

# Northland Lakes Annual Report

Spring 2018

*Prepared for Northland Regional Council*

*October 2018*



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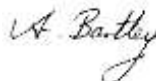

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*Photo Caption: Coastal dune lake on the Kelly property. [Paul Champion, NIWA]*

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## Executive summary

Northland Regional Council (NRC) has a programme of lake monitoring for around 90 lakes, of which 36 lakes are surveyed on a rotational basis over a maximum of five years. Lakes were assessed for ecological value including endangered species, wetland and emergent vegetation extent, submerged vegetation abundance and composition (including LakeSPI assessment), water bird, fish and aquatic invertebrate presence and abundance. NRC water quality sampling results and trends detected are referred to in this annual report to assist with calculation and interpretation of the Ecological Value Score. Identified threats and management recommendations were made for each lake. Additionally, annual surveillance is undertaken on prioritised lakes for early detection of weed incursions. NRC engaged NIWA to update its information by conducting the following assessments of lakes and water bodies. The field assessments involved a team of NIWA, Northland Regional Council and Department of Conservation aquatic and wetland ecologists with diving capability. The programme for Spring 2018 was:

1. Lake Ecological Assessments for:

*Kai Iwi and North of Dargaville:* Black (Black Lake), Lake Shag.

*Pouto:* Greville's Lagoon and Lakes Karaka, Mokeno Parawanui, Rotokawau, Rotopouua.

2. Reconnaissance visits to Kelly's Lake and the small pond on the coastal edge of the property (*Kai Iwi and North of Dargaville*), Lakes Kapoai, Otapuiti and Waingata (*Pouto*).

Surveillance for new submerged weed incursions in Lake Humuhumu and follow-up inspections of grey willow infestations.

No new pest plant incursions were detected in the 13 lakes investigated.

Two of the 13 lakes surveyed for ecological assessment were ranked as Outstanding (Karaka and Rotokawau), four as High or High-moderate (Black, Mokeno, Rotopouua and Shag), four were Moderate (Kelly's Pond, Greville's, Otapuiti and Parawanui) and three were Low (Kelly's, Kapoai and Waingata).

Major water quality issues were detected in eight of the lakes, including all Pouto lakes (except Greville's), Shag and Kelly's. Management recommendations include fencing lakes to exclude livestock, fence off inflows to prevent pugging and establish wetlands to mitigate nutrients.

Invasive plants were having minor to moderate impacts in seven lakes and also Lake Humuhumu. High covers of *Potamogeton crispus* were noted in four of those lakes, which is likely a consequence of survey timing rather than any other adverse influence. This species produces maximum biomass in winter and spring, declining during summer and autumn (when other LakeSPI assessments are routinely made). Impacts of *Utricularia gibba* were often lower than previous autumn assessments and may also reflect difference in survey timing. *Egeria densa* was rare within Lake Rotokawau, similar to assessments in 2012 and 2015.

The landowner at Lake Parawanui reported that commercial eel fishing occurred within the lake. This establishes an introduction pathway that presents a significant risk for new incursions of aquatic pests in this lake and potentially also Lakes Shag and Rotokawau.

## 1 Introduction

Northland Region has some of New Zealand's highest ranked examples of intact natural aquatic ecosystems (Champion and de Winton, 2012). However, they are being lost at an alarmingly rapid rate as invasive species spread as a result of human activities, and land use practices impact on lake condition. Often pristine lakes are limited to remote areas with difficult human access and limited land use development. With adequate recognition, community support and active protection, such exceptional lakes could be maintained in a close to pristine state for perpetuity.

Northland Regional Council (NRC) has a programme of lake monitoring for around 90 lakes that are surveyed on a rotational basis. This includes surveillance on prioritised lakes for early detection of weed incursions. From 17 to 21 September 2018 NRC engaged NIWA to undertake:

1. Lake Ecological Assessments of eight waterbodies:

*Kai Iwi and North of Dargaville:* Black (Black Lake), Lake Shag.

*Pouto:* Lakes Karaka, Mokeno, Parawanui, Rotokawau, Rotopouua and Greville's Lagoon.

2. Reconnaissance visits to Kelly's Lake and the small pond on the coastal edge of the property (*Kai Iwi and North of Dargaville*), Lakes Kapoai, Otapuiti and Waingata (*Pouto*).
3. Surveillance for new submerged weed incursions in Lake Humuhumu and follow-up inspections of grey willow infestations.

## 2 Methods

### 2.1 Ecological assessments and reconnaissance visits

#### 2.1.1 Lake description

Lakes were referenced according to assigned lake number and location (NZTM Easting and Northing) in the NRC lakes database. In addition, water bodies were photographed, and observations of catchment features and ease of access were noted.

#### 2.1.2 Wetland and emergent vegetation

The extent of emergent vegetation (percentage of shoreline, width of beds and depth range), plant species present, and wetlands associated with the lake were described.

Presence of pest plants were reported along with an estimate of population size.

#### 2.1.3 Submerged vegetation

A description of the submerged vegetation was carried out by divers using the lake vegetation survey method based on Clayton (1983). Divers swam perpendicular to the shore recording plant species present, their depth ranges, average and maximum heights and covers. These and other details including those required to complete LakeSPI surveys were recorded on data sheets (Figure 2-1).

1=1-25 % Cover  
2=26-50  
3=51-75  
4=76-95  
5=96-100

Profile Length  
S = <25m  
M = 25-100m  
L = >100m

☐ S  
☒ M  
☐ L

### PROFILE FIELD SHEET

Lake <i>Ristahina / Pouto</i>	Station <i>E</i>	Date <i>20-12</i>	Collector <i>RW</i>	GPS <i>2604034, 6549519</i>
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Species	Depth range (m)	Height		Cover		Station Description
		max	avg	max	avg	
<i>Ea</i>	0 - 0.3	1	1	6	6	<i>2604034</i> <i>6549519</i>
<i>Ge</i>	0 - 0.3	-	-	5	4	
<i>Ca</i>	0.2 - 4.1+	0.8	0.4	6	4	
<i>Stm</i>	0 - 0.1	1.7	1.7	1	1	
<i>NP</i>	0.8 - 1.2	0.4	0.4	2	2	
<i>PO</i>	0.8 - 3.9	1.7	1.5	6	3	
<i>NC</i>	0.2 - 4.1+	0.8	0.6	6	3	

**Additional LakeSPI Info.**

**Maximum depths**

<i>4.1+</i>	Natives ≥10%
<i>4.1+</i>	Charophyte meadows >75%
	Invasive sps. ≥10%

Native	Ratio (%)	Invasive
	<5	✓
	6-25	
	26-50	
	51-75	
	76-95	
✓	>95	

**Invasive Cover**

Occasional	<input checked="" type="checkbox"/> <10 plants
Common	<input type="checkbox"/>
Open Canopy	<input type="checkbox"/>
Partly Closed	<input type="checkbox"/>
Closed	<input type="checkbox"/> >2 x 2m

Max. depth of dive	<i>4.1</i>	Total vege Cover (%)	<i>96</i>	Visibility	<i>0.15</i>	Mussels	<i>X</i>	Koura	<i>X</i>
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**PROFILE SKETCH:**

Figure 2-1: Survey sheet. Data collection for an aquatic vegetation profile and LakeSPI assessment.



Generally, lakes were surveyed at five localities. Baseline sites were selected to be representative of the underwater vegetation and the range of plant communities present in the lake. Fewer than five sites were surveyed where lakes were small or de-vegetated. Table 2-1 shows details for the lakes surveyed in spring 2018.

**Table 2-1: Description of lakes surveyed for ecological assessment in September 2018.**

Lake name	NRC Lake No.	Lake area (ha)	NZTM Easting, Northing	Maximum depth (m)	LakeSPI survey conducted (Y/N)
Black	226	1.5	1656385E, 6038510N	19.8	Y
Kelly's	251	1.65	1661867E, 6029234N	> 2.5	N
Kelly's Pond	251A	0.04	1661320E, 6029185N	~ 4	N
Shag	221	15	1654908E 6039010N	12	Y
Greville's	295	2.6	1674139E; 6011706N	9.8	Y
Kapoi	296	1.6	1674985E, 6010755N	n/a	N
Karaka	347	11.1	1693415E, 5980559N	5.4	Y
Mokeno	356	148.3	1695174E, 5977171N	6.1	Y
Otapuiti	806	4.2	1696397E, 5975719N	n/a	N
Parawanui	297	6.47	1676581E, 6008811N	19.1	Y
Rotokawau	364	26.4	1702929E, 5976997N	13	Y
Rotopouua	348	< 5	1699531E, 590047N	~ 9	Y
Waingata	371	9	1703256E, 5976471N	9.5	N

#### 2.1.4 LakeSPI

LakeSPI (Submerged Plant Indicators) is a bio-monitoring tool used to report on the ecological condition of lakes and monitor change over time (Clayton and Edwards 2006 a & b, de Winton et al. 2012). LakeSPI surveys were carried out at selected baseline sites to record key characteristics of the vegetation structure and composition. These included measures of diversity from the presence of key

plant communities, the depth extent of vegetation and the extent that invasive weeds were represented. Following the surveys, data was entered into the NIWA LakeSPI database and used to generate three LakeSPI Indices:

- Native Condition Index – characterises the status of native vegetation within a lake. A higher score means healthier, deeper, more diverse beds of native submerged plants.
- Invasive Impact Index – captures the degree of impact from invasive weed species. Note that a higher score means more impact from exotic species, which is usually undesirable.
- LakeSPI Index – integrates scores from the other two indices and provides an overall indicator of lake ecological condition. The higher the score the better the condition.

LakeSPI indices are expressed as a percentage of their maximum potential score (adjusted for lake depth) to enable more direct comparisons of small, shallow water bodies with different lake types (e.g., larger and deeper lakes).

A full description of the vegetation features that were assessed for the LakeSPI method can be found in the technical report and user manual (Clayton and Edwards 2006a) and on the LakeSPI web-reporting website ([www.lakespi.niwa.co.nz](http://www.lakespi.niwa.co.nz)).

Note: LakeSPI should not be confused with the ‘Lake Ecological Value Assessment’ (see 2.1.9) which provides an overall assessment of indigenous biota and their habitat.

#### 2.1.5 Water birds

Habitat suitability for birds was assessed during the field visit by NRC, with bird species presence and abundance observed with binoculars. Results were compared with previous records from Ornithological Society of New Zealand (OSNZ) and DOC Species-Specific Biological Information (SSBI) surveys, with any nationally or regionally threatened species noted. The combination of scuba divers and various water craft involved in this survey was not conducive to observing water birds, with many flying away before their identity was ascertained. However, some secretive species such as the Nationally Critically endangered bittern (*Botaurus poiciloptilus*) were often disturbed and flight allowed their detection, whereas shore-based observation would probably not detect such species. A concerted effort to record bird species and abundance has been undertaken in the Northland lakes since 2015.

#### 2.1.6 Fish

Fish records for the Northland Region extracted from NIWA FBIS comprised 295 records since 1980. These records were assessed to identify lakes containing pest fish. While surveying plants communities, divers also record observations of fish but these were not specifically sampled for or quantified.

#### 2.1.7 Aquatic invertebrates

Large aquatic invertebrates such as torowai (freshwater mussels -*Echyridella menziesii*), kawai (freshwater crayfish -*Paranephrops planifrons*) and snails were noted by divers where observed during macrophyte surveys. Freshwater mussels have been identified as potentially important indicators of lake condition.

### 2.1.8 Endangered species

Estimation of population sizes were made based on presence of endangered species (de Lange et al. 2018; Forester and Townsend 2004; Dunn et al. 2018; Grainger et al. 2014; Robertson et al. 2017) and discussion of known occurrences with Department of Conservation (DOC) and NRC staff.

Recent changes to species threat rankings for species referred to in this report are shown in Table 2-2 below.

**Table 2-2: Change in threat status of species referred to in this report since the last assessment.**

Species	Common name	Current rank	Previous rank
<b>More threatened</b>			
<i>Botaurus poiciliptus</i>	Australasian bittern	Nationally Critical	Nationally Endangered
<i>Trithuria inconspicua</i>		Nationally Critical	Nationally Endangered
<i>Porzana tabuensis</i>	Spotless crane	At risk Declining	At risk Relict
<b>Less threatened</b>			
<i>Phalacrocorax varius</i>	Pied shag	At risk Recovering	Nationally Vulnerable
<i>Poliiocephalus rufopectus</i>	Dabchick	At risk Recovering	Nationally Vulnerable

Dunn et al. (2018) recommend the disestablishment of the taxon dwarf inanga (*Galaxias gracilis*) as recognised by McDowall (1967), now being recognised as land-locked stocks of inanga (*Galaxias maculatus*).

### 2.1.9 Lake Ecological Value Assessment

The rating of Lake Ecological Value uses the methodology presented in Champion and de Winton (2012).

The Lake Ecological Value Assessment is based on the following parameters:

- Habitat size.
- Buffering.
- Water quality.
- Aquatic vegetation diversity.
- Aquatic vegetation integrity.
- Endangered species.
- Presence of key species.
- Connectivity.

The higher the score, the higher the Lake Ecological Value Rating.

### 2.1.10 Impacts and threats

Biosecurity threats (current pest plant and fish impacts, potential impacts and risk of pest introduction), nutrient enrichment (nutrient sources, livestock access) and decreasing water levels were considered for impacts on ecological condition on each lake based on the surveys and discussion with landowners, NRC and DOC staff. Water quality monitoring is carried out by NRC for high ranked lakes and data are held by NRC.

### 2.1.11 Management recommendations

A monitoring strategy for each of the highest ranked lakes was reviewed and includes:

- Lake biodiversity monitoring, LakeSPI, additional assessment of nationally or regionally significant biota and assessment of any new threats to ecological condition.
- Pest plant surveillance targeting lake access and anchoring sites to detect early incursions of weed species.
- Additional routine monitoring of water quality, including measurement of all parameters required to generate the Trophic Level Index (TLI) as outlined by Burns et al. (2000).

Practical measures that could mitigate or avert threats to Northland lakes are identified where appropriate. We recommend that:

- Lakes where pests threaten lake ecology are identified alongside possible mitigation measures.
- Lakes where indicators suggest nutrient enrichment or catchment activities have (or threatens to have) significant impacts on lake ecology are identified and mitigation strategies put in place.

## 2.2 Pest plant surveillance

Annual surveillance for aquatic weeds was undertaken for seven high-risk lakes. Lakes were surveyed using scuba and snorkel, visually inspecting sites where introductions would be most likely, such as known access points and popular anchoring spots. The areas were inspected thoroughly (i.e., grid search) by scuba divers at depths where weed colonisation was likely to occur, to ensure all vegetation in the area was observed. Where large areas required surveillance, a diver was towed behind a boat to cover likely sites of colonisation.

The lake margins were walked and checked for drift of weed fragments on shore and marginal vegetation was also checked for emergent and sprawling wetland weeds both from the landward edge (where possible) and by boat.

This year surveillance was carried out by Northland Regional Council and NIWA snorkelers in Lake Humuhumu. The other surveillance lakes were monitored by other NRC contracted divers.

## 3 Results and Discussion

### 3.1 Ecological assessments and Reconnaissance visits

#### Kai Iwi and North of Dargaville

##### 3.1.1 Black Lake (Kai Iwi Lakes), NRC Lake No. 226.



**Figure 3-1: Black Lake.** Divers record submerged and emergent vegetation data in Black Lake, with regenerating forest seen in the catchment. (Photo: Susie Elcock, September 2018)

Summary	Black Lake
<b>Surveyed:</b>	September 2018.
<b>Overall ranking:</b>	<b>High:</b> A small, fully fenced lake, with extensive wetland and regenerating forest catchment, surrounded by raupo ( <i>Typha orientalis</i> ) and other emergent vegetation, with a predominantly native submerged vegetation. The lake is naturally heavily stained reducing the depth potential of submerged vegetation.
<b>Threats:</b>	Few threats as lake is on private property with limited access, despite its proximity to the Kai Iwi lakes.
<b>Management recommendations:</b>	Further monitoring including water quality and a fish survey (potential black mudfish ( <i>Neochanna diversus</i> ) habitat). Manage gambusia present in drains on the property. Undertake 5 yearly ecological monitoring.

#### Description

A small (1.5 ha) lake (1656385E, 6038510N), with a maximum depth of 19.8 m. The water was heavily stained orange/brown resulting from the dense wetland marginal vegetation, with a marked thermocline at 3 m depth. The lake was surrounded by a recently fenced wetland (0.86 ha), with over 2 ha of regenerating forest in the catchment, the remainder is grazed by cattle. Access is across private farmland, with no boat access to the lake.



**Figure 3-2: Black Lake.** Photo showing the brown-stained water, with submerged *Chara australis* and *Utricularia gibba*. (Photo: Tracey Burton 18 September 2018).

### Wetland vegetation

Raupo (*Typha orientalis*) was the dominant emergent vegetation, with associated harakeke (*Phormium tenax*), *Machaerina rubiginosa*, *Isolepis prolifera*, *Persicaria decipiens*, *Ranunculus amphitrichus* and *Isachne globosa*. This vegetation formed a complete almost 20 m band surrounding the lake, to a depth of 1.5 m. The wetland further away from the emergent vegetation was dominated by *Juncus* rushland, with four species noted including *Juncus pauciflorus*.

### Submerged vegetation

The submerged vegetation was dominated by *Chara australis* and *Nitella* sp. aff. *cristata*, both forming high covers from 1.0 to a maximum depth of 4.9 and 6.7 m respectively. *Potamogeton ochreatus* was common in the submerged vegetation, with *P. cheesemanii* also found on one profile. The invasive *Utricularia gibba* was common attached to raupo roots and sprawling over the other submerged species to a maximum depth of 3.9 m.

### LakeSPI

**Table 3-1: LakeSPI results for Black Lake.** LakeSPI Indices expressed as a percentage of lake maximum potential.

Survey Date	Status	LakeSPI %	Native Condition %	Invasive Impact %
September 2018	High	52% <div></div>	48% <div></div>	36% <div></div>

Black Lake is categorised as being in high ecological condition with a LakeSPI Index of 52%.

## Water birds

No water fowl were recorded during the visit.

## Fish

No fish including the invasive *Gambusia affinis* (abundant in the adjacent Kai Iwi lakes) were seen during the visit. Several introduced Australian golden bell frog (*Ranoidea aurea*) were observed on the lake margin.

## Aquatic invertebrates

Freshwater sponges were noted on submerged vegetation and the roots of raupo. A single leech (*Richardsonianus mauianus*) was observed on the lake margin.

## Endangered species

*Juncus pauciflorus* is rated as Nationally Vulnerable in the 2017 threat assessment (de Lange et al. 2018), and a national area occupied < 100 ha with a decline rate of 10 to 50% over ten years. This plant was the least abundant of the rushes noted at Black Lake.

## Lake Ecological Value

An ecological value rating of “12-high” was calculated for Black Lake based on the largely indigenous catchment, entire emergent fringe and submerged charophyte meadows, also including a nationally threatened species.

## Threats

Few threats are identified for Black Lake as it is situated on private property with limited access, despite its proximity to the Kai Iwi lakes. The risk of gambusia entering the lake from Lake Waikare is rated as high, with efforts to block drains between the two water bodies being supported.

## Management recommendations

Conduct fish surveys (targeting mudfish) and assessment of water quality. Manage the gambusia present in drains (either infill these and/or kill gambusia) on the property. Undertake 5 yearly ecological monitoring.



### 3.1.2 Kelly's Lake (N of Dargaville), NRC Lake No. 251.



**Figure 3-3: Kelly's Lake.** Photo showing the unfenced lake margins, with a marginal fringe of open water created by cattle trampling/browsing. (Photo: Paul Champion 17 September 2018).

Summary		Kelly's Lake
Surveyed:	2018 (reconnaissance).	
Overall ranking:	<b>Low:</b> A small, unfenced lake, with fenced wetland within a pasture catchment. The lake is surrounded by emergent vegetation, but significant submerged vegetation is lacking.	
Threats:	Lake on private property with limited access. The lake is highly nutrient enriched.	
Management recommendations:	Fencing the lake and surrounding emergent vegetation will increase the biodiversity values of the lake and potentially improve water quality. No further monitoring.	

#### Description

A small (1.65 ha) lake (1661867E, 6029234N), with a maximum depth exceeding 2.5 m. The water was turbid and impacted by a planktonic algal bloom. Situated in a pastoral catchment, the lake edges are unfenced and show signs of cattle impacts (emergent vegetation absent in water less than 1 m deep, pugging of lake margins). Access is across private farmland.

#### Wetland vegetation

Kuta (*Eleocharis sphacelata*) and raupo (*Typha orientalis*) were the dominant emergent vegetation, with associated *Machaerina articulata*, *Isolepis prolifera*, *Carex secta*, *Cyperus ustulatus* and *Persicaria decipiens*. This vegetation formed an almost complete band surrounding the lake (up to 20 m across), but there was a zone of shallow water, colonised by the introduced *Azolla pinnata* between the emergent vegetation and the shoreline, presumably due to cattle trampling and grazing of shallow (<1 m deep) emergent vegetation.



## Submerged vegetation

No submerged vegetation present. An algal bloom was present at the time of the survey.

## LakeSPI

Kelly's Lake is categorised as being non-vegetated with a LakeSPI Index of 0%.

## Water birds

A number of different species were observed at Kelly's Lake including mallard (*Anas platyrhynchos*), grey duck (*A. superciliosa*) or hybrids between these species, grey teal (*A. gracilis*) and individual bittern (*Botaurus poiciloptilus*), dabchick (*Poliiocephalus rufopectus*), little black (*Phalacrocorax sulcirostris*) and little shag (*Phalacrocorax melanoleucos*).

## Fish

No fish were observed. A large number of introduced Australian golden bell frogs (*Ranoidea aurea*) were heard and seen around the lake margins.

## Aquatic invertebrates

No aquatic invertebrates were seen during the visit.

## Endangered species

Bittern are rated as Nationally Critical in the 2016 threat assessment (Robertson et al. 2017), with an estimated national population of 250–1000 mature individuals and a predicted decline of 50–70% over ten years. This lake is unlikely to provide breeding habitat for this species but would provide food (frogs and possibly fish) and shelter in the emergent kuta and raupo.

Grey duck are also Nationally Critical, due to hybridisation with mallard duck. Five birds seen at Kelly's Lake had characters typical of grey duck. Dabchick are now classified as At risk – Recovering and little black shag are At risk - Naturally uncommon.

## Lake Ecological Value

A preliminary ecological value rating of “3-low” was assigned to Kelly's Lake based on the unfenced pasture catchment, eutrophication of the water body and lack of submerged vegetation.

## Threats

Kelly's Lake is on private property with limited access. Fencing the lake and surrounding emergent vegetation will increase the biodiversity values of the lake and potentially improve water quality.

## Management recommendations

Advocate fencing the margins of this lake to the landowner. No further monitoring.

### 3.1.3 Dune pond near Kelly's Lake (N of Dargaville), NRC Lake No. 251A.



**Figure 3-4: Dune pond near Kelly's Lake.** Photo showing the emergent vegetation fringing the pond, set in coastal scrub vegetation. (Photo: Paul Champion 17 September 2018).

Summary	Dune pond near Kelly's Lake
<b>Surveyed:</b>	2018 (reconnaissance).
<b>Overall ranking:</b>	<b>Moderate:</b> A small pond, within predominantly native dune vegetation, with an entire fringe of emergent and wetland vegetation. The lake has dense submerged charophyte dominated vegetation.
<b>Threats:</b>	Access through private property with limited access. The lake is isolated, so the risk of either invasive species introduction or nutrient enrichment is low.
<b>Management recommendations:</b>	The pond is in good condition, with no immediate threats identified. Occasional monitoring may be warranted.

#### Description

A very small (0.04 ha) pond (1661320E, 6029185N), with an estimated maximum depth of 4 m. The water was slightly brown-stained resulting from the wetland marginal vegetation. Surrounded by a wetland within coastal dune vegetation and fenced from the adjacent farmland. Access is difficult, across private farmland.

## Wetland vegetation

There was a contiguous ~ 4 m wide fringe of emergent vegetation bordering the pond, with a wetland margin outside of this. Emergent species included the dominant kuta (*Eleocharis sphacelata*) and lesser amounts of raupo (*Typha orientalis*), *Machaerina arthropphylla*, *M. juncea* and *Schoenoplectus tabernaemontani*. Other species in the wetland included *Machaerina rubiginosa*, *Isachne globosa*, *Ranunculus amphitrichus*, oioi (*Apodasmia similis*) and harakeke (*Phormium tenax*).

## Submerged vegetation

The submerged vegetation was dominated by *Nitella* sp. aff. *cristata*, both forming high covers from 1.0 to a maximum depth of 2.5 m. Other species included *Potamogeton cheesemanii*, *Myriophyllum propinquum* and the invasive *Utricularia gibba*.

## LakeSPI

No LakeSPI survey was carried out on this reconnaissance survey. However, due to the extent of charophyte meadows present in the lake, it is likely to have been classified in high condition.

## Water birds

No water fowl were recorded during the visit.

## Fish

One adult inanga (*Galaxias maculata*) was seen during the snorkel reconnaissance. The presence of this fish in the pond is puzzling as there appeared to be no connection with the adjacent tributary flowing east towards Omamari Stream.

## Aquatic invertebrates

A single leech (*Richardsonianus mauianus*) was seen during the snorkel reconnaissance.

## Endangered species

Inanga (*Galaxias maculata*) are assessed as At-Risk Declining in the 2017 threat assessment (Dunn et al. 2018), with a national area of occupancy >10 000 ha (100 km<sup>2</sup>), with a predicted decline 10–70% over ten years.

## Lake Ecological Value

An ecological value rating of “7 - Moderate” is assigned to Kelly’s dune pond based on the largely indigenous catchment, entire emergent/wetland fringe and charophyte meadows, also including an At Risk Declining species.

## Threats

Kelly’s dune pond is isolated, so the risk of either invasive species introduction or nutrient enrichment is low.

## Management recommendations

The pond is in good condition, with no immediate threats identified. Occasional monitoring may be warranted.

### 3.1.4 Shag Lake (Kai Iwi), NRC Lake No. 221.



**Figure 3-5: Shag Lake.** Photo taken from the south end of the lake showing the pastoral catchment, with Maunganui Bluff in the distance. (Photo: Tracey Burton 17 September 2018).

Summary		Shag Lake
<b>Surveyed:</b>	2001, 2010 and 2018.	
<b>Overall ranking:</b>	<b>High to Moderate:</b> A nutrient enriched lake with no significant invasive aquatic plants and submerged vegetation present at low covers to 7.4 m. Cattle have access to 85% of the lake margin and have either excluded or displaced emergent vegetation to deep water. Bullies, eels and <i>Gambusia affinis</i> present.	
<b>Threats:</b>	Poor water quality with cattle access to most of the lake. Susceptible to submerged vegetation loss. Although accessed through private land, the lake is threatened by liberation of pest fish and plants.	
<b>Management recommendations:</b>	Fencing the lake will encourage emergent species establishment, increase the biodiversity values of the lake and potentially improve water quality. Undertake 5 yearly ecological monitoring.	

#### Description

A 15 ha dune lake (1654908E 6039010N) with a maximum depth of 12 m, situated in a pasture catchment. Only ~15% of the lake margin is fenced. There was a small inflow at the south-eastern end of the lake but no outlet. Access is through private land via paddocks, boat access requires a 4-WD.

#### Wetland vegetation

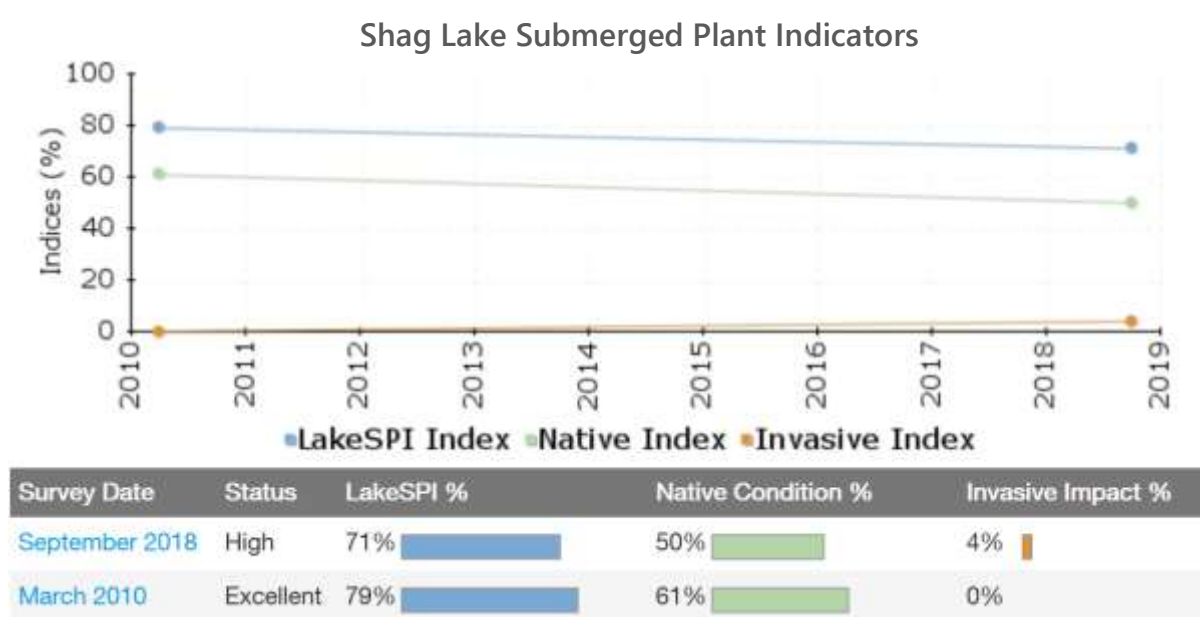
The dominant emergent species occupying <20% of the shoreline was kuta (*Eleocharis sphacelata*), which formed up to a 15 m wide band in the fenced part of the lake, but either a narrow band or absent elsewhere. In areas with cattle access, these emergent beds extended to depths of 2 m but were excluded from depths less than 1 m by cattle grazing/trampling.

## Submerged vegetation

The turf species *Glossostigma elatinoides*, *Limosella lineata* and *Myriophyllum votschii* were present in depths less than 0.7 m depth. *Chara australis*, *Nitella* sp. aff. *cristata* *Potamogeton cheesemanii* and *P. ochreatus* were the most common submerged species with maximum depth of vegetation extended to 7.4 m at one site, but no species had median average covers exceeding 5%.

Maximum depth of colonisation appears to be increasing from 4.5 m in 2001, 6.7 m in 2010 and 7.4 m in 2018, however the overall extent of submerged vegetation had declined since 2010. Low covers of submerged species were also reported in 2001, but in 2010 median overall covers of about 50% were recorded.

## LakeSPI



**Figure 3-6: LakeSPI results for Shag Lake.** LakeSPI Indices expressed as a percentage of lake maximum potential.

Shag Lake is categorised as being in high ecological condition with a LakeSPI Index of 71%. This has reduced slightly from 2010, a result of the minor invasive *Juncus bulbosus* being recorded at one site and a loss of charophyte meadows, previously found at two of the five transects in 2010. No species had median average covers exceeding 5% in the 2018 survey.

## Water birds

Poor aquatic habitat with mostly disturbed, grazed lake margins, limited emergent vegetation. The 2018 survey reported 55 black swans (*Cygnus atratus*) and 14 paradise shelduck (*Tadorna variegata*). The nationally threatened bittern (*Botaurus poiciloptilus*) and regionally important dabchick (*Poliocephalus rufopectus*) and Australasian little grebe (*Tachybaptus novaehollandiae*) were recorded in the late 1970's-1991. The lake was then regarded as an important refuge for birds disturbed from the Kai Iwi lakes when used for water skiing.



## Fish

Bullies (*Gobiomorphus cotidianus*) were observed on all sampling occasions. Eels were noted in previous surveys and NIWA FBIS reports both longfin and shortfin eels (*Anguilla dieffenbachii* and *A. australis*), bullies and the exotic *Gambusia affinis*, as present in Shag Lake.

## Aquatic invertebrates

Pea mussels (*Sphaerium novaezelandiae*) and backswimmers (*Sigara arguta*) have been recorded on all sampling occasions. Freshwater sponges were noted on submerged vegetation in 2018.

## Endangered species

Longfin eels (*Anguilla dieffenbachii*) were previously reported and are likely to still be present in the lake. This species is assessed as At-Risk Declining in the 2017 threat assessment (Dunn et al. 2018), with a national area of occupancy > 10 000 ha (100 km<sup>2</sup>), with a predicted decline 10–70% over ten years, or three generations (potentially hundreds of years in this case).

## Lake Ecological Value

An ecological value rating of “8-high to moderate” was assigned to Shag Lake based on the predominantly native submerged vegetation meadows and species diversity.

## Threats

The current lake condition is marginal for good submerged plant growth and potentially could become devegetated should water quality continue to decline. The lake is prone to nutrient enrichment and could also be threatened by liberation of pest fish and plants. The pest fish *G. affinis* is established in the lake. Access is through private land so recreational boating is not a strong pressure on this lake; introductions would be more like to come from eel fishers with contaminated nets or deliberate introduction of pest species.

## Management recommendations

Fencing off the entire lake and enhancing riparian vegetation will encourage emergent species establishment, increase the biodiversity values of the lake and potentially improve water quality. With this management, this lake could potentially improve in the short to medium term as no major weed species are present.

## Pouto Peninsula

### 3.1.5 Greville's Lagoon (Pouto), NRC Lake No. 295.



**Figure 3-7: Greville's Lagoon.** Photo from the east, showing the steep-sided fully fenced dune lake margins. (Photo: Paul Champion 17 September 2018).

Summary		Greville's Lagoon
<b>Surveyed:</b>	2005 and 2018.	
<b>Overall ranking:</b>	<b>Moderate:</b> A fully fenced lake with native submerged vegetation, but with pest plants alligator weed ( <i>Alternanthera philoxeroides</i> ) and dense areas of African feather grass ( <i>Cenchrus macrourus</i> ) impacting on the emergent zone and lake catchment.	
<b>Threats:</b>	Difficulty of access makes likelihood of pest plant introduction low, but a major impact could result should introduction occur. Catchment impacts on water quality are unlikely to change in the immediate future.	
<b>Management recommendations:</b>	No monitoring of submerged vegetation is recommended.	

### Description

This dune lake (1674139E; 6011706N) is 2.6 ha in area and 9.8 m in depth, fully fenced, with a steep-sided catchment comprised of regenerating coastal scrub and pampas, also heavily impacted by the terrestrial weed African feather grass (*Cenchrus macrourus*). Some plantings are evident on the north-west dune face (e.g., the Chatham Island *Corokia macrocarpa*). Access to the lake is across 3 km of steep private farmland and access to the lake perimeter by vehicle not possible.



**Figure 3-8: Flowerhead and plants of African feather grass (*Cenchrus macrourus*) on the margin of Greville's Lagoon.** (Photo: Paul Champion 17 September 2018).

### Wetland vegetation

Kuta (*Eleocharis sphacelata*) and raupo (*Typha orientalis*) were the dominant emergent vegetation, with associated *Schoenoplectus tabernaemontani*. This vegetation was continuous, but due to the steep-sided nature of the lake, only occupied a narrow <5 m band to 1.8 m deep apart from the inlet stream which was obstructed by a n emergent mat of these species and African feather grass. The pest plant alligator weed (*Alternanthera philoxeroides*) was abundant at the western end of the lake, forming floating mats amongst raupo.

### Submerged vegetation

No turf plants were found, with the steep lake edges failing to provide suitable habitat. Tall-growing native species *Potamogeton ochreatus* and *P. cheesemanii*, were recorded growing in low covers throughout the profiles from the fringe of emergent to a maximum of 4.3 m deep. Charophyte meadows of *Nitella* sp. aff. *cristata* and some *Chara australis* were present to 4.1 m depth. The invasive *Utricularia gibba* occurred at low covers within the emergent vegetation.

### LakeSPI

**Table 3-2: LakeSPI results for Greville's Lagoon.** LakeSPI Indices expressed as a percentage of lake maximum potential.

Survey Date	Status	LakeSPI %	Native Condition %	Invasive Impact %
September 2018	High	63% <div style="width: 63%; background-color: #4a86e8; height: 10px;"></div>	52% <div style="width: 52%; background-color: #7ed321; height: 10px;"></div>	20% <div style="width: 20%; background-color: #f19400; height: 10px;"></div>

Greville's Lagoon is categorised as being in high ecological condition with a LakeSPI Index of 63%, with well-developed native vegetation with slight impact from *U. gibba*.

### Water birds

This isolated and inaccessible lake provides good habitat for water birds, although the steep nature of the catchment reduces the extent of emergent vegetation around much of the lake. The 2018



survey recorded black swan (*Cygnus atratus*), paradise shelduck (*Tadorna variegata*), mallard (*Anas platyrhynchos*), dabchick (*Poliocephalus rufopectus*), little black shag (*Phalacrocorax sulcirostris*) and bittern (*Botaurus poiciloptilus*) from this lake. The introduced Australian golden bell frogs (*Ranoidea aurea*) were heard and seen around the lake margins.

## Fish

No fish were recorded during the survey.

## Aquatic invertebrates

No submerged invertebrates were recorded during the survey.

## Endangered species

Bittern are rated as Nationally Critical in the 2016 threat assessment (Robertson et al. 2017), with an estimated national population of 250–1000 mature individuals and a predicted decline of 50–70% over ten years.

Dabchick have been recently assessed as At Risk Recovering with a national population of 1000–5000 mature individuals or total area of occupancy  $\leq 100$  ha ( $1 \text{ km}^2$ ) and a predicted increase  $> 10\%$  and little black shag are At risk - Naturally uncommon. (Robertson et al. 2017).

## Lake Ecological Value

An ecological value rating of “7- moderate” was assigned to Greville’s Lagoon based on the predominantly native submerged vegetation and charophyte meadows, but low species diversity and buffering due to the steep nature of the catchment.

## Threats

The difficult access makes the likelihood of pest plant introduction low, but a major impact could result should introduction occur. Catchment impacts on water quality are unlikely to change in the immediate future.

## Management recommendations

The margins of Greville’s Lagoon have recently been retired from grazing and planting has been undertaken. Alligator weed is well established at this site. No regular monitoring is recommended.

### 3.1.6 Lake Kapoai (Pouto), NRC Lake No. 296.



**Figure 3-9: Lake Kapoai.** Photo showing the fenced margin with dense kikuyu (*Cenchrus clandestinus*) dominating the retired margin. (Photo: Paul Champion 18 September 2018).

Summary	Lake Kapoai
<b>Surveyed:</b>	2005, 2007 2014 and 2018 (reconnaissance).
<b>Overall ranking:</b>	<b>Low:</b> Limited submerged vegetation and marginal vegetation present. Fencing of lake margin almost complete, water quality may improve over time.
<b>Threats:</b>	High nutrient enrichment, with frequent algal blooms. Access difficult and likelihood of submerged pest plant establishment is currently low.
<b>Management recommendations:</b>	Lake native biodiversity value monitoring every 5 years. Complete fencing the lake and consider planting options around the margins. Eradicate African feather grass.

#### Description

A dune lake (1674985E, 6010755N) 1.6 ha where depth has not been determined. The lake is set within a pastoral catchment but has been recently fenced around much of the perimeter. There is an inlet at the northern end of the lake, draining approximately 2 km of pasture to the north-east. Access to the lake is across 2 km of private farmland with access through a locked gate.

#### Wetland vegetation

The emergent sedges *Schoenoplectus tabernaemontani* and kuta (*Eleocharis sphacelata*) were re-establishing on the lake margins but much of the lake margin was fringed by kikuyu (*Cenchrus clandestinus*).

Short turf communities were described as common in visits prior to 2018, with *Fimbristylis velata*, *Centipeda aotearoana* and *Alternanthera nahui* present with the amphibious *Limosella lineata*, *Myriophyllum propinquum* and *Callitriche petriei*. In 2018, lake levels were high and no turf species seen, apart from emergent mats of *Myriophyllum propinquum*.

The problem weed African feather grass (*Cenchrus macrourus*) was noted adjacent to the pump shed on the eastern side of the lake.

### Submerged vegetation

In 2018, open submerged beds of the native *Potamogeton ochreatus* and introduced *Potamogeton crispus* were common from the outer edge of the emergent species to a depth of ~3 m. Water clarity was poor with both filamentous and planktonic algal blooms evident.

No submerged vegetation was present in 2004 or 2007. In 2014 *Potamogeton ochreatus* formed submerged beds from 0.5 to 2 m deep. The lake also had algal blooms on all those sample occasions.

### LakeSPI

No LakeSPI score was generated.

### Water birds

Few birds were noted during the 2018 survey, with three black shag (*Phalacrocorax carbo*) and an individual little shag (*P. melanoleucos*) and black swan (*Cygnus atratus*).

### Fish

NIWA FBIS records from this lake include common bully (*Gobiomorphus cotidianus*), shortfin eel (*Anguilla australis*) and the pest fish rudd (*Scardinius erythrophthalmus*). There are reports of tench (*Tinca tinca*) introduced to this lake. A dead goldfish (*Carassius auratus*) was noted in 2007.

### Aquatic invertebrates

No invertebrates were recorded.

### Endangered species

Three black shag (At-risk Naturally Uncommon) were noted in 2018, probably indicating the continued presence of large coarse fish introduced into this lake. The At-risk Naturally Uncommon sedge *Fimbristylis velata* was previously common in the exposed lake-shore turf but no habitat for this plant was present in 2018.

### Lake Ecological Value

An ecological value rating of “4- moderate” was assigned to Lake Kapoai based on the highly enriched nutrient status, poor wetland and emergent buffering and poor species diversity. However, there are signs of improvement as fencing has permitted natural regeneration of some emergent species and submerged plants were recorded for the first time in 2014.

### Threats

Access difficulty and likelihood of submerged pest plant establishment is currently low. Elevated levels of nutrients remain the highest threat to Lake Kapoai.

### Management recommendations

Lake native biodiversity value monitoring every 5 years. Complete lake fencing and consider planting options around the margins. Advocate eradication of African feather grass to the landowner before it spreads further.

### 3.1.7 Lake Karaka (Pouto), NRC Lake No. 347.



**Figure 3-10: Lake Karaka.** Photo taken from the tall pasture covered dunes to the east of the lake. (Photo: Tracey Burton 20 September 2018).

Summary Lake Karaka	
<b>Surveyed:</b>	2005, 2007, 2012, 2015 and 2018.
<b>Overall ranking:</b>	<b>Outstanding:</b> A lake with an indigenous vegetation (no <i>U. gibba</i> ) and fauna, much of the margin surrounded by wetland with nationally endangered plants, fish and birds present.
<b>Threats:</b>	Isolation and difficulty of access through private farmland make likelihood of pest introduction low, but a major impact could result should introduction occur. Water quality is currently poor with submerged vegetation collapse occurring in May 2015. Water quality is likely to be impacted by cattle access, farming intensification and forest harvesting within the catchment.
<b>Management recommendations:</b>	Infrequent pest plant surveillance and lake ecological assessment (5 years). Recommend fencing of the eastern margin to exclude cattle. A consideration of nutrient sources might reveal why this lake is so enriched and inform possible mitigation measures.

### Description

This dune lake (1693415E, 5980559N) is 11.1 ha in size and 5.4 m deep with an undulating bottom. It is one of the lakes situated on the south-western Pouto Peninsula between consolidated dunes to the east and mobile dunes to the west. The immediate catchment is pastoral (25%), and flax/sedge/raupo wetlands (75%) extend to the north and south of the lake, linking it with other water bodies with mobile sand dunes at the western end. There are no inflow or outflow streams. Access is difficult through forestry roads and rough pasture over consolidated dunes. The lake has 4-WD access only, with difficult boat access.

## Wetland vegetation

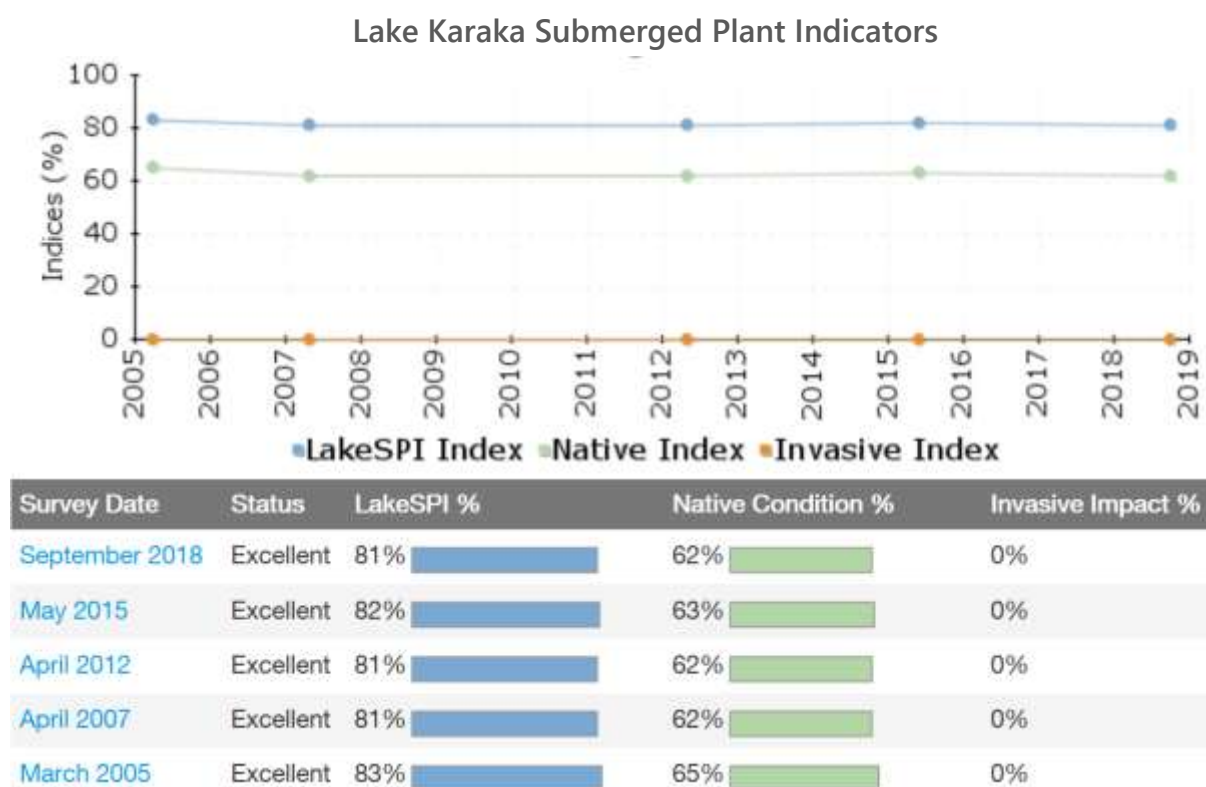
Emergent species encircle most of the lake, except the margin bordered by pasture and open to cattle grazing. *Typha orientalis* and *Machaerina articulata* dominated. These extended over a 20 m wide band in most areas growing to depths of 1.5 m. Other emergent species seen included *Apodasmia similis*, *Carex maorica*, *Carex secta*, *Cyperus ustulatus*, *Eleocharis acuta*, *Isachne globosa*, *Isolepis prolifera*, *Juncus pallidus*, *Machaerina arthropphylla*, *M. juncea*, *Schoenoplectus tabernaemontani*, flax and cabbage trees. The fern *Thelypteris confluens* was common amongst the *M. juncea* vegetation.

## Submerged vegetation

Only native vegetation was recorded in this lake. In 2018, the dominant species was *Chara australis*, which grew to a maximum depth of 2.4 m, in meadows up to 1.5 m tall. Another charophytes, *C. globularis* was recorded in the lake for the first time. The vascular species *Myriophyllum triphyllum* and *Potamogeton cheesemanii* were locally abundant, with lesser amounts of *P. ochreatus*.

The submerged vegetation had recovered from a partial vegetation collapse in 2015, most likely resulting from shading by dense algal blooms.

## LakeSPI



**Figure 3-11: LakeSPI results for Lake Karaka.** LakeSPI Indices expressed as a percentage of lake maximum potential.

Lake Karaka is categorised as being in excellent ecological condition with a LakeSPI Index of 81%.

## Water birds

The extensive wetland areas provide outstanding habitat for water birds. Dabchick (*Poliiocephalus rufopectus*), little black shag (*Phalacrocorax sulcirostris*), scaup (*Aythya novaeseelandiae*), paradise shelduck (*Tadorna variegata*), pukeko (*Porphyrio melanotus*) and black swan (*Cygnus atratus*) were seen in 2018. Other threatened species previously reported included bittern (*Botaurus poiciloptilus*), banded rail (*Rallus philippensis assimilis*) and spotless crane (*Porzana tabuensis plumbea*).

## Fish

Common bully (*Gobiomorphus cotidianus*) were very common, with most specimens having swollen abdomens indicative of an infestation of endoparasitic cestode or trematode species. Both longfin and shortfin eels (*Anguilla dieffenbachii* and *A. australis*) and inanga (*Galaxias maculatus*) are reported from this lake and several eels were seen during most surveys, including 2018. Giant kokopu (*Galaxias argenteus*) have been collected from Lake Karaka (T. Birch, DOC pers. comm.).

## Aquatic invertebrates

Snail feeding native leeches were noted in 2018. The native snail *Potamopyrgus antipodarum* was recorded from one profile in 2015.

## Endangered species

The At risk – Declining longfin eel (*Anguilla dieffenbachii*), inanga (*Galaxias maculatus*) and giant kokopu (*Galaxias argenteus*) have all been recorded from Lake Karaka. The At risk Naturally Uncommon *Theypteris confluens* was common, growing amongst emergent *Machaerina juncea* at the water's edge. Threatened birds seen in 2018 included At risk: Recovering dabchick and At Risk Naturally Uncommon little black shag.

## Lake Ecological Value

An ecological value rating of “13- outstanding” was assigned to Lake Karaka with an increase in aquatic vegetation diversity score. However, it appears the lake water quality is declining and trending towards super-trophic, and although submerged vegetation has re-established since 2015, further collapses may occur in the future.

## Threats

Relative isolation and difficulty of access makes risk of introduction of pest species low. However, should these be introduced they would displace or significantly impact indigenous biota. Nutrient enrichment from land management in the catchment (or of the aquifer) may be the cause of algal blooms and low water clarity noted. Decline of charophytes in 2015 is indicative of the lake being close to flipping from a clear water macrophyte dominated state to a turbid planktonic algal dominated state.

## Management recommendations

Lake native biodiversity value monitoring and pest plant surveillance are recommended every 5 years. Consideration of nutrient sources might reveal why this lake is so eutrophic and mitigations measures might be self-evident. Advocate fencing off the eastern shoreline to prevent cattle access to the lake. Information on seasonality of plant condition and water clarity would inform potential management actions.



### 3.1.8 Lake Mokeno (Pouto), NRC Lake No. 356.



**Figure 3-12: Lake Mokeno.** Photo taken from the northern end of the lake. (Photo: Tracey Burton 20 September 2018).

Summary Lake Mokeno	
<b>Surveyed:</b>	2005, 2007, 2012, 2015, 2016 and 2018.
<b>Overall ranking:</b>	<b>High:</b> A large lake set in a wetland / scrub / dune complex covering the south-western Pouto Peninsula, which contains nationally significant populations of endangered biota. Formerly with an intact native submerged vegetation, but prolonged poor water clarity has led to vegetation decline. Since 2016, submerged vegetation appears to be re-establishing.
<b>Threats:</b>	Nutrient inputs from land use in the catchment has led to an enriched (supertrophic) water quality causing algal blooms and loss of most submerged vegetation. Submerged weed invasion is unlikely due to the lakes isolation and poor water clarity. Royal fern ( <i>Osmunda regalis</i> ) is present in the surrounding vegetation and poses a severe threat to the wetlands surrounding this lake and elsewhere in the region.
<b>Management recommendations:</b>	Determine the drivers of poor water quality and consider remedial actions. A nutrient budget is recommended. Algal blooms indicate nutrient threat to ecological condition. Ensure royal fern management continues to mitigate its impact on marginal vegetation. Five yearly surveillance for pest plants and lake native biodiversity value monitoring.

### Description

Lake Mokeno (1695174E, 5977171N) is a dune lake 148.3 ha in area with a 6.1 m maximum recorded lake depth. The catchment is mostly kanuka scrub adjacent to pine plantation forestry, with large areas of wetland and some unconsolidated dunes on the western margin. There are no inflow or outflow streams, but it appears that water flows south from the lake towards Lakes Otapuiti and Whakaneke, eventually discharging to the entrance to Kaipara Harbour via an extensive wetland.

Access to the northern end of the lake is through forestry and Māori land (7 km of well-formed tracks) requiring access through a locked gate. Small boats can be launched with difficulty using a 4-WD.

### Wetland vegetation

The lake was surrounded by extensive beds of emergent species up to 20 m across and extending from the lake edge to 2 m deep. Species included *Typha orientalis*, *Eleocharis sphacelata*, *E. acuta*, *Machaerina articulata*, *M. arthropphylla*, *M. rubiginosa*, *M. juncea*, *Schoenoplectus tabernaemontani*, *Carex secta* and *Phormium tenax*. This vegetation merged into a manuka (*Leptospermum scoparium*) / flax (*P. tenax*) wetland zone around much of the lake. At the south east end of the lake a distinctive *C. secta* / *M. arthropphylla* / *Thelypteris confluens* wetland was noted. *Thelypteris confluens* was also found on the lakeward edges of flax and *C. secta* tussocks. The invasive royal fern (*Osmunda regalis*) is presently being managed at the northern end of Lake Mokeno by DOC. This species poses a severe threat to the wetlands surrounding this lake and elsewhere in the region.

### Submerged vegetation

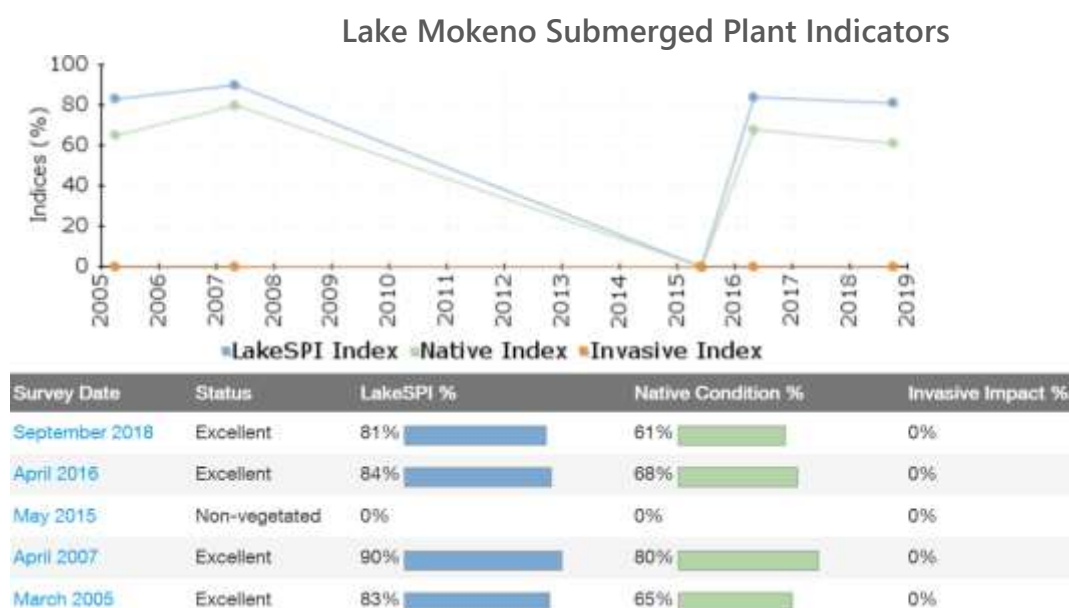
Only native submerged vegetation has been recorded in Lake Mokeno. In 2005 and 2007, the lake had clear water and was 100% vegetated with a charophyte meadows recorded to 6 m deep. In 2012, water clarity was poor with a dense algal boom and the deep charophytes were rotting in situ. In 2015 submerged plants were present but only within a few metres of the edge of the emergent vegetation, to a maximum depth of 2.5 m, and at average covers less than 10%.

In 2016, partial recovery was evident, the vegetated depth range had extended to a maximum depth of 4.2 m at covers between 10 and 20%. *Chara australis* was the most common submerged plant with lesser amounts of *Potamogeton ochreatus*, *Chara globularis* and *Myriophyllum triphyllum*.

In 2018, the submerged vegetation was variable in cover, with *C. australis* the dominant species with maximum covers greater than 50% and the deepest vegetation (*P. ochreatus*) was recorded at 3.1 m.



## LakeSPI



**Figure 3-13: LakeSPI results for Lake Mokeno.** LakeSPI Indices expressed as a percentage of lake maximum potential.

Lake Mokeno is categorised as being in excellent ecological condition with a LakeSPI Index of 81%, one of the highest LakeSPI indices recorded for the Northland lakes.

High LakeSPI scores recorded for the lake in 2005 and 2007 reflected the quality of native submerged vegetation in Lake Mokeno and lack of any invasive species. A LakeSPI survey planned for April 2012 could not be carried out due to very poor clarity and a dense algal bloom but was likely to still be high as grab samples confirmed charophyte meadows were still present beyond a depth of 5.3 m, although noted as rotting in situ. Plant collapse followed at some point after that survey and an absence of submerged plants resulted in a LakeSPI Index of zero in 2015. In 2016, the LakeSPI status had returned to excellent. In 2018, charophyte meadows were only present in two of the five profiles (present at all five sites in 2016), growing to slightly lower overall maximum depths.

## Water birds

The indigenous scrub, wetland and emergent margins provide excellent water bird habitat reflected in the large number of species reported from this lake and seen during the field visit. Bittern (*Botaurus poiciloptilus*), dabchick (*Poliiocephalus rufopectus*), mallard duck (*Anas platyrhynchos*), grey teal (*Anas gracilis*), scaup (*Aythya novaezeelandiae*), black swan (*Cygnus atratus*), little black (*Phalacrocorax sulcirostris*) and little shag (*Phalacrocorax melanoleucos*) were noted in 2018. Other threatened species reported include banded rail (*Rallus philippensis assimilis*), spotless crake (*Porzana tabuensis plumbea*), and formerly the critically endangered brown teal (*Anas aucklandica chlorotis*) were also recorded in this area.

## Fish

The lake represents good habitat, with fish access to the sea. Species recorded were common bully (*Gobiomorphus cotidianus*), inanga (*Galaxias maculatus*), smelt (*Retropinna retropinna*) and shortfin eel (*Anguilla australis*). Longfin eel (*Anguilla dieffenbachii*) were also reported in Lake Mokeno by

Rowe and Chisnall (1997). A possible sighting of grey mullet (*Mugil cephalus*) was made during the 2012 visit, which, if confirmed, would indicate temporary connection of Lake Mokeno to the sea during high water events.

### Aquatic invertebrates

No living freshwater mussels (*Echyridella menziesii*) have been found since 2015. Mussels were previously common and introduced freshwater jellyfish (*Craspedacusta sowerbyi*) were also noted in previous surveys.

### Endangered species

The At risk Declining longfin eel (*Anguilla dieffenbachii*) and inanga (*Galaxias maculatus*) have been recorded from Lake Mokeno. The At risk Naturally Uncommon *Thelypteris confluens* was common, growing amongst emergent species at the water's edge and in the wetland to the south of the lake, with Pouto being the national stronghold of this species. Threatened birds noted in 2018 included the Nationally Critically Endangered Australasian bittern, At risk Recovering dabchick and At risk Naturally Uncommon little black shag.

### Lake Ecological Value

The Lake Ecological Value score for 2018 is 11 (rated High). This score has improved from 2015 (score of 9, High-Moderate rating) where submerged vegetation had collapsed but is lower than the Outstanding rating assigned in 2007 and 2005.

### Threats

The catchment is well buffered by an extensive wetland, but water quality and observations of algal blooms indicate nutrient enrichment from land use or climatic factors influence the catchment.

No pest plant or fish impacts are evident and the likelihood of introduction of freshwater pests are low. However, royal fern (*Osmunda regalis*) could invade large areas of the wetland fringe.

### Management recommendations

Algal blooms had severely reduced in-water ecological values in this lake, so analysis of water quality monitoring and investigation of ground water nutrient fluctuations is required to determine the nutrient sources and the potential to mitigate these. The partial recovery since 2016 is encouraging. Ensure royal fern management continues to mitigate its impact on marginal vegetation.

It is recommended that lake native biodiversity value monitoring and pest plant surveillance is undertaken every five years.

### 3.1.9 Lake Otapuiti (Pouto), NRC Lake No. 806.



**Figure 3-14: Lake Otapuiti.** Photo taken from the eastern shore, with dense emergent band of kuta (*Eleocharis sphacelata*). (Photo: Paul Champion 20 September 2018).

Summary		Lake Otapuiti
Surveyed:	2018 (reconnaissance).	
Overall ranking:	<b>Moderate:</b> A lake set in a wetland / scrub / dune complex covering the south-western Pouto Peninsula, which contains nationally significant populations of endangered biota. Submerged vegetation was lacking.	
Threats:	Isolation and difficulty of access make the likelihood of pest introduction low. Water quality appeared poor with no submerged vegetation apparent.	
Management recommendations:	No further monitoring.	

#### Description

A 4.2 ha dune lake (1696397E 5975719N) with an undetermined maximum depth, situated in a coastal scrub catchment, with an extensive wetland margin extending from the south-eastern margin of Lake Mokeno. Access is very difficult, through manuka scrub and wetland vegetation, with no boat access.

#### Wetland vegetation

The dominant emergent species was kuta (*Eleocharis sphacelata*), which formed a 25 m wide zone, extending to depths of 2 m, with occasional raupo (*Typha orientalis*) and rare invasive *Utricularia gibba*. Surrounding this emergent zone was a diverse wetland with *Carex secta*, *Machaerina articulata*, *M. juncea*, *M. arthropphylla*, *M. rubiginosa*, manuka (*Leptospermum scoparium*), harakeke (*Phormium tenax*), ti kouka (*Cordyline australis*), *Thelypteris confluens*, *Isachne globosa* and *Hydrocotyle pterocarpa*.



**Figure 3-15: Wetland and emergent vegetation on the margin of Lake Otapuiti.** (Photo: Paul Champion 20 September 2018)

### Submerged vegetation

No submerged vegetation was observed.

### LakeSPI

Lake Otapuiti is categorised as being non-vegetated with a LakeSPI Index of 0%.

### Water birds

Excellent bird habitat, although only four black swans (*Cygnus atratus*) were seen in 2018.

### Fish

No fish were seen in 2018.

### Aquatic invertebrates

No aquatic invertebrates were seen in 2018.

### Endangered species

The At risk Naturally Uncommon marsh fern (*Thelypteris confluent*) was common, growing in the wetland.

### Lake Ecological Value

A preliminary ecological value rating of “7-moderate” was assigned to Lake Otapuiti based on the largely indigenous catchment and entire emergent vegetation fringe including an At risk endangered species. However, submerged vegetation was lacking, similar to the adjacent Lake Whakaneke.

### Threats

Isolation and difficulty of access make the likelihood of pest introduction low. Water quality appeared poor with no submerged vegetation apparent.

### Management recommendations

No further monitoring is advocated.

### 3.1.10 Lake Parawanui (Pouto), NRC Lake No. 297.



**Figure 3-16: Lake Parawanui.** Photo from Southern end of lake showing the fenced pasture margins and re-establishing marginal vegetation. (Photo: Tracey Burton 18 September 2018).

Summary Lake Parawanui	
<b>Surveyed:</b>	2001, 2016 and 2018.
<b>Overall ranking:</b>	<b>Moderate:</b> A degraded lake, with poor water quality, but fencing has prevented grazing from most of the lake margins permitting the re-establishment of an emergent vegetation band around the lake. Submerged vegetation appears to be well established around the margins despite the presence of pest fish.
<b>Threats:</b>	Pest fish (rudd, koi carp, orfe) have been introduced into this lake. Nutrient enrichment and algal blooms continuing despite fencing. The lake is fished for eels providing an introduction pathway for additional pest fish and pest plants.
<b>Management recommendations:</b>	Advocate the establishment of wetlands to mitigate impacts of the nutrients transported to the lake from the inlet. Advocate the closing of this lake to eel fishing. Five yearly surveillance for pest plants and lake native biodiversity value monitoring.

### Description

Lake Parawanui (1676581E, 6008811N) is a relatively steep sided dune lake 6.47 ha in area with a 19.1 m maximum recorded depth. The catchment is pasture with grazing excluded by the fenced lake margin. There are two inflows, the largest entering the eastern bay at the southern end of the lake draining from approximately 1 km to the east. There is no outlet. Access is through 1 km of private farmland, mostly on well-formed tracks. Small boats can be launched from parts of the shore with a 4-WD.

### Wetland vegetation

In 2001, emergent vegetation was sparse (5%) with *Schoenoplectus tabernaemontani* the dominant species. Since that time fencing has allowed the development of an almost entire dense margin of emergent species including *S. tabernaemontani*, *Apodasmia similis*, *Eleocharis sphacelata*, *Machaerina juncea* and *Juncus pallidus*. Floating rafts of alligator weed (*Alternanthera philoxeroides*)



were noted spreading out from the lake edge in 2018. This showed the heavy browsing by the biocontrol agent *Agasicles hygrophila* seen in 2016 only provided temporary control (Figure 3-17). The turf community lining the southern margin of the lake, previously reported as containing the locally rare *Fimbristylis velata*, was submerged during the 2018 survey and this plant was not recorded.



**Figure 3-17: Alligator weed on the margin of Lake Parawanui.** Photo on left shows Alligator weed in autumn 2016 (defoliated by alligator weed flea beetle) and on right, in spring 2018 (healthy). (Photos: Paul Champion March 2016 and September 2018).

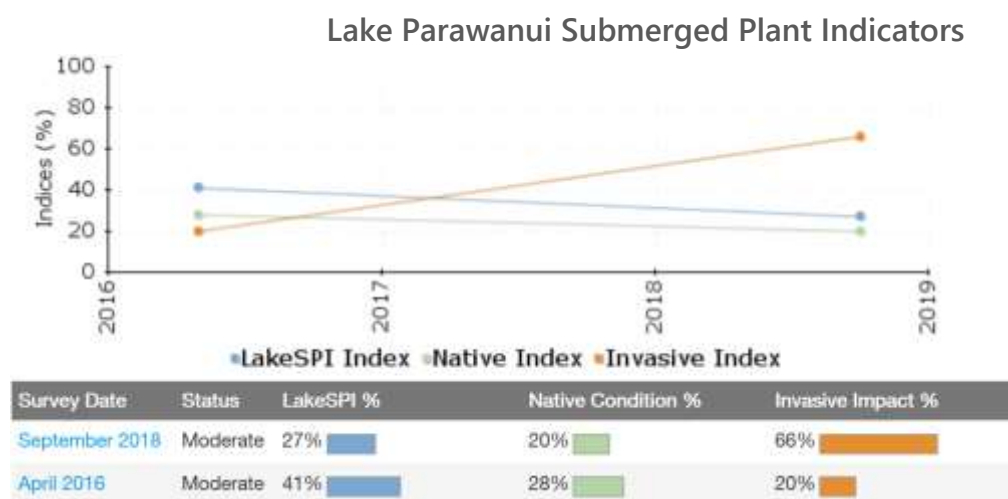
### Submerged vegetation

The submerged vegetation was dominated by the introduced weed *Potamogeton crispus* in 2018 forming high covers (median covers up to 50%) from 0.5 to 3.8 m. Native species were *Myriophyllum triphyllum* and *Potamogeton ochreatus*, with the latter species growing to 4.3 m, the maximum depth of submerged plants. No charophytes were recorded.

In 2016, the submerged vegetation was predominantly native with *Myriophyllum triphyllum*, *Potamogeton ochreatus* and *Chara australis* (to 3.5 m deep) the most common. The introduced *P. crispus* was also present.

The only vegetation present in 2001 was the introduced weed *P. crispus*, present at low covers from 0.2 to 2.4 m depth.

### LakeSPI



**Figure 3-18: LakeSPI results for Lake Parawanui.** LakeSPI Indices expressed as a percentage of lake maximum potential.

Lake Parawanui is categorised as being in moderate ecological condition with a LakeSPI Index of 27%.

Survey data from 2001 (not shown above) generated a LakeSPI score of zero as plant covers were below the minimum threshold for LakeSPI.

In 2016, several of the profiles had dense plant growths to 3.5 m. Lake Parawanui was categorised as being in moderate condition with a LakeSPI Index of 41%. The decline from 41% in 2016 to 27% in 2018 is likely to be a consequence of greater abundance of the invasive *Potamogeton crispus*, predominantly with maximum biomass produced in winter and spring, before declining during summer. However, continued input of nutrient rich inflows and possible extinction of freshwater mussels may also be related to this decline.

### Water birds

In 2018, 37 black swans (*Cygnus atratus*) and smaller numbers of mallard (*Anas platyrhynchos*) and paradise shelduck (*Tadorna variegata*) were seen. Chicks of mallard and paradise shelduck were noted. Dabchick and three species of shag (*Phalacrocorax carbo*, *P. varius* and *P. sulcirostris*) were also recorded. A bittern (*Botaurus poiciloptilus*) was noted flying over the lake.

### Fish

The pest fish rudd (*Scardinius erythrophthalmus*), koi carp (*Cyprinus carpio*) and orfe (*Leuciscus idus*) were reported as liberated into Lake Parawanui. NIWA FBIS records include shortfin eel (*Anguilla australis*), common bully (*Gobiomorphus cotidianus*) and rudd caught in this lake. A shortfin eel was noted in 2018.

### Aquatic invertebrates

Abundant freshwater mussels (*Echyridella menziesii*) were noted in surveys prior to 2018, but only empty shells were noted during the recent visit from one site (out from pump house).

### Endangered species

No threatened plant species were noted in 2018, but in previous surveys At-risk Declining freshwater mussels and the 'At risk' Naturally Uncommon sedge *Fimbristylis velata* were recorded. Threatened birds included bittern (National Critical), pied shag (At risk Declining), dabchick (At risk Recovering), black and little black shag (both At risk Naturally Uncommon).

### Lake Ecological Value

An ecological value rating of "6- moderate" was assigned to Lake Parawanui with a decrease in endangered species and loss of mussels affecting this score. It appears lake water quality is declining in Lake Parawanui. In 2016, the lake had an ecological value rating of 8 (High-Moderate), improving from the previous rating of Moderate to Low in 2001. This improvement reflected the increase in native emergent and submerged vegetation, likely a result of livestock exclusion. In 1988, seven submerged species were present, with beds of *P. ochreatus* and *Nitella* sp. aff. *cristata* extending to 5.5 and 8 m water depth respectively.

### Threats

It appears likely that coarse or pest fish have been deliberately stocked in this lake. Possibly a combination of this and nutrient run-off from the steep pasture catchment has resulted in nutrient



enrichment, algal blooms and a decline in submerged vegetation as well as the recent loss of freshwater mussels. Further pest plant or fish introductions are unlikely unless these are introduced by fishing activities, with eel fishing still permitted by the landowners.

### Management recommendations

Poor water quality remains a concern and continuation of restoration initiatives are advocated, especially the interception of nutrients from inflows, possibly by planting wetlands. The risk of new pests through contaminated fyke nets used for eel fishing is high and the recommendation to close this lake to eel fishing should be advocated to the landowner. Five-yearly monitoring is recommended.

### 3.1.11 Lake Rotokawau (Pouto), NRC Lake No. 364.



**Figure 3-19: Lake Rotokawau.** Photo from entry point on western margin looking over at a line of pine trees on the northern margin. (Photo: Tracey Burton 19 September 2018).

Summary Lake Rotokawau	
<b>Surveyed:</b>	2001, 2005, 2007, 2012, 2015 and 2018.
<b>Overall ranking:</b>	<b>Outstanding:</b> All submerged vegetation has declined significantly since 2015, charophyte meadows were absent and only low covers were recorded in depths greater than 0.6 m. This includes the continued decline of the invasive weed <i>Egeria densa</i> since 2007. These changes indicate a major deterioration in water quality. However, an outstanding ranking is maintained, as the lake still supports extensive turf communities dominated by the Nationally Critical <i>Trithuria inconspicua</i> and extensive beds of freshwater mussels.
<b>Threats:</b>	Presumably eel fishing nets were the mode of introduction of egeria and pose a threat for future introductions of pest species. Water quality has declined since 2015, with nutrient enrichment most likely relating to farming activities in the catchment. This deterioration could potentially lead to the loss of submerged vegetation, including the last Pouto population of <i>Trithuria inconspicua</i> .
<b>Management recommendations:</b>	Understanding the drivers for the water quality decline is critical to sustaining the outstanding ecology of this lake. Mitigating water quality deterioration in the lake should take priority over the planned management of <i>Egeria densa</i> in Lake Rotokawau. Lake ecological assessment should be carried out every 3 years.

### Description

This dune lake (1702929E 5976997N) is 26.4 ha in size and 13 m deep. A water sample taken from this lake in 2015 and analysed for chloride ion concentration showed a much lower value than concentrations for lakes Kanono, Humuhumu and Mokeno. Based on this Dr Max Gibbs (NIWA) surmised the lake is likely to be perched, rather than linked to surrounding lakes by a regional

aquifer. This is corroborated by an elevation assessment by Andrew Macdonald (NRC) showing this lake is an additional 10 m above Lakes Kanono and Humuhumu. The catchment is pastoral, with plantation pine and shrub land. Access is across private farmland, requiring 4-WD.

### Wetland vegetation

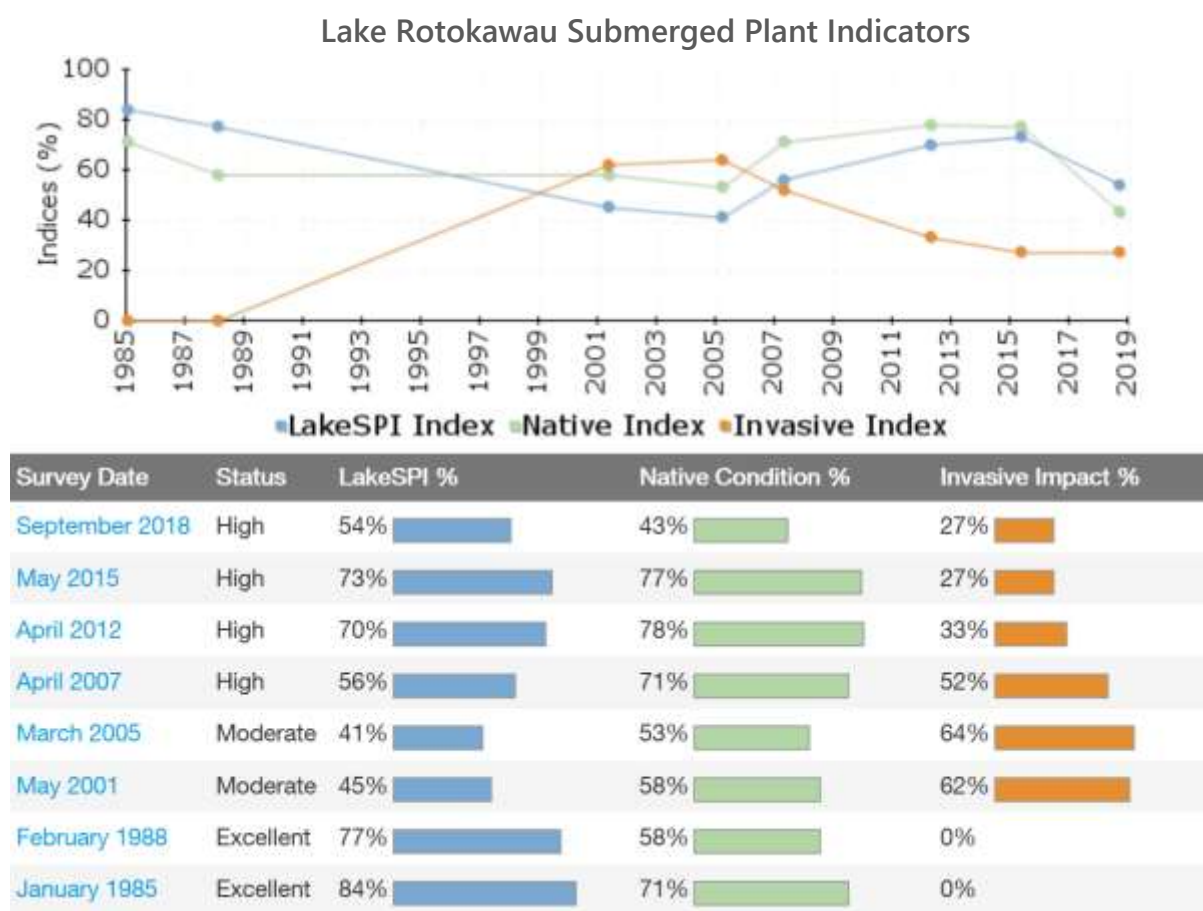
Pockets of emergent species on soft shores occupied 15% of the lake margin. Dominant species included *Schoenoplectus tabernaemontani*, *Machaerina articulata*, *M. arthropphylla*, *M. juncea*, *Eleocharis acuta*, *Eleocharis sphacelata*, *Isolepis prolifera*, *Typha orientalis* and *Apodasmia similis*. The sheltered northern arm of this lake has a well-developed wetland fringe with many of these species present. *Sphagnum falciculatum* was noted as an understory in 2018. High water levels in 2018 had flooded the normally exposed turf communities. Occasional plants of the pest plant royal fern (*Osmunda regalis*) have been recorded (and removed) from the lake margin on all surveys since 2010.

### Submerged vegetation

Turf communities were well developed with *Lilaeopsis novae-zelandiae* and the nationally threatened *Trithuria inconspicua* co-dominants, also including the regionally significant *Myriophyllum votschii* and *M. propinquum*, *Glossostigma elatinoides* and the charophytes *Nitella pseudoflabellata* and *Chara fibrosa*, all growing to a maximum depth of 0.6 m. Below this depth, submerged vegetation was sparse with median covers of 3% (maximum cover 5%). Only two species were recorded, the native *Potamogeton ochreatus* present at all transects to a maximum depth of 5.7 m and the introduced pest species *Egeria densa*, present at two of the five transects to a maximum depth of 3 m.

In 2015, tall-growing native species, *Potamogeton cheesemanii* and *P. ochreatus* were common. The introduced pest species *Egeria densa*, with lesser amounts of *Elodea canadensis*, were widespread but were having little impact on native vegetation. Charophytes were the dominant vegetation in much of the lake with *Chara fibrosa* and *Chara australis* the most abundant species and grew across the bottom of the lake to 10.4 m depth in the deepest basin.

## LakeSPI



**Figure 3-20: LakeSPI results for Lake Rotokawau.** LakeSPI Indices expressed as a percentage of lake maximum potential.

Lake Rotokawau is categorised as being in high ecological condition with a LakeSPI Index of 54%. LakeSPI had declined from 73% in 2015, reflecting a large decrease in the Native Condition Index, from 77% in 2015 to 43% in 2018 (Figure 3-20). With no further increase in the Invasive Impact Index, LakeSPI scores had declined as a result of water quality issues and not further invasive impact.

Prior to the 2018 survey, the LakeSPI index had continued to improve from 2005 to 2015 as a result of a reduction in the invasive impact scores. In 2015, *Egeria densa* and *U. gibba* did not exceed a 10% cover at any of the baseline sites, but improved water clarity (greater than 5 m during the 2012 and 2015 surveys) contributed to the expansion of native charophyte meadows down to >10 m.

## Water birds

Limited marginal vegetation provides restricted cover for resident water birds. Birds observed in 2018 included bittern (*Botaurus poiciloptilus*), dabchick (*Poliocephalus rufopectus*), shoveller (*Anas rhynchos*), mallard (*A. platyrhynchos*), grey duck (*A. superciliosa*) and/or their hybrids, paradise shelduck (*Tadorna variegata*), black swan (*Cygnus atratus*) and little black shag (*Phalacrocorax sulcirostris*). In 2012, a pair of Cape Barren geese (*Cereopsis novaehollandiae*) were seen at Lake Rotokawau.

## Fish

Good habitat for fish. Common bully (*Gobiomorphus cotidianus*) and inanga (*Galaxias maculatus*) have been observed in this lake, with NIWA FBIS records of these species and also shortfin eel (*Anguilla australis*).

The recent threatened species assessment (Dunn et al. 2018) recommend the disestablishment of the taxon dwarf inanga (*Galaxias gracilis*) as recognised by McDowall (1967), now being recognised as land-locked stocks of inanga (*Galaxias maculatus*).

## Aquatic invertebrates

Freshwater mussels (*Echyridella menziesii*) were abundant in the 2018 survey (Figure 3-21). Leeches (*Richardsonianus mauianus*), and *Potamopyrgus antipodarum* snails were noted in some surveys but not in 2018.



**Figure 3-21: Freshwater mussels in Lake Rotokawau.** (Photo: Tracey Burton, 19 September 2018).

## Endangered species

Lake Rotokawau supports possibly the last population of the Nationally Critical *Trithuria inconspicua* on the Pouto Peninsula and one of the largest populations in Northland. The At risk Declining freshwater mussels (*Echyridella menziesii*) and inanga (*Galaxias maculatus*) were both commonly found in Lake Rotokawau. Threatened birds seen in 2015 included the Nationally Critically Endangered grey duck and Australasian bittern and At risk Recovering dabchick, At risk Naturally Uncommon little black shag and Coloniser Australasian little grebe.

## Lake Ecological Value

An ecological value rating of “13- outstanding” was assigned to Lake Rotokawau, with a decrease in native LakeSPI scores and declining water quality and corresponding loss of deep water vegetation compared to the higher ecological value scores from 2012 and 2015.

## Threats

Although the hornwort risk has been eliminated from the adjacent Lake Swan, the mechanism for invasive species introduction via eel fishing nets, remains.

Of the utmost concern is the apparent collapse of submerged vegetation. Water quality has declined since 2015, with nutrient enrichment and algal blooms most likely relating to farming activities in the catchment. A paddock adjacent to the lake was devegetated at the time of the 2018 survey (Figure 3-22) and fertiliser application may have contributed additional nutrients to Lake Rotokawau (L. Forester, NRC, pers. comm.).



**Figure 3-22: Paddock adjacent to Lake Rotokawau (to the north (right)).** Run off from the bare earth is likely to run into the lake, contributing to phosphorus loading and stimulating algal blooms. (Photo: Paul Champion 19 September 2018).

Livestock access to parts of this lake could also affect water quality through direct nutrient addition, and damage to emergent and wetland vegetation that currently buffer the northern part of the lake from land-based nutrient sources.

### Management recommendations

Difficult access to the lake across farm land (and requiring permission) reduces the risk of weed incursions so annual weed surveillance monitoring has been suspended.

Understanding the drivers for the water quality decline is critical to sustaining the outstanding ecology of this lake. Mitigating water quality deterioration in the lake should take priority over the planned management of *Egeria densa* in Lake Rotokawau. Lake ecological assessment should be carried out every 3 years.



### 3.1.12 Lake Rotopouua (Pouto), NRC Lake No. 348.



**Figure 3-23: Lake Rotopouua.** Photo showing the pasture catchment to the east (foreground) with native scrub and pine forest to the east. (Photo: Tracey Burton 21 September 2018).

Summary Lake Rotopouua	
<b>Surveyed:</b>	2008, 2012 and 2018.
<b>Overall ranking:</b>	<b>High:</b> a small dammed lake with a well buffered margin and well developed submerged vegetation community, with minor invasive species impact.
<b>Threats:</b>	The restricted access to this lake reduces the threat of introduction of pest plants. Water quality continues to be poorer than expected, considering the intact submerged vegetation present in the lake. Several extensive pugged wetland areas were noted on the northern side of the lake that would contribute to deteriorating water quality.
<b>Management recommendations:</b>	5 yearly assessment of lake native biodiversity value is recommended. Analysis of nutrient sources to the lake would allow mitigation of ongoing eutrophication. Fencing and potentially planting of wetland areas to intercept nutrient rich runoff is suggested.

### Description

Lake Rotopouua (1699531E, 590047N) is a small (<5 ha) lake with a maximum depth c. 9 m. The lake is ponded between dunes to the west and weathered hill country, with heavy clay soils, to the east. The lake is dammed, with an outlet pipe noted at the eastern edge of the lake, with water flowing towards Lake Humuhumu via a large wetland. The catchment is primarily plantation pine forestry manuka/kanuka scrub and fenced pasture. Access is across farm land from the Ari Road and the lake has limited boat access as it is fenced off from stock.

### Wetland vegetation

The lake is completely fringed with emergent species to a depth of 1 m. The dominant emergent species are *Eleocharis sphacelata*, *Typha orientalis*, *Machaerina juncea*, *M. articulata*, *Schoenoplectus tabernaemontani* and *Carex secta*. The marsh fern (*Thelypteris confluens*) was common growing amongst emergent sedges, especially *M. juncea*.

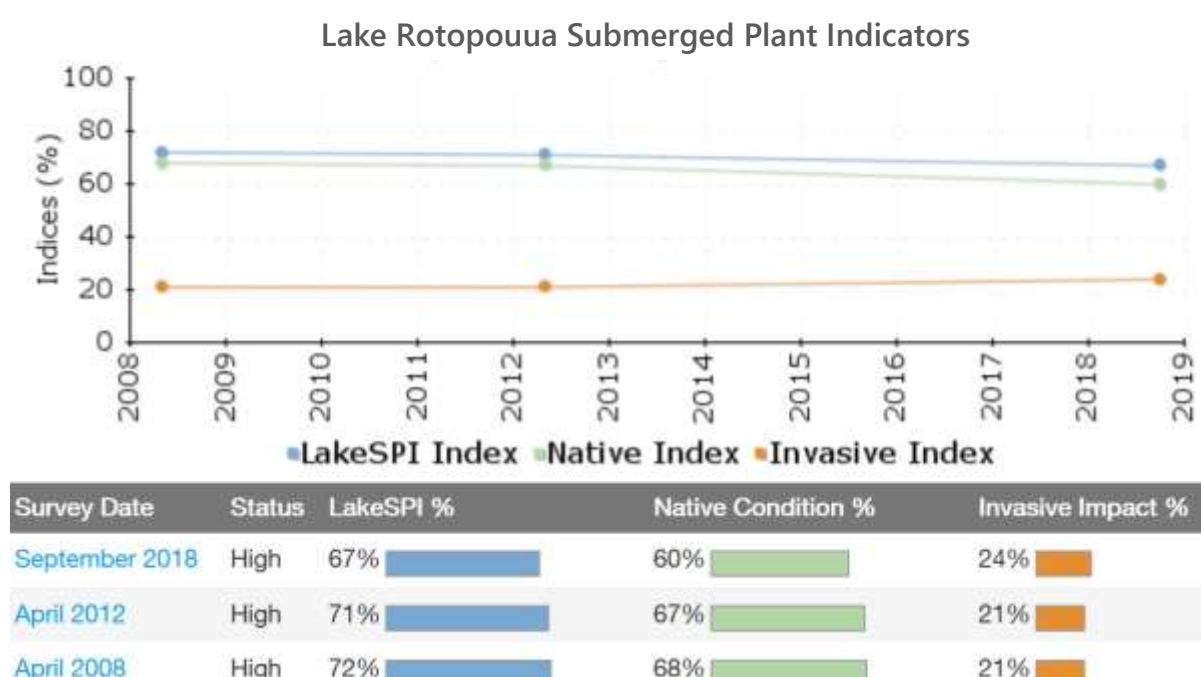


## Submerged vegetation

Turf communities were not recorded due to lack of suitable habitat with extensive and dense emergent vegetation beds present around the lake. The submerged vegetation (80% median cover) was dominated by *Potamogeton ochreatus* and *Chara australis* from the edge of emergent vegetation to 5.8 m. Other species with lower covers included *Nitella* sp. aff. *cristata*, *Myriophyllum triphyllum* (one site only) and the introduced *Potamogeton crispus* (two sites). No *Utricularia gibba* was found in the lake.

Apart from the lack of *U. gibba*, a similar vegetation was described in previous surveys.

## LakeSPI



**Figure 3-24: LakeSPI results for Lake Rotopouua.** LakeSPI Indices expressed as a percentage of lake maximum potential.

Lake Rotopouua is categorised as being in high ecological condition with a LakeSPI Index of 67% and has remained relatively stable over the three surveys.

## Water birds

Extensive emergent vegetation and a relatively isolated lake provide good habitat for water birds, with dabchick (*Poliocephalus rufopectus*), black swan (*Cygnus atratus*), mallard duck (*Anas platyrhynchos*), NZ scaup (*Aythya novaeseelandiae*) and little black shag (*Phalacrocorax sulcirostris*) seen in 2018. A bittern (*Botaurus poiciloptilus*) and a spotless crane (*Porzana tabuensis plumbea*) were observed at the lake margin in 2012.

## Fish

Abundant common bullies (*Gobiomorphus cotidianus*), were observed during vegetation surveys. Inanga (*Galaxias maculatus*) were reported as common in this lake (Rowe and Chisnall 1997), but a thorough search by DOC Northland Conservancy staff could not relocate this species.

## Aquatic invertebrates

Previously only dead shells of the freshwater mussels (*Echyridella menziesii*) were found in the lake. However, in 2018 living mussels were located at two of the four transects. Snails, *Potamopyrgus antipodarum*, as well as freshwater sponges and hydra were common.

## Endangered species

Living At risk Declining freshwater mussels (*Echyridella menziesii*) were found in 2018. After finding empty shells in 2008 and 2012, it was suspected that this species had been extirpated by bottom water anoxia. The At risk Naturally Uncommon marsh fern (*Thelypteris confluens*) was common, growing perched on emergent vegetation at the lake edge. Threatened birds seen in 2018 included the At risk Recovering dabchick and At-risk Naturally Uncommon little black shag.

## Lake Ecological Value

An ecological value rating of “11- high” was assigned to Lake Rotopouua, a small lake with a well buffered margin and well developed submerged vegetation, with minor invasive species impact.

## Threats

The restricted access to this lake reduces the threat of introduction of pest plants. Should invasive species be introduced to the lake it is likely that they would displace much of the current native vegetation.

Water quality continues to be poorer than expected, considering the intact submerged vegetation present in the lake. The heavy rainfall prior to and during the 2018 survey allowed investigation of point sources of nutrients running off from farmland. Several extensive pugged wetland areas were noted on the northern side of the lake (Figure 3-25) that would contribute to deteriorating water quality. These were compared with a fenced inlet at the western end of the lake which was completely vegetated (Figure 3-26) allowing processing of nutrients.



**Figure 3-25: Unfenced inflow to Lake Rotopouua.** (Photo: Paul Champion 21 September 2018).



**Figure 3-26: Fenced inflow into lake Rotopouua.** (Photo: Paul Champion 21 September 2018).

### Management recommendations

An assessment of lake native biodiversity value at 5 yearly intervals is recommended.

Analysis of annual monitoring of water quality should be undertaken to determine the extent of nutrient enrichment and consideration of sources of nutrients to the lake. This analysis may find a means of mitigating the nutrient enrichment threat from inflows and drains. Fencing and potentially planting of wetland areas to intercept nutrient rich runoff is suggested.

### 3.1.13 Lake Waingata (Pouto), NRC Lake No. 371.



**Figure 3-27: Lake Waingata.** Photo showing the re-establishment of emergent vegetation within the fenced area (Photo: Paul Champion 19 September 2018).

Summary	Lake Waingata
<b>Surveyed:</b>	2005, 2010 and 2018 (reconnaissance).
<b>Overall ranking:</b>	<b>Low:</b> Mostly de-vegetated by grass carp, but emergent vegetation starting to re-establish in fenced areas indicating grass carp numbers have declined below the threshold where grazing pressure can suppress plant growth.
<b>Threats:</b>	Low risk of introduction and establishment of invasive weeds. Water quality poor.
<b>Management recommendations:</b>	No lake native biodiversity value monitoring until grass carp removed. Advocate removal of grass carp.

#### Description

A small (9 ha) dune lake (1703256E, 5976471N) of 9.5 m depth, set in a pastoral catchment. Access through 2 km private farmland, mostly on a well-formed track and requiring 4-WD if wet. Small boats can be launched with 4-WD from northern lake edge.

#### Wetland vegetation

Emergent species were noted in 2018, for the first time since grass carp were stocked, within an area where stock are excluded by fencing. Species included *Schoenoplectus tabernaemontani*, *Eleocharis acuta*, oioi (*Apodasmia similis*) and *Juncus pallidus*. The pest plant alligator weed (*Alternanthera philoxeroides*) was well established around the lake in 2001 and has continued to proliferate.



## Submerged vegetation

The turf community was described as emergent in 2005 and 2010, with *Lilaeopsis novae-zelandiae*, *Elatine gratioloides* and *Glossostigma elatinoides*, noted in water less than 30 cm deep in 2018. The lake was turbid with a cyanobacterial bloom, no taller submerged species were recorded.

## LakeSPI

A LakeSPI score was not generated.

## Water birds

The lake provides minimal bird habitat. Despite this, 17 black swan (*Cygnus atratus*), 10 mallard (*Anas platyrhynchos*) and two pairs of paradise shelduck (*Tadorna variegata*) with ducklings were seen in 2018. Additionally, two pairs of dabchick (*Poliocephalus rufopectus*) and 38 black shag (*Phalacrocorax carbo*) and one little shag (*P. melanoleucos*) were seen on this survey.

## Fish

The lake was stocked with rainbow trout (*Oncorhynchus mykiss*) in the 1950's until 1980 but have since died out. Inanga (*Galaxias maculatus*) was present in the lake and was recorded as abundant in 1997. Common bully (*Gobiomorphus cotidianus*) were the only other fish present in Lake Waingata until 67 grass carp (*Ctenopharyngodon idella*) were introduced in 1995 to eradicate the pest plant elodea (*Elodea canadensis*).

## Aquatic invertebrates

Several introduced snails *Physa acuta*, were seen among emergent vegetation in 2018.

## Endangered species

The At risk Declining lake-bound population of inanga (*Galaxias maculatus*) is likely to persist in Lake Waingata. Threatened birds seen in 2018 included the At risk Recovering dabchick and At-risk Naturally Uncommon black shag, the large numbers of this species indicating an abundance of fish in Lake Waingata.

## Lake Ecological Value

An ecological value rating of “3- low” was assigned to Lake Waingata, a mostly unfenced small lake with poor water quality and largely devegetated due to the introduction of grass carp in 1995.

## Threats

The isolation of the lake and absence of eels provide a low risk of introduction and establishment of invasive weeds is unlikely due to grass carp browsing pressure. However, carp browsing pressure has apparently reduced sufficiently for emergent species to grow where cattle are excluded from the lake margin. Water quality is currently poor but could improve in the future with cattle excluding fencing, riparian planting and grass carp removal.

## Management recommendations

No lake native biodiversity value monitoring until grass carp removed.

Advocate fencing and removal of grass carp.

## 3.2 Weed surveillance

### 3.2.1 Lake Humuhumu

No new weed species were found in the lake adjacent to the boat launch area in Lake Humuhumu. The introduced *Potamogeton crispus* was abundant in the lake along with the native pondweeds *P. ochreatus* and *P. cheesemanii* and the charophytes *Chara globularis* and *C. australis*.

### 3.2.2 Grey willow (*Salix cinerea*)

Plants that seemed to be identical to grey willow were noted in a wetland near Kaihu and on the margin of Lake Rototuna in the Spring 2018 report (Champion 2018). These plants were flowering in September and samples were taken from both sites and several other plants seen on the road between Dargaville and Kaihu. Subsequently this plant has been found elsewhere in Northland. All material is male (Figure 3-28), the flowers and bark corresponding to specimens collected in the vicinity of Hamilton, where grey willow is abundant. Herbarium material has been collected from those sites.

Bob Cathcart (AGFIRST NORTHLAND, Land & Environmental Management Consultant pers. comm.) reports that a North American willow (*Salix discolor*) was used in Northland for soil conservation from the 1920's onwards, and that the willows reported in Champion (2018) relate to these. *Salix discolor* Muhl. is not recorded in New Zealand botanical literature (e.g. Flora of NZ, Landcare website, Virtual Herbarium, neither is it recorded here in international databases (e.g. GBIF)). Thompson and Reeves (1994) regard records of *S. discolor* in New Zealand as referable to *S. xreichardtii* (pussy willow). The identity of Northland 'pussy willows' should be confirmed by Landcare Research, possibly using genetic tools (e.g. EcoGene).

Despite the absence of female plants (seed are wind dispersed), an eradication programme is advocated at sites where this plant is spread vegetatively, as seen in the Kaihu wetland.



**Figure 3-28: Male flowers of grey willow (*Salix cinerea*) collected from the margin of Lake Rototuna.** (Photo: Tracey Burton 19 September 2018).

## 4 Summary and management recommendations

No new pest plant incursions were detected in the 13 lakes investigated.

A summary of individual lake finding is shown in Table 4-1, presenting Ecological Condition ranking and trend, water quality status based on submerged vegetation assessment, invaded status (Invasive Impact Assessment from LakeSPI) and risk of incursion and management recommendations.

Two of the 13 lakes surveyed for ecological assessment were ranked as Outstanding (Karaka and Rotokawau), four as High or High-moderate (Black, Mokeno, Rotopouua and Shag), four were Moderate (Kelly's Pond, Greville's, Otapuiti and Parawanui) and three were Low (Kelly's, Kapoai and Waingata).

Major water quality issues were detected in eight of the lakes, including all Pouto lakes (except Greville's), Shag and Kelly's. Management recommendations include fencing lakes to exclude livestock, fence off inflows to prevent pugging and establish wetlands to mitigate nutrients.

Invasive plants were having minor to moderate impacts in seven lakes and also Lake Humuhumu (surveillance by snorkel). High covers of *Potamogeton crispus* were noted in four of those lakes, which is likely a consequence of survey timing rather than any other adverse influence. This species produces maximum biomass in winter and spring, declining during summer and autumn (when other LakeSPI assessments are routinely made). Impacts of *Utricularia gibba* were often lower than previous autumn assessments and may also reflect difference in survey time. *Egeria densa* was rare within Lake Rotokawau, similar to assessments in 2012 and 2015.

The landowner at Lake Parawanui reported the commercial eel fishing occurred within the lake and this introduction pathway is also seen as a significant risk for new incursions in Lakes Shag and Rotokawau.



**Table 4-1: Summary of lake findings - Spring 2018.** Ecological Condition ranking and trend, water quality status based on submerged vegetation assessment, invaded status (Invasive Impact Assessment from LakeSPI) and risk of incursion and management recommendations.

Lake	Ecological condition	Trend	Water quality	Fencing status (y/n/partial)	Invasion status	Invasion risk	Management recommendations
Black	High	First assessment	Minor	y	<i>U. gibba</i> (36% III)	Low	Fish and water quality surveys, 5 yearly monitoring.
Kelly's	Low	First assessment	Major	n	No submerged plants	Low	Fencing to exclude livestock, no further monitoring.
Kelly's Pond	Moderate	First assessment	None	n/a	<i>U. gibba</i> rare	Low	Occasional monitoring.
Shag	High to moderate	Stable – loss of charophyte meadows	Major	partial	<i>J. bulbosus</i> (4% III)	Moderate - eels	Fencing to exclude livestock, 5 yearly monitoring.
Greville's	Moderate	First assessment	Minor	y	<i>U. gibba</i> (20% III), <i>A. philoxeroides</i>	Low	Occasional monitoring.
Kapoai	Low	Stable – slight improvement	Major	partial	<i>P. crispus</i>	Low	Establish wetlands to intercept nutrients from the inlet streams, 5 yearly monitoring.
Karaka	Outstanding	Stable	Major	n	No invasive species	Low	Fencing of E margin, investigate aquifer nutrient status, 5 yearly monitoring.
Mokeno	High	Declining - loss of most charophytes	Major	n/a	No invasive species	Low	Investigate aquifer nutrient status, 5 yearly monitoring.
Otapuiti	Moderate	First assessment	Major	n/a	No submerged plants	Low	Investigate aquifer nutrient status, 5 yearly monitoring.
Parawanui	Moderate	Declining - loss of mussels	Major	y	<i>P. crispus</i> (27% III)	Moderate - eels	Establish wetlands to intercept nutrients from the inlet streams, 5 yearly monitoring.

Lake	Ecological condition	Trend	Water quality	Fencing status (y/n/partial)	Invasion status	Invasion risk	Management recommendations
Rotokawau	Outstanding	Declining - loss of charophyte meadows	Major	n	<i>E. densa</i> (27% III)	Moderate - eels	Understanding the drivers for the water quality decline and mitigate inputs through riparian retirement and wetlands to intercept nutrients, 5 yearly monitoring.
Rotopouua	High	Stable	Moderate	partial	<i>P. crispus</i> (24% III)	Low	Fencing to exclude livestock from inflows, 5 yearly monitoring.

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