Ecological condition of the Ō Tū Wharekai lakes based on LakeSPI

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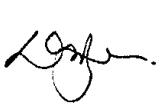

David Roper

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Executive summary

DOC commissioned NIWA to reapply the LakeSPI method to the eleven Ō Tū Wharekai lakes in 2012, report on the current status of the lakes, compare lake status on a regional and national basis, and identify changes evident since the previous assessments in 2007, their nature and significance.

The highest LakeSPI score in 2012 was recorded for Lake Donne (97%) which fell into the 'excellent' category of ecological condition based on diverse and exclusively native submerged vegetation. This shallow lake achieved a score close to the maximum expected for a lake of this type (close to pristine). A 'high' ecological condition was indicated for Spider Lake (LakeSPI score 72%) and Lake Camp (70%) where only minor impacts from exotic weeds were apparent on a diverse native submerged vegetation.

Included in the 'moderate' category of ecological condition was Lake Clearwater (48%) and Lake Heron (46%). Vegetation development in Lake Clearwater appeared to be constrained by water clarity relative to the other deep lakes (Camp and Heron) whilst well developed beds of the exotic weed elodea (*Elodea canadensis*) impacted on the vegetation composition in Lake Heron. The remainder of the smaller, shallower lakes, except Maori Lake East, had lower LakeSPI scores (28-34%) in the moderate category. These lakes were largely dominated by the invasive weed elodea.

Maori Lake East was the only Ō Tū Wharekai lake that did not record significant submerged vegetation presence and was designated as non-vegetated (LakeSPI score 0%), although contributing factors to this status are not clear.

The Ō Tū Wharekai lakes in the excellent to high categories fall within the top 25% of lakes assessed by LakeSPI, on both a regional (33 lakes) and national basis (237 lakes), with Lake Donne first regionally and second nationally. Most Ō Tū Wharekai lakes fell into the moderate category. Within this category, the higher scoring lakes (Clearwater and Heron) scored better than 60% of all lakes assessed nationally, and 33% of lakes assessed for the Canterbury Region. The remainder of the lakes in the 'moderate' category were similar and fell within the lower 50% of assessed lakes nationally and lower 25% of lakes for Canterbury. Maori Lake East was the lowest ranked lake for the Canterbury Region and was 154th equal with 59 other non-vegetated lakes nationally.

Based on LakeSPI, the ecological condition of the majority of the Ō Tū Wharekai lakes has been stable over the last 5 years (consistent with previous monitoring). A 10% reduction in the LakeSPI score for Maori Lake West between 2007 and 2012 was not statistically significant, but an apparent increase in the exotic weed elodea might indicate lake nutrient enrichment or other perturbation that requires additional LakeSPI monitoring to confirm. A statistically and ecologically significant improvement in ecological condition was determined for Lake Camp since 2007, reflective of an increase in long-term water clarity.

It is recommended that Maori Lake West be resurveyed using LakeSPI after c. two years to confirm if the lake shows signs of deterioration. The remainder of the Ō Tū Wharekai lakes should be monitoring at a frequency of 5 to 10 years, or earlier if either land use intensifies or additional exotic weeds are detected in the area. The improvement in Lake Camp is of interest and a consideration of contributing factors may be useful to management of other Ō Tū Wharekai lakes.

1 Introduction

Ō Tū Wharekai is an inter-montane wetland incorporating a number of lake systems, and is one of the sites making up the national Arawai Kākāriki wetland restoration programme managed by Department of Conservation (DOC). DOC monitors natural systems in the area to identify any impacts from changing land use pressures and to assess actions to protect ecological integrity.

In 2007 DOC commissioned NIWA to establish the ecological condition of eleven Ō Tū Wharekai lakes using LakeSPI, a monitoring method using submerged plant indicators. LakeSPI integrates responses of resident plants to anthropogenic pressures exerted upon New Zealand water bodies, including water quality impacts and the invasion of exotic weeds (Clayton & Edwards 2006, de Winton et al. 2012). It allows the ecological condition of lakes to be benchmarked relative to other lakes, and for ecologically significant change to be detected over time. LakeSPI provides simple indices to describe lake status, and has been used by a number of regional councils for State of the Environment reporting.

A NIWA client report (de Winton 2008) presented the results of baseline LakeSPI monitoring for eleven Ō Tū Wharekai lakes in 2007 and compared findings to available historical 1982 vegetation data for some lakes (Tanner et al. 1985). The lakes were recommended for resurvey at an interval of 5 to 10 years based on their apparent stability at that time, although earlier survey was recommended if change was suspected (de Winton 2008).

DOC commissioned NIWA to reapply the LakeSPI method to the eleven Ō Tū Wharekai lake systems in 2012. This report presents survey results with an emphasis on describing the current status of the lakes, identifying any changes evident since 2007, and their nature and significance. An indication of lake status on a regional and national basis is also provided.

2 Methods

2.1 Survey

Eleven lakes were re-visited in late November 2012 (Table 2-1, Figure 2-1). Baseline sites established in 2007 were resurveyed in each lake with reference to site maps, GPS references and shoreline photos. Access to sites on the larger lakes (Clearwater, Camp, Emma, Heron) was by boat, with vehicle and foot access to the smaller lakes.

Table 2-1: Summary of lake characteristics (from database described in Snelder 2006 and LakeSPI surveys*).

Lake	Area (km^2)	*Depth (m)	Altitude (m a.s.l.)	Catchment area	Native catchment (%)	Pasture catchment (%)
Heron	6.95	36.2	692.39	110.94	69	29
Clearwater	1.97	19	675	41.72	71	27
Emma	1.67	*2.7	639.76	35.60	92	24
Camp	0.44	18.9	675.94	6.06	25	73
Emily	0.19	*2.3	674.31	2.41	17	82
Roundabout	0.12	*1.7-1.8	658.81	8.62	16	75
Maori West	0.10	*2.2-2.6	629.77	14.93	52	39
Maori East	0.09	*1.3-1.2	626.83	83.55	15	73
Denny	0.05	*1.5-2.1	677.85	18.67	78	33
Spider	0.04	*0.8-1.5	671.07	2.03	34	44
Donne	0.01	*1.1-2	668.5	0.08	15	87

*Lake depths recorded in the 2007 and 2012 survey.

At each site, divers/snorkelers recorded key vegetation characteristics on data sheets. These included measures of diversity from the presence of up to six key plant communities (emergent or turf plants, isoetes (*Isoetes* species), milfoils, pondweeds, charophytes and high-cover charophyte meadows), and the depth extent of vegetation. Also scored was the presence of invasive exotic weeds and the extent to which they dominated (based on cover, height, depth range). A full description of the vegetation features that are assessed for the LakeSPI method is found in the technical report and user manual on the web-reporting pages (www.lakespi.niwa.co.nz).

Additional observations of plant species, the site frequency that they were encountered, their overall depth range and average and maximum cover and height are summarised in Appendix A with comparison to 2007 survey data. This survey method (Clayton 1983) provides complimentary information to the LakeSPI observations but is not essential for the interpretation of LakeSPI results.

Data was entered into the NIWA LakeSPI database which calculates three indices for each site per lake:

- Native Condition Index -provides a measure (score) of the diversity and abundance of indigenous submerged vegetation.
- Invasive Impact Index -scores the impact by any of ten invasive alien plant species, if present. Note that higher scores for the Invasive Impact Index denote lower lake ecological condition.
- LakeSPI Index -integrates scores from the other two indices.

LakeSPI indices are expressed as a percentage of their maximum (i.e., 100%) potential score (adjusted for lake depth) to enable direct comparisons of small, shallow water bodies with different lake types (e.g., larger, deeper ones). At sites where vegetation cover does not exceed 10%, LakeSPI scores default to 0%.

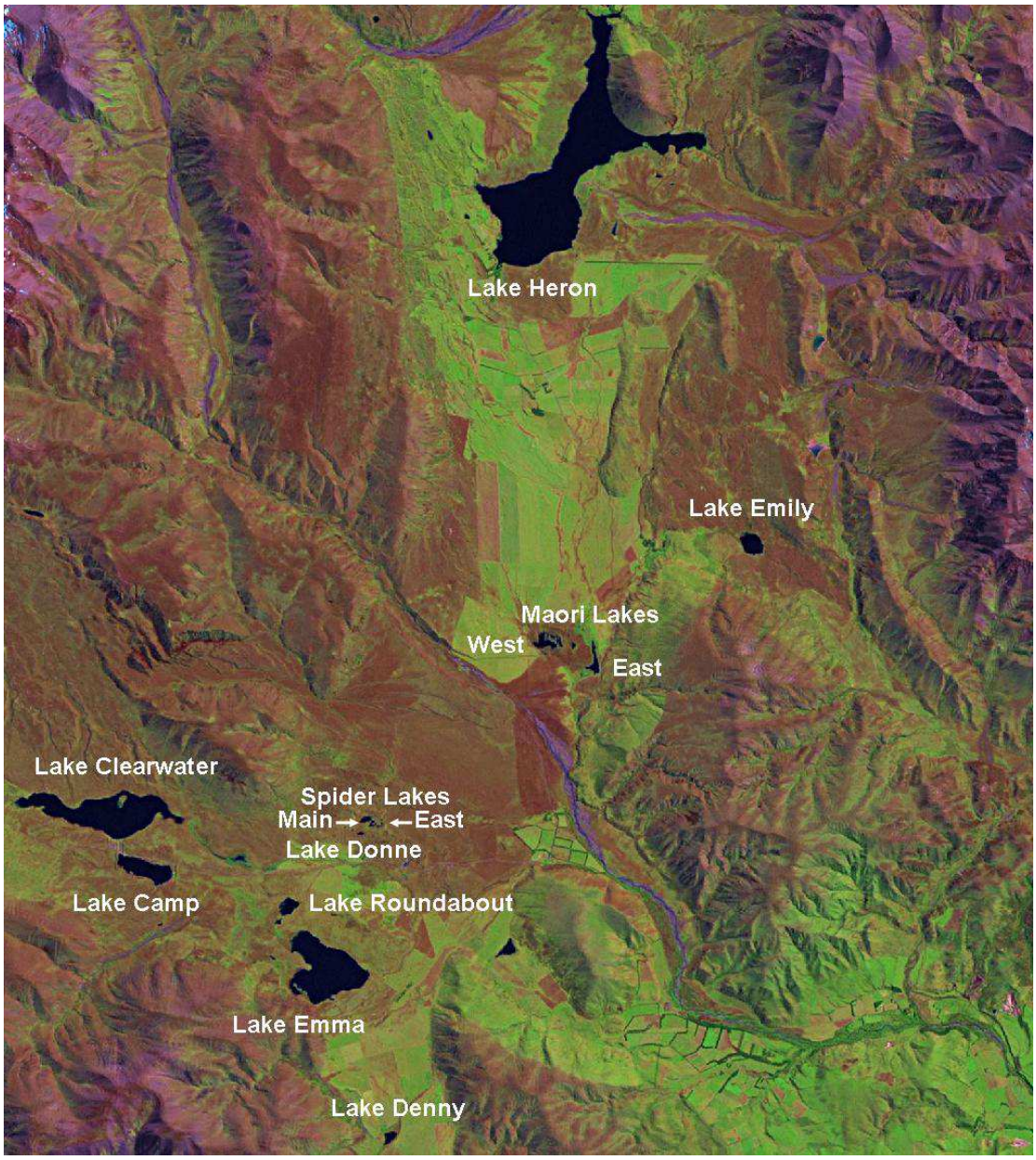


Figure 2-1: Location of surveyed lakes within the Ō Tū Wharekai area.

2.2 Data analysis

The likelihood of an ecologically significant change in lake status over time was based on analysis of the direction and magnitude of change in LakeSPI Indices across sites. A paired t test (GraphPad InStat) compared site results from 2007 to those in 2012 at a significance level $p < 0.05$.

General guidelines (Figure 2-2) also give a scale of probabilities for ecologically significant change in lake condition with change in averaged LakeSPI indices over repeated surveys. These guidelines, based on expert judgment, have considered variation by different observers and the response of LakeSPI scores to major ecological events in lakes.

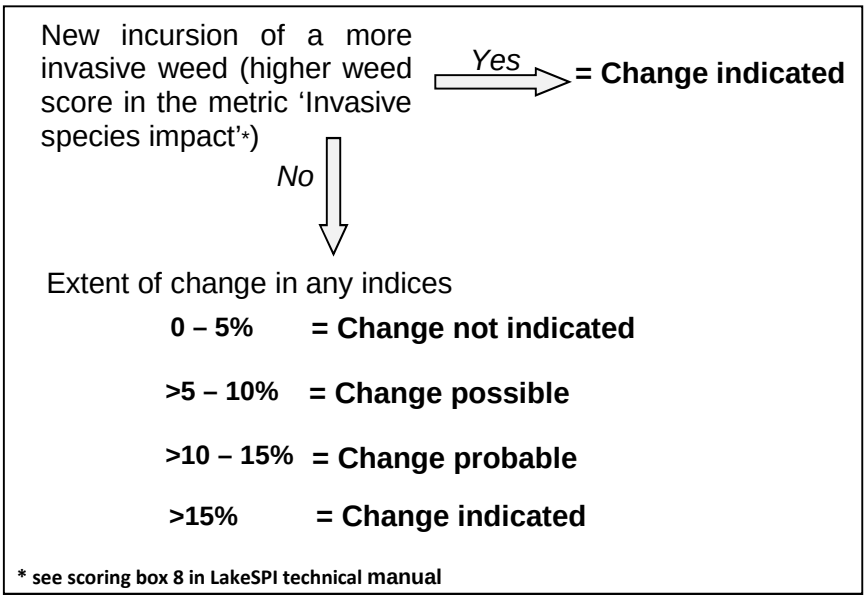


Figure 2-2: Guidelines for assessing the significance of change in LakeSPI Indices over multiple surveys of a lake.

2.3 Reporting

Average LakeSPI Indices are calculated and reported for each lake. For ease of reporting results, five lake condition categories are used to provide a description of a lakes status at the time of a survey. Where the majority of sites in a lake score 0% (vegetation covers < 10%), the lake is designated as Non-vegetated. Other categories are allocated according to the LakeSPI Index score:

LakeSPI score	Category
>75%	= Excellent
>50-75%	= High
>20-50%	= Moderate
>0-20%	= Poor
0%	= Non-vegetated

3 Results

3.1 Lake Camp

Lake condition: High **Stability:** Improving **Ō Tū Wharekai lake ranking:** 3rd

A high LakeSPI score of 70% in 2012 (Table 3-1) reflects the deep extent of vegetation development, the diverse native vegetation present, and the limited impact of exotic weeds.

To account for a temporary high water level for the 2012 survey, water levels were adjusted by -1 m based on the degree of inundation for terrestrial plants. Most of the lake bed was vegetated down to between 13.5 and 15.2 m depth, leaving a small unvegetated basin to the lake maximum depth of 18.9 m. Native charophyte meadows (>75% cover) dominated (Figure 3-1), with three main species contributing to a zonation pattern with increasing depth (Appendix A). Native pondweeds and milfoils were common between 2 and 5 m depth, and turf plants contributed to vegetation diversity in the shallow zone to 3.3 m depth (Figure 3-2). Interestingly, the other native community recognised by LakeSPI, that of native isoetes (quillworts, *Isoetes alpina)* were not recorded either currently, or historically (1982 or 2007), despite being present in many other Ō Tū Wharekai lakes. Exotic weeds, elodea (*Elodea canadensis*) and water buttercup (*Ranunculus trichophyllus*) were minor components of the vegetation in Lake Camp, with the exception of an elodea weed bed that occupied the 3.5 to 4.7 m depth range at one site (Figure 3-3).

Figure 3-1: A charophyte meadow is inspected by a diver at c. 7 m depth in Lake Camp in 2007.

Figure 3-2: Native turf plants (arrowed) amongst boulder margins of Lake Camp, with taller pondweeds (foreground) and sparse charophytes.

Figure 3-3: An elodea bed (left) in Lake Camp is fringed by pondweeds (foreground) and deeper charophyte meadows to the right.

There has been a significant increase in LakeSPI Index, which was driven by an increase in depth extent of the native vegetation by an average of 4.2 m (adjusted depth) between 2007 and 2012. Prior to this the maximum depth of vegetation was similar at 11.5 m in 2007 and 10 m in 1982. A similar vegetation composition was recorded in all years (Appendix A).

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

State	Year	LakeSPI Index (%)	Native Condition Index (%)	Invasive Impact Index (%)
Historical data	18/02/1982	61	57	30
Historical data	29/11/2007	58	59	36
Present day	28/11/2012	70	71	28

3.2 Lake Clearwater

Lake condition: Moderate **Stability:** Stable **Ō Tū Wharekai lake ranking:** 4th

Based on the 2012 survey, a LakeSPI score of 48 (Table 3-2) indicates a moderate condition for Lake Clearwater.

Vegetation extended over most of the lake bed to a depth of 5.5 to 6 m depth, leaving a small unvegetated basin at the deepest part of the lake. Vegetation was dominated by high cover charophyte meadows (>75% cover) comprised of three main species (Appendix A). Native pondweeds and milfoils were present as an open canopy over the charophyte meadows to c. 3 m depth. Isoetes formed swards at one site and low covers were mixed with turf plants at other shallow areas to c. 2 m depth. The cover of the exotic species elodea was variable and was mostly low (≤5% cover), but limited bands of this weed did commonly form an open to partly-closed canopy.

No significant change is apparent between 2012 and 2007, when similar vegetation was recorded to a maximum depth of 7 m. In 1982 the plant depth limit for Lake Clearwater could not be established but was known to extend deeper than 4 m, so the condition of the lake at that time is likely to have been under-estimated (Table 3-2).

Table 3-2: LakeSPI results for Lake Clearwater. LakeSPI Indices expressed as a percentage of lake maximum potential.

State	Year	LakeSPI Index (%)	Native Condition Index (%)	Invasive Impact Index (%)
Historical data	18/02/1982*	42	40	45
Historical data	29/11/2007	47	51	51
Present day	26/11/2012	48	54	48

* Plant depth limit not established.

3.3 Lake Denny

Lake condition: Moderate **Stability:** Stable **Ō Tū Wharekai lake ranking:** 8th

A moderate condition for Lake Denny is indicated by a LakeSPI score of 30% in 2012 (Table 3-3). This shallow lake (1.5 m depth in 2012) was dominated by the exotic weed elodea. Native milfoil formed surface-reaching, flowering patches (Figure 3-4) amongst the widespread elodea beds, while the exotic water buttercup *Ranunculus tricophyllus* was widespread at low covers. At some edges of the lake was found a turf plant (*Ranunculus limosella*), scattered plants of a charophyte (*Nitella tricellularis*), or raupo (*Typha orientalis*).

Figure 3-4: Patches of surface-reaching, flowering milfoil (*Myriophyllum triphyllum*) visible across the main lake basin of Lake Denny in 2012.

A similar overall Lake SPI score was recorded in 2007, but at that time the patches of native milfoil were less well developed than in 2012.

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

State	Year	LakeSPI Index (%)	Native Condition Index (%)	Invasive Impact Index (%)
Historical data	29/11/2007	26	18	74
Present day	28/11/2012	30	32	71

3.4 Lake Donne

Lake condition: Excellent **Stability:** Stable **Ō Tū Wharekai lake ranking:** 1st

Lake Donne recorded an excellent LakeSPI score of 97% in 2012 (Table 3-4), which reflected the all native status of this shallow, completely vegetated lake. It achieved a score close to the maximum potential for a shallow lake of this type. A mosaic of milfoils, pondweeds and high cover charophyte meadows (>75% cover) extended across the entire basin to 2 m depth. Turf plants were restricted to the edges to 1.5 m depth, however, isoetes was not recorded.

No significant change in lake ecological condition has occurred over the last 5 years (Table 3-4). A similar vegetation was recorded in 2007 (Appendix A), but at this time the lake was shallower at a maximum of 1.1 m depth and charophyte meadows and turf plants were more restricted in distribution.

Table 3-4: LakeSPI results for Lake Donne. LakeSPI Indices expressed as a percentage of lake maximum potential.

State	Year	LakeSPI Index (%)	Native Condition Index (%)	Invasive Impact Index (%)
Historical data	29/11/2007	93	82	0
Present day	28/11/2012	97	93	0

3.5 Lake Emily

Lake condition: Moderate **Stability:** Stable **Ō Tū Wharekai lake ranking:** 10th

A score of 28% in 2012 meant that Lake Emily was in a moderate ecological condition (Table 3-5). The weed elodea occupied the entire deeper lake basin from depths of between 0.9 and 1.5 m to the maximum lake depth of 2.3 m. Local high covers of turf plants were commonly found at the extreme lake edge (≤1.5 m). Isoetes was found at the shore to 1.7 m depth along the southern shore only, and pondweed formed a low cover fringe at the inside edge of the elodea bed. High cover charophyte meadows (>75% cover) were not recorded, although charophyte plants contributed to diversity in the shallow zone.

There was no significant change in LakeSPI condition between 2007 and 2012 (Table 3-5). Similar vegetation was recorded in both surveys (Appendix A).

Table 3-5: LakeSPI results for Lake Emily. LakeSPI Indices expressed as a percentage of lake maximum potential.

State	Year	LakeSPI Index (%)	Native Condition Index (%)	Invasive Impact Index (%)
Historical data	30/11/2007	29	27	76
Present day	30/11/2012	28	32	78

3.6 Lake Emma

Lake condition: Moderate **Stability:** Stable **Ō Tū Wharekai lake ranking:** 7th

Lake Emma recorded a moderate LakeSPI score of 32% in 2012 (Table 3-6). This reflected dominance of the vegetation by elodea, although up to five of the six key native plant groups recognised in the LakeSPI method were still represented. However, high cover charophyte meadows (>75% cover) were not recorded. Vegetation was recorded across the entire lake bed and to a maximum depth of 2.7 m in the deepest basins at the time of survey. However, gaps in the elodea bed and bare areas of sediment were common.

Compared with 2007, elodea occupied more of the lake bed and was slightly taller in 2012 (Appendix A), but differences in LakeSPI score (Table 3-6) were not significant overall. Otherwise, the vegetation in both the survey years was similar (Appendix A).

Table 3-6: LakeSPI results for Lake Emma. LakeSPI Indices expressed as a percentage of lake maximum potential.

State	Year	LakeSPI Index (%)	Native Condition Index (%)	Invasive Impact Index (%)
Historical data	30/11/2007	37	45	69
Present day	29/11/2012	32	40	77

3.7 Lake Heron

Lake condition: Moderate **Stability:** Stable **Ō Tū Wharekai lake ranking:** 5th

The 2012 LakeSPI score of 46% for Lake Heron (Table 3-7) indicates a moderate ecological condition. A depth vegetation extent of between 7 and 9.8 m contributed positively to the score, as did representation of six key native vegetation types recognised by LakeSPI. These included turf plants, isoetes, milfoils, pondweeds, charophytes and the development of high cover charophyte meadows. The only exotic species, elodea, typically formed extensive, low-growing, but high cover beds within Lake Heron.

Recently didymo (*Didymosphenia geminata*) has been recorded from Lake Heron (and Maori Lake East). Didymo was observed on rocks in the shallows at the south-western shoreline during the current survey, but no impacts were apparent on the submerged vegetation.

A slightly higher occupation of the lake bed by native vegetation relative to elodea beds was noted since 2007, but did not result in a significant change in overall LakeSPI condition (Table 3-7). All common species recorded in 2007 were re-recorded in 2012 (Appendix A).

Table 3-7: LakeSPI results for Lake Heron. LakeSPI Indices expressed as a percentage of lake maximum potential.

State	Year	LakeSPI Index (%)	Native Condition Index (%)	Invasive Impact Index (%)
Historical data	18/02/1982	42	45	59
Historical data	28/11/2007	42	45	60
Present day	27/11/2012	46	47	53

3.8 Maori East Lake

Lake condition: Non-vegetated **Stability:** Stable **Ō Tū Wharekai lake ranking:** 11th

The lack of vegetation cover exceeding 10% at the majority of investigated sites means Maori Lake East receives a default score of 0% (Table 3-8) and is categorised as non-vegetated. The only submerged plant cover exceeding 10% (the threshold for LakeSPI assessments) was a limited turf plants at one shallow margin. Elsewhere across most of the lake bed was seen isolated plants of elodea, pondweed and milfoil (Appendix A). The low stature of these plants might suggest browsing and uprooting by waterfowl in this shallow lake.

Didymo is known from Maori Lake East, but was not observed during this survey.

A non-vegetated LakeSPI condition was also scored in 2007 (Table 3-8), when a similar sparse vegetation was recorded (Appendix A).

Table 3-8: LakeSPI results for Maori Lake East. LakeSPI Indices expressed as a percentage of lake maximum potential.

State	Year	LakeSPI Index (%)	Native Condition Index (%)	Invasive Impact Index (%)
Historical data	28/11/2007	0	0	0
Present day	27/11/2012	0	0	0

3.9 Maori West Lake

Lake condition: Moderate **Stability:** Declining? **Ō Tū Wharekai lake ranking:** 9th

A LakeSPI score of 28% for Maori Lake West indicted a moderate ecological condition (Table 3-9). The exotic weed elodea dominated the vegetation, but in some places patches of native charophytes and scattered milfoil and pondweed plants were present (Appendix A).

The LakeSPI score had dropped by 10% between 2007 and 2012 due to a reduced diversity and occupation of the lake bed by native plants, however variability between the sites meant this change was not statistically significant.

Table 3-9: LakeSPI results for Maori Lake West. LakeSPI Indices expressed as a percentage of lake maximum potential.

State	Year	LakeSPI Index (%)	Native Condition Index (%)	Invasive Impact Index (%)
Historical data	29/11/2007	39	60	69
Present day	29/11/2012	29	31	78

3.10 Lake Roundabout

Lake condition: Moderate **Stability:** Stable **Ō Tū Wharekai lake ranking:** 6th

The LakeSPI score of 34% in 2012 (Table 3-10) indicates a moderate condition, reflecting dominance of the exotic weeds elodea and water buttercup (*Ranunculus trichophyllus*) in this shallow, vegetated lake. Elodea formed a low-growing, high cover bed across most the lake bed, with scattered taller clumps of buttercup and milfoil and limited areas of bare sediment. Turf plants and milfoils mainly contributed to native vegetation cover, although less abundant charophytes and pondweeds were also represented (Appendix A). Isoetes and charophyte meadows were not recorded.

There has been no change in LakeSPI scores since 2007 (Table 3-10) and vegetation composition patterns are very similar (Appendix A).

Table 3-10: LakeSPI results for Lake Roundabout. LakeSPI Indices expressed as a percentage of lake maximum potential.

State	Year	LakeSPI Index (%)	Native Condition Index (%)	Invasive Impact Index (%)
Historical data	30/11/2007	35	43	72
Present day	26/11/2012	34	46	75

3.11 Spider Lake

Lake condition: High **Stability:** Stable **Ō Tū Wharekai lake ranking:** 2nd

Spider Lake (two basins) had a high ecological status with a LakeSPI score of 72% in 2012 (Table 3-11). Native vegetation was extensive in the shallow bays and in the eastern basin, but more scattered across the centre of the main lake. Vegetation comprised a mosaic of milfoils, pondweeds, charophytes, with turfs plants restricted to the shallower areas to 1 m depth (Appendix A). The presence of exotic species, elodea and water buttercup, reduced the LakeSPI score for the Spider Lakes (Table 3-11), although their overall impact on native vegetation was minor (Appendix A).

There has been no significant change since 2007 (Table 3-11), although water levels were slightly higher in 2012 so that more areas of amphibious turf were inundated.

Table 3-11: LakeSPI results for the Spider Lakes. LakeSPI Indices expressed as a percentage of lake maximum potential.

State	Year	LakeSPI Index (%)	Native Condition Index (%)	Invasive Impact Index (%)
Historical data	29/11/2007	69	76	32
Present day	28/11/2012	72	81	31

4 Discussion

4.1 Current status

The highest score for the Ō Tū Wharekai lakes was recorded for Lake Donne (Figure 4-1) which showed an excellent ecological condition. This shallow lake had diverse, exclusively native vegetation extending over the entire bed, therefore it achieved a score close to the maximum expected for a lake of this type. The high score for Spider Lake (two basins) was reduced by the presence of exotic weeds (elodea and water buttercup) and fell into the high category of ecological condition (Figure 4-1). Lower plant covers in this lake may reflect heavy ice-over seen in the area over the winter of 2012, however this natural disturbance may also contribute to a high observed plant diversity. Lake Camp also scored in the high category of ecological condition on account of the deep extent of native vegetation development with only minor impacts apparent from exotic weeds. Interestingly, isoetes *(Isoetes alpina*) was not recorded from Lake Camp, Spider Lake or Lake Donne currently, or historically, although this species is widespread in South Island glacial lakes. The absence of this 'key' native community for the LakeSPI method did not result in a substantial scoring penalty (e.g., maximum reduction of 2% for Lake Camp).

Within the top of the moderate category of ecological condition (Figure 4-1) was Lake Clearwater and Lake Heron. Lake Clearwater had a modest depth extent of vegetation (maximum 6 m) compared to the other deep lakes, Camp (maximum 15.2 m) and Heron, maximum 9.8 m) suggesting greater clarity constraints to vegetation development in Lake Clearwater, indicative of poorer water quality. In Lake Heron, however, the exotic weed elodea had a more pervasive impact on the vegetation composition (higher Invasive Impact Index) resulting in a lower overall LakeSPI score.

Lower LakeSPI scores in the moderate category were recorded for the remainder of the smaller, shallower lakes except Maori Lake East (Figure 4-1). Notably these lakes had a similar Invasive Impact Index value (71-78%), reflecting the dominance of extensive elodea beds. However, some lakes had higher representation of native vegetation. In Lake Roundabout native plants co-existed between clumped elodea beds, while in Lake Emma native plants were well represented along the shallower exposed shoreline where elodea beds did not develop. Although native diversity was low in Lake Denny, surface-reaching clumps of milfoil reduced the overall occupation by elodea in this lake. Native diversity was variable across sites in Maori Lake West, but elodea dominated at all sites. In Lake Emily, native plants were restricted to the extreme margins, with a complete cover of elodea across the rest of the lake basin.

Maori Lake East was the only Ō Tū Wharekai lake that did not record significant submerged vegetation presence and was designated as non-vegetated, as in 2007 (de Winton 2008). The reasons for lack of plant development are not clear. We noted water clarity during the current survey was sufficient for short-stature plants to colonise the entire lake bed, but covers were extremely low. Maori Lake East receives more direct inflows from stream systems (Gentleman-Smith Stream and Jacobs Creek), that both drain farmland, and therefore may be more susceptible to turbid inflows. It was also noted that soft sediments had accumulated which may not be stable enough to provide a strong anchorage for plants. It is possible that water fowl grazing, combined with a shallow lake depth and soft substrates,

has led to the plants being easily uprooted and consumed, or that plants were easily disturbed by flows or wind/wave events.

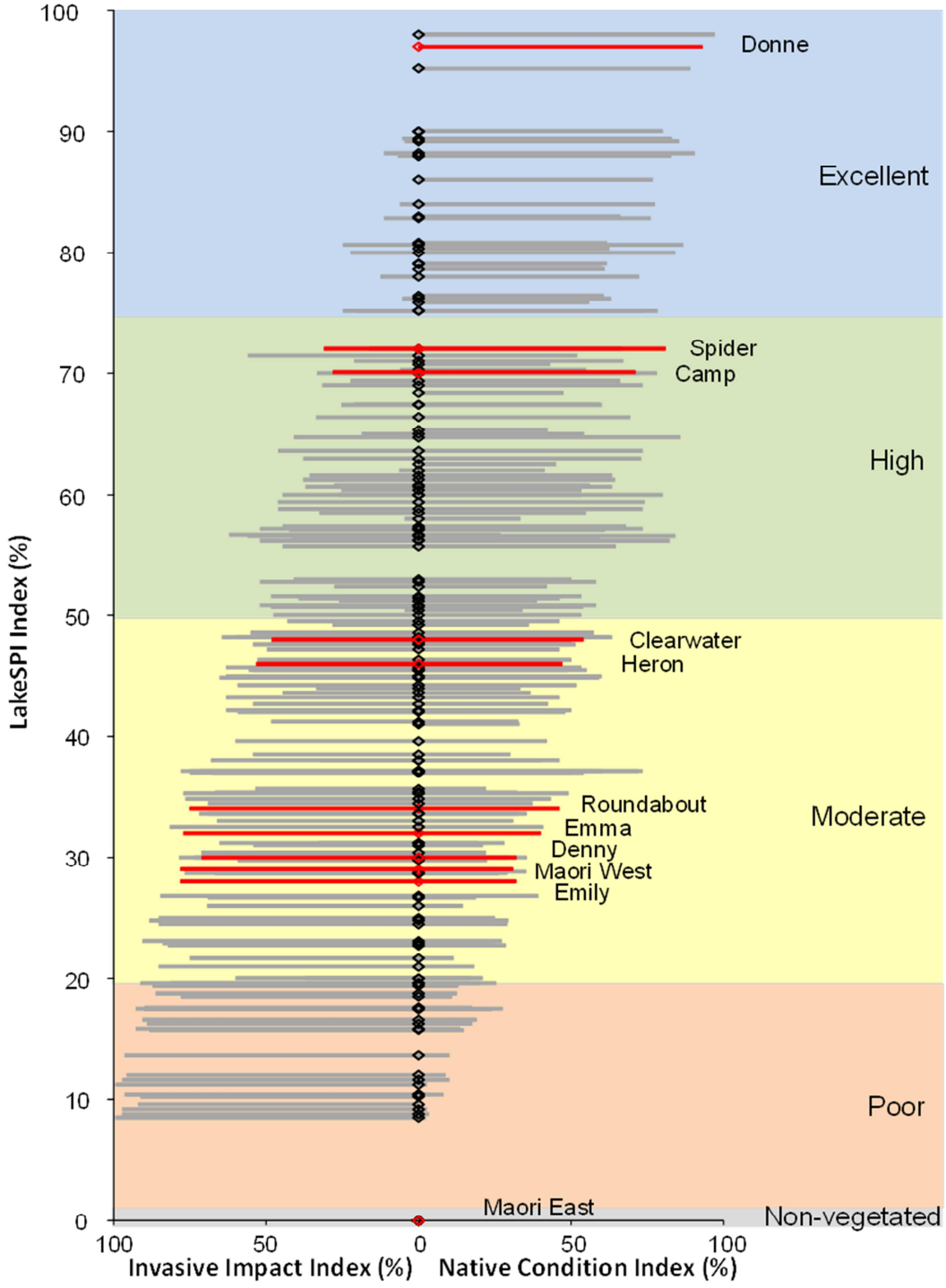


Figure 4-1: LakeSPI Indices based on the latest results for 236 lakes in grey, showing the relative scores for the Ō Tū Wharekai lakes as red lines. LakeSPI scores are plotted on the vertical axis, with the Native Condition Index plotted on the right hand horizontal axis, and Invasive Impact Index on the left hand to show the negative influence on LakeSPI scores.

4.2 Regional and national comparison

The ranking for LakeSPI scores of the Ō Tū Wharekai lakes relative to lakes assessed in the Canterbury Region, and to results for lakes nationally, is given in Table 4-1. Lakes assessed in the Canterbury Region were high-country glacial lakes similar to the Ō Tū Wharekai lakes.

The Ō Tū Wharekai lakes in the excellent to high categories of ecological condition fell within the top 25% of lakes regionally and nationally (Table 4-1), with Lake Donne ranked highest in the region and second highest nationally (after Lake Wakatipu). Close to pristine examples of native lake vegetation like Lake Donne are relatively rare, and this lake scores almost the highest possible score for a lake of its type (shallow tarn).

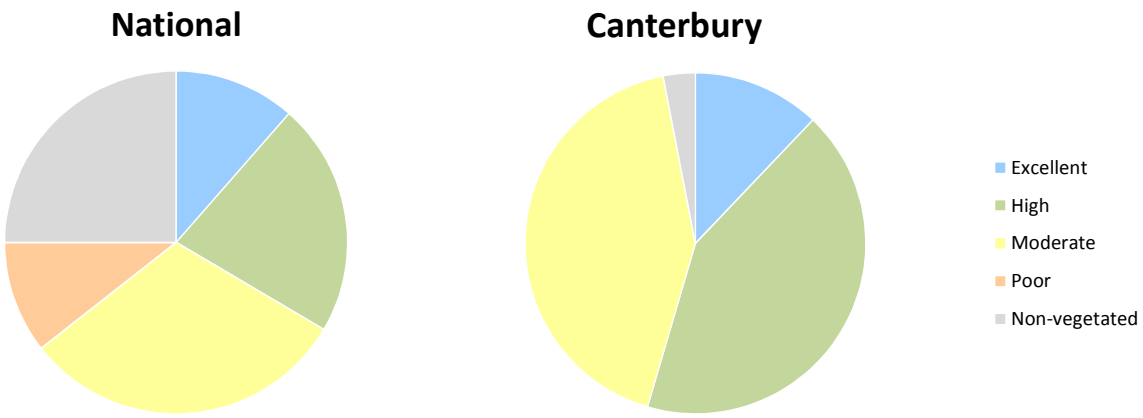
Lakes Clearwater and Heron scored better than 60% of lakes assessed nationally, and 30% of lakes assessed in the Canterbury Region. The similarity of the remainder of the Ō Tū Wharekai lakes in the moderate category (Table 4-1) was apparent in their positions on both a regional (across 7 rankings) and national (13 rankings). These lakes fell within the lower 50% of assessed lakes nationally and lower 25% of lakes for Canterbury. Maori Lake East was the lowest ranked lake for LakeSPI in the Canterbury Region and 154th equal with 59 other non-vegetated lakes nationally.

Table 4-1: Comparison of rankings for LakeSPI scores of the Ō Tū Wharekai lakes to assessed lakes in Canterbury Region (33 lakes and nationally (236 lakes). Note equal rankings are included in the positions provided.

Ō Tū Wharekai	Category	Canterbury Region	National
Donne	Excellent	1st	2nd
Spider	High	5th	26th
Camp	High	6th	31st
Clearwater	Moderate	19th	77th
Heron	Moderate	21st	82nd
Roundabout	Moderate	24th	107th
Emma	Moderate	27th	111th
Denny	Moderate	28th	115th
Maori West	Moderate	29th	117th
Emily	Moderate	31st	120th
Maori East	Non-vegetated	32nd	154th

Comparisons were also made on the basis of the category of lake ecological condition. Most of the Ō Tū Wharekai lakes fell within the moderate category, as found for Canterbury Region in general (Figure 4-2), although this category was not so strongly represented in lakes nationally. Representation in the excellent category by Lake Donne was proportionally similar to the region as a whole and nationally. However, fewer lakes were included in the high category (Spider Lake and Lake Camp) than for Canterbury as a whole, although proportions were similar to lakes nationally. None of the Ō Tū Wharekai lakes, or surveyed Canterbury Lakes, fell into the poor category, and Maori Lake East provided the only Canterbury lake in the non-vegetated category.

Figure 4-2: Proportion of lakes within five categories of lake ecological condition according to LakeSPI - . based on the most recent results for 236 lakes nationally, and 33 lakes in the Canterbury Region.



4.3 Change over time

Based on LakeSPI, the ecological condition of the majority of the Ō Tū Wharekai lakes has been stable over the last five years. Although changes in Maori Lake West between 2007 and 2012 were not statistically significant, an apparent increase in the dominance of the exotic weed elodea at the expense of native vegetation diversity is suggested. Rapid elodea expansion in lakes can be associated with disturbance events (e.g., flood inputs, sedimentation), and increased dominance of this species is apparent with increasing lake trophic condition, with a maximum development under mesotrophic to eutrophic conditions. Changes apparent at Maori Lake West suggest lower stability that requires additional LakeSPI monitoring to confirm.

A statistically and ecologically significant improvement in ecological condition was determined for Lake Camp since 2007. The nature of the change; an expansion in the depth extent of deeper charophyte meadows, suggests that the lake has become clearer (improved water quality). Although a higher than usual water level was observed at the time of the survey (estimated at +1 m), the magnitude of the change in vegetation depth at sites between 2007 and 2012 (>4 m, average 5.2 m unadjusted for water level) is greater than can be explained by a temporary high water level. Submerged vegetation responds to changes in water clarity by upwards or downwards migration along the littoral slope with a response time of months to years. Therefore any increase in water clarity must have been a substantial and sustained. There are no obvious changes in the lake catchment since 2007 that explain this improvement, although it is possible that an earlier (2000) provision of a 60m wide riparian strip on the southern side of the lake (Wendy Sullivan, DOC, pers. comm.) might have contributed.

Didymo would have little influence on LakeSPI scores in the future, as impacts on vegetation characteristics scored by the LakeSPI method are expected to be minor, based on observations in similar sized glacial lakes in the South Island. In contrast, the introduction of

highly invasive exotic weeds, such as *Lagarosiphon major*, would almost certainly lead to lower diversity and representation by native submerged plants, and reduced LakeSPI scores.

4.4 Recommendations

- Maori Lake West should be resurveyed within c. two years to confirm if deterioration in condition has occurred.
- The majority of the Ō Tū Wharekai lakes appear to be stable according to LakeSPI. Therefore we recommend a LakeSPI monitoring frequency of 5 to 10 yearly intervals. However, in the event of intensified land-use or the invasion by additional exotic weeds, an early re-assessment would be recommended.
- An improvement in Lake Camp is of interest and a consideration of contributing factors may be useful to management of other Ō Tū Wharekai lakes.

5 Acknowledgements

Many thanks to Wendy Sullivan and Rose Clucas (DOC) for for providing orientation for the lake surveys. Paul Champion (NIWA) assisted with vegetation assessments in Spider Lake and Lake Donne. We appreciate the additional information and comments that Sjaan Bowie (DOC), Wendy and Rose have provided to improve this report. Tracey Edwards (NIWA) entered data to the LakeSPI database.

6 References

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7 Appendix A

Summary tables for vegetation of the Ō Tū Wharekai lakes in 2012 and 2007. See de Winton (2008) for comparable survey results for Lakes Camp, Clearwater and Heron in1982, and for the threat classification status of species (2005 listing).

Summary for Lake Camp based on the 2012 and 2007 surveys at 5 sites. Heights not shown for species <0.1 m tall, or where insufficient data. Cover Scale - 1=1-5%, 2=6-25%, 3=26-50%, 4=51-75%, 5= 76-95, 6=96-100. * Name changes or new species since 1982.

Species	LakeSPI plant type	% of Profiles		Depth Range (m)		Median cover		Maximum cover		Average height (m)		Maximum height (m)	
		2012	2007	2012	2007	2012	2007	2012	2007	2012	2007	2012	2007
**Lilaeopsis ruthiana*	Turf	100	100	0 - 3.3	0.2 - 3.1	2	2	5	4				
**Pilularia novae-hollandiae*	Turf	20		0 - 1.6		1		1					
Ranunculus limosella	Turf		20		1.1 - 1.1		1		1				
Triglochin striata	-	20		0.8 - 1		1		1					
Elodea canadensis	Exotic	100	100	1 - 4.7	1.0 - 4.6	1	3	6	6	0.2	0.3	0.5	0.6
**Ranunculus trichophyllus*	Exotic	20		0 - 0.4		1		1		0.3		0.4	
Ruppia polycarpa	-	20	40	1 - 2	0.5 - 2.0	1	1	2	1		0.1		0.1
Myriophyllum triphyllum	Milfoil	80	20	0.5 - 4.1	2.2 - 2.2	1	1	3	1	0.4		1.1	0.1
Myriophyllum propinquum	Milfoil	20		1.1 - 2.3		1		1		0.1		0.1	
Potamogeton cheesemanii	Pondweed	100	100	0.5 - 5	0.5 - 4.0	1	1	2	3	0.3	0.3	0.6	0.8
**Chara australis*	Charophyte	100	100	2.2 - 15.2	2.0 - 11.5	6	5	6	6	0.3	0.4	0.4	0.7
Chara fibrosa	Charophyte	100	60	0.2 - 5.3	0.6 - 4.1	3	3	6	6				
Chara globularis	Charophyte	80	40	2 - 10.2	1.4 - 4.6	4	1	6	3	0.3	0.2	0.4	0.2
**Nitella leonhardii*	Charophyte		40		0.5 - 2.2		1, 3		6				
**Nitella* sp. aff. *cristata*	Charophyte	20		3.1 - 6.6		1		2					
**Nitella tricellularis*	Charophyte	100	80	0.2 - 6.1	0.5 - 11.5	1	5	3	6		0.1		0.1
Nitella hyalina	Charophyte	100	100	0.5 - 6	0.5 - 5.0	1	2	4	6		0.1		0.2
Nitella pseudoflabellata	Charophyte	100	100	0.5 - 6	0.4 - 5.6	1	1	3	4		0.1		0.2
Nitella subtilissima	Charophyte	20		1.1 - 6.1		2		3					

Summary for Lake Clearwater based on the 2012 and 2007 surveys at 3 sites. Heights not shown for species <0.1 m tall, or where insufficient data. Cover Scale - 1=1 5%, 2=6-25%, 3=26-50%, 4=51-75%, 5= 76-95, 6=96-100. * Name changes or new species since 1982.

Species	LakeSPI plant type	% of Profiles		Depth Range (m)		Median cover		Maximum cover		Average height (m)		Maximum height (m)	
		2012	2007	2012	2007	2012	2007	2012	2007	2012	2007	2012	2007
Elatine gratioloides	Turf	67	33	0.5 - 0.8	0.3 - 0.3	1	1	1	1				
**Glossostigma diandrum*	Turf	33	33	0.3 - 0.5	0.1 - 0.3	1	1	1	1				
**Lilaeopsis ruthiana*	Turf	67	67	0.5 - 1.3	0.1 - 0.6	1, 2	1	3	2				
Eleocharis pusilla	Turf	33		0.5 - 0.5		3		4					
**Pilularia novae-hollandiae*	Turf	33		0.5 - 0.6		1		3					
Ranunculus limosella	Turf	33		0.5 - 0.5		1		1					
**Isoetes alpina*	Isoetes	100	100	0.5 - 2.3	0.1 - 2.0	3	1	6	6				
Elodea canadensis	Exotic	100	100	1 - 5.5	0.3 - 6.1	1	1	5	6	0.5	0.6	1	2
Ruppia polycarpa	-	33		0.5 - 0.8		1		1		0.1		0.1	
Myriophyllum triphyllum	Milfoil	100	67	0.5 - 3	0.1 - 1.3	1	1, 2	4	2	0.2	0.1	0.5	0.1
Potamogeton cheesemanii	Pondweed	100	100	1 - 3.5	0.4 - 3.5	1	1	1	4		0.3	0.5	1
Potamogeton ochreatus	Pondweed	100		0.5 - 3.5		1		1		0.1		0.5	
**Chara australis*	Charophyte	100	100	1 - 6	1.2 - 7.0	4	5	6	6	0.3	0.3		0.5
Chara fibrosa	Charophyte	100	100	0.5 - 5	0.4 - 4.5	2	2	6	6		0.1		0.2
**Nitella masonae*	Charophyte	33	33	0.5 - 2.5	0.1 - 1.5	3	1	6	1		0.1		0.1
**Nitella tricellularis*	Charophyte		33		0.1 - 0.3		1		1				
Nitella hyalina	Charophyte	100	100	0.2 - 1.6	0.0 - 2.0	1	1	1	4		0.1		0.1
**Nitella leonhardii*	Charophyte	100	100	0.5 - 6	0.4 - 4.8	4	3	6	6		0.4		0.5
Nitella pseudoflabellata	Charophyte	33	100	1 - 2	0.1 - 4.2	1	1	6	5		0.1		0.2

Summary for Lake Denny based on the 2012 and 2007 surveys at 4 sites. Heights not shown for species <0.1 m tall, or where insufficient data. Cover Scale - 1=1-5%, 2=6-25%, 3=26-50%, 4=51 75%, 5=76-95, 6=96-100%.

Species	LakeSPI plant type	% of Profiles		Depth Range (m)		Median cover		Maximum cover		Average height (m)		Maximum height (m)	
		2012	2007	2012	2007	2012	2007	2012	2007	2012	2007	2012	2007
Carex sp.	-	25	25	0 - 0.5	0.0 - 0.0	2	5	6	6	0.5	0.5	0.5	0.5
Ranunculus limosella	Turf	25	50	0.1 - 0.5	0.1 - 0.3	3	1, 3	5	4				
Elodea canadensis	Exotic	100	100	0.3 - 1.5	0.2 - 2.1	5	6	6	6	0.1	0.5	0.5	0.5
**Ranunculus trichophyllus*	Exotic	75	25	0.3 - 1.5	0.2 - 0.3	1	1	1	2	0.5	0.3	1	0.3
Myriophyllum triphyllum	Milfoil	100	75	0.5 - 1.5	0.5 - 2.1	2	1	6	6	1.4	1.4	1.5	2.1
**Nitella tricellularis*	Charophyte	25		0.1 - 0.5		1		1					
Typha orientalis	Emergent	25		0 - 0.5		3		6			1		1

Summary for Lake Donne based on the 2012 and 2007 survey at 2 sites. Heights not shown for species <0.1 m tall, or where insufficient data. Cover Scale - 1=1-5%, 2=6-25%, 3=26-50%, 4=51-75%, 5=76-95, 6=96-100%.

Species	LakeSPI plant type	% of Profiles		Depth Range (m)		Median cover		Maximum cover		Average height (m)		Maximum height (m)	
		2012	2007	2012	2007	2012	2007	2012	2007	2012	2007	2012	2007
**Lilaeopsis ruthiana*	Turf	50	50	0.8 - 1.5	0.3 - 0.5	3	2	3	3				
Ranunculus limosella	Turf	100	50	0.8 - 1.5	0.2 - 0.2	2	1	4	1				
**Crassula sinclairii*	Turf	50		0.8 - 1.2		2		3					
Eleocharis pusilla	Turf	50		0.8 - 1.5		1		3					
**Glossostigma diandrum*	Turf	50		0.6 - 1.5		1		1					
Limosella lineata	Turf	50		0.6 - 1.2		1		1					
**Lobelia perpusilla*	Turf	50		0.6 - 1		1		1					
Myriophyllum propinquum	Milfoil	50	50	1 - 1.5	0.1 - 0.3	1	2	3	3				0.1
Myriophyllum triphyllum	Milfoil	100	100	0.8 - 2	0.2 - 1.0	3	2	6	4	1	0.3	2	0.5
Potamogeton cheesemanii	Pondweed	100	100	0.6 - 2	0.3 - 1.0	1	2	3	2	0.6	0.3	1.5	0.5
Chara fibrosa	Charophyte	100	50	1 - 2	0.2 - 0.7	2	1	6	1	0.3	0.1	0.3	0.1
Nitella pseudoflabellata	Charophyte	100	50	0.8 - 2	0.1 - 1.0	3	4	5	6	0.3	0.1	0.5	0.2
**Nitella tricellularis*	Charophyte		50		0.2 - 0.5		1		2				0.1
**Nitella masonae*	Charophyte	50		0.8 - 1.5		1		2		0.3		0.3	

Summary for Lake Emily based on the 2012 and 2007 survey at 4 sites. Heights not shown for species <0.1 m tall, or where insufficient data. Cover scale - 1=1 5%, 2=6-25%, 3=26-50%, 4=51-75%, 5=76-95, 6=96-100%.

Species	LakeSPI plant type	% of Profiles		Depth Range (m)		Median cover		Maximum cover		Average height (m)		Maximum height (m)	
		2012	2007	2012	2007	2012	2007	2012	2007	2012	2007	2012	2007
Carex species	-	25		0 - 0.3									
Elatine gratioloides	Turf	25	25	0.5 - 1.5	0.2 - 0.3	1	1	1	1				
Eleocharis pusilla	Turf	50	50	0.3 - 0.8	0.0 - 0.4	2	1	4	2				
Glossostigma elatinoides	Turf		25		0.9 - 0.9		1		1				
Glossostigma cleistanthum	Turf	75		0.3 - 1.5		1		2					
**Glossostigma diandrum*	Turf	25		0.5 - 0.5		1		1					
**Lilaeopsis ruthiana*	Turf	75	50	0.2 - 1.2	0.0 - 0.4	2	1, 2	6	2				
**Pilularia novae-hollandiae*	Turf	25		0.2 - 0.5		1		1					
Ranunculus limosella	Turf	50	25	0.3 - 1.2	0.1 - 0.5	1	2	2	4				
**Isoetes alpina*	Isoetes	25	25	0.6 - 1.7	0.3 - 1.6	4	5	6	6				0.1
Elodea canadensis	Exotic	100	100	0.3 - 2.3	0.2 - 2.3	6	5	6	6	0.7	0.9	1.5	1.3
Myriophyllum triphyllum	Milfoil		50		0.0 - 0.3		1		2				
Myriophyllum propinquum	Milfoil	25		0.3 - 0.4		2		3					
Potamogeton cheesemanii	Pondweed	75	50	0.4 - 2	0.1 - 1.4	1	1	1	2	0.3	0.2	1	0.2
Potamogeton ochreatus	Pondweed		75		0.5 - 2.1		1		1		0.3		0.3
Nitella pseudoflabellata	Charophyte	25		0.3 - 0.3		1		1					

Summary for Lake Emma based on the 2012 and 2007 survey at 4 sites. Heights not shown for species <0.1 m tall, or where insufficient data. Cover Scale - 1=1-5%, 2=6-25%, 3=26-50%, 4=51-75%, 5=76-95, 6=96-100%.

Species	LakeSPI plant type	% of Profiles		Depth Range (m)		Median cover		Maximum cover		Average height (m)		Maximum height (m)	
		2012	2007	2012	2007	2012	2007	2012	2007	2012	2007	2012	2007
**Lilaeopsis ruthiana*	Turf	75	100	0.5 - 1.1	0.1 - 1.3	1	1, 2	2	3				
Ranunculus limosella	Turf	25	25	0.5 - 1	0.4 - 0.4	1	1	2	1				
**Isoetes alpina*	Isoetes	75	75	0.6 - 1.7	0.3 - 1.5	5	3	6	6				
Elodea canadensis	Exotic	100	100	0.5 - 2.7	0.3 - 2.8	5	2, 3	6	6	0.7	0.2	1.5	1.0
Potamogeton crispus	Exotic	25		1.5 - 2.2		1		1				1.5	
**Ranunculus trichophyllus*	Exotic	100	100	1 - 2.4	0.2 - 2.5	1	1	1	2	0.7	0.2	1.5	0.5
Myriophyllum triphyllum	Milfoil	75	50	1 - 2.2	1.6 - 2.3	1	1	2	2	1.0	1.0	1.0	1.5
Potamogeton cheesemanii	Pondweed	25	50	2.2 - 2.5	1.6 - 2.3	1	1	1	1	0.1		0.2	0.1
Potamogeton ochreatus	Pondweed	75		1 - 2.5		1		1		0.1		0.2	
Chara australis	Charophyte		25		0.6 - 0.7		1		1				0.1
Chara globularis	Charophyte	25		2		1		1					
**Nitella masonae*	Charophyte	25	50	1 - 1.4	0.2 - 1.6	1	1	1	2		0.1		0.1
**Nitella tricellularis*	Charophyte	75	75	0.5 - 2.2	0.5 - 1.4	1	1	4	2		0.1		0.1
Nitella hyalina	Charophyte	75	75	0.8 - 1.7	0.2 - 1.6	1	1	1	1				

Summary for Lake Heron based on the 2012 at 5 sites and 2007 survey at 6 sites. Heights not shown for species <0.1 m tall, or where insufficient data. Cover Scale - 1=1-5%, 2=6-25%, 3=26-50%, 4=51-75%, 5= 76-95, 6=96-100. * Name changes or new species since 1982.

Species	LakeSPI plant type	% of Profiles		Depth Range (m)		Median cover		Maximum cover		Average height (m)		Maximum height (m)	
		2012	2007	2012	2007	2012	2007	2012	2007	2012	2007	2012	2007
**Crassula sinclairii*	Turf	20	17	3 - 3.5	0.8 - 0.8	1	1	1	1				
Eleocharis pusilla	Turf	40	17	0.5 - 1.5	0.5 - 1.0	1, 3	1	3	6				
**Glossostigma diandrum*	Turf	60	50	0.3 - 1	0.1 - 1.8	1	1	2	1				
**Lilaeopsis ruthiana*	Turf	60	67	0.6 - 1.9	0.3 - 2.0	2	1	3	2				
Ranunculus limosella	Turf	60	33	0.6 - 1.9	0.4 - 1.0	1	1	2	2				
**Pilularia novae-hollandiae*	Turf	20		0.5 - 0.6		1		1					
**Isoetes alpina*	Isoetes	80	50	0.3 - 4.3	0.1 - 3.2	2, 5	6	6	6	0.2	0.2	0.2	0.2
Triglochin striata	-	20		0.4 - 0.7		3		4		0.1		0.1	
Ruppia polycarpa	-	40	50	1.1 - 1.9	0.3 - 1.0	1	1	2	2				
Elodea canadensis	Exotic	100	100	0.6 - 7.5	0.4 - 7.5	5	5	6	6	0.2	0.2	1	0.6
**Ranunculus trichophyllus*	Exotic	60	33	1.3 - 4.1	1.0 - 1.2	1	1	2	3	0.7	0.2	0.8	0.2
Myriophyllum propinquum	Milfoil												
Myriophyllum triphyllum	Milfoil	100	100	1 - 5.2	0.2 - 4.0	2	2	6	5	0.6	0.7	1.5	2
Potamogeton cheesemanii	Pondweed	80	83	0.4 - 5	0.5 - 4.1	1	1	3	4	0.2	0.2	0.3	1
Potamogeton ochreatus	Pondweed	20	17	1.2 - 2.4	0.7 - 1.5	1	1	2	1	0.1	0.1	0.3	0.2
**Chara australis*	Charophyte	100	33	1.2 - 8.4	0.7 - 4.7	4	3, 5	6	6	0.3	0.3	0.5	0.3
Chara fibrosa	Charophyte	40	33	2 - 4.4	1.5 - 2.1	1, 2	1, 3	4	5	0.2	0.2	0.2	0.2
Chara globularis	Charophyte	40	17	1.2 - 7.3	6.5 - 9.0	1, 5	6	6	6	0.3		0.5	
**Nitella tricellularis*	Charophyte	80	100	0.5 - 9.8	0.3 - 8.5	3	1, 2	6	6	0.3	0.2	0.5	0.3
**Nitella claytonii*	Charophyte		33		6.0 - 9.7		2, 6		6				
Nitella hyalina	Charophyte	80	50	1.1 - 5.6	1.4 - 6.0	1, 2	1	3	2	0.1	0.1	0.1	0.1
Nitella pseudoflabellata	Charophyte	60	67	1.2 - 5	0.4 - 6.0	1	1	2	3		0.1		0.5
Nitella stuartii	Charophyte	20	17	1.3 - 2.2	5.4 - 6.0	1	1	1	2		0.1		0.1

Summary for Maori Lake East based on the 2012 and 2007 survey at 3 sites. Heights not shown for species <0.1 m tall, or where insufficient data. Cover Scale - 11=1-5%, 2=6-25%, 3=26-50%, 4=51-75%, 5=76-95, 6=96-100%.

Species	LakeSPI plant type	% of Profiles		Depth Range (m)		Median cover		Maximum cover		Average height (m)		Maximum height (m)	
		2012	2007	2012	2007	2012	2007	2012	2007	2012	2007	2012	2007
Typha orientalis	Emergent	67	67	0 - 1	0.0 - 0.5	3, 6	3, 6	6	6	1.8	1.4	1.8	1.8
unidentified mosses & liverworts	-		33		0.5 - 0.5		1		1				
Eleocharis pusilla	Turf	33	33	0.1 - 0.3	0.0 - 0.2	3	3	3	5				
Limosella lineata	Turf		33		0.0 - 0.2		1		2				
Ranunculus limosella	Turf	33	33	0.1 - 0.3	0.0 - 0.2	1	1	2	2				
Ruppia polycarpa	-	33	33	0.3 - 0.7	0.0 - 0.2	1	1	3	2	0.1		0.1	
Elodea canadensis	Exotic	100	100	0.3 - 1.3	0.3 - 0.8	1	1	1	1	0.1	0.1	0.1	0.1
Myriophyllum triphyllum	Milfoil	67	33	0.1 - 1.3	0.0 - 0.2	1	1	2	2	0.1		0.1	
Potamogeton cheesemanii	Pondweed	100	100	0.3 - 1.3	0.1 - 0.8	1	1	1	1	0.1	0.1	0.1	0.1
Potamogeton ochreatus	Pondweed	100		0.3 - 1.3		1		1		0.1		0.1	

Summary for Maori Lake West based on the 2012 and 2007 survey at 3 sites. Heights not shown for species <0.1 m tall, or where insufficient data. Cover Scale - 1=1-5%, 2=6-25%, 3=26-50%, 4=51-75%, 5=76-95, 6=96-100%.

Species	LakeSPI plant type	% of Profiles		Depth Range (m)		Median cover		Maximum cover		Average height (m)		Maximum height (m)	
		2012	2007	2012	2007	2012	2007	2012	2007	2012	2007	2012	2007
Typha orientalis	Emergent	*67*	67	0-0.6	0.0 - 0.8		2, 6	6	6		1.9		2
**Utricularia dichotoma*	Turf		33		0.1 - 0.3		3		4				
Elodea canadensis	Exotic	100	100	0.6 - 2.2	0.8 - 2.1	5	3	6	6	0.7	0.7	1.1	1.3
Myriophyllum triphyllum	Milfoil	33	100	1.5 - 1.5	0.5 - 2.1	1	2	1	6		0.4	0.3	0.8
Potamogeton cheesemanii	Pondweed	33	100	1.2 - 1.7	0.5 - 1.8	1	1	1	3	0.2	0.3	0.3	1
Potamogeton ochreatus	Pondweed	67	33	1.5 - 1.7	1.2 - 1.3	1	1	1	2	0.1	0.2	0.3	1
Chara australis	Charophyte	67	67	1.4 - 1.7	0.5 - 1.7	1, 6	1	6	4		0.1	1	0.1
Chara fibrosa	Charophyte		67		0.5 - 1.7		1, 5		6		0.2		0.2
**Nitella leonhardii*	Charophyte	33	67	1.5 - 1.7	0.5 - 1.8	1	1	2	3		0.2		0.2
Nitella pseudoflabellata	Charophyte	67	67	1.2 - 1.4	0.3 - 1.8	1	1, 3	2	6		0.2		0.3
**Nitella tricellularis*	Charophyte	33		0.6 - 1.5		1		1					

Summary for Lake Roundabout based on the 2012 and 2007 survey at 2 sites. Heights not shown for species <0.1 m tall, or where insufficient data. Cover Scale - 1=1-5%, 2=6-25%, 3=26-50%, 4=51-75%, 5=76-95, 6=96-100%.

Species	LakeSPI plant type	% of Profiles		Depth Range (m)		Median cover		Maximum cover		Average height (m)		Maximum height (m)	
		2012	2007	2012	2007	2012	2007	2012	2007	2012	2007	2012	2007
**Lilaeopsis ruthiana*	Turf	50	100	0.3 - 0.5	0.2 - 1.0	1	1, 2	2	4				
Ranunculus limosella	Turf	100	100	0.3 - 1.3	0.2 - 1.0	1, 2	1, 3	2	3				
Elodea canadensis	Exotic	100	100	0.4 - 1.8	0.2 - 1.5	5	5, 6	6	6	0.3	0.4	0.5	0.5
**Ranunculus trichophyllus*	Exotic	100	100	0.3 - 1.8	0.2 - 1.1	3	1, 2	6	6	1	0.3	1.2	1
Myriophyllum triphyllum	Milfoil	100	100	1 - 1.8	0.2 - 1.5	2	1, 2	3	5	1	1.5	1.2	1.5
Potamogeton ochreatus	Pondweed	100	100	0.5 - 1.8	0.6 - 0.8	1	1	1	2	0.3	0.4	0.5	0.5
**Nitella masonae*	Charophyte		50		0.2 - 1.0		1		1		0.1		0.1
**Nitella tricellularis*	Charophyte		100		0.2 - 1.0		1		1				
Nitella hyalina	Charophyte	50		0.3 - 0.3		1		1		0.1		0.1	

Summary for Spider Lake (main) based on the 2012 and 2007 survey at 2 sites. Heights not shown for species <0.1 m tall, or where insufficient data. Cover Scale - 1=1-5%, 2=6-25%, 3=26-50%, 4=51-75%, 5=76-95, 6=96-100%.

Species	LakeSPI plant type	% of Profiles		Depth Range (m)		Median cover		Maximum cover		Average height (m)		Maximum height (m)	
		2012	2007	2012	2007	2012	2007	2012	2007	2012	2007	2012	2007
Eleocharis pusilla	Turf	100	50	0.5 - 0.8	0.2 - 0.2	2	1	3	1				
Limosella lineata	Turf		50		0.2 - 0.3		2		3				
**Lilaeopsis ruthiana*	Turf	50	100	0.5 - 1	0.1 - 0.4	2	2	4	6				
Ranunculus limosella	Turf		50		0.2 - 0.3		2		3				
Elodea canadensis	Exotic	100	50	1 - 1.5	0.5 - 0.8	1	1	1	3	0.1	0.2	0.3	0.2
**Ranunculus trichophyllus*	Exotic		50		0.2 - 0.3		1		1				0.2
Myriophyllum propinquum	Milfoil	50	100	1 - 1.2	0.1 - 0.5	1	2	4	4	0.1		0.1	0.1
Myriophyllum triphyllum	Milfoil	100	100	0.8 - 1.5	0.1 - 0.8	2	2	5	4	0.5	0.3	1	0.4
Potamogeton cheesemanii	Pondweed	100	100	0.8 - 1.5	0.1 - 0.8	2	2	2	4	0.5	0.2	0.5	0.4
Potamogeton ochreatus	Pondweed	100	50	1 - 1.5	0.1 - 0.8	1	1	1	3	0.3	0.2	0.3	0.4
Ruppia polycarpa	-	100	50	1 - 1.5	0.2 - 0.3	2	1	4	2	0.2		0.3	0.2
**Chara* sp. aff. *muelleri*	Charophyte		50		0.3 - 0.3		1		1				
Chara fibrosa	Charophyte	100	50	1 - 1.2	0.1 - 0.5	2	1	6	2	0.3	0.1	0.3	0.1
Nitella pseudoflabellata	Charophyte	100	50	0.8 - 1.5	0.1 - 0.4	1	1	2	2	0.2	0.3	0.3	0.3
**Nitella tricellularis*	Charophyte	100	100	0.8 - 1	0.2 - 0.5	1	1	1	1	0.1		0.1	0.1
**Nitella masonae*	Charophyte	100			0.8 - 1	1		1		0.1		0.2	
Nitella hyalina	Charophyte	50		1 - 1		1		2		0.2		0.2	

Summary for Spider Lake East based on the 2012 and 2007 survey at 1 site. Heights not shown for species <0.1 m tall, or where insufficient data. Cover Scale - 1=1-5%, 2=6-25%, 3=26-50%, 4=51-75%, 5=76-95, 6=96-100%.

Species	LakeSPI plant type	% of Profiles		Depth Range (m)		Median cover		Maximum cover		Average height (m)		Maximum height (m)	
		2012	2007	2012	2007	2012	2007	2012	2007	2012	2007	2012	2007
Eleocharis pusilla	Turf	100		0.8		1		4					
Limosella lineata	Turf	100		0.5-1.0		2		3					
Ranunculus limosella	Turf	100		0.5-1.0		2		4					
Ruppia polycarpa	-	100		0.8-1.3		1		3		0.2		0.2	
**Ranunculus trichophyllus*	Exotic	100	100	0.8-1.3	0 - 0.8	2	2	4	2	0.5	0.5	1	0.8
Myriophyllum triphyllum	Milfoil	100	100	0.8	0 - 0.8	1	2	1	4	0.1	0.5	0.1	0.8
Myriophyllum propinquum	Milfoil	100		1		1		2		0.1		0.1	
Potamogeton cheesemanii	Pondweed	100	100	0.8-1.3	0 - 0.8	1	3	1	5	0.3	0.5	1	0.8
Potamogeton ochreatus	Pondweed	100		0.8-1.3		4		6		0.3		0.3	
**Chara sp.* aff. *muelleri*	Charophyte		100		0 - 0.8		2		3		0.1		0.1
Nitella pseudoflabellata	Charophyte	100	100	0.5-1.3	0 - 0.8	4	2	6	2	0.3	0.1	0.3	0.1
**Nitella tricellularis*	Charophyte		100		0 - 0.8		1		1		0.1		0.1
Nitella hyalina	Charophyte		100		0 - 0.8		1		2		0.1		0.1