# APPENDIX EIGHT

# Shallow Lakes Project Assessments

## Contents

| L 1<br>Priority: Medium | Increase eel habitat in Lake Waikare | BCR value |
|---|---|---|
| Relevant goals from Central/Lower Waikato unit and Shallow Lakes unit | Aquatic habitats, including spawning grounds, are protected, enhanced, restored and accessible to native fish.<br><br>The abundance of native fish, including taonga species, in the catchment is restored and protected. | |
| Name of feature | Lake Waikare | |
| Brief description of feature | Lake Waikare is located to the southeast of Te Kauwhata township and connected to the Whangamarino wetland by the Pungarehu Canal. It is the largest lake in the lower Waikato catchment, with 3442 hectares of open water. It has an average depth of 1.5 metres and a maximum depth of 1.8 metres. Lake Waikare has very poor water quality and is hypertrophic. The lake is de-vegetated.<br><br>In 1965 the lake level was lowered by 1 metre. This was in accordance with the Lower Waikato Waipā Flood Control Scheme and followed the construction of an outlet gate. Lake Waikare discharges to the Whangamarino Wetland from the artificial Pungarehu Canal. The lake is managed under a strict seasonal fluctuation regime of approximately 0.3 metres.<br>Lake Waikare was historically regarded as the most important lake tuna fishery in the Waikato, returning up to 85 tonnes per annum. The tuna fishery declined as a result of the hydrological changes associated with the flood control scheme, but eventually stabilised at a new level that reflected reduced levels of recruitment and habitat/food availability. The fishery is mostly focused on shortfin eels, particularly migratory shortfin eels that exit the lake to sea between February and April.<br><br>Lake Waikare is significant to Waikato-Tainui and its surrounding marae. The bed of the lake holds the kōiwi (bones) of people engaged in the Rangiriri Pakanga (battle) during the colonial invasion into the Waikato region. The lake bed is held in the title of the first Māori King, Pōtatau Te Wherowhero, so that the bones of the tribe's people are protected in his name. Lake Waikare was historically used to capture tuna (eels) to sustain the iwi. Its surrounding wetlands supplied rongoā (medicine), birds, trees for general use, dyes and an area for enjoyment.<br><br>This project involves rehabilitation of tuna habitat within the lake. Anecdotal evidence from New Zealand shows that in lakes and rivers, eels are always found where there is cover. Trials of wood installation in streams have shown benefits for a range of | |

<table>
<tr><td></td><td>species so scientists expect there to be habitat benefits for a range of biota in lakes (including tuna).<br><br>Research from overseas looking at the benefits of introducing woody structure also supports this concept.</td><td></td></tr>
<tr><td>Desired state to achieve Vision & Strategy</td><td>- The lake is swimmable, fishable and has access for recreation and gathering of kai.<br>- Native aquatic plants dominate the in-lake flora and provide habitat for healthy populations of other indigenous species.<br>- Lake margins retain natural hydrological function and are well vegetated with native plant communities that support indigenous fauna.<br>- Wetlands adjacent to lakes are densely vegetated with native plant species, connected to riparian corridors, protected from stock grazing and native plant regeneration occurs naturally.<br>- Iwi and community have a strong connection to the lake and are active in its use, protection and restoration.</td><td></td></tr>
<tr><td>Impact on Vision & Strategy</td><td>In a restored condition Lake Waikare would have a very high impact on giving effect to the Vision & Strategy at shallow lakes catchments level.</td><td>VS = 375</td></tr>
<tr><td>Key threats to the feature that this project addresses</td><td><table><tr><th>Key threat</th><th>Impact on feature</th></tr><tr><td>Lack of in-lake vegetation</td><td>Reduced habitat for native fish, increased turbidity.</td></tr><tr><td>People become disconnected from Lake Waikare</td><td>The lake becomes further degraded</td></tr></table></td><td></td></tr>
<tr><td>Project goal/s</td><td>Within 5 years of the project commencing:<br>- Woody structures provide habitat for tuna along a 200m stretch of the Lake Waikare northern foreshore.<br>- Woody structures provide habitat for tuna along a 1000m stretch of the Lake Waikare western shoreline.</td><td></td></tr>
<tr><td>Works required (by whom)</td><td>Suggested works could be implemented either by an organisation or private citizens (using contractors or their own labour). This project could be undertaken as a whole, or in multiple smaller components.<br><br>Monitoring<br>This project would benefit from pre and post construction monitoring to quantify the extent to which introduced structures provide habitat for tuna and other species, however this has not been costed as it is out of scope for the Restoration Strategy.<br><br>Installation of structures for fish habitat</td><td></td></tr>
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| | | |
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| | Along the northern foreshore of Lake Waikare (on Waikato Regional Council administered land) there are stands of alder trees (amongst willow and other species). This project involves topping (near the base of the tree) a 200m long section of alder trees and then using an excavator to orient the cut sections of the trees so they lie out into the lake. The network of branches and leaf material is expected to provide habitat for tuna (and other biota).<br><br>Work requirements along the western shoreline are similar. Work in this location involves topping a 1000m long section of alder/poplar trees and using an excavator to orient the felled trees so they lie out into the lake.<br><br>Topped trees should be secured to the lake bed and bank with rope/cable and duckbill anchors.<br><br>The cut alder stumps will regrow and continue to provide an erosion control function on the lake margin. However, due to aggressive lake shore erosion some additional planting may be appropriate.<br><br>Costs for northern foreshore site are based on the following estimates:<br>- Up to 4 days of digger time (12 tonne digger) ($5400).<br>- Two arborists for 4 days (incl 50km mileage at 0.72c per km) to top and install trees ($4870).<br>- Materials (e.g. duckbill anchors, wire ropes and wire clamps) for placement of 10 structures 20m apart ($1350).<br>Costs for the western shoreline site are based on the above costs multiplied by five ($58,100).<br><br><u>Planting</u><br>A small amount of planting along the lake shore where trees have been topped may be required to provide additional bank stability and erosion protection. It is recommended that a combination of native plant species and matsudana willow be planted for erosion control purposes.<br><br>Costs are based on one willow tree every 10m (120 matsudana willow poles in total is $1440) and a row of native plants at 1.5m spacing (approximately 800 native plants at $8 each is $6400). Note that native planting costs include plant purchase, planting labour and five releasing events.<br><br>**Resource consent fees**<br>Resource consent may be required from Waikato Regional Council for this work. Resource consent related costs are estimated at $5000.<br><br>**Project management/staffing/incidentals** | |

| | | |
|---|---|---|
| | Staff to carry out landowner liaison, iwi engagement, Health and Safety requirements, negotiate agreements, inspect works, manage parts of the work as required (e.g. fencing or planting), project reporting and financial management. Incidentals include transport, office overheads, consumables and miscellaneous professional fees.<br><br>This is estimated to be 25% of the direct project costs. | |
| Time lag for benefits to be realised | If works were implemented at an even pace over a 5-year period, it is estimated that the majority of the project benefits would be seen approximately three years after project commencement. | L = 3 |
| Effectiveness of works | When compared with desired state, Lake Waikare is currently in very poor condition with few of the Vision & Strategy aspirations being met. The lake is not swimmable, and the presence of pest fish and plant species impacts significantly on ecological integrity. The very poor water quality is an impediment to recreational use of the lake. Despite this the lake still retains very high significance with iwi and the local community and has some important biodiversity values. Some deterioration in the lake is expected over the next 20 years in the absence of this project. This is based on trends in water quality over the past decade which show the in-lake TN has increased 4-fold over this period. This project is small in relation to the size of the lake and the scale of issues, however it can be expected to have a localised impact on tuna habitat availability. It doesn't address the majority of threats to the lake and it is acknowledged that achieving the Vision & Strategy desired state for Lake Waikare will take longer than the 20 year horizon used for the purposes of the Restoration Strategy, and a fuller range of initiatives. | W = 0.001 |
| Risk of technical failure | There is a moderate risk of project failure due to technical feasibility. There is some uncertainty on how effective this technique will be in increasing tuna habitat in the lake. | F = 0.82 |
| Adoptability | The bed of the lake is owned by Waikato-Tainui who are expected to be fully supportive of the project. | A = 1 |
| Information quality | Good – advice of local and subject matter expert/s with a history of association to selected sites. | |
| Knowledge gaps | No known knowledge gaps other than those related to effectiveness and technical feasibility. | |
| Socio-political risks | Low risk that the project will fail to meet its goals over the long term due to socio-political risks. | P = 0.85 |
| Project duration (years) | 5 years | |

| | | |
|---|---|---|
| Up-front cost – total for implementation phase/project duration | | C = 0.10 |

| **Task** | **Cost ($)** |
|---|---|
| Lake Waikare – northern shoreline | |
| - Digger time | 5400 |
| - Arborists (felling and installation) | 4870 |
| - Materials | 1350 |
| Lake Waikare – western shoreline | 58,100 |
| Planting (both sites) | 7840 |
| Resource consent | 5000 |
| Project management/staffing/incidentals (25%) | 20,640 |
| **Total** | **103,200** |


Increase eel habitat in Lake Waikare

## WWRRS Project Map

Created by: Tane Desmond
Projection: NZTM
Date: December 2017

Status: Final
Request No.: N/A
File name:WWRRS.gws

0.0 0.4 0.8 1.2 1.6 2.0
Kilometers

Scale 1:35,000@A4 Landscape

A4


**ACKNOWLEDGEMENTS AND DISCLAIMERS**

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Waikato REGIONAL COUNCIL
Te Kaunihera ā Rohe o Waikato

Alder trees and recent native planting on Lake Waikare northern foreshore.

| L 2<br>Priority: High | Development of Lake Waikare South Reserve for recreation | BCR value |
|---|---|---|
| Relevant goals from Central/Lower Waikato unit and Shallow Lakes unit | Places that provide for safe recreational activities are identified and accessible.<br><br>A platform for tourism along the river is created and connects to inland opportunities.<br><br>Tribal and community histories proudly inform recreational users. | |
| Name of feature | Lake Waikare | |
| Brief description of feature | Lake Waikare is located southeast of Te Kauwhata township and connected to the Whangamarino wetland by the Pungarehu Canal. The lake is very significant to Waikato-Tainui and surrounding marae. The bed of the lake holds the kōiwi (bones) of people engaged in the Rangiriri Pakanga (battle) during the colonial invasion into the Waikato region. The lake bed is held in the title of the first Māori King, Pōtatau Te Wherowhero so that the bones of the tribe's people are protected in his name. Lake Waikare was historically used to capture tuna (eels) to sustain the iwi. Its surrounding wetlands supplied rongoā (medicine), birds, trees for general use, dyes and an area for enjoyment.<br><br>It is the largest lake in the lower Waikato catchment, with 3442 hectares of open water. It has an average depth of 1.5 metres and a maximum depth of 1.8 metres. Lake Waikare has very poor water quality and is hypertrophic.<br><br>In 1965 the lake level was lowered by one metre. This was in accordance with the Lower Waikato Waipā Flood Control Scheme and followed the construction of an outlet gate. The lake has a vital role in the Lower Waikato Waipā Flood Control Scheme as it acts as a water storage area during times of flood.<br><br>Lake Waikare discharges to the Whangamarino Wetland from the artificial Pungarehu Canal. The lake is managed under a strict seasonal fluctuation regime of approximately 0.3 metres.<br><br>The Lake Waikare South Reserve is a 2ha area of parkland on the eastern side of the lake, owned by Waikato District | |

<table>
<tr><td></td><td>Council. It is currently undeveloped and under-utilised by the community.</td><td></td></tr>
<tr><td>Desired state to achieve the Vision & Strategy</td><td>- The lake is swimmable, fishable and has access for recreation and gathering of kai.<br>- Native aquatic plants dominate the in-lake flora and provide habitat for healthy populations of other indigenous species.<br>- Lake margins retain natural hydrological function and are well vegetated with native plant communities that support indigenous fauna.<br>- Wetlands adjacent to lakes are densely vegetated with native plant species, connected to riparian corridors, protected from stock grazing and native plant regeneration occurs naturally.<br>- Iwi and community have a strong connection to the lake and are active in its use, protection and restoration.</td><td></td></tr>
<tr><td>Impact on Vision & Strategy</td><td>In a restored condition Lake Waikare would have a very high impact on giving effect to the Vision & Strategy at a shallow lakes and central and lower Waikato catchment level.</td><td>VS = 375</td></tr>
<tr><td>Key threats to the feature that this project addresses</td><td><table><tr><th>Key threat</th><th>Impact on feature</th></tr><tr><td>People become disconnected from Lake Waikare</td><td>The lake becomes further degraded.</td></tr><tr><td>Limited access</td><td>People see the area more as a resource than something that needs to be nurtured and cared for.</td></tr></table></td><td></td></tr>
<tr><td>Project goal/s</td><td>Within 5 years of the project commencing, a local amenity park is created in accordance with the Lake Waikare reserve concept landscape plan, resulting in:<br>- 20,600 native plants and 18 fruit trees planted.<br>- Stock 100% excluded from Lake Waikare reserve area.<br>- An 85m length of boardwalk created (approximately 2.5m wide).<br>- A 415m long gravel walkway (approximately 2.5m wide) created.<br>- Two seating areas installed for picnics.<br>- A grassed verge and boat ramp created to allow boat access to the lake.</td><td></td></tr>
<tr><td>Priority works for funding</td><td>Suggested works could be implemented either by an organisation or private citizens (using contractors or their own labour) in collaboration with Waikato District Council. This project could be undertaken as a whole, or in multiple smaller components.</td><td></td></tr>
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|---|---|---|
| | A Waikare reserve concept landscape plan has been developed for the site and is held by Waikato District Council. Works should be undertaken generally in accordance with the concept plan and involve:<br>- construction of a boardwalk along the edge of the lake (approximately 85m long and 2.5m wide), $45,000<br>- construction of a gravel walkway (approximately 415m in length and 2.5m wide), $125,000<br>- fencing approximately 450m to exclude stock from the site with a minimum 5 wire fence with 2 electric wires, $3600<br>- planting approximately 20,600 native trees, averaged at $8.50 per plant including site preparation, plant purchase, planting labour and 5 releasing events, $175,253.<br>- construction of two seating areas for picnicking. The estimated cost for this is $7000 per picnic table, including concrete pad and vandal proof design.<br><br>Resource consent may be required for earthworks and/or boardwalk development. Cost for this are estimated to be no more than $5000.<br><br>**Project management/staffing/incidentals**<br>Staff to carry out landowner liaison, iwi engagement, Health and Safety requirements, negotiate agreements, inspect works, manage parts of the work as required (e.g. fencing or planting), project reporting and financial management. Incidentals include transport, office overheads, consumables and miscellaneous professional fees.<br><br>This is estimated to be 15% of the direct project costs. | |
| Time lag for benefits to be realised | If works were implemented at the planned pace over a 5-year period, it is estimated that the majority of the project benefits would be seen approximately 3 years after project commencement. | L = 3 |
| Effectiveness of works | When compared with desired state, Lake Waikare is currently in very poor condition with few of the Vision & Strategy aspirations being met. The lake is not swimmable, and the presence of pest fish and plant species impacts significantly on ecological integrity. The very poor water quality is an impediment to recreational use of the lake. Despite this the lake still retains very high significance with iwi and the local community and has some important biodiversity values. Some deterioration in the lake is expected over the next 20 years in the absence of this project. This is based on trends in water | W = 0.001 |

<table>
<tr><td></td><td>quality over the past decade which show the in-lake TN has increased 4-fold over this period. This project is small in relation to the size of the lake and the scale of issues, however it can be expected to assist in improving access and recreation opportunities at the lake margins. It doesn't address the majority of threats to the lake and it is acknowledged that achieving the Vision & Strategy desired state for Lake Waikare will take longer than the 20 year horizon used for the purposes of the Restoration Strategy, and a fuller range of initiatives.</td><td></td></tr>
<tr><td>Risk of technical failure</td><td>There is a low risk of project failure due to technical feasibility. Similar projects have been successfully completed at numerous lake sites.</td><td>F = 0.97</td></tr>
<tr><td>Adoptability</td><td>Proposed works are on publicly owned land and are expected to be adopted if fully incentivised. Waikato District Council is supportive of this project.</td><td>A = 1</td></tr>
<tr><td>Information quality</td><td>Good – recommendations and cost estimates were provided by Waikato District Council staff who are involved in the management of the reserve.</td><td></td></tr>
<tr><td>Knowledge gaps</td><td>A full concept plan and associated costing has not been completed and would be required prior to project commencement.</td><td></td></tr>
<tr><td>Socio-political risks</td><td>Moderate risk that the project will fail to meet its goals over the long term due to socio-political risks. There may be concern from the community that resources are being put into development of recreational facilities while the lake itself is in such poor condition.</td><td>P = 0.62</td></tr>
<tr><td>Project duration (years)</td><td>5 years</td><td></td></tr>
<tr><td>Up-front cost – total for implementation phase/project duration</td><td><table>
<tr><th>Task</th><th>Cost ($)</th></tr>
<tr><td>Boardwalk construction (85m)</td><td>45,000</td></tr>
<tr><td>Gravel walkway construction (415m)</td><td>125,000</td></tr>
<tr><td>Fencing (450m)</td><td>3600</td></tr>
<tr><td>Planting (20,600 trees)</td><td>175,253</td></tr>
<tr><td>Picnic area development</td><td>14,000</td></tr>
<tr><td>Resource consent</td><td>5000</td></tr>
<tr><td>Project management/staffing/incidentals (15%)</td><td>55,178</td></tr>
<tr><td>Total</td><td>423,031</td></tr>
</table></td><td>C = 0.42</td></tr>
</table>


Development of Lake Waikare South Reserve for recreation

## WWRRS Project Map

Created by: Tane Desmond
Projection: NZTM
Date: December 2017

Status: Final
Request No.: N/A
File name:WWRRS.gws

0.00 0.04 0.08 0.12 0.16 0.20
Kilometers

Scale 1:4000@A4 Landscape

A4

**ACKNOWLEDGEMENTS AND DISCLAIMERS**



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Te Kaunihera ā Rohe o Waikato

Lake Waikare South Reserve located between Lake Waikare and Waikare Road.

| L 3<br>Priority: High | Biodiversity enhancement of Lake Rotokawau | BCR value |
|---|---|---|
| Relevant goals from Central/Lower Waikato unit and Shallow Lakes unit | Wetlands are protected, enhanced and where feasible expanded and re-established<br><br>Ecosystems, forest fragments and ecological corridors associated with aquatic environments are protected, enhanced and expanded. | |
| Name of feature | Lake Rotokawau (Black Lake) | |
| Brief description of feature | Lake Rotokawau (22ha) lies southwest of Lake Waikare and is connected to the latter by a 500m channel. Rotokawau is a peat lake and is unique amongst the Lower Waikato lakes in that it is completely surrounded by a 145ha wetland reserve, administered by the Department of Conservation (Stewardship Land). Peat in the area is up to 14m thick. The lake and its surrounding wetlands are significant to Waikato-Tainui and surrounding marae. They supplied tuna (eels), rongoā (medicine), birds, trees for general use, dyes and an area for enjoyment.<br><br>Monitoring undertaken in 1983 and 2007/08 showed the lake to be heavily nutrient enriched (hypertrophic). Submerged vegetation within the lake was once dominated by native plants but the lake became de-vegetated in the 1990s.<br><br>The lake has a large wetland margin that extends 170m to 600m from its edge. A number of rare species are known or thought to exist within the wetland and around the margins of the lake including black mudfish (at risk – declining), Australasian bittern (nationally endangered), banded rail (at risk), marsh crake, spotless crake (relict) and North Island fernbird (at risk). No recent detailed botanical surveys have been conducted but nationally threatened plant species may still be present. Previously *Amphibromus fluitans* has been recorded.<br><br>As a result of its hydrological connection with Lake Waikare, and the altered water level controls established through the Lower Waikato Flood Control Scheme, significant lake level fluctuation in Lake Rotokawau and the surrounding wetland have resulted in a substantial decline in biodiversity values and the lake is now hyper-eutrophic. However, the remaining peat bog is rare in type, diverse and considered the largest wetland | |

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|---|---|---|
| | surrounding a lake in the Lower Waikato. Most bogs have been drained and converted to pasture.<br><br>The site is within the top 30% of sites for biodiversity protection within the Waikato catchment because of its terrestrial biodiversity values and its representativeness of this ecosystem type.<br><br>In 2009 a new drain was created to divert the Frost Road drainage area into Lake Waikare directly to reduce nutrient inputs to Lake Rotokawau. The lake continues to receive inputs from the Lake Ohinewai catchment, dairy farmland to the west and south as well as from Lake Waikare.<br><br>Significant farmland adjoining the reserve boundary to the south and west is owned by Solid Energy (the Crown) and Glencoal (a subsidiary of Fonterra). Dairy farm activities from these areas (and other farms) have both direct (grazing of reserve land, peat loss) and indirect effects (drain and groundwater input into the lake of nutrients and sediment, including weed growth due to peat shrinkage on margins). | |
| Desired state to achieve Vision & Strategy | - The lake is swimmable, fishable and has access for recreation and gathering of kai.<br>- Native aquatic plants dominate the in-lake flora and provide habitat for healthy populations of other indigenous species.<br>- Lake margins retain natural hydrological function and are well vegetated with native plant communities that support indigenous fauna.<br>- Wetlands adjacent to lakes are densely vegetated with native plant species, connected to riparian corridors, protected from stock grazing and native plant regeneration occurs naturally.<br>- Iwi and community have a strong connection to the lake and are active in its use, protection and restoration. | |
| Impact on Vision & Strategy | In a restored condition Lake Rotokawau would have a very high impact on giving effect to the Vision & Strategy at a local level. | VS = 20 |

<table>
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<td>Key threats to the feature that this project addresses</td>
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<table>
<tr><th>Key threat</th><th>Impact on feature</th></tr>
<tr><td>Nutrient and sediment inputs from inflowing drains.</td><td>Reduced water quality.</td></tr>
<tr><td>Water levels are controlled beyond that which would occur naturally. Drainage of adjoining farmed peatland.</td><td>Reduced wetland areas, reduced water quality, unnatural hydrological regime. Irrecoverable shrinkage of peat bog habitat.</td></tr>
<tr><td>Weeds – particularly the potential introduction of alligator weed which has been found in the nearby Te Onetea Stream and Whangamarino wetland.</td><td>Compete with native plant communities.</td></tr>
<tr><td>Pest fish</td><td>Reduce lake water quality</td></tr>
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<tr>
<td>Project goal/s</td>
<td>- Within 5 years of the project commencing surface waters from surrounding farmland no longer enter the lake.<br>- Yellow flag iris and alligator weed is prevented from establishing at the wetland site, and other plant pests are reduced to less than 10% coverage.</td>
<td></td>
</tr>
<tr>
<td>Priority works for funding</td>
<td>Suggested works could be implemented either by an organisation or private citizens (using contractors or their own labour) in close collaboration with DOC. This project could be undertaken as a whole, or in multiple smaller components.<br><br>Investigate isolating the lake and its reserve from farmland surface flows<br>The lake continues to receive inputs from the Lake Ohinewai catchment which contributes to lake sediment and nutrient loads.<br><br>An investigation is required to identify what measures are needed to isolate the lake and wetland from farm drains (and overland flow sources) whose inputs are high in sediment and nutrients. Options are likely to include sediment traps, fence realignment, bunds and drain diversion.<br><br>The estimated cost of this investigation is $25,000. Phase 1 ($10,000) would focus on immediate farmland-related management issues and identifying principal sources of flow, fence boundary issues and landowner willingness to participate in restoration.</td>
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| | **Implementation of measures to isolate Lake Rotokawau from surface water flows.**<br>Although it is unknown what the recommended measures will be from the above investigation, an estimate of $140,000 has been made for implementation of any measures. This includes design and resource consent fees.<br><br>**Fencing and re-vegetation**<br>Approximately 571m of fencing is required along the DOC reserve boundary (8-wire post and batten fence) ($9707).<br><br>Riparian fencing and replanting of private land next to the reserve would be required to a minimum standard of 5-wire (2 electric) which is estimated to require 3km of fencing ($24,000) and replanting of approximately 2ha ($75,104).<br><br>**Weed control**<br>Weed control is a key management action required at this site. Terrestrial weeds such as pampas, willow and gorse have been identified at the site and a range of other weeds, including royal fern, are likely to be present.<br><br>In-lake weeds that are a threat at this site include yellow flag iris and alligator weed.<br><br>Department of Conservation estimate the cost for controlling weeds at this site to be $5420 per years for six years ($32,520).<br><br>**Project management/staffing/incidentals**<br>Staff to carry out landowner liaison, iwi engagement, Health and Safety requirements, negotiate agreements, inspect works, manage parts of the work as required (e.g. fencing or planting), project reporting and financial management. Incidentals include transport, office overheads, consumables and miscellaneous professional fees.<br><br>This is estimated to be 20% of the direct project costs. | |
| Time lag for benefits to be realised | If works were implemented at an even pace over a 5-year period, it is estimated that the majority of the project benefits would be seen approximately one year after project completion | L = 7.5 |
| Effectiveness of works | Lake Rotokawau is currently in very poor to poor condition when compared to Vision & Strategy desired state. Water quality and access are poor and the community does not appear to be closely connected to the lake. The lake does | W = 0.03 |

| | | |
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| | however retain significant associated wetland values which are under threat from weeds and hydrological changes. It is anticipated that further degradation in lake and wetland condition could occur over the next 20 years in the absence of this project given the threat of weeds and potential surrounding peat shrinkage. It is acknowledged that achieving the Vision & Strategy desired state at Lake Rotokawau will take longer than the 20-year horizon used for the purposes of the Restoration Strategy, and a fuller range of initiatives over the long term. However, if this project is successfully completed then it is expected that the Lake Rotokawau Wetland condition in 20 years will be improved, and overall this will counter some of the expected deterioration. | |
| Risk of technical failure | There is a moderate risk of project failure due to technical feasibility. There is uncertainty about the feasibility of isolation measures and whether this is technically possible. This will need to be determined by suitably qualified consultants. There are also some risks related to the success of weed control. Weed control will need to be led by experienced practitioners. | F = 0.82 |
| Adoptability | Works on publicly owned land is expected to be adopted if fully incentivised as the Department of Conservation is supportive of this project. Some private landowners may be concerned by loss of marginal grazing areas, however generally the benefits of avoiding loss of stock in wetlands are becoming well recognised. | A = 0.75 |
| Information quality | Good – information and recommendations have come from Department of Conservation staff with knowledge of the site and issues. | |
| Knowledge gaps | All known knowledge gaps have been documented in the project detail. | |
| Socio-political risks | Moderate risk that the project will fail to meet its goals over the long term due to socio-political risks. Consent would be required for isolation measures and this may not get support from affected landowners. Early stakeholder engagement will be very important for the successful delivery of this project. | P= 0.62 |
| Project duration (years) | 5 years | |

<table>
<tr>
<td>Up-front cost – total for implementation phase/project duration</td>
<td>
<table>
<tr><th>Task</th><th>Cost ($)</th></tr>
<tr><td>Investigate isolating the lake from surface flows</td><td>25,000</td></tr>
<tr><td>Implementation of isolation measures</td><td>140,000</td></tr>
<tr><td>Fencing (3.5km) and re-vegetation (2ha)</td><td>108,811</td></tr>
<tr><td>Weed control</td><td>32,520</td></tr>
<tr><td>Project management/staffing/incidentals (20% )</td><td>61,266</td></tr>
<tr><td>Total</td><td>367,597</td></tr>
</table>
</td>
<td>C = 0.37</td>
</tr>
</table>


Biodiversity enhancement of Lake Rotokawau

WWRRS Project Map

Created by: Tane Desmond
Projection: NZTM
Date: December 2017

Status: Final
Request No.: N/A
File name:WWRRS.gws

0.0 0.4 0.8 1.2 1.6 2.0
Kilometers

Scale 1:35,000@A4 Landscape

A4



Waikato REGIONAL COUNCIL
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Lake Rotokawau wetland as seen from Lake Waikare.

Lake Rotokawau Reserve with intensively farmed and drained land in the foreground. The brown coloured pasture was recently flooded.

| L 4<br>Priority: Medium | Enhancement of wetland habitat at Lake Te Kapa and Lake Waiwhata | BCR value |
|---|---|---|
| Relevant goals from Central/Lower Waikato unit and Shallow Lakes unit | A full range of ecosystem types associated with lakes in the catchment are protected and maintained with a focus on high natural environments. | |
| Name of feature | Lakes Te Kapa and Waiwhata | |
| Brief description of feature | Lake Te Kapa (0.7ha) and Lake Waiwhata (2.2ha) are two small peat lakes located between Lake Whangape and Lake Rotongaro-iti, about 10 minutes north of Huntly. Iwi historically accessed these lakes and surrounding wetlands to gather food, clothing and weaving materials, rongoā (medicine), birds and materials for general use. Pā tuna used to adorn the streams of this area.<br><br>Lake Te Kapa is very shallow (maximum depth 1.5m) and very turbid. Water quality was recorded as hypertrophic (TLI = 6.29) in 2015. No submerged plants were found during a survey in 2015. The lake is surrounded by fringe of mostly raupō with mānuka scrub, swamp cypress and grey willow located landward. No threatened or rare plant species were recorded in a 2015 survey of the lake margin.<br><br>Lake Waiwhata is also very shallow (maximum depth 1.5m) and turbid. Water quality was recorded as supertrophic (TLI=5.71) in 2015. No submerged plants were found during a survey in 2015. The lake is surrounded by mostly grey willow (70%) with some raupō (20%) and had a 20m long shoreline dominated by small amphibious plants known as 'turfs'. Two 'at risk' plants were recorded within the turfs.<br><br>Both lakes contain shortfin eels, catfish and common bully but only Waiwhata contained gambusia and goldfish as well. A strongly skewed size structure and large number of harvestable tuna at Te Kapa suggest that fish passage may be inconsistent and/or the lake has been stocked.<br><br>A bird survey hasn't been undertaken at these lakes, however Australasian bittern (nationally endangered) was observed at the lakes in 2015. | |

<table>
<tr><td></td><td>Both lakes are surrounded by extensive wetlands (total 27.46ha) which provide a buffer to the lakes and suitable habitat for a range of native plants and animals. The wetlands are reasonably diverse and are dominated by native plants, however grey willow and other ecosystem-changing weeds are present at low-medium abundance and pose a threat to the diversity and complexity of these wetlands. Not all of the wetland surrounding the lakes has been fenced and some of the fencing that has been done is inadequate for preventing stock access.<br><br>Both the lakes and the surrounding wetlands are privately owned and are not accessible to the public.</td><td></td></tr>
<tr><td>Desired state to achieve Vision & Strategy</td><td>- The lakes are swimmable, fishable and have access for recreation and gathering of kai.<br>- Native aquatic plants dominate the in-lake flora and provide habitat for healthy populations of other indigenous species.<br>- Lake margins retain natural hydrological function and are well vegetated with native plant communities that support indigenous fauna.<br>- Wetlands adjacent to lakes are densely vegetated with native plant species, connected to riparian corridors, protected from stock grazing and native plant regeneration occurs naturally.<br>- Iwi and community have a strong connection to the lakes and are active in their protection and restoration.</td><td></td></tr>
<tr><td>Impact on Vision & Strategy</td><td>In a restored condition these two lakes and associated wetlands would have a high impact on giving effect to the Vision & Strategy at a local level.</td><td>VS = 3</td></tr>
<tr><td>Key threats to the feature that this project addresses</td><td><table>
<tr><th>Key Threat</th><th>Impact on Feature</th></tr>
<tr><td>Stock access</td><td>Destruction of native plant communities, introduction of weed species. Direct inputs of nutrient and microbes into lakes.</td></tr>
<tr><td>Willow trees</td><td>Shade out native species and spread to other sites.</td></tr>
<tr><td>Weed species</td><td>Compete with native plant communities and are a threat to agriculture.</td></tr>
<tr><td>Further drainage and clearance of native wetland vegetation.</td><td>Reduced habitat for native plants and animals and game birds. Loss of nutrient attenuation areas, and loss of wetland areas to slow flood flows.</td></tr>
</table></td><td></td></tr>
<tr><td>Project goal/s</td><td>Within 2 years wetlands adjoining Lakes Te Kapa and Waiwhata are 100% fenced and protected from stock and drainage.</td><td></td></tr>
</table>

| | | |
|---|---|---|
| | Within 5 years wetlands adjoining Lakes Te Kapa and Waiwhata are mostly (i.e. > 90% cover) comprised of native plant communities. | |
| Priority works for funding | Suggested works could be implemented either by an organisation or private citizens (using contractors or their own labour). This project could be undertaken as a whole, or in multiple smaller components.<br><br>**Fencing:** Fencing should occur at the landward extent of wetlands. It can sometimes be difficult to accurately locate wetland margin. A wetland ecologist may be needed to determine the boundary.<br><br>**Willow control:** Willow control should be undertaken using ground based methods to minimise off-target damage. This is likely to be two stage process with all willows controlled in the first year and follow-up weed control to 'mop up' any willows that were not successfully killed in the first year.<br><br>**Weed control:** The wetlands contain several ecosystem changing weeds, including royal fern, gorse and blackberry. These weeds will need to be reduced to very low levels over a period of two years before any native planting occurs.<br><br>**Planting:** Native planting should be carried out within existing open areas and in areas where weed removal has created open areas. Planting at 1.5m spacing is recommended, matching wetland species with flooding depth and duration. All native plants should be species that naturally occur in the Meremere Ecological District.<br><br>Assumptions and cost estimates for the two wetlands can be found below:<br>Te Kapa Wetland – (20.3 ha, 3.7km perimeter)<br>- Assume 750m requires fencing at $25 per metre ($18,750)<br>- Assume 15% (3.05ha) of the wetland requires ground based willow control over 2 years at $4000 per hectare. In the second year it is assumed that approximately 0.5ha will need to be retreated ($14,200).<br>- Additional weed control using a knapsack over 30% (6.1ha) of the area over 3 years at $5000 per hectare in Year 1, $2500 per hectares in Years 2 and 3 ($61,000)<br>- Assumes 15% of the area (3.05ha) requires native planting at $37,552 per hectare ($114,533). | |

| | | |
|---|---|---|
| | - Assumes 15% (3.05ha) of the area requires native planting in areas where 2 years of weed control has been carried out prior ($114,533)<br>- Possum control (for plant establishment) over the 20.3ha site over 3 years ($12,180).<br><br>Waiwhata Wetland – (7.16 ha, 2km perimeter)<br>- Assume 20% (400m) requires fencing ($10,000)<br>- Assume 20% (1.4ha) requires ground based willow control over 2 years at $4,000 per hectare. In the second year it is assumed that approximately 0.5ha will need to be retreated ($7,600)<br>- Additional weed control using a knapsac over 10% (0.7ha) of the area over 3 years at $5,000 per hectare in Year 1, $2,500 per hectare in Year two and 3 ($7,000)<br>- Assume 5% (0.35ha) of the area requires native planting at $37,552 per hectare ($13,143)<br>- Possum control (for plant establishment) over the 7.16ha site over 3 years ($4,296)<br><br>**Project management/staffing/incidentals**<br>Staff to carry out landowner liaison, iwi engagement, Health and Safety requirements, negotiate agreements, inspect works, manage parts of the work as required (e.g. fencing or planting), project reporting and financial management. Incidentals include transport, office overheads, consumables and miscellaneous professional fees.<br><br>This is estimated to be 25% of the direct project costs. | |
| Time lag for benefits to be realised | If works were implemented at an even pace over a 5-year period, it is estimated that the majority of the project benefits would be seen approximately 2-3 years after project completion. | L = 7.5 |
| Effectiveness of works | These lakes are currently in poor condition when compared to desired state. However, both lakes have extensive marginal wetlands that are in moderate condition. Overall condition is expected to deteriorate over the next 20 years in the absence of this project – particularly as a result of increased pest plant dominance. If this project is successfully completed, biodiversity values will improve at these lakes and this is expected to offset potential decline and contribute to a small improvement in condition. It is acknowledged that achieving the overall Vision & Strategy desired state will take longer than the 20-year horizon used for the purposes of the Restoration Strategy, and a fuller range of initiatives over the long term. | W = 0.05 |

<table>
<tr><td>Risk of technical failure</td><td>There is a moderate risk of project failure due to technical feasibility. Risks are mostly related to the success of weed control. Weed control will need to be led by experienced practitioners to reduce the level of risk to project success.</td><td>F = 0.82</td></tr>
<tr><td>Adoptability</td><td>There are 3 landowners around these sites. It is estimated that two-thirds of landowners would adopt the works if they were fully incentivised. Some may be concerned by loss of marginal grazing areas however generally the benefits of avoiding loss of stock in wetlands are becoming well recognised.</td><td>A = 0.65</td></tr>
<tr><td>Information quality</td><td>Average – recommendations are based on the judgement of a wetland ecologist with knowledge of the sites. Quantities of work required are predominantly based on estimates made from aerial photographs.</td><td></td></tr>
<tr><td>Knowledge gaps</td><td>Extent of weeds and fencing has been estimated from aerial photographs. Specific requirements would need to be determined during project planning.</td><td></td></tr>
<tr><td>Socio-political risks</td><td>Very low risk that the project will fail to meet its goals over the long term due to socio-political risks.</td><td>P = 0.97</td></tr>
<tr><td>Project duration (years)</td><td>5 years</td><td></td></tr>
<tr><td>Up-front cost – total for implementation phase/project duration</td><td>
<table>
<tr><th>Task</th><th>Cost ($)</th></tr>
<tr><td>Te Kapa Wetland</td><td></td></tr>
<tr><td>Fencing (750m)</td><td>18,750</td></tr>
<tr><td>Planting (6.1ha)</td><td>114,533</td></tr>
<tr><td>Weed control</td><td>75,200</td></tr>
<tr><td>Possum control</td><td>12,180</td></tr>
<tr><td>Te Kapa Wetland Total</td><td>220,663</td></tr>
<tr><td>Waiwhata Wetland</td><td></td></tr>
<tr><td>Fencing (400m)</td><td>10,000</td></tr>
<tr><td>Planting (0.35ha)</td><td>13,143</td></tr>
<tr><td>Weed control</td><td>14,600</td></tr>
<tr><td>Possum control</td><td>4296</td></tr>
<tr><td>Waiwhata Wetland Total</td><td>40,039</td></tr>
<tr><td>Project management/staffing/incidentals (25%)</td><td>65,175</td></tr>
<tr><td>Total</td><td>325,877</td></tr>
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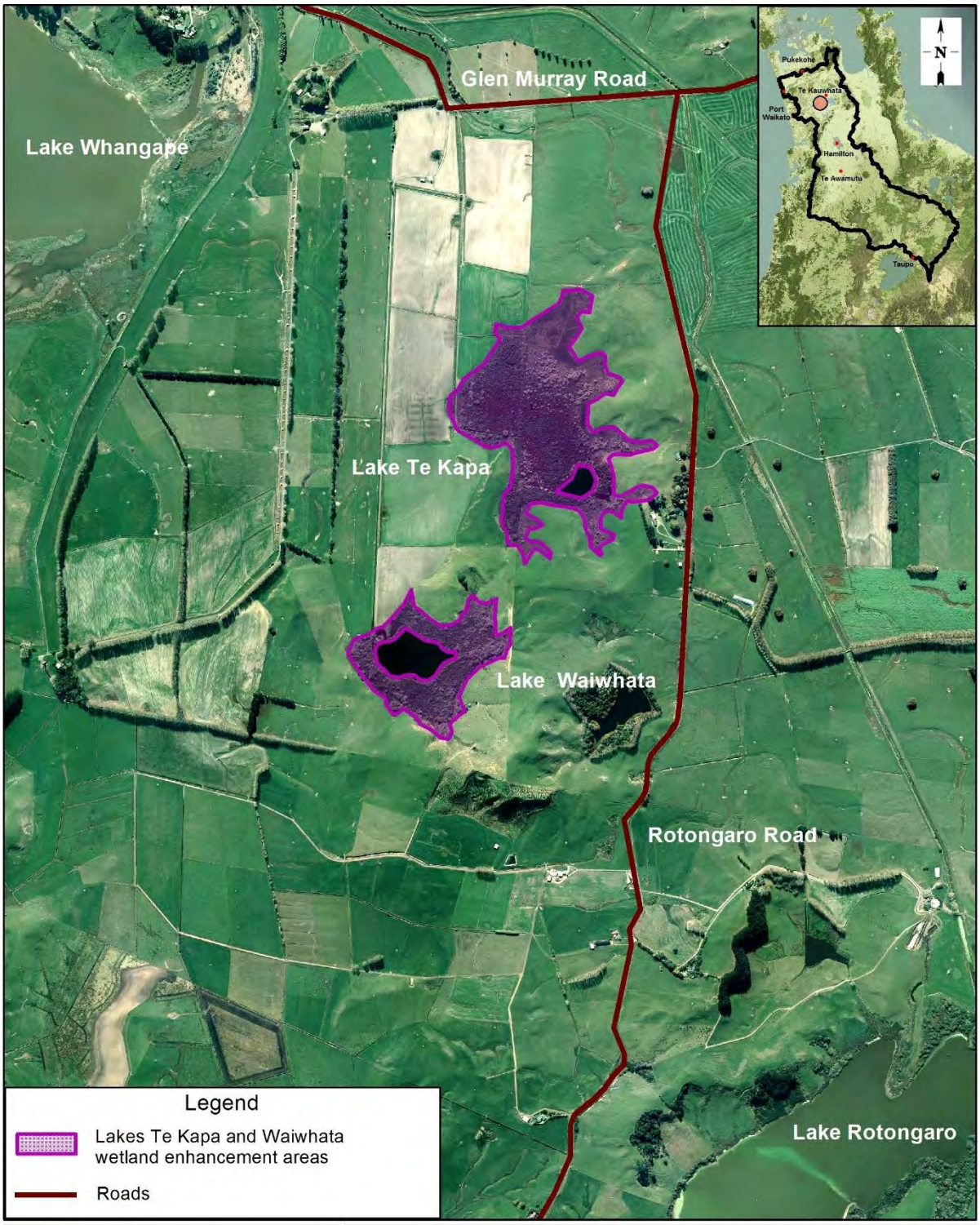
</td><td>C = 0.33</td></tr>
</table>




Enhancement of wetland habitat at Lake Te Kapa and Lake Waiwhata

## WWRRS Project Map

Created by: Tane Desmond
Projection: NZTM
Date: December 2017
Status: Final
Request No.: N/A
File name: WWRRS.gws

0.0 0.1 0.2 0.3 0.4 0.5
Kilometers

Scale 1:15,000@A4 Portrait

A4



Waikato REGIONAL COUNCIL
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In the centre of the foreground surrounded by a large wetland is Lake Te Kapa. To the left of this is Lake Waiwhata, also surrounded by wetland. Lake Whangape is shown in the background.

Lake Te Kapa and the western area of surrounding wetland. It is proposed to control willows (grey trees) at this lake along with other weeds.

Lake Waiwhata and the surrounding wetland. It is proposed to control willows (grey trees) at this lake to protect and enhance the mānuka shrubland and sedges surrounding this lake.

| L 5<br>Priority: High | Increase eel habitat in Lake Ohinewai | BCR value |
|---|---|---|
| Relevant goals from Central/Lower Waikato unit and Shallow Lakes unit | Aquatic habitats, including spawning grounds, are protected, enhanced, restored and accessible to native fish.<br><br>The abundance of native fish, including taonga species, in the catchment is restored and protected. | |
| Name of feature | Lake Ohinewai | |
| Brief description of feature | Lake Ohinewai is a shallow (4.5m deep) 16ha peat lake located within a pastoral catchment (347ha in size) near the township of Ohinewai.<br><br>The lake is fed by a single major drain entering the lake from the southwest and drains from its northeastern end into Lake Rotokawau, which is subsequently connected to Lake Waikare.<br><br>The lake is administered by DOC and has been fully fenced to exclude stock. The fenced margin has also recently been extensively planted with native species. Next to the lake is a 52ha Waikato District Council reserve which is currently grazed. A paper road also extends from Tahuna Road to Lake Ohinewai.<br><br>Native fish species recorded in the lake include common bully and longfin eel although their habitat has been dramatically reduced through land drainage and the lowering of the lake level.<br><br>The lake bed has been de-vegetated since 1991 and pest fish are an issue within the lake. The University of Waikato has recently undertaken an intensive research programme to test methods for mass removal of koi carp as a lake restoration tool.<br><br>Lake water quality is poor and the lake is considered hypertrophic (having high nutrient concentrations).<br><br>This project involves creation of tuna habitat within the lake. Anecdotal evidence from New Zealand shows that in lakes and rivers, eels are always found where there is cover. Trials of wood installation in streams have shown benefits for a range of species so scientists expect there to be habitat benefits for a range of biota in lakes (including tuna).<br><br>Research from overseas looking at the benefits of introducing woody structure also supports this concept. | |

<table>
<tr><td>Desired state to achieve Vision & Strategy</td><td>- The lake is swimmable, fishable and has access for recreation and gathering of kai.<br>- Native aquatic plants dominate the in-lake flora and provide habitat for healthy populations of other indigenous species.<br>- Lake margins retain natural hydrological function and are well vegetated with native plant communities that support indigenous fauna.<br>- Wetlands adjacent to lakes are densely vegetated with native plant species, connected to riparian corridors, protected from stock grazing and native plant regeneration occurs naturally.<br>- Iwi and community have a strong connection to the lake and are active in its use, protection and restoration.</td><td></td></tr>
<tr><td>Impact on Vision & Strategy</td><td>In a restored condition Lake Ohinewai would have a very high impact on giving effect to the Vision & Strategy at a local level.</td><td>VS = 5</td></tr>
<tr><td>Key threats to the feature that this project addresses</td><td><table><tr><th>Key threat</th><th>Impact on feature</th></tr><tr><td>Lack of in-lake vegetation</td><td>Reduced habitat for native fish, increased resuspension of sediments and reduced water quality.</td></tr><tr><td>People become disconnected from the lake</td><td>The lake becomes further degraded. People stop using the lake for recreation.</td></tr></table></td><td></td></tr>
<tr><td>Project goal/s</td><td>Within 5 years of the project commencing at least 6 woody structures provide habitat for tuna in Lake Ohinewai</td><td></td></tr>
<tr><td>Priority works for funding</td><td>Suggested works could be implemented either by an organisation or private citizens (using contractors or their own labour) in close collaboration with DOC. This project could be undertaken as a whole, or in multiple smaller components.<br><br>Investigation and design<br>Installation of woody structures for tuna habitat is recommended at Lake Ohinewai. The exact location and design for these structures needs to be determined as part of the project. These should be designed in a manner that will also maximize opportunities for reducing wave action and bank erosion.<br><br>One location that has been suggested by tuna experts but requires further investigation is at the west end of the lake (see photo below). The cost estimated for investigation and design is $10,000.</td><td></td></tr>
</table>

Suggested locations for woody structures.

**Installation of structures for fish habitat**

Details around the number and location of structures to be installed will be determined by the investigation and design phase of this project. However, for the purpose of providing a cost estimate the project assumes installation of between 6 and 9 woody debris structures. Costs are based on the cost estimates for installing woody debris structures in streams ($30,000).

**Resource Consent fees**

Resource consent may be required from Waikato Regional Council for this work. Resource consent related costs are estimated at $15,000. This would include cultural assessment (if required), consent application preparation and consent fees. Costs associated with consultation are incorporated into the project management costs below.

**Monitoring**

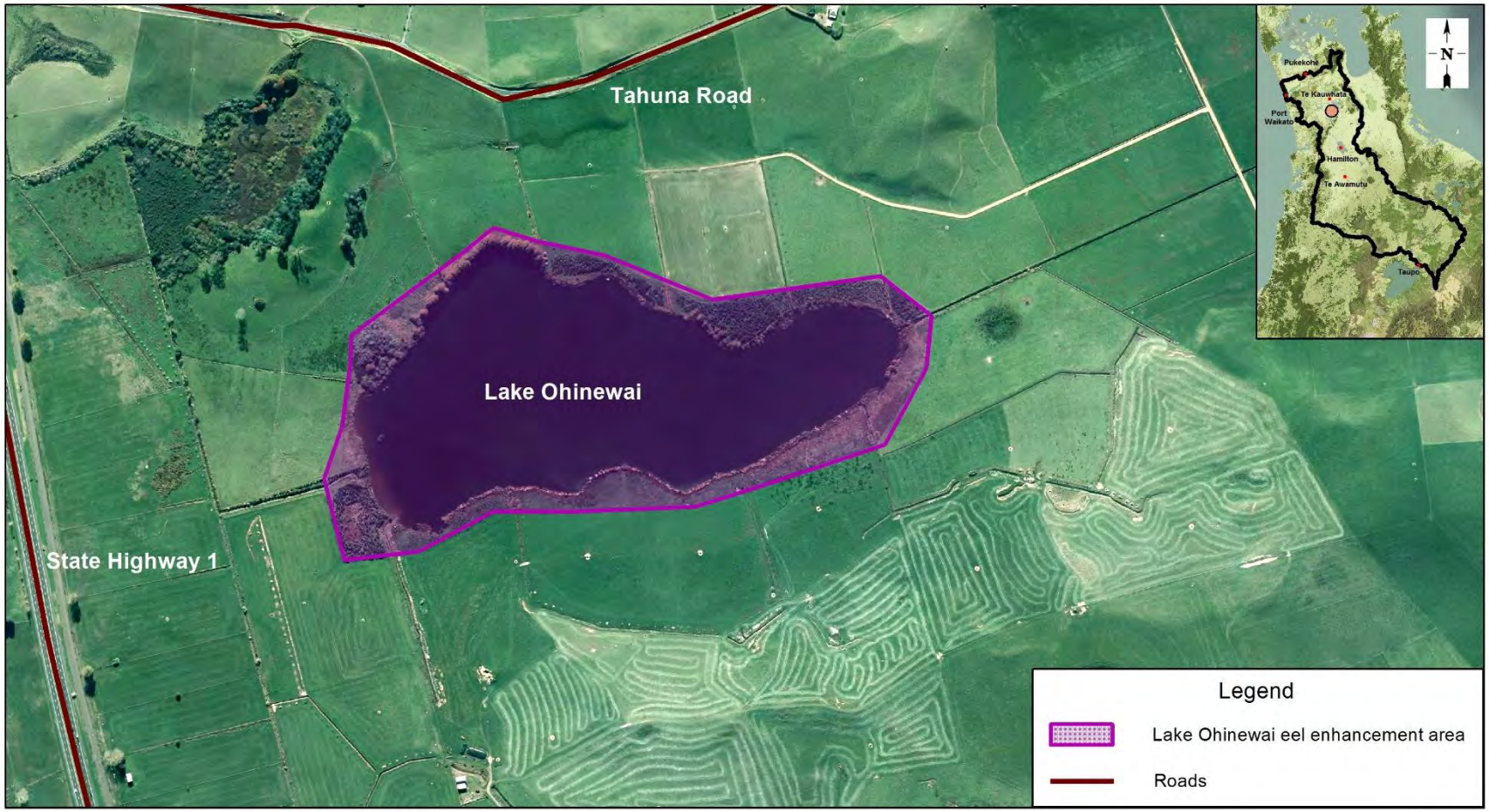
This project would benefit from pre and post construction monitoring to quantify the extent to which introduced structures provide habitat for tuna and other species, however this has not been costed as it is out of scope for the Restoration Strategy.

**Project management/staffing/incidentals**

Staff to carry out landowner liaison, iwi engagement, Health and Safety requirements, negotiate agreements, inspect works, manage parts of the work as required (e.g. fencing or planting), project reporting and financial management. Incidentals include transport, office overheads, consumables and miscellaneous professional fees.

This is estimated to be 25% of the direct project costs.

<table>
<tr><td>Time lag for benefits to be realised</td><td>If works were implemented at an even pace over a 2-year period, it is estimated that the majority of the project benefits would be seen at project commencement.</td><td>L = 2</td></tr>
<tr><td>Effectiveness of works</td><td>When compared with desired state Lake Ohinewai is currently in very poor condition with few of the Vision & Strategy aspirations being met. The lake is not swimmable, access is difficult and the presence of pest fish impacts significantly on ecological integrity. The poor water quality is an impediment to recreational use of the lake. Condition is not expected to change significantly over the next 20 years in the absence of this project. Proposed works are minor but can be expected to have a localised impact on tuna habitat availability. The project doesn't address the majority of threats to the lake and it is acknowledged that achieving the Vision & Strategy desired state for Lake Ohinewai will take longer than the 20 year horizon used for the purposes of the Restoration Strategy and a fuller range of initiatives.</td><td>W = 0.01</td></tr>
<tr><td>Risk of technical failure</td><td>There is a moderate risk of project failure due to technical feasibility. There is some uncertainty on how effective this technique will be in increasing tuna numbers in the lake.</td><td>F = 0.82</td></tr>
<tr><td>Adoptability</td><td>The lake is publicly owned and therefore it is anticipated that works would be adopted if they were fully incentivised.</td><td>A = 1</td></tr>
<tr><td>Information quality</td><td>Average – advice of subject matter expert/s based on experience in New Zealand and internationally.</td><td></td></tr>
<tr><td>Knowledge gaps</td><td>No known knowledge gaps other than those related to effectiveness and technical feasibility.</td><td></td></tr>
<tr><td>Socio-political risks</td><td>Very low risk that the project will fail to meet its goals over the long term due to socio-political risks.</td><td>P = 0.97</td></tr>
<tr><td>Project duration (years)</td><td>2 years</td><td></td></tr>
<tr><td>Up-front cost – total for implementation phase/project duration</td><td>
<table>
<tr><th>Task</th><th>Cost ($)</th></tr>
<tr><td>Lake Ohinewai</td><td></td></tr>
<tr><td>- Investigation and design</td><td>10,000</td></tr>
<tr><td>- Installation of structures</td><td>30,000</td></tr>
<tr><td>- Resource consent</td><td>15,000</td></tr>
<tr><td>Project Management/staffing/incidentals (25%)</td><td>13,750</td></tr>
<tr><td>Total</td><td>55,000</td></tr>
</table>
</td><td>C = 0.06</td></tr>
</table>




Increase Eel habitat in Lake Ohinewai

WWRRS Project Map

Created by: Tane Desmond
Projection: NZTM
Date: December 2017

Status: Final
Request No.: N/A
File name:WWRRS.gws

0.0 0.1 0.2 0.3 0.4
Kilometers

Scale 1:7,500@A4 Landscape

A4



Waikato REGIONAL COUNCIL
Te Kaunihera ā Rohe o Waikato

Lake Ohinewai.

| L 6<br>Priority: Medium | Development of Lake Ohinewai Reserve for recreation | BCR value |
|---|---|---|
| Relevant goals from Central/Lower Waikato unit and Shallow Lakes unit | Places that provide for safe recreational activities are identified and accessible. | |
| Name of feature | Lake Ohinewai | |
| Brief description of feature | Lake Ohinewai is a shallow (4.5m deep) 16ha peat lake located within a pastoral catchment (347ha in size) near the township of Ohinewai on the outskirts of the Ohinewai Peat Bog. It is of cultural significance to Ngāti Hine and Ngāti Naho, who accessed these lakes and historic wetlands to gather food, clothing and weaving materials, rongoā (medicine), birds and materials for general use.<br><br>The lake is fed by a single major drain entering the lake from the southwest and drains from its northeastern end into Lake Rotokawau, which is subsequently connected to Lake Waikare.<br><br>The lake is owned by DOC and has been fully fenced to exclude stock. The fenced margin has also recently been extensively planted with native species. Next to the lake is a 52ha Waikato District Council reserve which is currently grazed. A paper road also extends from Tahuna Road to Lake Ohinewai.<br><br>Native fish species recorded in the lake include common bully and longfin eel although their habitat has been dramatically reduced through land drainage and the lowering of the lake level.<br><br>The lake bed has been de-vegetated since 1991 and pest fish are an issue within the lake. The University of Waikato has recently undertaken an intensive research programme to test methods for mass removal of koi carp as a lake restoration tool.<br><br>Lake water quality is poor and the lake is considered hypertrophic (having high nutrient concentrations). | |
| Desired state to achieve the Vision & Strategy | The lake has a riparian margin well vegetated with native plant species and is a minimum of 50m wide.<br><br>Residents and visitors are able to access and recreate in the reserve and in the waters of the lake. The lake is swimmable, fishable and has a healthy population of native fish. | |

<table>
<tr><td>Impact on Vision & Strategy</td><td>In a restored condition Lake Ohinewai would have a very high impact on giving effect to the Vision & Strategy at a local level.</td><td>VS = 5</td></tr>
<tr><td>Key threats to the feature that this project addresses</td><td><table><tr><th>Key threat</th><th>Impact on feature</th></tr><tr><td>Opportunities for public recreation next to waterway not realised</td><td>People are disconnected from Lake Ohinewai and the lake becomes further degraded.</td></tr><tr><td>Weed species</td><td>Compete with native plant communities.</td></tr></table></td><td></td></tr>
<tr><td>Project goal/s</td><td>Within 10 years:<br>- A local amenity park is created providing public access to Lake Ohinewai via a sealed access road and car park.<br>- Approximately 25ha of district council reserve land is retired from grazing and revegetated with native plant species.<br>- The park contains a picnic area with picnic tables and lake access points for recreation such as fishing.<br>- There is a gravel path created around the perimeter of Lake Ohinewai for public recreation.</td><td></td></tr>
<tr><td>Priority works for funding</td><td>Suggested works could be implemented either by an organisation or private citizens (in close consultation with Waikato District Council). This project could be undertaken as a whole, or in multiple smaller components.<br><br>Concept plan development<br>Prior to any work taking place a full concept plan and costings should be developed for the reserve area. The costs provided below are estimates only. The estimated cost for development of a concept plan is $10,000.<br><br>Works required<br>On the ground works and actions required include:<br><br><u>Stage 1</u><br>- Construction of a 250m long sealed access road along current paper road and parking area at the end ($120,000).<br><br><u>Stage 2</u><br>- Removal of stock from the district council reserve.<br>- Re-vegetation of a 25ha area with native plants ($938,800).<br><br><u>Stage 3</u><br>- Install approximately 3km of gravel walking track around the perimeter of Lake Ohinewai ($600,000) including construction of bridges over inflowing drains.</td><td></td></tr>
</table>

| | | |
|---|---|---|
| | - Installation of 6 picnic tables and viewing areas (42,000).<br>- Installation of 3 interpretive signs ($5000).<br><br><u>Stage 4</u><br>- Additional planting and installation of amenity structures. Amenity structures include a jetty for lake access and potentially other lake access points. The estimated cost of this is $30,000 including resource consent.<br><br>**Project management/staffing/incidentals**<br>Staff to carry out landowner liaison, iwi engagement, Health and Safety requirements, negotiate agreements, inspect works, manage parts of the work as required (e.g. fencing or planting), project reporting and financial management. Incidentals include transport, office overheads, consumables and miscellaneous professional fees.<br><br>This is estimated to be 20% of the direct project costs. | |
| Time lag for benefits to be realised | If works were implemented at the planned pace over a 10-year period, it is estimated that the majority of the project benefits would be seen approximately 6 years after project commencement. | L = 6 |
| Effectiveness of works | When compared with desired state, Lake Ohinewai is currently in very poor condition with few of the Vision & Strategy aspirations being met. The lake is not swimmable, access is difficult and the presence of pest fish impacts significantly on ecological integrity. The poor water quality is an impediment to recreational use of the lake. Condition is not expected to change significantly over the next 20 years in the absence of this project. Proposed works focus on access and user experience at the lake, and will also have benefits to biodiversity. The project doesn't address other key threats and it is acknowledged that achieving the Vision & Strategy desired state for Lake Ohinewai will take longer than the 20 year horizon used for the purposes of the Restoration Strategy, and a fuller range of initiatives. However, if the project is completed Lake Ohinewai would have good access and a large reserve for visitors to enjoy. It is expected that this would move the lake closer to the Vision & Strategy desired state in 20 years' time. | W = 0.125 |
| Risk of technical failure | There is a low risk of project failure due to technical feasibility. Similar projects have been successfully completed at numerous lake sites. | F = 0.87 |
| Works by private citizens – likelihood of | Landowner is supportive. | A = 1 |

<table>
<tr><td>adoption and adoption circumstances</td><td></td><td></td></tr>
<tr><td>Information quality</td><td>Good – recommendations and cost estimates were provided by Waikato District Council staff who are involved in the management of the reserve.</td><td></td></tr>
<tr><td>Knowledge gaps</td><td>A full concept plan and associated costing has not been completed and would be required prior to project commencement.</td><td></td></tr>
<tr><td>Socio-political risks</td><td>Low risk that the project will fail to meet its goals over the long term due to socio-political risks. This project delivers on the community's aspirations for greater recreational opportunities around waterways.</td><td>P = 0.85</td></tr>
<tr><td>Project duration (years)</td><td>10 years</td><td></td></tr>
<tr><td>Up-front cost – total for implementation phase/project duration</td><td><table>
<tr><th>Task</th><th>Cost ($)</th></tr>
<tr><td>Development of concept plan</td><td>10,000</td></tr>
<tr><td>Stage1 – Access road construction</td><td>120,000</td></tr>
<tr><td>Stage 2 – Re-vegetation (25ha)</td><td>938,800</td></tr>
<tr><td>Stage 3 - Installation of walkways, picnic and viewing areas</td><td>647,000</td></tr>
<tr><td>Stage 4 - Additional planting and installation of amenity structures</td><td>30,000</td></tr>
<tr><td>Project Management/staffing/incidentals (20%)</td><td>349,160</td></tr>
<tr><td>TOTAL</td><td>2,094,960</td></tr>
</table></td><td>C = 2.09</td></tr>
</table>


Development of Lake Ohinewai Reserve for recreation

## WWRRS Project Map

Created by: Tane Desmond
Projection: NZTM
Date: December 2017

Status: Final
Request No.: N/A
File name:WWRRS.gws

0.000 0.075 0.150 0.225 0.300 0.375
Kilometers

Scale 1:7,500@A4 Landscape

A4

**ACKNOWLEDGEMENTS AND DISCLAIMERS**



Waikato REGIONAL COUNCIL
Te Kaunihera ā Rohe o Waikato

Western end of Lake Ohinewai showing approximate location of district council reserve land

| L 7<br>Priority: High | Restoring minimum water level at Lake Kimihia | BCR value |
|---|---|---|
| Relevant goals from Central/Lower Waikato unit and Shallow Lakes unit | Natural hydrology at key lakes is restored including through enhancing the size and extent of wetlands and margins and increasing water levels. | |
| Name of feature | Lake Kimihia | |
| Brief description of feature | Lake Kimihia is a medium sized (44ha) riverine lake on the northeastern outskirts of Huntly. It discharges to the Waikato River just north of Fisher Rd under SH1. The lake was originally 318ha but has been greatly modified as result of open cast mining. It is currently extremely shallow (< 0.8m) and very turbid. Water quality sampling in 2006/07 indicated that the lake is hypertrophic with an estimated TLI of 7.4. It does not support submerged plants.<br><br>The lake is very significant to the iwi, in particular Ngāti Naho, Ngāti Mahuta and Ngāti Whāwhākia. The name "kimihia" means to seek or search. It refers to a "right of passage" activity used by the iwi to determine the fittest and strongest of the young men, and ensure the mana of the iwi is maintained. There are historic pā sites near the lake which also provided sustenance and resources to iwi.<br><br>Lake Kimihia has a large catchment (1485ha). The main land uses are native forest (41%) and dry stock farming. The Waikato Expressway is currently being constructed along the southern margin of the lake and cuts through the southern part of the catchment. The lake is surrounded by 31ha of wetland which has only recently been fully fenced. It contains a reasonable diversity of native plant species which are threatened by the increasing abundance of weeds such as grey willow, primrose willow and blackberry. Several restoration projects are being carried out around the lake to improve the condition of the wetlands.<br><br>An unconsented weir was built at Lake Kimihia in the 1980s after agreement was reached on setting a minimum lake level (8.0m Moturiki Datum). It is positioned at the western end of the lake and is flanked by a bund along the lake margin that was possibly formed when an artificial watercourse was excavated along this edge. The weir and bund have not been maintained | |

<table>
<tr><td></td><td>and are no longer functioning. As a result, water levels in the lake sometimes drop considerably below the 8.0m minimum lake level that is listed in the Waikato Regional Plan. This is likely to further degrade water quality in the lake and affect wetland habitat.</td><td></td></tr>
<tr><td>Desired state to achieve Vision & Strategy</td><td>- The lake is fishable and has access for recreation and gathering of kai.<br>- Native aquatic plants dominate the in-lake flora and provide habitat for healthy populations of other indigenous species.<br>- Lake margins retain natural hydrological function and are well vegetated with native plant communities that support indigenous fauna.<br>- Wetlands adjacent to lakes are densely vegetated with native plant species, connected to riparian corridors, protected from stock grazing and native plant regeneration occurs naturally.<br>- Iwi and community have a strong connection to the lake and are active in its use, protection and restoration.</td><td></td></tr>
<tr><td>Impact on Vision & Strategy</td><td>In a restored condition, Lake Kimihia would have a very high impact on giving effect to the Vision & Strategy at a local level.</td><td>VS = 24</td></tr>
<tr><td>Key threats to the feature that this project addresses</td><td><table><tr><th>Key threat</th><th>Impact on feature</th></tr><tr><td>Further drainage of the lake.</td><td>Reduced habitat for native plants and animals and game birds. Degradation of water quality, particularly turbidity.</td></tr><tr><td>Pest fish</td><td>Contribute to re-suspension of sediment in the lake resulting in degradation of water quality, particularly turbidity.</td></tr><tr><td>Diffuse pollution from catchment land use</td><td>Further degradation of water quality due to increases in nutrients, sediment and harmful microbes.</td></tr></table></td><td></td></tr>
<tr><td>Project goal/s</td><td>Raise the minimum lake level at Kimihia to 8.0m (Moturiki Datum).</td><td></td></tr>
<tr><td>Priority works for funding</td><td>Suggested works should be undertaken by or in collaboration with an organisation with experience in bund design and construction.<br><br>This project will require an investigation to determine the most feasible method to repair/install a bund and weir along the western margin of the lake. This is likely to require some initial site investigation to determine ground levels.</td><td></td></tr>
</table>

| | | |
|---|---|---|
| | Results of the site investigation will be used to undertake hydrological modelling to determine the height of the bund and the design of the weir.<br><br>The length of the bund is likely to be the same length as the western lake margin (about 600m). It is anticipated that the bund could be built from sediment located close to the site. As the site is bounded by water on both sides (lake to the east, artificial watercourse to the west) and would be occurring within a wetland, it is likely that additional costs will be incurred to provide access to the site for heavy machinery.<br><br>It is proposed to build a wooden weir at the site.<br><br>Consent will be required to undertake the earthworks associated with building the bund and to construct a new weir. Consultation with tāngata whenua and adjoining landowner is likely to be required as part of the consent process.<br><br>**Project management/staffing/incidentals**<br>Staff to carry out landowner liaison, iwi engagement, Health and Safety requirements, negotiate agreements, inspect works, manage parts of the work as required (e.g. fencing or planting), project reporting and financial management. Incidentals include transport, office overheads, consumables and miscellaneous professional fees.<br><br>This is estimated to be 20% of the direct project costs. | |
| Time lag for benefits to be realised | If works were implemented at an even pace over a 2-year period, it is estimated that the majority of the project benefits would be seen at project completion. | L = 2 |
| Effectiveness of works | When compared with desired state, Lake Kimihia is currently in very poor condition with few of the Vision & Strategy aspirations being met. The lake is not swimmable, has been heavily modified and the presence of pest fish and pest plant species impacts significantly on ecological integrity. The very poor water quality is an impediment to safe recreational use of the lake. However, the lake still retains very high significance with iwi and has good populations of tuna. The lake is not expected to change in overall condition over the next 20 years in the absence of this project given its already highly degraded state and some existing riparian restoration efforts. This project focuses solely on re-establishing a minimum water level for the lake. It doesn't address the majority of threats to the lake and it is acknowledged that achieving the Vision & Strategy | W = 0.01 |

<table>
<tr><td></td><td>desired state for Lake Kimihia will take longer than the 20 year horizon used for the purposes of the Restoration Strategy and a fuller range of initiatives. However, if completed the works are expected to facilitate a very small improvement in condition over the next 20 years.</td><td></td></tr>
<tr><td>Risk of technical failure</td><td>There is a very low risk of project failure due to technical feasibility if works are designed and constructed by experienced and qualified contractors. Weirs have been constructed successfully at many Waikato shallow lake outlets.</td><td>F = 0.92</td></tr>
<tr><td>Adoptability</td><td>Works are expected to be adopted if fully incentivised. The land is publicly owned and the minimum lake level is set in the Waikato Regional Plan.</td><td>A = 1</td></tr>
<tr><td>Information quality</td><td>Very good – the site has been investigated by regional council lake management advisor and DOC senior ranger. Regional council engineers have provided advice on the costs of the different components of the project.</td><td></td></tr>
<tr><td>Knowledge gaps</td><td>Site constraints that could hinder the construction of a weir and bund. The work needs to be carried out in lake and may be logistically difficult. This will need to be assessed by appropriately qualified people.</td><td></td></tr>
<tr><td>Socio-political risks</td><td>Moderate risk that the project will fail to meet its goals over the long term due to socio-political risks. There could be concerns from surrounding landowners about flooding and this will need to be addressed through a consultation process.</td><td>P = 0.62</td></tr>
<tr><td>Project duration (years)</td><td>2 years</td><td></td></tr>
<tr><td>Up-front cost – total for implementation phase/project duration</td><td>
<table>
<tr><th>Task</th><th>Cost ($)</th></tr>
<tr><td>Site investigation, survey of ground levels</td><td>10,000</td></tr>
<tr><td>Design specification and plans for bund and weir</td><td>20,000</td></tr>
<tr><td>Consent preparation, consent fees stakeholder consultation</td><td>35,000</td></tr>
<tr><td>Bund construction</td><td>20,000</td></tr>
<tr><td>Weir construction</td><td>20,000</td></tr>
<tr><td>Annual maintenance of bund and weir (for 10 years)</td><td>10,000</td></tr>
<tr><td>Project management/staffing/incidentals</td><td>25,000</td></tr>
<tr><td>Total</td><td>150,000</td></tr>
</table>
</td><td>C = 0.15</td></tr>
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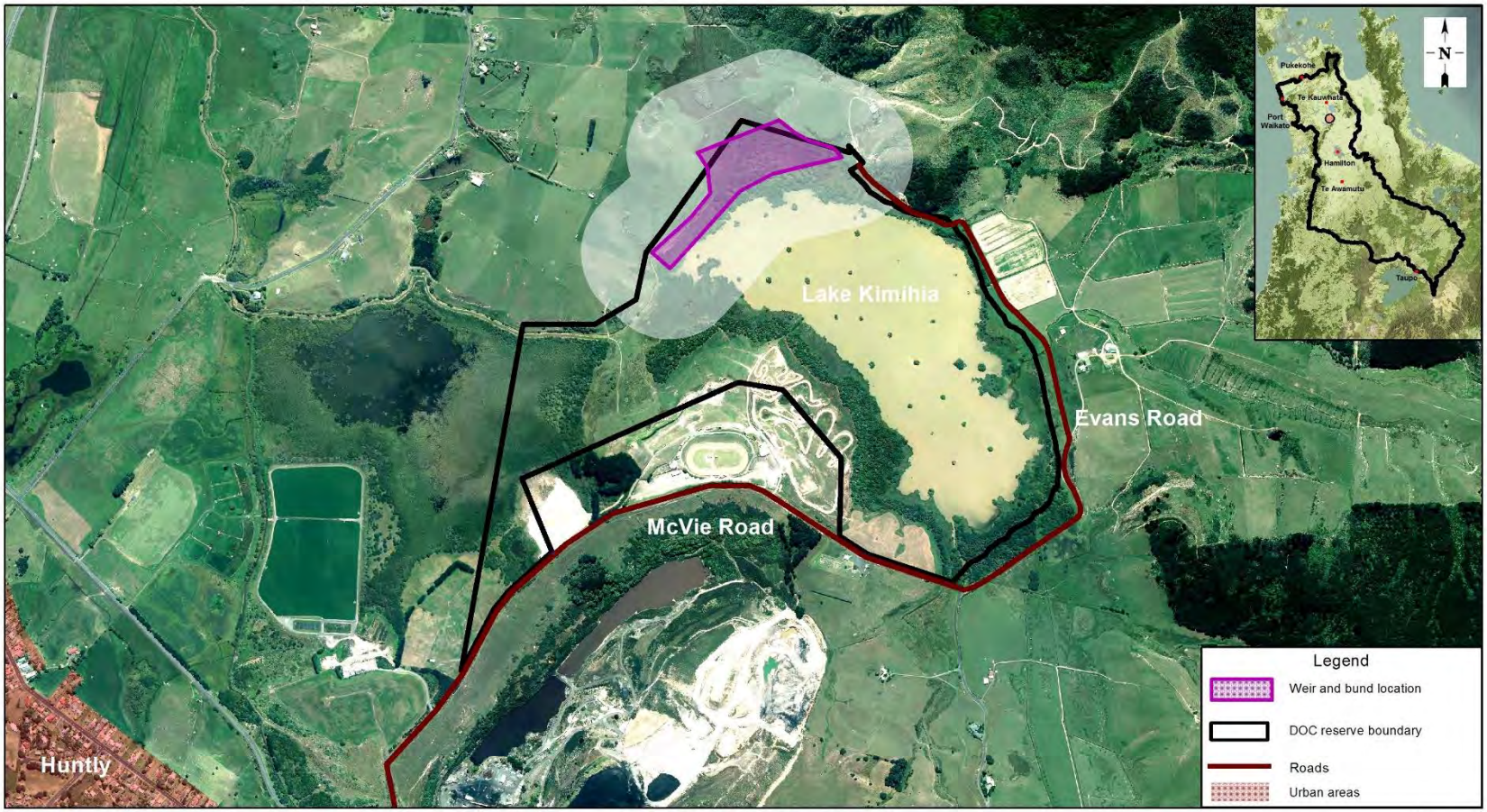


Restoring minimum water levels at Lake Kimihia

## WWRRS Project Map

Created by: Tane Desmond
Projection: NZTM
Date: December 2017

Status: Final
Request No.: N/A
File name:WWRRS.gws

0.00 0.15 0.30 0.45 0.60 0.75
Kilometers

Scale 1:15,000@A4 Landscape

A4

**ACKNOWLEDGEMENTS AND DISCLAIMERS**



Waikato REGIONAL COUNCIL
Te Kaunihera ā Rohe o Waikato

The western margin of Lake Kimihia is shown in the foreground. It discharges to the channel shown at the foot of the hill to flow underneath the Waikato Expressway which is under construction (on the right).

The wooden weir structure at Lake Kimihia that is no longer functional.

Waikato Expressway under construction along the southern margin of Lake Kimihia. The hills in the background are part of the Lake Kimihia catchment.

| L 8<br>Priority: High | Water quality and habitat enhancement at Lake Okowhao | BCR value |
|---|---|---|
| Relevant goals from Central/Lower Waikato unit and Shallow Lakes unit | A full range of ecosystem types associated with lakes in the catchment are protected and maintained with a focus on high natural environments.<br><br>Nutrient and sediment inputs to lakes are reduced by a proportion that leads to noticeable improvements in lake water quality so that lakes are safe for swimming and gathering of taonga species. | |
| Name of feature | Lake Okowhao | |
| Brief description of feature | Lake Okowhao is a small (8ha) riverine lake north of Huntly. It discharges under Te Ohaaki Road through an old oxbow (that has been enhanced to provide tuna habitat), before entering Waikato River. The lake was historically used as a food bowl for surrounding marae, in particular Hukanui-a-muri, Te Ohaaki and Waahi pā. Its resources clothed, sustained and healed the iwi. The lake is relatively close to the Waikato River and Taipōuri Island, where Kōkako used the waters of the Waikato to whakarite (bless) his grandson, Wairere, who became the tūpuna of Ngāti Wairere.<br><br>Lake Okowhao has poor water quality (hypertrophic) although it was one of the last of the Lower Waikato riverine lakes to lose its submerged plants. The catchment (about 390ha) is mainly dairy farming with some coal mining activity at the top of the catchment.<br><br>The lake fishery is depauperate and dominated by pest fish. Fish passage between the lake and the river is poor and limited to flood events.<br><br>The lake and its adjoining wetlands have been assessed as having moderate-high value for birds with two threatened species recorded (i.e. Australasian bittern, New Zealand dabchick). It is popular for game bird hunting.<br><br>Lake Okowhao is surrounded by a 14.6ha fenced wetland on public reserve land. It has an extensive native dominated emergent vegetation zone. The remaining wetland area is dominated by grey willow with a native understorey although | |

| | | |
|---|---|---|
| | there are some large areas of blackberry on the eastern margin.<br><br>A large area (12.4ha) of private wetland occurs on the southern boundary of the lake reserve which contains a mix of native and introduced plant communities. The main inflow to the lake (draining the majority of the catchment) flows through this wetland and has slowly filled it with sediment over this time. The low value areas of this wetland could be modified to improve water quality and provide additional open water habitat.<br><br>An unformed road could be developed to provide public access to the lake. The main recreational use of the lake is for gamebird hunting. | |
| Desired state to achieve Vision & Strategy | - The lake is swimmable, fishable and has access for recreation and gathering of kai.<br>- Native aquatic plants dominate the in-lake flora and provide habitat for healthy populations of other indigenous species.<br>- Lake margins retain natural hydrological function and are well vegetated with native plant communities that support indigenous fauna.<br>- Wetlands adjacent to lakes are densely vegetated with native plant species, connected to riparian corridors, protected from stock grazing and native plant regeneration occurs naturally.<br>- Iwi and community have a strong connection to the lake and are active in its protection and restoration. | |
| Impact on Vision & Strategy | In a restored condition, Lake Okowhao would have a very high impact on giving effect to the Vision & Strategy at a local level. | VS = 6 |

<table>
<tr>
<td>Key threats to the feature that this project addresses</td>
<td>
<table>
<tr><th>Key Threat</th><th>Impact on Feature</th></tr>
<tr><td>Stock access</td><td>Destruction of native plant communities, introduction of weed species. Direct inputs of nutrient and microbes into lakes.</td></tr>
<tr><td>Willow trees</td><td>Shade out native species and spread to other sites.</td></tr>
<tr><td>Weed species</td><td>Compete with native plant communities and are a threat to agriculture.</td></tr>
<tr><td>Further drainage and clearance of native wetland vegetation</td><td>Reduced habitat for native plants and animals and game birds. Loss of nutrient attenuation areas, and loss of wetland areas to slow flood flows.</td></tr>
<tr><td>Diffuse pollution from catchment land use</td><td>Further degradation of water quality due to increases in nutrients, sediment and harmful microbes.</td></tr>
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<td></td>
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<tr>
<td>Project goal/s</td>
<td>Within 5 years, wetlands surrounding Lake Okowhao are mostly (i.e. > 90% cover) comprised of native plant communities.<br>Within 5 years, water quality has measurably improved in Lake Okowhao.</td>
<td></td>
</tr>
<tr>
<td>Works required (by whom)</td>
<td>Suggested works could be implemented either by an organisation or private citizens (using contractors or their own labour) in collaboration with DOC. This project could be undertaken as a whole, or in multiple smaller components.<br><br><u>Wetland Habitat Enhancement</u><br>Willow control: Willow control should be undertaken using ground based methods to minimise off-target damage. This would be undertaken in both the wetland surrounding Lake Okowhao and on the adjoining private wetland to the south.<br>Weed control: The wetlands contain several ecosystem changing weeds, including pampas, gorse and blackberry. These weeds will need to be reduced to very low levels over a period of two years before any native planting occurs or constructed wetlands are created.<br><br>Planting: Native planting should be carried out within existing open areas and in areas where weed removal has created open areas. Planting at 1.5m spacing is recommended matching wetland species with flooding depth and duration.</td>
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</table>

| | | |
|---|---|---|
| | All native plants should be species that naturally occur in the Hamilton Ecological District.<br><br>**<u>Constructed wetland</u>**<br>This project involves modifying the wetland on private land south of Lake Okowhao to improve its effectiveness for removing sediment and nutrients. The main inflow to the lake currently comes through this wetland, which collects about 70% of the run off from the catchment.<br><br>**Design and specifications for constructed wetland:** These will need to be prepared by an appropriately qualified person using guidelines that target the reduction of nitrogen, phosphorus, *E.coli* and sediment arising from agricultural run off. The size of the constructed wetland would be 2.5% of the catchment size (i.e. 6.65ha). McKergow *et al.* (2007) estimate that the performance of a constructed wetland of this type and size (in relation to catchment area) is likely to result in the following reductions: about 80% of annual sediment load, 60% of nitrogen, 60-80% of particulate phosphorus and >90% of *E. coli*.<br><br>**Consent for constructed wetland:** Consents would need to be obtained for earthworks associated with the silt traps/constructed wetlands from both Waikato Regional Council and the Waikato District Council. This would include undertaking consultation with tāngata whenua and possibly commissioning a cultural impact assessment (although there are no known archaeological sites at this location). Based on costs for similar projects undertaken at other peat lakes the consent costs which include application preparation, consent fees and consultation is likely to cost about $25,000.<br><br>**Construction of treatment wetland:** This will involve carrying out earthworks to deepen areas and re-contour to best capture sediments and nutrients.<br><br>**Planting wetland:** Constructed wetlands require planting densities between 0.5m and 0.7m spacing depending on species. Infill planting (10% of original planting) in second year is recommended to replace plants that die in the first year. Assumptions and cost estimates for habitat enhancement at the two wetlands and the constructed wetland at South Okowhao are as follows: | |

| | | |
|---|---|---|
| | Lake Okowhao wetland enhancement – 14.6ha<br>- Ground based willow control over 5ha at $4000 per hectare ($20,000).<br>- Weed control over 50% of the area (7.3ha) over 2 years at $2800 per hectare ($40,880).<br>- Assumes 2ha of the area requires native planting in areas that are currently dominated by weeds and with allowance for 10% infill planting ($42,881 per hectare) ($85,762).<br>- Possum control (for plant establishment) over 3 years ($8,760).<br><br>South Okowhao wetland enhancement – 12.4ha, 1.58km perimeter<br>- Ground based willow control over 3.4ha at $4000 per hectare ($13,600).<br>- Weed control over 50% of the area (6.2ha) over 2 years at $2800 per hectare ($34,720).<br>- Assumes 3ha of the area requires native planting in areas that are currently dominated by weeds and with allowance for 10% infill planting ($42,881 per hectare) ($128,643).<br>- Fencing 1580m at $25 per metre ($39,500)<br>- Possum control (for plant establishment) over 3 years ($7440).<br><br>South Okowhao constructed wetland – 6.65ha<br>- Construction of wetland including earthworks and planting at $100,000 per hectare ($665,000).<br>- Planting maintenance for 2 years at $600 per hectare ($7980).<br>- Annual maintenance of sediment basins for 10 years at $1880 per annum ($18,800).<br><br>**Project management/staffing/incidentals**<br>Staff to carry out landowner liaison, iwi engagement, Health and Safety requirements, negotiate agreements, inspect works, manage parts of the work as required (e.g. fencing or planting), project reporting and financial management. Incidentals include transport, office overheads, consumables and miscellaneous professional fees.<br><br>This is estimated to be 20% of the direct project costs. | |
| Time lag for benefits to be realised | If works were implemented at an even pace over a 10-year period, it is estimated that the majority of the project benefits would be seen upon project completion. | L = 10 |
| Effectiveness of works | When compared with desired state, Lake Okowhao is in poor to moderate condition with few of the Vision & Strategy desired state aspects being met or partly met. Although lake water quality is not as poor as many of the other Lower | W = 0.15 |

| | | |
|---|---|---|
| | Waikato riverine lakes, it is not at a swimmable standard. Access to the lake is difficult which means many members of the community are not well connected to the site. Overall state is not expected to change over the next 20 years in the absence of this project. Works included here are expected to help in addressing some of the key threats to the lake including external nutrient – they will treat approximately 70% of lake inflows – and improve biodiversity values at the site. However, the lake water quality would still be expected to remain in a NOF D band even with this project being undertaken. It is acknowledged that achieving the Vision & Strategy desired state at Lake Okowhao will take longer than the 20-year horizon used for the purposes of the Restoration Strategy and a fuller range of initiatives over the long term. However, if this project is successfully completed it is expected that there will be a significant improvement in overall condition in 20 years and the lake will be closer to the desired Vision & Strategy state than it is currently. There would be benefits in this project being carried out in alignment with project L 9. | |
| Risk of technical failure | There is a moderate risk of project failure due to technical feasibility. Effectiveness of constructed wetland treatment systems has not yet been fully established. | F = 0.82 |
| Works by private citizens – likelihood of adoption and adoption circumstances | Works proposed on publicly owned land are expected to be adopted if fully incentivised. The constructed wetland is proposed for land that is owned by Solid Energy and there is come uncertainty about whether the company would agree to this going ahead. Early engagement with landowners, iwi and stakeholders will be critical to project success. | A = 0.75 |
| Information quality | Average – recommendations are based on advice of local expert/s and examination of aerial photographs. | |
| Knowledge gaps | The condition and extent of fencing of the wetland on private land has been estimated from aerial photographs. Specific requirements will need to be determined during project planning. | |
| Socio-political risks | Very low risk that the project will fail to meet its goals over the long term due to socio-political risks. | P = 0.97 |
| Project duration (years) | 10 years | |

<table>
<tr>
<td>Up-front cost – total for implementation phase/project duration</td>
<td>
<table>
<tr><th>Task</th><th>Cost ($)</th></tr>
<tr><td>Wetland habitat enhancement at Lake Okowhao</td><td>155,402</td></tr>
<tr><td>Wetland habitat enhancement at South Okowhao</td><td>223,903</td></tr>
<tr><td>South Okowhao constructed wetland</td><td>691,780</td></tr>
<tr><td>Project management/staffing/incidentals (20%)</td><td>214,217</td></tr>
<tr><td>Total</td><td>1,285,302</td></tr>
</table>
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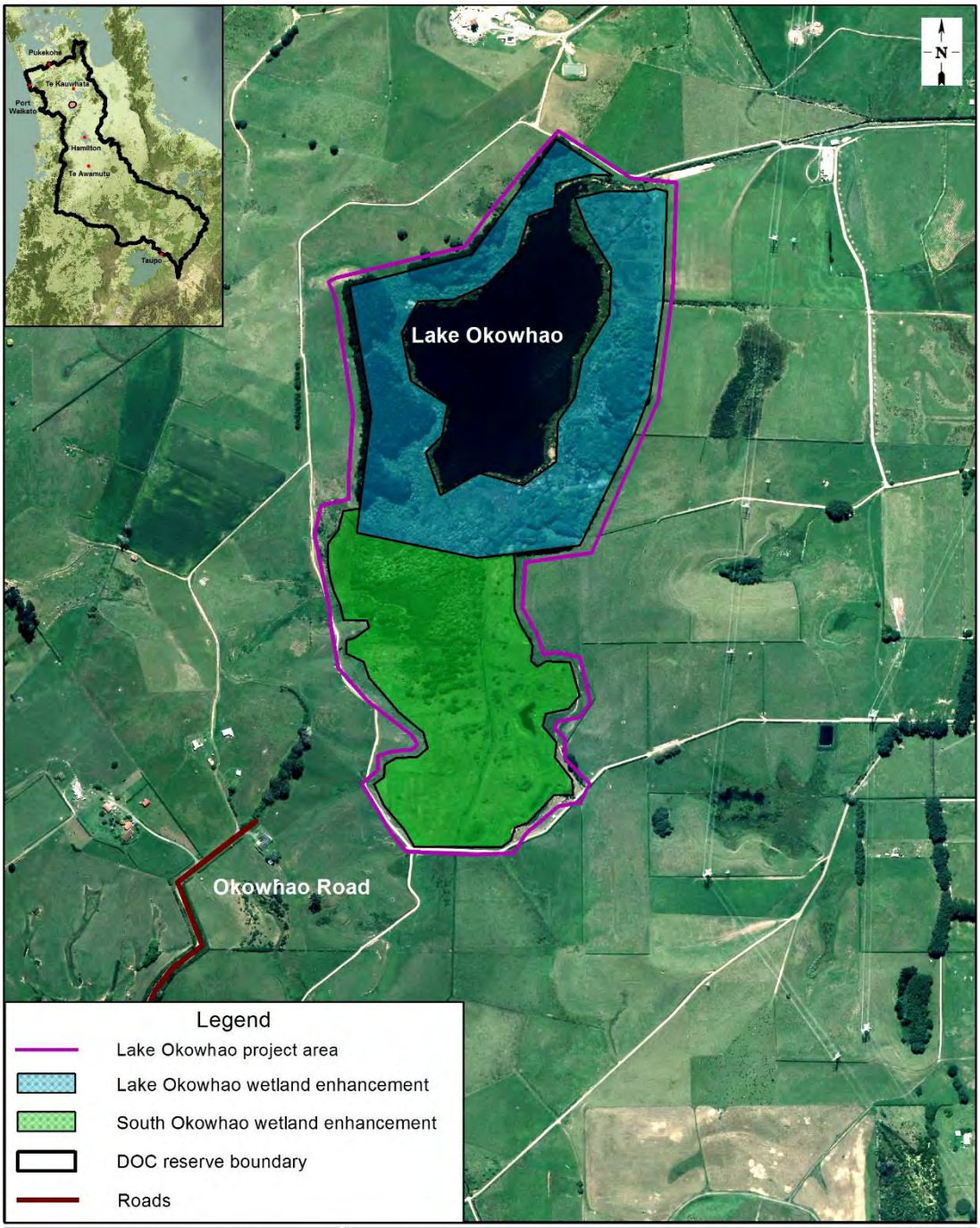
<td>C = 1.29</td>
</tr>
</table>




Water quality and habitat enhancement at Lake Okowhao

## WWRRS Project Map

Created by: Tane Desmond
Projection: NZTM
Date: December 2017

Status: Final
Request No.: N/A
File name: WWRRS.gws

0.00 0.06 0.12 0.18 0.24 0.30
Kilometers

Scale 1:8,000@A4 Portrait

A4



Waikato REGIONAL COUNCIL
Te Kaunihera ā Rohe o Waikato

The extensive wetland margin in the south of Lake Okowhao. The grey vegetation is grey willow, which is invading some of the native wetland plant communities around the lake.

The partially drained wetland area south of Lake Okowhao reserve where a constructed wetland is proposed.

| L 9<br>Priority: High | Provide fish passage past Lake Okowhao outlet stream pump station and floodgate | BCR value |
|---|---|---|
| Relevant unit goal(s) | Aquatic habitats, including spawning grounds, are protected, enhanced, restored and accessible to native fish.<br><br>The abundance of native fish, including taonga species, in the catchment is restored and protected. | |
| Name of feature | Lake Okowhao | |
| Brief description of feature | Lake Okowhao is an 8ha riverine lake located north of Huntly and lying within of the Okowhao drainage area. The lake has a maximum depth of 2.2m and is part of a Wildlife Management Reserve administered by DOC. The lake is de-vegetated and water quality hypertrophic meaning it has very high nutrient concentrations and poor clarity.<br><br>Lake Okowhao was historically used as a food bowl for surrounding marae, in particular Hukanui-a-muri, Te Ohaaki and Waahi pā. The lake is relatively close to the Waikato River and Taipōuri Island, where Kōkako used the waters of the Waikato to whakarite (bless) his grandson, Wairere, who became the tūpuna of Ngāti Wairere.<br><br>The lake receives water from drains that run through farmland to the south and east of the lake. The lake outlet discharges to the Waikato River via an incised drain that runs east to west. The lake either discharges through a gravity fed culvert passing under Te Ohaaki Road or water is pumped through another set of culverts during high flow events. Both of these culverts have flap gates installed at the downstream end to prevent ingress of water from the Waikato River during high flows (see Figure 1). | |

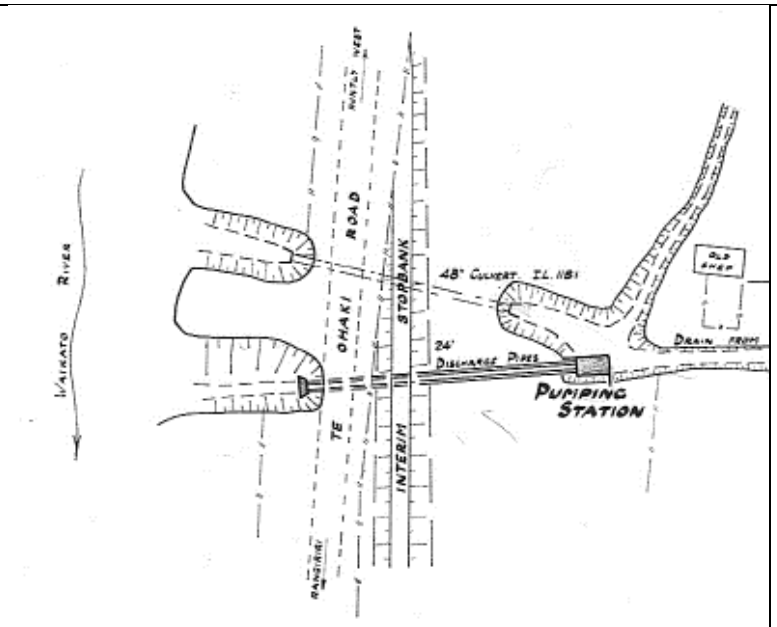



**Figure 1:** Site Plan Okowhao Pump Station.

**Fish passage issues past the flap gated culvert**

The drain and gravity fed culvert (Figure 2) allows water to flow naturally whenever downstream levels (i.e. the Waikato River) are lower than up levels. Under such conditions, downstream fish passage is possible, except that at very low flow there is usually not enough water pressure from upstream to keep the flap gate at the end of the pipe open (Figure 3). While the flap gate is closed, upstream fish passage is also not possible. To remedy this situation a fish-friendly flood gate needs to be installed (Figure 4).

This fish-friendly flap gate remains open at low flow, and has the added advantage of allowing good quality water to enter the upstream catchment until a pre-set trigger level allows the gate to close and prevent flooding.

**Figure 2:** Inlet of gravity flow outlet pipe at Okowhao Pump Station, February 2017. Photo: Taroi Rawiri, Waahi Whaanui

**Figure 3:** Outlet of gravity flow outlet pipe Okowhao Pump Station. Photo: Taroi Rawiri, Waahi Whaanui

**Figure 4:** Example of a fish friendly floodgate. In this example, the float and lever arrangement allow a portion of the gate to remain open at levels below a pre-set maximum thus allowing unhindered upstream (and downstream) fish passage during periods of low flows.

**Fish passage issues past the pump**

When downstream levels are higher than upstream levels the only way of preventing flooding upstream is to pump the water over the stopbank. Currently, this is done by the existing axial flow (impeller/propeller) Flygt pumps. These pumps, unfortunately, have now been shown to kill or maim fish, especially larger tuna, attempting to pass through the pumps. Given that tuna migrate on floods to reach spawning

<table>
<tr><td></td><td>sites at sea, at this site, while the gravity culvert outlet is closed, there is no free downstream passage.<br><br>An alternative type of pump is therefore recommended.</td><td></td></tr>
<tr><td>Desired state to achieve Vision & Strategy</td><td>- There are no manmade barriers to native migratory fish and there is an abundance of tuna in the lake.<br>- The lake is swimmable, fishable and has access for recreation and gathering of kai.<br>- Native aquatic plants dominate the in-lake flora and provide habitat for healthy populations of other indigenous species.<br>- Lake margins retain natural hydrological function and are well vegetated with native plant communities that support indigenous fauna.<br>- Wetlands adjacent to lakes are densely vegetated with native plant species, connected to riparian corridors, protected from stock grazing and native plant regeneration occurs naturally.<br>- Iwi and community have a strong connection to the lake and are active in its use, protection and restoration.</td><td></td></tr>
<tr><td>Impact on Vision & Strategy</td><td>In a restored condition Lake Okowhao would have a very high impact on giving effect to the Vision & Strategy at a local level.</td><td>VS = 6</td></tr>
<tr><td>Key threats to the feature that this project addresses</td><td><table><tr><th>Key threat</th><th>Impact on feature</th></tr><tr><td>The flood pump and floodgate are barriers to native fish migration</td><td>- Native fish are impeded from migrating between Lake Okowhao and the Waikato River.<br>- Reduced habitat available for tuna and other native migratory fish.</td></tr></table></td><td></td></tr>
<tr><td>Project goal/s</td><td>Within 5 years of the project commencing:<br>- Fish passage is provided past the floodgate and pump station between Lake Okowhao and the Waikato River.<br>- Lake Okowhao has an abundance of healthy tuna.</td><td></td></tr>
<tr><td>Works required</td><td>Suggested works should be implemented by an organisation that has engineering experience and experience in installing floodgates and pumps. It is envisaged that a project manager would be required to co-ordinate and manage aspects of the project, and work closely with Waikato Regional Council who are responsible for the flood control assets.<br><br>Installation of fish friendly floodgate<br>There are a number of fish-friendly flood gates on the market, and some investigation will be required to determine which one is best suited to this site. The estimated cost of</td><td></td></tr>
</table>

purchasing and installing a fish friendly floodgate has been generously estimated at $64,000. This cost is based on importing a gate from the United States. A cheaper gate may be able to be sourced locally but further investigation is required.

**Installation of fish friendly flood pump**

Overseas work has shown that Hydrostal and Archimedes screw pumps can pass fish with minimal damage, but there are still some uncertainties regarding the ability of Hydrostat pump to pass large eels. The alternative Archimedes screw pumps, especially those with a shroud around the screw and installed on a float, are reputed to be not only fish-friendly but also less noisy, so less prone to trigger avoidance reaction in fish. This type of pump is recommended as replacement for the existing pumps at the Okowhao pump station (Figure 5).

The Archimedes screw pump available from FishFlow technology in the Netherlands costs between €88,000 and €108,000 (NZ$135,000 to $165,000). This cost is excluding shipping, but includes mechanical installation (electrical installation and connection to the grid are additional). This cost assumes that the new pump can be connected to the existing pipework under Te Ohaaki Road.

For the purpose of the Restoration Strategy, installation of a fish friendly flood pump (Archimedes screw pump) has been estimated to cost $180,000.

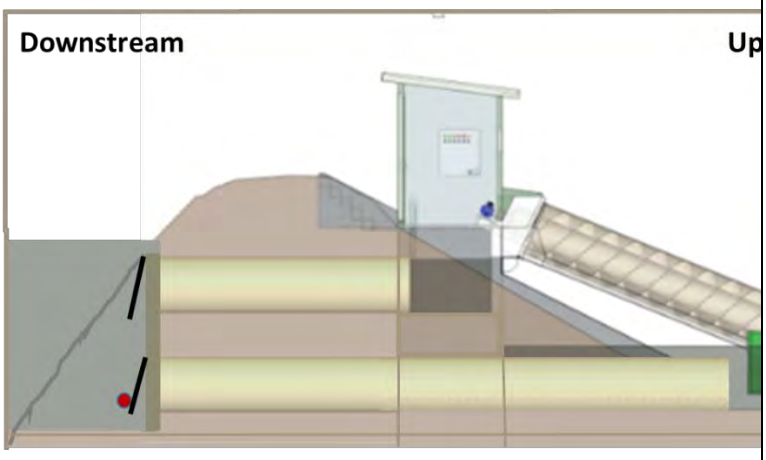
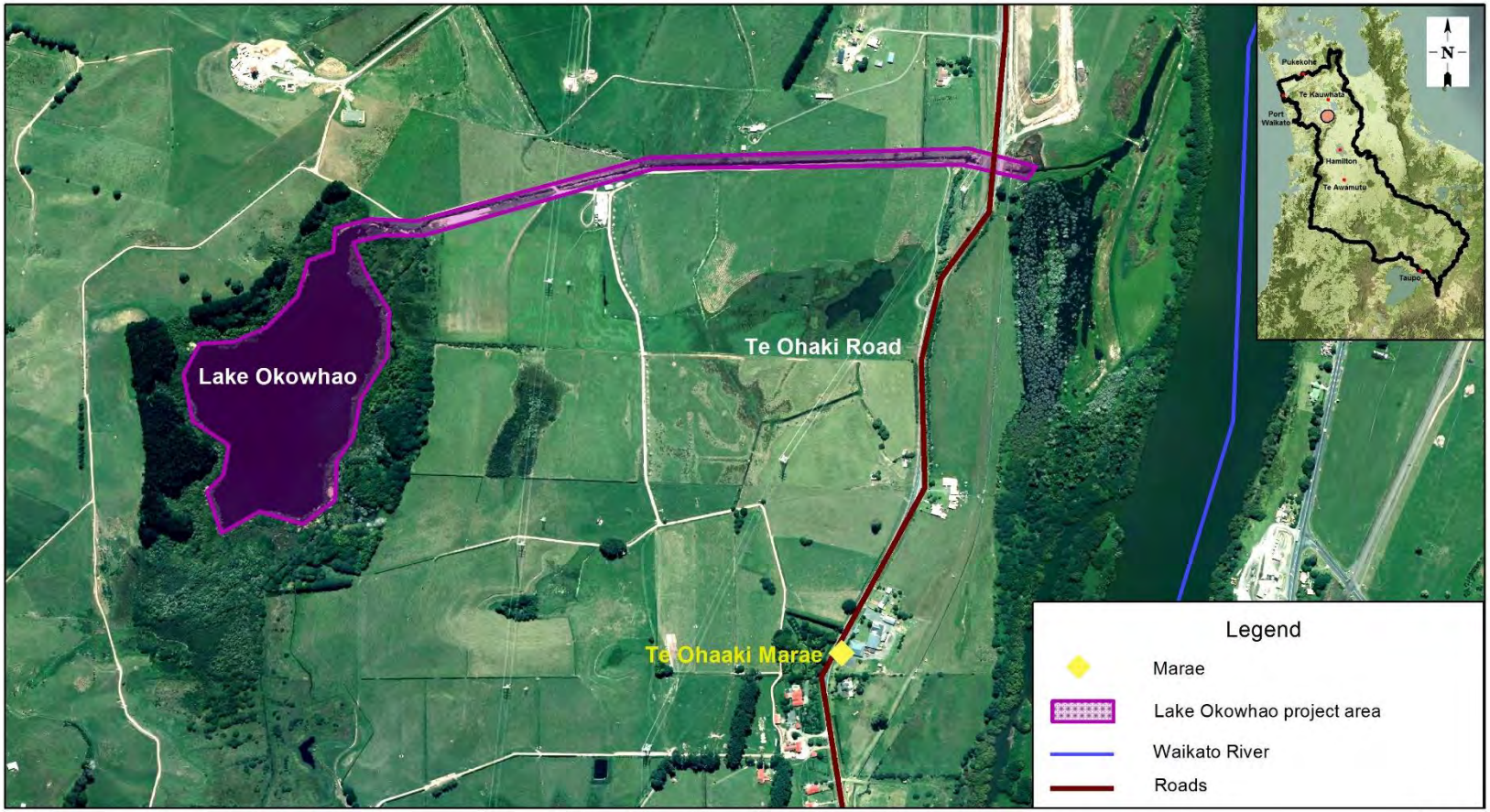



**Figure 5:** Concept diagram of a screw pump with variable level floating inlet and gravity flow culvert.

**Monitoring**

| | | |
|---|---|---|
| | As this will be the first such pump station installed in New Zealand, the site will likely serve as a model for future pump replacement, not only in the Waikato but for the whole of the country. It is therefore important that detailed monitoring be undertaken to fully document installation and maintenance issues, as well as determine effectiveness. For this it is recommended that fish surveys be undertaken prior to and after installation and that nets be installed on the outlet of the pump to document survival rate for at least one season.<br><br>This work has not been costed as it is out of scope for the Restoration Strategy.<br><br>**Project management/staffing/incidentals**<br>Staff to carry out landowner liaison, iwi engagement, Health and Safety requirements, negotiate agreements, inspect works, manage parts of the work as required (e.g. fencing or planting), project reporting and financial management. Incidentals include transport, office overheads, consumables and miscellaneous professional fees.<br><br>This is estimated to be 15% of the direct project costs. | |
| Time lag for benefits to be realised | If works were implemented at an even pace over a 3-year period, it is estimated that the majority of the project benefits would be seen approximately one year before project completion. | L = 2 |
| Effectiveness of works | Lake Okowhao is currently in poor condition with very few of the Vision & Strategy desired state aspects being even partially met. There is not expected to be significant deterioration or improvement in the lake over the next 20 years in the absence of this project. Works included here address only the threats to the fishery in the lake, however it is anticipated that if the project is fully completed there will be improvements in both the fish ability and biodiversity of the lake and that these aspects will move closer to the Vision & Strategy desired state. This project does not address catchment land use, water quality, or other threats to the lake, but would benefit from being undertaken in conjunction with project L 8 for broader outcomes to be achieved. | W = 0.075 |
| Risk of technical failure | There is a moderate risk of project failure due to technical feasibility. This technology has not yet been tested in the New Zealand environment. This project will need to be undertaken using qualified engineering expertise and in close consultation with Waikato Regional Council. | F = 0.82 |

<table>
<tr><td>Adoptability</td><td>This site is on publicly managed lands and therefore it is anticipated that works would be adopted if fully incentivised.</td><td>A = 1</td></tr>
<tr><td>Information quality</td><td>Very good – summary of work required is based on detailed advice of a fish ecologist and local experts.</td><td></td></tr>
<tr><td>Knowledge gaps</td><td>Some additional investigation is required to confirm costs. This would need to be done in the early stages of project planning.</td><td></td></tr>
<tr><td>Socio-political risks</td><td>Moderate risk that the project will fail to meet its goals over the long term due to socio-political risks. Early consultation on the potential impacts on drainage and flood control will be critical for the local community acceptance of this project.</td><td>P = 0.62</td></tr>
<tr><td>Project duration (years)</td><td>3 years</td><td></td></tr>
<tr><td>Up-front cost – total for implementation phase/project duration</td><td><table><tr><th>Task</th><th>Cost ($)</th></tr><tr><td>Installation of fish friendly floodgate</td><td>64,000</td></tr><tr><td>Installation of fish friendly flood pump</td><td>180,000</td></tr><tr><td>Project management/staffing/incidentals (15%)</td><td>36,600</td></tr><tr><td>Total</td><td>280,600</td></tr></table></td><td>C = 0.28</td></tr>
</table>




Provide fish passage past Lake Okowhao outlet stream pump station and floodgate

## WWRRS Project Map

Created by: Tane Desmond
Projection: NZTM
Date: December 2017

Status: Final
Request No.: N/A
File name:WWRRS.gws

0.0 0.1 0.2 0.3 0.4 0.5
Kilometers

Scale 1:8,500@A4 Landscape

A4



Waikato Regional Council
Te Kaunihera ā Rohe o Waikato

| L 10<br>Priority: Very high | Biodiversity enhancement of selected wetlands around shallow lakes | BCR value |
|---|---|---|
| Relevant goals from Central/Lower Waikato unit and Shallow Lakes unit | Wetlands are protected, enhanced and where feasible expanded and re-established<br><br>Ecosystems, forest fragments and ecological corridors associated with aquatic environments are protected, enhanced and expanded. | |
| Name of feature | Wetlands around Lakes Hakanoa, Rotongaro and Rotongaroiti, Waahi and Waikare | |
| Brief description of feature | Lake Rotongaro and Lake Rotongaroiti are located within a predominantly pastoral catchment northwest of Huntly township. Lake Rotongaro is 292ha in size and Rotongaroiti is 53ha in size. The lakes are connected via a small channel and both lakes are within the Lake Rotongaro Wildlife Management Reserve managed by Department of Conservation.<br><br>Wetland vegetation is present around the margins of the lakes and in seasonally damp hollows within the catchment. There are large areas that are dominated by grey willow, however, indigenous species are common beneath. A regionally significant area of mānuka scrub is located at the southwestern corner of Lake Rotongaro. There are historic pā tuna along the streams from these lakes.<br><br>Lake Waahi is a 522ha riverine lake located west of Huntly. It features two significant wetland areas, the Waikokowai Wetland on the western arm of the lake (55ha), and the southern wetland alongside Rotowaro Road (137ha). Both wetlands are dominated by a canopy of willow, but feature a native understorey of sedges and shrubs. Mānuka shrubland and raupō are also present in some parts. Lake Waahi historically provided many tuna (eels) for the iwi and marae. It was known as a great provider of kai (food) for the marae and was a regular stopover during journeys between the west coast and the Waikato River.<br><br>Lake Waikare is the second largest lake in the Waikato catchment (after Lake Taupō) and is 3442ha in size. It is located southeast of Te Kauwhata township and is connected to the Whangamarino Wetland by the Pungarehu Canal. Lake Waikare historically sustained many marae and holds the kōiwi (bones) of Waikato ancestors killed in the Waikato invasion at Rangiriri. | |

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| | The lakebed is held in the title of the first Māori King, Pōtatau Te Wherowhero, so that the bones of the tribe's people are protected in his name.<br><br>Lowering of the lake level by the Lower Waikato Waipā Flood Control Scheme and drainage of land for pastoral farming has resulted in the loss of vast areas of wetland habitat around the lake. Significant wetland areas remain on the southwest margins of the lake and many wetland restoration projects have been completed or are underway in areas around the lake.<br><br>The southeastern margin of the lake has been identified as a location where wetland enhancement and further creation could be undertaken. The approximate size of this area is 10ha.<br><br>Lake Hakanoa is a riverine lake located east of the Waikato River in Huntly. It is 52ha in size and part of a 73ha wildlife refuge reserve administered by the Department of Conservation. There is also a small area of Local Purpose Reserve land administered by Waikato District Council. Lake Hakanoa was named after the lifting of the rahui (prohibition) that allowed the regeneration of tuna (eels) within the lake. This was undertaken through a ceremony of noa, which makes the lake available for normal or common activities. A haka was performed to lift the tapu, therefore returning the lake to a noa (common) state, hence the name Haka-noa.<br><br>The lake has extensive areas of riparian wetlands mainly located to the south and east of the lake. One of these is an 11ha wetland in the southwest corner of the lake. The wetland is currently dominated by willows but has the potential for restoration into a native dominated ecosystem.<br><br>These wetlands have been identified as a priority as despite being significantly degraded sites they still retain high wetland ecosystem values. They have high potential for restoration and fit with the goals of the Restoration Strategy.<br><br>All of these lakes are culturally significant to iwi, hapū and marae as they provided food, recreation and in some instances hold the kōiwi (bones) of the people involved in the wars triggered by the invasion of the Waikato. | |
| Desired state to achieve Vision & Strategy | - The selected wetlands are fenced to exclude stock and have a natural functioning hydrology.<br>- Native fish are abundant and open water areas are fishable and have access for recreation and collection of kai. | |

<table>
<tr><td></td><td>- Iwi and communities have a strong connection to the wetlands and are active in their use, protection and restoration.<br>- Wetlands are dominated by native plant communities and native plant regeneration occurs naturally.<br>- Where wetlands provide habitat for native fauna these values are preserved e.g. native mudfish habitat</td><td></td></tr>
<tr><td>Impact on Vision & Strategy</td><td>In a restored condition the wetlands around these selected shallow lakes would have a high impact on giving effect to the Vision & Strategy at a shallow lakes catchment level.</td><td>VS = 35</td></tr>
<tr><td>Key threats to the feature that this project addresses</td><td><table><tr><th>Key threat</th><th>Impact on feature</th></tr><tr><td>Stock access</td><td>Reduced water quality and destruction of wetland vegetation through trampling, grazing and introduction of weeds.</td></tr><tr><td>Willow trees</td><td>Shade out native species and spread to other sites.</td></tr><tr><td>Weed species</td><td>Compete with native plant communities.</td></tr><tr><td>Land drainage</td><td>Lowers water levels and degrade the ecosystem.</td></tr><tr><td>Vegetation clearance</td><td>Destroys wetland ecosystems</td></tr></table></td><td></td></tr>
<tr><td>Project goal/s</td><td>- Within 2 years of the project commencing, wetlands are 100% fenced to exclude stock.<br>- Within 10 years, wetlands identified at Lake Hakanoa, Lake Waikare, Lake Rotongaro and Rotongaroiti are dominated by native plant communities, and native plant regeneration occurs naturally.<br>- Within 20 years, weed species (with the exception of willow) present at Lake Waahi make up less than 10% of the vegetation cover and there is a more natural hydrological regime within the surrounding wetlands.</td><td></td></tr>
<tr><td>Works required (by whom)</td><td>Suggested works could be implemented either by an organisation or private citizens (using contractors or their own labour). This project could be undertaken as a whole, or in multiple smaller components.<br><br>Management plan development<br>Management plans should be developed for the sites at Lake Waikare, Lake Hakanoa and Lake Waahi. The estimated cost of this is up to $10,000 per lake ($30,000).<br><br><u>Lake Rotongaro and Rotongaroiti</u></td><td></td></tr>
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| | A vegetation assessment and management plan has been undertaken for these lakes by Wildland Consultants (2013) in the document titled "Vegetation Assessment of Lake Rotongaro Wildlife Management Reserve". Anyone interested in this document should contact the Department of Conservation. Restoration work should be undertaken in accordance with Wildland's recommendations and the estimated costs provided below are based on these (excluding work that has already been undertaken on the Kerr property).<br><br>Some of the estimated costs provided below are more generous than those provided in the Wildland report but are consistent with standard costs used throughout the Restoration Strategy.<br><br>**Fencing**<br><u>Lake Rotongaro and Rotongaroiti</u><br>Fencing should be undertaken in locations recommended in the Wildland report. Fences should be a minimum of 20m back from the lakes and a minimum of 5 wire (2 electric) for cattle and 7 wire post and batten for sheep.<br>- It is estimated that 8.4km of fencing and/or fence upgrade is required at $8 per metre ($67,200).<br><br><u>Lake Hakanoa wetland</u><br>The boundary of the wetland should be fully fenced to a stock proof standard (a 5 wire fence with 2 electric wires at a minimum).<br>- It is assumed that approximately 1.2km of new fencing or fence upgrade is required at $8 per metre ($9600).<br><br><u>Lake Waahi wetlands</u><br>Fencing should be undertaken to exclude stock from the two main wetland areas.<br>- Waikokowai wetland – 1km fencing with 5 wire required at $8 per metre ($8000)<br>- Southern wetland – 1km fencing with 5 wire required at $8 per metre ($8000)<br><br><u>Lake Waikare wetland</u><br>Up to 5km of fencing at $8 per metre is expected to be required to exclude stock from this site ($40,000)<br><br>**Willow removal**<br><u>Lake Rotongaro and Rotongaroiti</u> | |

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| | Willow removal should be carried out in accordance with the recommendations made by Wildland.<br>- Approximately 9.3ha of willow control is required using ground based methods at $4000 per hectare ($39,320).<br><br><u>Lake Waahi</u><br>Large scale willow removal is not recommended for this site but willow should be contained within the current areas (see weed control section below).<br><br><u>Lake Hakanoa wetland</u><br>A staged approach to willow control should be undertaken at this site and willows gradually poisoned over time as native plants establish beneath them.<br><br>Ground based control of willow is estimated to be approximately $4000 per hectare over an 11 hectare area plus $2000 per hectare for follow-up maintenance ($66,000).<br><br>**Planting**<br><u>Lake Rotongaro and Rotongaroiti</u><br>Native planting should be carried out in accordance with the recommendations made by Wildland.<br>- It is estimated that 41ha of re-vegetation is required at a cost of $37,552 per hectare (including site preparation, plant purchase, planting labour and five releasing events) ($1,540,758)<br><br><u>Lake Hakanoa wetland</u><br>It is recommended that weed control and planting be undertaken in stages at this site by leaving willow trees in place, undertaking targeted weed control and planting, allowing native plants to grow up through the willows and then selectively poisoning willows over a 20-year period.<br><br>It is assumed that native planting is required over approximately 25% of the 11ha site (2.75ha) at $37,552 per hectare ($103,268). This includes site preparation, plant purchase, planting labour and five releasing events.<br><br><u>Lake Waahi</u><br>Native planting should be undertaken within the fenced area where there is currently no native vegetation and where native regeneration is not expected to occur naturally following fencing: | |

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|---|---|---|
| | - Waikokowai wetland – 10ha of native planting within open and weed control areas (assuming 20% of wetland requires planting at $37,552) is $375,520.<br>- Southern wetland – 15ha of native planting within open and weed control areas (assuming 10% of wetlands requires planting) is $536,280.<br><br><u>Lake Waikare wetland</u><br>The exact quantity of native planting required at this site is unknown as it will depend of what native regeneration occurs naturally. For the purpose of the Restoration Strategy a cost estimate is provided based on planting 80% (7.8ha) of the site at $37,552 per hectare ($292,905).<br><br>**Weed Control**<br><u>Lake Rotongaro and Rotongaroiti</u><br>Weed control should be carried out in accordance with the recommendations made by Wildland.<br>- Royal fern control across 8.4ha at $502 per hectare ($4216).<br>- Wattle/pine control across 0.7ha at $3000 per hectare ($2,100).<br><br><u>Lake Hakanoa wetland</u><br>A comprehensive weed control plan will be essential to ensure success of this project and should be undertaken as part of the management plan for the site.<br><br>Exact costs associated with undertaking weed control are unknown but for the purpose of the Restoration Strategy the following estimates have been made:<br>- $2800 per hectare three times per year over two years in order to establish weed-free areas in preparation for native planting ($92,400).<br>- Additional weed control following native plant establishment is estimated at $700 per hectare (11ha) every year for 13 years ($100,100).<br><br><u>Lake Waahi</u><br>Weed control is required to promote regeneration of native species and enhance biodiversity around the wetland margins. It is accepted that willow will always be a dominant component of these ecosystems, and thus widespread willow control is not considered. However some willow control has been allowed for within the weed control costings below. | |

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| | - Waikokowai wetland – 10ha of weed control (assuming 20% of wetland requires control) at an estimated cost of $2800 per hectare per year (using knapsack spray methods) over three years ($84,000).<br>- Southern wetland – 15ha of weed control (assuming 10% of wetlands requires control) at an estimated cost of $2800 per hectare per year (using knapsack spray methods) over three years ($126,000).<br><br><u>Lake Waikare wetland</u><br>Exact costs associated with undertaking weed control are unknown but for the purpose of the Restoration Strategy the following estimates have been made:<br>- The 7.8ha that is planted will require weed control for a period of three years following native plant establishment. This could be undertaken using a combination of knapsack spraying and use of a spray unit on a vehicle (estimated to cost $2100 per hectare per year). Spraying would be required over a three year period ($49,140).<br><br>**Hydrological reinstatement**<br>Hydrology could be reinstated to sections of some wetlands by blocking off historic drainage routes and constructing low earth bunds in key locations. Longer water retention times in the wetland will reduce the occurrence of pest plants including willow, improve overall wetland habitat, and act to retain some sediment from the catchment.<br><br><u>Lake Waahi</u><br>- Waikokowai wetland – 500m of earth bunding ($5000).<br>- Southern wetland – 500m of earth bunding ($5000).<br><br><u>Lake Waikare</u><br>Some earthworks may be required to infill drains and reinstate a more natural hydrological regime and restore the wetland margin. The exact extent and cost of this is unknown but for the purpose of the Restoration Strategy a cost of $6500 has been estimated which allows for one week of digger time.<br><br><u>Resource consent fees</u><br>Resource consent may be required for hydrological reinstatement work. This is estimated to be no more than $5000 per lake site ($10,000).<br><br>**Project management/staffing/incidentals** | |

| | | |
|---|---|---|
| | Staff to carry out landowner liaison, iwi engagement, Health and Safety requirements, negotiate agreements, inspect works, manage parts of the work as required (e.g. fencing or planting), project reporting and financial management. Incidentals include transport, office overheads, consumables and miscellaneous professional fees.<br><br>This is estimated to be 30% of the direct project costs. | |
| Time lag for benefits to be realised | If works were implemented at an even pace over a 20-year period, it is estimated that the majority of the project benefits would be seen approximately 13 years after project commencement. | L = 13 |
| Effectiveness of works | These wetlands are currently in poor to moderate condition when compared to desired state. This is not expected to change significantly over the next 20 years in the absence of this project given existing measures that are in place such as the Dairy Water Accord, and the fact that some of the sites are already very degraded. However, if this project is successfully completed then it is expected that wetland condition in 20 years will be significantly closer to the desired Vision & Strategy state than it is currently. This project addresses the many of the aspirations for these features and wetland condition can be expected to move to moderate to good as a result of this project. | W = 0.3 |
| Risk of technical failure | There is a moderate to high risk of project failure due to technical feasibility. Risks are mostly related to weed control. There is a particularly high risk of project failure due to technical feasibility if weed control isn't well planned and undertaken by experienced operators. This project would benefit from Project CLW 9 (control of yellow flag iris and alligator weed) being undertaken concurrently. | F = 0.8 |
| Adoptability | It is estimated that about three-quarters of landowners would adopt the works if they were fully incentivised. Works on publicly owned land are expected to be fully adopted. Some private landowners may be concerned by loss of marginal grazing areas, however generally the benefits of avoiding loss of stock in wetlands, and the value of wetlands in general, are becoming better recognised. There are also currently landowners around these lakes that are undertaking similar projects and these farmers can be good advocates to others in their catchments. | A = 0.75 |
| Information quality | Average – recommendations are based on the judgement of a wetland ecologist with local knowledge. Quantities of work required are predominantly based on estimates made from | |

<table>
<tr><td></td><td>aerial photographs and information taken from a recent survey of Rotongaro and Rotongaroiti Reserve.</td><td></td></tr>
<tr><td>Knowledge gaps</td><td>Further work is required to determine the specific amounts of fencing, planting and weed control required. This should be undertaken in the early stages of project planning.</td><td></td></tr>
<tr><td>Socio-political risks</td><td>There is low risk that the project will fail to meet its goals over the long term due to socio-political risks.</td><td>P = 0.85</td></tr>
<tr><td>Project duration (years)</td><td>20 years</td><td></td></tr>
<tr><td>Up-front cost – total for implementation phase/project duration</td><td>
<table>
<tr><th>Task</th><th>Cost ($)</th></tr>
<tr><td>Development of management plans</td><td>30,000</td></tr>
<tr><td>Fencing</td><td></td></tr>
<tr><td>- Lake Rotongaro and Lake Rotongaroiti (8.4km)</td><td>67,200</td></tr>
<tr><td>- Lake Hakanoa wetland (1.2km)</td><td>9,600</td></tr>
<tr><td>- Lake Waahi wetlands (2km)</td><td>16,000</td></tr>
<tr><td>- Lake Waikare wetland (5km)</td><td>40,000</td></tr>
<tr><td>Native planting</td><td></td></tr>
<tr><td>- Lake Rotongaro and Lake Rotongaroiti (41ha)</td><td>1,540,758</td></tr>
<tr><td>- Lake Hakanoa wetland (2.75ha)</td><td>103,268</td></tr>
<tr><td>- Lake Waahi wetlands (25ha)</td><td>536,280</td></tr>
<tr><td>- Lake Waikare wetland (7.8ha)</td><td>292,905</td></tr>
<tr><td>Willow control</td><td></td></tr>
<tr><td>- Lake Rotongaro and Lake Rotongaroiti (9.3ha)</td><td>39,320</td></tr>
<tr><td>- Lake Hakanoa wetland (11ha)</td><td>66,000</td></tr>
<tr><td>Weed control</td><td></td></tr>
<tr><td>- Lake Rotongaro and Lake Rotongaroiti</td><td>6,316</td></tr>
<tr><td>- Lake Hakanoa wetland</td><td>192,500</td></tr>
<tr><td>- Lake Waahi wetlands</td><td>210,000</td></tr>
<tr><td>- Lake Waikare wetland</td><td>49,140</td></tr>
<tr><td>Hydrological reinstatement</td><td></td></tr>
<tr><td>- Lake Waahi wetlands</td><td>10,000</td></tr>
<tr><td>- Lake Waikare wetland</td><td>6,500</td></tr>
<tr><td>- Resource consent fees</td><td>10,000</td></tr>
<tr><td>Project Management/staffing/incidentals (30%)</td><td>967,736</td></tr>
<tr><td>Total</td><td>4,193,523</td></tr>
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</td><td>C = 4.19</td></tr>
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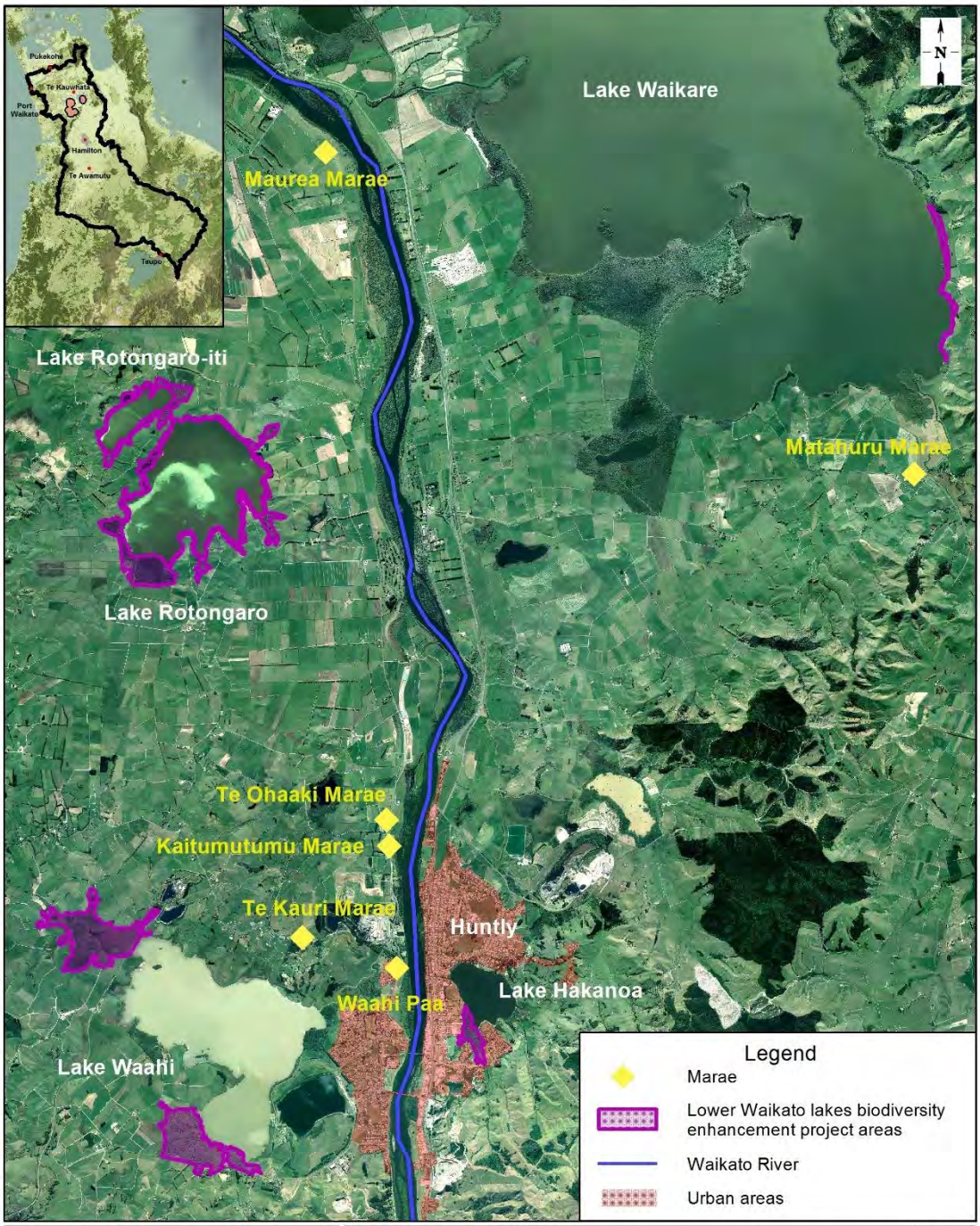


Biodiversity enhancement of selected wetlands around shallow lakes

## WWRRS Project Map

Created by: Tane Desmond
Projection: NZTM
Date: December 2017
Status: Final
Request No.: N/A
File name: WWRRS.gws

0.0 0.6 1.2 1.8 2.4 3.0
Kilometers

Scale 1:75,000@A4 Portrait

A4



Waikato REGIONAL COUNCIL
Te Kaunihera ā Rohe o Waikato

Willow wetland at Lake Hakanoa with native plant understorey beneath willow trees.

Willow wetland at Lake Waahi.

Lake Waikare's eastern shoreline, where wetland restoration is recommended.

| L 11<br>Priority: Very high | Water quality and habitat enhancement at Lake Whangape | BCR value |
|---|---|---|
| Relevant goals from Central/Lower Waikato unit and Shallow Lakes unit | A full range of ecosystem types associated with lakes in the catchment are protected and maintained with a focus on high natural environments. | |
| Name of feature | Lake Whangape | |
| Brief description of feature | Lake Whangape is the second largest lake (1450ha) in the lower Waikato River catchment and is associated with about 910ha of marginal wetlands, including the Awaroa Swamp and a large private wetland (Beverland Wetland). A large proportion of the lake and adjoining wetland is public conservation land (1330ha). It is located to the west of SH1, and is a short distance from Rangiriri. Lake Whangape was historically used to capture tuna (eels) to sustain the iwi. The raupō edges provided materials for clothing and baskets. Its surrounding wetlands supplied rongoā (medicine), birds, trees for general use, dyes and an area for enjoyment.<br><br>The lake is shallow (mean depth of 1.5m) but varies considerably in size between about 9.5km$^2$ to 21km$^2$ depending upon water levels. The lake has a short residence time of 1.5 to 2.5 months, and connects with the Waikato River via the Whangape Stream.<br><br>Lake Whangape receives water from a 35,000ha catchment to the west of the lake that includes steep hill country (upper catchment), moderately steep and strongly rolling hills (middle catchment) and flat to rolling land in the lower parts. The land is predominantly pasture with small areas of native bush and some forestry. Land use is mainly sheep and beef with dairy grazing on the rolling and flat land. Peat has formed around many parts of the lake which has been impacted by drainage and lowering of water tables in recent decades.<br><br>Lake Whangape and its adjoining wetlands and lowland forests are identified within the DOC Waikato Conservation Management Strategy as being key wetland sites within the region. District and regional planning has identified the wetlands adjoining Lake Whangape as being of national or | |

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| | regional significance. Of note are 32ha of seasonally flooded kahikatea forest, the second largest forest of this type remaining in the Waikato ecological region, and extensive and diverse amphibious turf (small stature) plant communities on the lake margin which contain several threatened plant species.<br><br>Recent analyses of water quality data collected by Waikato Regional Council between 2002 and 2016 indicate that:<br><br>- the lake has low water quality and supports high algal biomass that regularly exceeds recreational guideline levels<br>- the minimum annual water clarity is 0.2m and was highest in 2004 with 0.6m<br>- there is high inter-annual variability of chlorophyll a and nutrient (TP and TN) concentrations which are consistently higher than the national bottom line values.<br><br>Despite the degradation in water quality, Lake Whangape continues to support a diverse range of flora and fauna, including nationally important threatened species. It also retains important cultural and recreational values. Public access to the reserves is available at five locations and there are three boat launching sites. It is popular for game bird hunting.<br><br>Lake Whangape is identified as a priority 1 waterbody for stock exclusion in the Waikato Regional Plan. Whilst sections of the lake and wetlands are well fenced (e.g. Awaroa swamp) there are large areas that remain unfenced as large fluctuations in water levels (>2m), topography and geology of the lake shore make fencing particularly challenging. To date WRC and DOC have worked with landowners to fence about 10km of the lake along a boundary that supports the health of the lake while trying to minimise ongoing fence maintenance from flood inundation.<br><br>Alligator weed is both aquatic and terrestrial in the Waikato region and is classified under Waikato's Regional Pest Management Strategy as an 'eradication pest plant'. It is of limited distribution and is a high threat to the region, environmentally and economically. Lake Whangape has been identified as a source site for dispersal of the weed into the lower Waikato catchment. Control of alligator weed has been impeded by continued stock grazing of seasonally inundated land around Lake Whangape. Any restoration of the lake | |

<table>
<tr><td></td><td>margins at Lake Whangape needs to address management of alligator weed.</td><td></td></tr>
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<tr><td>Key threats to the feature that this project addresses</td><td><table><tr><th>Key threat</th><th>Impact on feature</th></tr><tr><td>Stock access</td><td>Destruction of native plant communities, introduction of weed species. Direct inputs of nutrient and microbes into lakes.</td></tr><tr><td>Willow trees</td><td>Shade out native species and spread to other sites.</td></tr><tr><td>Weed species</td><td>Compete with native plant communities and are a threat to agriculture. Alligator weed is a particular problem at Lake Whangape, occupying large areas of shoreline habitat and spreading into adjoining farmland.</td></tr><tr><td>Further drainage and clearance of native wetland vegetation.</td><td>Reduced habitat for native plants and animals and game birds. Loss of nutrient attenuation areas, and loss of wetland areas to slow flood flows.</td></tr></table></td><td></td></tr>
<tr><td>Project goal/s</td><td>Within 5 years:<br>- Lake Whangape and the adjoining wetland are 100% fenced and protected from stock.<br>- 12 hectares of lake marginal habitat has been revegetated. Willow and other ecosystem changing weeds have been reduced to < 5% of their current abundance in high value wetlands adjoining Lake Whangape.</td><td></td></tr>
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| | - Alligator weed within Lake Whangape has been reduced to an area that can be contained. | |
| Priority works for funding | Suggested works could be implemented either by an organisation or private citizens (using contractors or their own labour) in collaboration with DOC. This project could be undertaken as a whole, or in multiple smaller components.<br><br>Note: Some costings for this project differ from standard cost assumptions. This is due to more detailed knowledge of the site and management requirements at Lake Whangape.<br><br>**Fencing**<br>This project proposes to fence Lake Whangape close to the high water level where it adjoins pasture, and around wetlands and lowland forest where they adjoin the lake. This will involve 22.5km of new fencing at $25 per metre ($562,500) and upgrading a 3.6km stretch of fencing at $11 per metre ($39,600) that does not effectively exclude stock in its current state.<br><br>Fully fencing the lake margin is crucial to achieving containment of alligator weed at Lake Whangape.<br><br>**Alligator weed control**<br>Land based control of yellow flag iris and alligator weed around Lake Whangape (Additional to existing WRC programme).<br>- Years 1, 2, 3 – two contractors for 10 days per year ($1000 per day).<br><br>- Years 4, 5, 6 – two contractors for 5 days per year.<br><br>Total: $45,000 over 6 years.<br><br>**Weed and willow control**<br>There are a number of other weeds that are progressively impacting on the integrity of littoral and wetland plant communities adjoining Lake Whangape. These include grey willow, crack willow, yellow flag, blackberry, reed sweet grass and royal fern. This project involves controlling these weeds in areas of highest conservation values (e.g. Tikotiko Arm, Awaroa Wetland, Beverland Wetland). The objective is to reduce them to very low levels over the five years so that any ongoing control is of a scale that can be sustained by landowners, including DOC. The following works are proposed: | |

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| | Aerial willow control of 66ha of wetland habitat (with sparse native understorey) is required at $1200 per hectare ($79,200), with ground based control in following year at $400 per hectare ($26,400).<br><br>Ground based willow control of 40.24ha of high value wetland habitat at $4000 per hectare (low-high willow density) ($160,960) with follow-up control in following year at $400 per hectare ($16,096).<br><br>Ground based control of ecosystem changing weeds (e.g. yellow flag iris, blackberry, reed sweet grass and royal fern) over 37.91ha of high value wetland habitat at $2800 per hectare ($106,148), with follow-up control in following year at $400 per hectare ($15,164).<br><br>**Planting of lake shoreline**<br>Planting of the lake shoreline involves supplementary planting of 12.02ha of lake margin including adjoining wetlands and is estimated to require 53,500 native plants. Assumes planting at 1.5m spacing. 7.02ha of pasture to be planted at $37,552 per hectare ($263,615) and 5ha of weedy site to be planted at $39,552 per hectare ($197,760). Follow-up weed control for two years at $800 per hectare ($9616).<br><br>**Project management/staffing/incidentals**<br>Staff to carry out landowner liaison, iwi engagement, Health and Safety requirements, negotiate agreements, inspect works, manage parts of the work as required (e.g. fencing or planting), project reporting and financial management. Incidentals include transport, office overheads, consumables and miscellaneous professional fees.<br><br>This is estimated to be 20% of the direct project costs. | |
| Time lag for benefits to be realised | If works were implemented at an even pace over a 5-year period, it is estimated that the majority of the project benefits would be seen approximately 2-3 years after project completion. | L = 7.5 |
| Effectiveness of works | When compared with desired state Lake Whangape is currently in very poor condition with few of the Vision & Strategy aspirations being met. The lake is not swimmable, and the presence of pest fish and exotic plant species impacts significantly on ecological integrity. The very poor water quality is an impediment to safe recreational use of the lake. | W = 0.1 |

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| | However, the lake still retains very high significance with iwi and the local community, and retains very important cultural and biodiversity values. In particular, it has a good contiguam of ecosystem types, which is now rare for a Lower Waikato lake. Some decline in condition is expected over the next 20 years in the absence of this project due to the impact of alligator weed at the site. This project will address stock access and pest plant issues and is expected to improve biodiversity values at the lake. It is not expected to improve lake water quality. It is acknowledged that achieving the Vision & Strategy desired state for Lake Whangape will take longer than the 20 year horizon used for the purposes of the Restoration Strategy, and a fuller range of initiatives. However, this project will move the lake closer to this state by making significant improvements to surrounding wetlands and lake margins. | |
| Risk of technical failure | There is a moderate to high risk of project failure due to technical feasibility. Risks are mostly related to weed control. There is a particularly high risk of project failure due to technical feasibility if weed control isn't well planned and undertaken by experienced operators. This project would benefit from Project CLW 9 (control of yellow flag iris and alligator weed) being undertaken concurrently. | F = 0.7 |
| Adoptability | It is estimated that about half of landowners would adopt the works if they were fully incentivised. Works on publicly owned land are expected to be fully adopted. Some private landowners may be concerned by loss of marginal grazing areas, however generally the benefits of avoiding loss of stock in wetlands are becoming better recognised. There are also currently landowners around the lake that are undertaking similar projects and these farmers can be good advocates to others in the catchment. | A = 0.5 |
| Information quality | Very good – recommendations are based on advice of a trusted local expert with detailed on-the-ground knowledge. Department of Conservation and Waikato Regional Council staff who have worked at this site were consulted about what further work was required to enhance surrounding wetlands. | |
| Knowledge gaps | Some of the weed control and planting work has been estimated from aerial photographs. Specific requirements will need to be assessed during project planning. | |
| Socio-political risks | Very low risk that the project will fail to meet its goals over the long term due to socio-political risks. | P = 0.97 |
| Project duration (years) | 5 years | |

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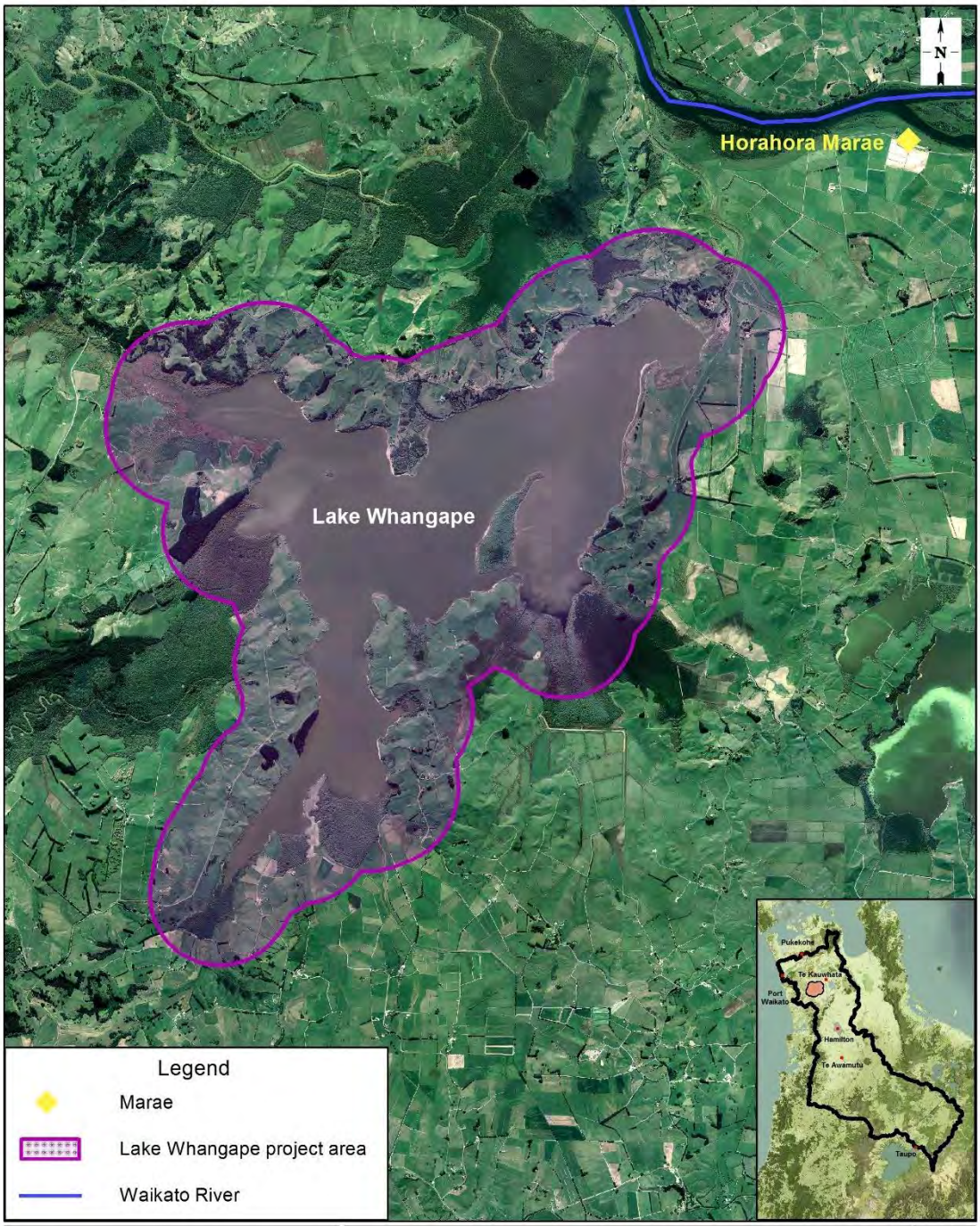
| Up-front cost – total for implementation phase/project duration | | C = 1.83 |

| **Task** | **Cost ($)** |
|---|---|
| Fencing (26.1km) | 602,100 |
| Alligator weed control | 45,000 |
| Willow control | 282,656 |
| Targeted weed control of other weeds | 121,312 |
| Planting of lake shoreline (12.02ha) | 470,991 |
| Project Management/staffing/incidentals (20%) | 304,412 |
| **Total** | **1,826,471** |




Water quality and habitat enhancement at Lake Whangape

WWRRS Project Map

Created by: Tane Desmond
Projection: NZTM
Date: December 2017

Status: Final
Request No.: N/A
File name: WWRRS.gws

0.0 0.4 0.8 1.2 1.6 2.0
Kilometers

Scale 1:55,000@A4 Portrait

A4



Waikato REGIONAL COUNCIL
Te Kaunihera ā Rohe o Waikato

Ineffective fence on the lake margin at Lake Whangape.

Alligator weed on the edge of the lake (by back the hooves of the front cow) gets trampled and spread around the lake margin at Lake Whangape.

Unfenced lake margins result in destruction of littoral vegetation, lakeshore erosion, spread of alligator weed and faecal contamination from stock.

Some of the high value wetlands and lowlands forests in the Tikotiko Arm that are contiguous with Lake Whangape.

| L 12<br>Priority: Very high | Water quality and habitat enhancement at Lake Waahi | BCR value |
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| Relevant goals from Central/Lower Waikato unit and Shallow Lakes unit | Innovative interventions are developed, tested and implemented to improve lake values, including options such as flocculants, dredging and enhancing lake embayments.<br><br>Communities have plentiful, safe access to lakes for a range of recreational purposes, including safe contact and immersion in water and food gathering.<br><br>Projects on lakes are prioritised according to cultural significance, ability to improve and ability or appropriateness to access.<br><br>Nutrient, sediment and *E. coli* inputs to lakes are reduced by a proportion that leads to noticeable improvements in lake water quality and so that it is safe for swimming and gathering of taonga species.<br><br>Catchment management programmes protected and enhance priority shallow lakes and their catchments<br><br>Flagship lakes catchments are established for educational and promotion purposes. | |
| Name of feature | Lake Waahi | |
| Brief description of feature | Lake Waahi is the third largest lake in the Lower Waikato catchment with a surface area of 522ha. It has a maximum depth of 5m and a catchment area of 9407ha. The lake is situated to the west of Huntly township, within a predominantly pastoral catchment. It receives inflows from a range of sources including Awaroa Stream and the much smaller Waikokowai Stream. A coal haulage road was constructed across the northwestern end of Lake Waahi in 1977, dissecting the northwest arm of the lake, and restricted water movement between the arm and the main body of the lake.<br><br>Diffuse and direct discharges from coal mining have contributed large quantities of suspended sediments to Lake Waahi which have altered the colour, clarity and chemistry of the lake's water. Coal mining was reportedly responsible for up to 90% of the sediment entering the lake at times (Dell 1988).<br><br>A significant shift in the lake water quality was observed after the lake aquatic vegetation collapsed in 1978-79, causing the waters of the main body of the lake to become highly turbid. | |

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| | Waikato Regional Council has monitored the water quality of Lake Waahi regularly since September 1995. In addition, a lake monitoring buoy was installed in Lake Waahi in 2014 to collect real-time information about the physico-chemical conditions (and dynamics) within the lake.<br>The most recent monitoring results indicate that Lake Waahi is currently supertrophic, with low water clarity, high nutrient levels and high phytoplankton density. Blue-green algae have also become abundant in recent years. Analysis of recent data indicates that between 2006 and 2010 there has been a probable decline in the trophic state of Lake Waahi (WRC 2012).<br><br>During the most recent LakeSPI survey in 2010, the lake was mostly devegetated and supported only sparse milfoil fringes (<5% cover) at depths of <0.3m (Edwards et al. 2010). This survey recorded a further decline in the extent of offshore stands of reeds (*Eleocharis sphacelata*). Poor aquatic plant regeneration levels have been attributed to the shallow nature of the lake, poor water clarity due to sediment re-suspension, and low levels of seeds.<br><br>Numerous planting and fencing initiatives have been undertaken around the lake over the last decade or more. This has involved a large number of contributors, including landowners, WRC, Solid Energy, WCEET, WRA, Waikato-Tainui, Waahi Whanui and Genesis Energy.<br><br>Native species known from the lake include shortfin eel, longfin eel, giant kōkopu, kōaro and grey mullet. Exotic species include koi carp, goldfish, rudd, perch and catfish. Koi and rudd in particular limit the regeneration of aquatic macrophytes.<br><br>Tuna have been commercially fished in the past, although the productivity of the fishery has declined significantly. The Lake Waahi tuna fishery is also very culturally significant, with an important traditional eeling site located on the Waahi outlet stream.<br><br>Lake modelling of Lake Waahi in 2017 has identified that algal blooms in the lake are most likely driven by internal release of phosphorus that has accumulated over time in the lake. Phosphorus in the lake sediments is released into the overlying lake water whenever the lake is depleted of oxygen, which occurs frequently during the summer and autumn | |

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| | **Reduce external sediment load**<br>Reducing sediment and phosphorus entering the lake is considered to be a high priority for the long term improvement of water quality in Lake Waahi. The upper catchment (Upper Awaroa) recommended works are detailed in a separate project assessment (total value $2,329,610). Recommendations for the remainder of the lake catchment are as follows:<br><br><u>Hill country soil conservation</u><br>- 41ha LUC 6e land managed with open space pole planting at $3000 per hectare ($123,000)<br>- 41ha LUC 6e land managed with plantation species (pine or mānuka) at $3000 per hectare ($123,000)<br>- 10km of fencing the managed LUC 6e land at $25 per metre (8-wire and batten) ($250,000)<br>- 3km fencing existing indigenous forest cover at $25 per metre (8-wire and batten) ($75,000).<br><br><u>Riparian management of rivers/streams in pasture for reducing erosion</u><br><br>*Costs for fencing are based on a 5-wire (2 electric), however in flood prone streams a 3-wire electric fence would also be acceptable.*<br><br>Carry out riparian fencing with a minimum 5m setback from the top of the streambank along an estimated 33km of streambank ($8 per metre is $264,000). Include adjoining wetland areas within the riparian fencing. Undertake a mix of native and exotic soil conservation riparian planting within the fenced area (where it doesn't exist naturally), estimated to be 13ha of planting, and associated weed control and maintenance ($37,552 per hectare is $488,176). 2976 willow poles are estimated to be required for river and stream erosion control ($14 per pole is $41,664). These should be planted a 10m intervals in erosion prone reaches.<br><br>**Addition of flocculent to lake inflow**<br><br>This project involves reducing phosphorus in Lake Waahi using continuous alum dosing, a highly effective method for removing phosphorus from freshwater systems. Continuous alum dosing is currently being employed by the Bay of Plenty Regional Council to help meet water quality targets for lakes Rotorua, Rotoehu and Okaro. Before this is undertaken at Lake Waahi, further trials are required to determine the likely effectiveness of this technique in Waikato lakes. | |

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| | Continuous alum dosing involves pumping low levels of alum (the chemical, aluminium sulphate) into major lake inflows. It requires a small facility to safely store alum close to the site and some method for dispensing the alum (e.g. chemical pump).<br><br>At Lake Waahi. works and costs are estimated as follows:<br><br>- Pump shed and pump ($150,000)<br>- Resource consent and consultation ($50,000)<br>- Investigations for establishing appropriate dose rate ($100,000)<br>- Dosing at $600,000 per year for 5 years ($3,000,000). This includes the ongoing monitoring to determine that dose rates are appropriate.<br><br>After a 5-year period the programme should be reassessed to determine the cost-effectiveness of continuing.<br><br>**Project management/staffing/incidentals**<br>Staff to carry out landowner liaison, iwi engagement, Health and Safety requirements, negotiate agreements, inspect works, manage parts of the work as required (e.g. fencing or planting), project reporting and financial management. Incidentals include transport, office overheads, consumables and miscellaneous professional fees.<br><br>This is estimated to be 15% of the direct project costs. | |
| Time lag for benefits to be realised | If works were implemented at an even pace over a 10-year period, it is estimated that the majority of the project benefits would be seen approximately 7-8 years after project commencement. | L = 7.5 |
| Effectiveness of works | When compared with desired state, Lake Waahi is currently in poor condition with few of the Vision & Strategy aspirations being met. The lake is not swimmable but it is sometimes fishable and access for recreation is good. The lake retains very high significance with iwi and the local community, as well as some important wetlands and biodiversity values. The lake is not expected to change in overall condition over the next 20 years in the absence of this project. This project will help address catchment sediment load and reduce internal P loading. It will also have secondary biodiversity benefits. Modelling undertaken by the University of Waikato in 2017 indicates that this work would move chl in the lake close to the National Objectives Framework C band and improve water | W = 0.15 |

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| | clarity. There would be significant benefits to this project being carried out in alignment with Lakes project L13. It is acknowledged that achieving the Vision & Strategy desired state for Lake Waahi will take longer than the 20 year horizon used for the purposes of the Restoration Strategy, and a fuller range of initiatives. However, this project is expected to lead to a measurable improvement in lake condition over the next 20 years. | |
| Risk of technical failure | There is a moderate to high risk of project failure due to technical feasibility. The highest risk component of the project relates to the alum dosing which has not yet been proven in a shallow lake in New Zealand. This work should not be attempted until smaller laboratory and field based trials have shown that it will be effective (see section on investigation priorities). | F = 0.80 |
| Adoptability | Works on publicly owned land are expected to be adopted if fully incentivised. There is uncertainty around the willingness of private landowners to sell land for wetland and constructed treatment system development. This would need to be confirmed before the project was initiated. Uptake of management of LUC class 6e and 7 land and riparian retirement may be low, and we are not aware of significant similar works being undertaken in this catchment to date. Early community engagement, flexibility of approach and identifying key farmers will be very important for the success of this project. | A = 0.6 |
| Information quality | Good – the lake is well known and has recently been the subject of detailed modelling by the University of Waikato. Estimates for reducing external sediment and phosphorus come from a desk top exercise. | |
| Knowledge gaps | There is uncertainty around the effectiveness of continuous alum dosing where koi carp are present. Trials should first be undertaken in a smaller lake or lake embayment. | |
| Socio-political risks | Moderate to high risk that the project will fail to meet its goals over the long term due to socio-political risks. This relates to the proposed use of alum which may not be acceptable to iwi, stakeholders and community. Early engagement with tāngata whenua during project scoping will be critical. | P = 0.62 |
| Project duration (years) | 10 years | |

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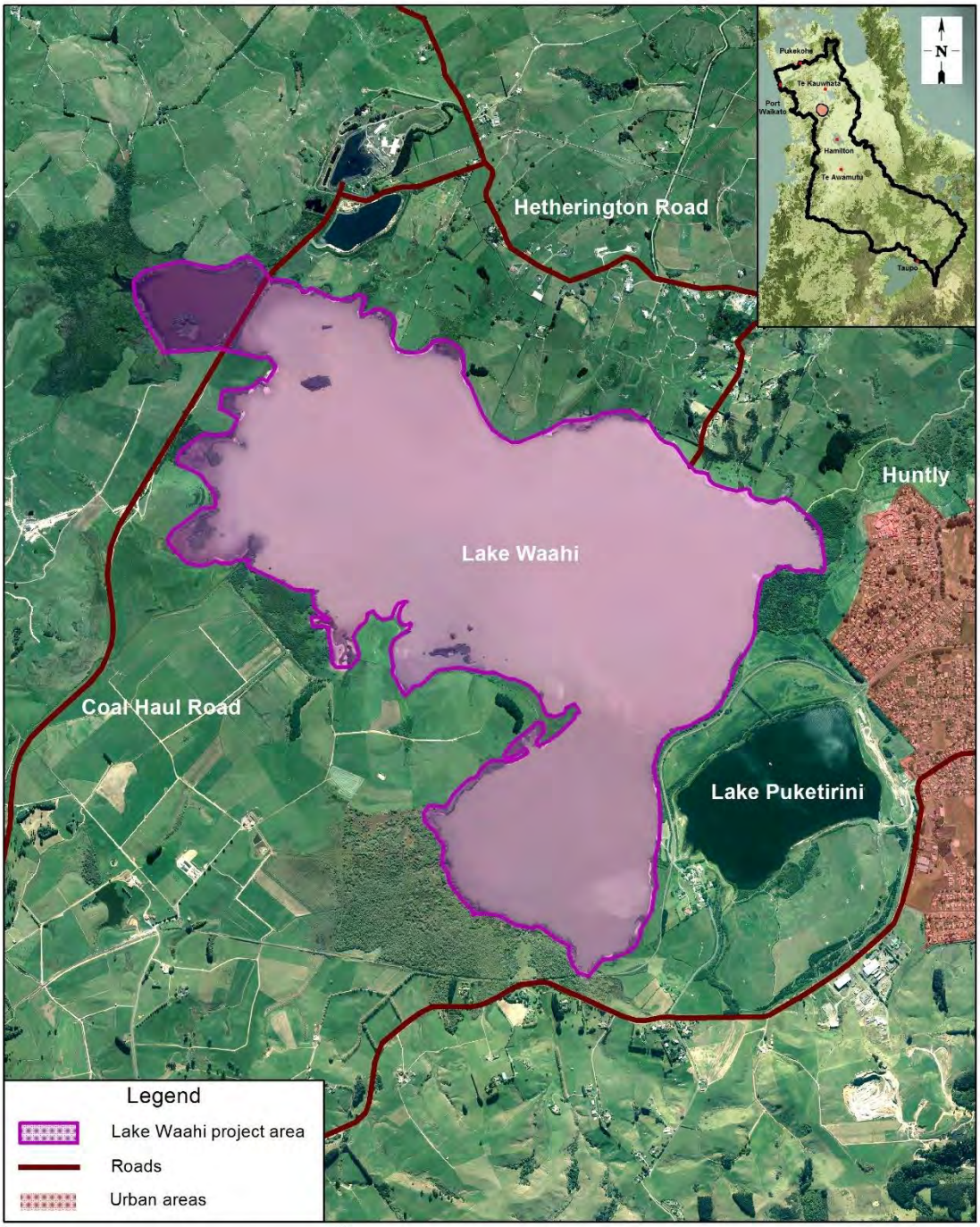
| Up-front cost – total for implementation phase/project duration | | C=5.36 |

| **Task** | **Cost ($)** |
|---|---|
| Reduce external sediment load | |
| - Hill country erosion | 571,000 |
| - Stream bank erosion | 793,840 |
| Addition of flocculant to lake inflow | 3,300,000 |
| Project management/staffing/incidentals (15%) | 699,726 |
| **Total** | **5,364,566** |




Water quality and habitat enhancement at Lake Waahi

WWRRS Project Map

Created by: Tane Desmond
Projection: NZTM
Date: December 2017

Status: Final
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0.0 0.2 0.4 0.6 0.8 1.0
Kilometers

Scale 1:25,000@A4 Portrait

A4



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Te Kaunihera ā Rohe o Waikato

Lake Waahi showing a high suspended sediment load. (Photo: NIWA)

| L 13<br>Priority: Very high | Intensive removal of pest fish at Lake Waahi | BCR value |
|---|---|---|
| Relevant goals from Central/Lower Waikato unit and Shallow Lakes unit | Nutrient and sediment inputs to lakes are reduced by a proportion that leads to noticeable improvements in lake water quality so that lakes are safe for swimming and gathering of taonga species.<br>Koi biomass is reduced by 80% in key lakes and maintained at this level. The impacts of other pest fish on lake water quality are managed. | |
| Name of feature | Lake Waahi | |
| Brief description of feature | Lake Waahi is the third largest lake in the Lower Waikato catchment with a surface area of 522ha. It has a maximum depth of 5m. The lake is situated west of Huntly township, within a predominantly pastoral catchment. It receives inflows from a range of sources, including Awaroa Stream and the much smaller Waikokowai Stream. A coal haulage road was constructed across the northwestern end of Lake Waahi in 1977, dissecting the northwest arm of the lake, and restricted water movement between the arm and the main body of the lake.<br><br>Diffuse and direct discharges from coal mining have contributed large quantities of suspended sediments to Lake Waahi, which have altered the colour, clarity and chemistry of the lake's water. Coal mining was reportedly responsible for up to 90% of the sediment entering the lake at times (Dell 1988).<br><br>A significant shift in the lake water quality was observed after the lake aquatic vegetation collapsed in 1978-79, causing the waters of the main body of the lake to become highly turbid. Waikato Regional Council has monitored the water quality of Lake Waahi regularly since September 1995. In addition, a lake monitoring buoy was installed in Lake Waahi in 2014 to collect real-time information about the physico-chemical conditions (and dynamics) within the lake.<br>The most recent monitoring results indicate that Lake Waahi is currently supertrophic, with low water clarity, high nutrient levels and high phytoplankton density. Blue-green algae have also become abundant in recent years. Analysis of recent data indicates that between 2006 and 2010 there has been a probable decline in the trophic state of Lake Waahi (WRC 2012). | |

| | | |
|---|---|---|
| | During the most recent LakeSPI survey in 2010, the lake was mostly devegetated and supported only sparse milfoil fringes (<5% cover) at depths of <0.3m (Edwards et al. 2010). This survey recorded a further decline in the extent of offshore stands of reeds (*Eleocharis sphacelata*). Poor aquatic plant regeneration levels have been attributed to the shallow nature of the lake, poor water clarity due to sediment re-suspension, and low levels of seeds.<br><br>Numerous planting and fencing initiatives have been undertaken around the lake over the last decade or more. This has involved a large number of contributors including landowners, WRC, Solid Energy, WCEET, WRA, Waikato-Tainui, Waahi Whanui and Genesis Energy.<br><br>Native species known from the lake include shortfin eel, longfin eel, giant kōkopu, kōaro and grey mullet. Exotic species include koi carp, goldfish, rudd, perch and catfish. Koi and rudd in particular limit the regeneration of aquatic macrophytes. Tuna have been commercially fished in the past, although the productivity of the fishery has declined significantly. The Lake Waahi tuna fishery is also very culturally signficant, with an important traditional eeling site located on the Waahi outlet stream.<br><br>Lake modelling of Lake Waahi in 2017, has identified that algal blooms in the lake are most likely driven by internal release of phosphorus that has accumulated over time in the lake. Phosphorus in the lake sediments is released into the overlying lake water whenever the lake is depleted of oxygen, which occurs frequently during the summer and autumn months. Sediment resuspension from wind and the impacts of pest fish also negatively impact on lake water quality. | |
| Desired state to achieve Vision & Strategy | - The lake is swimmable, fishable and has access for recreation and gathering of kai.<br>- Native aquatic plants dominate the in-lake flora and provide habitat for healthy populations of other indigenous species.<br>- Lake margins retain natural hydrological function and are well vegetated with native plant communities that support indigenous fauna.<br>- Wetlands adjacent to lakes are densely vegetated with native plant species, connected to riparian corridors, protected from stock grazing and native plant regeneration occurs naturally.<br>- Iwi and community have a strong connection to the lake and are active in its use, protection and restoration. | |

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<tr><td>In-lake nutrient load</td><td>Phosphorus is released from lake sediments when there are anoxic events, which can lead to algal blooms that affect the use of the lake for recreation.</td></tr>
</table></td><td></td></tr>
<tr><td>Project goal/s</td><td>Within 5 years of project commencement, water quality has measurably improved in Lake Waahi.<br><br>Knowledge and tools have been developed that can be applied at other large lakes, such as Whangape, Waikare, and Ngāroto, that are also koi carp spawning and recruitment hotspots.</td><td></td></tr>
<tr><td>Priority works for funding</td><td>This is an adaptive management project and works could be implemented by a single organisation but preferably as a collaboration. This project is an opportunity for wide community involvement, with the potential for iwi, landowners, agencies and other groups to partner and run the fish removal work and ongoing monitoring.<br><br>Barrier design and construction<br>- Engineering assessments to develop an effective adult koi carp barrier. The design may incorporate a cage to enable pest fish to be uplifted for processing into useful materials (refer to the Carp Neutral project at Lake Waikare).<br>- Undertake consultation with iwi and stakeholders.<br>- Prepare and submit documentation to gain necessary consents/permits, including any other assessments and consultation.<br>- Barrier construction and installation.<br><br>Intensive removal of pest fish<br>- Trial intensive and targeted trapping/netting work over a 10 year period. This will include using various techniques to</td><td></td></tr>
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|---|---|---|
| | account for species and size selectivity, and analysing the best places and times to do this, e.g. targeting work in weedy areas during spawning times.<br><br>**Monitoring and adapting approach**<br>- Undertake monitoring of water quality, changes in koi carp and other pest fish populations, barrier effectiveness, water quality, koi carp larval hotspots and the effects of the works on indigenous fish (also invertebrates, and plants, if possible). Various techniques could be trialled for this monitoring, such as drones to identify koi aggregation locations and larval hotspots, and/or remote sensing for water quality.<br>- Assessment of trialled methods to see how they can be improved and whether they will be applicable for other large waterbodies. This task should include not only possible modifications to existing methodologies, but also investigation of new techniques, e.g. slow-release baits, liquid rotenone, moveable barriers to isolate spawning areas, ways to identify and target important larval rearing sites.<br>- Ongoing barrier maintenance.<br><br>**Project management/staffing/incidentals**<br>Staff to carry out landowner liaison, iwi engagement, Health and Safety requirements, negotiate agreements, inspect works, manage parts of the work as required (e.g. fencing or planting), project reporting and financial management. Incidentals include transport, office overheads, consumables and miscellaneous professional fees.<br><br>This is estimated to be 30% of the direct project costs in Year 1 and 20% in Years 2-10. | |
| Time lag for benefits to be realised | If works were implemented at an even pace over a 10-year period, it is estimated that the majority of the project benefits would be seen approximately 7 years after project commencement. | L = 7 |
| Effectiveness of works | When compared with desired state, Lake Waahi is currently in poor condition with few of the Vision & Strategy aspirations being met. The lake is not swimmable, but it is sometimes fishable and access for recreation is good. The lake retains very high significance with iwi and the local community, as well as some important wetlands and biodiversity values. The lake is not expected to change in overall condition over the next 20 years in the absence of this project. This project will help address internal sediment resuspension in the lake. It will also have secondary biodiversity benefits through reducing pest fish biomass. There would be significant benefits to this project being carried out in alignment with | W = 0.15 |

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| | Lakes project L 12. It is acknowledged that achieving the Vision & Strategy desired state for Lake Waahi will take longer than the 20 year horizon used for the purposes of the Restoration Strategy, and a fuller range of initiatives. However, this project is expected to lead to a measurable improvement in lake condition over the next 20 years. | |
| Risk of technical failure | There is a high risk of project failure due to technical feasibility. There is uncertainty around how effective intensive fishing will be in reducing koi numbers significantly in a lake of this size. Magnitude of reduction required to improve water clarity is also not well known. This project should be viewed as an adaptive management project and therefore be flexible in response to monitoring results. | F = 0.7 |
| Adoptability | Works are on publicly owned land and are expected to be adopted if fully incentivised. | A = 1 |
| Information quality | Average – there is much known about the lake and species, but this would be the first attempt at an intensive removal of koi carp in a Lower Waikato lake. Recommendations have been made by subject matter experts and those with local knowledge of the site. | |
| Knowledge gaps | There is currently no known effective control and/or eradication methodology for koi carp in large waterbodies in New Zealand. This project would therefore be adaptive in nature. There is also limited options for barriers that prevent pest fish incursion whilst still enabling indigenous species access to and from the lakes (see section on investigation priorities). | |
| Socio-political risks | Low risk that the project will fail to meet its goals over the long term due to socio-political risks. | P = 0.85 |
| Project duration (years) | 10 years | |

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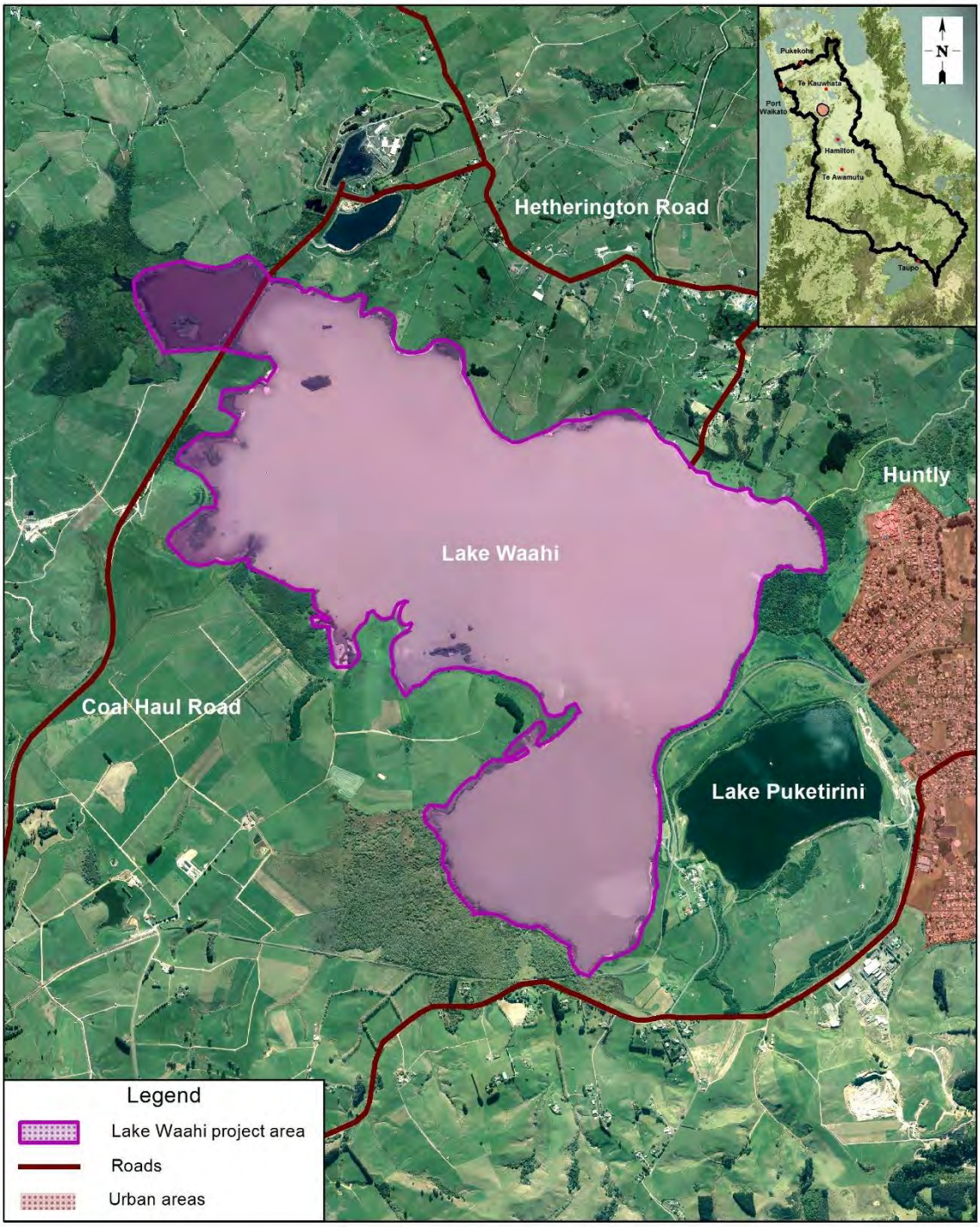
| Up-front cost – total for implementation phase/project duration | | C = 2.64 |

| Task | Cost |
|---|---|
| Detailed project plan | 20,000 |
| Engineering assessments and design of barrier | 40,000 |
| Consultation and cultural assessment | 30,000 |
| Consents/permits | 15,000 |
| Construction and installation of barrier | 70,000 |
| Fish removal using traps/nets (3 people for 40 days, $70 per hour; plus $35,000 for purchase of equipment and use of boats) | 102,200 |
| Monitoring for koi carp population changes and overall ecosystem effects of this work (3 people for 40 days, $70 per hour) | 67,200 |
| Landowner reparation (e.g. easements, fencing, flood mitigation) | 5000 |
| Project management Year 1 (30%) | 104,820 |
| ***Sub-total (up-front cost)*** | **454,220** |
| Project management per year (Years 2-10) (20%) | 40,258 |
| Fish removal using traps/nets (3 people for 40 days, $70 per hour; plus $25,000 for purchase of equipment and use of boats) | 92,200 |
| Monitoring for koi carp population changes and overall ecosystem effects of this work (3 people for 40 days, $70 per hour) | 67,200 |
| Technical reports analysing the monitoring data | 40,000 |
| Barrier maintenance (annual; 2 people for 2 days, $70 per hour plus $500 materials) | 2740 |
| Consent fees (annual) | 500 |
| ***Annual cost*** | **243,168** |
| ***Sub-total (annual costs × 9 years)*** | **2,188,512** |
| **TOTAL for 10 year period** | **$2,642,732** |




Intensive removal of pest fish at Lake Waahi

WWRRS Project Map

Created by: Tane Desmond
Projection: NZTM
Date: December 2017

Status: Final
Request No.: N/A
File name: WWRRS.gws

0.0 0.2 0.4 0.6 0.8 1.0
Kilometers

Scale 1:25,000@A4 Portrait

A4



Waikato REGIONAL COUNCIL
Te Kaunihera ā Rohe o Waikato

| L 14<br>Priority: High | Water quality and habitat enhancement at Lake Areare | BCR value |
|---|---|---|
| Relevant goals from Central/Lower Waikato unit and Shallow Lakes unit | Nutrient and sediment inputs to lakes are reduced by a proportion that leads to noticeable improvements in lake water quality so that lakes are safe for swimming and gathering of taonga species. | |
| Name of feature | Lake Areare | |
| Brief description of feature | Lake Areare is a 33ha peat lake in the Horsham Downs area. Lake water quality is poor (hypertrophic) with frequent algal blooms. The lake has an average depth of 3m and maximum depth of 4.5m. The lake is well mixed (i.e. oxygenated) all year round. It contains no submerged plants.<br>The lake is public reserve land managed by DOC with an accessway and car park off Driver Rd. An informal circuit track at the lake can be traversed by foot.<br><br>The Lake Areare catchment is 263ha with the main land use being pastoral farming, primarily dairy with a few dry stock farms. The Waikato Expressway bisects the catchment with stormwater from the four lane motorway discharging into the lake via a constructed wetland designed to mitigate effects of stormwater (not agricultural run off). The size of the constructed wetland is not sufficient to treat all of the inflow volumes which includes drainage water from about 140ha of dairy farming. All but one of the other inflows have silt traps with constructed wetlands built on them to attenuate nutrient and sediment inputs to the lake.<br><br>The lake is fully fenced and is surrounded by wetland which varies from 5m to 200m in distance from the lake edge. The wetland is dominated by native plants, many of which have been planted over the last 15 years. The extent of problematic weed species has been reduced to manageable levels in recent years. The lake provides habitat for a range of indigenous plants and animals, including eight threatened bird and fish species and good-sized populations of game-bird species.<br><br>Lake Areare and the Horsham Downs lakes are culturally and historically significant to iwi. There are many historic pā sites within the area between Gordonton and Taupiri. Iwi would | |

<table>
<tr><td></td><td>have accessed these lakes and wetlands to gather food, clothing and weaving materials, rongoā (medicine), birds and materials for general use.</td><td></td></tr>
<tr><td>Desired state to achieve Vision & Strategy</td><td>- The lake is swimmable, fishable and has access for recreation and gathering of kai.<br>- Native aquatic plants dominate the in-lake flora and provide habitat for healthy populations of other indigenous species.<br>- Lake margins retain natural hydrological function and are well vegetated with native plant communities that support indigenous fauna.<br>- Wetlands adjacent to lakes are densely vegetated with native plant species, connected to riparian corridors, protected from stock grazing and native plant regeneration occurs naturally.<br>- Iwi and community have a strong connection to the lake and are active in its protection and restoration.</td><td></td></tr>
<tr><td>Impact on Vision & Strategy</td><td>In a restored condition, Lake Areare would have a very high impact on giving effect to the Vision & Strategy at a local level.</td><td>VS = 6</td></tr>
<tr><td>Key threats to the feature that this project addresses</td><td><table><tr><th>Key threat</th><th>Impact on feature</th></tr><tr><td>Diffuse pollution from catchment land use</td><td>Further degradation of water quality due to increases in nutrients, sediment and harmful microbes.</td></tr></table></td><td></td></tr>
<tr><td>Project goal/s</td><td>Within 5 years of project commencement water quality has measurably improved in Lake Areare.</td><td></td></tr>
<tr><td>Priority works for funding</td><td>Extend the size of the constructed wetland on the main inflow to reduce nutrients, sediment and harmful microbes entering Lake Areare from agricultural run off.<br><br>Department of Conservation is currently negotiating with NZTA to add land that was obtained but not used for the Waikato Expressway to the Lake Areare Wildlife Management Reserve. This would enable the wetland to be increased from 1.8ha to 3.5ha. The size of the wetland would be 2.5% of the catchment size. McKergow et al. (2007) estimate that the performance of a constructed wetland of this type and size (in relation to catchment area) is likely to result in the following reductions: about 80% of annual sediment load, 60% of nitrogen, 60-80% of particulate phosphorus and >90% of E. coli.</td><td></td></tr>
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| | Work should be implemented by an organisation (using contractors) and is likely to need a project manager to co-ordinate the works and to work closely with the land managers (i.e. Department of Conservation).<br><br>The work would involve the following:<br><br>**Design and specifications for constructed wetland:** These will need to be prepared by an appropriately qualified person using guidelines that specifically target the reduction of nitrogen, phosphorus, *E.coli* and sediment arising from agricultural run off. Based on costs for similar projects undertaken at other peat lakes, it is estimated that this will cost approximately $10,000.<br><br>**Consent:** Consents would need to be obtained for earthworks associated with the constructed wetland, from both Waikato Regional Council and the Waikato District Council. This would include undertaking consultation with tāngata whenua and possibly commissioning a cultural impact assessment. Based on costs for similar projects undertaken at other peat lakes, the consent costs, which include application preparation, consent fees and consultation, is likely to cost approximately $25,000.<br><br>**Construction of wetland:** This will involve carrying out earthworks to create a large wetland or series of wetlands. It will also involve creating a connection to the existing stormwater wetland and filling the current outlet from this wetland to the lake. Estimated volume of earthworks is 17,000$m^3$ (based on area of 1.7ha and average depth of 1m). Cost – $21,000. Additional $4000 to cover costs to connect wetlands and close current outlet.<br><br>**Planting wetland:** Constructed wetlands require high planting densities. The area to be planted is 1.7ha at $100,000 per hectare ($170,000).<br><br>**Project management/staffing/incidentals**<br>Staff to carry out landowner liaison, iwi engagement, Health and Safety requirements, negotiate agreements, inspect works, manage parts of the work as required (e.g. fencing or planting), project reporting and financial management. | |

| | | |
|---|---|---|
| | Incidentals include transport, office overheads, consumables and miscellaneous professional fees.<br><br>This is estimated to be 20% of the direct project costs. | |
| Time lag for benefits to be realised | If works were implemented at an even pace over a 3-year period, it is estimated that the majority of the project benefits would be seen approximately 2-3 years after project completion. | L = 4.5 |
| Effectiveness of works | When compared with desired state, Lake Areare is in moderate condition with some of the Vision & Strategy desired state aspects already being met or partly met. This includes having access for recreation and some large and well planted margins. It is expected that over the next 20 years there may be a slight improvement in overall lake condition as a result of recent restoration works. Works included here are expected to help in addressing some of the key threats to the lake, including external nutrient and sediment inputs, as well as improve surrounding wetland biodiversity values. However, the lake water quality would still be expected to remain in a NOF D band even with this project being undertaken. It is acknowledged that achieving the Vision & Strategy desired state at Lake Areare will take longer than the 20-year horizon used for the purposes of the Restoration Strategy, and a fuller range of initiatives over the long term. However, if this project is successfully completed it is expected that there will be a small additional improvement in condition in 20 years and the lake will be closer to the desired Vision & Strategy state than it is currently. | W = 0.025 |
| Risk of technical failure | There is a moderate risk of project failure due to technical feasibility. Effectiveness of constructed wetland treatment systems has not yet been fully established. | F = 0.82 |
| Adoptability | Works proposed are on publicly owned land are expected to be adopted if fully incentivised. | A = 1 |
| Information quality | Average – recommendations are based on advice of local expert/s with a history of association to the site. | |
| Knowledge gaps | Only generic information on the likely expected reductions in contaminants is currently available. | |
| Socio-political risks | Very low risk that the project will fail to meet its goals over the long term due to socio-political risks. There have already been significant enhancement works successfully completed at the lake. | P = 0.97 |
| Project duration (years) | 3 years | |

<table>
<tr>
<td>Up-front cost – total for implementation phase/project duration</td>
<td>
<table>
<tr><th>Task</th><th>Cost ($)</th></tr>
<tr><td>Design and specifications</td><td>10,000</td></tr>
<tr><td>Consents, iwi consultation</td><td>25,000</td></tr>
<tr><td>Construction</td><td>25,000</td></tr>
<tr><td>Planting (1.7ha)</td><td>171,020</td></tr>
<tr><td>Project management/staffing/incidentals (20%)</td><td>46,200</td></tr>
<tr><td>Total</td><td>277,220</td></tr>
</table>
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<td>C = 0.28</td>
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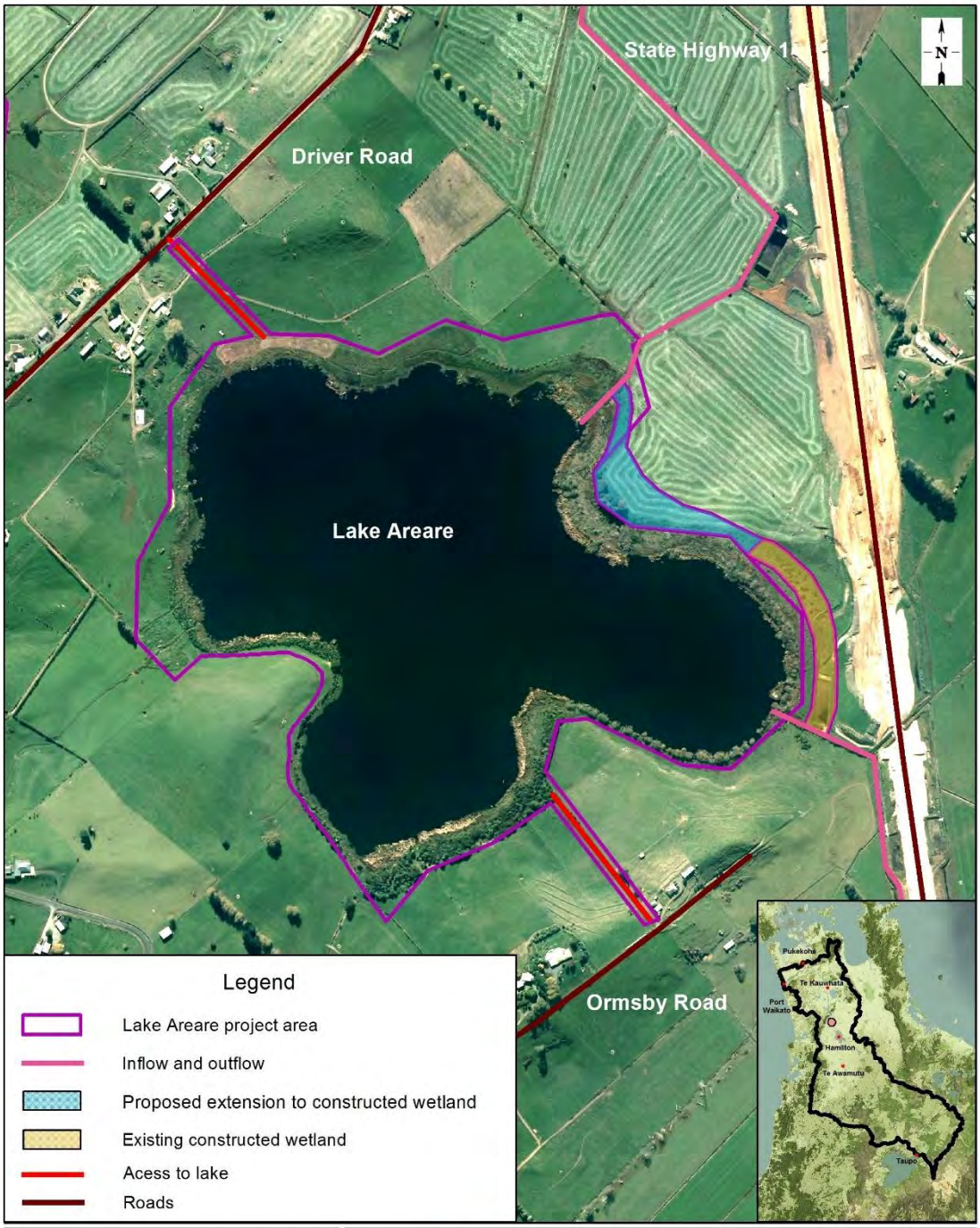
</table>




Water quality and habitat enhancement at Lake Areare

## WWRRS Project Map

Created by: Tane Desmond
Projection: NZTM
Date: December 2017

Status: Final
Request No.: N/A
File name: WWRRS.gws

0.00 0.05 0.10 0.15 0.20 0.25
Kilometers

Scale 1:7,000@A4 Portrait

A4



Waikato REGIONAL COUNCIL
Te Kaunihera ā Rohe o Waikato

Lake Areare in the foreground. Lake Pikopiko and Lake Hotoanaga can also be seen (top right).

The existing constructed wetland (small sequence of ponds) is shown between Lake Areare and the Waikato Expressway. It is proposed to extend this to the northwest, across the area of bare land.

| L 15<br>Priority: High | Wetland enhancement at Horsham Downs lakes | BCR value |
|---|---|---|
| Relevant goals from Central/Lower Waikato unit and Shallow Lakes unit | A full range of ecosystem types associated with lakes in the catchment are protected and maintained with a focus on high value natural environments. | |
| Name of feature | Lakes Pikopiko, Hotoananga, Kaituna, Tunawhakaheke, Whakatangi, Komakorau | |
| Brief description of feature | These small peat lakes are located in the Horsham Downs area. All of the lakes are surrounded by wetland habitat. The collective area of these lakes and their wetlands is 71.7ha. All of the lakes discharge to the Waikato River near Taupiri.<br><br>The Horsham Downs lakes are culturally and historically significant to iwi. There are many historic pā sites within the area between Gordonton and Taupiri. Iwi would have accessed these lakes and wetlands to gather food, clothing and weaving materials, rongoā (medicine), birds and materials for general use. The names of these lakes provide clues as to their historic use. E.g. kai (food) tuna (eels) or kōmako (bellbird) rau (hundred, numerous).<br><br>The lakes vary in size from 14ha (Lake Hotoananga) to less than 3ha(Lake Whakatangi). All of the lakes are situated within the historic Kainui peatland, which has been drained and converted to pasture. Collectively they are nationally significant and support a moderate waterfowl population and several threatened species.<br><br>Water quality sampling has been infrequent or not been undertaken at these lakes. From sampling that has been done it is most likely that lakes Kaituna, Komakorau and Tunawhakaheke are hypertrophic (i.e. TLI 6-7), Whakatangi supertrophic (i.e. TLI 5-6) and Hotoananga and Pikopiko are at least eutrophic (i.e. TLI 4-5). Note: the higher the TLI the more enriched the lake and the less suitable it is for swimming or kai gathering.<br><br>Submerged plants have disappeared from all of these lakes except Hotoananga, where a low cover of native submerged plants (charophytes and pondweeds) persists. | |

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| | Where willow control has been undertaken in the past (i.e. Komakorau, Kaituna, Hotoananga, Tunawhakaheke), wetlands are dominated by native plant communities. These wetlands still contain some weeds, including grey willow, crack willow, blackberry and gorse. Wetlands at Lakes Pikopiko and Whakatangi are dominated by grey willow and contain other weed species, including Japanese honeysuckle, privet and blackberry. The understorey contains some native wetland plants that would have typically comprised the sedge shrubland that would have originally occurred around these lakes.<br><br>With the exception of Lake Whakatangi, these lakes contain public reserve land managed by DOC and Waikato District Council. Public access is limited to these lakes at present but opportunities exist through the subdivision process to gain access and by utilising unformed roads. | |
| Desired state to achieve Vision & Strategy | - The lakes are swimmable, fishable and have access for recreation and gathering of kai.<br>- Native aquatic plants dominate the in-lake flora and provide habitat for healthy populations of other indigenous species.<br>- Lake margins retain natural hydrological function and are well vegetated with native plant communities that support indigenous fauna.<br>- Wetlands adjacent to lakes are densely vegetated with native plant species, connected to riparian corridors, protected from stock grazing and native plant regeneration occurs naturally.<br>- Iwi and community have a strong connection to the lakes and are active in their protection and restoration. | |
| Impact on Vision & Strategy | In a restored condition these lakes would have a very high impact on giving effect to the Vision & Strategy at a local level | VS = 10 |

<table>
<tr>
<td>Key threats to the feature that this project addresses</td>
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<table>
<tr><th>Key threat</th><th>Impact on feature</th></tr>
<tr><td>Stock access</td><td>Destruction of native plant communities, introduction of weed species. Direct inputs of nutrient and microbes into lakes.</td></tr>
<tr><td>Willow trees</td><td>Shade out native species and spread to other sites.</td></tr>
<tr><td>Weed species</td><td>Compete with native plant communities and are a threat to agriculture.</td></tr>
<tr><td>Further drainage and clearance of native wetland vegetation.</td><td>Reduced habitat for native plants and animals and game birds. Loss of nutrient attenuation areas, and loss of wetland areas to slow flood flows.</td></tr>
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<tr>
<td>Project goal/s</td>
<td>Within 2 years of project commencement, wetlands adjoining lakes Whakatangi and Pikopiko are 100% fenced and protected from stock.<br><br>Within 5 years, wetlands adjoining lakes Pikopiko, Hotoananga, Kaituna, Tunawhakaheke, Whakatangi, Komakorau are mostly (i.e. > 90% cover) comprised of native plant communities.</td>
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<tr>
<td>Priority works for funding</td>
<td>Suggested works could be implemented either by an organisation or private citizens (using contractors or their own labour). This project could be undertaken as a whole, or in multiple smaller components.<br><br>Fencing, weed control and native planting<br>Fencing, weed control or native planting (or a combination) is proposed at the six peat lakes in Horsham Downs to provide a wider buffer for the lake and to increase and improve the quality of wetland habitat surrounding the lake.<br><br>Fencing is required at Lake Pikopiko and Whakatangi. The fence needs to be moved to the landward boundary of the esplanade reserve at Pikopiko which will substantially increase the land buffer at this lake. Part of the fence at Lake Whakatangi needs to be upgraded to prevent stock access to the lake.<br><br>Willow control using ground based methods to minimise off-target damage is proposed at all the lakes. This is likely to be a two stage process at lakes where willows have not been controlled before, with all willows controlled in the first year</td>
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| | and follow-up weed control to 'mop-up' any willows that were not successfully killed in the first year. Where willows have been controlled in the past, 'mop-up' ground based spraying is recommended.<br><br>All of the wetlands contain several ecosystem changing weeds including royal fern, gorse and blackberry. Control of these weeds to very low levels that can be easily managed by landowners or DOC is proposed at all lakes.<br><br>Native planting is proposed at some lakes to extend wetland habitat surrounding the lake. Planting at 1.5m spacing is recommended, matching wetland species with flooding depth and duration. All native plants should be species that naturally occur in the Meremere Ecological District.<br><br>Assumptions and cost estimates for implementing fencing, weed control and planting at the six lakes follows:<br><br><u>Pikopiko Wetland</u> – (4.3ha, 1.2km perimeter)<br>- Assume 90% (1100m) requires fencing at $25 per metre ($27,500).<br>- Assume 1.24ha requires ground based willow control in Year 1 at $4000 per hectare with 15% of the area being retreated in Year 2 ($5704).<br>- Additional weed control at $1400 per hectare over 30% of the area over 3 years ($5418).<br>- Assume 3.5ha requires native planting where not much site prep is required and with provision for 10% infill planting ($42,880 per hectare) ($150,083).<br>- Possum control (for plant establishment) over 3 years ($2580).<br><br><u>Whakatangi Wetland</u> – (1.1 ha, 0.73km perimeter)<br>- Assume 20% (145m) requires fencing at $25 per metre ($3625).<br>- Assume 1ha requires ground based willow control in Year 1 at $4000 per hectare with 15% of the area being retreated in Year 2 ($4600).<br>- Additional weed control at $2800 per hectare over 50% of the area over 3 years ($4620).<br>- Assume 0.9ha requires native planting in area not requiring much site prep and with provision for 10% infill planting ($42,880 per hectare) ($38,592).<br>- Possum control (for plant establishment) over 3 years ($660).<br><br><u>Tunawhakaheke Wetland</u> – (3.9ha) | |

| | | |
|---|---|---|
| | - Assume 1.56ha requires ground based willow control in Year 1 at $4000 per hectare with 15% of the area being retreated in Year 2 ($7,176).<br>- Additional weed control at $1400 per hectare over 100% of the area over 3 years ($16,380).<br>- Assume 1.72ha (20% of wetland) requires native planting at $37,552 per hectare and with provision for 10% infill planting ($71,048).<br>- Possum control (for plant establishment) over 3 years ($2340).<br><br><u>Hotoananga Wetland</u> – (5.8ha)<br>- Assume 50% of wetland requires weed control (at $1400 per hectare) over 3 years ($12,180).<br>- Assume 10% of the area (0.6ha) requires native planting in at $37,552 per hectare and with provision for 10% infill planting ($24,784).<br>- Possum control (for plant establishment) over 3 years ($3,480).<br><br><u>Komakorau Wetland</u> – (6.3ha)<br>- Assume 50% of wetland requires weed control (at $1400 per hectare) over 3 years ($13,230).<br><br><u>Kaituna Wetland</u> – (7.8ha)<br>- Assume 50% of wetland requires weed control (at $1400 per hectare) over 3 years ($16,380).<br><br>**Project management/staffing/incidentals**<br>Staff to carry out landowner liaison, iwi engagement, Health and Safety requirements, negotiate agreements, inspect works, manage parts of the work as required (e.g. fencing or planting), project reporting and financial management. Incidentals include transport, office overheads, consumables and miscellaneous professional fees.<br><br>This is estimated to be 20% of the direct project costs. | |
| Time lag for benefits to be realised | If works were implemented at an even pace over a 5-year period, it is estimated that the majority of the project benefits would be seen approximately 2-3 years after project completion. | L = 7.5 |
| Effectiveness of works | These wetlands currently range in condition from very poor to moderate when compared to desired state. Lake water quality is very poor across all lakes. There has been substantial riparian restoration work around lakes Kaituna and Komakorau in the past 15-20 years, however other lakes have very limited vegetated margins. Condition is not expected to change over the next 20 years in the absence of this project. | W = 0.05 |

<table>
<tr><td></td><td>This project focuses solely on biodiversity restoration and it is expected to make a significant improvement in this area. It is acknowledged that achieving the overall Vision & Strategy desired state will take longer than the 20-year horizon used for the purposes of the Restoration Strategy, and a fuller range of initiatives over the long term. However, if this project is successfully completed, then it is expected that the lakes will move closer to the desired Vision & Strategy state than they are currently. Overall condition is still likely to be poor.</td><td></td></tr>
<tr><td>Risk of technical failure</td><td>There is a low risk of project failure due to technical feasibility. Plants generally establish quickly and with high survivorship around peat lakes. Work should be carried out by experienced practitioners to ensure weed control is effective.</td><td>F = 0.87</td></tr>
<tr><td>Adoptability</td><td>It is estimated that about three-quarters of landowners would adopt the works if they were fully incentivised. Works on publicly owned land are expected to be fully adopted. Some private landowners may be concerned by loss of marginal grazing areas, however generally the benefits of avoiding loss of stock in wetlands are becoming well recognised.</td><td>A = 0.75</td></tr>
<tr><td>Information quality</td><td>Average – recommendations are based on the knowledge of local land and lakes management staff and from examining aerial photographs.</td><td></td></tr>
<tr><td>Knowledge gaps</td><td>Some of the weed control and planting work was estimated from aerial photographs. DOC and regional council staff who have worked at these lakes were consulted about what further work was required to enhance wetlands surrounding the lakes. Specific quantities of work will need to be established for each lake during project planning.</td><td></td></tr>
<tr><td>Socio-political risks</td><td>Very low risk that the project will fail to meet its goals over the long term due to socio-political risks.</td><td>P = 0.97</td></tr>
<tr><td>Project duration (years)</td><td>5 years</td><td></td></tr>
<tr><td>Up-front cost – total for implementation phase/project duration</td><td><table><tr><th>Task</th><th>Cost ($)</th></tr><tr><td>Pikopiko Wetland enhancement</td><td>191,285</td></tr><tr><td>Whakatangi Wetland enhancement</td><td>52,097</td></tr><tr><td>Tunawhakaheke Wetland enhancement</td><td>96,944</td></tr><tr><td>Hotoananga Wetland enhancement</td><td>40,446</td></tr><tr><td>Komakorau Wetland enhancement</td><td>13,230</td></tr><tr><td>Kaituna Wetland enhancement</td><td>16,380</td></tr></table></td><td>C = 0.49</td></tr>
</table>

| | | | |
|---|---|---|---|
| | Project management/staffing/incidentals (20%) | 82,076 | |
| | **Total** | **492,458** | |


Wetland Enhancement at Horsham Downs Lakes Map 1/3

## WWRRS Project Map

Created by: Tane Desmond
Projection: NZTM
Date: December 2017

Status: Final
Request No.: N/A
File name:WWRRS.gws

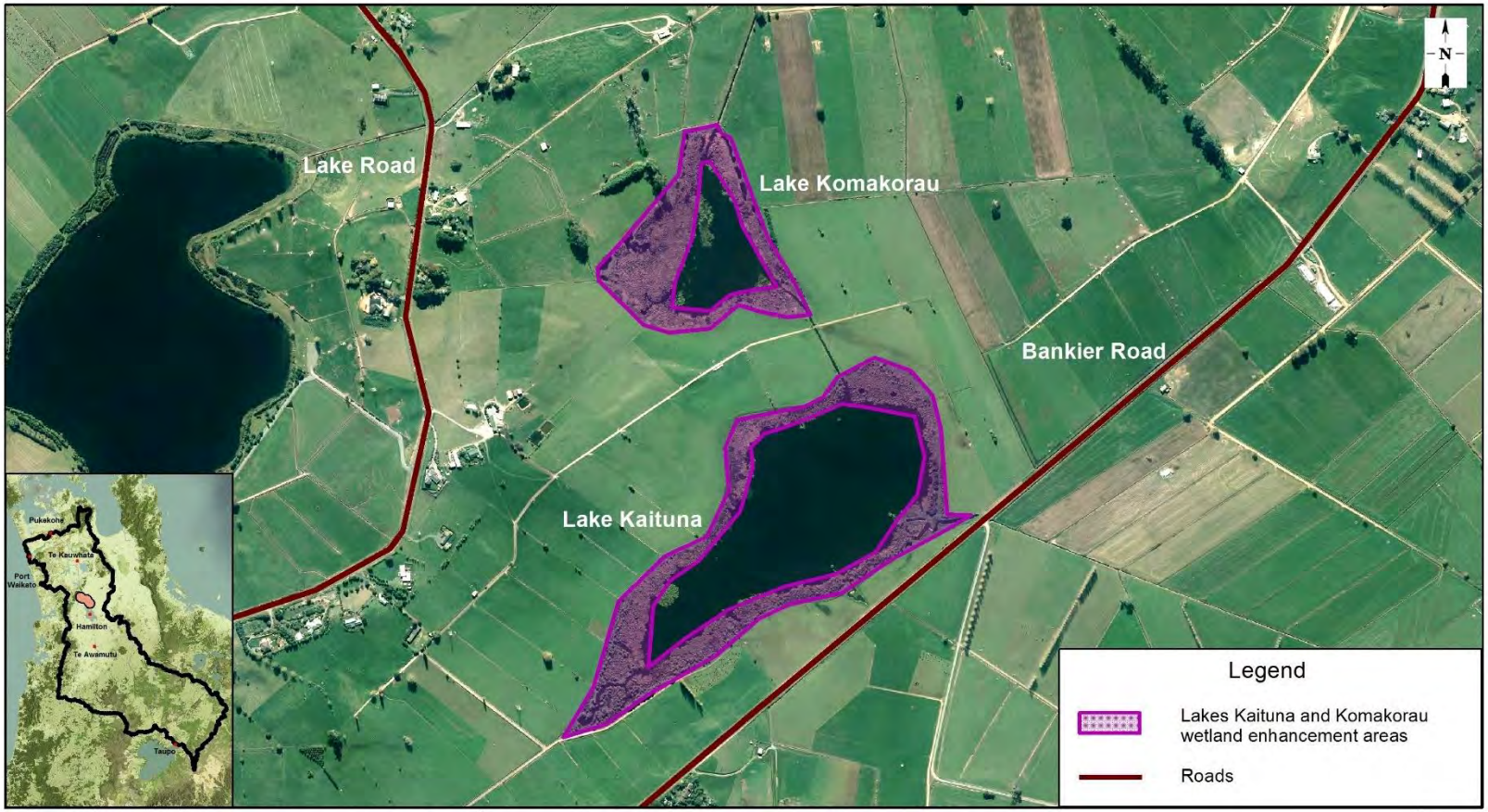
0.00 0.10 0.20 0.30 0.40 0.50
Kilometers

Scale 1:8,000@A4 Landscape

A4



Waikato REGIONAL COUNCIL
Te Kaunihera ā Rohe o Waikato




Wetland Enhancement at Horsham Downs Lakes Map 2/3

WWRRS Project Map

Created by: Tane Desmond
Projection: NZTM
Date: December 2017

Status: Final
Request No.: N/A
File name:WWRRS.gws

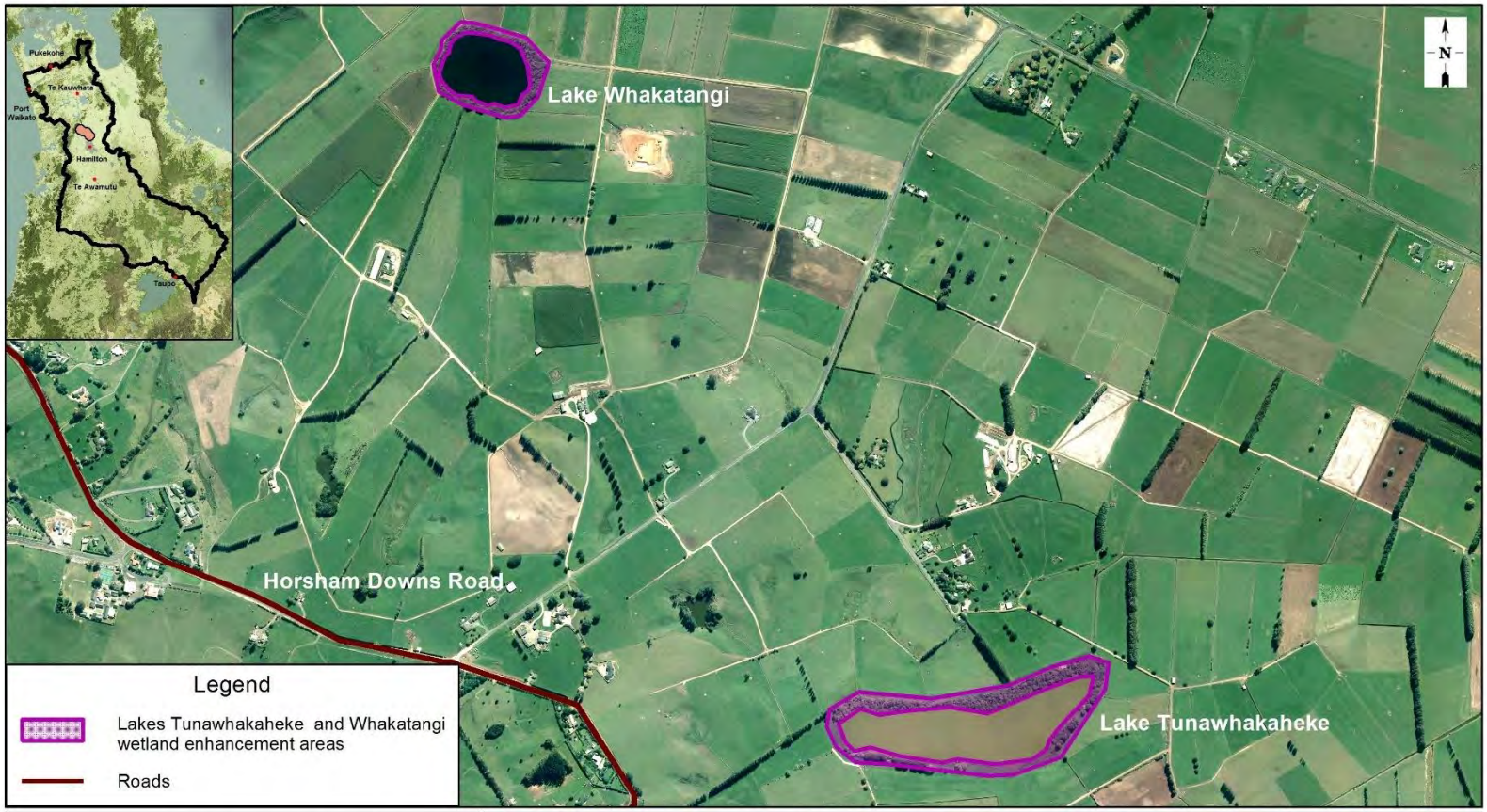
0.00 0.10 0.20 0.30 0.40 0.50
Kilometers

Scale 1:10,000@A4 Landscape

A4



Waikato Regional Council
Te Kaunihera ā Rohe o Waikato




Wetland Enhancement at Horsham Downs Lakes Map 3/3

WWRRS Project Map

Created by: Tane Desmond
Projection: NZTM
Date: December 2017

Status: Final
Request No.: N/A
File name:WWRRS.gws

0.00 0.15 0.30 0.45 0.60 0.75
Kilometers

Scale 1:12,000@A4 Landscape

A4



Waikato REGIONAL COUNCIL
Te Kaunihera ā Rohe o Waikato

A fenced area next to Lake Tunawhakaheke where re-vegetation with native wetland plants is proposed.

Lake Hotoananga before willow control. The extensive areas of emergent reeds in the lake can be seen in this photo.

Planting a seep on an inflow to Lake Pikopiko. Willows and blackberry can be seen on the lake margin.

Lake Kaituna (foreground) flows into Lake Komakorau (behind).


A floating wetland within one of the constructed treatment systems at Lake Kaituna.

Margin of Lake Whakatangi where weed control and native planting is proposed.

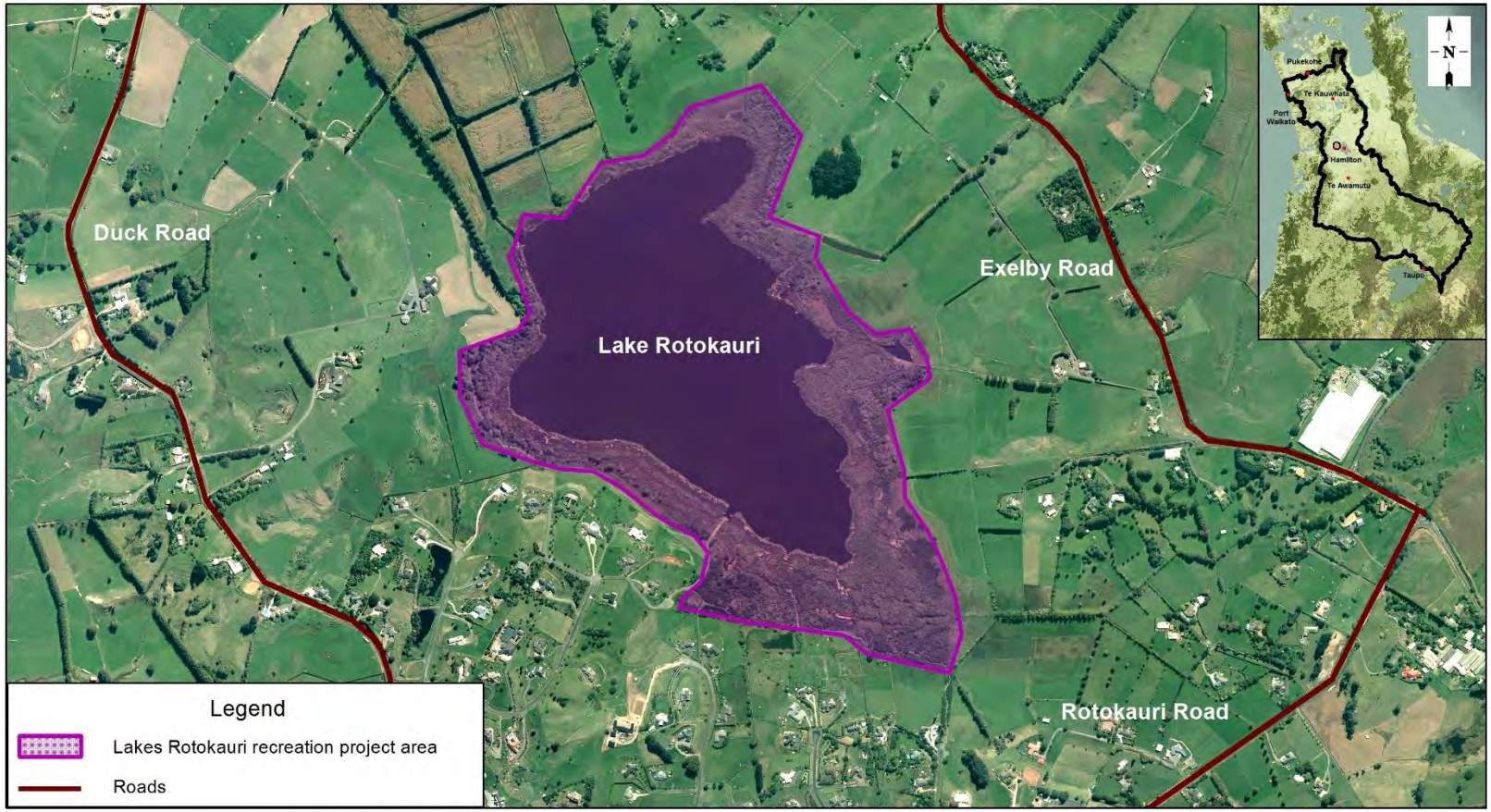
| L 16<br>Priority: High | Development of Lake Rotokauri Reserve for recreation | BCR value |
|---|---|---|
| Relevant goals from Central/Lower Waikato unit and Shallow Lakes unit | Places that provide for safe recreational activities are identified and accessible. | |
| Name of feature | Lake Rotokauri and surrounding reserve | |
| Brief description of feature | Lake Rotokauri is a 41.7ha lake that receives inflows from a 933ha catchment. Catchment land use is a mix of residential, industrial and dairy farming. The catchment also includes nearby Lake Waiwhakareke (Horseshoe Lake). Lake Rotokauri discharges into the Ohote Stream which then flows into the Waipā River.<br><br>Lake Rotokauri is located on the boundary between Waikato District Council and Hamilton City Council and its catchment is divided between the two councils. Approximately 37ha of reserve land surrounds the lake. A large proportion of this is owned and managed by Waikato District Council while Hamilton City Council administers a small area on the southeastern side of the lake. The lake is managed through the Lake Rotokauri Management Committee.<br><br>The lake is fully fenced to exclude stock and fenced margins vary in width from 25m-100m and mostly comprise a District Council Local Purpose (Ecological Management) Reserve. Some areas of the reserve land continues to be grazed by stock.<br><br>The lake water quality has deteriorated significantly since 1980 and has high concentrations of nutrients and phytoplankton and poor water clarity, which is indicative of a shift to a turbid, phytoplankton dominated state. Lake Rotokauri is considered to be hypertrophic.<br><br>There is no submerged aquatic vegetation within the lake but the lake does have extensive areas of emergent plants that provide habitat for a range of wetland bird species. Beyond this is a wide margin of willow and mānuka scrub.<br><br>The level of Ohote Stream has been significantly lowered by drainage activities, which has decreased the lake level by up to 5m and reduced the size of the lake to half of the size it was in 1860. A new rock-rubble weir was installed in 2000 in an effort to improve | |

<table>
<tr><td></td><td>native fish passage to the lake whilst maintaining minimum water levels.<br><br>As the amount of rural subdivision in the area has increased so has the demand for recreational facilities around the lake. A gravel walkway has been partially constructed, providing walking access to the southwest side of the lake, and there is demand to provide access around the full perimeter of the lake.</td><td></td></tr>
<tr><td>Desired state to achieve the Vision & Strategy of feature</td><td>- The lake is swimmable, fishable and has access for recreation and gathering of kai.<br>- Native aquatic plants dominate the in-lake flora and provide habitat for healthy populations of other indigenous species.<br>- Lake margins retain natural hydrological function and are well vegetated with native plant communities that support indigenous fauna.<br>- Wetlands adjacent to lakes are densely vegetated with native plant species, connected to riparian corridors, protected from stock grazing and native plant regeneration occurs naturally.<br>- Iwi and community have a strong connection to the lake and are active in its use, protection and restoration.</td><td></td></tr>
<tr><td>Impact on Vision & Strategy</td><td>In a restored condition, Lake Rotokauri and its surrounding reserve would have a very high impact on giving effect to the Vision & Strategy at a local level.</td><td>VS = 24</td></tr>
<tr><td>Key threats to the feature that this project addresses</td><td><table><tr><th>Key threat</th><th>Impact on feature</th></tr><tr><td>Lack of access to the lake reserve. Opportunities for public recreation next to waterway not realised.</td><td>People become disconnected from Lake Rotokauri and the lake becomes further degraded.</td></tr><tr><td>Land drainage</td><td>Alters the ecology of marginal wetlands.</td></tr><tr><td>Weed species</td><td>Compete with native plant communities and are a threat to agriculture.</td></tr></table></td><td></td></tr>
<tr><td>Project goal/s</td><td>Within 5 years of project commencement:<br>- Stock is excluded from reserve land around the lake and it is vegetated with a dense cover of native plant species.<br>- A 4km pathway is completed around Lake Rotokauri.<br>- A picnic area is developed and there are designated areas where people can access the lake for recreation, including a jetty.</td><td></td></tr>
<tr><td>Priority works for funding</td><td>Works could be implemented either by an organisation or private citizens (working closely with Waikato District Council). This project could be undertaken as a whole, or in multiple smaller components. Works would be undertaken in accordance with the</td><td></td></tr>
</table>

| | | |
|---|---|---|
| | concept plan developed for Lake Rotokauri and held at Waikato District Council.<br><br>**Works required**<br>On the ground works and actions required include:<br><u>Stage 1</u><br>- Construction of a 2km long walkway, approximately 2.5m wide, to join up with the existing walkway. The walkway will comprise of wooden boardwalk sections and metal tracks ($800,000).<br><br><u>Stage 2</u><br>- Planting of approximately 6ha of native plants within areas where weed control is undertaken ($237,321).<br>- Possum (and possibly rabbit control) will be required over a period of 3 years for native plant establishment. Costs are generously estimated at $200 per hectare over an area of 37ha ($22,200 over 3 years). The method of possum control will need to be determined following consultation with local residents.<br><br><u>Stage 3</u><br>- Installation of picnic and viewing areas. This will involve installation of picnic tables (including concrete pads), interpretive signage and exotic vegetation clearance (if required) ($15,000).<br><br><u>Stage 4</u><br>- Additional planting and installation of amenity structures. Amenity structures include a jetty for lake access and potentially other lake access points ($25,000).<br><br>**Project management/staffing/incidentals**<br>Staff to carry out landowner liaison, iwi engagement, Health and Safety requirements, negotiate agreements, inspect works, manage parts of the work as required (e.g. fencing or planting), project reporting and financial management. Incidentals include transport, office overheads, consumables and miscellaneous professional fees.<br><br>This is estimated to be 20% of the direct project costs. | |
| Time lag for benefits to be realised | If works were implemented at an even pace over a 5-year period, it is estimated that the majority of the project benefits would be seen near project completion. | L = 4.5 |
| Effectiveness of works | When compared with desired state, Lake Rotokauri is currently in poor to moderate condition with only some of the Vision & Strategy aspirations being partly met. The lake is not swimmable, and the presence of pest fish impacts significantly on ecological | W = 0.04 |

| | | |
|---|---|---|
| | integrity. The poor water quality is an impediment to recreational use of the lake, although it is still of high value to the local community. Recent enhancement works are improving the biodiversity of the lake margins. Overall lake condition is not expected to change significantly over the next 20 years in the absence of this project, with some aspects likely to improve as a result of current initiatives, while others have potential for some deterioration. This project addresses aspirations relating to the recreational use of the lake and if completed is expected to move the lake slightly closer to the Vision & Strategy desired state. It doesn't address the majority of threats to the lake and it is acknowledged that achieving the Vision & Strategy desired state for Lake Rotokauri will take longer than the 20 year horizon used for the purposes of the Restoration Strategy, and a fuller range of initiatives. | |
| Risk of technical failure | There is a low risk of project failure due to technical feasibility. Works proposed have been successful at other lake sites, and plantings around peat lakes generally have very high rates of survival and growth. | F = 0.92 |
| Adoptability | It is estimated that about three-quarters of landowners would adopt the works if they were fully incentivised. The works proposed on Waikato District Council managed land is expected to be fully adopted, with the council being very supportive of the project. There may be some difficulty with uptake on some privately owned lands, with the loss of marginal grazing areas likely to be the biggest challenge in terms of uptake. | A = 0.75 |
| Information quality | Very good – recommendations and estimates of work are based on a concept plan for the reserve and costings were developed with input from Waikato District Council staff. | |
| Knowledge gaps | Costs provided are estimates based on the concept plan, and a more detailed project plan with costings will need to be developed as part of this project. | |
| Socio-political risks | Low risk that the project will fail to meet its goals over the long term due to socio-political risks. | P = 0.85 |
| Project duration (years) | 5 years | |

<table>
<tr>
<td>Up-front cost – total for implementation phase/project duration</td>
<td>
<table>
<tr><th>Task</th><th>Cost ($)</th></tr>
<tr><td>Walkway construction (2km)</td><td>800,000</td></tr>
<tr><td>Native planting (6ha)</td><td>237,321</td></tr>
<tr><td>Possum control</td><td>22,000</td></tr>
<tr><td>Installation of picnic and viewing areas</td><td>15,000</td></tr>
<tr><td>Additional planting and installation of amenity structures</td><td>25,000</td></tr>
<tr><td>Project management/staffing/incidentals (20%)</td><td>219,864</td></tr>
<tr><td>TOTAL</td><td>1,319,185</td></tr>
</table>
</td>
<td>C = 1.32</td>
</tr>
</table>




Development of Lake Rotokauri Reserve for recreation

## WWRRS Project Map

Created by: Tane Desmond
Projection: NZTM
Date: December 2017

Status: Final
Request No.: N/A
File name:WWRRS.gws

0.00 0.15 0.30 0.45 0.60 0.75
Kilometers

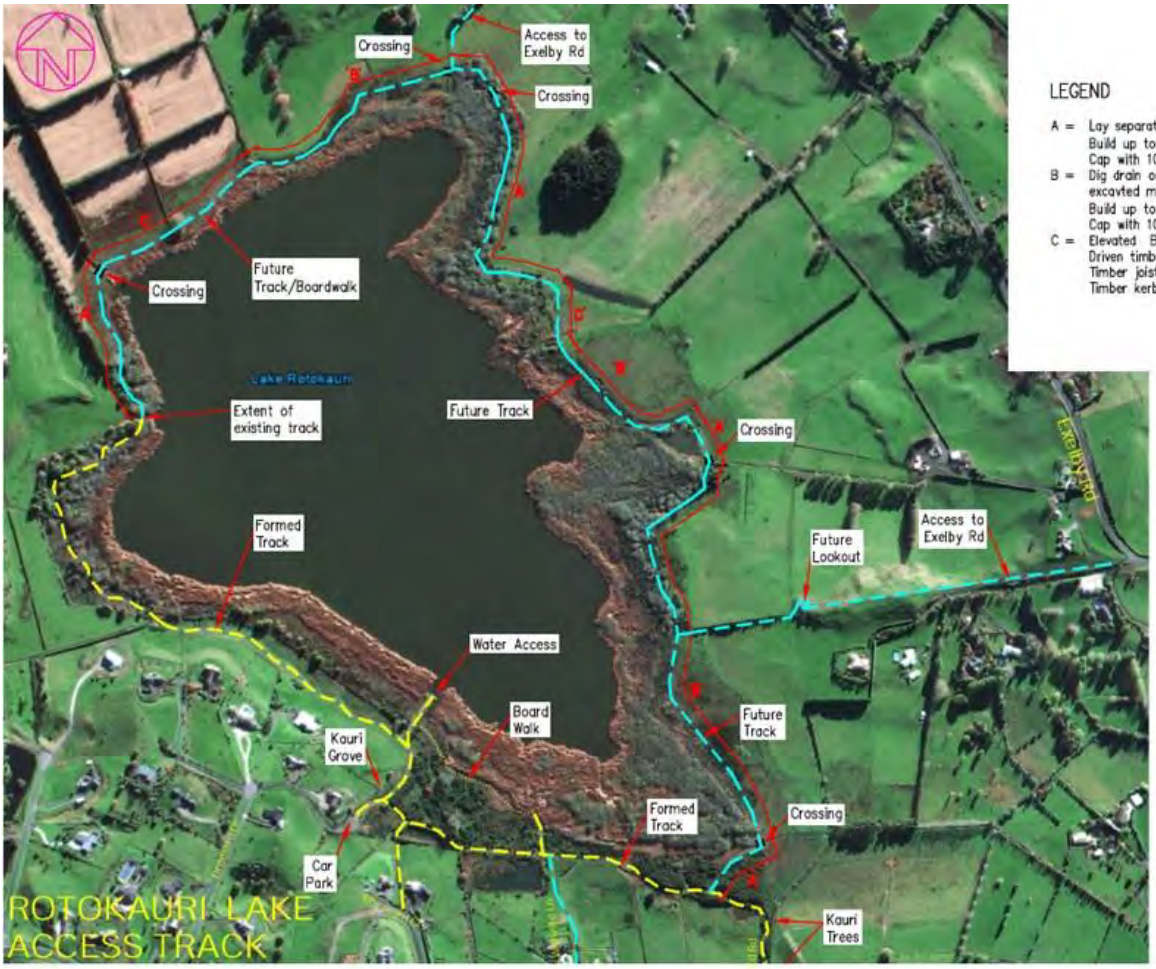
Scale 1:11,500@A4 Landscape

A4

**ACKNOWLEDGEMENTS AND DISCLAIMERS**



Waikato REGIONAL COUNCIL
Te Kaunihera ā Rohe o Waikato




LEGEND

A = Lay separation cloth on existing ground.
Build up to level (rotten rock)
Cap with 100mm GAP40 + PAP 6

B = Dig drain on land side of track using excavted material to form track.
Build up to level (rotten rock)
Cap with 100mm GAP40 + PAP 6

C = Elevated Board access track 3.6m wide.
Driven timber poles @ 5m crs
Timber joists and cross planks
Timber kerb either side

Date: May 2012

| L 17<br>Priority: Very high | Water quality and habitat enhancement at Lake Rotoroa | BCR value |
|---|---|---|
| Relevant goals from Central/Lower Waikato unit and Shallow Lakes unit | Communities have plentiful, safe access to lake for a range of recreational purposes, including safe contact and immersion in water and food gathering.<br><br>Projects on lake are prioritised according to cultural significance, ability to improve and ability or appropriateness to access.<br><br>Nutrient and sediment inputs to lakes are reduced by a proportion that leads to noticeable improvements in lake water quality so that lakes are safe for swimming and gathering of taonga species. | |
| Name of feature | Lake Rotoroa | |
| Brief description of feature | Lake Rotoroa (55ha) is situated in central Hamilton, and is the focus of land and water-based recreational activities including waka ama, sailing and running. The lake was associated with a former peat swamp that was initially drained for farming purposes and then developed for urban and residential use. Today, the lake receives water from stormwater drains, direct rainfall and overland flow. Water leaves the lake via a (constructed) piped outlet that flows into the Waitawhiriwhiri Stream and eventually to the Waikato River.<br><br>The water quality of Lake Rotoroa has fluctuated significantly in the past as it has flipped between being dominated by submerged plants and algae.<br><br>Recent water quality analyses from 2006-2010 data indicate that the trophic status of Lake Rotoroa has been eutrophic and stable during this period. The lake has a well-documented history of weed invasion that has seen it dominated by exotic weed species, completely devegetated, and then recolonised by native submerged plants. In 1959, sodium arsenite was aerially applied to Lake Rotoroa to control aquatic weeds. While this treatment effectively eliminated submerged aquatic plants for 5 years, elevated levels of arsenic persist in the lake sediments today. By 1991, submerged plant species had been completely removed from the lake through multiple herbicide treatments of Diquat, and the lake remained devegetated for several years. By 2005, native submerged plants had re-established, although recently Egeria has again been found in the lake. Rotoroa is one of a few shallow lakes in New Zealand that have transitioned from a devegetated, algal-dominated state to a clear water, macrophyte-dominated state, so | |

| | | |
|---|---|---|
| | has been of scientific interest. In recent years, *E. coli* concentrations in the lake – thought to be predominantly from duck faeces – have been an impediment to contact recreational activities with warnings often in place.<br><br>Considerable effort has been undertaken by Hamilton City Council to eradicate weeds in marginal plant communities. Revegetation with indigenous species within the marginal fringe now complements the large beds of indigenous emergent macrophytes.<br><br>Lake Rotoroa is dominated by exotic fish species, including perch, rudd, brown bullhead catfish, tench, goldfish and *Gambusia*. Whilst the coarse fishery is valued, there are ecological concerns about the presence of some of these fish species. Tuna and common bullies also occur in the lake, and freshwater mussels were re-introduced to the lake in 2001 in an attempt to re-establish a naturally reproducing population for water quality purposes. Common smelt historically occurred at the lake but are no longer present.<br><br>Lake Rotoroa was historically fished for tuna (eels), kākahi (freshwater mussels) and kōura (freshwater crayfish). The raupō edges provided materials for baskets and clothing. The historic Te Rapa pā site is situated nearby, towards the Waikato Hospital.<br><br>The lake was selected for inclusion in the Restoration Strategy as it has significant values for iwi and the community, including for recreational purposes; and is considered to be a strong candidate for successful enhancement due to its current condition being only eutrophic (compared to many Waikato lakes that are hypertrophic and devegetated). | |
| Desired state to achieve Vision & Strategy | - The lake is swimmable, fishable and has access for recreation and gathering of kai.<br>- Native aquatic plants dominate the in-lake flora and provide habitat for healthy populations of other indigenous species.<br>- Lake margins retain natural hydrological function and are well vegetated with native plant communities that support indigenous fauna.<br>- Wetlands adjacent to lakes are densely vegetated with native plant species, connected to riparian corridors, protected from stock grazing and native plant regeneration occurs naturally.<br>- Iwi and community have a strong connection to the lake and are active in its use, protection and restoration. | |

<table>
<tr><td>Impact on Vision & Strategy</td><td>In a restored condition, Lake Rotoroa would have a high impact on giving effect to the Vision & Strategy at a Central and Lower Waikato catchment level.</td><td>VS = 50</td></tr>
<tr><td>Key threats to the feature that this project addresses</td><td><table>
<tr><th>Key threat</th><th>Impact on feature</th></tr>
<tr><td>E. coli from game bird faeces</td><td>Results in water that is not safe for swimming or contact recreation.</td></tr>
<tr><td>Exotic fish</td><td>Prevent the re-establishment of self-sustaining native submerged plants.</td></tr>
<tr><td>Exotic submerged plants</td><td>Outcompete native plants and are a recreational hazard creating nuisance for boats and safety risks for swimmers.</td></tr>
</table></td><td></td></tr>
<tr><td>Project goal/s</td><td>Within 10 years of project commencement, water quality has measurably improved in Lake Rotoroa.<br><br>Native submerged plants dominate the aquatic flora and the lake has a LakeSPI score of at least 70%.</td><td></td></tr>
<tr><td>Priority works for funding</td><td>Suggested works could be implemented either by an organisation or private citizens (using contractors or their own labour). This project could be undertaken as a whole, or in multiple smaller components. Work needs to be undertaken in close collaboration with Hamilton City Council. Projects identified below are consistent with the Hamilton City Council Draft Hamilton Lake Domain Management Plan.<br><br>Public information campaign<br>Large populations of water fowl contribute to high levels of E. coli in Lake Rotoroa. This is exacerbated by public feeding these birds, particularly bread. An information campaign should be undertaken to increase awareness of the impact of water fowl on lake water quality.<br><br>To support the proposed programmes to reduce exotic fish, eradicate exotic submerged plants and re-establish native macrophytes at the lake, new signage discouraging the release of fish and encouraging cleaning of water craft should be erected at appropriate locations around the lake.<br><br>Public education programme tasks should include:<br><br>- Collation of existing public awareness material, availability and relevance to the Lake Rotoroa situation.<br>- Identification of needs for new material.</td><td></td></tr>
</table>

| | | |
|---|---|---|
| | - Design and production of necessary new material, in consultation with other relevant parties (including signage).<br>- Identification of key groups within the community to work with and ways to disseminate the information to the relevant people to inform and develop behaviour changes.<br><br>Estimated at $25,000 based on signage and fact sheet costs for similar projects (e.g. on pest fish). Stakeholder collaboration component is covered in Project Management.<br><br>**Management of pest fish**<br>The purpose of the pest fish removal programme is to enable re-establishment of healthy beds of native submerged plants. Prior to commencing removal work, a baseline survey should be undertaken to establish densities of exotic fish and confirm required fishing effort ($30,000). Annual fish removal should then be undertaken twice per year – in late August prior to spawning, and then in summer to coincide with periods of thermal stratification in the lake when fish are concentrated in the top 2m-3m of the water column. This is estimated to require 4 people for 20 days per year for the first 5 years, and then 2 people for 20 days per year for the following 5 years. Labour is estimated at $70 per hour (total cost $336,000). Fishing equipment (nets, clips, etc) is estimated at $150,000 over the 10 years.<br><br>**Re-establishment of native aquatic plants**<br>Aquatic plants stabilise lake bottom sediments and contribute to improved water quality through nutrient uptake. Investigations in Lake Rotoroa indicate that there is a seed bank that is sufficient to enable plants to naturally re-establish once the pressure from exotic fish and plants is reduced or removed. To address the removal of exotic plants the following tasks are recommended:<br><br>- Establish current status of exotic macrophytes – diver survey delimitation (2 days for dive team) and hydro-acoustic transects ($10,000).<br>- Treatment of lake with Diquat – Diquat application at $2000 per hectare for 55ha ($110,000), with consenting requirements, signage and follow-up water quality monitoring ($10,000).<br>- Annual monitoring of submerged plants to assess recovery of natives and any new incursions of exotics. This will allow an adaptive response with treatment as required – LakeSPI once per year using 20 sites within the lake, including the existing 5 long term sites ($15,000 per year for 9 years – $135,000), with any exotics being removed by hand or through the use of coconut fibre matting ($10,000 per year for 9 years – $90,000).<br><br>**Project management/staffing/incidentals** | |

| | | |
|---|---|---|
| | Staff to carry out landowner liaison, iwi engagement, Health and Safety requirements, negotiate agreements, inspect works, manage parts of the work as required (e.g. fencing or planting), project reporting and financial management. Incidentals include transport, office overheads, consumables and miscellaneous professional fees.<br><br>This is estimated to be 20% of the direct project costs. | |
| Time lag for benefits to be realised | If works were implemented at an even pace over a 10-year period, it is estimated that the majority of the project benefits would be seen approximately 8 years after project commencement. | L=8 |
| Effectiveness of works | When compared with desired state, Lake Rotoroa is in moderate to good condition with some of the Vision & Strategy desired state aspects already being met or partly met. This includes being fishable, highly valued by iwi and community, and having excellent access for recreation. Condition is not expected to change over the next 20 years in the absence of this project. Works included here are expected to improve in-lake biodiversity and contribute to maintaining water lake quality. They won't, however, fully address the *E. coli* issues in the lake or bring water quality back to swimmable levels. In order to do this the sources of *E. coli* need to be confirmed and further actions developed in response to this information (see section on investigation priorities). However, if the proposed project is successfully completed it is expected that the lake will progress closer to desired state and be in good condition in 20 years' time. | W=0.1 |
| Risk of technical failure | There is a moderate risk of project failure due to technical feasibility. There is still some uncertainty around the relationship between pest fish densities and re-establishment of macrophytes. It is critical that aquatic pest plant control and surveillance is undertaken by experienced contractors. | F=0.82 |
| Adoptability | All works are proposed to be undertaken on publicly owned and managed sites. It is expected that full adoption would be achieved if the works were fully incentivised. | A=1.0 |
| Information quality | Average – recommendations are based on judgement of subject matter experts with local knowledge. | |
| Knowledge gaps | A LakeSPI assessment of Lake Rotoroa has not been undertaken since 2010 and therefore the current status of macrophytes in the lake needs to be established prior to management work commencing. Disposal options for pest fish removed from the lake will also need to be agreed during project planning. | |
| Socio-political risks | Moderate risk that the project will fail to meet its goals over the long term due to socio-political risks. The use of Diquat to eradicate exotic aquatic plants may be met with some resistance | P=0.62 |

<table>
<tr><td></td><td>from iwi and the community, although it has been used previously in the lake for the same purpose. Early stakeholder engagement will be very important for the successful delivery of this project.</td><td></td></tr>
<tr><td>Project duration (years)</td><td>10 years</td><td></td></tr>
<tr><td>Up-front cost – total for implementation phase/project duration</td><td>
<table>
<tr><th>Task</th><th>Cost ($)</th></tr>
<tr><td>Public information campaign</td><td>25,000</td></tr>
<tr><td>Management of pest fish</td><td></td></tr>
<tr><td>- Baseline survey</td><td>30,000</td></tr>
<tr><td>- Fish removal over 10 years</td><td>336,000</td></tr>
<tr><td>- Fishing equipment and consumables</td><td>150,000</td></tr>
<tr><td>Eradication of Egeria and native plant re-establishment</td><td></td></tr>
<tr><td>- Delimitation survey</td><td>10,000</td></tr>
<tr><td>- Diquat application/consents/monitoring</td><td>120,000</td></tr>
<tr><td>- Follow-up survey and adaptive management over 10 years</td><td>225,000</td></tr>
<tr><td>Project management/staffing/incidentals (20%)</td><td>179,200</td></tr>
<tr><td>Total</td><td>1,075,200</td></tr>
</table>
</td><td>C=1.08</td></tr>
</table>


Water quality and habitat enhancement at Lake Rotoroa

## WWRRS Project Map

Created by: Tane Desmond
Projection: NZTM
Date: December 2017
Status: Final
Request No.: N/A
File name: WWRRS.gws

0.00 0.05 0.10 0.15 0.20 0.25
Kilometers

Scale 1:7,000@A4 Portrait

A4



Waikato REGIONAL COUNCIL
Te Kaunihera ā Rohe o Waikato

| L 18<br>Priority: Medium | Wetland enhancement at Lake Rotopotaka, Lake Pataka and Lake Posa | BCR value |
|---|---|---|
| Relevant goals from Central/Lower Waikato unit and Shallow Lakes unit | A full range of ecosystem types associated with lakes in the catchment are protected and maintained with a focus on high natural environments. | |
| Name of feature | Lake Rotopotaka, Lake Pataka, Lake Posa | |
| Brief description of feature | These small peat lakes are located in the Waipā district. Lakes Posa (2ha) and Pataka (4.6ha) are located south of Templeview. Lake Pataka flows into Lake Posa and discharges to the Waipā River. They would have once abutted the historic Rukuhia Bog. Lake Rotopotaka (2.8ha) is located north of Te Awamutu and would have once abutted the now greatly diminished Moanatuatua Bog. It discharges to the Waikato River.<br><br>All of the lakes have small catchments (< 100ha) that are mostly in pasture with dairy farming the dominant land use.<br><br>There is no recent water quality information for these lakes. In 1997 when the last sampling was done, all of the lakes were nutrient enriched. Only Lake Pataka retains submerged plants but at low covers.<br><br>All of the lakes have extensive raupō beds at the edges of the lake but there is limited wetland habitat beyond this. Willow and weed control has been undertaken at all of the lakes and some native plantings have been established. Further weed control and planting is required to establish self-sustaining native wetland plant communities around these lakes.<br><br>Lakes Posa and Pataka are on private land, with Posa visible from Tuhikaramea Rd. Lake Rotopotaka is public reserve land administered by DOC and the Waipā District Council. There is an unformed road that provides foot access to Lake Rotopotaka from Thompson Rd. Given the proximity of Rotopotaka to the Moanatuatua Wetland and the Waipā River, the area would have provided rich resources for iwi. There are historic pā sites within the area.<br><br>Minimum water levels have been set at all of the lakes, however the weir at Rotopotaka needs to be repaired. | |

<table>
<tr><td>Desired state to achieve Vision & Strategy</td><td>- The lakes are swimmable, fishable and have access for recreation and gathering of kai.<br>- Native aquatic plants dominate the in-lake flora and provide habitat for healthy populations of other indigenous species.<br>- Lake margins retain natural hydrological function and are well vegetated with native plant communities that support indigenous fauna.<br>- Wetlands adjacent to lakes are densely vegetated with native plant species, connected to riparian corridors, protected from stock grazing and native plant regeneration occurs naturally.<br>- Iwi and community have a strong connection to the lakes and are active in their protection and restoration.</td><td></td></tr>
<tr><td>Impact on Vision & Strategy</td><td>In a restored condition these lakes would have a very high impact on giving effect to the Vision & Strategy at a local level.</td><td>VS = 3</td></tr>
<tr><td>Key threats to the feature that this project addresses</td><td><table><tr><th>Key threat</th><th>Impact on feature</th></tr><tr><td>Stock access</td><td>Destruction of native plant communities, introduction of weed species. Direct inputs of nutrient and microbes into lakes.</td></tr><tr><td>Willow trees</td><td>Shade out native species and spread to other sites.</td></tr><tr><td>Weed species</td><td>Compete with native plant communities and are a threat to agriculture.</td></tr><tr><td>Further drainage and clearance of native wetland vegetation.</td><td>Reduced habitat for native plants and animals and game birds. Loss of nutrient attenuation areas, and loss of wetland areas to slow flood flows.</td></tr></table></td><td></td></tr>
<tr><td>Project goal/s</td><td>- Within 2 years, wetlands adjoining lakes Rotopataka and Posa are 100% fenced and protected from stock.<br>- Within 5 years, wetlands adjoining lakes Rotopataka, Potaka and Posa are mostly (i.e. > 90% cover) comprised of native plant communities.</td><td></td></tr>
<tr><td>Priority works for funding</td><td>Suggested works could be implemented either by an organisation or private citizens (using contractors or their own labour). This project could be undertaken as a whole, or in multiple smaller components.<br><br>Fencing: Fencing should occur at the landward extent of wetlands or the legal boundary of the reserve, if that is the greater distance from the lake margin. Fences need to be moved out to the esplanade reserve boundary at Lake Rotopotaka. Maintenance of</td><td></td></tr>
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| | | |
|---|---|---|
| | fences at Lake Posa is required to ensure stock aren't accessing the wetland.<br><br>**Willow control:** Willow control should be undertaken using ground based methods to minimise off-target damage. All of these lakes have had previous willow control undertaken in the past 10 years but follow-up has been limited. Willow control density has been considerably reduced but ground based control of young willow (and some regrown older willow) is required.<br><br>**Weed control:** The wetlands contain several ecosystem changing weeds, including Japanese honeysuckle, gorse and blackberry. These weeds will need to be reduced to very low levels over a period of two years before any native planting occurs.<br><br>**Planting:** Native planting should be carried out within existing open areas and in areas where weed removal has created open areas. Planting at 1.5m spacing is recommended, matching wetland species with flooding depth and duration. All native plants should be species that naturally occur in the Hamilton ecological district.<br><br>Assumptions and cost estimates for the three wetlands follow:<br><br>Rotopotaka Wetland – 3.25 ha, 0.9km perimeter<br>- Assumes 395m requires fencing at $25 per metre ($9875).<br>- Weed control over 80% of the area over 3 years at $2800 per hectare in Year 1 and $1400 per hectare in Years 2-3 ($14,650).<br>- Assumes 0.5ha of the area requires native planting at $37,552 ($18,776).<br>- Assumes 2ha of the area requires native planting in weedy areas at $39,552 per hectare ($79,104).<br>- Possum control (for plant establishment) over 3 years ($1950).<br><br>Pataka Wetland – 1.28 ha, 1.1km perimeter<br>- Ground based willow control over 0.5ha at $4000 per hectare in Year 1 and $600 per hectare in Year 2 ($2300).<br>- Weed control over 50% of the area over 3 years at $2800 per hectare in Year 1 and $1400 per hectare in Years 2-3 ($3584).<br>- Assumes 1ha of the area requires native planting in weedy areas ($39,552).<br>- Possum control (for plant establishment) over 3 years ($770).<br><br>Posa Wetland – 3.05 ha, 1.2km perimeter<br>- Assumes 400m requires fencing at $25 per metre ($10,000).<br>- Ground based willow control over 0.5ha at $4000 per hectare in Year 1 and $600 per hectare in Year 2 ($2300). | |

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| | - Weed control over 70% of the area over 3 years at $2800 per hectare in Year 1 and $1400 per hectare in Years 2-3 ($11,956)<br>- Assumes 2ha of the area requires native planting in weedy areas at $39,552 ($79,104).<br>- Possum control (for plant establishment) over 3 years ($1830).<br><br>**Project management/staffing/incidentals**<br>Staff to carry out landowner liaison, iwi engagement, Health and Safety requirements, negotiate agreements, inspect works, manage parts of the work as required (e.g. fencing or planting), project reporting and financial management. Incidentals include transport, office overheads, consumables and miscellaneous professional fees.<br><br>This is estimated to be 20% of the direct project costs. | |
| Time lag for benefits to be realised | If works were implemented at an even pace over a 5-year period, it is estimated that the majority of the project benefits would be seen approximately 2-3 years after project completion. | L = 7.5 |
| Effectiveness of works | These wetlands are currently in very poor condition when compared to desired state. There has been substantial drainage and modification at these sites in recent years, intermittent stock access, and the presence of plant pests and small riparian margins limits biodiversity values. It is anticipation that further degradation in lakes and wetlands condition could occur over the next 20 years in the absence of this project given the recent dairy conversion that has occurred around lakes Posa and Pataka. It is acknowledged that achieving the Vision & Strategy desired state will take longer than the 20-year horizon used for the purposes of the Restoration Strategy, and a fuller range of initiatives over the long term. However, if this project is successfully completed, then it is expected that wetland condition in 20 years will be moderate, and closer to the desired Vision & Strategy state than it is currently. | W = 0.025 |
| Risk of technical failure | There is a low risk of project failure due to technical feasibility. Plants generally establish quickly and with high survivorship around peat lakes. Work should be carried out by experienced practitioners to ensure weed control is effective. | F = 0.87 |
| Adoptability | It is estimated that about three-quarters of landowners would adopt the works if they were fully incentivised. Works on publicly owned land are expected to be fully adopted. Some private landowners may be concerned by loss of marginal grazing areas, however generally the benefits of avoiding loss of stock in wetlands are becoming well recognised. There are also landowners around these lakes who have undertaken similar projects in the past and indicate a willingness to protect these wetland sites. | A = 0.75 |

<table>
<tr><td>Information quality</td><td>Average – recommendations are based on the knowledge of local land management staff and from examining aerial photographs.</td><td></td></tr>
<tr><td>Knowledge gaps</td><td>Weed control and planting requirements have been predominantly estimated from aerial photographs. More detailed costings will be required to be done during project planning.</td><td></td></tr>
<tr><td>Socio-political risks</td><td>Very low risk that the project will fail to meet its goals over the long term due to socio-political risks.</td><td>P = 0.97</td></tr>
<tr><td>Project duration (years)</td><td>5 years</td><td></td></tr>
<tr><td>Up-front cost – total for implementation phase/project duration</td><td><table><tr><th>Task</th><th>Cost ($)</th></tr><tr><td>Rotopotaka Wetland</td><td>124,355</td></tr><tr><td>Pataka Wetland</td><td>46,206</td></tr><tr><td>Posa Wetland</td><td>105,190</td></tr><tr><td>Project management/staffing/incidentals (20%)</td><td>55,150</td></tr><tr><td>Total</td><td>330,901</td></tr></table></td><td>C = 0.33</td></tr>
</table>


Wetland enhancement at Lake Rotopataka, Lake Pataka and Lake Posa Map 1/2

## WWRRS Project Map

Created by: Tane Desmond
Projection: NZTM
Date: December 2017

Status: Final
Request No.: N/A
File name: WWRRS.gws

0.00 0.06 0.12 0.18 0.24 0.30
Kilometers

Scale 1:8,000@A4 Portrait

A4



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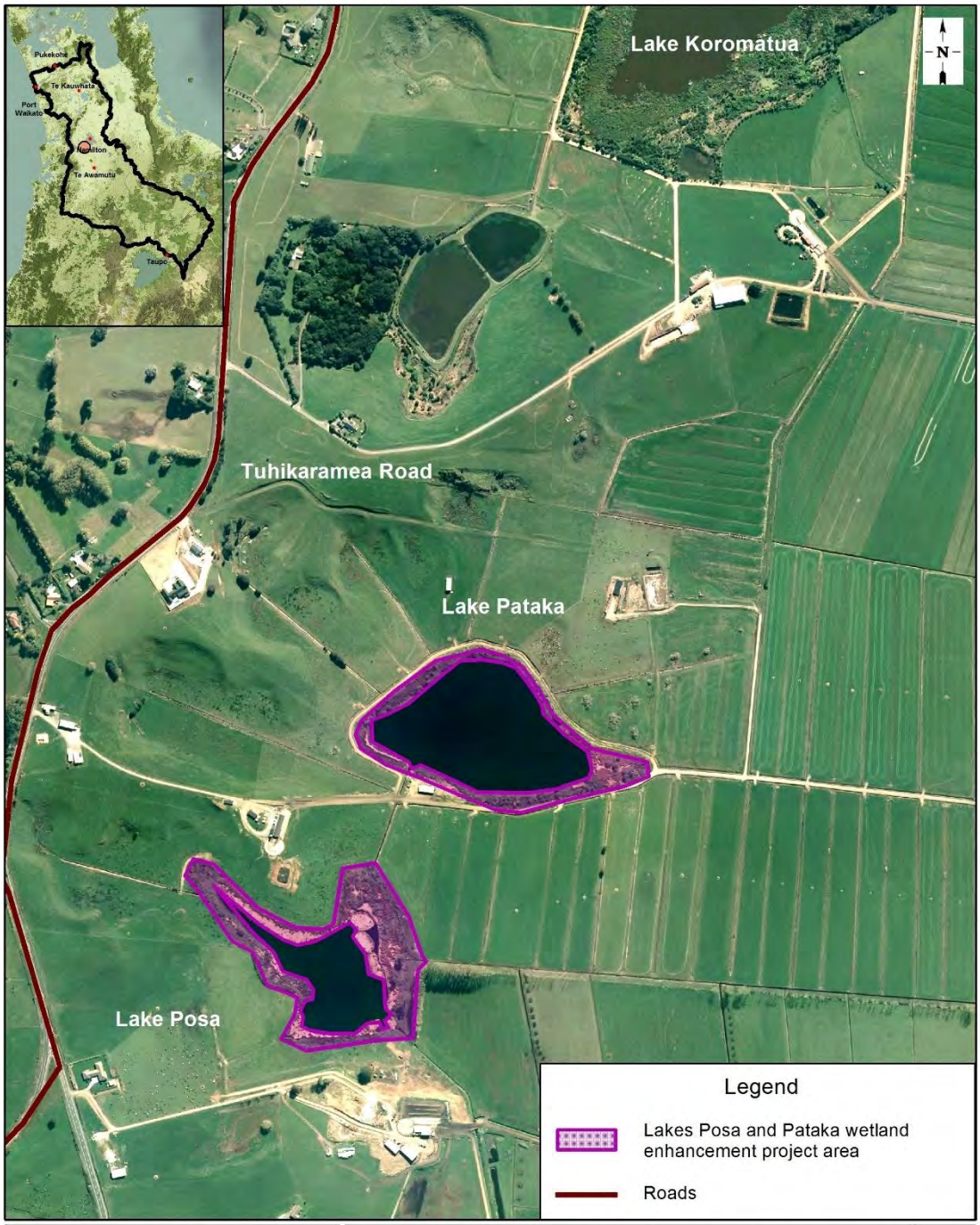


Wetland enhancement at Lake Rotopataka, Lake Pataka and Lake Posa Map 2/2

WWRRS Project Map

Created by: Tane Desmond
Projection: NZTM
Date: December 2017

Status: Final
Request No.: N/A
File name: WWRRS.gws

0.00 0.06 0.12 0.18 0.24 0.30
Kilometers

Scale 1:7,500@A4 Portrait

A4



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Extensive raupō beds (pale brown plants) encircle Lake Posa. Not all of the lake has been fenced.

Lake Pataka, in the foreground, discharges to Lake Posa in the background.


Lake Pataka is ringed by a farm race. There are extensive raupō beds (pale brown) around parts of the lake margin, but limited wetland habitat landward of the raupō.

Wetland surrounding Lake Rotopotaka, with blackberry (foreground) and grey willow (on the left and right).

| L 19<br>Priority: Very high | Protecting and enhancing water quality at Lake Rotomanuka | BCR value |
|---|---|---|
| Relevant goals from Central/Lower Waikato unit and Shallow Lakes unit | Nutrient and sediment inputs to lakes are reduced by a proportion that leads to noticeable improvements in water quality so that lakes are safe for swimming and gathering of taonga species.<br><br>Integrated catchment management programmes protected and enhance priority shallow lakes and their catchments. | |
| Name of feature | Lake Rotomanuka | |
| Brief description of feature | Lake Rotomanuka was previously a single waterbody, but is now a complex of two separate lake basins that are hydrologically connected through a 10ha shallow seasonally flooded wetland. Lake Rotomanuka (North) has a surface area of 12.3ha and is the oldest and deepest of the Waipā peat lakes (up to 8.7m). Lake Rotomanuka South lake (Lake Gin) is considerably smaller with a surface area of 5.4ha and a depth of 4.8m. Historically, it was a significant lake and wetland which provided bountiful food and resources for iwi including tuna (eels), dyes, birdlife and materials for clothing. The name suggests that the area was populated with mānuka which was useful for rongoā (medicines) and general domestic use.<br><br>The beds of the lakes and connecting wetlands are administered by the Department of Conservation as a Government Purpose (Wildlife Management) Reserve. Additional reserves have been subsequently acquired by Waipā District Council to buffer the lakes from the effects of adjoining land uses. Most recently an area of approximately 6ha was purchased on the eastern side of South Lake and added to the reserve.<br><br>The Rotomanuka lakes sit within a catchment of 479 ha, which is predominantly pastoral with intensive agriculture on all sides and also includes the Rotopiko lakes complex. Approximately 79% of the catchment is privately owned, whilst Crown owned reserve land (including the 5 lake beds of the Rotomanuka and Rotopiko lakes) accounts for 19% of the catchment.<br><br>Lake Rotomanuka ranks highly for its natural and biodiversity values. In the most recent assessment of biodiversity values of shallow lake SNAs within the Waikato Regional Council boundaries, Lake Rotomanuka ranked third of the 37 peat lakes, and 18th of all 96 lakes. The wetlands associated with the lakes have been | |

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| | assessed to be nationally significant, and the site is part of a Special Landscape Character Area designation in the Waipā District Plan.<br><br>The results of water quality testing show a distinct difference in water quality between South and North lakes. Water quality monitoring has been undertaken by Waikato Regional Council in Rotomanuka North since 1995 and it has relatively good water quality in comparison to other peat lakes within the catchment, with an average trophic level index (TLI) score of 4.8, which has been stable over the last 5 years. South Lake was extremely nutrient enriched (i.e. hypertrophic) when it was last surveyed in 2001.<br><br>Lake modelling of the Rotomanuka lakes in 2017 has identified that Rotomanuka North is vulnerable to increases in external inputs of phosphorus and therefore restoration efforts to improve water quality should focus on reducing external nutrient loads. These studies have confirmed that a substantial portion of the water column in Rotomanuka North is anoxic for 3-4 months per year during periods of prolonged thermal stratification. The combination of low water levels and thermal stratification means that only a shallow surface layer (2-3m) of the entire water column contains oxygen.<br><br>In the most recent (2007) submerged plant survey, some plants were located in Rotomanuka North but they were not present at sufficient density to generate a LakeSPI score. There is no recent fish data for the lakes, however it is notable that koi have not been recorded from this lake or the upstream Rotopiko lakes. Caged fish-exclusion experiments have established that some of the pest fish that are present in these lakes are preventing the re-establishments of submerged plants.<br><br>A baseline bird survey was carried out at Rotomanuka in 2015/16 and showed that the lake supported significant populations of wetland birds, including the following threatened or at risk species: black shag, pied shag, little black shag, spotless crake, pied stilt, grey ducks and New Zealand dabchicks. It is a popular lake for game bird hunting.<br><br>The five major catchment landowners (all dairy farms) have had whole farm plans carried out on their farms. A catchment plan for the lake was created by NZ Landcare Trust, and this included recommended actions to improve the quality of water entering the | |

<table>
<tr><td></td><td>lake. Since then the lake was chosen to be one of the Living Water (DOC-Fonterra partnership) project areas. Living Water and NZ Landcare Trust have installed a total of four silt traps on drains entering the lakes (three on North Lake and one on South Lake) and another one has been consented for North Lake, due for construction in summer.<br><br>Substantial weed control has taken place removing willows as well as other large exotic trees to make room for native plantings. Approximately 20,000 native plants have been planted around the lake margin as well as into the silt traps. Animal pest control is taking place using DOC 200s, Timms traps and some Goodnature self-resetting traps. The trapping is being undertaken by local residents adjoining the lake with funding and support from Living Water.</td><td></td></tr>
<tr><td>Desired state to achieve Vision & Strategy</td><td>- The lake is swimmable, fishable and has access for recreation and gathering of kai.<br>- Native aquatic plants dominate the in-lake flora and provide habitat for healthy populations of other indigenous species.<br>- Lake margins retain natural hydrological function and are well vegetated with native plant communities that support indigenous fauna.<br>- Wetlands adjacent to lakes are densely vegetated with native plant species, connected to riparian corridors, protected from stock grazing and native plant regeneration occurs naturally.<br>- Iwi and community have a strong connection to the lake and are active in its protection and restoration.</td><td></td></tr>
<tr><td>Impact on Vision & Strategy</td><td>In a restored condition, Lake Rotomanuka would have a very high impact on giving effect to the Vision & Strategy at a local level.</td><td>VS = 20</td></tr>
<tr><td>Key threats to the feature that this project addresses</td><td><table><tr><th>Key threat</th><th>Impact on feature</th></tr><tr><td>Pest fish</td><td>Prevent re-establishment of submerged plants.</td></tr><tr><td>Diffuse pollution from catchment land use</td><td>Further degradation of water quality due to increases in nutrients, sediment and harmful microbes.</td></tr></table></td><td></td></tr>
<tr><td>Project goal/s</td><td>- Within 5 years, water quality has measurably improved in Lake Rotomanuka, and native submerged aquatic plants have been re-established in the littoral zones of Rotomanuka North.<br>- Within 5 years, rudd densities have been reduced to levels that support submerged aquatic plants.<br>- Within 5 years, wetlands surrounding Lake Rotomanuka are mostly comprised of native plant communities (i.e. > 90% cover).</td><td></td></tr>
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| Priority works for funding | Suggested works could be implemented either by an organisation or private citizens (using contractors or their own labour) in collaboration with DOC and Waipā District Council. This project could be undertaken as a whole, or in multiple smaller components.<br><br>**Land purchase:** This project proposes purchasing 6ha of wetland soils that are estimated to be contributing to significant overland flow of nutrients and sediment into Lake Rotomanuka. Estimated costs of land purchase for land of this type is $50,000 per hectare ($300,000). Conveyancing fees are estimated to be approximately $2500 and surveying new parcel boundaries is estimated to be $5000. This land would be fenced (1500m at $25 per metre – $37,500) and planted. A 'swamp pā' occurs in the land proposed for purchase and is likely to be left as ungrazed pasture. Total cost for purchase survey and fencing is estimated to be $345,123.<br><br>**Planting:** Native planting should be carried out within the existing open area of reserve land on the eastern side of the lake (3ha at $39,552 per hectare is $118,656). As well as on the proposed land for purchase (5ha at $37,552 per hectare is $187,760) Planting at 1.5m spacing is recommended, matching wetland species with flooding depth and duration. All native plants should be species that naturally occur in the Hamilton Ecological District. Total cost for planting is $306,416.<br><br>**Re-establishment of submerged aquatic plants in Lake Rotomanuka North:** Prior to re-establishing aquatic plants a baseline survey should be undertaken to establish densities of exotic fish ($30,000). Annual fish removal should then commence and be undertaken twice per year – in late August prior to spawning, and then in summer to coincide with periods of thermal stratification in Rotomanuka North when fish are concentrated in the top 2-3m of the water column. This is anticipated to require 4 people for 10 days per year for the first 5 year, and then 2 people for 10 days per year for the following 5 years. Labour is estimated at $70 per hour (total cost $168,000). Fishing equipment (nets, clips etc) is estimated at $75,000 over the 10 years.<br><br>After undertaking 1-2 years of fishing (when rudd populations have been reduced), appropriate native submerged aquatic plants should be translocated to the littoral zones of Lake Rotomanuka. Translocation would include retrieving plants from Rotopiko lakes using divers, placing plants into biodegradable pots, growing plants for 3 months and then 'bombing' plants from the lake surface so | |

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| | pots wedge into the lake bottom sediments. Monitoring of plant survival and condition would be undertaken as part of the project. Some plants may be caged to provide a baseline comparison (i.e. no fish interference). Translocation of submerged plants to approximately 1ha of littoral habitat (1-2m depth around the lake margin) will require 11,460 plants at a cost of $10 per plant to translocate ($114,600). Plants will need to be monitored by divers every 2 years to confirm establishment and health ($5000 per visit for 5 visits is $25,000).<br><br>**Constructed treatment systems (CTS) on drains**<br>Investigations have been undertaken at lakes Rotomanuka and Rotopiko to identify the best locations, types and sizes of constructed treatment systems (CTS) for incoming drains. Six of these have been constructed within the last 2 years. Four remaining CTS are a high priority. Costs associated with their construction are listed below:<br><br>**Rotopiko 2:** This CTS consists of a sediment basin (826$m^2$), average depth 1.5m and an infiltration wetland (684 $m^2$), average depth 1.2m. This would require 1500$m^3$ of earthworks ($2200), 1500$m^2$ of planting ($15,100), planting maintenance for two years ($400) and annual maintenance of sediment basin to remove sediment for 10 years ($18,800).<br><br>**Rotomanuka 7**: This CTS consists of a large circular silt trap (140$m^2$), average depth 1.8m. This would require 140$m^3$ of earthworks ($940), 80$m^2$ of planting ($2000), planting maintenance for two years ($100) and annual maintenance of sediment basin to remove sediment for 10 years ($6800).<br><br>**Rotomanuka 11**: This CTS consists of a small circular silt trap (140$m^2$), average depth 1.8m. This would require 29$m^3$ of earthworks ($680), 20$m^2$ of planting ($500), planting maintenance for two years ($50) and annual maintenance of sediment basin to remove sediment for 10 years ($6800).<br><br>**Rotomanuka 12:** This CTS consists of an infiltration wetland (330$m^2$), average depth 0.3m. This would require 100$m^3$ of earthworks ($780), 330$m^2$ of planting ($5710) and planting maintenance for two years ($100). It would also require 220m of fencing ($3740) and a planted riparian setback (330$m^2$, cost $840) of 1.5m either side of the wetland. | |

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| | Consent would be required for all of these from both Waikato Regional Council and the Waikato District Council. This would include undertaking consultation with tāngata whenua and possibly commissioning a cultural impact assessment (although there are no known archaeological sites at the CTS locations). Based on costs for similar projects undertaken at other peat lakes, consent application preparation, consent fees and consultation is likely to cost about $25,000.<br><br>**Project management/staffing/incidentals**<br>Staff to carry out landowner liaison, iwi engagement, Health and Safety requirements, negotiate agreements, inspect works, manage parts of the work as required (e.g. fencing or planting), project reporting and financial management. Incidentals include transport, office overheads, consumables and miscellaneous professional fees.<br><br>This is estimated to be 20% of the direct project costs (excluding the land purchase cost). | |
| Time lag for benefits to be realised | If works were implemented at an even pace over a 10-year period, it is estimated that the majority of the project benefits would be seen approximately 8 years after project commencement. | L = 8 |
| Effectiveness of works | When compared with desired state, Lake Rotomanuka is in a moderate to good condition with some of the Vision & Strategy aspirations already being met or partly met. This includes being fishable and having access for recreation. It is expected that over the next 20 years there may be some improvement in overall lake condition as a result of restoration works that have been carried out at the lake recently by a range of stakeholders and landowners. Works included in this project are expected to address some of the key threats to the lake, including external nutrient and sediment inputs and pest fish, as well as facilitate in-lake restoration through re-establishment of native aquatic plants. The proposed wetland area would also have significant biodiversity benefits. Modelling undertaken by the University of Waikato in 2017 indicates that works would move some water quality parameters in North lake from the D to the C band under the NOF framework. The project is focused on Lake Rotomanuka North and won't directly address pest fish and contaminant issue in South lake. However it is anticipated that if completed, the proposed work will complement and build on existing programmes and progress the lake to a good/very good condition and measurably closer to the Vision & Strategy desired state in 20 years' time. | W = 0.2 |

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| Risk of technical failure | There is a moderate risk of project failure due to technical feasibility. There is still some uncertainty around the relationship between pest fish densities and re-establishment of macrophytes. Effectiveness of constructed wetland treatment systems has not yet been fully established. | F = 0.82 |
| Adoptability | Works on publicly owned land is expected to be adopted if fully incentivised as Waipā District Council and the Department of Conservation are both very supportive of this project. There is uncertainty around the willingness of private landowners to sell land for wetland and constructed treatment system development. This would need to be confirmed before the project was initiated. | A = 0.7 |
| Information quality | Very good – analysis of area required for purchase has been done. Analysis of location, type and size of constructed treatment systems has been completed by NIWA for Rotopiko and Landcare Trust for Rotomanuka. Previous studies have confirmed the survival of native submerged aquatic plants in the littoral areas of Lake Rotomanuka North. | |
| Knowledge gaps | No known gaps other than those identified in the technical feasibility section. | |
| Socio-political risks | Low risk that the project will fail to meet its goals over the long term due to socio-political risks. | P = 0.85 |
| Project duration (years) | 10 years | |

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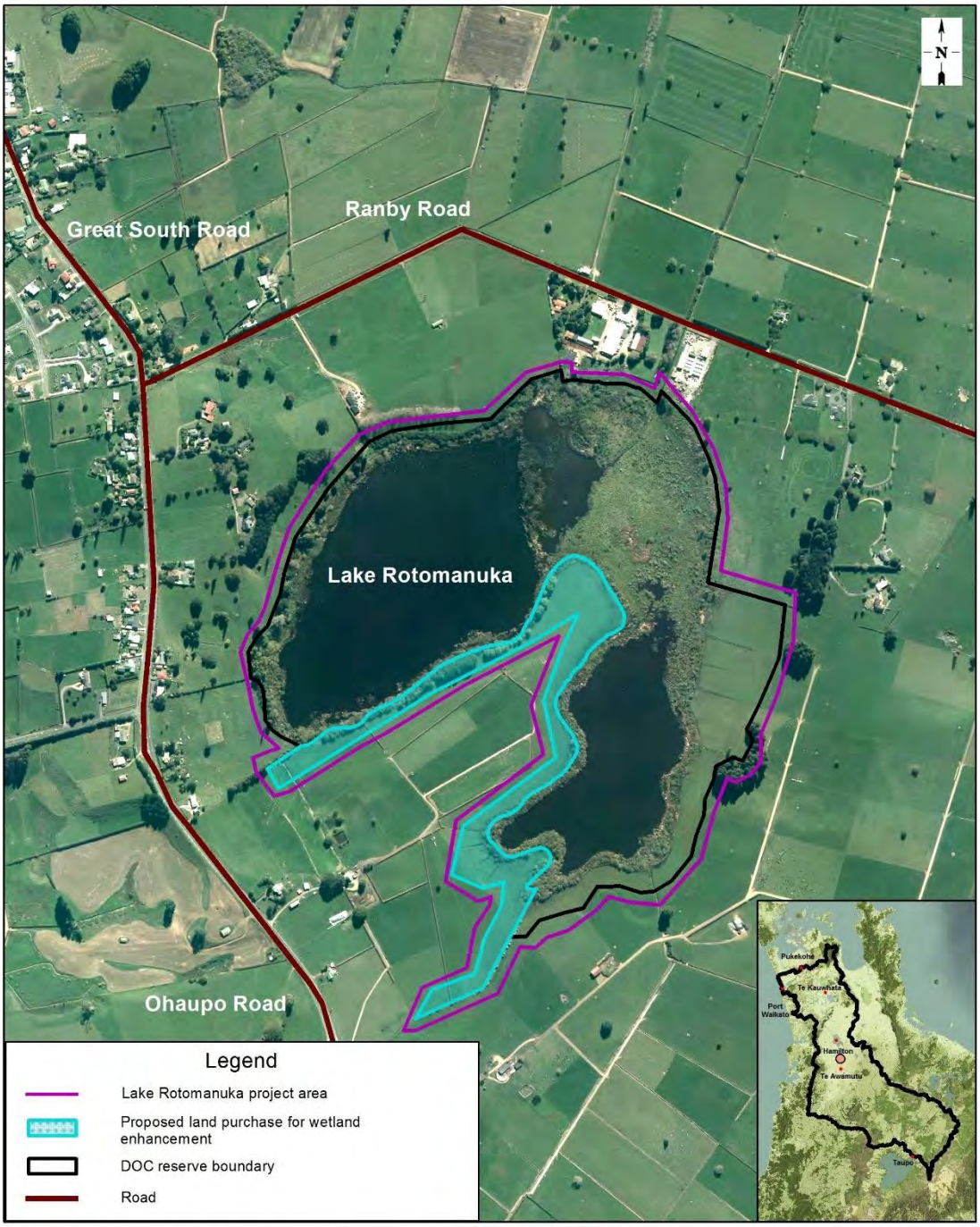
|---|---|---|
| Up-front cost – total for implementation phase/project duration | | C = 1.3 |

| **Task** | **Cost ($)** |
|---|---|
| Proposed purchase of land | 307,500 |
| Fencing purchased land | 37,500 |
| Planting purchased land | 187,760 |
| Planting reserve land on eastern side of lake | 118,656 |
| CTS construction Rotopiko 2 | 36,500 |
| CTS construction Rotomanuka 7 | 9840 |
| CTS construction Rotomanuka 11 | 8030 |
| CTS construction Rotomanuka 12 | 11,170 |
| CTS consents and consultation | 25,000 |
| Baseline survey of Lake Rotomanuka North to establish fish densities. | 30,000 |
| Annual fishing of Rotomanuka North | 168,000 |
| Fishing equipment and operational costs (nets, clips, fuel) | 75,000 |
| Submerged plant translocation | 114,600 |
| Aquatic plant monitoring | 25,000 |
| Project management/staffing/incidentals (20% excluding land purchase) | 169,411 |
| **Total** | **$1,323,967** |




Protecting and enhancing water quality at Lake Rotomanuka

WWRRS Project Map

Created by: Tane Desmond
Projection: NZTM
Date: December 2017

Status: Final
Request No.: N/A
File name: WWRRS.gws

0.000 0.075 0.150 0.225 0.300 0.375
Kilometers

Scale 1:9,000@A4 Portrait

A4



Waikato REGIONAL COUNCIL
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Lake Rotomanuka South in the foreground with Rotomanuka North in the background. The large wetland that separates them can be seen on the right.

Constructed treatment system on the main inflow into Rotomanuka South (2016). (Photo: Department of Conservation)

Grazed pasture between Rotomanuka North (left) and Rotomanuka South. This land is proposed for purchase.

| L 20<br>Priority: Medium | Lake Rotopiko pest fish eradication | BCR value |
|---|---|---|
| Relevant goals from Central/Lower Waikato unit and Shallow Lakes unit | Projects on lakes are prioritised according to cultural significance, ability to improve and ability or appropriateness to access.<br><br>A full range of ecosystem types associated with lakes in the catchment are protected and maintained with a focus on high value natural environments.<br><br>Koi biomass is reduced by 80% in key lakes and maintained at this level. The impacts of other pest fish on lake water quality are managed. | |
| Name of feature | The Rotopiko lakes and wetlands | |
| Brief description of feature | This peat lake complex is situated south of Ōhaupō and is remnant of a larger peat lake that was historically lowered by artificial drainage. It is managed by DOC as a Wildlife Management Reserve.<br><br>This would have originally been a closed system, but is now connected to the surrounding catchments by several inlets and one outlet (on the eastern side). There remain three permanent lakes named North (5.3 ha, 4 metres deep), East (1.6 ha, 4.4 metres deep) and South (8.3 ha, 3.6 metres deep). There is an ephemeral wetland area between North and South lakes, and this connects them during wet seasons (referred to as Winter Lake). Historically, these were part of a significant wetland area which provided bountiful food and resources for iwi, including tuna (eels), dyes, medicines, birdlife and materials for clothing and domestic use.<br><br>The lakes have been monitored for water quality by Waikato Regional Council since 2002 and these results indicate that the Rotopiko lakes are eutrophic – supertrophic, although they are in better overall condition than other shallow lakes in the Waikato region overall. All three lakes still support healthy almost wholly indigenous macrophyte communities, and this is rare both in the Waikato catchment and nationally. There are five indigenous fish species recorded in these lakes; including “at risk-declining” black mudfish and longfin eel (the tuna population is unfished).<br><br>The greatest direct threat to the macrophyte community at this site is rudd, but goldfish, catfish, and gambusia are also present and they contribute to direct and indirect adverse effects through feeding on the plants, altering ecosystem processes, and causing degraded water quality. DOC has been carrying out annual set-netting in these lakes, with the aim of controlling rudd to low levels (since 2001), and has also removed other pest fish species during | |

<table>
<tr><td></td><td>this work. Notably, rudds have not been detected in East Lake since 2007.<br><br>A weir was installed in 2012, approximately 2km downstream of the Rotopiko outlet. This weir was designed as a barrier to prevent pest fish moving from Lake Rotomanuka into Lake Rotopiko, whilst still allowing some native fish access (e.g. elver passage). The weir has been damaged, however work is underway to gain a revised resource consent that would enable DOC to remedy the problem and satisfy landowner concerns. There is no current evidence as to the effectiveness, or otherwise, of this weir as a pest fish barrier. In 2013 a predator-proof fence was installed around the entire margin of East Lake. This fence goes through the connecting waterways in such a way as to form a barrier to all fish passage. A manually-operated fish cage was installed in the outlet of this lake, to control passage of fish such as eels. The presence of this fence means that reincursion of pest fish into East Lake can be prevented and the success, or otherwise, of an eradication operation can be determined.</td><td></td></tr>
<tr><td>Desired state to achieve Vision & Strategy</td><td>- The lakes are swimmable, fishable and has access for recreation and gathering of kai.<br>- Native aquatic plants dominate the in-lake flora and provide habitat for healthy populations of other indigenous species.<br>- Lake margins retain natural hydrological function and are well vegetated with native plant communities that support indigenous fauna.<br>- Wetlands adjacent to lakes are densely vegetated with native plant species, connected to riparian corridors, protected from stock grazing and native plant regeneration occurs naturally.<br>- Iwi and community have a strong connection to the lakes and are active in their use, protection and restoration.</td><td></td></tr>
<tr><td>Impact on Vision & Strategy</td><td>In a restored condition, the Rotopiko lakes and wetlands would have a high impact on giving effect to the Vision & Strategy at a shallow lakes catchment level.</td><td>VS = 25</td></tr>
<tr><td>Key threats to the feature that this project addresses</td><td><table><tr><th>Key threat</th><th>Impact on feature</th></tr><tr><td>Rudd, a largely herbivorous species.</td><td>Destruction of indigenous macrophytes; increased threat of aquatic plant collapse and decreased water quality.</td></tr><tr><td>Goldfish, catfish, and gambusia</td><td>Modification of invertebrate and fish communities; disturbance of sediments and resuspension of nutrients leading to decreased water quality.</td></tr></table></td><td></td></tr>
<tr><td>Project goal/s</td><td>- Within 5 years of project commencement, LakeSPI score in East Lake is at least 80%.</td><td></td></tr>
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| | - Within 5 years of project commencement rudd, goldfish and catfish will be unable to be detected in East Lake.<br>- The eradication in East Lake provides important learnings for the methodology to be applied in the remainder of the Rotopiko complex and in other small shallow lakes in the Waikato. | |
| Priority works for funding | Works could be implemented by a specific organisation or preferably be a collaboration between multiple parties.<br><br>Due to the nature of this site and the pest species present, more than one fish pesticide application would need to be carried out.<br><br>Key tasks:<br><br>- Assess the lake and prepare an implementation plan for an eradication programme using fish pesticide. This would include assessment of inflows/outflows, best time of year, quantity of pesticide, delivery method (aerial and/or ground), number of applications, tuna and other fish relocation methods and new location/holding area, post-eradication restocking of native fish. Also identify resource requirements (e.g. people and equipment), potential risks, benefits and opportunities of this work. (This is included in the project management cost.)<br>- Undertake consultation with iwi and stakeholders. A cultural impact assessment should be undertaken by tāngata whenua.<br>- Prepare and submit documentation to gain necessary consents/permits, including any other assessments and consultation.<br>- Carry out eradication operation in East Lake: remove indigenous fish species, control inlets/outlets, public notification, apply pesticide, monitor water.<br>- Monitor East Lake to ensure that pest fish species are absent.<br>- Return indigenous fish species to East Lake.<br>- If pest fish eradication is successful, then begin process to carry out eradications in the other Rotopiko lakes (this will require sourcing of additional funds).<br>- Ongoing monitoring to ensure the eradication was successful and that the project goals are being achieved.<br><br>**Project management/staffing/incidentals**<br>Staff to carry out landowner liaison, iwi engagement, Health and Safety requirements, negotiate agreements, inspect works, manage parts of the work as required (e.g. fencing or planting), project reporting and financial management. Incidentals include transport, office overheads, consumables and miscellaneous professional fees. | |

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| | This is estimated to be 30% of the direct project costs in Year 1. For Years 2-5 it is assumed that this would be carried out by a staff member of an organisation at approximately 0.25 FTE. | |
| Time lag for benefits to be realised | If works were implemented at the planned pace over a 5-year period, it is estimated that the majority of the project benefits would be seen approximately within a year of project completion. | L = 5.5 |
| Effectiveness of works | When compared with desired state, the Rotopiko lakes are in good condition with some of the Vision & Strategy aspirations already being met or partly met. This includes being fishable, having healthy populations of native aquatic plants and tuna, and having good access for recreation. Significant restoration works have been undertaken at this site over the last 15 years and therefore overall condition is not expected to deteriorate in the next 20 years in the absence of this project. Works included in this project are focused only on East Lake and so impacts won't extend to North or South lakes. However, project learnings could be extended to these sites if the work is successful. Eradication of pest fish from East Lake would re-establish a natural food web there and thereby enhance the biodiversity and intrinsic values of the lake. If the project is successfully completed it is expected that the Rotopiko lakes complex will move closer to Vision & Strategy desired state. | W = 0.05 |
| Risk of technical failure | There is a high to very high risk of project failure due to technical feasibility. Risks are mostly related to the efficacy of rotenone in a vegetated and peat influenced environment. This project is dependent on further work being undertaken to assess this at a laboratory and field trial scale prior to attempting at a lake scale (see section on investigation priorities). | F = 0.4 |
| Adoptability | Works are identified to be undertaken on publicly owned land, however managing agencies would require more certainty on the efficacy of the work before agreeing for it to be undertaken. | A = 0.75 |
| Information quality | Average – there is generally a good understanding of the pest fish populations, water quality and condition of macrophytes at this site, and the toxicity effects on pest fish using this lake water (through previous trials at the University of Waikato). Methodology of applying the fish pesticide will need fine-tuning, due to the vegetated peaty lake environment and whether that will provide difficulties in getting good toxin coverage to eliminate refugia for pest fish. | |
| Knowledge gaps | Feasibility of using fish pesticide in all lakes at this site – duration of toxin effectiveness in the water column and the peaty substrate, drawdown capability, presence of pest fish refugia and practicality of getting full coverage of the toxin in swampy vegetated areas, | |

<table>
<tr><td></td><td>effectiveness of the toxin on each pest species (including their behavioural response, particularly catfish).</td><td></td></tr>
<tr><td>Socio-political risks</td><td>There is a high to very high risk that the project will fail to meet its goals over the long term due to socio-political risks. The use of a toxin in this lake may not be acceptable to local iwi, particularly given the good populations of longfin eel that are present. The local community and other stakeholders may also be averse to the use of a toxin for pest fish control. This project would rely on several organisations working together to progress approvals, permits and consents and this may be quite challenging. Early stakeholder engagement is critical for the successful delivery of this project.</td><td>P = 0.25</td></tr>
<tr><td>Project duration (years)</td><td>5 years</td><td></td></tr>
<tr><td>Up-front cost – total for implementation phase/project duration</td><td>
<table>
<tr><th>Task</th><th>Cost ($)</th></tr>
<tr><td>Consultation and cultural assessment</td><td>30,000</td></tr>
<tr><td>Consents/permits</td><td>35,000</td></tr>
<tr><td>Eradication operation (includes native fish removal; 2 dosing attempts, initial monitor – 10 people for 8-10 days plus toxin purchase and storage, applicators/tanks/pumps/boats/helicopter)</td><td>180,000</td></tr>
<tr><td>Monitor for eradication success (2 people for 8 days, $70 per hour)</td><td>8960</td></tr>
<tr><td>Return indigenous fish species (2 people for 15 days, $70 per hour)</td><td>16,800</td></tr>
<tr><td>Landowner reparation (e.g. repairing fencing, flood mitigation)</td><td>5000</td></tr>
<tr><td>Project management Year 1 (30%)</td><td>82,728</td></tr>
<tr><td>Sub-total (up-front cost)</td><td>358,488</td></tr>
<tr><td>Project management/incidentals (staff member, 0.25 FTE)</td><td>25,000</td></tr>
<tr><td>Monitoring/surveillance (annual: 2 people for 8 days, $70 per hour)</td><td>8960</td></tr>
<tr><td>Consent fees (annual)</td><td>500</td></tr>
<tr><td>Sub-total per year for 4 years</td><td>34,460</td></tr>
<tr><td>Sub-total (annual costs × four out years)</td><td>137,840</td></tr>
<tr><td>Total</td><td>496,328</td></tr>
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</td><td>C = 0.5</td></tr>
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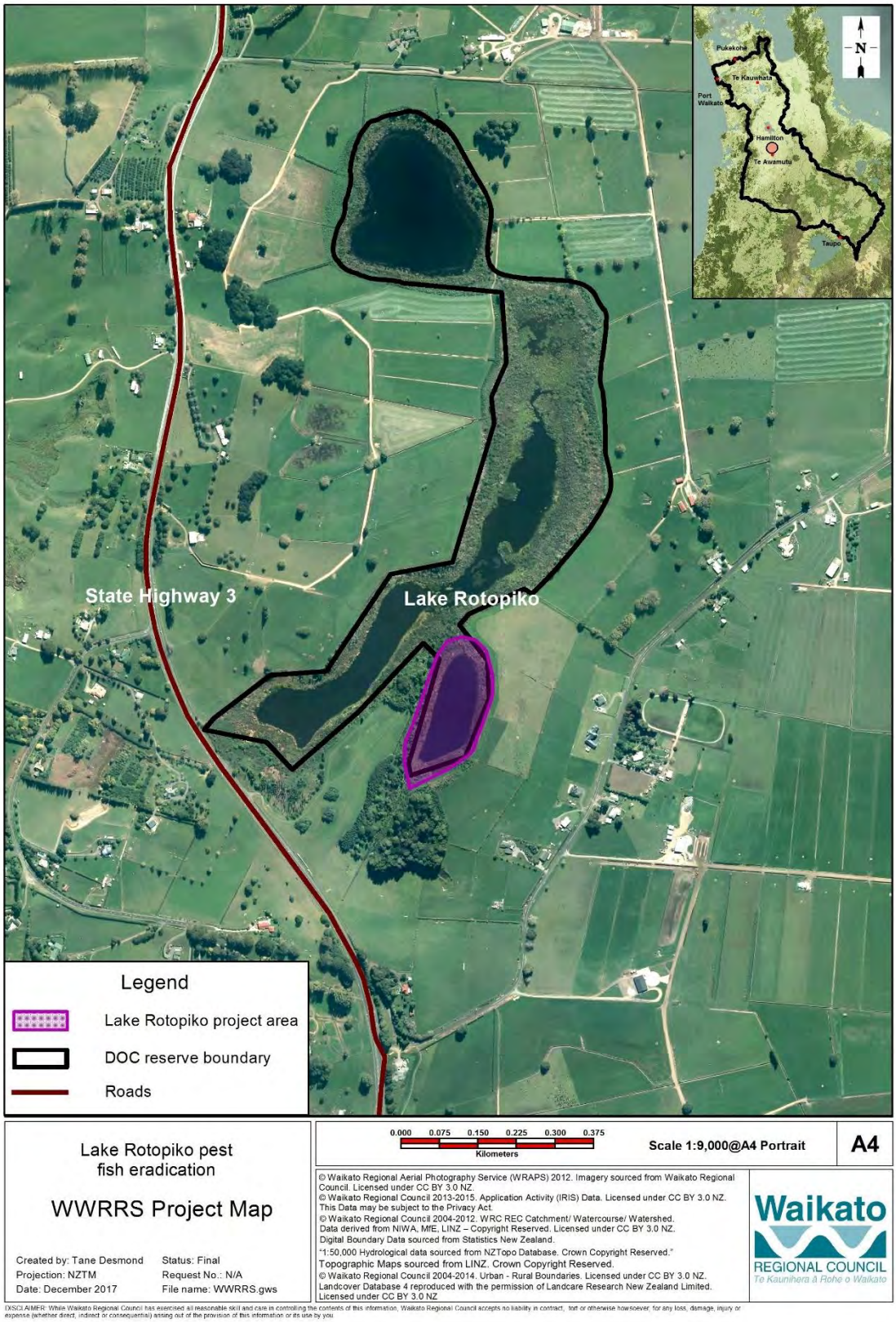


The Rotopiko lakes complex – with East Lake at the southeast corner.

Target species for eradication – rudd. (Photo: DOC)

| L 21<br>Priority: Very high | Restoration of wetland and aquatic plant ecosystems at Lake Mangakaware. | BCR value |
|---|---|---|
| Relevant goals from Central/Lower Waikato unit and Shallow Lakes unit | A full range of ecosystem types associated with lakes in the catchment are protected and maintained with a focus on high natural environments.<br><br>Nutrient and sediment inputs to lakes are reduced by a proportion that leads to noticeable improvements in lake water quality so that lakes are safe for swimming and gathering of taonga species.<br><br>Important lake species such as kāeo and native aquatic plants are reproduced for retention and re-establishment. | |
| Name of feature | Lake Mangakaware | |
| Brief description of feature | Lake Mangakaware lies west of Te Awamutu and is situated within a basin of peat. The lake is managed by Waipā District Council as part of a large (about 48ha) recreational reserve, which at its widest extends 240m from the lake edge. This is a considerably larger lake buffer than any other peat lake in the Waipā District. The lake's area is 12.9ha and has a catchment area of approximately 238ha.<br><br>There are five recorded archaeological sites at Lake Mangakaware that are all associated with pre-European Māori occupation. These include three swamp pā, burrow pit and cached items on the lake bed.<br><br>The lake has three major inflows and 10 smaller inflows. Two of the major inflows have large constructed treatment systems on them and have been planted with submerged, emergent and wetland plants which are all well established.<br><br>Water quality data indicates that the lake is nutrient enriched (hypertrophic) with a TLI of 6.41. Algal blooms frequently occur in summer and early autumn. The lake still retains a small cover of submerged plants which has recently recovered to > 10% cover in a survey in 2015. These plants included native submerged plants (pondweed and milfoils) but also the exotic weed Egeria.<br><br>The lake has been fully fenced to exclude stock but the fenced area does not include about 25ha of the reserve. The unfenced areas of the reserve are currently grazed by adjoining landowners through leasing arrangements. | |

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| | Waipā District Council has undertaken extensive willow, blackberry and yellow flag control around the lake. Approximately 10,000 native plants have been planted in the reserve area and in the silt traps in recent years.<br><br>Grey duck, grey teal, NZ shoveler, large black shag, little shag, pied stilt, whitefaced heron and morepork have been recorded in the area, along with other more common species of birds and waterfowl. NZ dabchick (threatened species) appears to be breeding at the lake. An extensive trapping network targeting feral cats, possum, mustelids, hedgehogs and rats is run by Hamilton Fish and Game Club.<br><br>Four species of native fish are present – common bully, smelt, shortfin and longfin eels. Catfish, gambusia and goldfish are the only pest fish species known to be in the lake. There is a small waterfall approximately 500m downstream of the lake which is likely to be preventing pest fish from accessing the lake from the wider Waipā catchment. The lack of koi and rudd is likely to be beneficial for re-establishing submerged plants.<br><br>An access road that terminates in a small car park next to the lake was built in 2016 providing public access to the lake. The lake is used by game bird hunters. | |
| Desired state to achieve Vision & Strategy | - The lake is swimmable, fishable and has access for recreation and gathering of kai.<br>- Native aquatic plants dominate the in-lake flora and provide habitat for healthy populations of other indigenous species.<br>- Lake margins retain natural hydrological function and are well vegetated with native plant communities that support indigenous fauna.<br>- Wetlands adjacent to lakes are densely vegetated with native plant species, connected to riparian corridors, protected from stock grazing and native plant regeneration occurs naturally.<br>- Iwi and community have a strong connection to the lake and are active in its protection and restoration. | |
| Impact on Vision & Strategy | In a restored condition, Lake Mangakaware would have a high impact on giving effect to the Vision & Strategy at shallow lakes catchment level. | VS = 28 |

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<tr>
<td>Key threats to the feature that this project addresses</td>
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<tr><th>Key threat</th><th>Impact on feature</th></tr>
<tr><td>Diffuse pollution from catchment land use</td><td>Further degradation of water quality due to increases in nutrients, sediment and harmful microbes.</td></tr>
<tr><td>Egeria</td><td>Smother the recovering native submerged plants. Egeria is prone to ‘collapsing’ in nutrient rich lakes leading to a flip back to an algal dominated state.</td></tr>
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<tr>
<td>Project goal/s</td>
<td>- Within 3 years, eradicate egeria from Lake Mangakaware.<br>- Within 10 years, native submerged plant cover at Lake Mangakaware has reached 30%.<br>- Within 5 years, CTS are established on all inflowing drains to the lake leading to a 50% reduction in sediment, nitrogen and phosphorus entering the lake.<br>- Within 10 years revegetate all of the surrounding reserve land to establish a sequence of ecosystem types that would have naturally occurred at peat lakes in the Waipā District.</td>
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<tr>
<td>Priority works for funding</td>
<td>Suggested works could be implemented either by an organisation or private citizens (using contractors or their own labour). This project could be undertaken as a whole, or in multiple smaller components. Work would need to be undertaken in close collaboration with Waipā District Council.<br><br>Revegetation of Lake Mangakaware Reserve<br><u>Fencing:</u> It is proposed to fence all of the reserve area. Total length of fencing required is 2050m at $8 per metre ($16,400).<br><br><u>Planting:</u> Native planting is proposed in the currently unfenced areas of the reserve. Planting at 1.5m spacing is recommended, matching wetland species with flooding depth and duration. All native plants should be species that naturally occur in the Hamilton Ecological District. The area requiring revegetation is 27.3ha at $39,552 per hectare ($1,079,770).<br><br>Constructed treatment systems (CTS) on drains<br>Some investigations have been undertaken at Lake Mangakaware to identify the best locations, types and sizes of constructed treatment systems (CTS) on incoming drains. Many of the small drains (< 100m) originate within the reserve and won’t require CTS once the reserve is fully fenced and replanted. Four remaining inflows are considered a high priority for establishing a CTS. Costs associated with their construction are listed below:</td>
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| | **Mangakaware 4-6:** A CTS has been designed to capture inflows from 3 drains including the last major drain without a CTS. It consists of a sediment basin (400$m^2$), average depth 1.5m, and an infiltration wetland (800 $m^2$), average depth 1.2m. This would require 2200$m^3$ of earthworks ($3100), 1200$m^2$ of planting ($19,420) and planting maintenance for two years ($600).<br><br>**Mangakaware 1**: The CTS designed for this inflow consists of a large sediment basin (270$m^2$), average depth 2.0m, and an infiltration wetland (589$m^2$), average depth 1.2m. This would require 1240$m^3$ of earthworks ($2000), 720$m^2$ of planting ($11,185) and planting maintenance for two years ($500).<br><br>**Mangakaware East 1**: A CTS has not been designed for this inflow. It is similar sized drain/catchment to Rotomanuka 7 CTS so the same specifications are given here. A large circular silt trap (140$m^2$), average depth 1.8m. This would require 140$m^3$ of earthworks ($940), 80$m^2$ of planting ($2000) and planting maintenance for two years ($100).<br><br>**Mangakaware East 2:** A CTS has not been designed for this inflow. It is similar sized drain/catchment to Rotomanuka 7 CTS so the same specifications are given here. A large circular silt trap (140$m^2$), average depth 1.8m. This would require 140$m^3$ of earthworks ($940), 80$m^2$ of planting ($2000) and planting maintenance for two years ($100).<br><br>Consent would be required for CTS from both Waikato Regional Council and the Waipā District Council. This would include undertaking consultation with tāngata whenua and commissioning a cultural impact assessment. Based on costs for similar projects undertaken at other peat lakes, consent application preparation, consent fees, cultural impact assessment and consultation is likely to cost approximately $35,000.<br><br>Annual maintenance of sediment basins to remove sediment for 10 years for all proposed CTS at Manakaware ($1880 per annum) would be required to keep them operational and prevent sediment being washed into the lake in an extreme flood event.<br><br>**Eradication of Egeria**<br>Egeria, a serious aquatic weed, is present at low abundances in the lake. It is proposed to eradicate this weed from the lake while it occurs at low covers and before there is an anticipated | |

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| | improvement in lake water clarity (resulting from a decrease in sediment from CTS on all inflows). In increase in water clarity in the lakes is highly likely to result in a rapid expansion of Egeria in the lake.<br><br>The proposed method is to handweed with divers and use hessian or coconut fibre matting for any large patches (total area of patches up to 5000m$^2$). This has been successfully used in other parts of New Zealand to eradicate Egeria and other nuisance oxygen weeds. It is a natural product that breaks down over two years. Native submerged plants such as pondweeds and charophytes will grow through the matting. The project will require a scoping survey with divers to assess the extent of Egeria, purchase of the hessian and pins, divers to lay the matting, and monitoring to assess the effectiveness.<br><br>**Project management/staffing/incidentals**<br>Staff to carry out landowner liaison, iwi engagement, Health and Safety requirements, negotiate agreements, inspect works, manage parts of the work as required (e.g. fencing or planting), project reporting and financial management. Incidentals include transport, office overheads, consumables and miscellaneous professional fees.<br><br>This is estimated to be 20% of the direct project costs. | |
| Time lag for benefits to be realised | If works were implemented at an even pace over a 10-year period, it is estimated that the majority of the project benefits would be seen approximately 8 years after project commencement. | L = 8 |
| Effectiveness of works | When compared with desired state, Lake Mangakaware is in moderate condition with some of the Vision & Strategy desired state aspects already being met or partly met. This includes being fishable and having access for recreation. It is expected that over the next 20 years there may be a slow deterioration in lake condition as a result of recent intensification of land use in the catchment. Works included here are expected to address some of the key threats to the lake, including external nutrient and sediment inputs, as well as facilitate in-lake restoration through re-establishment of native aquatic plants. Significant biodiversity gains can also be expected through the proposed planting programme. It is anticipated that this will offset predicted declines and progress the lake measurably closer to the Vision & Strategy desired state. If this project is successfully completed it is expected that the lake will be in good condition in 20 years' time. | W = 0.15 |

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| Risk of technical failure | There is a moderate risk of project failure due to technical feasibility. Effectiveness of constructed wetland treatment systems has not yet been fully established. It is critical to the success of this project that works are carried out by experienced practitioners. | F = 0.82 |
| Adoptability | Proposed works are entirely on publicly owned land and therefore full adoption is expected if the project was fully incentivised. | A = 1 |
| Information quality | Very good – a recent (2015) LakeSPI survey was undertaken and the divers who did the work have assessed the methods and costs involved in the Egeria eradication component of the project. Other recommendations were developed by a subject matter expert with detailed knowledge of the site. | |
| Knowledge gaps | Data on the abundance of Egeria is 2 years old and so current status has been assumed. | |
| Socio-political risks | There is a low to moderate risk that the project will fail to meet its goals over the long term due to socio-political risks. The lake is highly significant for local iwi and there are numerous interested stakeholders. Support from these partners and interested parties will be critical to project success and therefore engagement will be required early in the project development stage. | P = 0.7 |
| Project duration (years) | 10 years | |

<table>
<tr>
<td>Up-front cost – total for implementation phase/project duration</td>
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<table>
<tr><th>Task</th><th>Cost ($)</th></tr>
<tr><td>Fencing (2.05km)</td><td>16,400</td></tr>
<tr><td>Native re-vegetation of lake margin/reserve</td><td>1,079,770</td></tr>
<tr><td>CTS Mangakaware 4-6</td><td>23,120</td></tr>
<tr><td>CTS Mangakaware 1</td><td>13,685</td></tr>
<tr><td>CTS Mangakaware East 1</td><td>3040</td></tr>
<tr><td>CTS Mangakaware East 2</td><td>3040</td></tr>
<tr><td>Consent, consultation for CTS</td><td>35,000</td></tr>
<tr><td>Annual maintenance of sediment basins/silt traps for 10 years</td><td>18,800</td></tr>
<tr><td><u>Eradication of Egeria</u><br><br>Consent costs (about $15,000)<br>Scoping survey and handweeding in spring and autumn ($8740)<br>Barrier control ($15,000)<br>Monitoring for 3 years ($7,500)</td><td>47,480</td></tr>
<tr><td>Project management/staffing/incidentals (20%)</td><td>248,067</td></tr>
<tr><td>Total</td><td>1,488,402</td></tr>
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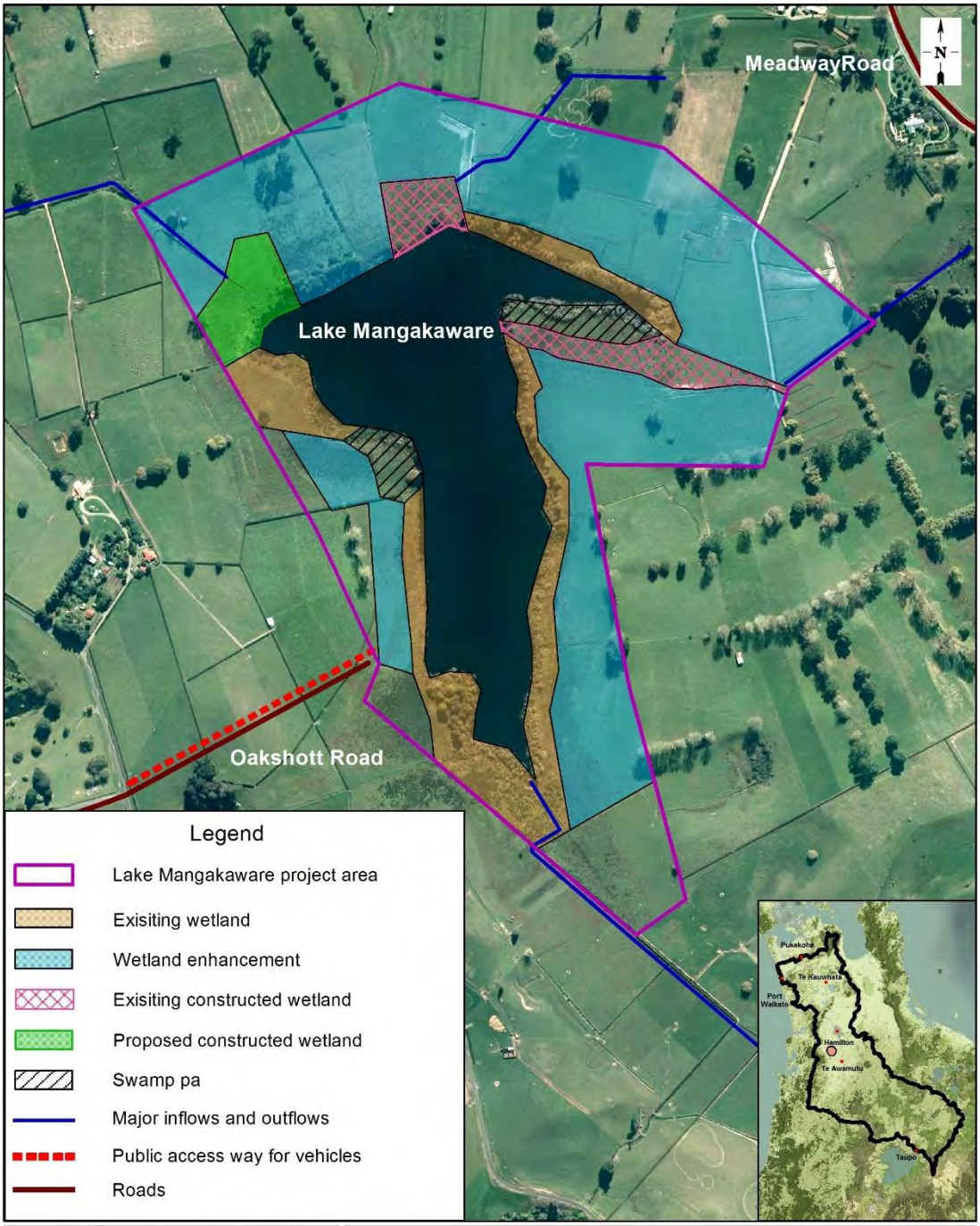
<td>C= 1.49</td>
</tr>
</table>




Restoration of wetland and aquatic plant ecosystems at Lake Mangakaware

WWRRS Project Map

Created by: Tane Desmond
Projection: NZTM
Date: December 2017

Status: Final
Request No.: N/A
File name: WWRRS.gws

0.00 0.05 0.10 0.15 0.20 0.25
Kilometers

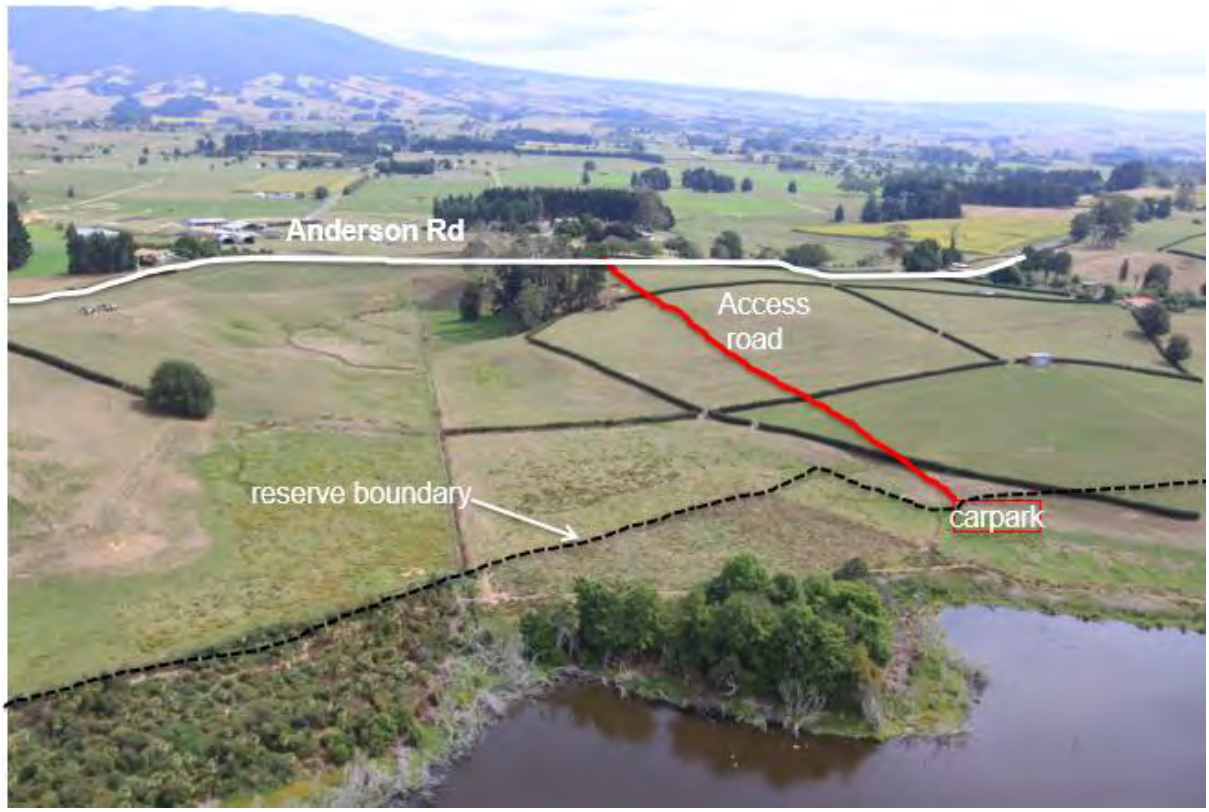
Scale 1:7,000@A4 Portrait

A4

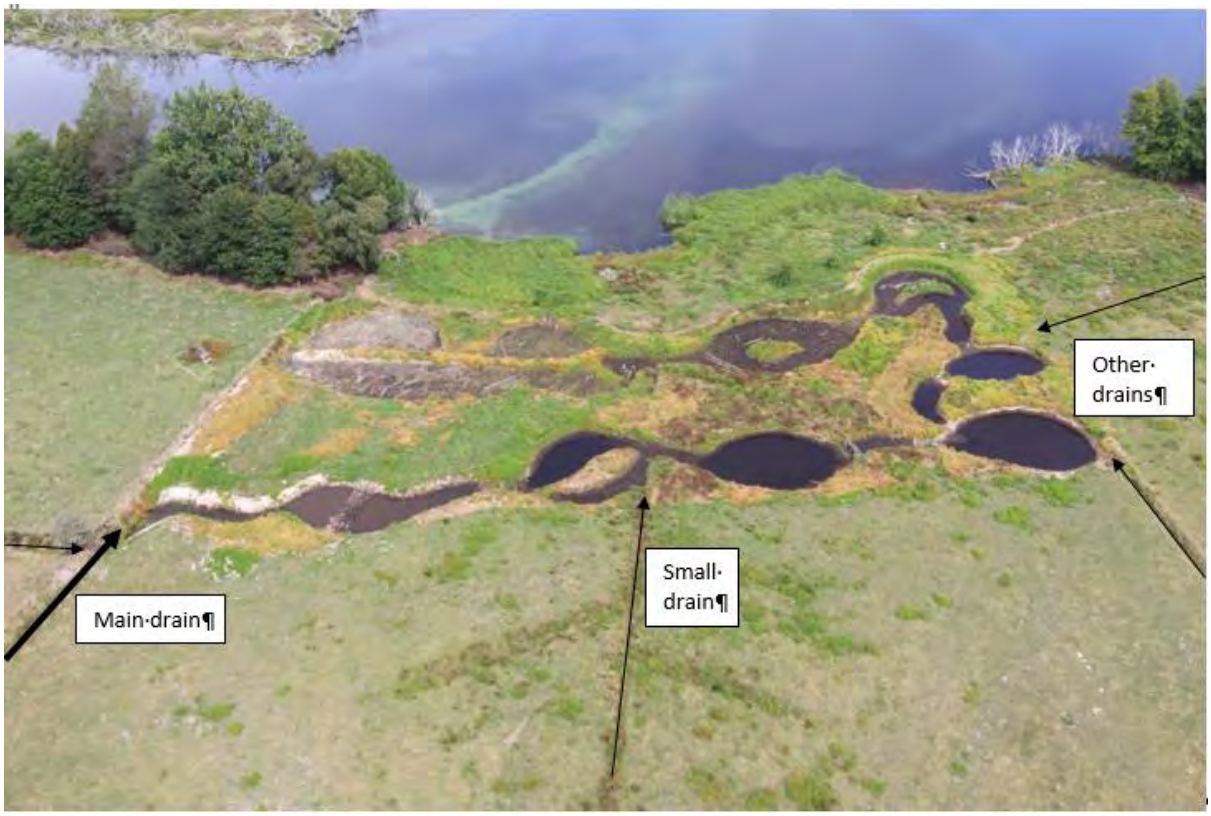


Waikato REGIONAL COUNCIL
Te Kaunihera ā Rohe o Waikato


Informal circuit track and one of the areas that has been revegetated at Lake Mangakaware.




Location of the access road and car park (have been completed since this photo) at Lake Mangakaware. (Photo: copyright Waipā District Council)




A constructed treatment system at Lake Mangakaware that consists of a series of silt traps and infiltration wetlands. This CTS treats the main inflow and several smaller drains. A green algal bloom can be seen in the lake. (Photo: copyright Waipā District Council)


Hessian matting being deployed in a lake in Ireland to eradicate oxygen weeds. (Photos: copyright Joe Caffery, Central Fisheries Board, Ireland)


Native plants growing through hessian matting deployed in Lake Wanaka to eradicate lagarosiphon. (Photos: copyright Mary de Winton, NIWA)

| L 22<br>Priority: Medium | Water quality and habitat enhancement at Lake Ngāroto | BCR value |
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| Relevant goals from Central/Lower Waikato unit and Shallow Lakes unit | Nutrient and sediment inputs to lakes are reduced by a proportion that leads to noticeable improvements in lake water quality so that lakes are safe for swimming and gathering of taonga species.<br><br>Innovative interventions are developed, tested and implemented to improve lake values, including options such as flocculants, dredging and enhancing lake embayments. | |
| Name of feature | Lake Ngāroto | |
| Brief description of feature | Lake Ngāroto is the largest of the peat lakes in the Waikato region with an area of 108ha. This is part of a 149ha recreation reserve that is managed by Waipā District Council via a reserve management plan to protect and maintain its important recreational, cultural and natural values. The reserve is fully fenced.<br><br>Lake Ngāroto is highly significant to Māori with six pā sites located in close proximity to the lake, including 2 swamp pā on the lake shoreline. The lake provided numerous resources to Māori, including kai, clothing, medicines and shelter. Lake Ngāroto is a central figure in the battle of Hingakaka, which is regarded as the biggest battle fought within the Tainui lands before the introduction of guns.<br><br>The lake is easily accessible to the public and has toilets, boat ramps, a 6km walking track around the lake, yacht club and rowing club. The lake and its reserve is used by a large number of people on a daily basis including motorhomes, which can stay overnight. Game bird hunting remains popular.<br><br>Lake Ngāroto receives water from 3 major inflows as well as about 20 smaller drains. It discharges to the Waipā River via the Mangaotama Stream. The three main subcatchments are to the south (755ha), east (620ha), and west (300ha) of the lake. The subcatchment to the east was diverted around the lake in 2015.<br><br>Water quality sampling has been undertaken at Lake Ngāroto periodically since the 1970s. The lake is very nutrient enriched (hypertrophic, TLI=6.81) with high levels of turbidity. Toxic blue-green algal blooms occur frequently in the warmer months | |

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| | resulting in closures for contact recreation. High turbidity has resulted in the loss of submerged plants from the lake.<br><br>Lake modelling of Ngāroto in 2017 identified that algal blooms are most likely driven by external inputs of nutrients (coming into the lake via the surrounding drains) and phosphorus that has accumulated over time in the lake itself. Phosphorus in the lake sediments is released into the overlying lake water whenever the lake is depleted of oxygen, which occurs frequently during the summer and autumn months.<br><br>The reserve surrounding the lake is mostly revegetated with native wetland and lowland forest plants but also contains several ecosystem changing weeds such as grey willow, blackberry, gorse and inkweed.<br><br>A catchment action plan was created by NZ Landcare Trust in 2014 to provide recommendations to farmers as well as agencies in order to help improve the water quality of the lake and prevent it from degrading further. Eight farms in the catchment have had whole farm plans done as part of this process. Inflows to the lake were assessed to determine the best type of constructed treatment system (CTS) to install to reduce nutrients and sediment entering the lake. Two farmers have since installed CTS on some inflows and Waipā District Council has consent to install CTS on some drains on the eastern side of the lake.<br><br>Shortfinned eels are the most abundant fish species found in the lake. Other native fish species present include longfinned eel and common bully. Pest fish present in the lake include bullhead catfish, rudd, goldfish, koi carp and gambusia.<br><br>The extensive wetland habitat around the lake attracts a high number of bird species. Twenty-nine species of wetland birds have been recorded, including one “nationally critical” species (white heron), two “nationally endangered” species (Australasian bittern and grey duck) and one “nationally vulnerable” species (Caspian tern). Ngāroto is close to several other lakes (e.g. Ruatuna, Ngāroto-iti, Rotopiko), with birds observed flying between them. | |
| Desired state to achieve the Vision & Strategy | - The lake is swimmable, fishable and has access for recreation and gathering of kai.<br>- Native aquatic plants dominate the in-lake flora and provide habitat for healthy populations of other indigenous species. | |

<table>
<tr><td></td><td>- Lake margins retain natural hydrological function and are well vegetated with native plant communities that support indigenous fauna.<br>- Wetlands adjacent to lakes are densely vegetated with native plant species, connected to riparian corridors, protected from stock grazing and native plant regeneration occurs naturally.<br>- Iwi and community have a strong connection to the lake and are active in its protection and restoration.</td><td></td></tr>
<tr><td>Impact on Vision & Strategy</td><td>In a restored condition, Lake Ngāroto would have a high impact on giving effect to the Vision & Strategy at a shallow lakes catchment level.</td><td>VS = 60</td></tr>
<tr><td>Key threats to the feature that this project addresses</td><td><table><tr><th>Key threat</th><th>Impact on feature</th></tr><tr><td>Diffuse pollution from catchment land use</td><td>Further degradation of water quality due to increases in nutrients, sediment and harmful microbes.</td></tr><tr><td>In-lake nutrient load</td><td>Phosphorus is released from lake sediments when there are anoxic events which can lead to algal blooms that effect the use of the lake for recreation.</td></tr></table></td><td></td></tr>
<tr><td>Project goal/s</td><td>Within 5 years of project commencement, water quality has measurably improved in Lake Ngāroto.</td><td></td></tr>
<tr><td>Priority works for funding</td><td>Suggested works could be implemented either by an organisation or private citizens (using contractors or their own labour). This project could be undertaken as a whole, or in multiple smaller components. Work would need to be undertaken in close collaboration with Waipā District Council.<br><br>Reduction of external nutrients and sediment<br>This project would install constructed treatment systems (CTS) on the highest priority drains entering Lake Ngāroto. These have been identified in the community catchment plan for Lake Ngāroto. Most of these would occur on private land.<br><br>Most of the CTS would occur on private land but it is proposed to purchase low-lying land at the southern end of the lake to construct a very large constructed wetland to treat all the water entering the lake from the southern catchment.<br><br>Works required on the priority drains are detailed below:<br><br>Ngāroto 1: This CTS is the proposed large constructed wetland at the southern end of the lake. It involves purchasing 19ha of low</td><td></td></tr>
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| | lying land. Estimated costs of land purchase for land of this type is $50,000 per hectare ($950,000). Conveyancing fees are estimated to be $2500 and surveying new parcel boundaries is estimated to be about $8000. This land would be fenced (2600m) at $20 per metre ($52,000). The size of the constructed wetland would be 2.5% of the catchment size (i.e. 18.9ha). It is estimated that the performance of a constructed wetland of this type and size (in relation to catchment area) is likely to result in the following reductions: about 80% of annual sediment load, 60% of nitrogen, 60-80% of particulate phosphorus and >90% of *E. coli*. Cost of this type of constructed wetland is $100,000 per hectare ($1,890,000) and would involve significant earthworks and planting. It would also require the preparation of design specifications ($10,000).<br><br>**Ngāroto 4, 6:** The CTS recommended for these two drains is a circular sediment trap discharging to an infiltration wetland. Sediment trap (140m$^2$) would require 140m$^3$ of earthworks ($940), 80m$^2$ of planting ($2000), and planting maintenance for two years ($100). The infiltration wetland (330m$^2$, average depth 0.3m) would require 100m$^3$ of earthworks ($780), 330m$^2$ of planting ($5710) and plant maintenance for two years ($100). It would also require 220m of fencing at $20 per metre ($4400) and a planted riparian setback (330m$^2$, cost $840) of 1.5m either side of the wetland. Cost per drain is $14,870 ($29,740).<br><br>**Ngāroto 9, 13:** The CTS recommended for these two drains is a circular sediment trap discharging to an infiltration wetland and then a habitat pond (the pond located within the reserve). The sediment trap (140m$^2$) would require 140m$^3$ of earthworks ($940), 80m$^2$ of planting ($2000) and planting maintenance for two years ($100). The infiltration wetland (330m$^2$, average depth 0.3m) would require 100m$^3$ of earthworks ($780), 330m$^2$ of planting ($5710) and plant maintenance for two years ($100). It would also require 220m of fencing at $20 per metre ($4400) and a planted riparian setback (330m$^2$, cost $840) of 1.5m either side of the wetland. The habitat pond would be same size as the sediment trap and involve the same quantity of earthworks and planting ($3040). Cost per drain is $17,910 ($35,820).<br><br>**Ngāroto 10, 11 & 12:** The CTS recommended for these drains consists of a small circular silt trap (140m$^2$), average depth 1.8m. This would require 29m$^3$ of earthworks ($680), 20m$^2$ of planting ($500), planting maintenance for two years ($50), and 60m fencing at $20 per metre ($1200). Cost per drain is $2430 ($7290). | |

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| | Consent would be required for all CTS from both Waikato Regional Council and the Waipā District Council. This would include undertaking consultation with tāngata whenua and may include commissioning a cultural impact assessment. Based on costs for similar projects undertaken at other peat lakes, consent application preparation, consent fees, cultural impact assessment and consultation is likely to cost about $35,000.<br><br>Annual maintenance of sediment basins to remove sediment for 10 years for all proposed CTS at Ngāroto ($3760 per annum) would be required to keep them operational and to prevent sediment being washed into the lake in an extreme flood event.<br><br>**Reduction of internal nutrients and sediment**<br>This project involves reducing phosphorus in Lake Ngāroto using continuous alum dosing, a highly effective method for removing phosphorus from fresh water systems. Continuous alum dosing is currently being employed by the Bay of Plenty Regional Council to help meet water quality targets for lakes Rotorua, Rotoehu and Okaro. Before this is undertaken at Lake Ngāroto, further trials are required to determine the likely effectiveness of this technique in Waikato lakes.<br><br>Continuous alum dosing involves pumping low levels of alum (the chemical, aluminium sulphate) into major lake inflows. It requires a small facility to safely store alum close to the site and some method for dispensing the alum (e.g. chemical pump). Costs of implementing a continuous alum dosing plant at Lake Ngāroto are still being investigated.<br><br>**Project management/staffing/incidentals**<br>Staff to carry out landowner liaison, iwi engagement, Health and Safety requirements, negotiate agreements, inspect works, manage parts of the work as required (e.g. fencing or planting), project reporting and financial management. Incidentals include transport, office overheads, consumables and miscellaneous professional fees.<br><br>This is estimated to be 20% of the direct project costs. | |
| Time lag for benefits to be realised | If works were implemented at an even pace over a 10-year period, it is estimated that the majority of the project benefits would be seen approximately 8 years after project commencement. | L = 8 |
| Effectiveness of works | When compared with desired state, Lake Ngāroto is currently in very poor condition with few of the Vision & Strategy aspirations being met. The lake is not swimmable, and the presence of pest | W = 0.1 |

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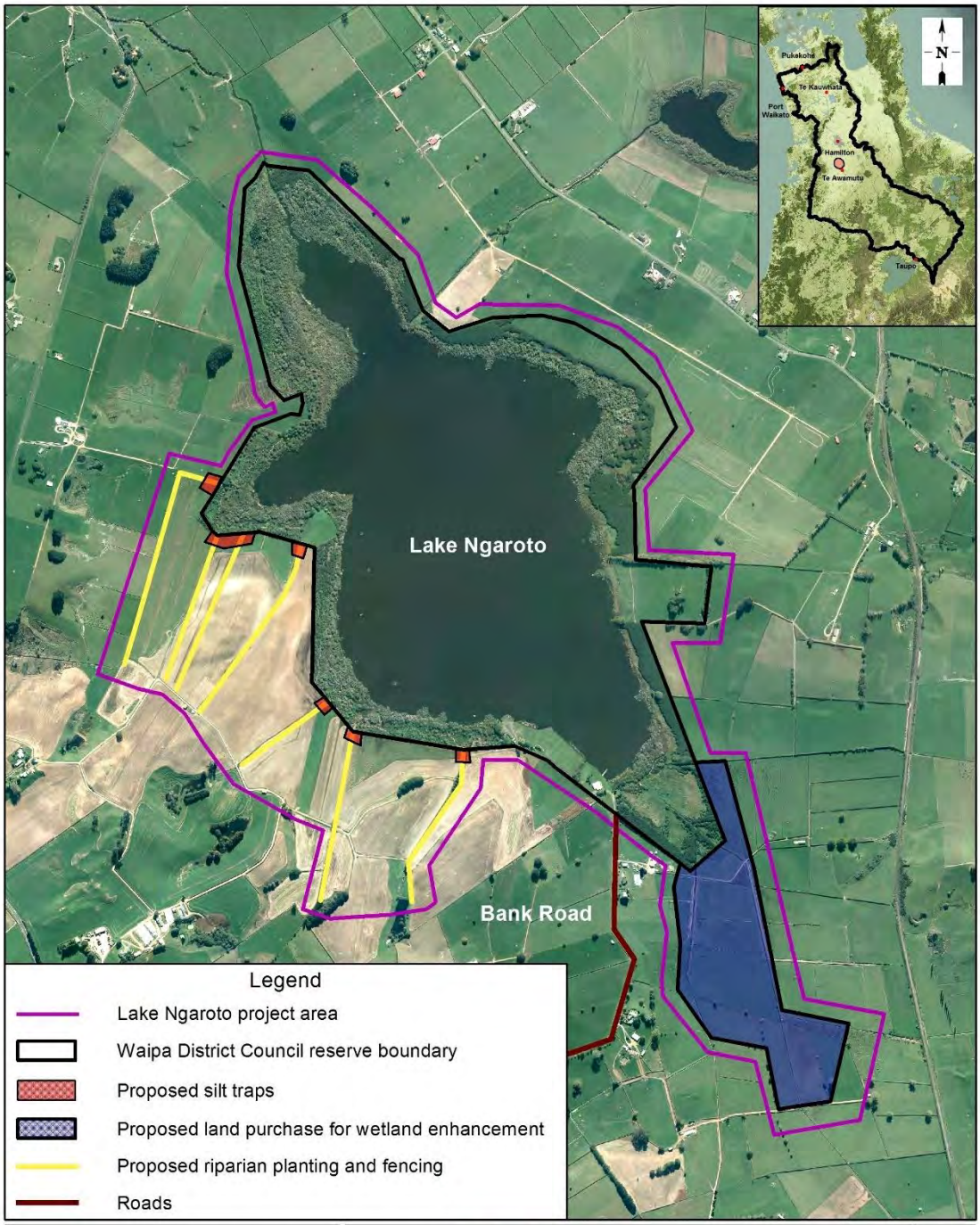
| | fish and plant species impacts significantly on ecological integrity. The very poor water quality is an impediment to safe recreational use of the lake. However, the lake still retains very high significance with iwi and the local community, has a well-used walking track and retains some important wetland and biodiversity values. The lake is not expected to change in overall condition over the next 20 years in the absence of this project. There have been ongoing restoration efforts at the site which should help offset potential declines. This project will address catchment inflows and reduce internal P loading. It will also significantly increase the extent of wetland habitat around the lake. Modelling undertaken by the University of Waikato in 2017 indicates that this work would still not move the lake into the National Objectives Framework C band, or meet swimmable targets, however it may increase clarity in the lake and move it closer towards the Vision & Strategy desired state. It doesn't address the majority of threats to the lake and it is acknowledged that achieving the Vision & Strategy desired state for Lake Ngāroto will take longer than the 20 year horizon used for the purposes of the Restoration Strategy, and a fuller range of initiatives. | |
| Risk of technical failure | There is a moderate to high risk of project failure due to technical feasibility. Effectiveness of constructed wetland treatment systems has not yet been fully established. However, the highest risk component of the project relates to the alum dosing which has not yet been proven in a high peat environment. This work should not be attempted until smaller laboratory and field based trials have shown that it will be effective (see section on investigation priorities). | F = 0.7 |
| Adoptability | Works on publicly owned land is expected to be adopted if fully incentivised as Waipā District Council is very supportive of this project. There is uncertainty around the willingness of private landowners to sell land for wetland and constructed treatment system development. This would need to be confirmed before the project was initiated. | A = 0.5 |
| Information quality | Good – recommendations for land retirement and constructed treatment systems have come from subject experts who have a history of association with the lake. Recommendations for alum are less accurate and site specific costings will need to be developed if trials indicate that it is likely to be successful in the lake. | |
| Knowledge gaps | Only generic information on the likely expected reductions in sediment and nutrients is currently available. | |
| Socio-political risks | Moderate risk that the project will fail to meet its goals over the long term due to socio-political risks. This relates to the proposed | P = 0.62 |

<table>
<tr><td></td><td>use of alum which may not be acceptable to iwi, stakeholders and the community. Early engagement with tāngata whenua during project scoping will be critical.</td><td></td></tr>
<tr><td>Project duration (years)</td><td>10 years</td><td></td></tr>
<tr><td>Up-front cost – total for implementation phase/project duration</td><td>
<table>
<tr><th>Task</th><th>Cost ($)</th></tr>
<tr><td>Land purchase</td><td>950,000</td></tr>
<tr><td>CTS Ngāroto 1</td><td>1,962,500</td></tr>
<tr><td>CTS Ngāroto 4 & 6</td><td>29,740</td></tr>
<tr><td>CTS Ngāroto 9 & 13</td><td>35,820</td></tr>
<tr><td>CTS Ngāroto 10, 11 & 12</td><td>7290</td></tr>
<tr><td>Consent, consultation for CTS</td><td>35,000</td></tr>
<tr><td>Annual maintenance of sediment basins/silt traps for 10 years</td><td>37,600</td></tr>
<tr><td>Continuous alum dosing</td><td></td></tr>
<tr><td>- Storage shed and pump</td><td>150,000</td></tr>
<tr><td>- Investigations on dose rates and impacts</td><td>100,000</td></tr>
<tr><td>- Consents and consultation</td><td>50,000</td></tr>
<tr><td>- Dosing with alum (5 years)</td><td>1,500,000</td></tr>
<tr><td>Project management/staffing/incidentals (20% excluding land purchase)</td><td>781,590</td></tr>
<tr><td>Total</td><td>5,639,540</td></tr>
</table>
</td><td>C = 5.64</td></tr>
</table>




Water quality and habitat enhancement at Lake Ngaroto

## WWRRS Project Map

Created by: Tane Desmond
Projection: NZTM
Date: December 2017
Status: Final
Request No.: N/A
File name: WWRRS.gws

0.0 0.1 0.2 0.3 0.4 0.5
Kilometers

Scale 1:15,000@A4 Portrait

A4



Waikato REGIONAL COUNCIL
Te Kaunihera ā Rohe o Waikato


The southern end of Lake Ngāroto showing the adjacent low-lying area (which appears flooded) proposed for purchase for a large constructed wetland.