ASSESSMENT OF POTENTIAL ECOLOGICAL EFFECTS FOR THE PROPOSED RESTORATION OF TE POUARUHE WETLAND COMPLEX AT LAKE ŌNOKE, WAIRARAPA

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Te Pouaruhe proposed restoration area. March 2021.

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1. INTRODUCTION

The Department of Conservation is managing the restoration of Te Pouaruhe wetland; an 18 hectare area located on the western side of Lake Ōnoke in the southern Wairarapa. This site previously consisted of estuarine wetland and freshwater wetlands, surrounded by patches of coastal or semi-coastal forest vegetation. The site has been modified extensively by human activity; particularly by drainage and changes to stream hydrology, stock grazing, and cropping.

The land is being returned to Ngāti Kahangunu ki Wairarapa as part of a Tiriti o Waitangi settlement. A restoration plan has been prepared (Graeme and Dahm 2018) to restore the natural values and functioning of the area and to enhance the indigenous fishery.

The Department of Conservation and the treaty partners now require an assessment of ecological effects in order to apply for a resource consent to undertake the physical works set out in the restoration plan.

2. SITE DESCRIPTION

2.1 Overview

Te Pouaruhe wetland is located on the western shore of Lake Ōnoke, 38 kilometres from Featherston on Western Lake Road. The project area is an 18 hectare former arm of the lake, which is bisected from north to south by a stopbank (Stopbank A, Figure 1) separating an extensive saltmarsh on the lakeside from an internal mixed indigenous-exotic wetland.

The proposed restoration site has a highly modified hydrological regime due to the historic drainage, stopbanking and diversion of natural flows, and major flooding is frequent and ongoing. It is surrounded on its northern, western, and southern sides by exotic pasture grassland, and on the eastern side by Lake Ōnoke. Another stopbank (Stopbank B) extends east from the northern point of Stopbank A, curving southwards towards the lake after *c*.275 metres. Two other stopbanks are within the project area: one (Stopbank C) extends east to west from the southern end of Stopbank A, gradually tapering to ground level, while the other (Stopbank D) separates Te Pouaruhe from Pounui Lagoon to the northeast.

Stopbanks B and C have deep water channels on both sides of the banks, while Stopbank A has a water channel on the western inland side and saltmarsh on the eastern side. Stopbank D is an accessway into Pounui lagoon, and has a water-filled channel at its base on the lake side (Figure 1).

The proposed restoration site consists of the highly modified mixed indigenous-exotic wetland area to the west of Stopbank A. This area was used for cropping and grazing until 2019, and contains several excavated ditches and two streams leading to the channel adjacent to Stopbank A.

3. OBJECTIVES AND PROPOSED RESTORATION WORKS

3.1 Objectives

The objectives of the restoration project are to:

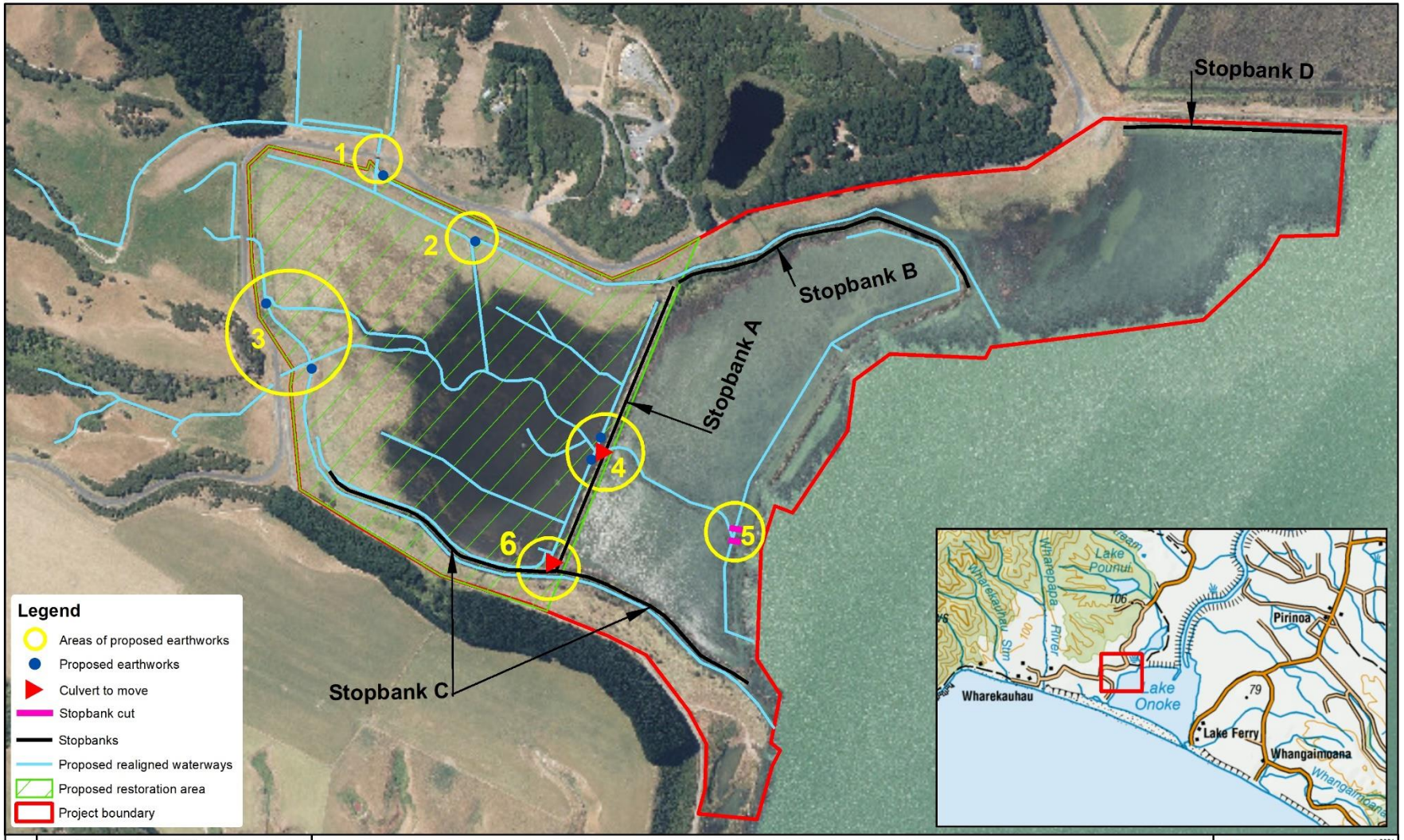
- Hydrologically reconnect the restoration area with Lake Ōnoke and its upstream catchments, with the aim to re-establish more natural water flows.
- Re-establish plant communities that were likely to have been historically present, with estuarine and freshwater wetland plant communities on the flood plain and coastal scrub on higher ground.
- Re-establish the traditional use of the area for mahinga kai and improve opportunities for iwi to gather and teach.

3.2 Description of proposed restoration works

The restoration plan proposes the diversion of streams back into Te Pouaruhe, along routes similar to the original paths seen on historical aerial photographs (e.g., Plate 1), with existing diversion channels and other side channels to be partially infilled (Graeme and Dahm 2018). These works are designed to encourage water to flow into Te Pouaruhe, rather than diverting around the project area through perimeter channels. These hydrological changes are to be accompanied by pest plant control and the restoration of vegetation communities.

Earthworks under consideration for this Assessment of Potential Ecological Effects include:

- 'Partially' infill existing diversion channels (and other side channels) where they intercept the 'restored' stream path (Areas 1, 2, 3, and 4, Figure 1). Refer detail below.
- Excavation of a single gap in Stopbank A, including the removal of the large box culvert (Area 4, Figure 1). Partial infilling of the channels parallel to the stopbank is also required to encourage water flow through the restored stream channel.
- Removal of the flapped metal culvert at the end of Stopbank A (Area 6, Figure 1).
- Removal of the section of the stopbank between the two culverts described above. This item is not recommened to proceed due to the scale of earthworks required, the potential significant impacts to the wetland, and the financial cost involved in undertaking the works. The ecological benefits can be achieved through the other management recommendations in this report. Therefore this item is not considered further in this assessment of ecological effects.
- Create an new opening through the outer stopbank (Area 5, Figure 1), slightly wider than the channel on the inside of the stopbank.



Data Acknowledgment

Map contains data sourced from LINZ
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Figure 1. Area of Te Pouaruhe wetland and the proposed restoration site

0 165 330 m

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Scale:	1:6,500
Date:	6/10/2021
Cartographer:	DBM
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Earthworks are required to partially close off the outer diversion channel in Area 1 (Figure 1, immediately downstream of the road bridge) to redivert the stream flow back into the site, via Area 2. At Areas 2, 3, and 4 partial infilling is also required.

The plan is to redistribute any excavated material back into the site to partially infill existing channels as per the restoration plan, and detailed above.

4. METHODS

A desktop assessment of relevant literature, reports, and data sets were utilised to provide a basis for vegetation and fauna habitats present within the project area, and to inform the ecological impact assessments of the proposed restoration works. These information sources included:

- Graeme M. and Dahm J. 2018: Lake Ōnoke Freshwater Improvement Fund Project – Restoration Plan. *Focus Report No. 18/128*.
- Enright Pat 2020: Te Pouaruhe botanical survey, *Department of Conservation Report 6255092*.
- Todd M. *et al*. 2016: Estuarine systems in the Lower North Island/Te-Ika-a-Māui: ranking of significance, current status, and future management options.
- Cameron 2019: CF Projects Report 19033; Catchment analysis and stream flow calculations.
- Riverscapes Freshwater Ecology Report 17-24; Ōnoke salt marsh mudfish survey.
- Riverscapes Freshwater Ecology Report 19-10; Pou Aruhe baseline fish surveys.
- Protected Natural Areas Programme (PNAP) survey report for the Wairarapa Plains Ecological District (Beadel *et al*. 2000).
- Matuku Ecology Report; Wairarapa Moana Bittern/Matuku Management Strategy.
- New Zealand Freshwater Fish Database (NZFFD; Crow 2017).
- Department of Conservation Bioweb Herpetofauna database: for records of lizards and frogs (accessed March 2021). In addition, a checklist of lizard species (Bell and Wiles 2015) and a lizard field guide (van Winkel *et al*. 2018) were also checked.
- The eBird database maintained by Cornell University, which has bird records for sites within New Zealand (accessed March 2021).
- Department of Conservation Te Pouaruhe bird count survey results 2019-2021.
- National threat classification lists for birds (Robertson *et al*. 2018), reptiles (Hitchmough *et al*. 2016), bats (O'Donnell *et al*. 2018), vascular plants (de Lange *et al*. 2018), freshwater invertebrates (Grainger *et al*. 2018), terrestrial invertebrates (Leschen *et al*. 2012), and freshwater fish (Dunn *et al*. 2018).
- Threatened Environment Classification (TEC; Cieraad *et al*. 2015).

- Landcover database (Version 4.1, Landcare Research 2015).

5. ECOLOGICAL CONTEXT

5.1 Wairarapa Plains Ecological District

Te Pouaruhe lies within the Wairarapa Plains Ecological District. The District is characterised by low lying Pleistocene and Holocene alluvial terraces and plains with Lake Wairarapa located at the southern end. The climate is typically dry, with rainfall ranging from 800 to 1,200 millimetres per annum, with very warm summers. Day temperatures occasionally rise above 32^0C, with dry, foehn northwest winds and moderate winter temperatures with most rain in winter (McEwen 1987).

There are few remaining areas of indigenous forest within the Wairarapa Plains Ecological District, with most of the district now farmed. Indigenous vegetation is limited to small remnants of kahikatea (*Dacrycarpus dacrydioides*) forest, quite large areas of scrub, and extensive wetlands around Lake Wairarapa.

Estimated current land cover is dominated by 'High Producing Exotic Grassland' (98,938 hectares; 74.9%), with smaller amounts of 'Lake or Pond' (8,058 hectares; 6.1%), 'Short-rotation Cropland' (4,719 hectares; 3.6%) and 'Indigenous Forest' (3,860 hectares; 2.9%) (Landcare Research 2015).

Descriptions of the geological features of the ecological district are provided by Beadel *et al.* (2000). These authors describe the character of the Wairarapa Plains Ecological District as low-lying Pleistocene and Holocene marine and alluvial deposits, with gravel terraces, fans and alluvial plains forming the floor of the Wairarapa basin. The District's terrain slopes gradually from its maximum altitude of 300 metres a.s.l. in the north, to low lying land near Lakes Wairarapa and Ōnoke, and the Palliser Bay coast. In the west, this lowland plain adjoins the steep foothills of the high greywacke Tararua and Remutaka Ranges, and on the southeastern boundary the Aorangi greywacke range also forms a steep border. The western boundary closely following the line of the West Wairarapa Fault, which has noticeably moved both vertically and horizontally in the last few hundred years.

Further descriptions of the area surrounding Te Pouaruhe cover the terrace-like benches that have formed on a block of older Late Pleistocene siltstone and sandstone, south of Lake Wairarapa and west of Lake Ōnoke. Dissection of these benches have resulted in the largest area of hilly land in this ecological district. Another distinctive feature of this Ecological District is the many lakes with Lake Wairarapa being the third largest lake in the North Island (yet is only a few metres deep). The Wairarapa Valley was, until recently, a shallow arm of the sea and was infilled mainly by alluvial deposits derived from the western ranges. Lake Ōnoke is a shallow lagoon formed by the development of a shingle spit and during periods of low rainfall, the reduced output allows for an extension of the spit to form which can subsequently block the exit to the sea.

Soils of the western Wairarapa Plains are predominantly alluvial, formed on greywacke and gley and organic soils are also found around Lake Wairarapa. Fertile alluvial soils

occur on the river flats ranging from stony, sandy and silty well drained soils bordering rivers to poorly drained, heavier textured soils in back-swamps and around Lake Wairarapa. Limited areas of sandy soils on dunes are also present adjacent to this lake.

The Tararua and Remutaka Ranges have also had a large influence on the climate of the Ruamāhanga catchment. The ranges shelter the lowland plains from the predominantly westerly weather systems, and during summer this can cause high temperatures and dry weather. When westerly frontal rainfall systems pass over the region, the Tararua Range receives high rainfall but a 'rainshadow' occurs east of the range in the Ruamāhanga valley. Similarly, the ranges influence rainfall distribution during southeasterly rainfall events: orographic enhancement of the air masses, as they are forced up and over the Tararua Range, can result in very heavy rainfall within the Ruamāhanga valley (Thompson 1982).

5.2 Ecological domains

Ecological Domains, also known as eco-domains, combine information on geology, geomorphology, meteorology, biology, and human use of natural resources with expert knowledge of the ecological processes and characteristics of the region. A mosaic of more than 60 eco-domains - areas that have unity within themselves but are distinct from each other - cover the Greater Wellington region (Greater Wellington Regional Council 2002). Twenty-one of these are further divided into sub-domains.

The restoration area occurs in two eco-domains: **13**: Pounui in the west, and **16**: Lake Ferry – Lake Wairarapa in the east:

- **13 Pounui** is comprised of deeply dissected Remutaka footslopes, old marine terraces and a small lake. This Ecodomain has diverse microclimates with overall little seasonal variation and vegetation is dominated by lowland beech species.

- **16 Lake Ferry - Lake Wairarapa** is a homogeneous domain of flat, low-lying floodplains and shallow lakes. Lake Ōnoke (Lake Ferry) is subtidal, whilst Lake Wairarapa is freshwater with an extensive hinterland that is periodically inundated and, without drainage, would be waterlogged year-round. This climate is frost-free, in part because of the wind-run off from the Remutaka Range and light northeasterly night-time winds. Windspeeds can be high here, with moderately seasonal rainfall. The ground is cold and wet through winter but has an 'early spring'. Vegetation within this Ecodomain is tolerant of poor drainage, with reed and turf zones around the lake edges.

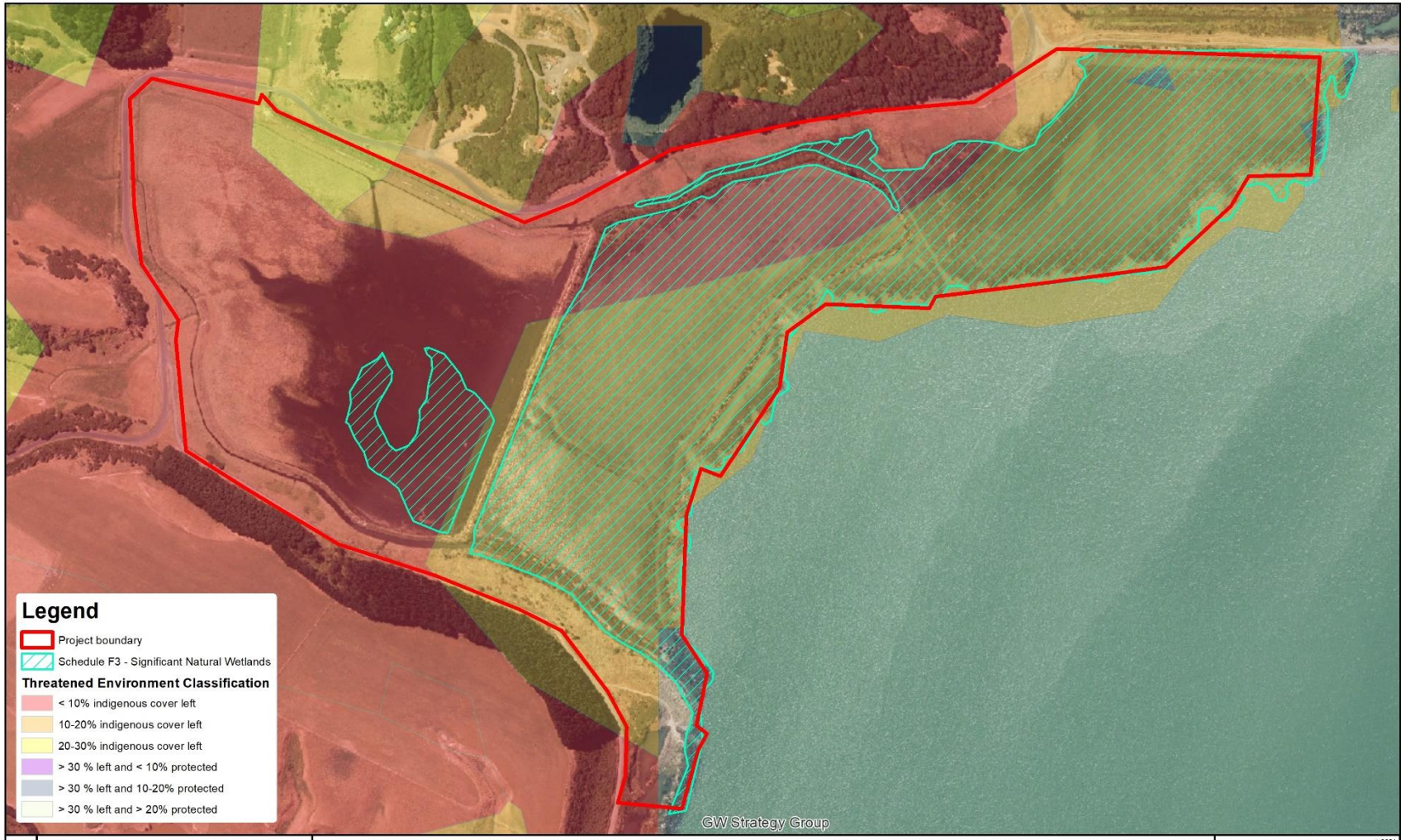

Figure 2. Threatened Environment Classification and the Significant Natural Wetland at Te Pouaruhe

5.3 Threatened Environment Classification

The Threatened Environment Classification (TEC) is a combination of three national databases: Land Environments New Zealand (LENZ), Land Cover Database (LCDB4) and the protected areas network. It shows how much indigenous vegetation remains within land environments, and how past vegetation loss and legal protection are distributed across New Zealand's landscape. The TEC is most appropriately applied to help identify places that are priorities for formal protection against clearance and/or incompatible land-uses, and for ecological restoration to restore lost species, linkages and buffers (Cieraad *et al*. 2015).

Most of the restoration area occurs within land environments with <10% indigenous vegetation remaining (Category 1), with smaller amounts of land environments with 10-20% or 20-30% indigenous vegetation remaining. Land in Category 1 is considered to be a threatened environment (Figure 2).

5.4 Protected areas

The Protected Natural Areas Programme (PNAP) survey report (Beadel *et al*. 2000) identified recommended areas for protection (RAP) in each ecological district. Te Pouaruhe is adjacent to **RAP17**:

- **RAP17: Lake Ōnoke, Kiriwai Lake and Ocean Beach Dunes** is an area which abuts the eastern boundary of the restoration area. This RAP is described as sand and shingle beaches, estuarine channels, estuarine lakes, mud and sand flats, wetlands, riparian flats, younger aggradation plain, and marine terraces within the coastal bioclimatic zone (Beadel *et al*. 2000).

- This RAP is contiguous with the Lake Wairarapa Wetland Stewardship Area and lies very close to the Ocean Beach Stewardship to the west. This area includes nationally and regionally threatened species and a variety of wetland and dune vegetation, as well as a wide range of land types. The coastal scrub in the gully leading to Kiriwai Lagoon is also noteworthy as this vegetation type was previously widespread but is now very uncommon in the Wairarapa Plains Ecological District.

5.5 Ramsar status

Ramsar refers to the UNESCO Convention on Wetlands of International Importance, which was signed in Ramsar, Turkey, in 1971. This is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources so that they can be sustained economically, socially and environmentally. New Zealand became a Ramsar signatory in 1976, and currently has seven Ramsar designated sites.

Te Pouaruhe occurs within the greater Wairarapa Moana wetland complex, which was granted Ramsar status in 2020 based on the following criteria:

- Criterion 1: "it contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region."

- Criterion 2: "it supports vulnerable, endangered, or critically endangered species or threatened ecological communities."
- Criterion 3: "it supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region."
- Criterion 4: "it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions."
- Criterion 5: "it regularly supports 20,000 or more waterbirds."
- Criterion 6: "it regularly supports 1% of the individuals in a population of one species or subspecies of waterbird."
- Criterion 7: "it supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity."
- Criterion 8: "it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend."

6. HYDROLOGICAL ENVIRONMENTS

6.1 Freshwater environments

The Te Pouaruhe wetland is fed by a catchment of *c.*478 hectares that contains three main tributaries located to the west of the site. These tributaries originate in the eastern foothills of the Remutaka Ranges amid dense native forest and are bordered by substantial riparian margins throughout their upper and mid reaches. The surrounding land-use transitions to pastoral farming in their lower reaches immediately before they enter the wetland area.

6.1.1 Context of existing and proposed waterways

The wetland area contains extensive areas of artificial channels that have been historically created to drain surface and ground water to allow pastoral farming to occur. These channels extend around the perimeter of the wetland, as well as through the centre of the wetland. The restoration plan proposes to restrict the outflow of water through the majority of these channels to retain water levels within the wetland, and increase ground water levels throughout the wetland. This will accelerate natural regeneration to indigenous vegetation and habitats within the wetland.

6.1.2 Barriers to fish passage

Barriers to fish passage identified in McEwan (2019) include a concrete box culvert, a fallen tree and a perched culvert.

The concrete boxed culvert under Western Lake Road (Area 1, Figure 1) is located on the main tributary that enters the northern extent of the wetland. The downstream lip of the concrete apron associated with the box culvert is around 15 centimetres above the water level, which presents a minor impediment to upstream movement for swimming species such as īnanga.

The fallen tree (located approx. 600 metres upstream of the box culvert noted above), where the stream flows out of the bush, was assessed by McEwan (2019) as presenting a barrier only during low flows, with the presence of an upstream īnanga population indicating that fish can negotiate this obstacle when water levels are higher.

The perched culvert located under the road on the western margin of the wetland (Area 3, Figure 1) was assessed to be the most significant of the barriers identified, with two vertical drops of 15 and 50 centimetres at its outlet, preventing fish from accessing the tributary reach upstream. However, this impact was somewhat mitigated by the lack of available fish habitat within this tributary during low flow conditions (McEwan 2019).

6.2 Estuarine environments

Lake Ōnoke is a large (650 hectare) Category C (Tidal River Lagoon) estuarine system, into which flow the Ruamāhanga and Tūranganui Rivers. The lake is separated from Palliser Bay by a three kilometre-long shingle spit. The lake is normally open to the sea near the settlement of Lake Ferry, but the outlet may be blocked during southerly conditions, particularly when combined with low river levels. If the blockage is sustained, the outlet is opened mechanically to avoid lake levels rising over farmland. Historically, a sustained blockage (an integral part of the natural system) of the outlet caused a backup of brackish water upriver. (Todd *et al.* 2016)

6.3 Past/present/future scenarios

One of the biggest challenges to the hydrology of Lake Ōnoke is the loss of filtering wetlands in the Ruamahanga valley, with the recent history of Lake Ōnoke and Te Pouaruhe characterised by drainage to convert wetland into grazing land (Todd *et al*. 2016). From mid-century, modification of Te Pouaruhe has occurred with the construction of channels, culverts, and stopbanks (Plates 1–4). These modifications have allowed for drainage of the land and subsequent agricultural use.

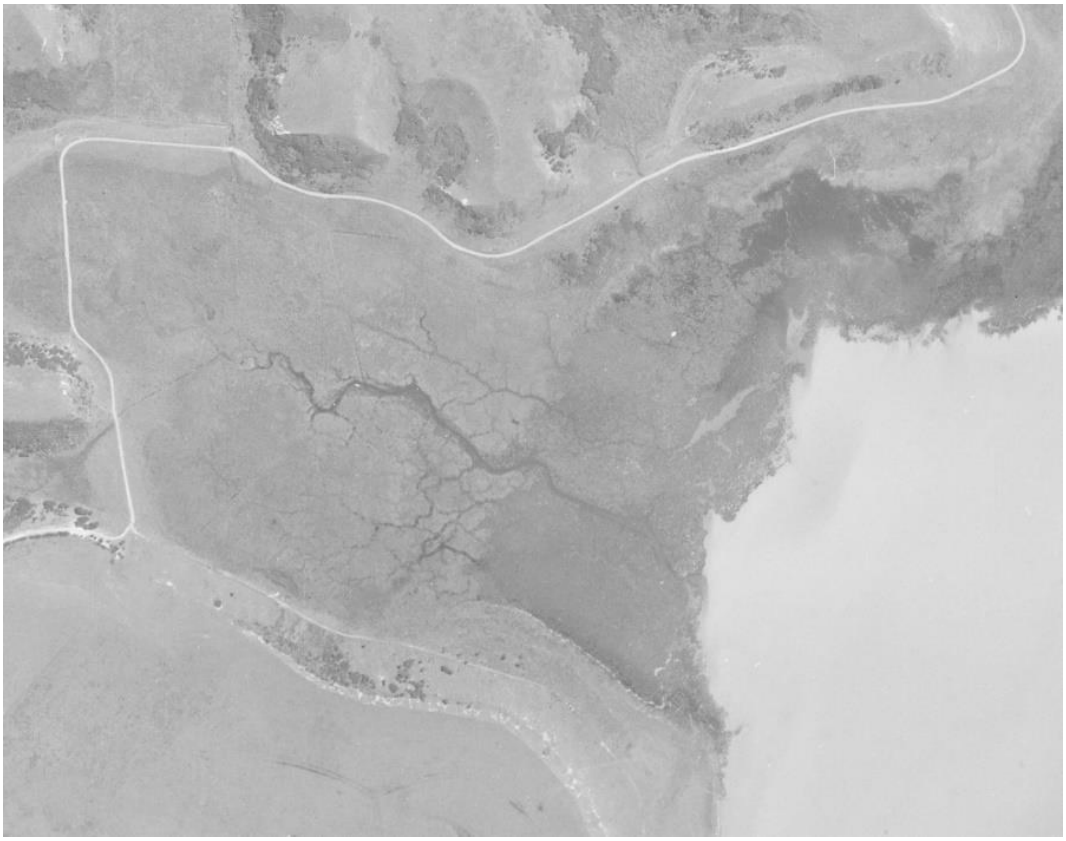

Plate 1: Te Pouaruhe wetland 1941. Image courtesy of Retrolens.

Plate 2: Te Pouaruhe wetland 1961. Image courtesy of Retrolens.

Plate 3: Te Pouaruhe wetland 1988. Image courtesy of Retrolens.

Plate 4: Te Pouaruhe wetland 2021. Image courtesy of Google Earth.

Current hydrological features of the project area include water flow and drainage through open channels and culverts immediately adjacent to the proposed restoration site. Currently flow from the three main catchments is directed into Lake Ōnoke via seven culverts and two outer channels (Cameron, 2019). Two culverts (i.e., located within Area 1 and Area 3, Figure 1) are the main drainage points, and the remaining five culverts within the restoration site, as identified by Cameron (2019), are for overland flow that occurs mostly during heavy rainfall events. Apart from during times of heavy rain, these drainage points channel much of the water into Lake Ōnoke, allowing exotic pasture species to persist within the project area.

Based on modelling, flow rates through the three main catchments during high rainfall events are at their greatest June-August and at their lowest January-March (with predictions of summer flows being up to 50% lower than predicted given evaporation and infiltration).

7. VEGETATION AND HABITAT TYPES

7.1 Vegetation/habitat types

A map of the seven vegetation/habitat types in shown in Figure 3. Descriptions of these types are provided below.

7.1.1 Vegetation Type 1: Oīoī-wīwī rushland (*c.*18.67 hectares)

The wetland on the lake side of the stopbank is predominantly open rushland dominated by oīoī (*Apodasmia similis*) and wīwī (sea rush; *Juncus kraussii* subsp. *australiensis*). Saltmarsh ribbonwood (*Plagianthus divaricatus*) is locally common towards the channel and outer lake side edges. Ground cover species include remuremu (*Selliera radicans*) and mākoako (*Samolus repens* var. *repens*).

7.1.2 Vegetation Type 2: Saltmarsh ribbonwood shrubland (*c.*2.77 hectares)

This vegetation type is dominated by saltmarsh ribbonwood, and mostly adjoins the areas of oīoī-wīwī rushland on the lake side of the stopbank. Oīoī and wīwī are present under the shrub layer, and ground cover species include remuremu and mākoako. In his 2020 plant survey, Pat Enright recorded triglochin (*Triglochin striata*) at the gravel extraction pit to the south of the saltmarsh, and it is likely it occurs throughout this vegetation type (Enright 2020). Along the foot of the Pounui stopbank in the northeast, this vegetation type contains patches of purua grass (*Bolboschoenus caldwellii*) and three-square (*Schoenoplectus pungens*).

7.1.3 Vegetation Type 3: Wet exotic grassland (*c.*9.06 hectares)

This vegetation type is characterised by exotic pasture species such as sweet vernal (*Anthoxanthum odoratum*), perennial ryegrass (*Lolium perenne*), lotus (*Lotus pedunculatus*), and white clover (*Trifolium repens*) in association with exotic wetland species such as tall fescue (*Lolium arundinaceum* subsp. *arundinaceum*), jointed rush (*Juncus articulatus*), marsh bedstraw (*Galium palustre* subsp. *palustre*), creeping bent (*Agrostis stolonifera*), Mercer grass (*Paspalum distichum*), and water pepper (*Persicaria hydropiper*). Several indigenous wetland plant species are present, including spike sedge (*Eleocharis acuta*), *Isolepis prolifera* and leafless rush (*Juncus australis*). Scattered patches of oīoī and mixed *Juncus* species are present throughout, along with the occasional toetoe upoko-tangata (*Cyperus ustulatus*), and a local patch of threatened sea holly (*Eryngium vesiculosum*; Threatened – Nationally Vulnerable) at the northeastern end of the project area.

Areas of this vegetation type dry out over the summer months, particularly around the restoration area and the entrance to Pounui wetland.

7.1.4 Vegetation Type 4: Dry exotic grassland (*c.*6.37 hectares)

Areas of dry exotic grassland interspersed with exotic herbs occur on well drained sites and the outer edges of the project area. Stopbanks of this type are scattered with larger species such as pampas (*Cortaderia selloana*), Montpellier broom (*Genista monspessulana*), and fennel (*Foeniculum vulgare*), and the area adjacent to Pounui Lagoon contains patches of Californian poppy (*Eschscholzia californica*). Some parts of this type have wetter soils in winter, particularly where it adjoins Vegetation Type 3.

7.1.5 Vegetation Type 5: Mixed indigenous-exotic rushland and herbfield

This extensive vegetation type covers most of the restoration area inland from the north-south running stopbank. Two water courses meet here, and water levels throughout this area fluctuate seasonally depending on the time of year and the water level of Lake Ōnoke. A slight slope upwards towards Western Lake Road has resulted in two distinct versions of this vegetation type:

- **Vegetation Type 5a (*c.*3.17 hectares)**

  This type occurs along the western and northern sides of the restoration area, between Vegetation Types 3 (on the outer roadside) and 5b. It is comprised largely of low-growing herbs and grasses interspersed with stands of rushes such as soft rush (*Juncus effusus* var. *effusus*), Edgar's rush (*Juncus edgariae*), and *Juncus sarophorus*. Other common species include creeping bent, bachelor's buttons (*Cotula coronopifolia*), lotus, and creeping buttercup (*Ranunculus repens*).

- **Vegetation Type 5b (*c.*7.25 hectares)**

  This type remains inundated for a longer period through summer than 5a, and will refill if lake levels are high. While this area is also comprised of low growing herbs, there is a higher density of rushes and indigenous species, such as three-square, bachelor's buttons, mudwort (*Limosella lineata*), mākoako and *Isolepis cernua* var.

cernua. This vegetation type also contains most of the At Risk and Threatened plant species found within the project area, including native musk (*Thyridia repens*; At Risk – Naturally Uncommon), Kirk's crassula (*Crassula kirkii*), and *Isolepis basilaris* (At Risk – Declining). The streams here are brackish due to Lake Ōnoke, and support patches of horse mane weed (*Ruppia megacarpa*; At Risk – Naturally Uncommon), and *Althenia bilocularis* (synonym of *Lepilaena bilocularis*; Threatened – Nationally Vulnerable).

7.1.6 Vegetation Type 6: Indigenous regenerating shrubland (*c.*0.56 hectares)

Two areas have been planted with indigenous woody species in the past, on Stopbanks B and C at the northern and southern ends of the saltmarsh ribbonwood shrubland. Planted species include ngaio (*Myoporum laetum*), purple akeake (*Dodonaea viscosa* "Purpurea"), mingimingi (*Coprosma propinqua* var. *propinqua*) and tī koukā (*Cordyline australis*). Saltmarsh ribbonwood, Kirk's crassula, *Carex sinclairii*, rautahi (*Carex geminata*), and raupō (*Typha orientalis*) have established in the channels and on the edges of these areas.

7.1.7 Vegetation Type 7: Open water (*c.*1.10 hectares)

Where open water occurs at the foot of stopbanks within the restoration area, indigenous sedges and rushes dominate the edges, interspersed with patches of exotic grasses from Vegetation Types 3 and 4. Species present include rautahi, leafless rush, wīwī, three-square, and giant rush (*Juncus pallidus*), with occasional patches of oīoī. The channel beneath Stopbank A contains the highest density of horse mane weed in the restoration area and *Althenia bilocularis* was primarily recorded in the channel footing the southern side of Stopbank D (Enright 2020).

Channels on the lake side of the stopbanks in the wider project area have edges with strips of saltmarsh ribbonwood, oīoī, and wīwī.

7.2 Information sources

Species lists were collated from the following sources:

- Enright Pat 2020: Te Pouaruhe botanical survey. *Department of Conservation Report 6255092*.
- Graeme M. and Dahm J. 2018: Lake Ōnoke Freshwater Improvement Fund Project – Restoration Plan. *Focus Report No. 18/128*.
- Todd M. *et al*. 2016: Estuarine systems in the Lower North Island/Te-Ika-a-Māui: ranking of significance, current status, and future management options.

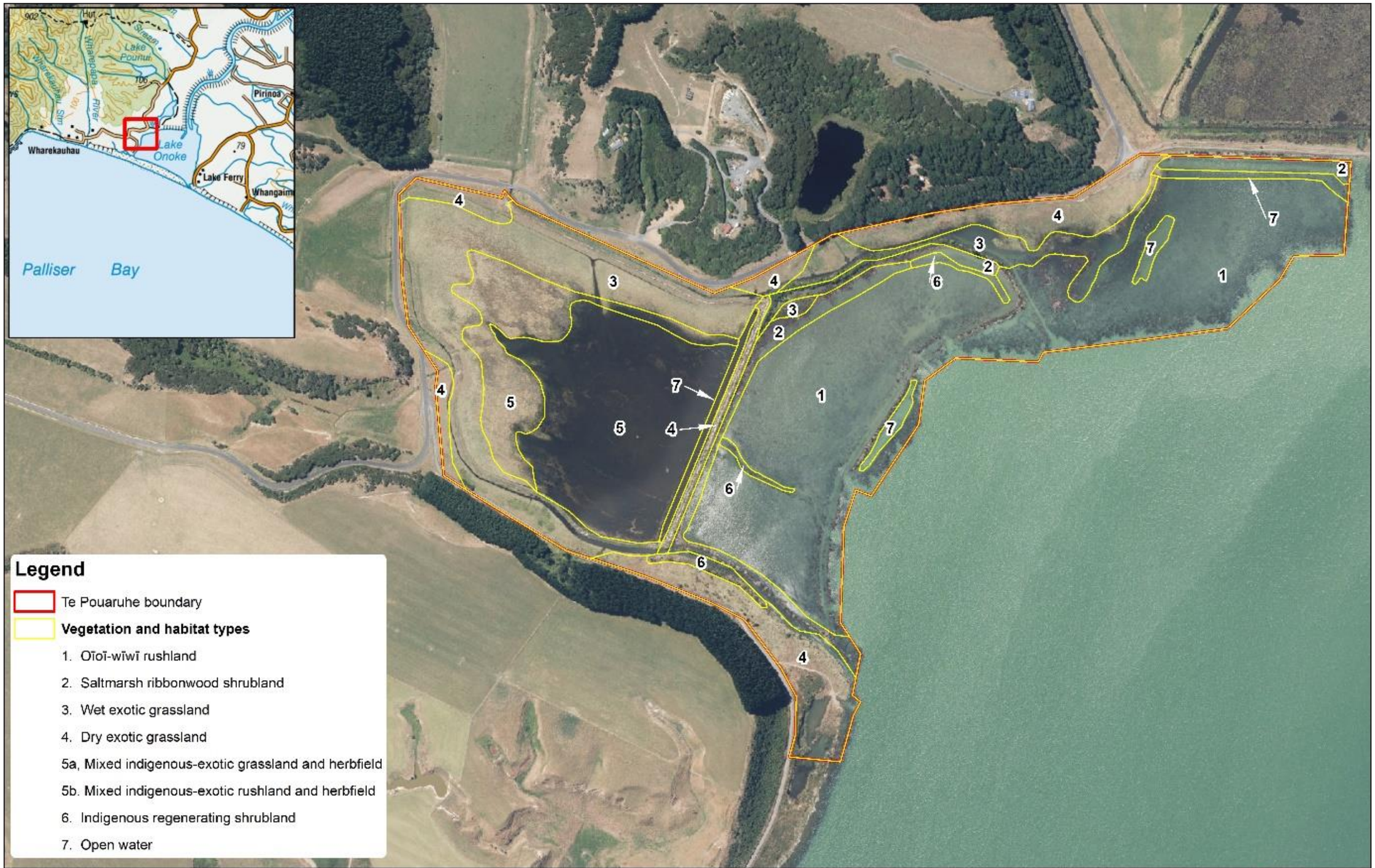

Figure3: Vegetation and habitat types at Te Pouaruhe wetland.

7.3 Threatened, At Risk and Regionally Rare species

Eight species with threat rankings have been recorded within the project area, as set out in Table 1.

Table 1: Vascular plant species with conservation rankings from the Te Pouaruhe project area.

Species	Common Name	NZTCS Status
Althenia bilocularis *†		Threatened – Nationally Vulnerable
Crassula kirkii *†	Kirk's crassula	At Risk – Naturally Uncommon
Eryngium vesiculosum *	Sea holly	Threatened – Nationally Vulnerable
Isolepis basilaris *	Pygmy clubrush	At Risk – Declining
Juncus distegus *		At Risk – Naturally Uncommon
Kunzea robusta *	Kānuka	Threatened – Nationally Vulnerable
Ruppia megacarpa *†	Horse mane weed	At Risk – Naturally Uncommon
Thyridia repens *	Native musk	At Risk – Naturally Uncommon

* Species recorded in DoC Report 6255092.
† Species recorded as observed in Focus Report No. 18/128.

Additionally, there is a record for swamp greenhood orchid (*Pterostylis micromega*; Threatened – Nationally Endangered) in the Department of Conservation Bioweb Threatened Plants database, approximately 550 metres to the northeast of the restoration area.

7.4 Pest plants

Twenty-four pest plant species have been recorded within the project area. One species (*Pinus radiata*) is listed as a Progressive Containment (PC) species in the Greater Wellington Regional Pest Management Plan 2019-2039 (GWRC RPMP), and a further seven are listed as harmful organisms. Fourteen species are not listed in the GWRC RPMP but are considered to be ecological weeds that can have adverse impacts on indigenous species and the ecological values of the site. Two additional non-invasive exotic plant species have been identified that are not ecologically-appropriate for the area, and may prove to be ecologically damaging under future climate scenarios.

Table 2: Pest plant species regarded in the Te Pouaruhe project area.

Species	Common Name	Pest Status
Asparagus scandens *	Climbing asparagus	GW RPMP; HO*
Buddleja davidii *	Buddleia	GW RPMP; HO
Carex otrubae *	False fox sedge	Ecological weed
Chamaecytisus palmensis *	Tree lucerne	Ecological weed
Conium maculatum *	Hemlock	GW RPMP; HO
Cortaderia selloana *	Pampas	GW RPMP; HO
Erica arborea *	Tree heath	Potential weed
Eschscholzia californica *	Californian poppy	Potential weed
Foeniculum vulgare *	Fennel	Ecological weed
Genista monspessulana *	Montpellier broom	Ecological weed
Glyceria fluitans *	Floating sweet grass	Ecological weed

Species	Common Name	Pest Status
Isolepis setacea	Bristle clubrush	Ecological weed
Lolium arundinaceum subsp. *arundinaceum**†	Tall fescue	Ecological weed
Lupinus arboreus *	Tree lupin	Ecological weed
Lycium ferocissimum *	Boxthorn	GW RPMP; HO
Parentucellia viscosa *	Tarweed	Ecological weed
Paspalum dilatatum *	Paspalum	Ecological weed
Paspalum distichum *†	Mercer grass	Ecological weed
Persicaria hydropiper †	Water pepper	Ecological weed
Pinus radiata *	Radiata pine	GW RPMP; PC
Prunus species *	Ornamental cherry etc	Ecological weed
Solanum chenopodioides *	Velvet nightshade	Ecological weed
Ulex europaeus *†	Gorse	GW RPMP; HO
Zantedeschia aethiopica *	Arum lily	GW RPMP; HO

* Species recorded in DoC Report 6255092.
† Species recorded as observed in Focus Report No. 18/128.
* HO = Harmful Organism.

Pest species recorded in the wider Lake Ōnoke surrounds include spartina (*Spartina* species), yellow flag iris (*Iris pseudacorus*), and Chilean rhubarb (*Gunnera tinctoria*).

Pest plant control is not currently underway within the project area. In the Lake Ōnoke area, gorse and tall fescue are difficult to remove from wetlands once established. Spartina occurs within the wider Lake Ōnoke area and whilst small patches are easy to eliminate, spartina can overwhelm salt-flats, requiring ongoing monitoring and control (Todd *et al.* 2016). It is, nevertheless, possible to eliminate it with a well-planned and implemented control programme.

8. FAUNA

8.1 Avifauna

The site provides habitat for various coastal wading bird species, which use the pasture as high tide roosts, and as feeding sites when water inundates the area. According to eBird records (for birds that breed in NZ and were seen in the last 20 years), there are 46 records within one kilometre of the restoration area, including five Threatened, 11 At Risk, 12 Not Threatened, and 17 Introduced and Naturalised species.

The threatened species are:

- Matuku/Australasian bittern (*Botaurus poiciloptilus*; Threatened - Nationally Critical).
- Black-fronted tern (*Chlidonias albostriatus*; Threatened - Nationally Critical).
- Taranui/Caspian tern (*Hydroprogne caspia*; Threatened - Nationally Vulnerable).
- Banded dotterel (*Charadrius bicinctus*; Threatened - Nationally Vulnerable).
- Black-billed gull (*Larus bulleri*, Threatened – Nationally Critical).

The Department of Conservation has been carrying out bird counts - along a single transect that follows the perimeter of Te Pouaruhe wetland - every 1-2 months since August 2019, with 33 different species of birds observed at least once in the 14 surveys undertaken to date. Of these 33 species observed, two are Threatened (matuku/bittern, seen in March 2021; and the banded dotterel seen August and October 2019), five species are At Risk, 14 are Not Threatened, and 12 are Introduced and Naturalised species.

8.2 Freshwater

At least 32 fish species have been recorded from the wider Lake Ōnoke catchment (Todd *et al.* 2016; Table 3), although a survey within the Ōnoke saltmarsh restoration zone by Riverscapes Freshwater Ecology (McEwan 2019) recorded only eight species of freshwater fish plus kōura (freshwater crayfish; *Paranephrops planifrons*). Īnanga *(Galaxias maculatus)* were the most common species recorded, followed by shortfin eel (*Anguilla australis*) and common bully (*Gobiomorphus cotidianus*).

Estuarine species such as kahawai (*Arripis trutta*), yellow-eyed mullet (*Aldrichetta* forsteri) and grey mullet (*Mugil cephalus*) are also likely to utilise the habitat within the wetland area during high tide cycles.

Two of the species recorded during the 2019 survey, īnanga and longfin eel(*Anguilla dieffenbachii*) were classified as 'At Risk -Declining' under the NZ Threat Classification System (Dunn *et al.* 2018).

Īnanga (which is one of the six native whitebait species) were observed in the western drain below the road culvert, indicating that these watercourses are still used by migratory fish to access upstream habitat (Graeme and Dahm 2018).

Table 3: Freshwater and estuarine species present in Lake Ōnoke (from Todd *et al.* 2016).

Common Name	Scientific Name	Threat Rankings[1]	Currently Present[2]	Likely To Be Present Following Restoration
Bluegill bully	*Gobiomorphus hubbsi*	At Risk-Declining		
Brown mudfish	*Neochanna apoda*	At Risk-Declining		
Giant kōkopu	*Galaxias argenteus*	At Risk-Declining		*
Īnanga	*Galaxias maculatus*	At Risk-Declining	Yes	Yes
Kōaro	*Galaxias brevipinnis*	At Risk-Declining		*
Longfin eel	*Anguilla dieffenbachii*	At Risk-Declining	Yes	Yes
Redfin bully	*Gobiomorphus huttoni*	At Risk-Declining		
Torrentfish	*Cheimarrichthys fosteri*	At Risk-Declining		
Banded kōkopu	*Galaxias fasciatus*	Not Threatened		*
Black flounder	*Rhombosolea retiaria*	Not Threatened		*
Cockabully/estuarine triplefin	*Forsterygion nigripenne*	Not Threatened		*

[1] As per Dunn *et al.* 2018.
[2] As recorded in McEwan 2019.

Common Name	Scientific Name	Threat Rankings[1]	Currently Present[2]	Likely To Be Present Following Restoration
Common bully	*Gobiomorphus cotidianus*	Not Threatened	Yes	Yes
Common smelt	*Retropinna retropinna*	Not Threatened	Yes	Yes
Estuarine stargazer	*Leptoscopus macropygus*	-		
Estuarine triplefin	*Forsterygion nigripenne*	Not Threatened		
Grey mullet	*Mugil cephalus*	Not Threatened		*
Gurnard	*Chelidonichthys kumu*	-		
Hoki	*Macruronus novaezelandiae*	-		
Kahawai	*Arripis trutta*	-		*
Kōura/freshwater crayfish	*Paranephrops planifrons*	Not Threatened	Yes	Yes
Lamprey	*Geotria australis*	Threatened-Nationally Vulnerable		
Red cod	*Pseudophycis bacchus*	Not Threatened		
Sand flounder	*Rhombosolea plebeia*	-		
Shortfin eel	*Anguilla australis*	Not Threatened	Yes	Yes
Shortjaw kōkopu	*Galaxias postvectis*	Threatened-Nationally Vulnerable		*
Trevally	*Caranx georgianus*	Not Threatened		
Variable triplefin	*Forsterygion varium*	-		
Yellowbelly flounder	*Rhombosolea leporina*	Not Threatened		*
Yellow-eyed mullet	*Aldrichetta forsteri*	Not Threatened		*
Brown trout	*Salmo trutta*	Introduced and naturalised		
Goldfish	*Carassius auratus*	Introduced and naturalised	Yes	Yes
Perch	*Perca fluviatilis*	Introduced and naturalised		
Rudd	*Scardinius erythrophthalmus*	Introduced and naturalised	Yes	Yes

* Indicates that fish may be present within Te Pouaruhe wetland following restoration works.

A targeted survey to detect the presence of any brown mudfish (*Neochanna apoda*) populations within the saltmarsh area was undertaken in 2017 (McEwan 2017). This survey did not record any mudfish, or areas of suitable mudfish habitat, within the areas to be restored but Graeme and Dahm (2018) warn that this result should be interpreted with caution as the study did not cover the entire extent of the proposed restoration works.

A baseline survey of exotic fish populations at Te Pouaruhe found goldfish (*Carassius auratus*) and rudd (*Scardinius erythropthalmus*). Other exotic fish species present in Lake Ōnoke are also likely to enter this system and could threaten indigenous fish populations, especially once there is a larger opening in the Stopbank A. Perch, in particular, are voracious predators of other fish, whilst other exotic species, including brown trout, rudd and goldfish, will also have negative impacts on indigenous fish species (Todd *et al.* 2016).

8.3 Herpetofauna

The currently known lizard fauna of the Wairarapa includes ngāhere gecko (*Mokopirirakau* "southern North Island"), barking gecko (*Naultinus punctatus),* Raukawa gecko (*Woodworthia maculata*), northern spotted skink (*Oligosoma kokowai*), northern grass skink (*O. polychroma*), glossy brown skink (*O. zelandicum*), copper skink (*O. aeneum*), and ornate skink (*O. ornatum*) (Romijn *et al.* 2012; van Winkel *et al*. 2018). Most of these species are widespread, although the known distributions of some species are highly restricted.

Northern spotted skinks are extremely rare on the North Island mainland, with only a few known remnant populations between Wellington and Hawke's Bay, including a small population in a predator-proof fenced sanctuary at Ponatahi, north of Martinborough. There are scattered historical records of northern spotted skink along the eastern Wairarapa coastline, but it is not known whether these populations have persisted to the present day. Further, the glossy brown skink is represented by a single record near Martinborough.

A speckled skink taxon (*Oligosoma* aff. *infrapunctatum)* was previously recorded from near Carterton (1970 and 1974) and Mikimiki (1969), and these records have generally been attributed to the "southern North Island speckled skink", now known as Kupe skink (*Oligosoma* aff. *infrapunctatum* "southern North Island") (Romijn *et al.* 2012; van Winkel *et al*. 2018). However, these records have yet to be confirmed as Kupe skink and may refer to another species within the speckled skink complex. Kupe skink are presently only confirmed from the coast around Whanganui and the Kaimanawa Range (Rod Hitchmough, Department of Conservation, pers. comm. 2021). The records of speckled skink from the Wairarapa could therefore represent either (i) a significant range extension for a currently known species (i.e. Kupe skink or Hawke's Bay skink/ *Oligosoma auroraense*), or (ii) a new species, or (iii) even the presumably extinct Boulenger's skink (*O. infrapunctatum*). There is a possibility that unknown populations of rare and threatened species may yet be discovered.

There are no records in the Department of Conservation's BioWeb Herpetofauna Database for the restoration area, however, there are records of three lizard species - as well as one undetermined species of gecko, one species of frog, and one species of turtle - within five kilometres of the restoration area:

- Three records of barking gecko (including one record at the western end of Ocean Beach close to Corner Creek in 2011, and two records further west at Mt Matthews).
- Eight records of Raukawa gecko (including two in the western part of Ocean Beach and one record further west along the coast at Mukamuka Stream, with the other five records all around Lake Pounui inland to the north).
- Three records of an undetermined gecko species, all around Lake Pounui. These records are likely to be Raukawa gecko, as this species has been recorded in the area and is generally the most abundant gecko in many areas of the southern North Island.
- One record of a copper skink, at the western end of Ocean Beach, *c.*500 metres back from the beach up the Corner Creek valley, from 1964.

- Three records of the introduced southern bell frog (*Ranoidea raniformis*).
- One record of a hawksbill turtle (*Eretmochelys imbricata*) from 1982 at the western end of Ōnoke Spit.

Barking gecko and copper skink are classified as At Risk - Declining, while Raukawa gecko is classified as Not Threatened (Hitchmough *et al*. 2016).

The species most likely to occur at the site is the northern grass skink (high likelihood of occurrence), in grassy habitats such as Vegetation Type 4 (dry exotic grassland) and Vegetation Type 6 (indigenous regenerating shrubland). Northern grass skink is a widespread species that favours rank grass and edge habitats such as coastal grassland and forest/pasture edges.

Other widespread species that have a lower likelihood of occurrence, due to their more restricted habitat requirements, are copper skink (requiring complex ground cover, i.e. deep leaf litter, fallen logs), and Raukawa gecko (dense scrub and areas with rocky refugia). Finally, one species relatively unlikely to occur at the site (and considered to be rare due to predation by introduced mammals, habitat loss or inadequate surveying), is the barking gecko, a well-camouflaged arboreal species requiring dense vegetation. There is also potential for the discovery of skinks affiliated to the speckled skink (*Oligosoma* aff. *infrapunctatum)* species-complex, as any Wairarapa populations are likely to represent a highly threatened taxon. This species favours rank grassland and edge habitats, similar to northern grass skink. Although speckled skinks could therefore be found in habitats such as Vegetation Types 4 and 6, they are unlikely to be present in the artificially created habitat of the stopbanks. Therefore, negative effects of stopbank excavation on lizard populations is likely to be low. and in the long-term, the effects of restoration should be very positive for lizard populations at the site.

8.4 Bats

Long-tailed bats (*Chalinolobus tuberculatus*) are classified as ‘Threatened-Nationally Critical’ by O’Donnell *et al*. (2018). They are known to preferentially forage in forest edge and riparian habitats of both indigenous and exotic forest types (O’Donnell 2001, Griffiths 2007, Rockell 2017), and have adapted to roosting in exotic tree species such as pine (*Pinus* sp.) and macrocarpa (*Cupressus macrocarpa*). They also forage over farmland and urban areas (Griffiths 2007, O’Donnell and Borkin 2021).

The Department of Conservation bat distribution database (September 2021 version) includes records of long-tailed bats within 19 kilometres of the wetland. The closest record is 12.9 kilometres away from forested streams and farm-forest margins in the Aorangi Forest Park in 2020. A 2012 survey of a wetland <3 kilometres to the north of Te Pouaruhe failed to detect bats, and no bats were detected in surveys 19 kilometres to the west in 2017 on the western side of the Remutaka Range. Their presence on the eastern side of the Remutaka Range cannot be discounted as no surveys of bats have been undertaken there. Bats might be present in the habitat mosaic between the confirmed records and the site because gullies in the agricultural landscape offer good habitat, and populations of bats have recently been found in similar habitats in the Wairarapa (Jim O’Malley, Sustainable Wairarapa, pers. comm.).

There is therefore a moderate probability that long-tailed bats use Te Pouaruhe for foraging. However, as there are no trees suitable for roosting habitat at the site, it is highly unlikely that long-tailed bats are resident. The habitat is not suitable for short-tailed bats (*Mystacina tuberculata*).

8.5 Terrestrial invertebrates

There are no records in the invertebrate database for the southern North Island within the restoration area. Based on Todd *et al*. (2016), invertebrates of note that could occur around the margins of the Lake Ōnoke, and therefore at this site, include: katipō spider, (Todd *et al.*, 2016), and two moths: *Notoreas perornata* "Wairarapa/ Wellington" and the "At-Risk (Declining) *Ericodesma aerodana* (Patrick *et al.* 2010). Furthermore, based on what has been found in the wider Wairarapa region (Hewitt 2021), including at modified sites (Fea 2010), it is also possible that the endemic stag beetle, *Geodorcus novaezealandiae*, could be present in terrestrial habitats at the site. This species also has a conservation status of At-Risk (Naturally Uncommon and Range Restricted) (Leschen *et al.* 2012). Although these four species are known to occur in the Wairarapa, the likelihood that they are present in the highly modified habitats around the stopbanks is low.

8.6 Pest mammals

Pest mammals that occur in the terrestrial area around Lake Ōnoke include cats (*Felis catus*), rodents, possums (*Trichosurus vulpecula*), mustelids (*Mustela* spp.), and hedgehogs (*Erinaceus europaeus*). Hares (*Lepus europaeus*) and rabbits (*Oryctolagus cuniculus cuniculus*) also cause significant damage to the herbfields at Ōnoke Spit (Todd *et al.* 2016).

Mustelid control is currently being undertaken along the spit. There are also plans for pest mammal trapping at Pouaruhe, with placement of 10 stainless DOC 250 traps and 10 Timms traps around the perimeter of the proposed restoration area.

9. POTENTIAL ECOLOGICAL EFFECTS

9.1 Overview

The aim of the proposed earthworks is to alter the area's hydrology so that the it can revert to its former state as a large wetland and provide valuable habitat for coastal wading bird species and fish.

Desired outcomes include a change from the current dominant exotic habitat type (degraded pasture) to indigenous wetland vegetation, and an increase in threatened indigenous avifauna, such as matuku/bittern, parera/grey duck, and puweto/spotless crake.

These works are also intended to provide an increased amount of quality habitat for indigenous fish species that favour coastal floodplains with slow-moving water and well-vegetated waterway margins.

Potential effects of the proposed earthworks and deposition of excavated material can be summarised as:

- Modification of stopbanks/channels and clearance of terrestrial vegetation.
- Modification of stopbanks/channels and flooding of terrestrial vegetation.
- Construction effects on indigenous terrestrial birds.
- Construction effects on indigenous wetland and open habitat birds.
- Construction effects on indigenous lizards.
- Construction effects on indigenous freshwater fauna.
- Stormwater run-off and contamination of receiving environments.

Each of these effects is described in further detail below.

9.2 Modification of stopbanks/channels and clearance of terrestrial vegetation

Overall, the ecological effects of the proposed stopbank modifications on terrestrial vegetation will be minor as the area that is to be removed primarily comprises terrestrial exotic grassland that has low ecological value and does not contain significant indigenous vegetation. The same applies to terrestrial sites where excavated material is likely to be placed, as all such sites also comprise terrestrial exotic grassland. Deposition sites need to be identified and clearly marked prior to the works being undertaken.

Care does need to be taken to ensure that pest plants are not spread with the fill as it is moved around the project area, and that excavation of stopbanks does not also remove significant amounts of significant indigenous vegetation. This is unlikely if the excavation works are supervised by an appropriately qualified and experienced ecologist.

Additionally, after excavation works have ceased, the remaining disturbed area will become an establishment site for pest plants. Provided that pest plants are to be controlled within the project area, and bare areas of earth are revegetated, the effects of the stopbank modification on vegetation will be low.

9.3 Modification of stopbanks/channels and flooding of terrestrial vegetation

Excavation of stopbanks will result in the inundation of the restoration area. Some terrestrial vegetation will be inundated and lost. This is a minor effect as the vegetation types and species to be affected are all exotic and are of low ecological value.

9.4 Construction effects on indigenous terrestrial birds

Bird species that occur at the site are highly mobile and the noise and movement associated with the earthworks and disturbance to the area is likely to scare most of them away from the immediate work area for the duration of the works. All four of the indigenous bird species identified at the site are common throughout Aotearoa New Zealand. However, if active indigenous bird nests are present in vegetation at the time of removal, the adult birds, chicks, and/or eggs may be harmed or destroyed. For common and 'Not Threatened' bird species, any such harm to individual birds is likely to have a negligible effect on the overall population of these species.

9.5 Construction effects on indigenous wetland and open habitat birds

Potential effects include:

- Disturbance of nesting birds, or nest destruction.
- Creation of more habitat.

Both of these potential effects are discussed further below.

For the 'Threatened' species that have been detected at the site in the last two years (matuku/bittern and banded dotterel), disturbance to nests of these endangered species could have a significant effect on their local populations. That said, the substrates at the site feature very limited amounts of potential nesting habitat for either of these species (dense wetland vegetation such as raupō or *Bulboschoenus* spp. for matuku/bittern (Williams 2018), gravel, sand or stony soil for banded dotterel), therefore it is unlikely that nesting by these species occurs at the sites to be affected during the construction phase, especially at the sites earmarked for earthworks. The level of this effect is therefore considered to be 'low'.

Opening of the stopbank and flooding of the pasture, and the re-instalment of an extensive area of intertidal habitat, will result in the creation of a large area of habitat for wetland birds and waders. This will be a very positive effect.

9.6 Construction effects on indigenous lizards

Proposed works could potentially involve risk of disturbance, injury and mortality to legally protected lizards and loss of their habitat, as a result of earthworks required to remove sections of stopbanks. Lizards are likely to be present near Stopbank A where Vegetation Types 4 and 6 habitats occur. Relocation of excavated material will need to be carefully considered, to not bury lizards elsewhere.

As no lizard surveys have yet been undertaken, the species present and their abundance is unknown. The three most likely species present are northern grass skink (Not Threatened), copper skink (At Risk – Declining) or a form of speckled skink (likely Threatened). Their abundance cannot be predicted without survey effort. Without such a survey effort, the risk to lizards also remains unquantified but the overall level of effect may be 'low', unless a Threatened species is present.

Effects on lizards will obviously depend on the location and scale of excavations and the exact location (and volume) of where excavated material is deposited. If the works are relatively small scale, then potential adverse effects are also likely to be small scale.

Additional Information

A lizard survey of the restoration site may be required. Such surveys would need to be undertaken within the accepted lizard season (October-April), and be undertaken by qualified and experienced herpetologists using appropriate survey methodology.

9.7 Effects on indigenous freshwater fauna

Potential effects on indigenous freshwater fauna as a result of the proposed earthworks include:

- Sedimentation of waterways,
- Bunding/modification of waterways, and
- Increased and improved habitat for freshwater fauna.

9.7.1 Sedimentation of waterways

Carrying out earthworks within the wetland area has the potential to result in sediment discharges, affecting both the habitats within the channels and potentially the receiving environment in Lake Ōnoke. Although the proposed works are relatively limited in scale and duration, there is still a risk of increasing sedimentation within these aquatic habitats.

Adverse effects of sedimentation within the channels and receiving environment could affect the feeding ability of indigenous fish and result in the smothering of benthic fauna, such as kākahi/freshwater mussels.

The limited scale and duration of the proposed earthworks means that the overall effects of sedimentation are assessed as low.

9.7.2 Bunding/modification of waterways

Bunding/modification of some sections of the waterways has the potential to have significant adverse effects on the instream habitats upstream of the bunded sections. If flow is totally restricted by a bund, there is a substantial risk of stagnation occurring within these 'offline' channels. This risk is highest during summer when flows will naturally be at their lowest and water temperatures at their highest. These conditions are likely to result in dissolved oxygen concentrations decreasing to levels below those that are required to sustain aquatic life. If large areas of warm, stagnant water are created within these channels then conditions are also conducive to outbreaks of avian botulism (with resulting negative effects on indigenous waterfowl).

However, if partial bunding of these waterways is implemented that allows for an adequate amount of water flow (i.e. smaller bunds across the channels, that sit 250 mm below the elevation of the adjacent pasture, and can therefore be easily overtopped), the desired management outcomes of increasing the volume of water retained within the wetland and an overall increase in the groundwater level can still be achieved. Under this scenario, the overall adverse effects on freshwater fauna will be low.

9.7.3 Increased and improved habitat for freshwater fauna

The proposed works to improve the hydrology of the area are expected to result in a net benefit for freshwater fauna, with an increased area of habitat made available and improved connectivity between the marine environment, Lake Ōnoke, and the tributaries upstream of the wetland area.

An improvement in the type and quantity of freshwater habitats available will also result in a greater diversity of indigenous fish species utilising the wetland area for feeding, spawning or transiting through to access habitat within the upstream reaches of the associated tributaries.

9.8 Stormwater run-off and contamination of receiving environments

The proposed earthworks will not result in an increase of impermeable surfaces at the project site. In the context of the wider catchment, the underlying character, composition and attributes of the receiving environments will remain similar. As such, the magnitude of this effect is considered to be negligible.

10. OPPORTUNITIES TO AVOID, REMEDY AND/OR MITIGATE POTENTIAL ADVERSE EFFECTS

10.1 Overview

Overall the beneficial ecological effects associated with the proposed works are assessed as being greater than any potential adverse effects. However, there are opportunities to minimise the potential adverse effects identified in Section 9.

10.2 Modification of stopbanks/channels and clearance of terrestrial vegetation

Ensure that pest plants are controlled within the project area, and bare areas of earth are revegetated with appropriate indigenous species. This will ensure that the effects of the proposed stopbank modifications on vegetation will be negligible.

To avoid adverse effects to the existing indigenous vegetation within the project area, earthmoving machinery should not enter Vegetation Type 5b if possible, and a survey of the affected stretch of channel should be carried out to ensure that no locally rare plant species are present within the removal area (e.g., Kirk's crassula). If these are found, plants could be transplanted to an appropriate area before works commence.

A replanting plan has been outlined in Graeme and Dahm (2018) that considers the historic vegetation of the site and works in tandem with the land contouring, brackish water gradients, and flooding regimes. The authors have provided adaptive management options and a monitoring approach that, if adhered to, will remedy any adverse effects on vegetation from the proposed earthworks. However, while the restoration plan does address pest plants and provides measures for control of them, it does not provide full pest plant management options and guidelines to ensure ongoing and effective control of pest plants within the project area, nor were pest plant distributions adequately surveyed. A Pest Plant Management Plan would fill this gap in the restoration plan.

10.3 Modification of stopbanks/channels and flooding of terrestrial vegetation

Inundation of existing exotic terrestrial vegetation will have low levels of impact as natural regeneration of indigenous wetland vegetation is likely to occur as a result. This will have an overall positive ecological effect and therefore mitigation is not required.

10.4 Construction effects on indigenous terrestrial birds

If active indigenous bird nests are present in vegetation at the time of removal, the adult birds, chicks, and/or eggs may be harmed or destroyed. For common and 'Not Threatened' bird species, any such harm to individual birds is likely to have a negligible effect on the overall population of these species.

10.5 Construction effects on indigenous wetland and open habitat birds

It is unlikely that Threatened species, specifically matuku/bittern and banded dotterel, will nest within the sites to be affected during the construction phase, especially at the sites earmarked for earthworks. The level of construction effects on these species is therefore considered to be low.

10.6 Construction effects on indigenous lizards

Adverse effects associated with a deposition site for the excavated material from the stopbanks will be avoided by primarily using this material to create the partial bunds within the existing drains.

Any excess excavated material will be deposited in areas of 'wet exotic grassland' where indigenous lizards are unlikely to be present.

A lizard survey of the restoration site may be required. Such surveys would need to be undertaken within the accepted lizard season (October-April), and be undertaken by qualified and experienced herpetologists using appropriate survey methodology.

10.7 Effects on indigenous freshwater fauna

According to a recently commissioned hydrology assessment (Cameron 2020), the proposed works are not anticipated to have any impact on the surrounding stream, catchments, or roading infrastructure, subject to the following:

a. That all works are carried out in the summer months.

b. Works are not carried out during high intensity rainfall events.

c. Flow-through to the proposed wetland exceeds the current flow rates around the existing stopbanks.

The deposition of any excess fill within the 'wet exotic grassland' area will require measures to ensure that this material is suitably stabilised and will not generate sediment discharges to waterways.

All earthworks to be undertaken in or around watercourses will require an Erosion and Sediment Control Plan specific to that site that include measures to prevent the discharge of sediment to active stream channels.

For works that involve the creation of partial bunds within the channels, these measures should include the use of coffer dams to isolate areas of channel while the material is deposited to create the bunds. This will reduce the amount of sediment generated during the works and minimise impacts on downstream environments.

These plans will also need to ensure that the earthworks comply with the NES-FW 2020 regulations (refer Section 11).

A Spill Response Plan will also be required to ensure that processes are in place to minimise the risk of accidental discharges of fuel or other contaminants to the environment during these works.

A Fish Management Plan should also be produced to provide methodologies for capturing and relocating any indigenous fish that may be directly affected by the construction of the partial bunds within the channels.

10.8 Stormwater run-off and contamination of receiving environments

No additional stormwater run-off will be generated as a result of the proposed works. Therefore no mitigation will be required.

10.9 Remediation of barriers to fish passage

Additional mitigation that could be undertaken at the site is the remediation of known barriers to fish passage. Barriers to fish passage identified in McEwan (2017) (see Section 6.1.2) could be remediated to ensure that migratory access for all species of indigenous fish is maintained between the wetland and upstream tributaries.

The perched culvert situated under Western Lake Road and located at the western margin of the wetland (Area 3, Figure 1) appears to be the highest priority fish barrier requiring remedial work. The vertical drops below the culvert outlet are likely to require spat ropes or rubber ramps to be retrofitted to the culvert to provide a continuous wetted surface that would allow climbing fish species access to the tributary upstream. The exact requirements to remediate this structure will need to be determined based on the specific details of the site, so a separate assessment is likely to be necessary.

The small drop at the downstream lip of the concrete apron associated with the box culvert (Area 1, Figure 1) can be rectified by fixing suitably sized rocks to the streambed to create a ramp-like feature that would allow īnanga to easily swim past this obstacle.

The location of the fallen log identified in McEwan (2017), that is approximately 600 metres upstream of Area 1, should be assessed to determine whether it still poses a barrier to fish passage, and work undertaken to remove, or modify it, if necessary.

11. REGULATORY REQUIREMENTS

Section 38 of the National Environmental Standards for Freshwater (NES-FW) states that:

(1) Vegetation clearance within, or within a 10 m setback from, a natural wetland is a permitted activity if it -

(a) is for the purpose of natural wetland restoration; and

(b) complies with the conditions.

(2) Earthworks or land disturbance within, or within a 10 m setback from, a natural wetland is a permitted activity if it -

(a) is for the purpose of natural wetland restoration; and

(b) complies with the conditions.

Because the purpose of the proposed works are to restore the function of a natural wetland, they should therefore be classed as a Permitted Activity under the NES-FW.

12. MONITORING

Suggested monitoring that could be undertaken to assess short-term outcomes of the earthworks and the long-term outcomes of replanting and other restoration efforts at the site are presented in Table 4.

Table 4: Suggested monitoring for ongoing assessments of effects on indigenous plants and fauna at Te Pouaruhe.

Taxa	Description/Schedule
Freshwater species	Monitoring the diversity and abundance of freshwater species, including species of importance to iwi.
Water quality	Monitoring of water quality parameters, primarily water temperature and dissolved oxygen levels, should be carried out within the channels upstream of the partial bunded areas to ensure that conditions remain suitable for aquatic life. This monitoring should be primarily conducted over the summer months when low flows and warmer temperatures tend to put aquatic habitats under stress.
Terrestrial plants: indigenous	Monitoring of the development of restoration plantings and natural recruitment of indigenous species; annually or twice a year for five years.
Terrestrial plants: exotic	Pest plant monitoring and control should be undertaken as per the restoration plan (Graeme and Dahm 2018) for five years.
Terrestrial fauna: lizards	Not likely to be required unless at risk or threatened species are discovered in a survey and/or are relocated.
Terrestrial fauna: bats	Bat monitoring could be undertaken at the site every 1-2 years with ABMs set during Spring or Summer (for up to one week) to record possible use of the site. This is not a high priority.

13. CONCLUSIONS

Overall, positive ecological effects associated with the proposed works far outweigh any potential adverse effects. Positive effects relate to the extensive area of wetland habitat that is to be restored, which will provide substantial benefits for indigenous flora and fauna.

The inundation of the exotic pasture areas and their transition to indigenous wetland habitat will have significant positive benefits for īnanga populations within the catchment, as this is expected to substantially increase the areas of habitat that are suitable for īnanga spawning. This species is highly valued as it forms the main component of the whitebait catch, which has clear implications for the objectives of this project regarding mahinga kai.

Likewise, the additional wetland habitat created will be beneficial to the tuna/eel population within the Lake Ōnoke catchment, as it will provide ideal nursery conditions for juvenile eels. Tuna are highly valued for mahinga kai, and therefore the creation of additional habitat to bolster these populations will be of significant benefit to these taonga species.

The following are suggested as conditions of resource consent for the proposed works:

Pest Plants

- A Pest Plant Management Plan is suggested to provide pest plant management recommendations to ensure ongoing and effective control of pest plants within the project area. This plan should include a survey of current pest plant distribution and abundance within the project area, and provide appropriate control methods.

Lizards

- If lizards are informally found to be present where fill is to be placed, then works should cease, and formal lizard survey undertaken. If necessary, a Lizard Management Plan (LMP) and a project-specific Wildlife Act Authority prepared by a suitably qualified and experienced herpetologist will need to be submitted to the Department of Conservation and Council for approval. The LMP would provide strategies to protect any lizard populations, whether *in situ* or by relocating them to a safe release site. If no lizards are detected during the survey, no lizard management will be required.

Aquatic Fauna

- Erosion and Sediment Control Plans will be required for all earthworks to be undertaken within or near watercourses on the site. This plan will need to specify how the construction of the partial bunds and removal of the culvert will be undertaken in a manner that minimises the discharge of sediment to downstream environments.

- A Fish Management Plan (FMP) should be created to minimise the direct effects of the proposed streamworks on indigenous fish populations resident within the affected watercourses.

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APPENDIX 1

SITE PHOTOGRAPHS

Plate 4: Oīoī-wīwī rushland, bordered by saltmarsh ribbonwood shrubland. March 2021.

Plate 6**:** Wet exotic grassland. March 2021.

Plate 7**:** Dry exotic grassland on Stopbank A. March 2021.

Plate 8**:** Mixed indigenous rushland and herbfield, with open water and dry exotic grassland in the foreground. March 2021.

Plate 9**:** Indigenous regenerating shrubland and wet exotic grassland. March 2021.

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