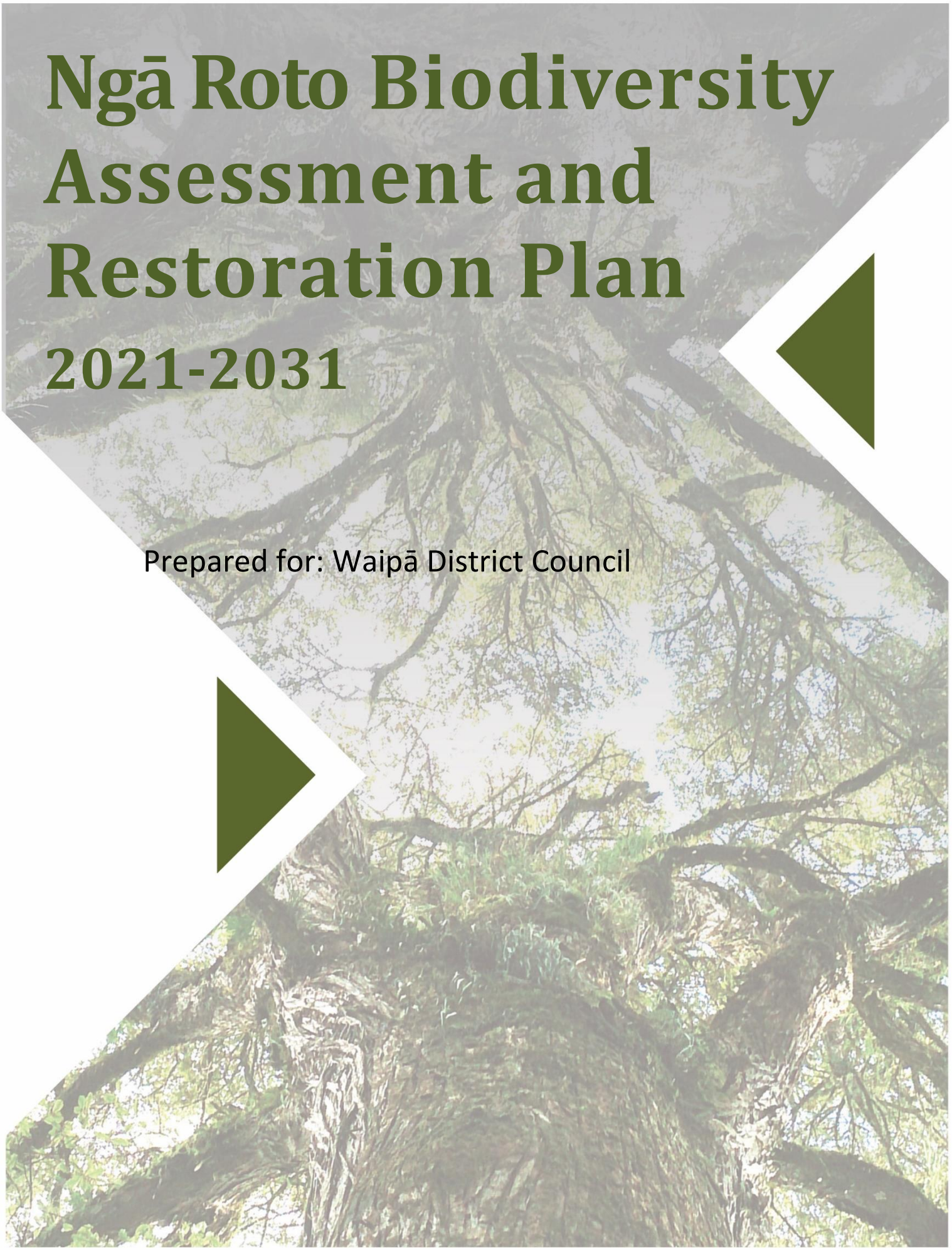
Ngā Roto Biodiversity Assessment and Restoration Plan 2021-2031

Prepared for: Waipā District Council



Nicholas Singers
Ecological Solutions
Innovation in conservation

NSES Ltd report 8:2021/22

Author(s): Alana Delich for Singers Ecological

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1. Introduction

Tupu te toi,
Ora te toi,
Whanake te toi,
Te toi i ahu mai i Hawaiki

Grow the treasure,
Sustain the treasure,
Develop the treasure.
The treasure that stems from Hawaiki
(unknown)

1.1. Purpose

The restoration of Ngā Roto began in 1995, and over the past 25 years much has been achieved, with extensive revegetation (with some areas now forming closed canopy forest), the setting of a new lake level, the diversion of the channel from Lake Ngā Rotoiti, and sustained control of willows. Unfortunately, there have been some stumbling blocks in the restoration process, primarily the collapse of revegetation zones that were planted as dense mānuka monocultures.

The Waipā District Council has contracted Singers Ecological to undertake this biodiversity assessment and restoration plan to provide a stocktake of where the restoration process has got to in 2021, identify what key challenges remain, and the priorities going forward. This report includes:

- A stocktake of work undertaken to date at Ngā Roto
- A description of ecological values, and description and map of vegetation types
- A description and map of the current status of weed invasion
- Restoration plan and priorities - including weed control, planting preparation, planting and maintenance prescriptions
- A discussion of culturally significant sites and species and designing culturally appropriate restoration based on mana whenua feedback and input into the plan.
- An assessment of existing predator control network and recommended approach going forward.

This plan exceeds the requirements of Schedule 2: of the National Environmental Standards for Freshwater Management 2020 (hereafter NES-FW 2020) - Restoration plans for natural wetlands. As this plan contains much more detail than that required by Schedule 2, the specific details of each component required for a schedule 2 restoration plan are referenced with page number in Appendix 1 of this plan.

The term of this plan is ten years (2021-2031) and this plan should be reviewed within ten years.

1.2.Vison

The long-term vision of the Ngā Roto restoration project is that:

- The entire lake shore margin of Ngā Roto is vegetated in native dominant vegetation, that is self-sustaining with minimal herbicide control.
- Wildlife numbers at Ngā Roto are increasing.
- The water quality of Ngā Roto is improving.
- The important cultural sites at Ngā Roto are protected and appreciated by the public, and the stories of culturally important species are told.
- Ngā Roto has areas of harakeke and rongoā species set aside for cultural use, where teachings of traditional use of these species can be passed on to future generations.

Figure 1: Ngā Roto from the Eastern side viewshaft location.

1.3. Methodology

This report was compiled after undertaking a site visit to Ngā Roto, reviewing the existing literature, reviewing citizen science databases eBird and iNaturalist, and carrying out GIS mapping. Mapping of vegetation, weeds and other features was undertaken using QGIS on recent aerial images (Waikato 0.3m Rural Aerial Photos (2016–2019).

A site visit was undertaken on 16th March 2021. During the site visit vegetation types around the lake were noted, and a plant species list compiled (Appendix 2). The extent of weed infestations were documented, and other general observation were made.

We engaged with mana whenua in the preparation of this report. Singers Ecological met with a representative of Ngāti Apakura and Waipā D.C. staff on site prior to undertaking field work. The preliminary assessment was shared with Ngāti Apakura though a hui on 14th April 2021 at the Waipā D.C. office in Te Awamutu. This hui identified restoration goals of Ngāti Apakura, including the creation of a pā harakeke and rongoā rākau at Ngā Roto.

1.4. Site Description

1.4.1. Site Details

The Ngā Roto restoration project area is approximately 171.5 ha. The majority of the Ngā Roto project area is within the Lake Ngā Roto Recreation reserve (161.7 ha), and is and managed by Waipā District Council via a Reserve Management Plan (Waipā D.C. 2009) to protect and maintain its important recreational, cultural and natural values. This is Crown land set apart as a recreation reserve within 7 parcels (145.5 ha), with an area of encircling road reserve (16.2 ha). Also included in the project are is a Fee Simple block to the south of the main recreation reserve that was acquired by Waipā District Council in 2018 (9.7 ha). The map of the project area, and full legal description details for these blocks

can be found in Appendix 1.2. The Ngā Roto Recreation Reserve is located at 65 Bank Road, Te Awamutu.

1.4.2. Site Features

Ngā Roto is a shallow, highly eutrophic peat lake in the Waipā District. It is the largest of the peat lakes in the Waipā District, with a surface area of approximately 89 ha, and an average depth of less than 2 metres (max depth 4 m). The lake is drained by Mangaotama Stream at the northern end of the lake. It is 12 km from the lake outlet to the confluence of the Mangaotama Stream and Waipā River. Ngā Roto is in the Hamilton Ecological District.

The hydrology of the wetland surrounding Ngā Roto is governed by the Lake level, and while the wetland vegetation surrounding Ngā Roto would have once been low-nutrient fen vegetation, it has now transitioned into a more fertile swamp.

The Lake is surrounded by approximately 72 ha of marginal wetland and regenerating forest vegetation. While the wetland surrounding Ngā Roto would have once been a low-nutrient fen vegetation, it has now transitioned into a more fertile swamp. Ngā Roto has a catchment of c. 1846 ha. Land use in the catchment is 77% dairy pasture, 15% drystock pasture and 3% non-agricultural use. There are 31 farms greater than 20 ha in the catchment.

Ngā Roto was formed some 19,000 years ago at the end of the last glaciation, when river valleys were blocked with silt and sand from the ancient Waikato River. Ngā Roto is thought to have been about 220 ha in size (open water/surface area) at the turn of the 20th Century. This area was reduced to its current size by 1960 through drainage activities that were undertaken to reclaim the lake and its margins for agricultural use.

The lake is fully fenced with margins ranging from about 30 – 200 m in width. While most of the reserve area is included within the fenced boundaries, small areas of the reserve continue to be farmed.

2. Ecological Values

2.1. Vegetation

2.1.1. Vegetation History

The Waipā Catchment was heavily populated when the first Europeans arrived. The Austrian geologist Dr Ferdinand Hochstetter, recorded in detail the vegetation and people he met during his geological survey in March 1859. Hochstetter travelled from Auckland to Lake Taupō via the Waipā River and stayed at numerous locations along the way (Johnston & Nolden 2011). From his observations he noted a landscape that was a mosaic of cleared land along the river flats, including areas of bracken fern, lakes, and wetlands which were surrounded by dense swamp vegetation and extensive forests present on surrounding hillslopes such as Mt Pirongia, with small pockets in the lowlands. Throughout this landscape were cultivated areas growing a range of crops. European farming had already begun at this time and there were a number of Europeans, such as John Cowell who married Keke Tumohe, the half-sister of the Chief Wiremu Toetoe Tumohe. They had been gifted a large block of land and had transformed it into a prosperous farm.

By the 1940's most of the catchment was in pasture, and cattle had access to the lake shoreline in places, particularly on the north-eastern side of the lake, though some of the wider wetland areas to the west remained (see 1943 historic aerial images, Appendix 3). Today only 0.51% of the catchment remains in indigenous vegetation (Dean-Speirs et al. 2014).

In 1935 the vegetation of the southern and eastern shores of Ngā Roto were described as mānuka/blackberry scrub. In 1978 the marginal vegetation was described as a mostly pastoral margin with widespread areas of willows, blackberry, and gorse. In 1993 it was reported that the northern half of the lake was dominated by willows, and the southern part of the lake dominated by rough pasture species (Champion et al. 1993).

Waipā District Council started the restoration project at Ngā Roto in 1995. With funding support from funds such as the Waikato River Clean Up Trust, Waipā District Council initiated programmes to fence the entire lake margin, undertake and enhance riparian plantings at Ngā Roto, and control willows and other weeds. Willow control over the last 5 years has removed the willow forest vegetation type described in previous ecological plans (Champion et al. 1993, Wildlands 2008). Only occasional live willows remain, amongst areas of standing-dead willow. The margins of Ngā Roto are now a mix of exotic and native plant communities, including raupō reedland, swamp meadow wetlands, kahikatea swamp, and regenerating mixed broadleaved forest. No threatened plants are known from Ngā Roto.

2.1.2. Macrophytes

Ngā Roto once had widespread beds of native submerged aquatic vegetation. Introduced aquatic macrophytes were first recorded in the lake in the late 1960's and came to dominate the lake by the late 1970's as nutrient levels soared over this time. The submerged weed beds were sprayed throughout the 1980's and by 1992 no submerged species could be found in the Lake (Champion et al. 1993).

Ngā Roto is currently classified as de-vegetated (Dean-Speirs et al. 2014). The re-establishment of macrophytes is likely to be prevented due to the turbid water conditions, and further impeded by the presence of coarse fish in the lake, particularly koi carp and rudd, which disturb sediments and feed on submerged aquatic vegetation (Rowe 2007).

2.1.3. Marginal vegetation

The marginal communities occupying the zone between open water and dry land, consist of a diverse array of plants which change according to the degree of "wetness", soil mineralisation, and restoration history. The dominant communities are described below and mapped in Figure 2.

Raupō Reedland (4.9 ha)

The lake perimeter is fringed by a broken band of emergent reeds, primarily Raupō (*Typha orientalis*) and in places kuta (*Eleocharis sphacelata*). The water level in this zone is 5cm – 1m deep. This band has expanded and contracted over time as drainage, sedimentation and past water level regimes have impacted on it. The now consistent water level is likely to allow this vegetation type to stabilise.

Swamp Meadow (7.3 ha)

This vegetation type usually borders the Raupō reedland, and is dominated by wetland species that float, prefer soft, saturated substrates and tolerate seasonal inundation like water primrose (*Ludwigia peploides),* native willow weed (*Periscaria decipiens*), water milfoil (*Myriophyllum propinquum*)*, Carex*

geminata, Eleocharis acuta and swamp millet *(Isachne globosa).* The water level in this zone varies seasonally, is estimated to vary from -20 cm to +20 cm depth.

Former Willow Treelands (17 ha)

These areas are now similar to swamp meadows, though are slightly drier, with water levels estimated to vary from -5 cm to +5 cm depth. Standing dead willow stems with occasional woody natives such as kahikatea (*Dacrydium dacrydioides*), Coprosma sp., cabbage tree (*Cordyline australis*) and mānuka (*Leptospermum scoparium*) over a groundcover of introduced grasses, bindweed (*Calystegia* sp.), gypsywort (*Lycopus europaeus*), beggar's ticks (*Bidens frondosa*) and in the wetter places, *Ludwigia* spp., native carex sedges, native willow weed, spearwort (*Rununculus flammula*) and rush (*Juncus*) species persist.

Amongst exotic grasses, small remnants of low nutrient bog/fen vegetation were observed. This vegetation type would have been the original dominant marginal vegetation type at the Lake. This was a small area (less than 10 m^2) on the western side of the lake with *Machaerina rubignosa*, sphagnum moss, *Centella uniflora* and *Lobelia anugulata*. On the landward margins of this vegetation type bordering mānuka stands, ring fern (*Paesia scaberula*), and *Hypolepis ambigua* are common. These areas also have Japanese honeysuckle, bindweed and gypsywort encroaching on the edges.

Kahikatea swamp (2.4 ha)

These areas are located at the northern end of the lake on seasonally saturated soils and are very similar to former willow treelends, however relatively frequent kahikatea have been planted into these areas, and so form kahikatea treeland. The understorey is very similar to the former willow treelands, however the frequency of native species is higher. Additional species noted in this vegetation zone include the ferns *Hiya distans* and *Diplazium australe*.

Bindweed – Exotic grasslands (6.5 ha)

From 1995 large numbers of mānuka plants were planted around the lake at very high densities in order to suppress the growth of troublesome weeds like blackberry and gorse. Unfortunately, the dense monoculture of mānuka suppressed regeneration of other native species beneath it. The mānuka has reached a senescent stage, and in many places has collapsed. These collapsed mānuka stands have reverted back to exotic grasslands with abundant bindweed and bracken (*Pteridium esculentum*) in places. This vegetation is located on areas of peat soil that are seasonally saturated to generally dry.

Examination of past aerial imagery on Google Earth shows that some of these former mānuka stands had a dense sub-canopy of treeferns, which briefly formed areas of treefernland between 2015-2020, however these treeferns have now largely died. This is likely a combination of factors including flooding in autumn 2017, lack of shade due to loss of the mānuka canopy, drought in the summer of 2019-2020, and spray drift from willow and other weed control as tree ferns are very sensitive to herbicides. Studying the aerial imagery we believe that the 2020 drought was the most dominant factor in this die-off.

Established mixed native plantings (7.5 ha)

These are areas that were either less densely planted in mānuka monoculture or have been re-planted in mixed native species since the mānuka begun to collapse. This vegetation is located in areas that are generally dry. The areas have not yet formed a canopy as the regenerating broadleaved forest

area but are largely past the point where they need release spraying. Common species planted include kahikatea, cabbage trees, karamu (*Coprosma robusta*), harakeke (*Phormium tenax*) and mānuka (which is an appropriate revegetation species when planted at a lower density). Some non-ecosourced native revegetation species which would not normally be found growing near a peat lake have also been used in places. For example, karo (*Pittosporum crassifolium),* karaka (*Corynocarpus laevigatus)* and akeake (*Dodonea viscosa*) are usually coastal species; and *Veronica parviflora* which in the Taupō District grows in frost flats. There are also hybrid native plants grown for landscaping purposes, such as a range of hybrid *Pseudopanax*, golden tōtara (*Podocarpus*), and ramarama (*Lophomyrtus* x *ralphii*).

Sparsely planted bindweed grasslands (7.51 ha)

These are planted areas, planted prior to 2019, which have not had a high level of plant establishment, and will required supplementary planting in order to form a closed canopy to shade out competing bindweed and other herbaceous weed species. Due to the sparse native plant cover, some of these trees require on-going releasing from bindweed.

Regenerating broadleaved forest (2.1 ha)

The most successful, less densely planted, former mānuka stand, which had a greater diversity of native species planted amongst the mānuka is now very close to a self-sustaining native forest. This site is on higher, drier granular soils, and now has a canopy of mānuka, mahoe (*Melicytus ramiflorus*), karamu (*Coprosma robusta*), putaputaweta (*Carpodetus serratus*), tōtara (*Podocarpus totara*), broad leaf (*Griselinia literalis*) and lowland ribbonwood (*Plagianthus regius*). The understorey includes the tree ferns silver fern (*Cyathea dealbata*), black mamaku (*Cyathea medullaris*) and wheki (*Dicksonia squarrosa*); and turepo (*Streblus heterophyllus*) which will have self-established. The ground cover is a mixture of native ferns including thread fern (*Icarus filiformis*), shining spleenwort (*Asplenium oblongiferum*), rasp fern (*Doodia australis*) and *Diplazium australe*; and seedlings of kahikatea, pate (*Schefflera digitata*) and pigeonwood (*Hedycarya arborea*).

Minor vegetation types

Other minor vegetation types include:

- **Kahikatea plantation forest (0.22 ha)** where a kahikatea monoculture was planted, which now forms a closed canopy with only a few native fern and sedge species in the understorey.
- **Established planted sedgeland (2.78 ha)** around the wildlife ponds which include carex species, and purua grass (*Bolboschoneus fluviatilis*).
- **Recent mixed revegetation planting areas (1.47 ha)** which are not at a self-sustaining stage and will require on-going releasing from weeds in order to become established.
- **Exotic trees (e.g., oaks and poplars – 1.44 ha)**
- ***Hypolepis* fernland (0.09 ha).**

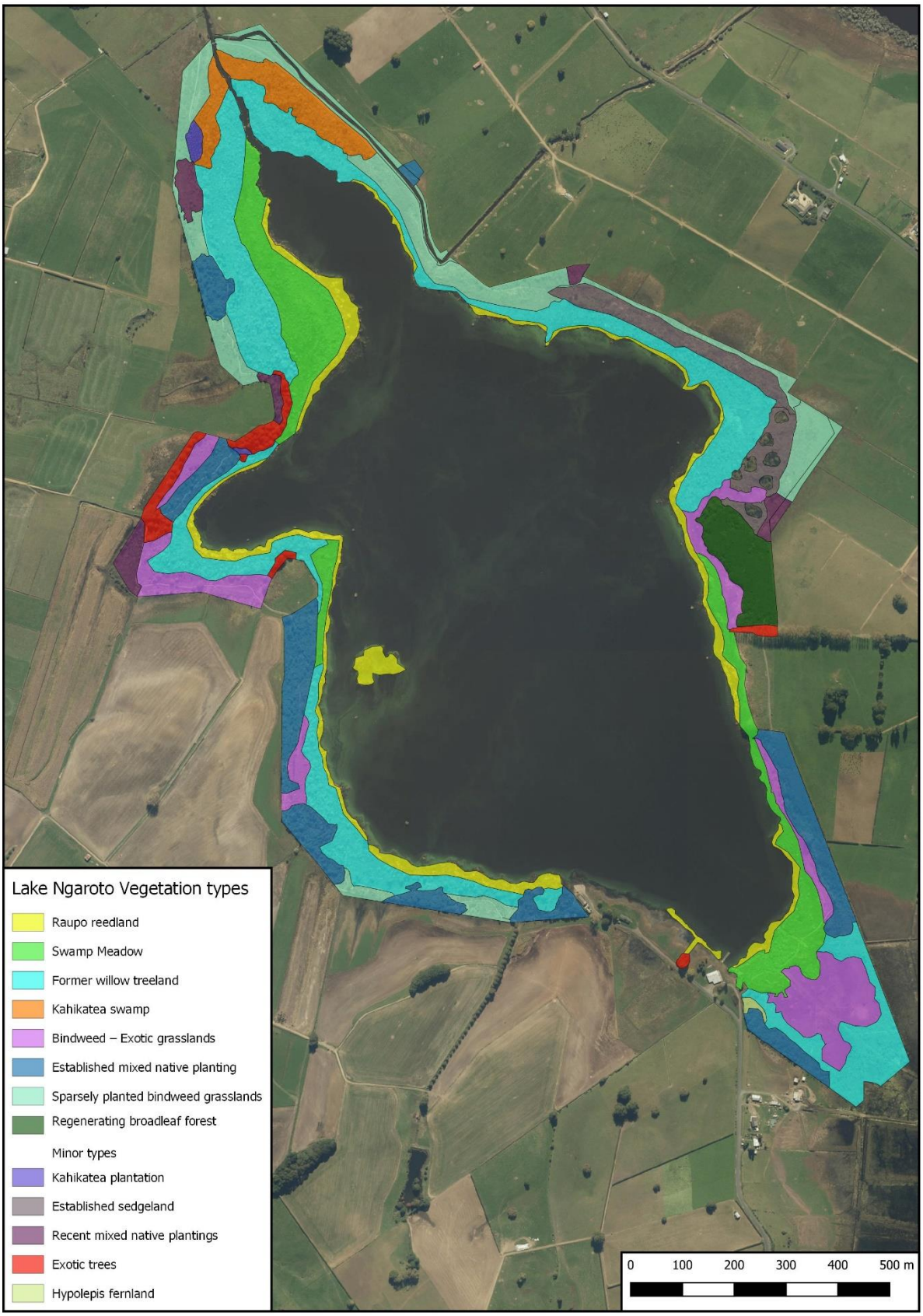

Figure 2: Vegetation Map of Ngā Roto, 61.1 ha of vegetation mapped. Areas of pasture/mown grass, and water are not included on this map.

2.2.Birds

Fifty-four bird species have been recorded at Ngā Roto, in both published reports (Wildland Consultants Ltd 2008, Dean-Speirs et al. 2014), and through citizen science. The New Zealand Ornithological Society has opted to use citizen science through the website eBird.org to update the New Zealand bird distribution atlas. Birders around Ngā Roto have been making observations on eBird and have made records of 53 bird species.

Rare birds that have recently been recorded through eBird are Australasian bittern (Nationally critical), black-billed gull (Nationally critical), caspian tern (Nationally vulnerable), marsh crake (At-risk–declining), spotless crake (At-risk–declining), dabchick (At-risk–recovering), pied shag (At-risk–recovering), black shag (At-risk–naturally uncommon), little black shag (At-risk–naturally uncommon) and New Zealand bush falcon (At-risk–recovering – Robertson *et al.* 2017). Other threatened species recorded historically include kotuku, banded rail and mātātā (fernbird).

Of the rare birds recorded at Ngā Roto, pied shag, black shag, little black shag and marsh crake were observed during the site visit on 16 March 2021. The kawau were observed roosting on dead willows on the eastern side of the lake, and a marsh crake was heard calling on the eastern shore of the lake, just past the grassed view shaft area. While some species (e.g., kotuku, Caspian tern and karearea) may only be occasional visitors, Ngā Roto is an important part of wetland networks for many species such as the Australasian bittern.

2.3. Invertebrates

The invertebrate fauna was surveyed in 1977 (Boubee 1977). Damselfly nymphs, water boatmen and backswimmers were present around the lake edge. Purse caddis (*Oxyethira albiceps*) and the freshwater snail taxa *Potamopyrgus antipodarum* and *Physa* sp. were found using net sampling. At the lake edge were scattered beds of kākahi/kāeo (*Echyridella menziesii*).

It is unlikely that kākahi/kāeo persist due to the degradation of water quality, but the other invertebrate fauna is likely to be very similar today.

2.4. Lizards

There have been no records of native lizards at Ngā Roto, but lizards have been recorded nearby. Ngā Roto is within the known range of copper skink (*Oligosoma aeneum*), which has been recorded nearby at Lake Rotopiko, as well as Pacific gecko (*Dactylocnemis pacificus*) and forest gecko (*Mokopirirakau granulatus*) which have both been recorded on Mt. Pirongia, and Auckland green gecko/elegant gecko (*Naultinus elegans*).

Lizards are culturally significant to Ngāti Apakura as kaitiaki of the lake and are depicted on Pou at the Southern entrance to the track.

2.5. Fish

A comprehensive fish survey carried out in 2001 recorded nine species, four native species and five introduced species (Hicks et al. 2001). The most common native species was the short-finned eel (*Anguilla australis*) with common bullies (*Gobiomorphus cotidianus*), a few longfin eels (*Anguilla dieffenbachii*) and a single common smelt. Over 70% of the catch was the brown bullhead catfish (*Ameiurus nebulosus*), followed by rudd (*Scardinius erythrophthalmus*), goldfish (*Carassius auratus*) and a single mosquito fish (*Gambusia affinis*) and koi carp (*Cyprinus carpio*).

Of the fish species present or recorded, long-fin tuna is classified as At-risk – Declining in the New Zealand Threat Classification System (Dunn et al. 2018).

The fish population was resurveyed in early 2009 and was found to be less diverse than the 2001 surveys with no smelt or longfin eels captured. Seventy percent of the total catch in 2001 was catfish but in the 2009 sampling they only contributed 5% of total catch. Goldfish contributed 27% of the catch, (1% in 2001), rudd 20% (similar to earlier survey), and koi carp and mosquito fish 10 and 15%, respectively (only single specimens recorded earlier). Unfortunately, it is difficult to draw firm conclusions about these results as different methods were used for each of these surveys. However, the low variety of native fish in Ngā Roto is likely to be the result of poor habitat quality (lack of macrophytes, hyper-eutrophic water quality), past commercial fishing of eels, and predatory pressures and competition from exotic fish species (Waipā District Council 2008). Until recently there was no fish passage at the weir which may have contributed to the low numbers of common smelt. (Dean-Spiers et al. 2014)

Eel abundance has declined significantly. Commercial eeling data from between 1983 – 1989 gave an average eel catch rate of 6.5kg/net/night. In a 2001 fish study eel catch rate was only 0.73kg/net/night. This decline has been largely attributed to prior eel fishing pressure (Hicks et al. 2001).

Freshwater Fish Database

Species recorded in the Lake and surrounding catchment in the NIWA Freshwater Fish Database (FFDB) are listed in Table 1below:

Table 1: All records in the NIWA Freshwater Fish Database. (some years/species were not enumerated – p = present, r = rare, o = occasional, c = common)

Year	Comment	Catfish	Shortfin Tuna	Longfin Tuna	Goldfish	Koi Carp	Mosquito Fish	Common Bully	Common Smelt	Freshwater Shrimp	Rudd
1976								p	p		
1979		c	c		r			c			
1996							c	c			
2001*	Extensive netting study in 6 locations. Not in FFDB	3141	247	6	42	1	1	20	2		857
2005						c				p	
2009		8	21		52	23	29	22			34
2011	Ngā Rotoiti channel pre-diversion						4	4			
2015	Ngā Roto tributary		8					p	p		
2019	Ngā Rotoiti channel post-diversion	30	23		7	1	p	14	1		

3. Weeds

3.1. Priorities for weed control

Weed control at Ngā Roto should focus on weeds that can alter ecosystems, and those that are currently at low density and can easily be eradicated. These weeds are listed as target weeds for control in section 3.2.

There are large areas at Ngā Roto that are dominated by herbaceous weeds (inkweed, bindweed and beggar's ticks). These weeds are at a level where they are not feasible to control as environmental weeds. The priority for these weeds is to control them in revegetation areas to aid the establishment of the native trees and plants. These herbaceous weeds are light demanding species, so should disappear in the long term as the ecosystems are restored, and native species overtop and outcompete them.

3.2. Target weeds for management

During fieldwork all weed species were noted. Of the weeds noted, certain weeds stand out as priority for control. Most are at a very early stage of invasion, and this is the ideal time to get on top of them.

Amongst revegetation zones, and in the kahikatea fen area, sensitive ground-based control methods should be used such as manual weeding, cut and pasting of small trees, and drilling and poisoning of larger trees. If herbicides are used basal spraying should be at low volume, and if knapsack sprayers are used a shield must be used when spraying around native plants. For example, the regenerating broadleaved forest area on the eastern edge is very close to becoming a self-sustaining forest ecosystem. However, there are a few environmental weeds present that could derail this site. Weed control of ivy, privet, Queensland poplar, and wild kiwifruit to protect this area would require 2 people for 2 days (up to $1200). These priority weeds are detailed in Table 2 and mapped in Figure 3. Photographs of some of these weeds follow (Figures 4-10).

Table 2: Priority weed species recorded at Ngā Roto.

*** Eradication** means total clearance of a weed from the site. (e.g. only a few currently present at site); **Zero density** means control of all known infestations/ populations of the target pest, to the last individual, control before the mature, flower and set seed – non-reproducing (a more realistic term than eradication, because in the case of plants, seed banks can lay dormant for years; **Very low density** weeds will have to be controlled on a cycle. Will keep re-invading to need to control on a cycle – e.g. things that are constantly introduced by birds

Priority	Weed	Target*	Notes	Control Method	Time (hrs)
1	Scrambling dock (*Rumex sagittatus*)	Eradication	One infestation noted. High priority to prevent this spreading further. A difficult plat to control. Should die down over winter.	Best to cut any climbing stems first, then dig out tubers. Spray regrowth in summer with BANVINE, cut climbing vines and spray the ground. Regrowth is likely to require multiple treatments.	4 hours over 4 months
2	Tradescantia (*Tradescantia fluminensis*)	Eradication	One site at the boating club end of the walking track. Only a small area, manual hand pulling, or "rake and roll" control would be best.	First hand-weed around native trees and seedlings. Bag all material and dispose of by burning or landfill, then spray any regrowth a few months later - 3 sprays Triclopyr, low pressure, low volume. 1st spray will kill 90% (knockdown), 2nd and 3rd spray will clean up missed bits.	4 hours over 4 months
3	Queensland poplar (*Homalanthus populifolius*)	Eradication	One site with multiple seedlings. We hand pulled quite a few of these, but more are present. National pest plant accord species. Shade tolerant, so a threat to establishment of a native subcanopy.	Hand pull small seedlings and Large seedling should be basal sprayed, or cut and basal spray cut stem. OR Drill/poison	Weed control of ivy, tree privet, Queensland poplar, wild kiwifruit and sumac to protect the regenerating forest area would require up to 2 people for 2 days (up to $1,920 at standard hourly rate of $60/hr)
	Ivy (*Hedera helix*)	Eradication	A few sites, under poplar shelterbelt and in the well-established eastern restoration area. Best treatment is hand pulling. This is quicker than it seems and is a good volunteer weedbusting activity.	Where it is climbing trees all vines must be cut, but cut vines can be left in trees to decay (see photos). Bag all material and dispose of by burning or landfill, then spray any regrowth with BANVINE a few months later.	

	Wild kiwifruit (*Actinidia deliciosa*)	Eradication	One large vine noted. Control to prevent further invasion of the established regeneration area.	Recommended control by Kiwifruit Vine Health Inc: Cut vines at ground level. Apply Vigilant Gel® herbicide to the top and sides of the cut stump or any exposed roots. Ring-bark stumps or large roots with a machete or pruning saw to assist absorption of the herbicide gel. Carefully trace all vine stems to find where they may have taken root. Cut any rooted stems at ground level and apply Vigilant Gel®.	
	Tree Privet/Shining Privet (*Ligustrum lucidum*)	Eradication	One tree noted at the back of the regenerating native bush, on boundary with the farm.	Basal spray, or cut and basal spray cut stem. OR Drill/poison	
	Staghorn sumac (*Rhus typhina*)	Eradication	One tree noted. Not sure of weed potential, possibly the more weedy stinking sumac (*Ailanthus altissima*) best to remove now.	Basal spray, or cut and basal spray cut stem. OR Drill/poison	
4	Grey Willow (*Salix cinerea*)	Very low density	Some of the aerially sprayed areas have a survival rate of 30-50%, with green leaves being present within the centre of the plants. Drilling and poisoning of these stems is recommended in accessible areas, and amongst kahikatea to prevent non-target damage. A large tree is present in the grassed recreation reserve area, and some smaller ones growing on the roadside, these should be removed to remove future seed source.	Helicopter spot spray with 1% Glyphosate 360 with the addition of a surfactant and anti-foam adjuvant can be used. For accessible trees Drill/poison OR Basal spray, or cut and basal spray cut stem (only in dry locations, no basal spray in wetlands). For willows in dry locations Metsulfuron-methyl is the recommended herbicide at 35gm per 100L. In addition to the herbicide, it is recommended that Agpro Metruon Enhancer, and a surfactant safe for use over water (e.g. Aquakynd) at	Up to $25,000 in 2021/22. Discussed in report section 3.3.

				250ml per 100L plus anti-foam adjuvant be applied.	
5	Pampas (*Cortaderia selloana*, *C. jubata*)	Zero density	Both pampas species are present, but primarily *C. selloana*. These may be being mistaken for toetoe, as mature plants noted right next to areas that had been sprayed. Have GPS'd the ones we saw. NPPA species.	Spray with Glyphosate (100ml/10L + penetrant). Use a foaming agent to help prevent spray drift. Some plants may require helicopter spraying. Leave the plants in the ground until the roots have died off. Glyphosate granules also work well.	Up to 2 days ground treatment, 1 hour helicopter treatment
6	Japanese honeysuckle (*Lonicera japonica*)	Zero density	Two main infestations noted.	Hard to kill - mixture of Glyphosate & Metsulfon-methyl at label rates works well (or Metsulfuron alone). Treat in spring. Cut vines where it is climbing trees and spray the weed on the ground. 2 treatments in first year to get missed stems. Follow up annually for 3 years.	Up to 3 days, 3 repeat visits timed 4-6 weeks apart
7	Wild cherry/taiwan cherry (*Prunus campanulata*)	Eradication	A few saplings noted. Control early to prevent establishment.	Basal spray, or cut and basal spray cut stem. OR Drill/poison	All these low density scattered species could be treated in 4-8 hours
	Himalayan honeysuckle (*Leycesteria formosa*)	Eradication	One plant noted. Be good to prevent this spreading further.	Basal spray, or cut and basal spray cut stem.	
	Gorse (*Ulex europaeus*)	Eradication	Only a few small plants noted in area of diggings by Ngā Rotoiti diversion. Control now to prevent establishment.	Basal spray, or cut and basal spray cut stem.	
	Broom (*Cytisus scoparius*)	Eradication	Only a few small plants noted in area of diggings by Ngā Rotoiti diversion. Control now to prevent establishment.	Basal spray, or cut and basal spray cut stem.	

	Box elder (*Acer negundo*)	Eradication	One tree noted on fence line at Boating club end of the track. Female trees produce winged seeds which germinate prolifically.	Basal spray, or cut and basal spray cut stem. OR Drill/poison	
8	Chinese privet (*Ligustrum sinense*)	Zero density	Most on the eastern side are small. Some larger ones are present on the western side one the fenceline side of the track.	Basal spraying recommended (hard-to-kill, 30% mix recommended), though may need to drill and poison largest ones on the western side.	up to 2 days
9	Crack willow (*Salix fragilis*)	Very low density	This is a lesser problem than grey willow as does not produce seed, but should be controlled where it is found. Some small ones noted in the diggings of the Ngā Rotoiti diversion canal	Basal spray, or cut and basal spray cut stem. OR Drill/poison	1 hour. Treat at same time as other weeds in vicinity.

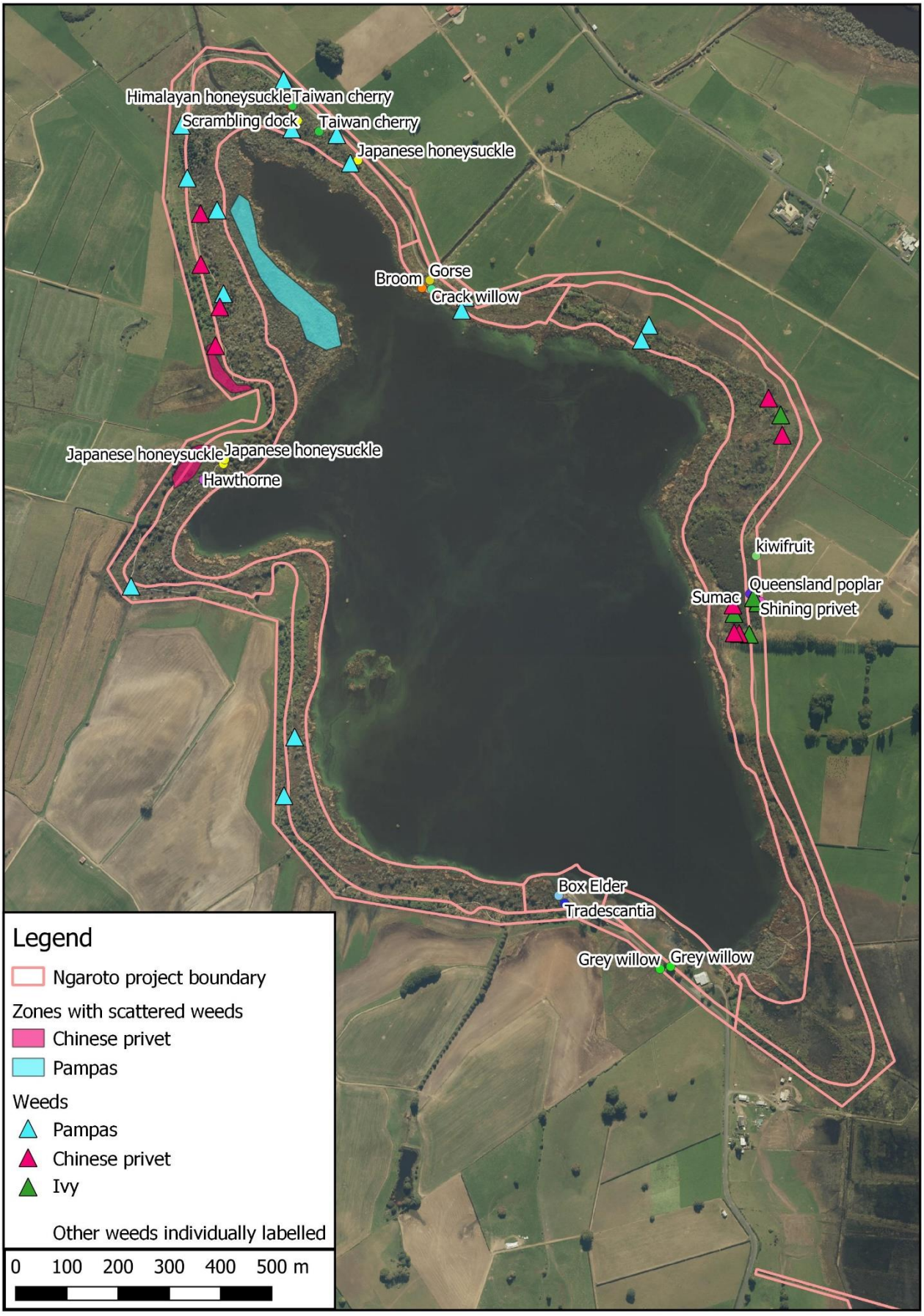

Figure 3: location of priority weeds for control at Ngā Roto.

Figure 4: Queensland poplar (*Homalanthus populifolius*). In understorey at eastern regenerating forest.

Figure 5: Sumac (likely *Rhus typhina*), on western edge of the regenerating forest. Some of the leaves are turning red.

(a)  (b) 

Figure 6: Hand weeding of Ivy (using Fiskars Brush Hook) quickly clears the forest floor and will allow the regeneration of these kahikatea seedlings that would have been killed by spraying (a) climbing stems should be cut from the trees (b) and pulled vines bagged and composted in open grassy site.

Figure 7: Wild kiwifruit, growing on boundary fence at the native forest restoration area on the eastern side of the lake.

Figure 8: Climbing dock (*Rumex sagittatus*); and Both at the kahikatea fen area at the northern end of the lake.

Figure 9: Himalayan honeysuckle (*Leycesteria Formosa*).

Figure 10: Tradescantia near the western track entrance

3.3. Willows

3.3.1. Aerial spraying

Aerial spraying has been very effective for knock-down of the willows around the lake. Aerial spot spraying of willows from a helicopter using Garlon® 360 (Triclopyr triethylene amine) has been used over dry areas in 2020/21 (K. Barnes Pers. Comm.). For willows in areas close to water aerial spot spraying with a drone has been most recently used. Of the willows treated by drone sprayer in 2020/21 30-50% of the willow trees have not died, and the central branches of the tree remain alive (see photos in figure 11). These will need to be re-treated next year, with a total of three years of re-treatment required to get willows to zero-density. While a drone is a very helpful tool for controlling a small number of inaccessible weeds, a much higher volume of herbicide is required to get high willow mortality, we estimate up to 50% more herbicide. A drone spray tank is only small. And if the correct volumes of herbicide are delivered to kill willow trees, the spray tank will need to be re-filled very frequently. For these reasons, a drone was not the appropriate tool for willow control at the knock-down stage. It is our expectations that significant regrowth will occur next spring.

Figure 11: Willows on the eastern side of Ngā Roto which have survived in the centre due to insufficient volume of herbicide delivered.

Instead, we recommend helicopter spot spraying with a wand or targeted nozzle for 2021–22 re-treatment using Glyphosate 360 at 1% (as per label rates). This is because helicopter spot spraying can deliver a higher volume of herbicide and can be just as targeted. Spraying is most effective from November to January when willows are in full leaf, as the more leaves that are present on a plant, the more effective foliar spraying will be. Willow control using a drone sprayer at Ngā Roto cost around $25,000 in 2020–21. Helicopter spot spraying is likely to be a similar or slightly higher price (based on helicopter rates for spraying elsewhere in the Waipā). Any extra cost is worth it to ensure more effective willow control.

Glyphosate 360 is non-selective, so it will kill willows and any surrounding vegetation whether native or exotic. Therefore spot spraying with glyphosate will need to be very targeted. 360g/L is the concentration approved for use over water, a surfactant that is safe in aqautic environment (e.g. aquakynd) and defoaming agent is also required. The benefit of glyphosate is that the pampas on the

margins of the lake can be sprayed at the same time without having to change the type of spray in the tanks.

Ideally, the herbicide Metsulfuron-methyl would be used for willow control. Metsulfuron-methyl is a broadleaf selective herbicide, so would kill willows and broadleaf herbaceous weeds such as gypsywort and bindweed, but will not kill native sedges, therefore giving these a chance to recover. However, Metsulfuron-methyl is not registered for use over water, and a resource consent for discharge to air would be required to spray Metsulfuron-methyl over water. Waikato Regional Council & the Department of Conservation currently hold a 20 year consent for use of Metsulfuron-methyl over water in the Waikato (consent no: 124871), however it is not a simple process to obtain a consent such as this, and the administrative effort outweighs the potential non-target damage from aerial spraying with Glyphosate 360, particularly as willows have already been reduced so much at Ngā Roto.

For willows on dry land, Metsulfuron-methyl is the best tool for the job, and should be used at a rate of 35 g Metsulfuron per 100 L, plus surfactant and defoaming agent.

The willows will need to be re-treated each year for 3 years, at which time zero-density should be achieved. It is likely that a very high level of control will occur using a helicopter and this may only be needed for another 1 – 2 treatment cycles. However, we recommend that it would be prudent to budget the following for the next three years: $25,000 in 2021–22, $12,500 in 2022–23 and $6,250 in 2023–24.

Occasional willow seedlings will establish which will require control in perpetuity. A drone sprayer will be an excellent tool for future maintenance if weed management occurs frequently, every 1 – 2 years. Any drone sprayer used for this purpose must have a camera. The drone used in 2020–21 was operated by line of sight. This was not accurate enough to ensure sufficient herbicide was applied to kill willows, and failed to minimise non-target damage. The estimated cost of annual willow maintence after achieving zero-density using a drone sprayer is $1,500 – $2,000.

Table 3: Estimated cost of re-treating willows at Ngā Roto, helicopter spot spraying.

Year	Activity	Cost
2021-22 Late November - January	Re-treat willows – helicopter spot spray	$25,000
2022-23 Late November - January	Re-treat willows – helicopter spot spray	$12,500
2023-24 Late November - January	Re-treat any willows remaining– helicopter spot spray (or drone?)	$6,250
2024-25 onwards: Late November - January	Drone surveillance and treatment of any new willows	$1,500 - $2,000

3.3.2. Ground-based willow control

In the kahikatea swamp vegetation at the northern end on Ngā Roto there are some surviving willows. These are not appropriate to spray aerially and would cause considerable non-target damage, particular to tree ferns which are very sensitive to herbicides.

A large grey willow still stands near the boating club, and several smaller grey willows are in the drain along the fenceline along the road to the back carpark. These are a seed source so need to be removed.

For willow trees in sensitive locations, and accessible trees that need to be re-treated, drilling and poisoning willows is the best method. Getting around the lake to undertake drilling and poisoning could be made faster with an electric UBCO motorbike like those used by the Department of Conservation (DOC). We estimate up to 6 person days for this work ($2,880 at a contractor rate of $60/hour).

3.4. Herbaceous weeds

Herbaceous weeds such as gypsywort, beggar's ticks and inkweed are common around the lake. However, it is not feasible to remove these, as repeated spraying will be more harmful to non-target native vegetation than the weeds themselves. Many of these weeds die back in winter, and re-grow the following spring, so do not grow larger year-on-year. These herbaceous species are all light demanding species, so as the revegetation areas grow, and develop a closed canopy shrubland and forest, they will be shaded out. They may look ugly now, but in time the prevalence of the weeds will reduce.

These weeds will however need to be controlled by release spraying around young native plants in recent revegetation zones.

In places there are native carex species growing in amongst these herbaceous weeds. In these mixed zones a Metsulfuron-methyl trial could be carried out, as Mesulfuron-methyl will kill the broadleaved weeds, and at low volume will not impact the native sedges and rushes (monocots). Liberal use of Metsulfuron-methyl could result in a decline of some native herbaceous species (e.g., water milfoil – (*Myriophyllum propinquum*)) so should be used with care.

3.5. Bindweed

There are vast areas of bindweed (*Calystegia* sp.) around the lake. The bindweed seems to be mostly a hybrid between the native, pink-flowered bindweed (*Calystegia sepium* subsp. *roseata*) and the introduced, white-flowered greater bindweed (*C. sylvatica* subsp. *disjuncta*). These species are shown in Figures 11 and 12.

Bindweed is difficult to control. The best approach is to spray 2—3 times in the spring and summer, prior to restoration planting. Likewise, it is a problem in newly planted areas, and needs to be cut and pulled back from the base of native plants when releasing, then sprayed on the ground. It usually dies back over winter, so releasing in spring is most effective. If it is growing in areas where it does not threaten native vegetation, then it is acceptable to leave it. As metsulfuron-methyl is the most effective herbicide for control of bindweed, it is recommended for use where bindweed is prevalent,

in a mixture with glyphosate. However, Metsulfuron-methyl is a residual herbicide1 which remains active in the soil, especially in dry weather, though does break down rapidly in wet conditions.

If planning to re-plant a zone we recommend a Metsulfuron-methyl/glyphosate mixture as follows:

- Blanket spray with a Metsulfuron-methyl/Glyphosate mixture earlier in the spring and summer to achieve initial knockdown, then
- For any regrowth of weeds in the late summer/early autumn use predominantly glyphosate, but spot spray any bindweed regrowth with Metsulfuron-methyl.
- Just before planting use predominantly Glyphosate, but spot spray any bindweed regrowth with Metsulfuron-methyl.

Figure 11: Native, pink-flowered bindweed (Calystegia sepium subsp. roseata) and Figure 12: Introduced, white-flowered greater bindweed (C. sylvatica subsp. disjuncta) (photo credit NZPCN).

3.6. Exotic Grasses

There are areas of exotic grasses at Ngā Roto, the most prevalent is mercer grass (*Paspalum disctichium*). This species is very tolerant of fluctuating water levels, so controlling it is not feasible other than when release spraying in revegetation areas. Exotic grasses are light demanding and will eventually be shaded out in areas that are revegetated.

1 Mestulfuron-methyl is highly toxic to broadleaf plants, but is of low toxicity to mammals, birds, bees, worms, fish and other aquatic organisms. Residual activity of the soil affects plants only.

https://www.co.thurston.wa.us/health/ehipm/pdf_terr/terrestrial%20actives/Metsulfuron%20methyl.pdf

3.7. Surveillance weed species

These weeds were not noted at the site but are serious weeds of wetlands elsewhere in the Waikato, so are weeds to watch for. Surveillance species are listed in Table 4.

Table 4: Surveillance weed species for Ngā Roto.

Surveillance Species	Comments
Yellow flag iris (Iris pseudacorus)	This was not noted at Ngā Roto but is present at nearby Lake Mangakaware where it is under sustained control. A Waikato RPMS, and national pest plant accord species.
Royal fern (Osmunda regalis)	No plants found during 2021 field survey; but has been at the lake in the past - one patch, and a further single plant of royal fern were found by Wildlands in 2008.
Reed sweet grass (Glyceria maxima)	This was not noted at Ngā Roto. However, there are quite large infestations at nearby Lake Mangakaware, so care should be taken not to transport this species between the sites when using contractor for weed control at both lakes.
Purple loosestrife (Lythrum salicaria)	There are few records of this weed in the Waikato, but it is a weed to watch for, as it is a national plant pest accord species which can rapidly invade wetlands and riparian areas. It forms dense stands that overtop native species.
Alligator weed (Alternanthera philoxeroides)	Alligator weed is a serious environmental and agricultural weed. It is found in a several locations in the Waikato and is a progressive containment weed under the Waikato RPMS.
Bridal creeper/Smilax (Asparagus asparagoides)	This is a national pest plant accord species. It is located on hedges near Yarndley's bush. It is bird dispersed, so is a species to keep an eye out for at Ngā Roto. There is a biocontrol for this species – Smilax rust (*Puccinia mysiphylli*) which does seem to be having an impact.

3.8. Maintaining Track edges

Spraying edges has resulted in some non-target damage, particularly to treeferns. While track margins at Ngā Roto need to be maintained, this can be done in a more sensitive way.

We recommend that track edges are sprayed in the spring (October) when the herbaceous weeds are small. Glyphosate is not selective but is best suited to the range of weeds along the track edges. Spray only the weeds that threaten to encroach on the track and take care not to let spray drift damage the native plant species. Use a petrol-driven hedge trimmer or scrub bar to trim back branches and foliage from any native trees and shrubs that are encroaching on the track later in the season.

3.9. Poplar shelterbelt & Oak trees

There are several areas dominated by exotic trees at Ngā Roto. For example, poplar shelterbelts, and oak trees. While these are not weedy *per se*, they are not native species, and there may be a desire to remove these in future.

Oak trees are allelopathic. They have chemicals in the leaves that discourage the growth of other plants. This was observed in the oak forest, as no growth of ferns etc. was evident beneath the canopy, whereas under the kahikatea canopy bordering this there is a groundcover of cutty grass (*Carex lessoniana*). Acorns also provide a large food source for rats.

The exotic tree areas are currently suppressing weeds in the understorey and may provide nesting habitat for some birds. If it is decided that these should be removed in the future, those trees that would not cause a risk to public safety should be drilled and poisoned, and trees next to the track should be carefully felled. If a shelterbelt is still required in the poplar area, the current shelterbelt could be underplanted with canopy trees like tītoki and tōtara. Then the poplars can be poisoned/felled once these trees have established.

3.10. Herbicide choice

The choice of herbicide for the target weed is very important in order to have successful control with minimal non-target damage. There is evidence of non-target damage around Ngā Roto, so Table 5 is a list of recommended herbicides to minimise a recurrence.

It will be inefficient to return to the carpark each time a spray tank needs filling, so organising access to the reserve margins and water from neighbouring farms is recommended. If access can be negotiated though neighbouring land, then spraying on a quad bike or ute may be able to be used for some accessible areas. Larger sprayers should be fitted with pressure reducing valves so low volumes can be sprayed to minimise non-target damage.

Table 5: recommended herbicides for use at Ngā Roto.

Herbicide	Rate	Use
Glyphosate	Label rates – generally 1% OR 360g/l (over water)	**Broad-spectrum herbicide:** Glyphosate does not require consent, for use over water. It is a non-selective herbicide that kills both broadleaf plants and grasses, so will kill native plants, and planted tree seedlings if spray contacts them. If used for releasing then careful hand weeding is required around each plant, followed by spraying weeds on the ground. Although Glyphosate is non-selective, it is registered for use over water, therefore we recommend it is used to carefully spot spray the limited remaining willows located in wet areas, and for control of pampas and weeds on the track edges. For aerial control of willows, 1% Glyphosate 360 with the addition of a surfactant safe for use over water (e.g. Aquakynd) and anti-foam adjuvant can be used.
Metsulfuron-methyl	Label rates	**Woody weeds, scrub weeds and bindweed**: Metsulfuron-methyl is selective for broadleaf species and is very effective for control of scrub

	OR 35g/ 100L (over water)	weeds such as blackberry and gorse. It is recommended for willow treatment in dry areas (as native sedges/rushes in spray zone will not be affected). However, Metsulfuron-methyl is a residual herbicide which remains active in the soil, especially in dry weather. Therefore, it should not be sprayed onto re-vegetation areas within 3 months of planting. We recommend that Metsulfuron-methyl is used to treat willows in dry areas, to limit surrounding non-target damage. In addition to the herbicide, it is recommended that Agpro Metruon Enhancer, water-safe surfactant (eg. Aquakynd) at 250ml per 100L plus anti-foam adjuvant be applied. Metsulfuron-methyl is not registered for use over water and would require a resource consent for discharge to air from Waikato Regional council to use over water. WRC hold a consent for the in-house use of Metsulfuron-methyl over water (consent no. 124871), and it is not a simple process to obtain this.
Haloxyfop mixed with Clopyralid	Label rates	**Releasing:** Using a combination of the grass specific herbicide Haloxyfop, and broadleaf spray Clopyralid at label rates works well for releasing around native plantings and is less damaging if spray drift occurs. Kānuka, mānuka and tōtara are resilient to this spray combination, but other species (e.g. kahikatea, tītoki) are sensitive, so hand weeding before spraying is still required.
Triclopyr TEA (triethylene amine – e.g. Garlon® 360)	600 g /100 L (0.6%)	Triclopyr TEA/ Garlon® 360 is selective for broadleaf woody species and herbs. It is registered for use in wetlands and aquatic sites in New Zealand, however, Garlon® 360 is now no-longer sold in NZ so is difficult to source and expensive. It has been used for willow control by Waipā DC in the past. Research has shown significant re-growth of grey willows following treatment with Garlon® 360 (Champion et. al. 2011). For spot spraying it is not as effective as Metsulfuron-methyl or Glyphosate (both of which are cheaper and easier to source). The main advantage of Garlon 360 over Metsulfuron-methyl is that it is registered for use over water, and the main advantage over Glyphosate is that it is selective for broadleaved species.
Drilling and Poisoning.	20g/1L (Metsulfuron-methyl) OR Neat Glyphosate	Drilling and poisoning is recommended for tree weeds with stems >150mm diameter, smaller stems can be treated by cut and stump application with glyphosate (or Vigilant gel). Follow minimum hole methodology (Appendices).

Basal Spraying – only in dry locations, can not be used in wetland vegetation	20% Triclopyr mix in diesel or suitable oil. e.g. X-tree basal	Good for small woody weeds in dry locations that are difficult to drill and poison, e.g. small wild cherries, willows. Some hard to kill weeds such as privet and hawthorn require a 30% Triclopyr mix. A basal spray mixture can be carried in a small 2L spray bottle during other work within the site (e.g. pest control). A small bottle such as this can also be carried during drill/poison operations, this is an efficient weed control method.
Triclopyr butoxy ethyl ester (e.g. Grazon)	Label Rates (use with care)	Triclopyr butoxy ethyl ester is selective for broadleaf woody species and herbs and is very effective for tradescantia. It has been used for weed control at Ngā Roto in the past, however it is much more ecotoxic than Triclopyr TEA and has been found to be volatile at high temperatures – which means it vaporises, and the vapour can kill the foliage of the native plant above the release spraying zone.
NOT RECCOMENDED		
Tordon Brushkiller (picloram & aminopyralid)	NR	Highly mobile in the soil, and can be a contaminant, so should not be used around water. Native plants are also very sensitive to it – particularly treeferns.

3.11. National Environmental Standards for Freshwater 2020

The new National Environmental Standards for Freshwater (NES-FW)2 came into effect in September 2020. Part 38 of the NES-FW sets out permitted activities for the restoration of natural wetlands. Vegetation clearance in a natural wetland is a permitted activity only if it complies with the conditions that the "vegetation clearance, earthworks, or land disturbance… must not occur over more than 500 m^2 or 10% of the area of the natural wetland, whichever is smaller". This is a very restrictive threshold, and for a large area of wetland like Ngā Roto, is does not take much weed control to exceed the permitted 500m^2. There is also a lack of detail about the definition of vegetation clearance (i.e., does spot spraying of scattered willows, or land preparation spraying for revegetation count at vegetation clearance?).

Under the current wording of the NES-FW, the ongoing weed control the is undertaken at Ngā Roto will require a resource consent from Waikato Regional Council. For the purposes of this plan, it is assumed that spot spraying of willows and other weeds, land preparation spraying before planting, release spraying of seedlings in revegetation areas, and track maintenance spraying all count towards land clearance of greater than 0.05ha at Ngā Roto. The links to the forms required to obtain consent are in Appendix 3. This restoration plan will need to be submitted with the resource consent application, as per schedule 2 of the NES-FW.

2 https://environment.govt.nz/acts-and-regulations/regulations/national-environmental-standards-for-freshwater/

No consents of this nature have yet been processed by WRC, so no examples can be given. The issues with the new regulations for wetland restoration have been flagged to the Ministry for the Environment, and work is currently being done to refine them, so this situation may change in the future.

4. Revegetation

4.1. History

In the 1990's a great deal of effort was expended fencing the lake margin and planting the pioneer species, mānuka, by the Waipā District Council. This was a ground-breaking restoration project at the time and transformed the lake margin. However, mānuka is a short-lived seral species, and stands have reached a senescent stage, and have been affected by citrus borer, which has led to the gradual collapse of these stands around the lake.

Because mānuka was planted as a dense monoculture, as it has collapsed there have been limited other native species to take its place. This is a danger whenever native plant species are planted as a monoculture. This has opened up areas for weeds to establish. There is now a considerable need to remove these weeds and to replant with a more diverse range of native species suitable for the lake's current hydrology and soils.

Some non-eco-sourced native revegetation species have been used in places, which would not normally be found growing near a peat lake. For example, karo (*Pittosporum crassifolium*) and akeake (*Dodonea viscosa*) are coastal species, and *Veronica parviflora* usually grows in frost flats. There are also hybrid native plants grown for landscaping purposes, such as a range of hybrid *Pseudopanax*, golden tōtara, and hybrid ramarama (*Lophomyrtus* x *ralphii*).

In the 2000's the weeding and replanting work at Ngā Roto was carried out by volunteers. Waipā District Council received funding from the Waikato River Authority (WRA) Clean-Up Trust to support volunteer work to restore the lake margin over three years (2014–2017). Waipā District Council planted around 4,000 – 5,000 plants per annum from 2014-2017, in 2018 around 8,000 plants were planted, 3,500 plants were planted in 2020, and 2,500 plants have been planted so far in 2021 (K. Barnes pers. comm.).

4.2. Re-vegetation Priorities

Thousands of plants have been planted since 2014, however there is considerable weed pressure at Ngā Roto, which aggressively compete with the planted trees. Some planting areas have established very well, but the success of other planting areas is low, we estimate as much as 70% mortality in places. This is a large loss on the investment put in to planting these areas and highlights the need to restore smaller areas well and ensure they are well prepared prior to planting. Given the weed pressure at Ngā Roto, it is unrealistic to expect restoration to result in an exclusively native species composition. However, native dominant vegetation composition should be aimed for. We recommend the following re-vegetation priorities, which are described briefly below, and expanded on throughout Section 4.

Stage 1 (3 Years: 2021-2024)

We recommend investing in very targeted release weeding/spraying, and supplementary planting in areas previously planted at Ngā Roto, that are not yet at a closed canopy state (10.7 ha, pink and green areas in Figure 13). This will allow good establishment of what is already there, and protect the investment already made into these areas. Once current trees are established, there will be a need to reassess priority areas for supplementary planting to fill in the gaps.

In addition, to avoid the canopy collapse of monoculture plantings that has occurred the past, supplementary planting of canopy and understorey species may be required with a 5 x 5 m spacing for canopy trees, and potentially 2 x 2 m spacing of understorey species. On the eastern edge of Ngā Roto, just past the floating boardwalk is an established revegetation area that had several monoculture pockets. The monoculture of karamu in the area is one pocket which will require removal of karamu in gaps at a 5m x 5 m spacing, and some supplementary planting of canopy trees to avoid vegetation collapse.

Stage 2 (4-6 years: 2025-2027)

We recommend planting swamp forest, and swamp marginal shrubland in the areas shown in Figure 13 (23.7 ha, orange and light blue areas); as time and funding allows. Recommended plant species are listed in Table 6. As discussed above, a robust methodology to achieve the revegetation of small areas, and doing this well is the recommended approach, and is likely to result in better success.

Revegetate the southern land acquisition area (Lot 6 DP 526717) in kahikatea forest.

We also recommend beginning the restoration of the lake edge swamp zone (3.18 ha, dark blue-purple area in Figure 13), this is an ongoing project that should be done gradually as time allows/vegetative material can be harvested. The exotic species in this zone will not be controlled, but the zone will be supplemented with native species primarily though dividing and planting kukuraho at 1m – 2m spacings. Some raupō and kuta could also be propagated at the waters edge, and pūrei could be planted on the drier inland edge of these areas.

Stage 3 (6-10 years: 2027-2031)

Continue revegetation in the swamp forest and swamp margin zones mapped in Figure 13 and outlined in table 6 & 8.

Continued restoration of the lake edge swamp zone though dividing and planting kukuraho at 1m – 2m spacings

Emerging priorities

If any pasture is retired near the lake and becomes available for planting, this will automatically become a high priority for replanting, and should take priority over any other revegetation planed for that year. It is much easier to establish native forest on recently retired pasture before more aggressive weeds such as bindweed take hold. 12.75 ha of pasture is identified that is suitable for this purpose (yellow areas in Figure 13). It is acceptable to continue grazing pasture until replanting can be organized/funded.

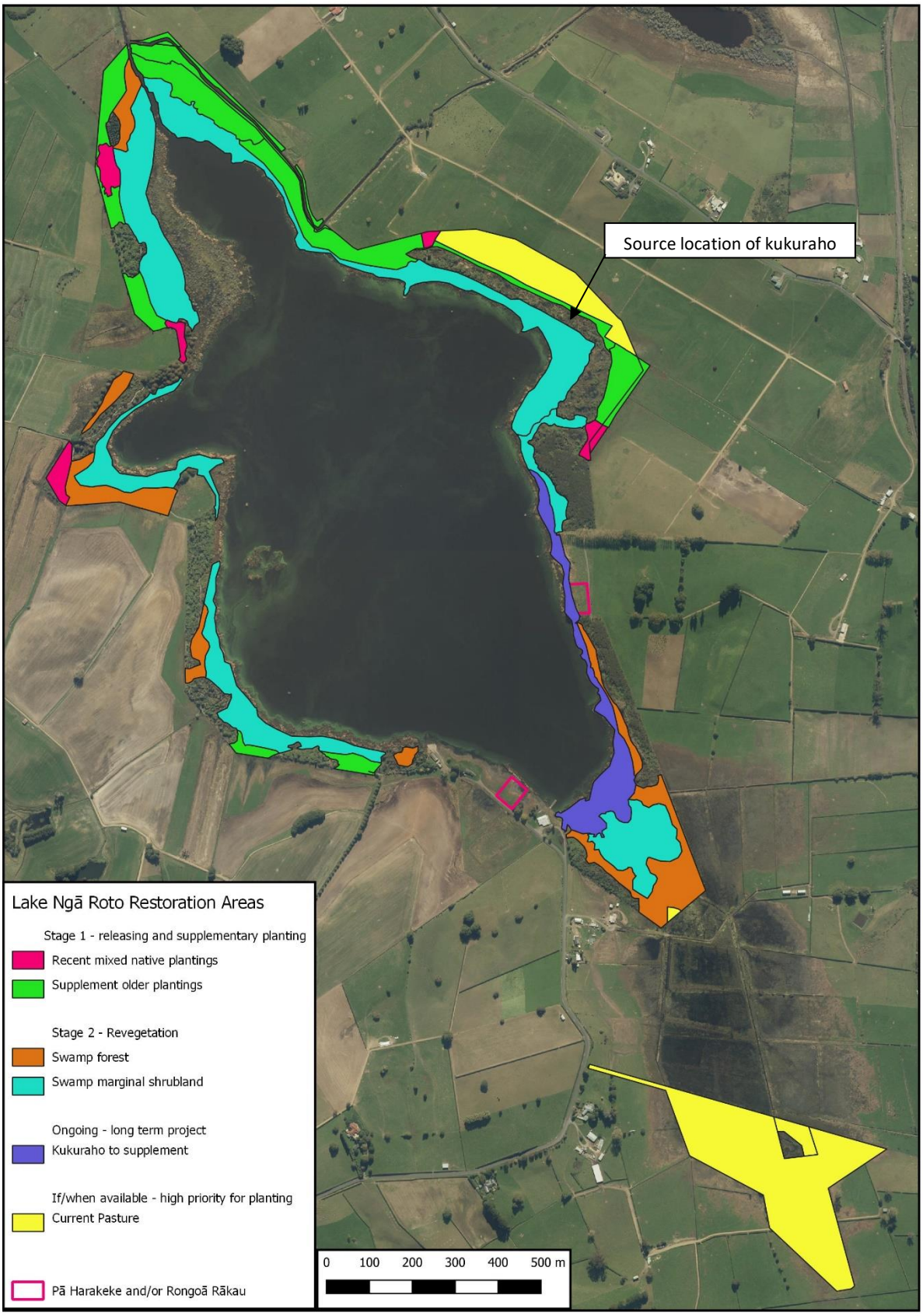

Figure 13: Restoration areas at Lake Ngāroto, and suggested stage in the restoration (Pā Harakeke and Rongoā Rākau described in sections 5.2.4 & 5.2.5)

4.3.Revegetation zones

For ongoing revegetation work there are four main revegetation zones at the lake. These are listed in Table 6, mapped in Figure 16, and the revegetation process is described in detail below. Relatively few plant species have been recommended, as these are known to perform well for revegetation planting and are suited to the site.

Table 6: Recommended plant species for the different revegetation zones at Ngā Roto.

Revegetation Zone	**Plant community** (Area requiring restoration)	**Revegetation species/%**
Swamp	Swamp Meadow (3.2 ha)	Supplementary planting of predominantly (90%) Kukuraho (*Bolboschonus fluviatilis*) at a density of 1 x 1 m (or as required depending on existing density of native/exotic species). Raupō (*Typha orientalis*) and kuta (*Eleocharis sphacelata*) could also be divided and planted in this fashion on the lake edge (5%), and some pūrei (*Carex secta*) and pūkio (*C. virgata*) (5%) could also be planted on the inland edge of the swamp zone. Up to 1m x 1m spacing – 10,000 plants/ha
Swamp Margins	Swamp Marginal Shrubland (17.6 ha)	Mingimingi (*Coprosma propinqua*), hukihuki (*C. tenuicaulis*) shrubland grading into harakeke, toetoe and cabbage trees (20% of each species, 620 per/ha depending on plant spacing). Some Purei could be planted on the swamp edge. 1.8m x 1.8m spacing, 3,100 plants/ha
Peaty Soils	Swamp Forest (6.15 ha – plus 12.75 h suitable pasture)	Kahikatea (300 ha), pukatea (150/ha), swamp maire (50/ha) (Overall 500 stems/ha, 4x5m spacing) mānuka (up to 1300/ha), cabbage trees (650/ha), hukihuki (650/ha). 1.8m x 1.8m spacing, 3,100 plants/ha
Granular Soils (Most of this zone is already planted)	Podocarp-Broadleaf forest (~ 1 ha – grassy area on eastern side of lake).	Tōtara (200/ha), tītoki (100/ha mahoe (200/ha), kānuka (200/ha) and mangeao (100/ha), with mānuka (up to 1100/ha) and karamu (up to 1100/ha) as the dominant subcanopy species. Tawa supplementary planted in later (up to 100/ha). 1.8m x 1.8m spacing, 3,100 plants/ha

4.3.1. Swamp

This zone is located on saturated soils, with a water level estimated to vary from -20 cm to +5 cm depth. The vegetation is currently dominated by the swamp meadow vegetation type is currently dominated by exotic species, such as beggars' ticks (*Bidens frondosa*), gypsywort (*Lycopus europaeus*), Mercer grass (*Paspalum distichum*) and water primrose (*Ludwigia peploides* subsp. *montevidensis*). Native carex species grow amongst the exotic herbaceous species. A margin of Raupō forms at the

lake edge. This zone once had willow forest on its inland edge, and occasional willow seedlings are present.

This zone has approximately 30-40% native, 60-70% exotic species. Control of the exotic species is difficult and costly, and they are likely to be replaced by more exotic species. Therefore weed control in this zone is not recommended. This zone would be best supplementary planted with native species that is able to compete here, kukuraho (*Bolboschonus fluviatilis*).

Kukuraho is a native species that is very aggressive, and spreads by rhizomes, so it likely to compete with the herbaceous weeds. It is also commonly used in water treatment areas to remove nutrients from water, so may have some positive impacts on lake water quality once established. Kukuraho was noted near the wildlife ponds (the location is shown in Figure 13), and it is common at Lake Mangakaware (Figure 14). It is unknown whether this species was already at Ngā Roto, or whether it was introduced when the wildlife ponds were created. It does occur at many of the Waikato peat lakes, though tends to be a more coastal lowland species. It has been suggested that this species was planted deliberately by Māori at the Waikato Lakes to provide a food source.

Kukuraho can be harvested from its current location near the wildlife ponds. The rhizomes can be dug up easily and can then be divided into rooted sections. These can be planted directly into the swamp meadow habitat at a density of 1 x 1 m or greater. It is recommended to do this in spring, based on studies of *B*. *maritimus* to restore saltmarsh habitat in Scotland (Maynard 2014.). Raupō (*Typha orientalis*) and kuta (*Eleocharis spaceolata*) could also be divided and planted in this fashion on the waters edge, and some pūrei (*Carex secta*) and pūkio (*C. virgata*) could also be planted on the drier inland edge of the swamp zone.

Given the current area of kukuraho at Ngā Roto is small, this activity will have to be carried out slowly over time. Harvesting only a small amount in the first year and transplanting into a new area. It will likely take three years for newly established areas of kukuraho to be dense enough for harvest. Propagation of kukuraho could be done as a volunteer activity.

Kukuraho seedlings could be purchased from a nursery to speed up this process. It is not recommended to transplant kukuraho from other nearby lakes such as Lake Mangakaware, as this risks the introduction of reed sweet-grass (*Glyceria maxima*) to Ngā Roto. This is an aggressive weed of the swamp meadow zone and was not seen at Ngā Roto during the site visit.

Figure 14. Kukuraho (*Bolboschoenus fluviatilis*) forming a dominant community within the swamp meadow zone at Lake Mangakaware

4.3.2. Swamp margins

The swamp margin zone is between the raupō dominant wetland edge, and its neighbouring swamp meadow vegetation, and the taller forest vegetation, with water levels estimated to vary from -5 cm to +5 cm depth. These swamp margin zones were once willow forest, and are currently dominated by bindweed, buttercup, and mercer grass. The ideal vegetation for these areas is a mingimingi — hukihuki shrubland grading into flax, toetoe and cabbage trees. Some pūrei (*Carex secta*) could be planted on the swamp edge.

Ideally a 2-year weed control operation should be undertaken to knock down bindweed before planting. These areas are relatively flat. At the time of survey (late March) the soil was dry but in spring may be boggy. If the soil is solid enough a 4WD ute or quad bike sprayer could be used, or if there is good access but the soil it too boggy, a gun and hose could be used from firm ground. Knapsack sprayers may be required to prepare the site if vehicle access is not feasible. A combination of a broad-spectrum herbicide (e.g. Glyphosate + Metsulfuron-methyl) will be required of up to three sprays over spring and summer, in order to prepare the area for planting in late autumn. The entire area should be sprayed, as these weeds are too aggressive for spot-spraying to be successful.

As described in section 3.5, Metsulfuron-methyl is the most effective herbicide for bindweed control, but it can remain residual in the soil, so pre-planting we recommend use of a Metsulfuron-methyl/glyphosate mixture as follows:

- Blanket spray with a Metsulfuron-methyl/Glyphosate mixture earlier in the spring and summer to achieve initial knockdown, then
- For any regrowth of weeds in the late summer/early autumn use predominantly glyphosate, but spot spray any bindweed regrowth with Metsulfuron-methyl.
- Just before planting use predominantly Glyphosate, but spot spray any bindweed regrowth with Metsulfuron-methyl

4.3.3. Peaty soils

These zones have peat soils which are seasonally saturated to generally dry, and are the ideal zones for swamp forest, made up of kahikatea, pukatea, swamp maire, mānuka, cabbage trees, hukihuki. Although mānuka has collapsed at Ngā Roto in the past, this was due to it being planted as a monoculture. Eco-sourced mānuka is a great species to use as a sub-canopy species to achieve intermediate canopy closure, as long as there are also tall canopy trees included within the planting mix, so that when short-lived manuka becomes senescent there are other native species waiting to take its place. Canopy species, kahikatea, pukatea and swamp maire should be planted at 5 x 5 m spacings (400 stems/ha), then interplant with the mānuka, hukihuki and cabbage trees for an overall spacing of 1.8 x 1.8 m. Kahikatea will be the predominant canopy tree, with more infrequent pukatea and swamp maire. Mulch mats around the canopy trees would be a good investment to help prevent release spraying damage. The kahikatea forest on the western side of the lake was planted at a 5 x 5 m spacing. This canopy is now closed, and successfully suppressing weeds underneath (Figure 15).

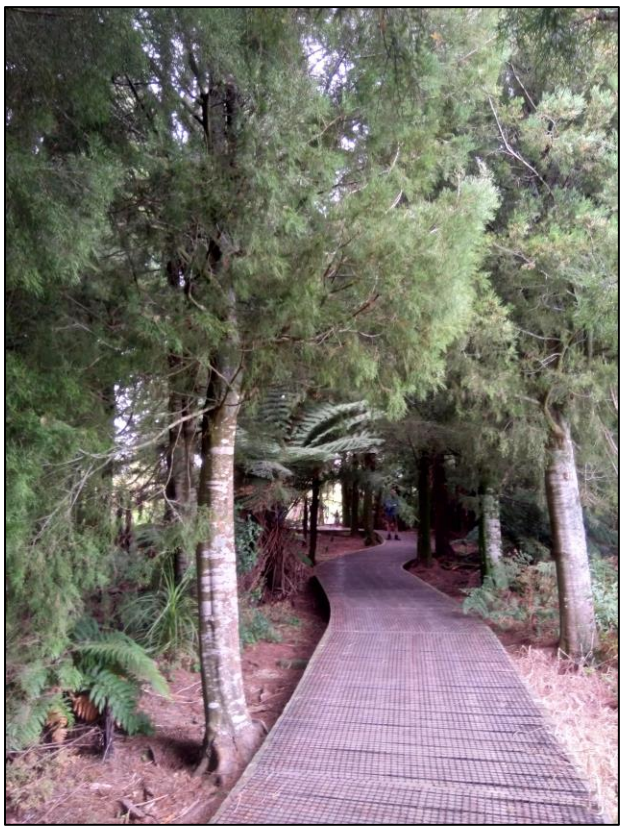

Figure 15: The small stand of established kahikatea forest at 5 x 5 m spacing in the north-west side of the lake has formed a canopy that supresses weeds beneath. Native ferns and sedges grow on the forest floor.

Swamp maire is a culturally significant tree to Ngāti Apakura, and they would like to see it established at the lake. However, it can be difficult to find at nurseries, so will likely have to be grown to order. Swamp maire is susceptible to myrtle rust, so any seed collected to grow for order should be collected from trees that have not been affected by myrtle rust, as these are more likely to be myrtle rust resistant. Particularly any unaffected swamp maire trees growing in the vicinity of affected trees.

If any of the paddock edges are retired from grazing in the future, they would be the ideal place to create a swamp forest edge. These areas should be planted quickly if the opportunity arises, as there is currently no bindweed, so trees will be able to establish with much less release spraying. In these

areas it would be easy to spot spray the grass for planting at 1.8m x 1.8m from a quad bike prior to planting, as there is good access. Likewise, this vegetation mix is the ideal type for the 9.4 ha of low-lying farmland to the south of Ngā Roto that was purchased by Waipā District Council. There have been some native plantings around the sediment trap demonstration site in this area, and a small area of pasture around this site has been retired but is still largely being grazed (Photograph in Figure 16 and mapped in Figures 13 & 17).

Most of the peaty soils around the lake have been planted with swamp forest species to some degree, however the success of these plantings varies due to bindweed being an aggressive competitor that has smothered many seedlings. It is recommended that the current focus in these zones is on high quality releasing twice per year, once in spring while the herbaceous weeds are still low, and again in summer, for 2-3 years until the current trees are established. These sites should then be assessed for supplementary planting of any gaps. Supplementary planting should be done gradually over time, ensuring there are enough resources for releasing of the supplemental plants for at least three years.

Figure 16: Part of the Southern area of farmland to the south of Ngā Roto that was purchased by Waipā District Council (blue line is approximate boundary). Most is still currently grazed, a small area of pasture is retired around the silt trap demonstration site, and the silt trap site itself has established native plantings. This area should be retired and revegetated with swamp forest species when funding allows.

4.3.4. Granular soils

Granular soils are the driest soils at Ngā Roto, as they are slightly elevated from the lake and are more free draining than the lake edge peat soils. Most of the granular soils at Ngā Roto have already established native plantings on them (Figure 2). Any further plantings on granular soils are likely to be associated with land acquisitions on neighbouring land. There is an area of open grass on the eastern edge of the lake, where granular soils are present, however this is one of the few view shafts to the lake, and has been deliberately maintained as open space, with only a low planting of sedges at

the lake edge. It may be appropriate to carry out cultural planting in this location, particularly on the eastern side of the walking track so that the view shaft is maintained.

At these sites, some diversity can be introduced to Ngā Roto by planting the canopy trees tōtara, mahoe, kānuka, mangeao and tītoki. Mānuka and karamu can be planted amongst these as subcanopy species. As with peaty soils, 15–20% tall canopy species (400 stems/ha) are required in the planting mix to create a long-term succession and avoid the problem of a short-lived monoculture collapse. The current small karamu monoculture area on the eastern edge of Ngā Roto should have gaps cut, and canopy trees supplementarily planted at 5 x 5 m spacings to allow a continued succession of native species, and prevent later collapse of this vegetation. Mānuka should still be part of the mix, as it grows well and quickly creates a low canopy to suppress weeds, it is still a good choice provided there is greater diversity in the planting mix. Mahoe is also good for creating a canopy and supressing weeds and allowing a sub-canopy of tree ferns to develop. Tall canopy trees should be laid out at 5m x 5m spaces first when preparing to plant a revegetation zone, then the subcanopy species laid out amongst these. Tawa would also be an appropriate canopy species here, but it is very slow growing, and requires shelter. We recommend that larger grade tawa seedlings (minimum PB12) are supplementary planted into these areas at 10m spacings in year 5. This has been done in a few places in the established bush planting from the mid-90s.

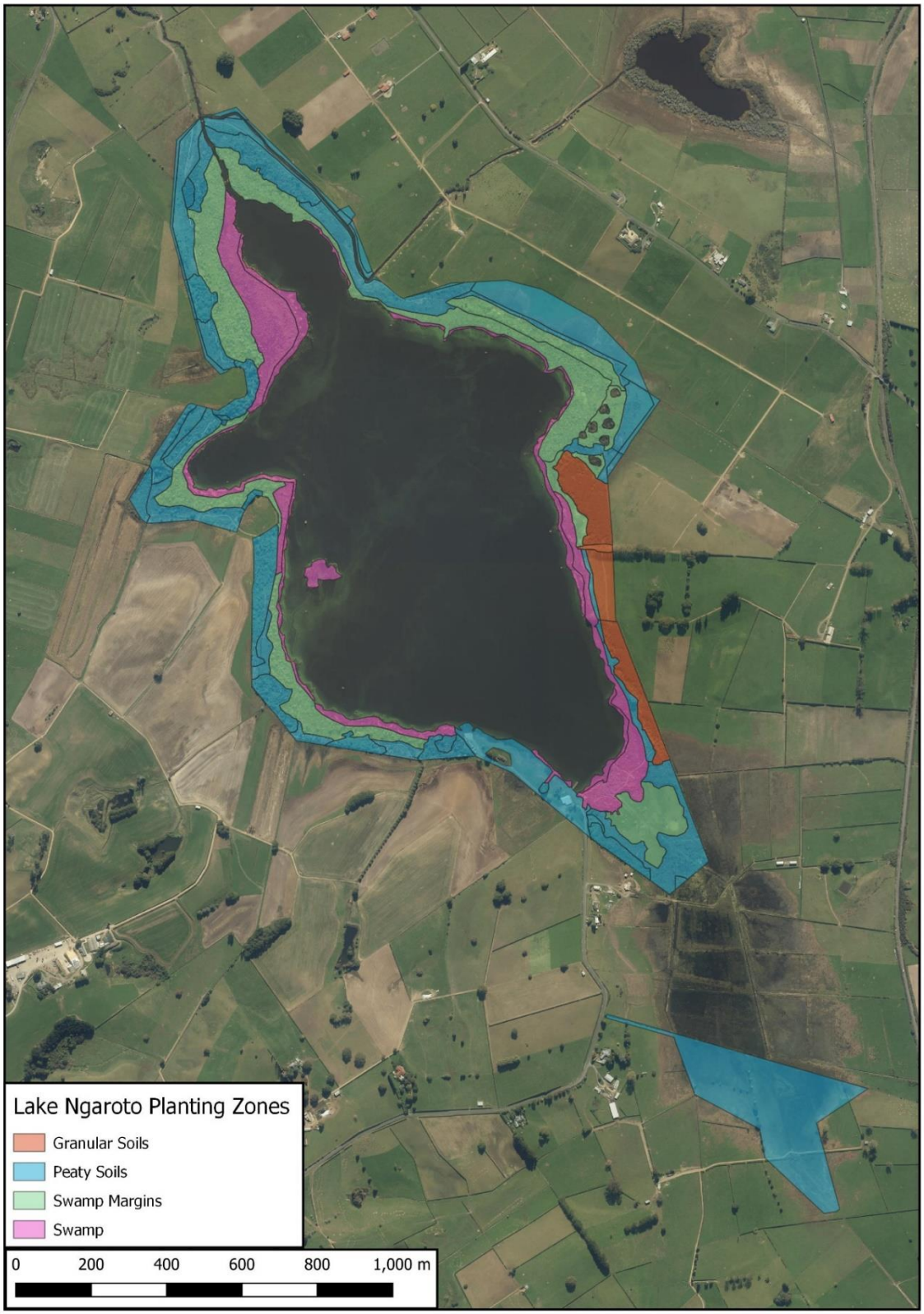

Figure 17: Broad planting zones to determine appropriate revegetation species at Ngā Roto.

4.4.Releasing Plants

Releasing of grass and other weeds is vital for increasing plant survival and growth rates. Weed releasing involves removing all weeds within 50 cm diameter of the plant. This is to ensure minimal competition over the growing season from August to April. Between planted seedlings brush-weeds,

such as gorse, broom and any climbing weeds (e.g., bindweed) should also be controlled. Usually, plants do not require further weed releasing once they get above 1.5 m tall. In areas where bindweed is prevalent, weed releasing will be required until trees are closer to 3 m. In wet summers most species usually have attained 1.5 m at the end of Year 2 (if fertilised, well planted and well released), so releasing is likely required for 3 – 5 years.

Herbaceous weeds die down over winter, so it is most effective to carry out release spraying when the herbaceous weeds are still low. In the spring from August — November is the ideal time. Later in the summer a second round of release spraying can be carried out for any plants that have been missed.

Releasing is most efficient and successful using a combination of hand weeding close to the plant and spraying further away from the plant using selective herbicides, ensuring spraying is undertaken with extreme care. Using a combination of the grass specific herbicide, haloxyfop and broadleaf spray Clopyralid at label rates works well and is less damaging if spray drift occurs. Glyphosate is another option but must be carefully applied to ensure no herbicide contacts seedlings, especially sensitive species such as kahikatea and kōhūhū. Releasing at Ngā Roto will take up to 1 minute per plant, this is 52 hours/ha for 1.8 x 1.8 m plant spacing. This can be contracted out but is also an activity that can be undertaken by experienced volunteers or well supervised community groups.

We observed release spraying over the top of plants that are being smothered by bindweed. This will likely also kill/damage the underlying native plant (Figure 18). In this situation careful hand releasing should be undertaken followed by herbicide application — "Cut It Down, Then Spray The Ground". The weeding process is made more efficient by use of a brush hook, and generally clearing the weeds prior to spraying takes less than 30 seconds per plant. This time investment reduces spray damage and increases the chance of plant establishment (Figure 19).

Preventative measures could be employed to increase the success of establishment of canopy trees in particular. Staking trees reduces the chance of them being pulled down by weeds, and allows for easier relocation of plants for releasing, particularly if the tips of stakes are sprayed with fluorescent spray paint. Tree protectors around the base of trees minimise non-target spray damage. Wool mulch mats can be placed around plants when planted. Control of invasive weeds between plants is still required. Depending on whether plastic or biodegradable tree protectors are purchased, tree protector/mulch mats combos can cost as little as $1.70 per tree3. If used for every plant in a 1.8 x 1.8 m planting this would cost an extra $4,650/ha. However, if used only to protect more expensive and slower growing canopy trees (e.g., kahikatea, swamp maire, pukatea planted at 5 m spacings) this would only cost in the region of $680/ha and may be a worthwhile investment to increase revegetation success. We suggest this is trialled, as due to the prevalence of bindweed at Ngā Roto, tree protectors and mulch mats may be less effective than other methods of weed control.

3 E.g. https://www.advancelandscape.co.nz/shop/Plant+Establishment.html

Figure 18: Releasing damage at Ngā Roto. The bindweed has been sprayed right over top of the plant which also kills the underlying native plant. Bindweed needs to be pulled off/cut back from the plants to at least half a metre and then weeds sprayed on the ground away from the plants.

(a)  **(b)** 

Figure 19: Kahikatea smothered in bindweed (a) and following clearing around base with a brush hook (b), clearing the weeds took less than 30 seconds.

4.5.Revegetation Costs

4.5.1. Stage 1 - Releasing and supplementary planting costs

When mapping vegetation at Ngā Roto 1.47 ha of recent revegetation planting areas were mapped (shapefiles provided by Waipā D.C.), and it was estimated that there were 7.51 ha of sparsely planted bindweed grasslands (estimated 500 stems/ha), which will require on-going releasing from bindweed due to the sparse native plant cover. These estimates of area are based on aerial images taken in 2016, supplemented by notes and photographs taken in the field, and true extent will vary.

Given the estimated releasing time of 1 min/plant; 52 hours/ha, these areas will take approximately 442 hours (excluding site access). The cost of releasing will depend on the on contractor's hourly rate, but we have estimated a rate of $50/hour for an experienced operator with good plant ID skills and Growsafe qualifications.

Supplementary planting is also required in the 7.51 ha of sparsely planted bindweed grasslands, estimated at 500 – 700 plants/ha. Using an average costing of $7 per canopy tree, and $4 per shrub or wetland plant (based on the pricelist of the Forest Flora nursery, currently used by Waipā D.C.), and assuming half canopy trees required, supplementary planting in these areas would cost in the vicinity of $2,750 – $3,850/ha.

The Stage 1 estimated costs are outlined in Table 7 below:

Table 7: Average releasing and supplementary planting costs per hectare for revegetation areas at Ngā Roto.

Task	Average costs per ha using a mix of volunteers and contractors	Average costs per ha using contractors only	Total
Releasing in new revegetation areas (2 releases per year at approx. $3,120 per release – for a contractor charging $60/hr)	$3,120 (hand weeding, herbicides and x2 knapsack sprayers)	$6,240 (hand weeding, herbicides and x2 knapsack sprayers)	$4,590 – $9,180 for 1.47ha
Releasing in sparse areas (500 stems/ha) (2 releases per year at approx. $500 per release – for a contractor charging $60/hr)	$500 (1 min per plant, hand weeding, herbicides and x2 knapsack sprayers)	$1000 (1 min per plant, hand weeding, herbicides and x2 knapsack sprayers)	$3,755 - $7,510 for 7.51 ha
Supplementary planting in the 7.51 ha of sparsely planted bindweed grasslands 500-700 plants/ha	Volunteer planting $250 Plants from local commercial nursery $2,750 – $3,850/ha. (Average per plant $7 canopy (50%), $4 shrub/wetland plant (50%)	Commercial planting $1,600 Plants from local commercial nursery $2,750 – $3,850/ha. (Average per plant $7 canopy (50%), $4 shrub/wetland plant (50%)	$22,530 - $40,930 for 7.51 ha

4.5.2. Stage 2 - Revegetation costs

Key revegetation areas identified at Ngā Roto are the 6.15 ha of bindweed grasslands and 17 ha of former willow treelands.

The stage 2 revegetation areas are mapped in Figure 13 (23.7 ha, orange and light blue areas). To increase the success of plantings we recommend planting smaller areas, and increasing investment in a robust plant release regime, then once established move on to the next zone.

Waipā District Council has an existing relationship with a nursery to purchase plants at a good rate. Another option may be to investigate a relationship with the Waikeria Prison Nursery. Project Tongariro, a community group based in Turangi and Taupō, sources cheaper plants for community planting projects through the Tongariro Prison Nursery. The Tongariro Prison Nursery is not a commercial nursery and was set-up specifically to provide plants solely for community conservation projects. Consequently, plants can be provided at approximately 50–70% below retail price. The nursery does not provide plants like a commercial nursery, rather plants are grown to order from eco-sourced seed provided to it.

Table 8: Average costs per hectare for revegetation planting at Ngā Roto.

Task	Average costs per ha using a mix of volunteers and contractors	Average costs per ha using contractors only
Pre-planting herbicide control (2 – 3 sprays)	$500 - $1500	$500 - $1500
Plant cost — (3100 plants /ha)	$7,750 (Prison nursery, average $2.50 per plant)	$13,600 (local commercial nursery, average per plant $7 canopy (400/ha), $4 shrub/wetland per plant(2,800/ha)
Planting	$1,000 (community planting days)	$5,500 (inc. delivery costs)
Weed releasing first year (2 releases at approx. $3,120 per releases – for a contractor charging $60/hr)	$3,120 (hand weeding, herbicides and x2 knapsack sprayers)	$6,240
Total	**$13,370**	**$26,840**

As discussed in Section 4.2, if any pasture is retired near the lake and becomes available for planting, this will automatically become a high priority for replanting, and should take priority over any other revegetation planed for that year. 12.75 ha of pasture have been identified that could potentially become available for replanting (Yellow areas in Figure 13). Planting should be costed as above in table 6, however pre-planting herbicide control is likely to be cheaper, as it will be easy to spot-spray grass (using Clopyralid/Haloxyfop) from a quad bike prior to planting.

4.5.3. Lake edge swamp - Ongoing Project

Dividing and planting of kukuraho into the swamp meadow vegetation can be done gradually over time. This was described in section 4.3.1. We estimate that a 1 x 1 m to 2 x 2m spacing would be required (2,500 to 10,000 plants/ha). As this is amongst other native plants this would likely be at the lower density. If using paid contractors an approximate estimate may be $1 per bulb kukuraho to harvest, prepare and plant.

However, this would be a good activity for volunteers who don't mind getting a bit muddy, and this would be substantially cheaper than using paid contractors. Volunteer harvesting and planting out could start at one day per year and ramp up as the population of kukuraho to harvest from grows, and if volunteer interest allows.

5. Cultural Significance

5.1. Cultural history

Ngā Roto has also been known as Wairoto to Ngāti Apakura[4]. This site has a rich cultural history. The hilltop pā of Taurangamirumiru, is thought to have been located to the south-west of Ngā Roto, between the lake and Pāterangi Road. This was the ancestral home of Ngāti Apakura from the beginning of the 16th century and remained so for three centuries.

At least three of the smaller pā located around Ngā Roto are thought to be man-made island pā. When the northern pā (s15/9) was excavated in 1964 it was found that over 2 metres of imported soil had been added to the site at various times (Simmons 2019a). These Island pā may have been seasonal fishing camps and were likely also defensive locations. These sites are now well above the water level as the lake level has lowered. Floating pa may also have been present. The known pā locations are mapped in Figure 18.

Ngā Roto sits within the site of the Battle of Hingakākā. Waikato, Ngāti Maniapoto and allies are said to have assembled at Taurangamirurmiru pā, to defend against the invasion by a war troop made up of southern allied tribes and led by Ngāti Toa chief, Pikau-te-rangi. Many thousands died in the battle which was eventually won by the Waikato collective of subtribes. The battle was said to have been named after the red cloaks made of kākā feathers, worn by the fallen chiefs. Due to the great number of lives lost in and around Ngā Roto, many members of Ngāti Apakura feel that the lake is an urupā, and wāhi tapu.

The ancient taonga Uenuku, was rediscovered in the swampy margins of Ngā Roto in 1906 when the lake levels had been lowered by more than two metres. Uenuku is a 2.7 m tall carving that symbolises the guardian life force of the rainbow. It may have been carried into battle as a standard, and been lost or hidden during the battle, or hidden in the Lake by Ngati Apakura during the British invasion of 1863 (Luiten 2011). Uenuku is a taonga of great significance for Ngāti Apakura, Ngāti Maniapoto and the Waikato-Tainui people. Other taonga have also been recovered from the lake including a waka tīwai and hoe (a paddle), and the lake level of Ngā Roto is an issue for tangata whenua as further taonga may lie beneath its waters, which should not be disturbed (Luiten 2011).

Four pou were installed at Ngā Roto in 2016 and acknowledge the rediscovery of Uenuku at Ngā Roto (Figure 17). The pou are named "Te Paenga o Uenuku" the resting place of Uenuku and represent the resting place of Uenuku in the past and a possible home for Uenuku in the future. They are placed as close as possible to where Uenuku was found. The four pou and spaces between them represent seven Atua: Tāne-mahuta, Tangaroa, Tāwhari-mātea, Tūmatauenga, Haumia-tiketike and Ruamoko. The lizards that are painted at the top of the pou embody the gods, spirits or kaitiaki that protect the

[4] The name Wairoto was used at the Rangiaowhia Tribal Committee wananga held at Te Iti o Apakura Papakainga, Otorohanga (1970's). As told to Hazel Wander, from Jack Cunningham (Hikairo).

lake. The pou also have large scallop shapes carved out, which are referred to as “Kape Rua”, with kōwhaiwhai patterns painted on them. These shapes and patterns symbolise parts of the lake and swamps that have dried out and acknowledges that Ngā Roto was once a lot bigger than what it is now (Jenny Charman & Samuel Roa in Waipā Peat Lakes and Wetlands booklet – Waikato Regional Council).

Figure 17: Pou at Ngā Roto - Te Paenga o Uenuku – near the location that Uenuku was discovered.

5.2. Culturally appropriate restoration

This restoration plan for Ngā Roto seeks to secure and protect the cultural and historic sites and features around the margin of the lake, and to recognise the spiritual importance of the Lake to Ngāti Apakura.

Ngāti Apakura would like to see the lake as a drawcard, with stories and species that are unique to this place. Following consultation with Ngāti Apakura and in order to respect the cultural importance of Ngā Roto, the following culturally appropriate restoration projects are proposed, and species of cultural significance are discussed.

5.2.1. Pā sites

The known pā sites at Ngā Roto are mapped in Figure 18. Many of the names of pā and their histories have been lost; a consequence of land confiscation and displacement, the range of names used has been noted on Figure 18, and they will be referred to by the archaeological site number in this document (Simmons 2019a). Within the boundaries of the restoration area there are three pā sites. The northern pā site (S15/9) is still grazed, the central pā (S15/7) is fenced off, and the southern pā site (S15/5), which was formerly thought lost, has been confirmed to have had the sailing clubhouse built on top of it (Simmons 2019b). The grazed northern pā site (S15/9) is currently on private land, and it is recommended that this site be legally protected in the future if possible.

It is the preference of Ngāti Apakura that these sites remain non-vegetated, so that any archaeological features are protected from tree roots. A buffer of 5–10 m should be left around these sites. Any current trees that may be impacting on the pā sites could potentially be removed. Careful felling, taking care not to disturb the root plate, or drilling and poisoning would be the best methods to remove trees without damaging archaeological features. The approximate extent of the two pā sites within the vegetated part of the Ngā Roto reserve have been mapped n Figure 18 (based on Simmons 2019a).

Weed control by spraying with a knapsack sprayer to keep these sites in low vegetation is recommended. Currently the vegetation of the fenced off central pā (S15/7) site is bindweed grassland, and there are no issues with it remaining in this vegetation. The is a patch of blackberry on the site that should be sprayed.

5.2.2. Use of locally used māori common names

Species lists have been compiled for Ngā Roto with the range of te reo māori names that have been used within Aotearoa. These lists have been submitted to Ngāti Apakura in order to select the locally used name for these species (where known). Once the names used by Ngāti Apakura have been documented, these should be used as the primary common names of these species, including on any interpretation panels installed around the lake. The species lists and range of known te reo māori names for each species are listed in Appendix 1.

5.2.3. Traditional food species

Kukuraho was a traditional food species for Waikato Māori, the nut-like roots were called ngā raho o tuna and were collected and eaten (Figure 19). As discussed in section 4.3.1, kukuraho does not naturally grow as far inland as Ngā Roto and may have been planted deliberately by the tūpuna of Ngāti Apakura to provide a food source. Ngāti Apakura are supportive of the use of this species as a dominant restoration species in the swamp meadow areas, as this honours the traditional importance of this species. The propagation of existing kukuraho was discussed in section 4.3.1.

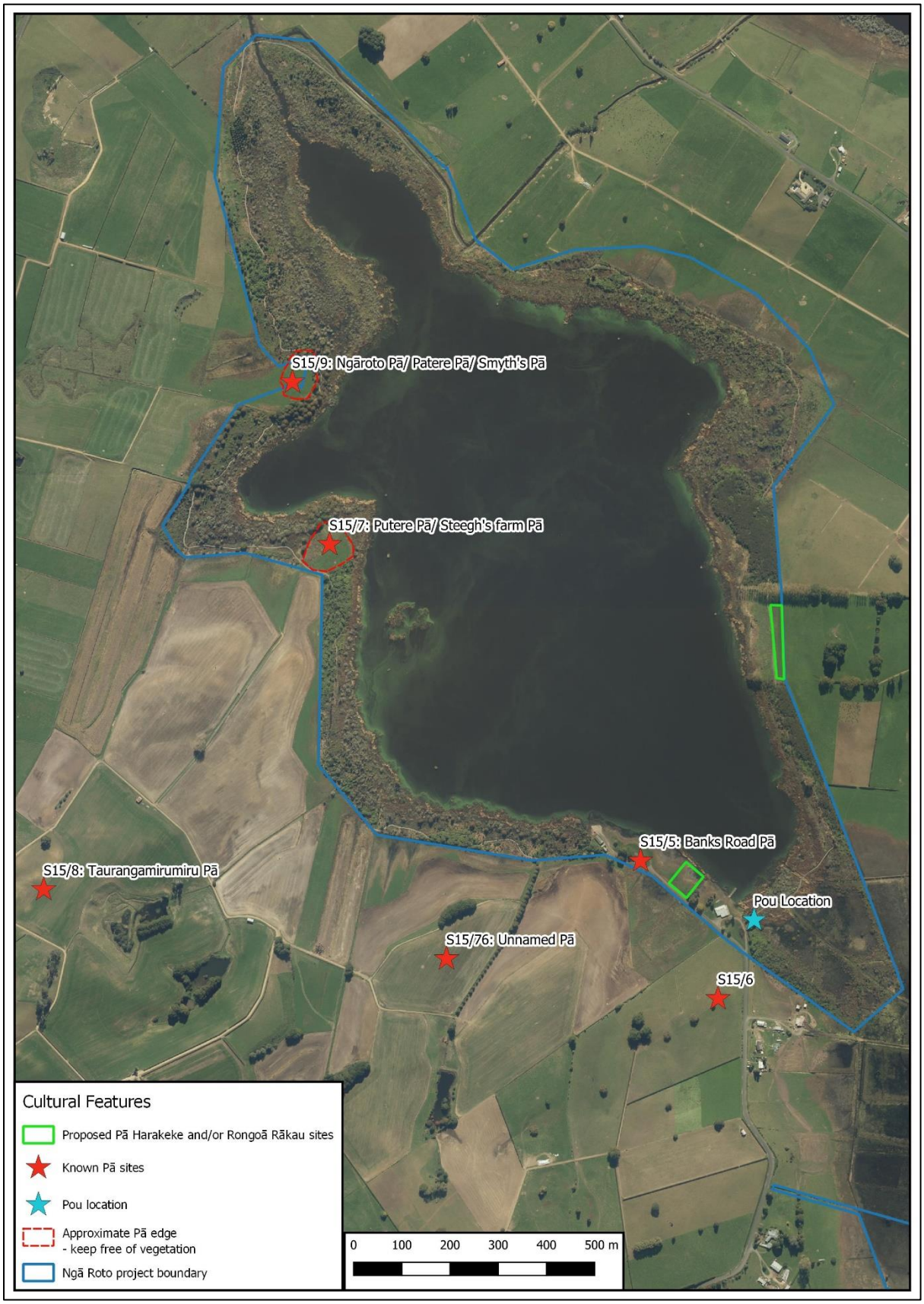

Figure 18: Known pā sites at Ngā Roto, and other cultural features referred to in the text.

(a)  (b) 

Figure 19: Ngā raho o tuna; the globular, nut-like roots of *Bolboschoenus fluviatilis*, (a) whole, and (b) cross section.

5.2.4. Pa Harakeke

Ngāti Apakura would like to see a pā harakeke developed at Ngā Roto. A pā harakeke is where varieties of harakeke, selected for their good muka (fibre) or raranga (weaving) qualities, are planted together for easy access and maintenance (Scheele 2017). Harakeke of different varieties that are significant for raranga could easily be translocated to Ngā Roto. Suitable varieties may be available through local weavers. Another source is the Rene Orchiston Collection maintained by Manaaki Whenua at Lincoln.

The ideal location for a pā harakeke will have easy access for harvesting and be on relatively flat ground that is not too boggy, as when harvesting harakeke some of the initial processing happens right on site next to the plants. The grassed recreation area at the carpark and sailing club would be an ideal site for the pā harakeke, as it is flat and firm land that has easy vehicle access (Figure 20). No walking is required to reach this location, which is ideal, as carrying harakeke along the walking track would be difficult. This site is also culturally important, as it is adjacent to one of the historic pā sites that is now beneath the sailing clubrooms. This area is currently designated as a dog exercise area, and this may need to be changed to allow the creation of a pā harakeke here.

An alternative option is in the grassed area on the opposite side of the lake (on the eastern side of the walkway in order to maintain view shafts Figure 21). This area is also flat, with firm soils which would provide good access around the plants for harvesting, however it is a 650 m/15-20 minute walk from the car park. Alternative access through the neighbouring farm on Lake Road may be able to be organised for harvesting. Many of the existing farm tracks are already located on unformed roads, and ideally an access agreement to this area will be organised for ongoing work at the lake. A potential benefit of the alternative site is that it will be harder to harvest from without organised access, so this may prevent people harvesting from the pā harakeke without permission.

Figure 20: Proposed site for pā harakeke at Ngā Roto.

Figure 21: Alternative site for pā harakeke at Ngā Roto. If a pā harakeke is planted in this area it should be located to the east of the walking track to maintain the view shaft

A pā harakeke has recently been set up at Lake Rototuna[5], the project was part of the Living Waters Partnership between the Department of Conservation and Fonterra, advice could be sought from the developers of that project. At Lake Rototuna divisions of 11 varieties of harakeke were planted, from the private collection of a local weaver Penney Cameron. Harakeke grown from divisions will take several years to grow to a size where they can be harvested for raranga. Planting divisions rather than harakeke grown from seed will ensure a plant has the same properties as the parent bush, therefore sustaining the unique genetic makeup of the varieties chosen. When they are large enough, the initial plants are able to be divided and re-planted to increase the stock to harvest from within the pā harakeke, or to donate to establish a pā harakeke at a new location. Sue Steele of Manaaki Whenua has put together an excellent resource on developing a pā harakeke in the wetland restoration handbook Te Reo o Te Repo6.

5.2.5. Rongoā Rākau

Rongoā is the Māori term for medicine. Rongoā rākau (plant remedies) are plant or tree-based medicinal remedies produced from native plants. Rongoā rākau include a range of leaves, berries, roots, seeds and flowers. Ngāti Apakura would like to see a rongoā rākau area created at Ngā Roto. This area would only include rongoā that are used externally, as it would not be appropriate to ingest material grown at a site considered by many to be an urupā and wāhi tapu.

A list of suggested rongoā species that would grow well at Ngā Roto are listed in Table 7. All of these species are already present at Ngā Roto, spread around the different revegetation areas. However, planting them together as a rongoā rākau would allow for ease of finding and harvesting the rongoā. The rongoā rākau could be planted in the same location as the pā harakeke, though is planted on the eastern side of the lake view shafts must be taken into consideration. The selected rongoā species could be planted in rows like an orchard, or in a more natural layout so they will grow to look like a forest in time. At least ten plants of each rongoā species should be planted to allow for trees to recover after harvesting. The rongoā area could include interpretation panels or be left unmarked, for use only by mana whenua.

Table 7: Suggested suitable rongoā rākau species to grow at Ngā Roto, which are used as externally applied rongoā (it is likely that not all of these remedies will have been used by Ngāti Apakura as they come from a national database, and there may be further uses, not listed here).

Rongoā Rākau species	Use as externally applied Rongoā
Harakeke (*Phormium tenax*)	The clear gel from the cut outer leaves can be directly applied to burns, cuts and scratches.
Houhere (*Hoheria populnea*)	Bark soaked in water to make a jelly used for sore eyes. Inner bark, plus sap from harakeke used as a dressing for burns.

5 https://www.livingwater.net.nz/catchment/lakes-areare-ruatuna-rotomanuka/ngati-apakura-consultation-and-pa-harakeke/

6 Te Reo o Te Repo - Section 4.3 Harakeke: Weaving People Together
https://www.landcareresearch.co.nz/publications/te-reo-o-te-repo/

Kahikatea (*Dacrycarpus dacrydiodes*)	The leaves of the kahikatea tree were boiled and then applied to the affected area to treat bruising
Kānuka (*Kunzea robusta*)	Kānuka seeds were boiled, and the resulting fluid was used as an anti-inflammatory cream. Bark was also used for pain relief and to help promote healing of fractures. - The white gum of the kānuka tree was applied to wounds or burns. Kānuka bark was boiled was boiled in water and the infusion used to treat inflamed breasts.
Karamū (*Coprosma robusta)*	The inner bark of the karamū branch was placed in cold water and the liquid applied to relieve aches and pains. To treat broken limbs, karamū leaves, and twigs were boiled, and the liquid extract applied to the broken limb.
Kareao/Karewao/Pirita (*Ripogonum scandens*)	Sap from young shoots was placed on wounds and cuts to stop bleeding. The root also could be crushed and used for this purpose. An infusion of the root was also useful when applied to rheumatic or painful joints
Kōwhai (*Sophora microphylla*)	Bruises: bark from the tree was crushed and steeped in boiling water for some hours. Severe bruises were bathed in the liquid. Wounds: the leaves were boiled in water and the wound then bathed in the extract before being bandaged with the boiled leaves. Itching: an infusion of the inner bark of kowhai treats itching. Back-aches: kowhai and mānuka bark were boiled together and the liquid extract was then rubbed over the patient's back.
Māhoe (*Melicytus ramiflorus*)	Leaves can be boiled and bandaged onto skin for skin troubles. Liquid from boiled leaves can treat sore joints.
Makomako (*Arisotelia serrata*)	Boil leaves and apply liquid to sore eyes and boils. Use boiled leaves as a poultice on burns.
Mamaku (*Cyathea medularis*)	Juice good for burns/sunburn Pith was applied raw to sores and areas of chafing as a dressing. The hairy outer skin of the inner curled frond was scraped off and the slimy tissue underneath then rubbed onto a wound up to three times a day. The gum was also applied to cuts to stop bleeding
Mānuka (*Leptospermum scoparium*)	Seeds boiled in water and the liquid extract could be applied externally for bruises and inflammation. Boiled bark could also be rubbed into the skin to ease the pain of a fracture
Mātātā /mātā (*Histiopteris incisa*)	Fronds bruised and applied to ulcers
Ponga (*Cyathea dealbata*)	Pith used as poultice for wounds and boil, skin disease and sore eyes. Young fronds were also heated and used as a poultice for a mother's inflamed breasts.
Tītoki (*Alectryon excelsia*)	Seeds crushed and oil used for sore eyes, ears and breasts
Toetoe (*Austroderia toetoe*)	Feathery heads used for gauze to stem bleeding. Ashes used to make a poultice for burns Sap of the lower part of the stem used directly to treat thrush on babies Stems also used for tukutuku panels
Tutu (*Coriaria arborea*)	Shoots scraped and heated for poultice for bruises. Leaves boiled until black to use as a poultice to apply to bruises and sprains (good for rugby injuries - also used to treat lame horses).

5.2.6. Species of cultural significance

Kawau

There are several kawau (shag) species found at Ngā Roto, including kawau (black shag), kawau tuī (little black shag), kāruhiruhi (pied shag), and kawau paka (little pied shag). Of these species kāruhiruhi is classified as At-risk Recovering, and kawau and kawau tuī are classified as Naturally Uncommon (Robertson et al. 2016). The main food of kawau is fish, and fisherman thought that they were competing for the same fish, so they were often shot, which has contributed to the lower numbers.

Kawau are of cultural significance to Maniapoto and Ngāti Apakura, as during the Battle of Hingakākā the Maniapoto forces used the battle tactic Te Kawau Mārō (swoop of the cormorant), which was a charge into battle as a flying wedge. Today, this is the name given to the Maniapoto hui a Iwi and Marae games. This is likely to reference the kawau tuī, as this species forms flocks, and flies close to the water in a 'V' formation.

Kawau can been seen roosting on some of the larger dead willow trees near the lake. Kawau tend to migrate to common roost areas on the coast to breed, and are unlikely to be breeding at Ngā Roto. As long as kawau are left in peace, they are likely to continue to visit and feed at Ngā Roto. Some interpretation about kawau at the lake could help raise awareness of, and respect for these species.

Lizards

For Ngāti Apakura, lizards are kaitiaki that protect the lake, and they have been painted on top of the Pou at Te Paenga o Uenuku. It is not known if any lizards are present at the lake. Both skinks and geckos are known as mokomoko. Geckos are the lizards most often found in wetland vegetation, such as moko kākāriki (Auckland green gecko). Many of the wetland shrubs that have been planted such as mingimingi and hukihuki can provide habitat for geckos, and have small berries that geckos eat. Most skinks prefer drier habitat and copper skinks have been sighted in rocks along the nearby main trunk railway line and have been recorded at Lake Rotopiko. Copper skinks would most likely be present in the drier forest on the eastern side of the lake.

Rats and mice are the main predators of native lizards, therefore the best way to protect lizards at Ngā Roto would be to implement targeted rat control. This is more intensive than the existing predator trapping network and is discussed in section 7.

6. Water Quality and Catchment Management

6.1. Water quality monitoring

Water quality has been measured periodically in Ngā Roto since the 1970's. Since 2009, Waipā District Council has collected water quality information via an automatic monitoring buoy that is installed and serviced by Waikato University. Water quality information reported by Waikato Regional Council to 2014 show that the lake has very high levels of nutrient enrichment (hypertrophic), high levels of turbidity, and poor transparency.

Escherichia coli was monitored weekly for recreational water quality guidelines at Ngā Roto over the summer period in 2018/2019 and 2019/2020 by LAWA. *E. coli* levels were considered safe for swimming 83% of the time (LAWA, 2021). However, the high nutrient levels in the lake cause recurrent

algal blooms that are dominated by *Microcystis* spp., a toxic blue-green alga. During these blooms, Ngā Roto is closed to contact recreation.

6.2. Lake Levels

The previous lake level regime artificially lowered water levels over winter (33.89 m MD) and maintained higher levels in summer (34.34 m Moturiki Datum) for recreational reasons. The old weir was a reinforced concrete weir structure with a steel radial control gate located under the bridge on Sing Rd. This regime benefitted adjacent farmers and recreational users but removed natural seasonal fluctuations and contributed to the ecological deterioration of Ngā Roto (Dean-Speirs 2014).

The new weir began operation in 2017. The new weir provides a minimum level 34.34 m Moturiki Datum for the lake all year round. The new weir was intended to benefit the ecology of the lake by returning the lake to a more natural water level regime. The new minimum depth also benefits recreational users of the lake for water sports, as yachting is now possible year-round with the higher water level.

6.3. Diversion of the Ngā Rotoiti inflow

The Lake Ngā Rotoiti inflow is diverted via a channel around the edge of the lake, to join the Mangaotama Stream and the edge of the Recreation Reserve (mapped in Figure 22). This diversion was completed in 2016. The diversion was created in part to minimise the extent of winter flooding[7] of adjoining land following the construction of the new weir at Ngā Roto. The diversion channel reduces the water entering the lake by about 30%. The diversion was also created in the hope that there would be some improvements in water quality of Ngā Roto as a result of the diversion, as it no longer receives sediment and nutrient inputs from Ngā Rotoiti and its catchment (*c.* 400 ha). The diversion was designed to trap silt and remove excess nutrients, therefore improving the quality of water reaching the Mangaotama Stream from Ngā Rotoiti.

6.4. Fish Passage

A fish ladder was installed at the lake outlet weir as part of its construction. On 16th March 2021 the water level was lower than the top of the weir, and the fish ladder was overgrown with grasses and other seedlings (Figure 23). The fish ladder does not work under these conditions.

The fish ladder is most important during the season when elvers are migrating upstream. Generally late November to early March each year (Jellyman 1977, Martin et al. 2009). As the site visit was undertaken in mid-March it is very likely that the fish ladder was not working as intended over the entire elver migration season. The fish ladder must be inspected and cleaned annually to ensure it is in good working order for the migration season. This should be done in the autumn when the water levels are typically low. We recommend that the fish ladder maintenance in programmed into a maintenance schedule at Waipā District Council.

Downstream migration of adult eels for breeding begins as early as February for male shortfin tuna, with the last female longfin tuna migrating in early June (Boubee et al. 2001). However, while low water levels at the weir in autumn and early winter may hamper the down-stream migration of adult

7 Waipā District Council are aware of flooding issues and have offered to buy flood prone land on the lake margin in the past, but none of the adjoining landowners took up this offer (Catchment action Plan 2014).

tuna, it is unlikely migration would be prevented, as eels tend to migrate during periods of heavy rain, and adult eels can travel overland around barriers, so are likely to find a way around the weir.

Water needs to be flowing spring and early summer at a depth of 5 cm in the fish pass, and velocity of 0.3-0.4 m/s for easy passage for smelt and inanga. Though inanga haven't been recorded in the lake it is possible they can migrate this far upstream in summer (Hickes et al. 2001).

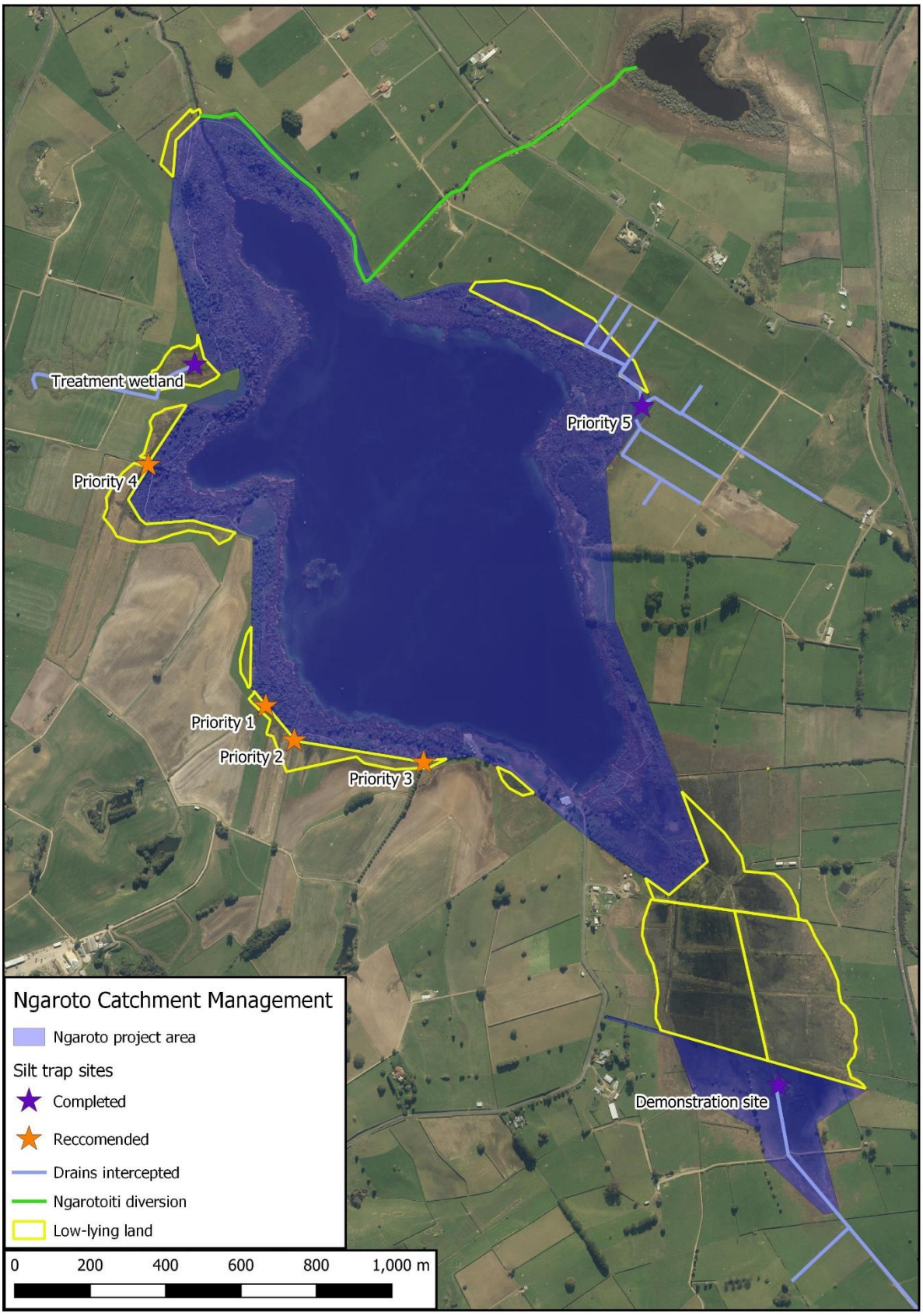

Figure 22: Ngā Roto catchment management projects including silt trap sites, and Lake Ngā Rotoiti diversion.

Figure 23: Fish ladder at the lake outlet weir overgrown with grasses and herbaceous weeds. Taken on 16th March 2021.

6.5. Pest Fish

Pest fish removal

Pest fish present in the lake include bullhead catfish, rudd, goldfish, koi carp and gambusia. It is estimated that up to 8.9 tonnes of pest fish are present in the lake. The fish have detrimental effects on water quality, lake marginal habitat and native fish species (Rowe, 2007). A 60% reduction in pest fish biomass at Lake Ohinewai had no measurable effect on water quality but did correspond to an increasing body condition of tuna in the lake and some recovery of marginal vegetation (Tempero and Hicks 2017).

Pest fish removal was carried out in Ngā Roto in 2015[8], however it is unclear how well this worked at reducing pest fish numbers, and if so, how long pest fish numbers remained low. Regardless, koi are currently common in the lake.

Koi biomass at Lake Ohinewai was reduced by 97% from 2011 to 2014 (LERNZ 2015). However, experience from Lake Ohinewai suggests that without sustained control, pest fish return to the pre-control levels within 4 years. Lake Ohinewai had a pest fish screen fitted at the outlet, however the mesh size did not prevent young koi from entering (as it was designed to allow access for native fish), so this is thought to be why the population rebounded.

[8] Confirmed by Paula Reeves, pers. comm. with K. Barnes.

Pest fish control is labour intensive, and expensive. It should only be carried out at Ngā Roto if pest fish are becoming a nuisance. For example, if excessive grazing by koi is affecting marginal raupō at the lake. If pest fish removal is a goal for Ngā Roto, sustained control will be required. The weir at Ngā Roto is likely to be a barrier to koi migrating into the lake, so pest fish control may be more successful here.

To control pest fish in Ngā Roto it has been recommended by commercial eel fishermen Mike Homes that 16 nights of fyke netting per annum will be required to keep the catfish population at lower levels (correspondence from Mike Holmes – Waipā District Council file note ECM Number: 3848413). Although fyke nets are very effective at removing catfish they have a high bycatch of native eels, that could lead to mortality in water temperatures above 23 °C (Daniel & Morgan 2011). Fyke netting should not be carried out in warm conditions, and any eels caught in fyke nets should be returned. Koi and rudd do not tend to be caught easily in fyke nets, but baited koi traps proved to be the most successful control method in a study at Lake Ohinewai, so could be used for these species (Daniel & Morgan 2011).

6.6. Catchment action plan

A scoping study of Ngā Roto was completed by PhD Researcher Rebecca Eivers, for New Zealand Landcare Trust, in May 2014. Rebecca assessed and mapped all the waterways draining into the lake in February 2014, (from the lake reserve) and measured their physical characteristics (length, width, depths and flows) as well as giving a brief description about each site.

This survey identified a number of sites where actions could be taken to reduce suspended sediment and nutrient loads draining to the lake. Recommendations included fencing off watercourses; riparian planting to provide shade and improve bank stability; and the installation of silt-traps, wetlands and habitat ponds. Five priority sites were identified in the action plan, for construction of silt traps/infiltration wetlands (Landcare Trust 2014). These locations are shown on the map in Figure 22.

The main in-flow drain at the southern end of the lake has a silt-trap demonstration site that was constructed in 2014/2015 with design and funding contributions from New Zealand Landcare Trust. This land was later acquired by Waipā District Council9.

In March 2018 silt traps were constructed in the area identified as Priority 5 in the 2014 scoping study. An area of farmland was retired to build these traps (however the majority of this farmland was within the Ngā Roto Recreation Reserve, and road reserve land parcels). Drains from Ngar-15, 16, 17 and 18 were all diverted through 3 sediment traps and a series of wildlife ponds before reaching the lake (Mapped at priority site 5 in Figure 22, aerial image Figure 24). No work was obvious at the priority 1-4 silt trap sites identified in the 2014 action plan.

9 The land acquisition for demonstration site occurred in 23/04/2018, settlement / transfer date to WDC in 14/03/2019 - refer ECM_7989056.

Figure 24: Sediment traps were installed at the North-eastern corner of the lake in March 2018 (Priority 5 location from Landcare Trust 2014). Water from four drains is diverted through this system. Google Earth Image – August 2020.

6.7.National Policy Statement for freshwater management

The National Policy Statement for freshwater management (NPS-FW)10 also came into effect in September 2020, along with the NES-FW. This new legislation potentially has some impact on some of the land adjoining Ngā Roto. Under section 3.23 of the NPS-FW natural wetlands must be mapped. Natural inland wetlands are defined as any areas greater than 0.05ha (500m^2), with more than 50% wetland vegetation. The wetland delineation protocols (clause 1.8) are listed in Appendix 3. Certain areas of low-lying land in the pasture adjoining Ngā Roto may meet the definition of natural wetland in the NPS-FW and may be required to be protected in future (Figure 25). If any areas such as this are identified for retirement, they will be a high priority for restoration planting before exotic weeds take hold.

10 https://environment.govt.nz/publications/national-policy-statement-for-freshwater-management-2020/

Figure 25: Rushland area within pasture adjacent to Ngā Roto Recreation Reserve.

6.8.Challenges with restoring water quality

There are significant challenges in restoring the water quality of Ngā Roto, and there is no easy fix. The largest driver of the water quality issues is that only 0.51% of the catchment remains in indigenous vegetation. Retiring adjoining flood prone and low-lying land would likely have the greatest benefit for the water quality of the lake, but the reluctance of adjoining landowners to retire or sell land is understandable. Much of the adjoining low-lying land was flooded for an extended period of time in April 2017, following ex-tropical cyclone Debbie (see Photos in Appendix 4). Peat soils do become less productive over time, as they oxidise and subside, so landowners may become more interested in retiring land in the future.

Improving water quality will require a multigenerational approach. The recommendations of Catchment Action Plan 2014, such as the installation of sediment traps and filtration wetlands, will make a difference to water quality. These have not yet been implemented at all the identified priority sites, so these recommendations should continue to be pursued. The greatest challenge of this is working with multiple adjoining landowners.

7. Pest Control

The trapping network at Ngā Roto is managed by volunteers, as a project on Trap.nz. This project is currently lead by Thomas Emmitt on a voluntary basis in his free time. In his professional role, Thomas is a Technical Advisor-Threats for the Department of Conservation, so the pest control regime has been set up to a high standard. The current pest control is mapped in Figure 26 and consists of 56 double-set DOC 200s to target stoats, and at least 4 SA2 kat traps that target possums and feral cats (these are being added to over time), and several A12 self-resetting possum traps that are moved around the reserve regularly. 25 Timms traps that were formerly used for possum trapping have now

been removed from the reserve, as they were not effective, and the SA2 is a more effective and humane possum trap.

Figure 26: Current trapping network at Ngā Roto.

The trapping data on Trap.nz shows that a full range of predators are present at Ngā Roto (Figure 27). Since records have been kept on trap.nz the project has caught 141 hedgehogs, 136 rats, 71 mustelids, 14 possums and 11 other pests (including cats and mice).

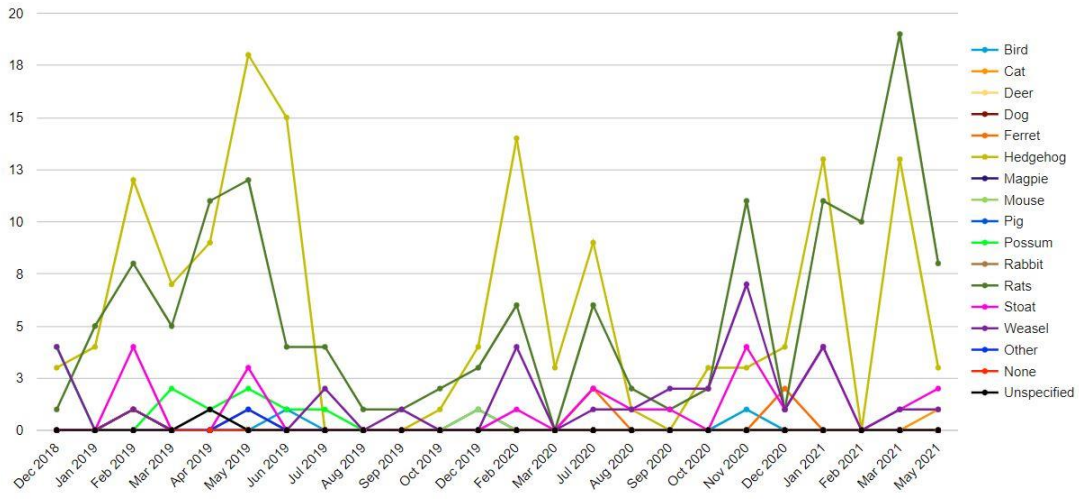

Figure 27: Records of pests trapped at Ngā Roto, December 2018 – May 2021 (Chart from the Ngā Roto Trap.nz project).

Hedgehogs are the most frequently trapped predator at Ngā Roto. The impacts of hedgehogs in wetlands habitats are not well understood, but the current knowledge suggests that specific predator control targeting hedgehogs is not required in wetlands. They have been found to have serious impacts on ground-nesting birds in braided river environments, and on threatened lizards and invertebrates in other habitats. However, are not likely to prey on nesting wetland birds that nest off the ground or build floating nests (O'Donnell *et al*. 2015).

The long thin shape of the Recreation Reserve surrounding Ngā Roto makes effective predator control challenging, as it is essentially one big edge, and there will be constant re-invasion of pests from the surrounding farmland. Generally, the minimum trapped area to be effective for protecting stoat vulnerable birds is approximately 1000 hectares, because these predators travel long distances. However, the area of the recreation reserve is only 72 ha (162 ha including the lake). To cover an area of 1000 hectares at Ngā Roto would require pest control in adjoining private land in approximately a 1.8 km radius around Ngā Roto.

The predator control work is currently being run by one volunteer. The predator traps are currently checked monthly, which takes 3-4 hours. For predator control to be more effective, more frequent traps checks are required in the bird breeding season, and any expansion in the network to target rats will require a much greater labour effort. For predator control at Ngā Roto to be sustainable in the long-term, it is likely that Waipā District Council will need to provide an annual budget for this work.

7.1. Pest control objective

When assessing the predator control regime, it is important to identify the objective of predator control. The current pest control network will be reducing the numbers of stoats, cats and possums,

therefore provide some protection to the birds and vegetation in the reserve. If a general reduction in predator density is the objective of control, then the current network will be providing this.

The development of further predator control at Ngā Roto will depend on the pest control objective. A specific objective for predator control is developed by taking stock of the unique biodiversity values of the site, and seeking ways to enhance them. Of the rare birds recorded at Ngā Roto, the species likely to be resident breeders are spotless crake and marsh crake. Therefore, we suggest that a more specific predator control objective for Ngā Roto would be to increase the breeding success of crakes. Norway rats can be the most plentiful predators in wetland habitats (O'Donnell et al 2015) and. crakes are most vulnerable to rats, so an objective to increase breeding success of crakes would require the initiation of targeted rat control. This is discussed in section 7.6

Ngā Roto is likely to be providing overflow habitat for birds from Rotopiko Wildlife Sanctuary, due to increased breeding success within the predator proof fence. The National Wetland Trust aspires to return pāteke (brown teal) to the Waipā. Rotopiko East is the proposed release site, as it has been protected by a predator proof fence since 2013. As dispersal of pāteke from the predator free enclosure would be expected, the National Wetland Trust and Waipā D.C. funded a feasibility study for returning pāteke to the Waipā (Sheppard 2018). This report ranked Ngā Roto third of the Waipā lakes in suitability for pāteke (with a score of 21/50), however the predator pressure at Ngā Roto was noted as a concern. Therefore, providing protection for pāteke may become an emerging priority for pest control if pāteke are ever returned to the Waipā.

Pāteke are most vulnerable to dogs, cats, and mustelids (O'Conner *et al.* 2007), so an emerging pest control objective to protect pāteke at Ngā Roto would require an increase in the area trapped for cats and stoats to include a buffer of surrounding farmland and include traps in the network to target ferrets (DOC250 or other).

Therefore, there are three potential objectives for predator control at Ngā Roto:

- Status quo: a general reduction in predator density to provide some protection to the birds and vegetation in the reserve.
- More specific objective to increase breeding success of crakes by implementation of rat control.
- Emerging priority to protect pāteke by increasing extent of mustelid and feral cat control.

Increasing breeding success for crakes or providing protection for pāteke at Ngā Roto are long-term ongoing objectives. Relying on volunteer labour alone is not a sustainable approach, and ongoing annual funding from Waipā District Council would be required to achieve either of these objectives.

7.2 Trap Placement and Timing

Trap placement is very important to intercept predators where they are most likely to be living or moving though the landscape. Keeping records on Trap.NZ enables managers to determine which traps are successful and which are not. An unsuccessful trap may need to be relocated to a better site but moving a trap only a few meters away to an area that has a bit more cover or is more likely to be a natural path for a pest can be the difference between a successful and unsuccessful trap. For example, over a period of seven years trapping to protect whio in the upper Waimarino River, only 50

traps from 138 have caught stoats. In the last year, traps which have never caught a stoat have been moved and some have become successful.

It is also important to understand that continually using the same control method for predators creates trap-shy and bait shy individuals. A study in a Whangarei Kiwi Sanctuary (Robertson et al. 2016) found that untrappable stoats accumulate in areas subjected to continuous predator trapping and concluded that conservation managers should build into their long-term pest control programmes a periodic pulse of an alternative tool to kill pests that, for whatever reason, actively avoid the primary control tool. Therefore, it is important to mix up a pest control regime. Bait stations with paired traps can be a good way to do this. By pre-feeding a bait station with non-toxic bait for two rounds, in order to create a feeding pattern amongst the pest population, then switching to toxic bait for a round. Likewise, pre-feeding traps but not setting them for a few rounds, then setting the traps can be a good way to reduce caution among the pest population.

To provide resident birds with the greatest chance of breeding success traps should be checked and cleared more frequently in spring to early summer, to ensure the lowest possible pest population for the peak bird breeding season. The more frequently traps are checked the better, but this should be at least fortnightly during spring, summer and autumn, and can drop to monthly in the winter.

One risk of predator trapping is by-catch or non-target poisoning of native species. This has been minimised at Ngā Roto by the way the traps are set. For example, the cat traps are set on trees, with ramps up to them, to prevent the by-catch of ground-nesting birds. Possum traps can also be set on trees for this purpose, and trap-boxes for mustelid traps have been specifically designed to prevent by-catch of native species.

7.3 Mustelids

71 mustelids have been trapped at Ngā Roto since records have been kept. Weasels have been caught most frequently, followed by stoats, and a few ferrets. There are 56 double-set DOC 200s at Ngā Roto. These traps target stoats and weasels, but also catch rats and hedgehogs. Double sets are more effective at catching stoats than single set traps. These are spaced an average of 100 m apart. This is a good trap spacing for a single line of trapping such as this. There is a gap in trapping around the southern end of Ngā Roto, and we recommend the addition of a further six traps spaced at 100 m intervals around the fenceline in this area. This will require the approval of adjoining landowners, as the most efficient way to trap this area would be to walk around the outer fenceline of the reserve.

The highest catch rate of stoats in figure 27 generally aligns with the juvenile dispersal period from November to January, which coincides with bird breeding season. The more frequently traps are checked, the more effective pest control is. For best results the traps should be checked at least every 2 weeks, in the bird breeding season and when chicks are fledging (August – April). If additional volunteers could be found, trap servicing could be undertaken weekly during this period, with volunteers cycled on a roster. After breeding (and moulting), traps can be checked monthly between April – August. If this work was undertaken by a paid contractor, it would cost approximately $5,040 per annum (for fortnightly checks in the breeding season, 4 hours per check, at $60 per hour).

Trapping in combination with periodic poisoning would increase the efficacy of stoat control even further, because it controls trap shy animals. The poisons which are most effective for mustelids, and have been approved for stoat control, are 1080 paste, and the predator specific poison Para-

aminopropiophenone (PAPP). However, as Ngā Roto is such a well-used public space, it would likely be difficult to obtain public support for the use of these toxins.

Mustelids will be hunting rabbits on the surrounding farmland, so population abundance of mustelids will be in cycle with the local rabbit abundance. These relationships between predators and prey are worth keeping in mind. If rabbits in the surrounding area are controlled it may drive stoats into the reserve, which would increase the numbers of stoats being caught in the traps. Ferrets would also be likely to prey-switch to birds as their main food item if rabbit numbers are drastically reduced. While a few ferrets have been caught in the current traps, the larger DOC 250 trap is required for targeted ferret control, which are not currently in place around the lake.

If a priority of protecting pāteke at Ngā Roto emerges through the re-introduction of pāteke to Rotopiko East, an upgrade in the mustelid control occurring at Ngā Roto will be required. Traps to target ferrets must be included in the network to protect pāteke, and the area of mustelid control must be expanded by creating a buffer in the surrounding private land. This cannot rely on volunteer effort alone, and would require the cooperation of surrounding landowners, and ongoing annual funding for trapping from Waipā District Council.

7.4 Feral Cats

Cats are thought to mainly use the periphery of wetlands but will travel up to 200m into it. Cats tend to travel through areas where they have shelter, such as tall grasses, but will use walking tracks, and bridges to cross waterways that they cannot jump across. Cat trapping has only recently been established at Ngā Roto, and one feral cat has been recorded as caught at Ngā Roto in May 2021.

Four SA2 kat traps have recently been installed at Ngā Roto, with a further traps yet to be put out. The SA2 trap is very strong. It is set on a tree with a ramp up to it in areas with ground nesting birds. Feral cats can be difficult to control using traps and trapping is usually most effective in winter when targeting adult breeding animals. As for mustelid traps, pre-feeding the traps, by baiting with meat, but leaving the traps unset for a few rounds can be a good way to reduce caution in the cat population and avoid creating trap-shy animals.

If cat trapping loses efficacy over time the predator specific poison Para-aminopropiophenone (PAPP) could be used. PAPP is a relatively new toxin available for stoat and feral cat control (Boffa Miskell 2018). This is a humane toxin because animals fall to sleep. It is also non-toxic to humans and many other animals. Use of PAAP requires a vertebrate pesticides license. The method involves placing prefeed meat balls into ‘chimney’ bait stations which prevent other animals from accessing the bait. Two pre-feed applications are undertaken followed by two applications with PAAP. Case studies involving pre-feeding has resulted in >80% control of tracked cats and stoats. This method is potentially an option as a winter pulse to control resident animals that are trap shy. Unfortunately, it is not effective for controlling ferrets. Financially it is a cost-effective method for cat and stoat control (de Burgh et al. 2021).

7.5 Possums

14 possums have been trapped at Ngā Roto since December 2018. Of the recommended revegetation species tītoki is preferred by possums, and the success of tītoki plantings may depend on possum control. There are currently at least 4 SA2 kat traps that target possums and feral cats (these are being added to over time), and several A12 self-resetting possum traps that are moved around the reserve

regularly. 25 Timms traps that were formerly used for possum trapping have now been removed from the reserve, as they were not effective, and the SA2 is a more effective and humane possum trap.

SA2 traps are set on a tree with a ramp up to the trap. This is more effective than Timms traps set on the ground, which can result in trap-shy animals if possums reach for the bait with their paws rather than mouth, which results in injuries but does not kill the possum.

The recommended trap-spacing for possum traps around Ngā Roto would be every 200m, the Timms traps formerly located at the lake were at this spacing. As for mustelid traps - there is a gap in trapping around the southern end of the lake. There would be space for a total of 28 traps, spaced at 200m intervals around the entire lake.

Possums breed much more slowly than rats and stoats, having only one joey at a time. So, a 6–8 week period of possum control in late winter—early spring, followed by a break is usually sufficient. Possum traps can however be routinely checked during predator traps checks. The lure used should always be refreshed at least every two weeks during the trapping period. The traps could be left un-set but lured occasionally for the rest of the year to reduce caution from any possums migrating into the area.

The A12 self-resetting traps are currently moved around the reserve, located in places where possum sign has been noted. This is a good approach. The traps can also be placed on the trees that possums will be seeking out. Good sites to install possum traps are on large cabbage trees, as possums love cabbage tree flowers and fruit. Fruiting kahikatea are also favoured. Using this approach, the timing of possum control would be in November to early December (flowering), and April to early May (fruiting).

Over time possums who have not yet been trapped tend to become trap-shy. Minimising avoidance of the existing traps could be reduced by pre-feeding prior to undertaking control. This trains the possum to learn that 'dinner is served' at the trap location. Optimal possum control involves cycling more than one method. A different trapping method could be employed to catch trap-shy possums, for example putting pre-feed possum lure out on trees for a couple of weeks, with no traps set, and then setting leg-hold traps. Leg hold traps may not be acceptable in such a publicly used area.

Shooting is another possum control alternative. This would require adjoining landowner approval, and public notification, which may include locking the gates. We recommend initially beginning with four shooting nights per year in spring and autumn, with a 22 rifle and a thermal scope. A night each in September and October, and in April and May. Records must be kept of number of possums seen and shot, sex of possums shot (if known) and numbers of other predators seen, as this provides monitoring data as well as possum control. The number of shooting nights can be adjusted depending on the quantity of possums seen.

7.6 Rats

Norway rats can be the most plentiful predators in wetland habitats (O'Donnell et al 2015) and are likely to be the primary predator of crakes. Rat control in July/August prior to the crake breeding season would be the best method of increasing crake nesting success. There is currently no targeted control for rats at Ngā Roto. Although targeted to mustelids, the DOC 200 trapline will provide some rat control, but the catch rate of traps is not sufficient to control rats to a level to protect native birds (usually 5% detection of tracking tunnels, chew cards).

If targeted rat control is initiated at Ngā Roto, then the best method of reducing rat numbers is toxic bait. Bait stations with Diphacinone are recommended. Diaphacinone has a low persistence in the environment (3-4 weeks) and does not persist in the food chain. In comparison the widely used brodifacoum has a much longer persistence in the environment, and food chain. The most effective rat control would be to install two lines of bait stations at 100 m intervals (approximately 120 bait stations), one at the wetland edge, mounted on posts with a ramp to access the bait (in order to keep bait dry, and prevent non-target poisoning of wetland birds), and a second line of bait stations around the outer fence line of the reserve, mounted on trees or fence posts. The cost for 120 bait stations would be $2,400, and it would take 6 person days to set out the bait station network ($2,880 for a contractor charging $60/hour). Rat control should be undertaken from 1 month before crake breeding begins, up to the end of the breeding season (August – December). The bait stations will need to be filled with 500g of bait initially, and refilled fortnightly until bait take drops, then checked monthly from then on. Once bait take drops only around 200g of bait is required in the bait stations. Refilling bait stations can be made more efficient by carrying pre-filled 100g zip-lock bags and adding as required. The annual cost of toxin/lure, and labour to fill the bait stations is estimated at $7,050 (bait for 120 stations, for approx 5 fills of 300g on average = $2,250; labour 2 days x 5 fills = $4800).

Before beginning rat control at Ngā Roto, the first step is to index the rat population. Tracking tunnels will be difficult to set in the wetland, so chew cards are likely to be an easier indexing method. Chewcards can be set on transects of 6–10 cards, 20–50 m apart, 20–30 cm from the ground, for 3 nights in order to give rats time to overcome caution of new objects. Chewcards can be nailed to tree trunks and fence posts where available and attached by cable tie to a stainless steel stake, pegged into the ground in open areas. It is important to look at different habitats e.g., pasture edge, wetland, mixed native forest, kahikatea forest and oak forest. Oak forest is likely to provide good habitat for rats, as the acorns are a food source that can be cached for an on-going food supply (Ruffle et al. 2015. Landcare Research 2020). Chewcards can be used to monitor the rat population over time and should be set at the same time each year. Late winter is a good time to monitor rat populations. The cost of rat indexing each year would be 2 person days per annum ($960/yr for a contractor charging $60 an hour).

7.6 Predator Control Summary and Priorities

The current trapping network which has been set up by volunteers is well designed for the space in which it is operating. However, the predator control work is primarily being run by one volunteer. This is not sustainable in the long-term, and Waipā District Council needs to provide support in recruitment and management of volunteers, and/or an annual budget for this work. Maintaining low predator densities at Ngā Roto is difficult due to the reserve being a long thin strip with high reinvasion pressure. If more comprehensive predator control is desired, then a predator control objective must first be decided on. Increasing breeding success for crakes or providing protection for pāteke at Ngā Roto are long-term ongoing objectives.

In summary, we recommend that Waipā District Council undertake the following predator control actions at Ngā Roto:

1) Extend traps lines around the southern end of Ngā Roto to optimise the status quo predator trapping. Add 6 double-set DOC 200's at 100m spacing, and 3 SA2 traps at 200m spacing. (With adjoining landowner approval. Estimated cost is approximately $1,125 (for 6 double-set DOC 200's

(including wooden housing) at $145 each, and 3 SA2 traps at $85 each – assuming volunteer labour).

2) Review the current volunteer system, and either provide support in recruitment and management of volunteers, and/or an annual budget for this work (estimated at approximately $5,040 per annum for fortnightly checks in the breeding season, 4 hours per check, at $60 per hour – excludes lure etc).
3) Add 4 nights per year possum shooting to the predator control programme (approximately $960 per year for a contractor charging $60 per hour; with adjoining landowner approval, and public notification).
4) Determine predator control objective:
    a) Status quo: trapping for general reduction in predator density.
    b) Increase the breeding success of crakes at Ngā Roto.
    c) Emerging priority to provide protection to pāteke at Ngā Roto in the event they are released at Rotopiko East.
5) Depending on the pest control objective decided, either:
    a) Continue with status quo (with the addition of recommendations in 1, 2 & 3),
    b) Implement rat control as per section 7.6, or
    c) Extend the cat and mustelid control to include a buffer of surrounding private land. This will require engagement with surrounding landowners, and consultation with an expert in pāteke protection to ensure the trapping network is designed to standard.
6) Predator indexing (chew cards or tracking tunnels) must be part of any revised predator control programme, to ensure predator control objectives are being met
7) Relying on volunteer labour alone is not a sustainable approach, and ongoing annual funding from Waipā District Council would be required for the implementation of an expanded predator control programme to achieve objectives b) or c).

8. Effects of Recreation

Ngā Roto is a Recreation Reserve, and a variety of recreational pursuits are carried out at the site. These include walking and cycling around the 6 km track, sailing and rowing on the lake, dog walking and contained camping. Duck shooting is permitted at Ngā Roto during the May—June season, with permits from Waipā District Council. Motorised boats are not permitted on Ngā Roto for recreational use (exceptions are made for safety purposes, management of yachting, rowing, waka paddling events; or for managing hunting stands prior to and during the hunting season; Waipā D. C. Reserve Management Plan 2009).

8.1. Disruption to wildlife

In general recreation activities involving loud noise, and sudden or rapid movements are most disruptive to wildlife (Walls 1999). Recreational power boating is not permitted at Ngā Roto, this ban provides protection to wildlife, as power boating can affect feeding of herons, and damage nests of native birds that build floating nest platforms such as weiweia (Walls 1999).

Ngā Roto is classified as a dog walking area by Waipā District Council. Dogs are permitted to walk around the track but must be kept on a leash. It is critical that dogs around the lake are kept on a leash, as both banded rail and marsh crake have been reported to be vulnerable to being killed by domestic dogs (Walls 1999).

The primary impact of duck shooting on wetland birds is the accidental shooting of protected species such as pāpango (scaup) and tētē (grey teal). Other native waterfowl such as kuruwhengi (Australasian shoveler) and pūtangitangi (paradise shelduck) are permitted to be shot. Duck dogs may kill crakes and rails if not kept under control. Duck shooting can also impact on wetland birds due to the noise disruption, which can delay the breeding season of kawau (black shag) (Walls 1999).

The removal of raupō to provide direct access to the water from the sailing club, and more surface area for sailing and rowing also impacts on water clarity, and habitat provision for wildlife. Raupō traps sediment, and prevents erosion of the lake shore, provides important nesting and feeding habitat for birds such as matuku (Australasian bittern), and is also the preferred habitat for juvenile tuna in Waikato Lakes. Raupō provides a nursery area for small tuna, with better availability for of the food they require, and cover to grow to size safely and avoid predation (Chisnall 1996).

8.2. Erosion

Although there is a concrete boat ramp and jetty at Ngā Roto, sailing boats are still commonly launched directly from the grassed area in front of the sailing club (Figure 27). Launching directly from the shore is causing erosion over time, as trampling the soil and pushing the boats over it kills the grass and physically damages the peat soils. This site also lacks a protective margin of raupō, which leads to erosion of the bare grass and earth banks via wave action.

A boat launching area has been developed at the bottom carpark, with timber retaining walls. This prevents erosion and boats should be encouraged to launch from here.

Figure 27: Youth sailing lessons launching directly form the grassed shore in front of the Sailing Club.

8.3. Contained camping

Contained camping is permitted at Ngā Roto. Contained campers should have minimal impacts at Ngā Roto, provided they do have self-contained vehicles, and do use the facilities in these vehicles. There was no evidence of increased rubbish, or toileting in the bushes in the vicinity of the contained camping area. Contained camps could potentially have positive security impacts. During a second visit to Ngā Roto (April 14th 2021) vandalism of the grassed areas adjacent to the back carpark was observed, caused by vehicles doing "donuts" (Figure 28). This damage to the grassed area will potentially result in increased sediment and erosion at Ngā Roto. If contained campers had been present in the area, it is unlikely the culprits would have committed this vandalism. Further vandalism events such as this could be prevented by placing large rocks on the grassed area, which would create separate "bays" for campers to park in and decrease the area of open grass available for "donuts".

Figure 28: Vandalism of grassed area next to back carpark at Ngā Roto.

8.4. Recreation recommendations.

We recommend that Waipā District Council undertake the following activities to minimise the effects of recreation at Ngā Roto:

- Highlight the importance of keeping dogs on leashes at Ngā Roto for wildlife protection.
- Review whether duck shooting is an appropriate activity at Ngā Roto, given the conservation and restoration goals at the lake. This is also a public safety issue, given the high recreational use by walkers/cyclists.

- Liase with the sailing club to prevent launching directly from the grassed bank. The sailing club should investigate building a retained launching area in front of the clubhouse if they want to continue this activity.
- Install rocks or bollards in freedom camping area, and along the entire road edge, to prevent unwanted vehicle access to grass.

9. Delivery of the work program

All the work at Ngā Roto is currently done by contractors or volunteers. However, given the extent of the work, and the cost involved in engaging contractors, it may make more sense for Waipa District Council to bring some of this work in-house. Particularly considering there are multiple council-managed restorations projects within the Waipā, including Lake Mangakaware, Lake Kareaotahi (Cameron Lake), Yarndley's bush, Mount Kakepuku, Rangimarie Reserve and Mātakitaki Pā in Pirongia.

A two-person environmental team within the Waipā District Council parks team, trained in GrowSafe and Chainsaw use could carry out weed control and tree releasing at Ngā Roto and the other council restoration sites over the spring and summer, and carry out restoration planting in the autumn and winter. This team could also organise and supervise volunteer work. There may be scope for the team to manage a small in-house nursery as most nursery work such as sowing seed and potting on plants occurs over the quiet winter months. An in-house team would ensure the consistent methods and effort are used over the restoration sites, resulting in better outcomes.

An environmental team could help with general parks work during quiet times, or could also carry out predator trapping, particularly in late winter/early spring when more intensive trapping will have to greatest impact for bird nesting success.

10. Restoration Priorities

The following restoration priorities have been tied to three-year periods, to work in with District Planning timetables, and costs for these priorities have been estimated in line with the details in this plan. Please note that the estimated costs with be increasingly inaccurate with time.

10.1. Priorities in 1-3 years (2021-2024)

Priority Description	Approximate cost
Control of priority weeds (as outlined in section 3.1) that are currently at low densities but have the potential to become serious ecological weeds.	**$6,300** Excluding cost of herbicide and disbursements, for a contractor charging $60 per hour as per table 2.
Re-treat surviving willows. We recommend spot spraying with a helicopter for best success. Use Metsulfuron-methyl over dry areas, and Glyphosate over water. (Treat pampas in wet areas with glyphosate at the same time). Willows will need to be re-treated every year for 3 years as per section 3.3.	As per Table 3. **$25,000** in 2021–22, **$12,500** in 2022–23 **$6,250** in 2023–24. **$1,500 - $2,000** annually for ongoing surveillance from 2025 onwards

Treat willows within the kahikatea swamp vegetation at the northern end of the lake, and willows near the recreation area using ground control methods.	**$2,880** At a contractor rate of $60/hour, as per section 3.3.2.
Protect the investment in planting already done at Ngā Roto through a comprehensive releasing programme for the current planted areas (As mapped in Figure 13, following prescription in Table 7) over the next three years to ensure establishment of the plants in these areas. Release spraying should be done in spring when herbaceous weeds are lower, as these die down over the winter. Before spraying, hand weeding should be carried out around each plant, then the weeds sprayed on the ground around the plants (as per section 4.4).	**$8,345 – $16,69 0** in 2021-22 As per section 4.5.1, Table 7. $28,080 in subsequent years following supplementary planting (at $3,120/ha for 9 ha)
Assess plant survival in the currently planted areas (as above) and supplementary plant into gaps at 1.8m x 1.8m spacings (as per table 7). Chose species for supplementary planting depending on what revegetation zone the area is in (as per table 6). Ensure 5x 5 m spacing of canopy trees.	**$22,530 - $40,930** For 7.51 ha. as per section 4.5.1, Table 7.
Chose sites for Pā Harakeke and Rongoā Rākau and plant these areas in partnership with Ngāti Apakura.	Dependant on scale. Approximately $2000 for trees for rongoā rākau with 10 of each rongoā tree (small trees - cost increasing with increasing tree size). Pā harakeke likely to be a similar cost. Costs for hui, interpretation etc. additional.
Extend pest control around the southern end of Ngā Roto to optimise the status quo predator trapping.	**$1,125** For 6 double-set DOC 200's (including wooden housing) at $145 each, and 3 SA2 traps at $85 each – assuming volunteer labour
Evaluate the current contractor cost of the Waipā District Council biodiversity programme and consider creating an in-house team to deliver the biodiversity work in the district, as per section 9.	WDC staff time

10.2. Priorities within 3-6 years (2024-2027)

Priority Description	**Approximate cost**
Begin revegetation in the swamp forest and swamp margin zones mapped in Figure 13 and outlined in table 6 & 8. Do this on a step-wise basis, choosing manageable areas to revegetate, with thorough and careful follow-up release spraying, before moving on to the next area.	$13,850 - $26,840/ha Total cost dependant on number of hectares planted, but up to $636,108 for 23.7 ha.

	$3,1200/ha for release spraying for 3 years
Begin the propagation of kukuraho in the wet swamp meadow area along the floating boardwalk at the southern end of the lake.	$1 per bulb kukuraho to harvest, prepare and plant. $2,500 - $10,000 per ha. As per section 4.5.3. (Substantially cheaper if done by volunteers).
Revegetate the southern Land acquisition area (Lot 6 DP 526717) in kahikatea forest	**$132,960 – $257,664** For 9.6 ha at $13,850 - $26,840/ha as per table 6 and table 8.
Decision on objective of pest control at Ngā Roto. 1. Status quo: trapping for general reduction in predator density. 2. More specific objective to increase the breeding success of crakes at Ngā Roto 3. If it is decided that a specific predator control objective is to be set, initiate rat control as per section 7.6, and programme ongoing annual funding towards predator control.	Dependant on the objective decided on. Status Quo: no additional costs New objective: Rat control and indexing estimated at $13,290 in year 1, and $8,010 annually thereafter (see section 7.6).
Ongoing surveillance for willows	**$1,500 - $2,000** per annum as per section 3.3.1

10.3. Priorities within 6-10 years (2027-2031)

Priority Description	**Approximate cost**
Continue revegetation in the swamp forest and swamp margin zones mapped in Figure 13 and outlined in table 6 & 8. Do this on a step-wise basis, choosing manageable areas to revegetate, with thorough and careful follow-up release spraying, before moving on to the next area.	$13,850 - $26,840/ha Total cost dependant on number of hectares planted, but up to $636,108 for 23.7 ha. $3,120/ha for release spraying for 3 years
Continue propagation of kukuraho in the wet swamp meadow area along the floating boardwalk at the southern end of the lake.	$1 per bulb kukuraho for contractors to harvest, prepare and plant. $2,500 - $10,000/ha. As per section 4.5.3. (Substantially cheaper if done by volunteers).
Ongoing surveillance for willows	**$1,500 - $2,000** per annum as per section 3.3.1

10.4. Emerging Priorities

- If any adjoining areas of wet pasture are retired from grazing, it is of high priority to plant these before invasive species take hold. These areas would be ideal for kahikatea swamp forest. These should be planted with swamp forest species recommended for peat soils (with plant mix depending on revegetation zone as defined in table 6 and per hectare costs as described in table 8).
- Continue to work with adjoining landowners to develop silt traps and treatment wetlands in high priority locations 1-4, as shown in Figure 22.
- In the event that pāteke are released at Rotopiko East, the expansion of cat and mustelid control to include a buffer of surrounding private land merging priority to provide protection for pāteke at Ngā Roto will become a priority.

11. Review and Reporting

The progress against the restoration plan can be evaluated by assessing how many of the priorities outlined in section 10 have been achieved, within the defined timeframes, with a full review of this plan at year 10 (2031). In addition to this review, the following record keeping and monitoring should be undertaken in order to assess if priorities have been achieved:

Weed control monitoring:

To monitor weed control operations at Ngā Roto the following records should be kept:

- Maps of weed control undertaken each year
- Record contractor hours and spray diaries.
- Maps and numbers of weed species recording during weed surveillance.

Revegetation monitoring:

Photo-points of restoration sites, and vegetation mapping using high resolution imagery will be the simplest way to monitor the success of the project.

Additional recommendations for record keeping and monitoring of revegetation at Ngā Roto are:

- Records of provenance (location of seed collected) for native trees planted.
- Records of date and actual number of plants planted (by species), as estimates provided in this report will vary from actuals.
- Plant establishment success measured following the first, second and third summers. This should be measured in April–May to inform how many additional plants are required in order to achieve a uniform plant density of 2m x 2m spacing.
- Post planting management, including release sprays to control grass, or if any invasive weeds invade and are controlled.

Pest control monitoring:

To monitor the current pest control network at Ngā Roto, keep records of volunteer effort (number of trap checks per annum) and annual counts of animals killed.

If a rat control objective is adopted then records of bait take should be kept, and annual indexing of the rat population using chew cards carried out (as per section 7.6.).

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Appendix 1 – Requirements of the National Environmental Standard for Freshwater Management 2020 (NES-FW 2020)

Appendix 1.1 - Table of Schedule 2 restoration plan requirements

A restoration plan must be submitted with the Resource Consent application, as per Regulation 39 and Schedule 2 of the NESFW:

https://www.legislation.govt.nz/regulation/public/2020/0174/latest/LMS364330.html

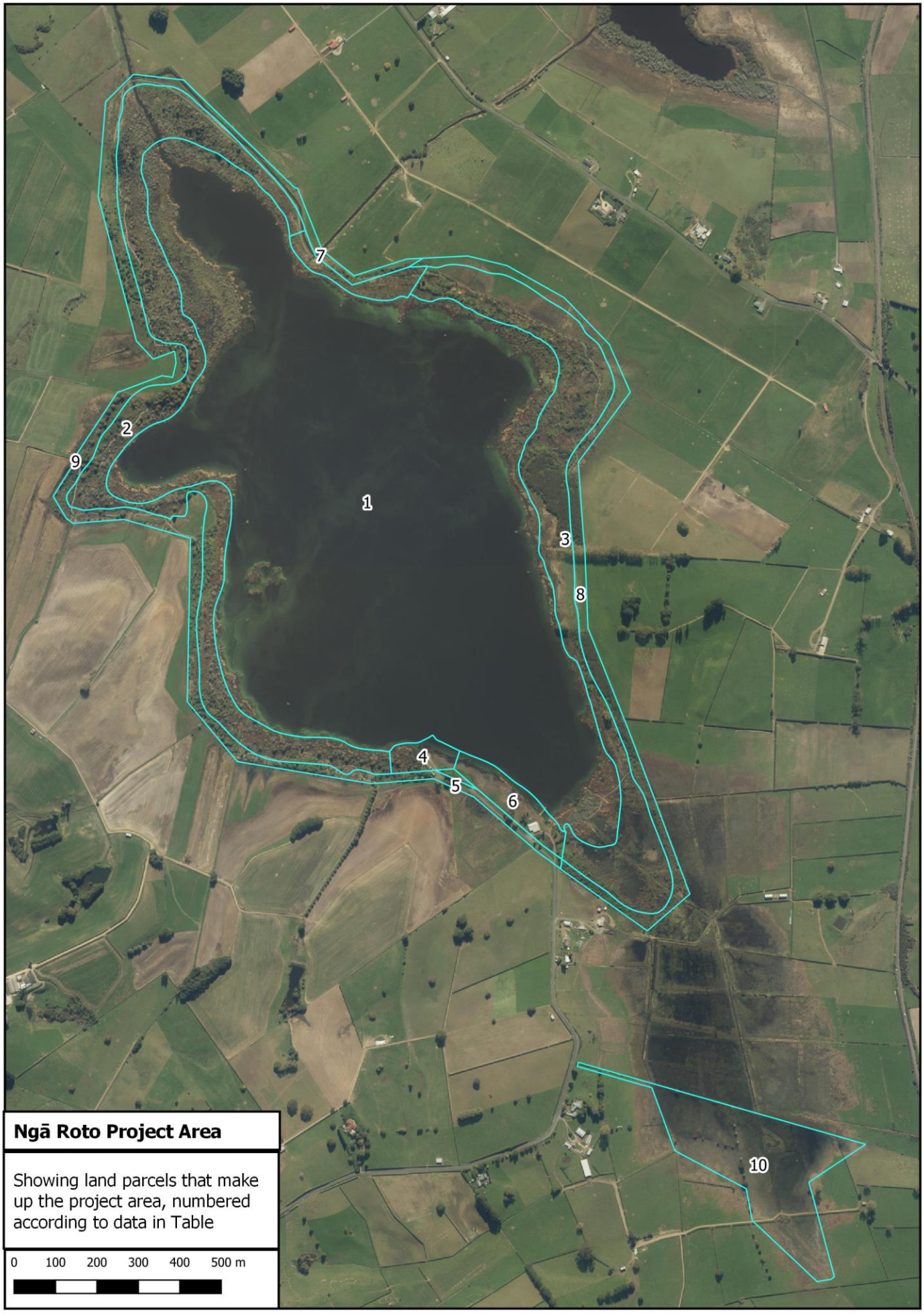
Resource Management (National Environmental Standards for Freshwater) Regulations 2020 **Schedule 2: Restoration plans for natural wetlands**					
			In plan Y/N	Page reference	If not in plan, add a statement to address clause here
1		**Details of activity site and natural wetland** The following information:			
	a	the physical address of the site of the activity:	Y	Section 1.4.1	65 Bank Road, Te Awamutu 3883
	b	the names of the owners of the site:	Y	Section 1.4.1	Waipā District Council.
	c	the contact details for the owners:	N		Waipā District Council. 101 Bank St., Te Awamutu, 3800 0800 924 723 Waipadc.govt.nz
	d	the legal description of the site, including the estate or interest held by the owners and any legal status or designation that applies to the site:	Y	Appendix 1.2	See map and table, Appendix 1.2
	e	a map showing the location and boundaries of the natural wetland:	Y	Figure 2	Only 61.1 ha of the project area is vegetated (the remainder is water, grass reserve, and pasture) and some of this is non-wetland vegetation (e.g. 2.1 ha of regenerating broadleaf forest, 1.4 ha exotic trees). However, for the purposes of this plan, we will treat all 61.1 ha of vegetated area as wetland.
	f	the details of the legal status of the natural wetland under any enactment or plan:	Y	Appendix 1.2	See map and table, Appendix 1.2
	g	the details of any management partners or key stakeholders involved in the restoration plan.	N		Partners and key stakeholders involved in this plan are: Tangata whenua - Ngāti Apakura Ecological Consultant - Nicholas Singers Ecological Solutions Ltd.
2		Features and values of natural wetland A description of the features and values of the natural wetland that are relevant to a restoration plan, including the following information:	Y		Mainly covered in section 2, with additional sections described below.
	a	the type of natural wetland:	Y	Section 1.4.2	While the wetland surrounding Ngā Roto would have once been low-nutrient fen vegetation, it has now transitioned into a more fertile swamp

	b	the vegetation in the natural wetland, including the dominant types of vegetation and any species of note (for example, rare species, invasive weeds, or unusual plant communities):	Y	Section 2.1, Section 3.	
	c	the hydrology of the natural wetland, including— **(i)** its water sources and flows (for example, streams, rivers, seeps, or solely rain): **(ii)** its water levels (for example, permanent open water of more than 1 m depth, shallow water of 5 cm to 1 m depth, or conditions of being saturated with water of -5 to +5 cm depth, seasonally saturated, generally dry, or dry): **(iii)** any modifications (for example, drains, weirs, culverts, canals, or stop banks):	Y	(i) Section 1.4.2, section 6.2. (ii) Detail within section 2.1.3 (iii) Section 6.2, 6.3, Figure 22	(i) The hydrology of the wetland surrounding Ngā Roto is governed by the Lake level. (ii) Raupo-reedland 4.9ha: The water level in this zone is 5cm – 1m deep. Swamp meadow: The water level in this zone varies seasonally, is estimated to vary from -20 cm to +20 cm depth. Former willow treeland: Slightly drier, with water levels estimated to vary from -5 cm to +5 cm depth. Kahikatea swamp: seasonally saturated. Bindweed exotic grasslands seasonally saturated to generally dry. All other vegetation types are generally dry to dry.
	d	the types of soil in the natural wetland:	Y	Section 4.3	
	e	any artificial features in the natural wetland (for example, roads, electricity lines, buildings, and access points):	N		Within the wetland, there is a 6km walking track and board walk, with occasional bridges. For the most part the track is a gravelled trail located on the drier soils, apart from a few sections of boardwalk at the southern end of the lake and at places on the eastern side of the lake. All building and roads are located in the grassed domain areas, not within the wetland vegetation.
	f	any fauna known to use the natural wetland or its surrounding area:	Y		See section 2.2-2.5
	g	any special features of the natural wetland (for example, sites of cultural significance such as archaeological features, areas of cultural harvest, historic sites, or recreational areas).	Y	See section 5.	
3		**Issues with natural wetland** The following information:			
	a	a description of the current state or condition of the features and values of the natural wetland:	Y	Section 2	
	b	a discussion of the threats to the natural wetland and the opportunities for restoring its features and values.	Y	Sections 3, 7, 8 & 4	Threats: Section 3 – weed threats. Section 7 – pest threats. Section 8 – recreational effects. Opportunities: Section 4 - revegetation
4		Management objectives for natural wetland The specific objectives for managing the natural wetland based on its features, values, and issues, and taking into account—	Y	Section 1.2 Section 10.	Section 1.2 - Long-term Objectives, Section 10- Restoration priorities
	a	its legal status under any enactment or plan; and	Y		Recreation Reserve (see Table Appendix 1.2)

	b	any existing or required resource consents or agreements with landowners or other relevant persons.	N		Required resource consent for vegetation clearance – this application Other Consents: Waikato Regional Council Consents: AUTH970223, AUTH131266, AUTH131669 (01.01, 02.01, 03.01), AUTH134944, AUTH135544, AUTH137549 (02.01, 03.01) Waipā District Council Consent: LU/0043/14. (As listed in Waipa DC ECM_10558297 Tables 1 and 2)
5		Operational details for achieving management objectives An outline of the activities that will be carried out to achieve the objectives for managing the natural wetland, including the following:			
	a	the timelines for the activities and the persons responsible for resourcing and delivering them:	Y	Section 10.	
	b	Scale plans showing the operational areas	Y	Sections 3.2, 4.3 & 7.2	Figures: 3 (weeds), 13 (revegetation) & 26 (pest control).
	c	the planting to be done, including— **(i)** a diagram showing the general areas for planting: **(ii)** the species to be used within specific areas (for example, areas of standing water, wetter margin areas, or drier areas): **(iii)** the spacing of the plants: **(iv)** the sources of the plants (for example, local native plant nurseries or locally-sourced seed): **(v)** the approach to releasing the plants (including how often, for how many years, and by what method weeding will be done around the plants):	Y	Covered in detail in Section 4.	
	d	any vegetation to be removed, including species and methods of removal (for example, cutting, digging, or spraying):	Y	Section 3. Section 4.5	
	e	Any machinery to be used and the purpose of its use:	NA	NA	
	f	a description of the approach to water management, including— **(i)** any changes to water levels or movement of water during and after the restoration works:	NA	NA	Exiting weir. No further water management planned as part of this project

		(ii) if water will be dammed or diverted,— (A) how that will restore or enhance the natural wetland: (B) any structures that will be installed: (C) the time of year when the works will be carried out: (D) the methods to be used to minimise effects on flora and fauna:			
	g	the approach to managing erosion and sediment to be used during all of the works:	NA	NA	None expected
	h	any animal pest control to be carried out, including— **(i)** which animal pests are present: **(ii)** how often, and for how many years, the animal pest control will be carried out: **(iii)** the method by which the animal pest control will be carried out:	Y	Section 7.	Existing trap network, checked by volunteers as described in Section 7. 4 x per year night shooting of possums recommended To be carried out indefinitely to allow continued protection of native fauna.
	i	a description of the actions to be taken to minimise any adverse effects on fauna or to enhance values for fauna.		Detail – Section 7.2	By-catch or non-target poisoning of native species can be minimised by the way the traps are set. For example, the cat traps are set on trees, with ramps up to them, to prevent the by-catch of ground-nesting birds. Possum traps can also be set on trees for this purpose, and trap-boxes for mustelid traps have been specifically designed to prevent by-catch of native species.
6		Review and reporting A description of the approach for assessing progress against the restoration plan and reporting that progress to the consent authority, including—			
	a	timelines for reporting progress; and	Y	Section 10 & 11	
	b	how any requirement to report under a resource consent will be met.	N		Reporting will be resourced by WDC to comply with conditions of consent or out sourced to consultants, if required

Appendix 1.2 – Map and table of legal description of parcels within the restoration area.



Appendix 1.2 Table: Description of each land parcel, as numbered in map above.

Parcel No	Legal Description	Area (ha)	Title Reference	Acquisition History	Classification
1	Allot. 481 Ngaroto Parish	107.500	NA	Crown land set apart as a recreation reserve and Waipa County appointed to control and manage NZ Gazette notice 1984 p.853	Recreation Reserve. NZ Gazette notice 1984 p.853
2 3	Allot 461 Ngaroto Parish Allot 462 Ngaroto Parish	17.5000 16.0000	Req	Crown land set apart as recreation reserve and vested in Waipa County Council NZ Gazette 1975 p.97 (Document H.028726)	Recreation Reserve. NZ Gazette notice 1979 p.462 (Document H.222328)
4 5 6 7	Allot 454 Ngaroto Parish Allot 460 Ngaroto Parish Section 1 Blk XVI, Hamilton SD Section 2, Blk XVI, Hamilton SD	0.9156 0.1241 1.9273 1.5631	Req	Formerly part of (Crown owned) Te Awamutu Domain deemed recreation reserve and vested in Waipa County Council by NZ Gazette 1974 p.328 (Document S.646950A)	Recreation Reserve. NZ Gazette 1979 p.462 (Document H.222328)
8 9	Parcel ID 4586983 Part Parcel ID 4604108	5.6393 10.5836	NA		Road
10	Lot 6 DP 526717	9.6792	RT 855334	Acquired via EBL and RMA subdivision, owned by Waipa District Council	Fee Simple

Appendix 1.3 - Further information for gaining consent for restoration of a natural inland wetland.

This restoration plan must be submitted to Waikato Regional Council. In addition to the restoration plan, the following three forms must be completed to apply for resource consent for vegetation clearance over 0.0 5ha/500m^2 at Ngā Roto.

https://www.waikatoregion.govt.nz/assets/WRC/WRC-2019/RCAppln-Form-A.pdf

https://www.waikatoregion.govt.nz/assets/WRC/WRC-2019/Form-B-Land-use-projects.pdf

https://www.waikatoregion.govt.nz/assets/WRC/WRC-2019/Form-C-Other-matters.pdf

MFE Wetland delineation protocols, as required to be used by the NPSFW:
https://environment.govt.nz/assets/Publications/Files/wetland-delineation-protocols.pdf

Appendix 2 – Species Lists

1. Scientific name, Te Reo Māori name/s, and English common name/s of plant species found at Ngā Roto.

*Denotes introduced species; # Denotes planted species.

Scientific Name	Known Te Reo Māori Name/s (These are to be refined to the names used by Ngāti Apakura as this knowledge is shared)	Common Name/s
Mosses		
Sphagnum cristatum	kohukohu	Sphagnum moss
Ferns and fern allies		
Asplenium oblongifolium	paretao	shining spleenwort
Cyathea dealbata	ponga	silver fern
Cyathea medularis	mamaku	black tree fern
Dicksonia squarrosa	whekī	rough tree fern
Diplazium australe		
Doodia australis		rasp fern
Histiopteris incisa	Mātā	water fern
Hiya distans		
Hypolepis ambigua		
Icarus filiformis		thread fern, climbing hard fern
Parablechnum novae-zelandiae	kiokio	kiokio
Pteridium esculentum	rarauhe	bracken
Gymnosperms		
# Agathis australis	kauri	kauri
# Dacrydium cupressinum	rimu	rimu
Dacrycarpus dacrydioides	kahikatea	kahikatea
# Podocarpus totara	tōtara	tōtara
**Taxodium distichum*		swamp cypress
Flowering plants - dicots		
**Actinidia deliciosa*		kiwifruit
**Acer negundo*		box elder maple
# Aristotelia serrata	makomako	wineberry
# Alectryon excelsus	tītoki	tītoki
# Beilschmiedia tawa	tawa	
**Berberis glaucocarpa*		barberry
**Bidens frondosa*		beggar's ticks
Calystegia sepium subsp. roseata	pōhue	pink bindweed
**Calystegia silvatica subsp. disjuncta*		greater bindweed
Centella uniflora		Centella
# Carpodetus serrata	putaputaweta	marbleleaf
**Crataegus monogyna*		hawthorn
# Coprosma grandifolia	kanono, manono,	

Coprosma robusta	karamū, kākaramū, kākarangū, kāramuramu	
Coprosma propinqua	mingimingi, mingi	
Coprosma tenuicaulis	hukihuki	swamp coprosma
# Corynocarpus laevigatus	karaka	
# Dodonaea viscosa	akeake	
**Erigeron sumatrensis*		broad-leaved flea-bane
**Galium palustre*		marsh bedstraw
# Griselinia littoralis	kāpuka, pāpāuma	broadleaf
Hedycarya arborea	porokaiwhiri	pigeonwood
**Helix hedera*		Ivy
**Homalanthus populifolius*		Queensland poplar
Hydrocotyle pterocarpa		
knightia excelsa	rewarewa	
# Kunzea ericoides	kānuka	
Laurelia novae-zelandiae	pukatea, puketea	
Leptospermum scoparium	mānuka	mānuka
**Leycesteria Formosa*		Himalayan honeysuckle
**Ligustrum lucidum*		tree privet, shining privet
**Ligustrum sinense*		Chinese privet
Litsea calicaris	mangeao, tangeao	
Lobelia anceps	punakuru, waewaekoukou, pūrao	NZ lobelia
**Lonicera japonica*		Japanese honeysuckle
# Lophomyrtus X ralphii	ramarama, rōutu	ramarama hybrid
**Lotus pedunculatus*		lotus
**Ludwigia palustris*		water purslane, marsh ludwigia
**Ludwigia peploides*		water primroase
**Lycopus europeaus*		gypsywort
Melicytus ramiflorus	māhoe, hinahina, moeahu	mahoe
Muehlenbeckia australis	pōhuehue, pōhue, pōpōhue, tororaro, waekāhu	
**Myosotis laxa*		water forget-me-not
Myriophyllum propinquum		water milfoil
**Nasturtium officinale*	wātakirihi	watercress
# Olearia albida	tanguru, tanguru-rake	tree daisy
# Olearia paniculata	akiraho	golden akeake
Parsonsia heterophylla		New Zealand jasmine
Persicaria decipiens	tūtunāwai, tūtuna	swamp willow weed
# Pittosporum crassifolium	karo	karo
Pittosporum eugenoides	tarata	lemonwood
Pittosporum tenuicaulis	kōhūhū	
**Populus nigra*		Lombardy poplar
Pseudopanax arborea	whauwhaupaku, whaupaku	five finger
# Pseudopanax crassifolius	horoeka	lancewood
# Pseudopanax X		Pseudopanax hybrids
**Phytolacca octandra*		inkweed

**Quercus alba*		white oak
**Quercus ilex*		holm oak
**Ranunculus flammula*		spearwort
**Ranunculus repens*		buttercup
Rhabdothamnus solandri	taurepo, kaikaiatua, mātā, mātātā, waiuatua	NZ gloxinia
**Rhus typhina*		staghorn sumac
**Rubus fruiticosus agg.*		blackberry
**Rumex crispus*		curled dock
**Rumex sagittatus*		climbing dock
**Salix cinerea*		
**Salix fragilis*		
Schefflera digitata	pate, patete	seven finger
Senecio bipinnatisectus		Australian fireweed
**Stachys sylvatica*		hedge woundwort
**Tradescantia fluminensis*		Tradescantia, wandering willie
**Ulex europeaus*		gorse
# Veronica parviflora	koromiko, koromuka, kōkoromuka, korohiko, kōkoromiko, korokio	hebe
# Veronica stricta	Koromiko, koromuka, kōkoromuka, korohiko, kōkoromiko, korokio	koromiko
**Viola sp.*		wild violet
Flowering plants - monocots		
*Agrostis stolonifera		creeping bent
# Astelia grandis	kakaha	swamp astelia
Austroderia toetoe	*Toetoe, toetoe-kākaho, toetoe-mokoro, kaho, toetoe-rākau*	toetoe
Bolboschoenus fluviatilis	kukuraho, pūrua grass	Marsh clubrush
Carex geminata	rautahi, toetoe rautahi	cutty grass
Carex virgata	pūkio, toitoi, toetoe	swamp sedge,
Carex maorica		Māori sedge
Carex secta	pūrei, pūkio	
Cordyline australis	tī, tī kōuka	cabbage tree
**Cortaderia jubata*		purple pampas
**Cortaderia selloana*		pampas
**Cyperus eragrostis*		umbrella sedge
Cyperus ustulatus	upoko-a-tangata	giant umbrella sedge
Eleocharis sphacelata	kuta, paopao, ngāwhā kutakuta, kūwāwā, wāwā	giant spike sedge
Eleocharis acuta		spike sedge
**Holcus lanatus*		Yorkshire fog
Isachne globosa		swamp millet
**Juncus acuminatus*		sharp-fruited rush
**Juncus effusus*		soft rush

Juncus pallidus	wī, wīwī, kōpūngāwhā, kōpūpūngāwhā	giant rush, leafless rush
Machaerina rubiginosa		baumea
Oplismenus hirtellus subsp. imbecillis		bamboo grass
**Paspalum distichum*		Mercer grass
Phormium tenax	harakeke	flax
**Prunus serotina*		wild cherry, rum cheery
Scheonoplectus tabernaemontani	kāpūngāwhā, kōpūngāwhā, kōpūpūngāwhā; kuta, kūkuta, kutakuta; wāwā, kūwāwā, pūwāwā; paopao, papao	lake clubrush
Typha orientalis	raupō, kōpūngāwhā, kōpūpūngāwhā, ngāwhā	raupō

2. Scientific name, Te Reo Māori name/s, and English common name/s of fish species referred to in this report.

Scientific Name	**Known Te Reo Māori Name/s** (These are to be refined to the names used by Ngāti Apakura as this knowledge is shared)	**Common Name/s**
**Ameiurus nebulosus*		brown bullheaded catfish
Anguilla australis	tuna, tuna hinahina	shortfin eel
Anguilla dieffenbachii	tuna, tuna kūwharuwharu	longfin eel
**Carassius auratus*	morihana	goldfish
**Cyprinus carpio*		koi carp, common carp
**Gambusia affinis*		mosquito fish
Gobiomorphus cotidianus	toi toi	common bully
Retropinna retropinna	pōrohe, kehakeha paraki, ngaore	smelt
**Scardinius erythrophthalmus*		rudd

3. Scientific name, Te Reo Māori name/s, and English common name/s of bird species recorded at Ngā Roto.

*Denotes introduced species; # Denotes occasional visitors; + Historic records

Scientific Name	**Known Te Reo Māori Name/s** (These are to be refined to the names used by Ngāti Apakura as this knowledge is shared)	**Common Name/s**
**Acridotheres tristis*		common myna
**Alauda arvensis*		Eurasian skylark
Anas gracilis		grey Teal
**Anas platyrhynchos*		mallard
Anas rhynchotis	kuruwhengi	Australasian Shoveler
Anas superciliosa		grey duck
# Ardea modesta	kōtuku	white heron

Aythya novaeseelandiae		scaup
Botaurus poiciloptilus		Australasian bittern
+ Bowdleria punctata	mātātā, koroātito, kāroti	fernbird
**Branta canadensis*		Canada goose
**Bubulcus ibis*		cattle egret
**Callipepla californica*		California quail
**Carduelis carduelis britannica*		European goldfinch
**Chloris chloris*		European greenfinch
Circus approximans	kāhu	swamp harrier
**Columba livia*		feral pigeon, rock pigeon
**Cracticus tibicen*		Australian Magpie
Chrysococcyx lucidus	pīpīwharauroa	shining cuckoo
**Cygnus atratus*		black swan
Egretta novaehollandiae	matuku moana	white-faced heron
**Emberiza citronella*		yellowhammer
# Falco novaeseelandiae	kārearea	NZ falcon
**Fringilla coelebs*		common chaffinch
+ Gallirallus philippensis	mioweka, kōnini, kata tei, moho-pererū	banded rail
Gerygone igata	riroriro	grey warbler,
# Haematopus finschi	tōrea	South Island pied oystercatcher
Hemiphaga novaeseelandiae	kererū, kūkupa, kūkū	NZ wood pigeon
Himantopus himantopus leucocephalus	poaka	pied stilt
**Hirundo neoxena*	warou	welcome swallow
# Hydroprogne caspia	taranui	Caspian tern
# Larus bulleri	tarāpuka, tarapuka	black-billed gull
# Larus dominicanus	karoro	Southern black-backed gull
**Passer domesticus*		house sparrow
Phalacrocorax carbo ssp. Novaehollandiae	kawau	black shag
Phalacrocorax melanoleucos	kawau paka	little pied shag
Phalacrocorax sulcirostris	kawau tūi	little black shag
Phalacrocorax varius	kāruhiruhi, kawau	pied shag
**Phasianus colchicus*		common pheasant
*Platycercus eximius		Eastern rosella
Poliocephalus rufopectus	weiweia	dabchick, NZ grebe
Porphyrio melanotus	pūkeko	pukeko
Porzana pusilla	koitareke, kotoreke	marsh crake
Porzana tabuensis	pūweto, pūtoto	spotless crake
Prosthemadera novaeseelandiae	tūi	tui
**Prunella modularis*		dunnock
Rhipidura fuliginosa	pīwakawaka, pīwaiwaka, tīrairaka	New Zealand Fantail
**Streptopelia chinensis*		spotted dove
**Sturnus ulgaris*		common starling
Tadorna variegata	pūtangitangi	paradise shelduck

Todiramphus sanctus	kōtare	sacred kingfisher
**Turdus merula*		Eurasian blackbird
**Turdus philomelos*		song thrush
#*Vanellus miles novaehollandiae*		spur-winged plover
#*Zosterops lateralis*	tauhou, pihipihi, hiraka, iringatau, kanohi mōwhiti, mōtengitengi, pīkaraihe, poporohe, whiorangi	silvereye

Appendix 3 – Historical Aerial Photos

Photographs of Ngā Roto from 1943 - Sourced from http://retrolens.nz and licensed by LINZ CC-BY 3.0

Appendix 4 – Photos of 2017 Flooding

Photos taken 16/5/2017 at Ngā Roto, showing the extended period of flooding following ex-tropical cyclone Debbie which hit on April 5th 2017.

Appendix 4a: Flooding at the southern end of Ngā Roto, looking towards the south. Photo supplied, Waipā D.C.

Appendix 4b: Flooding on the Western side of Ngā Roto, looking towards the North-west. Photo supplied, Waipā D.C.