little black shag	*Phalacrocorax sulcirostris*	+	
Mallard	*Anas platyrhynchos*	+	+
Muscovy duck	*Cairina moschata*		+
Myna	*Acridothered tristis*	+	+
New Zealand Dabchick	*Poliocephalus rufopectus*		+
New Zealand pipit	*Anthus novaeseelandiae*	+	+
New Zealand scaup	*Aythya novaeseelandiae*	+	+
Paradise shelduck	*Tadorna variegata*	+	+
Pheasant	*Phasianus colchicus*		+
Pied oystercatcher	*Haematopus ostralagus*		+
Pied shag	*Phalacrocorax varius*	+	+
Pied stilt	*Himantopus himantopus*	+	+
Pukeko	*Porphyrio porphyrio*	+	+
Red billed gull	*Larus novaehollandiae*		+
Reef heron	*Egretta sacra*		+
Royal spoonbill	*Platalea regia*		+
Silver eye	*Zosterops lateralis*	+	+
Skylark	*Alauda arvensis*	+	+
Song thrush	*Turdos philomelos*	+	+
Spur winged plover	*Vanellus miles*	+	+
Starling	*Sturnus valgaris*	+	+
Tui	*Prosthemandera novaeseelandia*		+
Variable Oystercatcher	*Haematopus unicolor*		+
Welcome swallow	*Hirundo tahitica*	+	+
White-faced heron	*Ardea novaehollaniae*	+	+
White-winged black tern	*Chlidonias leucopterus*		+
Yellowhammer	*Emberiza citrinella*	+	+

4.8.2 Aquatic species

The NIWA Freshwater Biodata Information System (FBIS) holds several fish records for the Waipu Lagoons and Mangati Stream from six surveys conducted between December 1990 and June 2007 (Table 2). Sample collection methods included electric fishing (mains set and pack set), bait trapping and hand netting. Three fish taxa were identified in the Waipu Lagoons and five in the Mangati Stream (Table 2). No fish records were available for the oxidation ponds; however it is quite possible they could contain eels at the least. The native freshwater crayfish, koura, were also recorded in the Mangati stream. Koura have a threatened status and populations are thought to be in a state of gradual decline. During field work the introduced Australian southern bell frog (*Litoria raniformis*) was sighted amongst timber near Waipu lagoons (Figure 16), and golden bell frogs (*Litoria aurea*) are also likely to be present there.

Table 2: List of Fish species recorded for the Waipu Lagoons and Mangati Stream between 1990 and 2007, compiled from the NIWA Freshwater Biodata Information System (FBIS).

Fish species			+ indicates presence	
Scientific name	**Common name**	**Status**	**Waipu**	**Mangati Stream**
Anguilla dieffenbachii	Longfin eel	Native, Gradual decline		+
Angulla australis	Shortfin eel	Native, not threatened		+
Carassius auratus	Goldfish	Introduced	+	
Galaxias brevipinnis	Koaro	Native, not threatened		+
Galaxias fasciatus	Banded kokopu	Native, not threatened		+
Galaxias sp.	-	-	+	
Gobiomorphus huttoni	Redfin bully	Native, not threatened		+
Perca fluviatilis	Perch	Introduced	+	
Invertabrates				
Paranephrops planifrons	koura	Native, gradual decline		+

Figure 16: Southern bell frog (*Litoria rnaiformis*) found near Waipu Lagoons.

4.8.3 Other animals

The diverse habitats within Hickford Park undoubtedly host a wide range of animals. Flaxland, present along the coastline provides ideal habitat for the Taranaki gold-striped gecko (*Hoplodactylus chrysosireticus*), known to inhabit the narrow coastal strip which extends from Waitara to just north of Pātea. Although the species is nocturnal, individuals have been sighted sunning themselves upon flax leaves in the Taranaki Region. The species is considered endangered (Department of Conservation 2012), however has adapted well to urban environments and have often been found in locations such as in or around hay sheds and barns, and under old timber; all of which are also present within Hickford Park area. It was hoped inked tracking tunnels deployed during this study would provide evidence for the gold-stripped gecko in Hickford Park, however this was not the case; mice and mustelids were the only animals tracked. Two night-time searches for gecko under torchlight were also unsuccessful. However, a local Bell Block resident has reported weta within the park, sighted near the Mangati Stream and planted stand of pohutukawa.

A number of introduced mammals including brushtail possums, mustelids, rats, mice, rabbits, hares and hedgehogs are also likely to be present within Hickford Park. Domestic dogs and cats also frequent the park. The presence of both wild and domestic animals within Hickford Park could impact upon any restoration work, for example hares, rabbits and possums may interfere with new plantings.

5 Management recommendations

5.1 Restoration planting and weed control

5.1.1 Sand dunes

Invasion of exotic species in sand dunes at Hickford Park was quite high, in part because of the high levels of disturbance which occur there (e.g. environmental processes, foot traffic) and proximity to farmed and urban land which act as a source (Figure 17). Weedy exotic species present in the sand dunes and wider park area ranged from small herbaceous plants to woody trees; a full list of exotic species is provided in Appendix 1. A number of these species pose a potential risk because they are very successful at colonising open areas and could, in time, predominate. For example coastal banksia has been planted and naturalised throughout the Hickford Park area, and has locally spread via seed fall. In many regions of New Zealand (e.g. Auckland Region) coastal banksia is considered a pest plant as it is quick to establish and dominate open sites, particularly dune lands. However, the species does provide copious amounts of nectar to our native birds (e.g. tui and bellbird) in autumn and winter, when few native species are flowering. The high growth rates of coastal banksia also make it a suitable nurse plant, facilitating the establishment of native understory species. It is recommended that no further planting of this species occurs within the park, though the existing banksia could probably be left for site stabilisation, facilitation of natives in the understory and as a resource for birds. If possible however, any newly established individuals within the duneland should be removed, before the species proliferates further and displaces native vegetation. Because of the scattered distribution of coastal banksia individuals within the dunes removal via cutting and painting with Vigilant® gel may be most appropriate.

Wilding pine, pampas grass, boxthorn, exotic ice-plant and marram grass have also invaded the dune vegetation, with pines and pampas being particularly prevalent in close vicinity to the Mangati Road car park. If possible, these species should also be removed, to return the vegetation to a more native state and prevent any further spread.

Because weed species readily establish on disturbed open sites, weed removal should be undertaken in conjunction with enrichment planting of suitable native species to avoid re-invasion. Coleman et al. (2012) recommend species suitable for use in restoration planting in the various types of dunes along the coastal walkway:

Active foredunes areas	Sheltered foredune areas
Pingao (*Ficinia spiralis*)	Shore groundsel (*Senecio lautus* subsp. *lautus*)
Spinifex (*Spinifex sericeus*)	Tauhinu (*Ozothamnus leptophyllus*)
Sand sedge (*Carex pumila*)	Sand Coprosma (*Coprosma acerosa*)
Native ice plant (*Disphyma australe*)	Toetoe (*Austroderia fulvida*)
Sand pimelea (*Pimelea villosa*)	Small leaved pohuehue (*Muehlenbeckia complexa*)

Consolidated dunes

Flax (*Phormium tenax*)	Karo (*Pittosporum crassifolium*)
Taupata (*Coprosma repens*)	Tauhinu (*Ozothamnus leptophyllus*)
Toetoe (*Austroderia toetoe, A. fulvida*)	Coastal tree daisy (*Olearia solandri*)
Cabbage tree (*Cordyline australis*)	Koromiko (*Hebe stricta*)
Karamu (*Coprosma robusta*)	Corokia (*Corokia cotoneaster*).

Figure 17: Invasion of exotics boxthorn, pine, pampus, coastal banskia and marram grass in duneland vegetation.

5.1.2 Waipu Lagoons

Vegetation which currently surrounds the Waipu Lagoons is predominantly native. However, dense swards of arum lily had established in some locations, particularly on the peripherals of the eastern lagoon, where it has smothered the ground layer and prevented regeneration of native flora. Arum can be dug out, but the broken roots readily re-sprout; cutting and painting of the stumps with metsulfuron-methyl 600g/kg (1g) + glyphosate (100ml) + penetrant/1L water may be the most effective control option (Weedbusters 2012). The recent pruning of mature puriri trees, in close vicinity to the properties of Ludlow Place residents, has created canopy openings in which an array of weed species have established (e.g. wandering Jew, German ivy). This pruning of native trees which

appeared to be growing on council land may wish to be investigated further. Any removal of weed species in the understory (e.g. arum) should occur in conjunction with enrichment planting. Coleman et al. 2010 have identified a number of species suitable for restoration planting in the lagoons area:

Littoral Zone

Raupo (*Typha orientalis*)
Kuawa (*Schoenoplectus tabernaemontani*)
Kuta (*Eleocharis sphacelata*)
Giant Rush (*Juncus pallidus*)
Sharp spike sedge (*Eleocharis acuta*)

Riparian zone

Flax (*Phormium tenax*)
Kiokio (*Blechnum novae-zelandiae*)
Swamp kiokio (*Blechnum minus*)
Kotukutuku (*Fuchsia excorticata*)
Karamu (*Coprosma robusta*)
Whau (*Entelea arborescens*)

Inland forest

Mahoe (*Melicytus ramiflorus*)
Pigeonwood (*Hedycarya arborea*)
Kohekohe (*Dysoxylum spectabile*)
Whau (*Entelea arborescens*)
Puriri (*Vitex lucens*)
Karaka (*Corynocarpus laevigatus*)
Ngaio (*Myoporum laetum*)

5.1.3 Planted areas/parkland

The removal of other exotic tree species, such as woolly nightshade, brush wattle, and flowering cherry, common within planted areas of the park, is also recommended. Woolly nightshade is particularly problematic in public areas, as the berries and leaf hairs are toxic/allergens, especially to children. However, not all exotic weed species can or need to be controlled. Available resources should target woody species mentioned above, particularly those invading the dune lands. Grasses (e.g. kikuya grass) and other herbaceous weeds (e.g. wandering Jew), growing amongst the planted natives, need only be controlled if resources allow, as this would further encourage the regeneration of natives. For weed control efforts to be successful, it must be undertaken in conjunction with restoration planting and monitoring. Monitoring is required to assess the effectiveness of weed management and the expected recovery of native vegetation following weed removal or suppression. This may involves the use of before and after photographs, mapping of weedy areas, survivorship surveys and monitoring plots.

5.1.4 Planted pohutukawa and Mangati stream

Historically, it was thought pohutukawa did not naturally occur in New Plymouth, the southern limit of the species is suggested to be near Urenui, 25 km north of New Plymouth (Allan 1961). However, suspected possible natural stands near to New Plymouth have more recently been identified (Benson 1995; Simpson 1997); trees here have physical characters distinct from those found elsewhere and

thus any future enrichment plantings of pohutukawa should include individuals of known local provenance (Simpson 1997).

The Mangati Stream has a narrow catchment, located between the Waiwhakaiho and Waiongana River systems. The stream probably extends 5 km in length, initiating from headwaters near Paraite and Corbett Roads and flowing northward, towards bell block beach. The final 500 metres of the stream runs adjacent to the eastern boundary of Hickford Park; stream margins here provide an ideal site to focus restoration planting. Currently, widely spaced planted natives (including pohutukawa and karaka) overtop open pasture grass. Exotic weed species are also common. Removal of weed species and restoration planting would enhance the ecological value of the stream, stabilise the stream channel and improve the stream channels' service as a wildlife corridor for bird and fish migration, further bridging the gap between mountain and sea. A mowed walkway already runs through this area and it is the site of the proposed walkway route 2.1, thus restoration planting would also add to the aesthetic and community values of the park.

It is recommended that low growing, native species be planted nearest to the stream edge. Recommended species include native toetoe (*Austroderia toetoe, A. fulvida*), kiokio, swamp kiokio, *Carex virgata, Carex secta* and *Carex flagellifera.* Moving away from the stream edge and on drier ground, species such as cabbage tree, flax, koromiko, kotukutuku (*Fuchsia excorticata*), karamu, whau, and taupata would be more suitable. Beneath the planted pohutukawa, early-mid successional species, common beneath suspected natural pohutukawa stands in vicinity of New Plymouth, and in natural pohutukawa stands near Urenui, could be planted; replicating a natural pohutukawa ecosystem. It is recommended the following species are included in restoration planting here:

Pohutukawa forest associates

Harakeke (*Phormium tenax*)
Taupata (*Coprosma repens*)
Kawakawa (*Macropiper excelsum*)
Karaka (*Corynocarpus laevigatus*)
Koromiko (*Hebe stricta* var. *macroura*)
Karo (*Senecio lautus* subsp. *lautus*)
Tauhinu (*Ozothamnus leptophyllus*)
Hangehange (*Geniostoma rupestre* sp. *Ligustrifolium*)
Mangeao (*Litsea calicaris*)
Wharangi (*Melicope ternata*)

5.2 Animals and pest eradication

A number of mammalian pests are known to be present within the Hickford Park area. Rabbits are prevalent in the farmland and may pose a threat to future planting efforts. Rats, mustelids and domestic/feral cats may threaten native wildlife, particularly nesting birds. Dogs are not currently thought to be a significant threat to the native wildlife at Hickford Park. However, the "dogs-on-leash" rule on the walkway is a good precautionary measure.

5.3 Monitoring

As part of this investigation three permanent quadrats were installed, it is our recommendation that permanent quadrats are re-measured at 5 yearly intervals. This time frame is sufficient to monitor any adverse changes in ecosystem health that may be occurring and also track natural ecosystem succession. This survey made no quantitative assessment of water quality within the Waipu Lagoons, and to our knowledge no baseline data on the lagoon water quality exists. We recommend a nutrient analysis be conducted and also repeated at five yearly intervals, to determine the nutrient status of the lagoons and to what degree they are losing or gaining nutrients.

5.4 Route options

Proposed route options through Hickford Park are illustrated in Figure 18 and described in Sections 5.4.1-5.4.5.

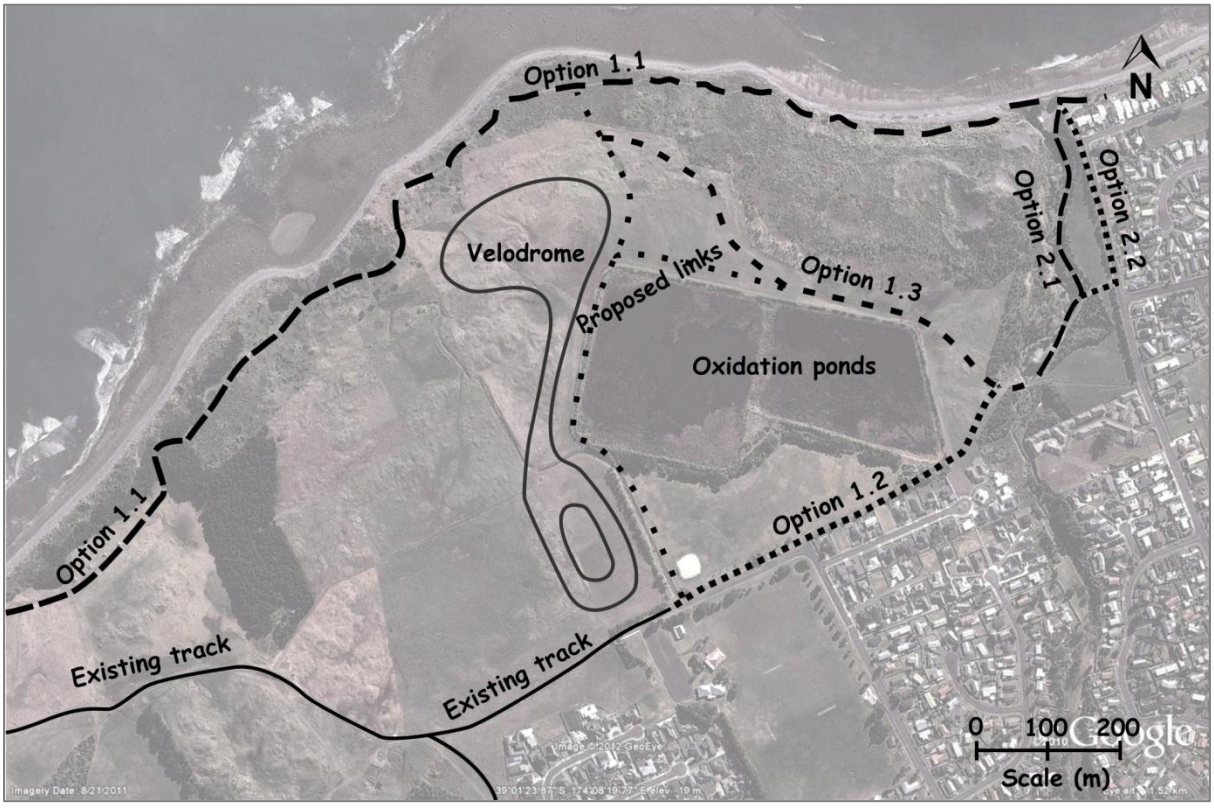

Figure 18: Map showing proposed routes for the coastal walkway extension through Hickford Park, and for extension from Hickford park to Bell Block Beach.

5.4.1 Originally proposed walkway route (1.1)

In 2009, the coastal walkway development plan proposed that the walkway follow the coastline, linking to Bell Block beach at the Mangati Road car park. This route option would involve the construction of a pathway through consolidated and unconsolidated sand dunes (Figure 19). A well-used, informal path already exists along this stretch of coastline and is frequently used by walkers, runners and horse riders. The initial two kilometres of walkway, starting from the north-western boundary of Hickford Park, would traverse grazed pasture of gentle slope. Construction of the walkway here would require a low degree of land stabilization and the widening of the existing informal path.

The final one kilometre of this walkway route, linking to Bell Block beach, would need to traverse steeper dunes that are not fully vegetated. Open areas where unconsolidated sands are actively migrating are also present in this area, and there is evidence of previous coastal erosion, reaching rates of -1.3 to -2.8 m/year between 1970 and 1981 (Taranaki Regional Council 2009). Any public access-way developed along this section of coastline would require a large degree of land stabilisation and need to be established sufficiently back from the coast to prevent adversely effecting dune processes; as well as ensuring the walkway assets are not be detrimentally affected by erosion. The current, informal pathway traverses some fairly steep dune sections; if the walkway extension was to follow this exact route, then alteration to the slope and dune contour may be required to ensure the walkway is suitable for pushchairs and elderly etc. Thus the development of the coastal walkway along this route option would require both vegetation removal and re-contouring and result in a decrease or degradation of natural dune habitat.

Figure 19: Sections of both consolidated and unconsolidated sand dunes along walkway option 1.1.

5.4.2 Route proposed in sports park management plan (1.2)

In 2011, as part of the Sports Park Management Plan, a route was proposed to continue from St Andrews Drive, through the playing fields, past the Parkvue residents' homes and connecting to the boxing club driveway. This route would continue on from the recently completed walkway section that ends near the velodrome entrance. This proposed route option will have an insignificant effect on the current ecology. The route passes through approximately 600 metres of mowed reserve and a further 200 meters of grazed pasture, and thus no native vegetation will need to be cleared for construction. Recently, the Waitara sewer line had been installed along the same route, so development of the walkway here would have very little additional impact (Figure 20).

Figure 20: Levelled soil after the recent installation of the Waitara sewer line along walkway route 1.2.

5.4.3 Alternative coastal walkway route (1.3)

As part of the Sports Park Management Plan submission process, Bell Block residents proposed a third walkway route. This option would continue along the coast, from the north-western boundary of Hickford Park, following the path of the originally proposed walkway route for approximately 1.8 kilometres before moving inland to avoid the sand dune system. In doing so, the walkway would pass through grazed pasture, which runs between the oxidation ponds and sand dunes. Before tracking inland, the walkway will pass through approximately 700 metres of low and consolidated dunes, adjacent to the northern edge of the velodrome. Here, the existing track would need to be widened and some ground stabilization required; dune vegetation may be disturbed as a consequence. The construction of this route option would have only a slightly higher ecological impact than route option 1.2, as similarly the majority of the track passes through pasture. However, this route may also provide greater opportunities to appreciate the ecological values within Hickford Park, as it runs adjacent to both an area of planted pohutukawa and the oxidation ponds. Although the banks around the oxidation ponds obscure the view of the ponds, the construction of a viewing platform along this route could provide a suitable vantage point for bird watching etc. (Figure 21).

Figure 21: Oxidation ponds showing water bird habitat and reedland vegetation.

5.4.4 Proposed walkway links

A walkway link has been proposed to run from St Andrews Drive, along the eastern side of the velodrome before following the western border of the oxidation ponds embankment and connecting with the coastal walkway option 1.3, at two locations. This link would pass through parkland, pasture and also a belt of natives which have been planted along the oxidation ponds embankment, shown in Figure 22. An informal path, approximately 1.5 metres wide, already exists through the centre of this planting, thus the development of a walkway here would only require a small amount of pruning in order to widen the existing track and remove overhanging vegetation; it is likely flax would be the species most heavily affected. A developed pathway through this area would enable the public to better appreciate wildlife in the oxidation ponds, and also the opportunity to view activities occurring on the velodrome, as the embankment provides a good vantage point for both. The removal of gorse, which has established along the oxidation pond embankment is recommended.

Figure 22: Proposed walkway link through planted natives around oxidation pond (left) and view of reedland vegetation (right).

5.4.5 Extension options from Hickford Park to Bell Block Beach (2.1 and 2.2)

Two route options have been proposed to connect walkway options 1.3 and 1.2 to Bell Block Beach Mangati Road car park. Option 2.1 connects to the Boxing Club driveway before linking up with a pre-established, unpaved walkway (Figure 23), which runs along the eastern side of Mangati Stream. The pre-established walkway is approximately 2.5 metres wide, so few or no existing native plants would need to be removed. Native plantings along the stream margin and below existing pohutukawa would enhance this area. Removal of exotic tree species e.g. woolly nightshade, brush wattle and flowering cherry is also recommended.

Alternatively, route option 2.2 would link Hickford Park to Bell Block beach via Mangati Road. Although this option would not impact on the ecology of the park, it would not provide any opportunities for pubic to appreciate the Mangati Stream.

Figure 23: Coastal walkway route 2.1 along Mangati Stream showing the width of the already established path.

5.5 Summary of environmental impacts and mitigation options

A summary of environmental impacts associated with the construction of each walkway route is given in Table 3. Construction of the walkway route option 1.2 would have no significant adverse effects on the ecology of Hickford Park. Once established, walkway route option 1.3 would also have no long term impacts; however, there is potential for short-term environmental effects during the construction phase of this route. Earthworks required to construct the walkway along the coast before tracking inwards, could produce erosion as vegetation (some native) would need to be cleared to allow for the wider path. Such effects could be minimised by use of appropriate construction techniques and erosion control.

Environmental impacts would be greatest and on-going for route option 1.1, as the walkway would traverse unstable coastal fore dunes, requiring a large degree of land stabilisation. The dune system is highly vulnerable to erosion and disturbance; though appropriate construction and erosion control

may help to reduce this. Any imported soil/fill used in construction should be from a weed free source if possible.

To prevent adversely affecting future dune processes and erosion, where possible the walkway would need to be situated at a sufficient distance back from the coast, avoiding both the beach-dune interface and areas of un-consolidated sands. Any open areas created during the installation of the walkway would require stabilisation through rapid re-vegetation with natives; to avoid further loses to erosion and also prevent weed establishment. Coleman et al. (2010) recommend a number of native species suitable for restoration plantings in this zone of unconsolidated dunes, species are listed in Section 6.1.1. Where the proposed walkway route 1.1 passes through consolidated dune land (the initial two kilometres of the walkway starting from the north-western boundary of Hickford Park), a different suite of native species should be used for re-vegetation, these are also listed in section 6.1.1. To preserve the genetic integrity of local populations, the use of planting stock from known and local provenance is strongly advised.

No permanent adverse effects are anticipated for any of the water bodies (Mangati Stream, oxidation ponds, Waipu Lagoons) within the park as a result of the proposed walkway developments. However, construction of route 2.1, from Hickford Park to Bell Block Beach, along the Mangati Stream side could result in sediment inputs to the Mangati Stream. Appropriate erosion control methodology used during the construction phase will help to mitigate this effect (e.g. the use of sediment socks).

Table 3: Potential environmental impacts which are likely to occur from the installation of the coastal walkway extension through Hickford Park and also from Hickford Park to Bell Block Beach. X denotes impact occurrence.

Potential environmental impacts of walkway route options	Options for extension through Hickford Park			Extension options from Hickford Park to Bell Block Beach		
	1.1	1.2	1.3	2.1	2.2	Walkway links
Removal of native vegetation	X		X			X
Impact active dune system	X					
Alteration to land contours and slope	X					
Soil disturbance and/or compaction	X		X			X
Sediment input to waterways				X		

5.6 Recommended route from an ecological perspective

From an ecological perspective, indigenous vegetation and habitats of indigenous fauna should not be disturbed if an alternative option, which avoids disruption, is available. Route option 1.2 thus appears to be the most feasible option, as the Waitara sewer line has previously been installed along this route. Also, this route primarily only passes through pasture and parkland, thus its construction will have little effect on the existing vegetation and wildlife. However, route option 1.3 is also feasible; this

route passes through pasture and no significant areas of native vegetation would need to be cleared. This option could also offer more opportunities to offset the effects of the proposed walkway elsewhere via enhancement and restoration plantings.

The dunes in the eastern region of the park near Mangati road show some signs of degradation as a result of foot traffic. Offering an alternative walkway route which bypasses the area of sand dunes would decrease anthropogenic pressures on the dune system. Both the proposed walkways options 1.2 and 1.3 are located a sufficient distance from the beach front that their construction and utilisation by the public will not result in any accelerated erosion.

The two proposed routes for linking Hickford Park with Bell Block beach (options 2.1 and 2.2) would have very little ecological impact. Option 2.1, an established track near the Mangati Stream, has good potential for native enrichment planting and would allow public to appreciate the stream and native vegetation in this area.

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7 Appendices

7.1 Appendix 1: Vascular Plants of Hickford Park

Vascular plant list for Hickford Park, New Plymouth. This list was compiled from observations made for the Waipu Lagoons by A.P Druce (1964-1973) and C.C Ogle (2004), with additions for the wider Hickford park area by E.J Coleman et al. (2010) and J.T Efford and R.J Bylsma (present survey). "P" after a species denotes a planted native.

Taxonomic Group	Formal name	Common name
1. Native Plants		
Monocot trees		
	Cordyline australis	Cabbage tree
Dicot trees & shrubs		
	Coprosma repens	Taupata
	Coprosma robusta	Karamu
	Corynocarpus laevigatus [P]	Karaka
	Dodonaea viscosa var. [P]	Akeake
	Entelea arborescens [P]	Whau
	Geniostoma rupestre var. ligustrifolium	Hangehange
	Hebe stricta var. stricta [P]	Hebe
	Macropiper excelsum	Kawakawa
	Melicytus ramiflorus	Mahoe
	Metrosideros excelsa [P]	Pohutukawa
	Myoporum laetum	Ngaio
	Olearia albida [P]	Tanguru
	Olearia solandri	Coastal shrub daisy
	Pittosporum crassifolium [P]	Karo
	Pittosporum tenuifolium [P]	kohuhu
	Pomaderris apetala [P]	Tainui
	Pseudopanax crassifolius [P]	Lancewood
	Pseudopanax lessonii [P]	Houpara
	Pseudopanax crassifolius X P. lessonii	*Pseudopanax* hybrid
	Solanum aviculare	Poroporo
	Vitex lucens [P]	Puriri
Dicot lianes and related trailing plants		
	Calystegia sepium ssp.	Larger bindweed
	Calystegia soldanella	Beach morning glory
	Muehlenbeckia australis	Pohuehue
	Muehlenbeckia complexa	Small-leaved pohuehue
	Tetragonia implexicoma	Native spinach
Ferns		

	Asplenium flaccidum	Hanging spleenwort
	Asplenium oblongifolium	Shining Spleenwort
	Azolla filiculoides	Water fern
	Blechnum minus	Swamp kiokio
	Blechnum novae-zelandiae	Kiokio
	Cyathea dealbata	Silver fern
	Cyathea medullaris	Mamuku
	Dicksonia squarrosa	Wheki
	Diplazium australe	Lady fern
	Hypolepis ambigua	Pig fern
	Microsorum pustulatum	Hounds tounge
	Pteridium esculentum	Bracken fern
	Pteris tremula	Tender brake
	Pyrrosia eleagnifolia	Leather leaf
Grasses		
	Austroderia toetoe	Toetoe
	Amphibromus fluitans	Water brome
	Isachne globosa	Swamp millet
	Cyperus ustulatus	Coastal cutty grass
	Spinifex sericeus	spinifex
Sedges		
	Baumea rubiginosa	Baumea
	Carex pumila	Sand sedge
	Carex secta	Pukio
	Carex virgata	Pukio
	Cyperus ustulatus	Giant umbrella sedge
	Eleocharis acuta	Sharp spike sedge
	Eleocharis sphacelata	Kuta
	Isolepis distigmatosa	-
	Isolepis inundata	-
	Isolepis nodosa	Knobby club rush
	Isolepis prolifer	
	Schoenus maschalinus	Dwarf bog rush
	Schoenoplectus tabernaemontani	Kuawa
Rushes		
	Juncus caespiticius	Grass-leaved rush
	Juncus edgariae	Wiwi
	Juncus pallidus	Giant rush
	Juncus planifolius	Grass-leaved rush
Monocot herbs (other than orchids, grasses, sedges, rushes)		
	Lemna disperma	Duckweed
	Phormium cookianum [P]	Mountain flax
	Phormium tenax	Flax

	Potamogeton cheesemanii	Red pondweed
	Typha orientalis	Raupo
Composite herbs (F. Asteraceae)		
	Cotula coronopifolia	Batchelors buttons
	Euchiton involucratus	-
Dicot herbs other than Composites		
	Centella uniflora	Centella
	Utricularia sp.	Bladder wart
	Epilobium pallidiflorum	Swamp willow herb
	Gratiola sexdentata	Gratiola
	Haloragis erecta	Fire weed
	Hydrocotyle pterocarpa	-
	Myriophyllum propinquum	Water milfoil
	Solanum americanum	Small flowered nightshade
2. Adventive Plants		
Monocot trees		
	Yucca filamentosa	Yucca
Gymno-sperms		
	Araucaria heterophylla	Norfolk pine
	Cupressus macrocarpa	Macrocarpa
	Chamaecyparis lawsoniana	Lawsons cyprus
	Eucalyptus sp.	Gum
	Pinus radiata	Radiata pine
Dicot trees & shrubs		
	Acca sellowiana	Feijoa
	Banksia integrifolia	Coastal banksia
	Eucalyptus sp.	Gum
	Fatsia japonica	Fatsia
	Lupinus arboreus	Yellow tree lupin
	Lycium ferocissimum	Boxthorn
	Paraserianthes lophantha	Brush wattle
	Prunus sp.	Flowering cheery
	Salix babylonica	Weeping willow
	Salix cinerea	Grey willow
	Solanum mauritianum	Wolly nightshade
	Ulex europaeus	Gorse
Dicot lianes and related trailing plants		
	Calystegia silvatica	Great bindweed
	Delairea odorata	German ivy
	Hedera helix ssp. helix	Ivy

	Rubus fruticosus agg.	Blackberry
	Rumex acetosella	Sheeps sorrel
	Rumex sagittatus	Climbing dock
	Senecio angulatus	Cape ivy
Grasses		
	Agrostis stolonifera	Creeping bent
	Ammophila arenaria	Marram grass
	Anthoxanthum odoratum	Sweet vernel
	Bromus willdenowii	Prairie grass
	Cortaderia selloana	Pampus
	Glyceria declinata	Blue sweet grass
	Glyceria maxima	Floating sweet grass
	Holcus lanatus	Yorkshire fog
	Lagurus ovatus	Hares-tail
	Lolium perenne	Rye grass
	Paspalum dilatatum	Paspalum
	Paspalum distichum	Mercer grass
	Pennisetum clandestinum	Kikuyu grass
	Poa annua	Annual medow grass
	Schedonorus arundinaceus	Tall fescue
Sedges		
	Cyperus alternifolius	Umbrella sedge
	Cyperus eragrostis	Umbrella sedge
Rushes		
	Juncus articulatus	Jointed rush
	Juncus effusus	Leafless rush
Monocot herbs (other than orchids, grasses, sedges, rushes)		
	Agapanthus praecox	Agapantha
	Allium triquetrum	Onion weed
	Arum italicum	Italian Arum lilly
	Crocosmia X Crocosmiflora	Montbretia
	Lagarosiphon major	Oxygen weed
	Potamogeton crispus	Curly-leaf pondweed
	Tradescantia fluminensis	Wandering jew
	Alocasia brisbanensis	Elephants ear
	Zantedeschia aethiopica	Arum lily
Composite herbs		
	Carduus	Thistle
	Crepis capillaris	Hawksbeard
	Conyza albida	Fleabane
	Conyza sumatrensis	Fleabane
	Hypochoeris radicata	Cats ear
	Leontodon taraxacoides	hawkbit

	Senecio bipinnatisectus	Australian fireweed
	Sonchus oleraceus	Sow thistle
	Taraxacum officinale	Dandelion
Dicot herbs other than Composites		
	Callitriche stagnalis	Star weed
	Carpobrotus edulis	Ice plant
	Conium maculatum	Hemlock
	Euphorbia peplus	Milkweed
	Hedychium sp.	Ginger
	Fumaria muralis	fumaria
	foeniculum vulgare	fennel
	Lotus pedunculatus	Lotus
	Ludwigia palustris	Water purselane
	Lythrum hyssopifolia	Hyssop lossestrife
	Medicago nigra	medick
	Myosotis laxa ssp. caespitosa	Water forget-me-not
	Oxalis incarnata	Lilac oxalis
	Persicaria maculosa	Willow weed
	Physalis peruviana	Cape gooseberry
	Phytolacca octandra	Ink weed
	Plantago australis	Mexican plantain
	Plantago lanceolata	Narrow-leaved plantain
	Plectranthus ciliatus	Plectranthus
	Ranunculus flammula	Spearwort
	Ranunculus repens	Buttercup
	Rumex crispus	Curled dock
	Rumex obtusifolius	Broard-leaved dock
	Silene gallica	Catchfly
	Solanum nigrum	Black nightshade
	Stachys arvensis	Staggerweed
	Stachys sylvatica	Hedge woundwort
	Trifolium pratense	Red clover
	Trifolium repens	White clover
	Vinca major	Periwinkle

7.2 Appendix 2: 'i-Tree' quadrat data

Site Data	
Location	Waipu Lagoon
Date	27.6.2012
Crew	Rebecca Bylsma & Jackson Efford
GPS	NZTM E 1698360 N 5679298

Shrub Data

Species	% Shrub Area	Height (m)	% Mass Missing
Macropiper excelsum	20	<0.5 m	2
Macropiper excelsum	30	0.5-1 m	2
Macropiper excelsum	10	> 1m	2
Melicytus ramiflorus	3	<0.5 m	-
Melicytus ramiflorus	2	0.5-1 m	-
Melicytus ramiflorus	2	> 1m	-
Pseudopanax hybrid	0.5	<0.5 m	-
Pseudopanax hybrid	0.5	0.5-1 m	-
Coprosma repens	0.1	<0.5 m	-
Coprosma repens	0.1	0.5-1 m	-
Pittosporum crassifolium	0.1	0.5-1 m	-
Pittosporum crassifolium	1.1	<0.5 m	-

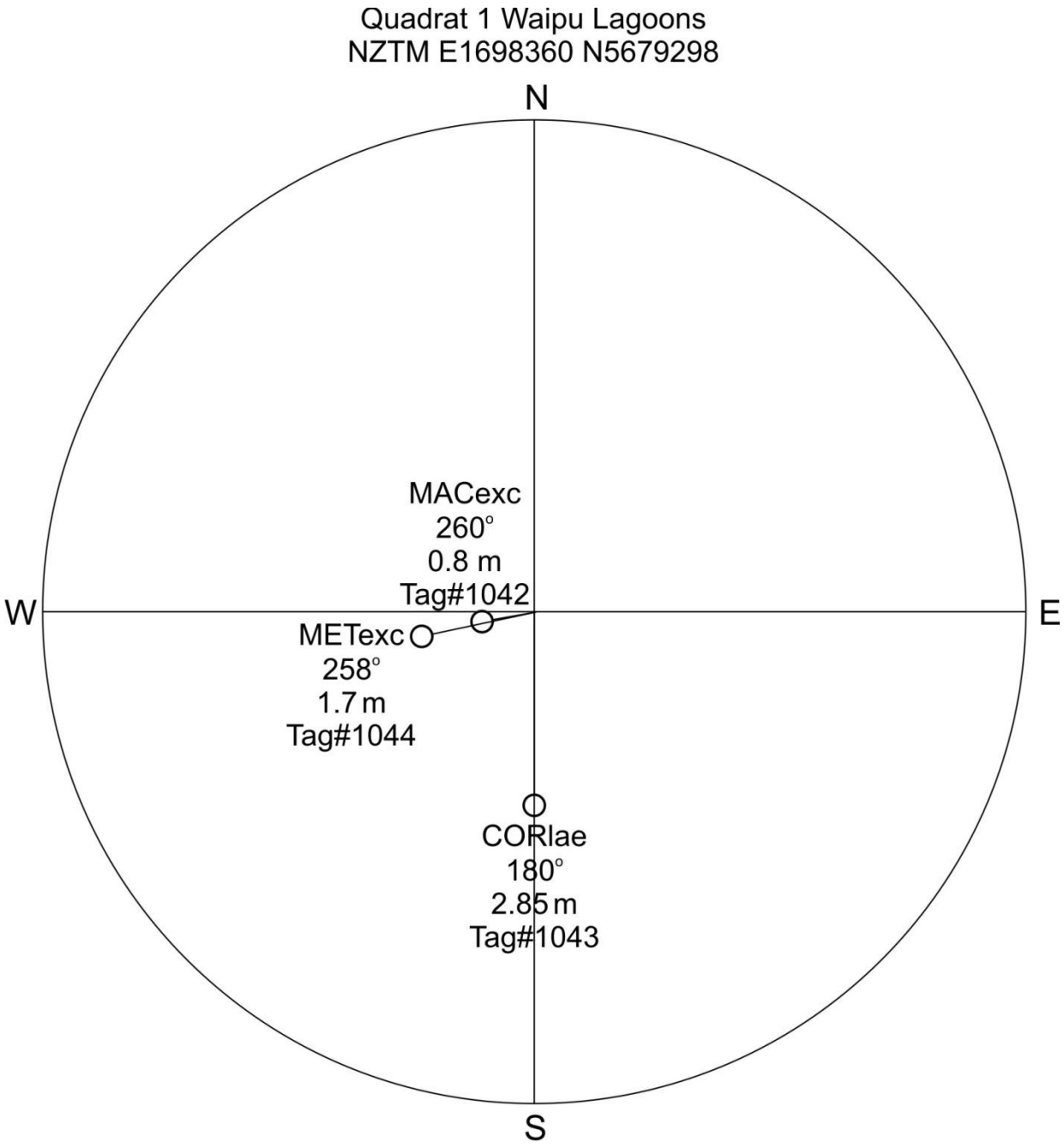
Seedling Data (1/4 plot tally)

species	Height Classes (cm)				
	< 15	16-45	46-75	76-105	106-135
Melicytus ramiflorus	1	1	1	2	4
Macropiper excelsum	2	27	27	19	4
Pseudopanax hybrid	1	2	-	-	-
Pittosporum crassifolium	1	8	-	1	-
Corynocarpus laevigatus	13	-	-	-	-

Species: MACexc, *Macropiper excelsum*, CORlae, *Corynocarpus laevigatus*, CORaus, *Cordyline australis*, MELram, *Melicytus ramiflorus*,MET exc, *Metrosideros excelsa*, CYAmed, *Cyathea medullaris*.

Tree data

			Stem diameters (cm dbh)												
Dist.	**Dir.**	**Spp.**	**d1**	**d2**	**d3**	**d4**	**d5**	**d6**	**Crown Base (m)**	**Height (m)**	**Width (m)**	**Width (m)**	**CLE**	**% Canopy Missing**	**% Die Back**
0.9	0	MACexc	9.7	9.5	4.3				7	6	2	1.5	1	90	90
2.2	18	MACexc	4.2						1.5	6	2.3	1.7	1	-	-
3.1	19	CORlae	11.7						1.9	8	3.5	3.7	1	-	-
1.2	20	MACexc	4.8	2.7	2.6				2	4	2	2	1	-	-
4.6	30	CORaus	17.8						5	9.5	2	2.1	1	10	40
6.4	25	CYAmed	23						3	6	4	3.7	1	-	-
3.6	57	METexc	14.5	15.8	18.3	18	20.7	23.8	5.2	15	10	11.5	1	-	-
			28.2	21.6	15.7	7.5	10.1				2.1	2.5	1	-	-
4.2	71	MACexc	3.1						3	4	2.5	2	1	-	-
7.1	69	MACexc	4.3						2.5	4	2.5	2	1	-	-
6.8	72	CORlae	6.3	6					3	5.2	4.1	3.5	1	-	10
4.7	80	MELram	5.1	4.3	3.6	6.2			2.5	6	3.9	4.2	1	-	50
6.4	84	CORlae	11						5	10	5	4.5	1	-	-
6.3	95	CORlae	11.7						5	11	5	4.9	1	-	20
2.3	95	MACexc	2.9						3	3.1	1.5	1.5	1	-	-
4.8	140	CORlae	9						2	6	3	3.5	1	-	50
6.6	110	MACexc	4.9	4.1					2.3	5	3.5	3	1	-	-
1.6	130	METexc	9.4	18						10	5	5	1	d	d
2	130	MACexc	5.5						2	5	3.2	3	1	-	-
6.1	140	METexc	12.7	15	8					7	4	3	1	d	d
4	158	MACexc		6.1					2.1	5.5	3	2	1	-	-
3.3	180	CORlae		18.2					4	12	5	6	1	-	-
5.4	182	MACexc		4	2.7	3.4			2	4	4	2.5	1	-	-
1.9	182	MACexc		2.7					2	3.7	1.2	1.5	1	-	-
2.8	210	MACexc		3.2					1.7	4	3	2.1	1	-	-
6.9	210	CORlae		17.1					4	12.5	5.5	5	1	-	-
7	220	CYAmed		6					4.5	6	4.5	4	1	-	-
2.5	240	METexc		10.4	5.6	11.9	7.4		3	8	4.7	5.1	1	-	-
4.5	255	METexc	11.6	12.2					3	8	5	5	1	d	d
6.3	255	CORaus	12.9						4.5	6	2	2	1	-	-
5.2	281	CYAmed	29						8	10	5	4	1	-	-
3.8	300	CYAmed	21.2						6	7	2.5	3.5	1	-	-
3	310	METexc	13.7						-	5	3	3	1	d	d
5.6	315	CORlae	4.2	2.8					2.7	5	1	1	1	-	-
6.8	320	CORlae	18.8						4	11.5	6	6	1	-	-
4.7	322	CORlae	16.5						4	12	5	6	1	-	-
3.5	325	CORlae	4.8						3	7	2	2	1	-	-
6.1	340	CORlae	9.7	5.9					3	10	4	4	1	-	-
6	350	CORaus	23.4						6	8	5	3	1	-	-
3.6	280	METexc	10.9	7.1					-	5	2	2	1	d	d


Quadrat 1 Waipu Lagoons
NZTM E1698360 N5679298
N
W
E
S
MACexc
260°
0.8 m
Tag#1042
METexc
258°
1.7 m
Tag#1044
CORlae
180°
2.85 m
Tag#1043

7.3 Appendix 3: Wetland Record Sheet

Wetland name: Waipu Lagoons
Region: Taranaki
Altitude: 15 m

Date: 25/06/2012
GPS/Grid Ref.: NZMG E2608508 N6241088
No. of plots sampled: 2

Classification System I	IA Subsystem	II Wetland Class	IIA Wetland Form
Palustrine (+lacustrine)	Permanent	Swamp	Basin

Field team: J. Efford, R. Bylsma

Indicator	Indicator components	Specify and Comment	Score 0–5[1]	Mean score
Change in hydrological integrity	Impact of manmade structures	None observed	5	4.66
	Water table depth	No detectable changes	5	
	Dryland plant invasion	Some arum, blackberry, gorse on margins	4	
Change in physico-chemical parameters	Fire damage	No evidence of fire damage	5	4.5
	Degree of sedimentation/erosion	All margins vegetated, banks stable	4.5	
	Nutrient levels	Probably some minor input from pasture runoff	4	
	Von Post index	N/A		
Change in ecosystem intactness	Loss in area of original wetland	Probably little change	4	4
	Connectivity barriers	Spring fed lagoons, with drains linking to coast	4	
Change in browsing, predation & harvesting regimes	Damage by domestic or feral animals	Wetland securely fenced, but gate has been left open recently causing minor trampling in one area	4	4
	Introduced predator impacts on wildlife	Mustelids, domestic cats, rats, mice, possums. Residents conduct some pest control.	3	
	Harvesting levels	Some planted flax harvested (Pa harakeke on site)	5	
Change in dominance of native plants	Introduced plant canopy cover	Some banksia on margins	3.5	3.5
	Introduced plant understorey cover	Some Mercer grass and kakuya	3.5	
Total wetland condition index /25				20.66

[1] Assign degree of modification as follows: 5=v. low/ none, 4=low, 3=medium, 2=high, 1=v. high, 0=extreme

Main vegetation types:

Raupo and kuta Reedland, flaxland

Native fauna:

pukeko, shelduck, tui, fantail

Pressure	**Score**[2]	**Specify and Comment**
Modifications to catchment hydrology	4	Catchment is pasture and residential
Water quality within the catchment	2.5	Stock and urban impact
Animal access	3	Stock fenced only, predators present
Key undesirable species	2.5	Gorse, blackberry, pampas, arum
% catchment in introduced vegetation	4	Pasture and residential
Other landuse threats	2	Chance of future urban development south of lagoons
Total wetland pressure index /30	18	

Other comments: Total of 3 lakelets, two joined together and 1 isolated by pasture (with connecting drain). Listed as a PNA and regionally significant wetland. Australasian bittern recorded here in past. Perch and goldfish present in lagoon. Druce recorded *Amphibromus fluitans* here.

[2]Assign pressure scores as follows: 5=very high, 4=high, 3=medium, 2=low, 1=very low, 0=none

WETLAND PLOT SHEET

Wetland name: Waipu Lagoons **Date:** 25/06/2012 **Plot no:** 1

Plot size (2m x 2m default): **Altitude:** 15 m **GPS/GR:** NZMG E2608508 N6241088

Field leader: J. Efford **Structure:** Reedland **Composition:** *Eleocharis sphacelata*

Canopy (bird's eye view)			**Subcanopy**			**Groundcover**		
Species[1] (or Substrate)	**%**	**H**	**Species**	**%**	**H**	**Species**	**%**	**H**
Eleocharis sphacelata	75	1.4				*Utricularia* sp. (in water)	5	
Isachne globosa	9	0.3				*Centella uniflora*	+	
Isolepis sp. (*prolifer*?)	2	0.6						
Open water	7							
Litter	7							

[1] % = % cover: total Canopy % cover = 100%; H = maximum height in m; indicate introduced species by *

Additional species in vicinity in same vegetation type:

Raupo, *Eleocharis acuta*, Yorkshire fog, Mercer grass

Comments:

Plot located in water close to the bank. 2 bamboo pegs on plot corners closest to bank, outer corners, water too deep to peg. Accessed through gate and along track between lagoon and houses. Some winter dieback of kuta in plot, and raupo in the wider area.

Indicator (use plot data only)	**%**	**Score 0–5**[2]	**Specify & Comment**
Canopy: % cover introduced species	0	5	
Understorey: % cover introduced spp[3]	0	5	
Total species: % number introduced spp	0	5	
Total species: overall stress/dieback	NA	5	
Total /20	NA	20	

[2]5=0%: none, 4=1– 24%: very low, 3=25–49%; low, 2=50–75%: medium, 1=76–99%: high, 0=100%; v. high

WETLAND PLOT SHEET

Wetland name: Waipu Lagoons **Date:** 25/06/2012 **Plot no**: 2

Plot size (2m x 2m default): **Altitude:** 15 m GPS/GR: NZMG E2608449 N6241061

Field leader: J. Efford **Structure:** Flaxland **Composition:** Flax

Canopy (bird's eye view)			**Subcanopy**			**Groundcover**		
Species[1] (or Substrate)	%	H	**Species**	**%**	**H**	**Species**	**%**	**H**
Phomium tenax	75	2.4				*Calystegia sepium*	+	
Blechnum minus	8	0.6						
Eleocharis sphacelata	1	1.0						
Eleocharis acuta	1	0.8						
Litter	10							
Open Water	5							

[1] % = % cover: total Canopy % cover = 100%; H = maximum height in m; indicate introduced species by *

Additional species in vicinity in same vegetation type:
kiokio, cabbage tree, *Austroderia toetoe*, *Coprosma grandifolia, Coprosma robusta*

Comments:

Access: walk past plot 1 around edge of lagoon, follow fence line. Four bamboo pegs used on plot.

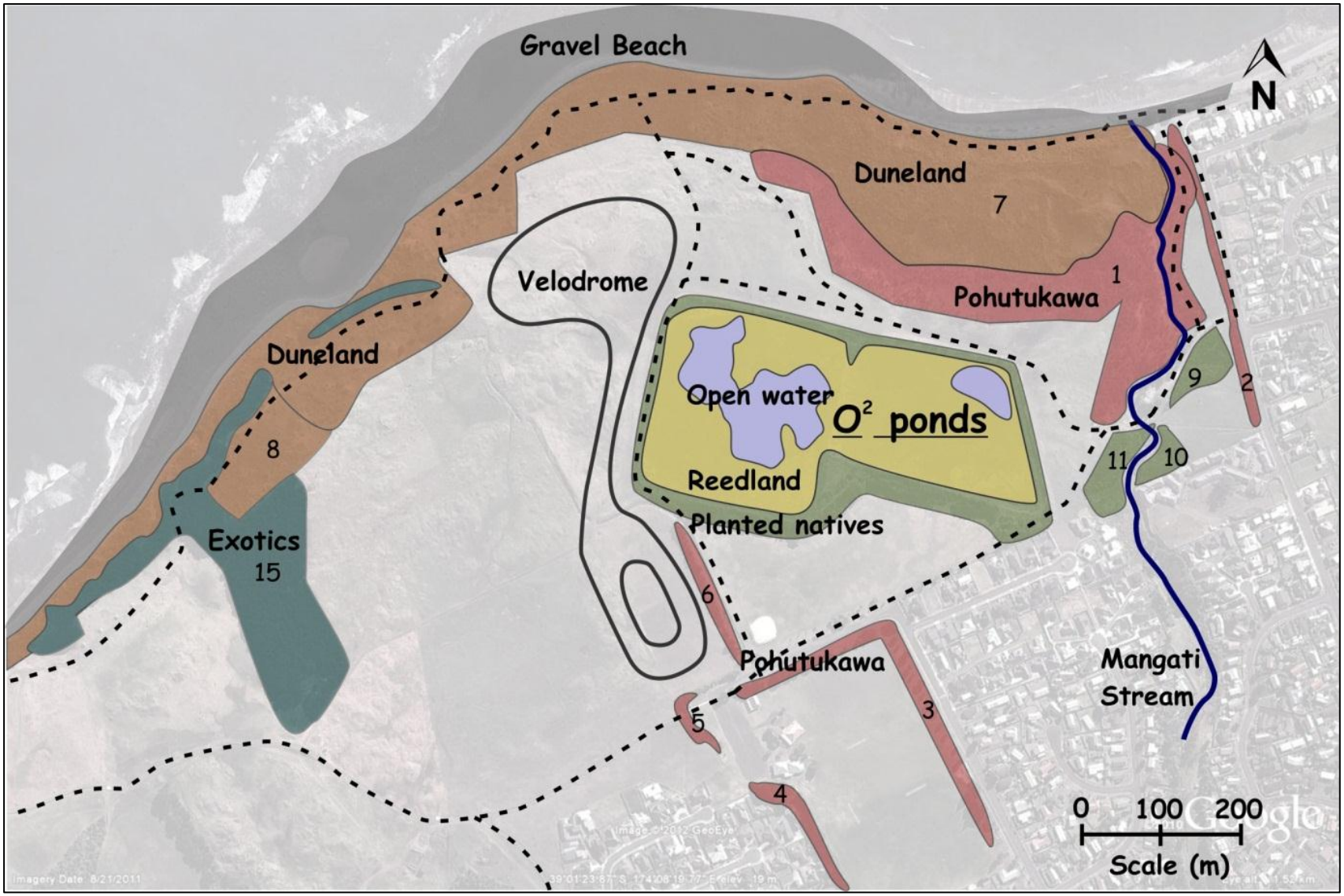
Indicator (use plot data only)	**%**	**Score 0–5**[2]	**Specify & Comment**
Canopy: % cover introduced species	0	5	
Understorey: % cover introduced spp[3]	0	5	
Total species: % number introduced spp	0	5	
Total species: overall stress/dieback	NA		
Total /20	NA	20	

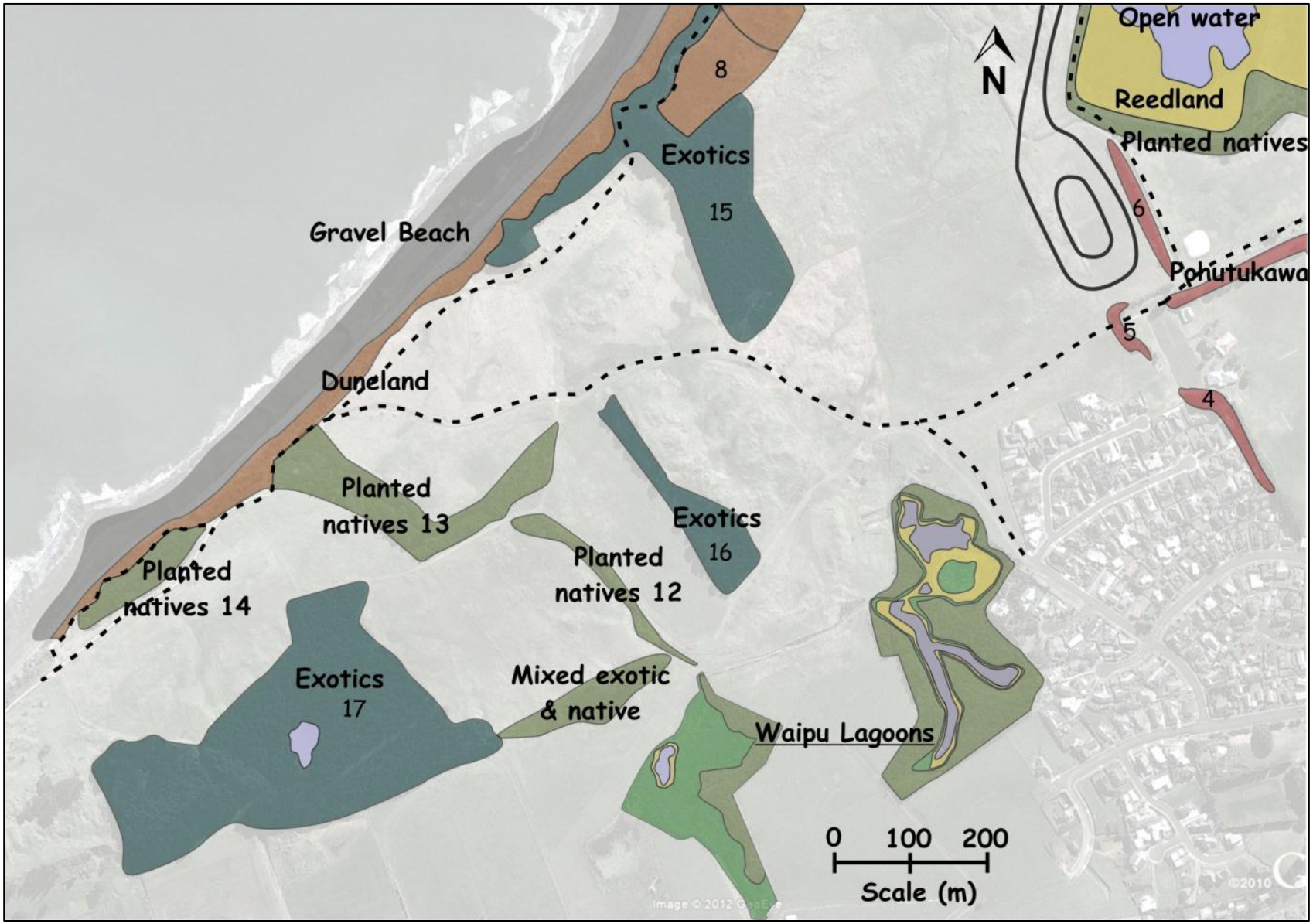
[2]5=0%: none, 4=1– 24%: very low, 3=25–49%; low, 2=50–75%: medium, 1=76–99%: high, 0=100%; v. high

[3]Add subcanopy and groundcover % cover for introduced species

7.4 Appendix 4: Permanent quadrat positions

7.5 Appendix 5: Map of ecological features (enlargement)




Open water
N
Reedland
Planted natives
8
Exotics
15
6
Gravel Beach
Pohutukawa
5
Duneland
4
Planted
natives 13
Exotics
16
Planted
natives 12
Planted
natives 14
Exotics
17
Mixed exotic
& native
Waipu Lagoons
0 100 200
Scale (m)