

Assessment of lakes in the Hawke's Bay Region using LakeSPI

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Executive summary

NIWA was contracted by the Hawke's Bay Regional Council to assess the condition of eight lakes within the Hawke's Bay Region in the 2016/17 summer using LakeSPI (Submerged Plant Indicators).

This report presents LakeSPI results for eleven lakes in the Hawke's Bay region that have been surveyed using LakeSPI to date. This includes the eight lakes surveyed for this contract: Hatuma (Whatumā), Oingo, Poukawa, Rotongaio, Rotoroa, Rotonuiaha, Runanga and Whakaki; and three additional lakes: Kaweka West, Waikaremoana and Waikareiti, where LakeSPI results were already available.

LakeSPI indices for the lakes of the Hawke's Bay Region ranged widely from 0% to 79%, with one lake assessed as being in 'excellent' condition, one in 'high' condition, four in 'poor' condition and four as 'non-vegetated'. Another was found unsuitable for assessment using the LakeSPI methodology due to its shallow depth (<1 m).

Lake Kaweka West is currently the highest ranked lake in the Hawke's Bay region and it is categorised in 'excellent' condition according to LakeSPI. It is the best example of a waterbody that still remains in an all-native vegetated state in the region, most likely on account of its remote location and difficult access.

Lake Waikaremoana is categorised in 'high' condition and has one of the best examples of diverse aquatic vegetation in a large, deep, clear lake in the North Island, with little apparent impact from invasive pest species. The presence of the invasive weed *Lagarosiphon major* remains a major concern for future lake condition should it continue to spread.

The Putere lakes (Rotonuiaha, Rotoroa and Rotongaio) and Lake Oingo were all categorised in 'poor' condition. These lakes were all dominated by an invasive species with little or no native vegetation remaining. Lakes Rotonuiaha and Rotoroa were both noted to have good water clarity at the time of the recent survey but were being heavily impacted on by the submerged weed, hornwort. Lake Rotongaio sits on the cusp between being vegetated and non-vegetated on account of some sites having no vegetation. While invasive species are not favourable in terms of overall lake condition, the presence of any submerged plants in a lake is noted as preferable to none.

Lakes Poukawa, Runanga, Whakaki and Waikareiti have all been categorised as non-vegetated. With the exception of Waikareiti, this 'non-vegetated' group of lakes represents those in the most degraded state, where water quality condition has deteriorated to the point where growth of submerged plants can no longer be supported. Submerged plants were recorded from within Lake Waikareiti in an earlier survey, but did not exceed the 10% cover threshold required to generate a LakeSPI score.

Lake Hatuma did not qualify for a LakeSPI result for this report because of its shallow depth (0.8 m). Despite this the lake had predominantly native plants extending across the entire lake bottom.

It is recommended that a schedule for LakeSPI monitoring be developed with priorities and timing of re-surveys based on perceived lake value, stability and known threats to the lakes. On average LakeSPI surveys are recommended every five years but if a lake is under pressure from a new invasive species or land-use intensification, then more frequent surveys are recommended.

1 Introduction

1.1 Background

The LakeSPI method uses submerged plants as indicators to assess the ecological condition of New Zealand lakes. It provides indices that allow lake managers to quickly assess and report on the status of their lakes at an individual, regional or national level, monitor changes occurring within an individual or group of lakes over time, and the opportunity to prioritise lake management initiatives (e.g., protection, monitoring, weed surveillance). LakeSPI is recommended by Ministry for the Environment (MFE, 2014) as one of two indicators of water quality for State of the Environment (SOE) reporting.

This report presents the results of LakeSPI surveys for eleven lakes: Hatuma, Kaweka West (Kuripapango 1), Oingo, Poukawa, Rotongaio, Rotoroa, Rotonuiaha, Runanga, Waikareiti, Waikaremoana and Whakaki. Hawke's Bay Regional Council contracted NIWA to survey eight of these lakes (Hatuma, Oingo, Poukawa, Rotongaio, Rotoroa, Rotonuiaha, Runanga and the Whakaki Lagoon) in November 2016. Lake Kaweka West was surveyed for the HBRC in April 2007. Lake Waikareiti was surveyed by Department of Conservation divers in 2009, and Lake Waikaremoana was surveyed by NIWA for Genesis Energy Ltd in February 2013.

1.2 Study lakes

The eleven Hawke's Bay lakes assessed for this report include: Hatuma, Kaweka West (Kuripapango), Oingo, Poukawa, Rotongaio, Rotoroa, Rotonuiaha, Runanga, Waikareiti, Waikaremoana and Whakaki (Figure 1-1).



Figure 1-1: Map showing location of the eleven Hawke's Bay lakes.

2 Study methods

2.1 LakeSPI

LakeSPI is a management tool that uses Submerged Plant Indicators (SPI) for assessing the ecological condition of New Zealand lakes and for monitoring changes in lakes. Key features of aquatic vegetation structure and composition are used to generate three LakeSPI indices:

- ‘Native Condition Index’ – This captures the native character of vegetation in a lake based on diversity and extent of indigenous plant communities. A higher score means a healthier, deeper, and more diverse native community.
- ‘Invasive Impact Index’ – This captures the invasive character of vegetation in a lake based on the degree of impact by invasive weed species. A higher score means more impact from exotic species, which is often undesirable.
- ‘LakeSPI Index’ – This is a synthesis of components from both the native condition and invasive impact in a lake and provides an overall indication of lake condition. The higher the score the better the condition.

Key assumptions of the LakeSPI method are that native plant species and high plant diversity represents healthier lakes or better lake condition, while invasive plants are ranked for undesirability based on their displacement potential and degree of measured ecological impact (Clayton & Edwards 2006).

Because lakes have differing physical characteristics that can influence the extent and type of submerged vegetation, each of the LakeSPI indices are expressed in this report as a percentage of a lake’s maximum scoring potential. Scoring potential reflects the maximum depth of the lake to normalise the results from very different types of lakes. A lake scoring full points for all LakeSPI indicator criteria would result in a LakeSPI Index of 100%, a Native Condition Index of 100% and an Invasive Impact Index of 0%.

A complete description of measured characteristics can be found in the LakeSPI user manual at www.lakespi.niwa.co.nz/about. The LakeSPI method is supported by a web-reporting service www.lakespi.niwa.co.nz, which provides LakeSPI results in the form of an individual lake report card. To date, LakeSPI has been used to assess 283 lakes within New Zealand. This secure and freely-accessible data repository allows agencies to compare lake scores with other lakes regionally and nationally as required.

2.2 Field surveys

The LakeSPI method (Clayton and Edwards 2006, de Winton et al. 2012) was applied to 4-5 selected (baseline) sites within each of the 11 lakes between April 2007 and November 2016. Baseline sites were selected to be representative of maximal vegetation development and situated away from local influences such as streams.

At each LakeSPI site, divers recorded relevant vegetation characteristics on data sheets. A full description of the vegetation features assessed for LakeSPI can be found in the LakeSPI User Manual at www.lakespi.niwa.co.nz, but include measures of diversity from the presence of key plant communities, the depth extent of vegetation and the extent that invasive weeds are represented.

Observations were then entered into the NIWA LakeSPI database to calculate LakeSPI indices for each lake. Additionally an inventory of all submerged plant species encountered was made.

Lake maximum depths recorded at the start of each lake section, represent the maximum depth located at the time of survey if depth information was unavailable.

2.3 LakeSPI status

For ease of reporting results, five lake condition categories are used to provide a description of lake status and are allocated according to the LakeSPI Index score:

Score = LakeSPI Category

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

3 LakeSPI report cards

LakeSPI results for each lake are summarised in Table 1, with the indices presented as a percentage of maximum scoring potential.

Table 3-1: Summary of LakeSPI results. Data summarised for eleven Hawke’s Bay lakes in order of their overall lake condition.

Lake	Most Recent LakeSPI Survey	LakeSPI Index (%)	Native Condition Index (%)	Invasive Impact Index (%)	Overall Condition
Kaweka West	03/04/2007	79	61	0	Excellent
Waikaremoana	26/02/2013	74	77	26	High
Rotonuiaha	08/11/2016	17	11	95	Poor
Rotoroa	08/11/2016	13	6	97	
Oingo	09/11/2016	12	0	89	
Rotongaio	08/11/2016	11	0	47	
Poukawa	10/11/2016	0	0	0	Non-vegetated
Runanga	09/11/2016	0	0	0	
Waikareiti	09/05/2009	0	0	0	
Whakaki	07/11/2016	0	0	0	
Hatuma (Whatumā)	09/11/2016	Too shallow for assessment using LakeSPI			

In the following section, LakeSPI results are presented and the lakes are discussed in order of their LakeSPI Index scores, beginning with the highest ranked lake.

3.1 Lake Kaweka West (Kuripapango 1, The Lakes)

3.1.1 Results



Lake condition:	Excellent
Lake ranking:	1 st
Lake maximum depth:	12.6 m
Max depth of vegetation:	8.1 m

Kaweka West Lake Submerged Plant Indicators

Survey Date	Status	LakeSPI %	Native Condition %	Invasive Impact %
April 2007	Excellent	79% 	61% 	0%

Figure 3-1: LakeSPI results for Lake Kaweka West.

Lake Kaweka West is categorised in excellent condition with a LakeSPI Index of 79% (Figure 3-1).

The high LakeSPI Index generated for this lake in 2007 reflected the presence of a well-developed native plant community (Native Condition Index of 61%) and the absence of any invasive weed species at baseline sites (de Winton & Champion, 2007).

The lake vegetation was dominated by three species of native charophyte (freshwater macroalgae) which typically formed 100% cover ‘meadows’ from the lake edge to a maximum depth of 8.1 m. Meadows comprised a deeper zone of *Chara australis* with beds that extended from between 3 and 7 m to an abrupt boundary at the vegetation limit between 7.8 and 8.1 m depth (Figure 3-2). The shallow water charophyte meadow was dominated by *Chara globularis*, with extensive patches of *Chara fibrosa*, and *C. australis* was also common. Vascular submerged species were limited to occasional shallow plants of *Myriophyllum triphyllum* and *Potamogeton ochreatus* to 1 m depth.

Other less common submerged species recorded outside of the survey sites included a native *Callitriche* sp. (most likely *C. petriei*), *Myriophyllum propinquuum* and the seed-spread weed, *Ranunculus trichophyllus*. A species list of marginal and turf species was also made at the time of survey and included five species designated as threatened (de Winton & Champion, 2007).

Historic notes: A visit to the lake by Druce (in Clarkson and Druce 1984), recorded, in addition to the plants described above, two seed-spread submerged weeds *Ottelia ovalifolia* and *Potamogeton crispus*. These were not observed at the time of the 2007 survey. This earlier visit in 1984 did not provide sufficient information for a LakeSPI assessment.

3.1.2 Discussion

Lake Kaweka West is the best example of a waterbody in the Hawke's Bay Region that remains in an all-native vegetated state. This is most likely due to the lakes isolation and difficult access with forestry controlled locked gates providing a good measure of protection against incidental weed introductions.

Furthermore, a large reduction in the water level noted at the time of 2007 survey likely affected the current LakeSPI scores. During a higher water regime the LakeSPI Index could have been expected to exceed 90% (de Winton & Champion, 2007).

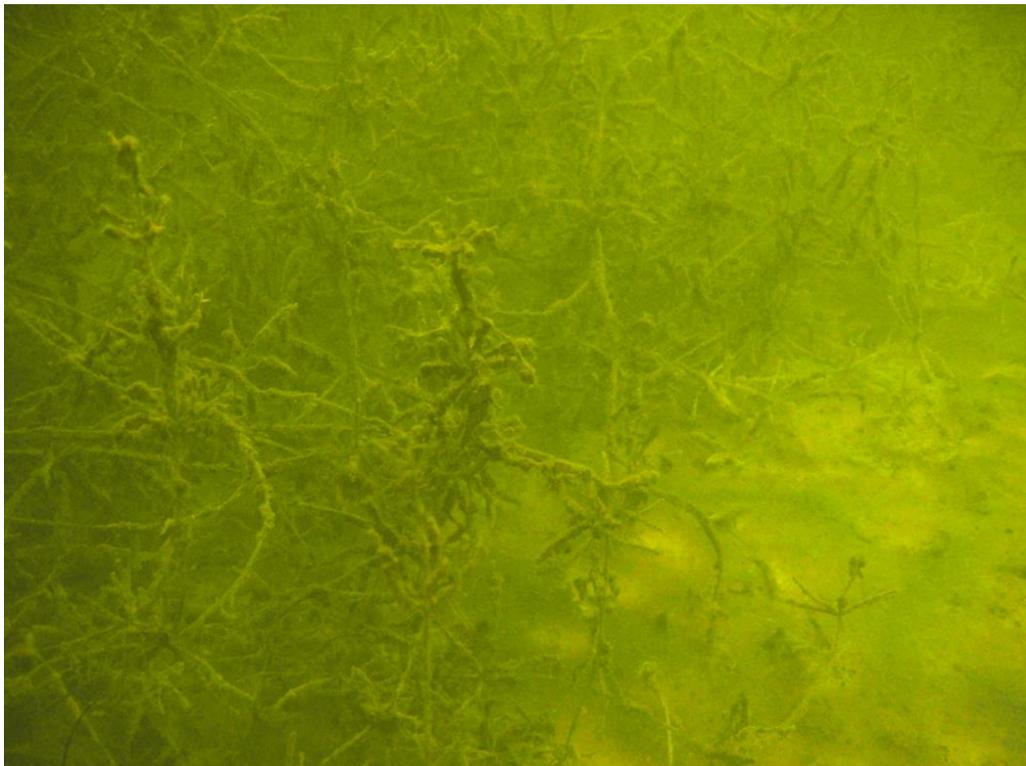


Figure 3-2: Bottom depth boundary of *Chara australis* at 8 m depth in Kaweka West.

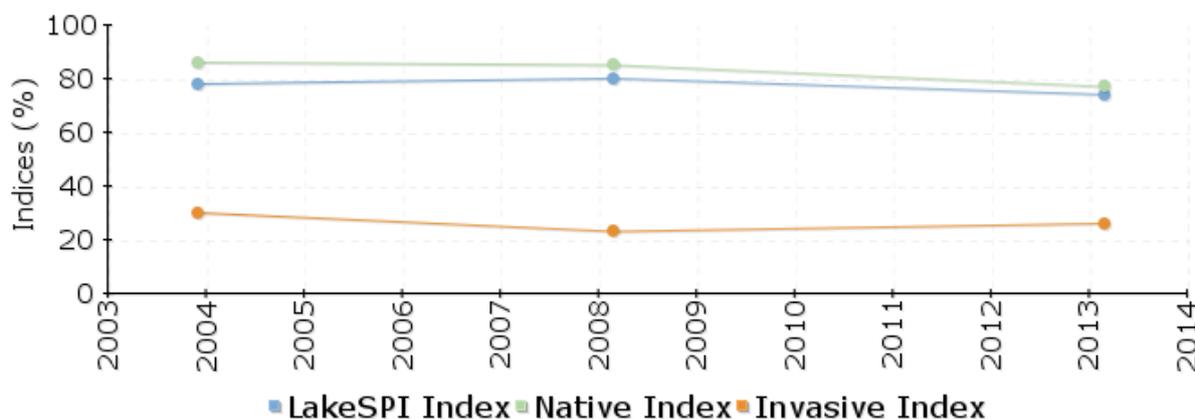
3.2 Lake Waikaremoana

3.2.1 Results



Lake condition:	High
Lake ranking:	2 nd
Lake maximum depth:	248 m
Max depth of vegetation:	21.1 m

Waikaremoana Lake Submerged Plant Indicators



Survey Date	Status	LakeSPI %	Native Condition %	Invasive Impact %
February 2013	High	74%	77%	26%
February 2008	Excellent	80%	85%	23%
November 2003	Excellent	78%	86%	30%

*2013 survey completed with funding from Genesis Energy Ltd.

Figure 3-3: LakeSPI results for Lake Waikaremoana.

Lake Waikaremoana is categorised as being in high condition with a LakeSPI Index of 74% (Figure 3-3).

A high Native Condition Index of 77% (Figure 3-3) reflects the high diversity of native species in Lake Waikaremoana, with little apparent impact from invasive weed species (Wells and de Winton, 2013).

Twenty-two species of submerged plants were recorded during the 2013 survey. A well-developed low growing turf community (Figure 3-4) often started above the water and extended to a depth of around 3 m. The most abundant species in this community were *Isoetes kirkii*, *Lilaeopsis ruthiana*, *Eleocharis pusilla*, *Pilularia novae-hollandiae*, and *Glossostigma diandrum*. The taller growing vascular species were dominated by the invasive species, elodea (*Elodea canadensis*) in sheltered

areas, but in the main body of the lake the native milfoil *Myriophyllum triphyllum* was dominant and elodea less prevalent. The native charophyte community commonly started below the tall-growing species at about 7 m and extended to between c. 14 and 21 m deep. *Chara australis* and *Chara globularis* formed extensive underwater meadows and were the most abundant species in the lake. The nationally rarer *Nitella opaca* was the next most abundant charophyte.

3.2.2 Discussion

Lake Waikaremoana is the second highest ranked lake in the Hawke's Bay region, and has one of the best examples of diverse aquatic vegetation in a large, deep, clear lake in the North Island. This lake has similar characteristics to a pristine lake in the South Island. It has high native species diversity with little apparent impact from invasive pest plants, introduced fish, or land-use (Wells and de Winton, 2013).

LakeSPI scores for Lake Waikaremoana have remained stable between consecutive surveys (Figure 3-3) indicating no significant ecological change in lake condition. Between 2003 and 2013 lake vegetation continued to occupy an average depth range of 18 -19 m, where conditions (such as slope, substrate and exposure) were favourable. Vegetation species, composition and abundance also remained similar over this time frame.

The invasive weed *Lagarosiphon major* was not found at any of the LakeSPI profiles but is present in the lake and is currently subject to an eradication program (Wells and de Winton, 2013). The presence of *Lagarosiphon major* in Lake Waikaremoana remains a major concern for the lakes future condition.



Figure 3-4: Diver surveying turf plant community in Lake Waikaremoana.

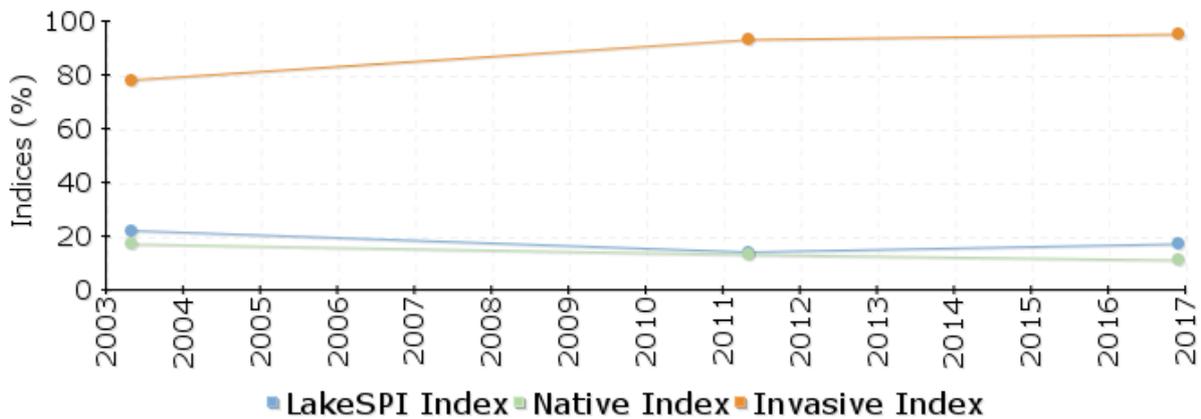
3.3 Lake Rotonuiaha

3.3.1 Results



Lake condition: Poor
 Lake ranking: 3rd
 Lake maximum depth: 30 m
 Max depth of vegetation: 16.1 m

Rotonuiaha Lake Submerged Plant Indicators



Survey Date	Status	LakeSPI %	Native Condition %	Invasive Impact %
November 2016	Poor	17%	11%	95%
April 2011	Poor	14%	13%	93%
April 2003	Moderate	22%	17%	78%

* The 2003 and 2011 surveys were based on a limited assessment of only one site.

Figure 3-5: LakeSPI results for Lake Rotonuiaha.

Lake Rotonuiaha is categorised as being in poor condition with a LakeSPI Index of 17% (Figure 3-5).

Hornwort dominated the submerged vegetation in Lake Rotonuiaha forming a dense band of weed around the lake margin extending down to between c. 9 and 16 m deep and growing up to c. 3 m tall. The invasive weeds *Elodea canadensis*, and pondweed *Potamogeton crispus* were also present but having little effect on other submerged vegetation compared to hornwort (Figure 3-6). *Elodea* formed a band of weed on the inner side of the hornwort at all sites down to a maximum depth of 5.5 m.

Five native plants were recorded including a charophyte species *Chara globularis* which formed meadows (>75% cover) at two of the five baseline sites down to a maximum depth of 2 m. Another

charophyte (*Nitella hyalina*), a native pondweed (*Potamogeton cheesemanii*), milfoil (*Myriophyllum propinquum*) and *Ruppia polycarpa* were also present growing in shallow water, less than 2 m deep (Figure 3-7). This shallow depth range and low native ratio contributed to a low Native Condition Index of 11% (Figure 3-5).

The total cover of submerged vegetation (native and invasive species) at selected LakeSPI sites in Lake Rotonuiaha, over the depth range occupied by vegetation, was estimated to be 100%.

At the time of the survey, the water in Lake Rotonuiaha was noted to be clear with through-water visibility estimated by divers to be between 4 – 5 m. Plants were clean with no signs of epiphytic algae. A Secchi disk measurement of 3.82 m was recorded from the lake centre. No freshwater mussels were observed.

Historic notes: A survey of submerged plants in Lake Rotonuiaha was carried out in 1983 (Howard-Williams et al. 1983), at which time the lake was described as having a diversity of native charophyte species (*Chara australis*, *Chara globularis*, *Nitella opaca*, *Nitella leonhardii*) extending down to a maximum depth of 4 m. Other submerged plants recorded during this time included three native species (*Potamogeton cheesemanii*, *Lilaeopsis lacustris*, *Ruppia polycarpa*), and the invasive pondweed *Potamogeton crispus*. A quick survey of the vegetation was also undertaken at one site by NIWA in April 2003, and again in 2008 and 2011. Hornwort was absent from the 2003 survey site and was noted for the first time forming high covers in 2008. By 2011 hornwort was recorded forming dense clumps down to a maximum depth of 6.6 m. Freshwater mussels were observed in the lake during all earlier (2003, 2008, 2011) surveys.

3.3.2 Discussion

The LakeSPI scores for Lake Rotonuiaha suggest that the lake has remained in a poor but stable condition over the last five years, with the full impact of hornwort having already taken place. Hornwort extended down to a maximum depth of 16.1 m during the 2016 survey reflecting the lakes good water clarity. All submerged plants in Lake Rotonuiaha were in a clean, healthy condition with no obvious signs of epiphytic algae on plants reflecting well on longer term lake stability.

An increase in the Invasive Impact Index between 2003 – 2011, from 78% to 93%, was driven by the invasion of hornwort, first recorded in the lake in 2008. Changes in the Native Condition scores were less obvious during this same time frame as elodea was already impacting on any native vegetation in the same depth range.



Figure 3-6: Hornwort formed a dense band of weed up to 3 m high in Lake Rotonuiaha.

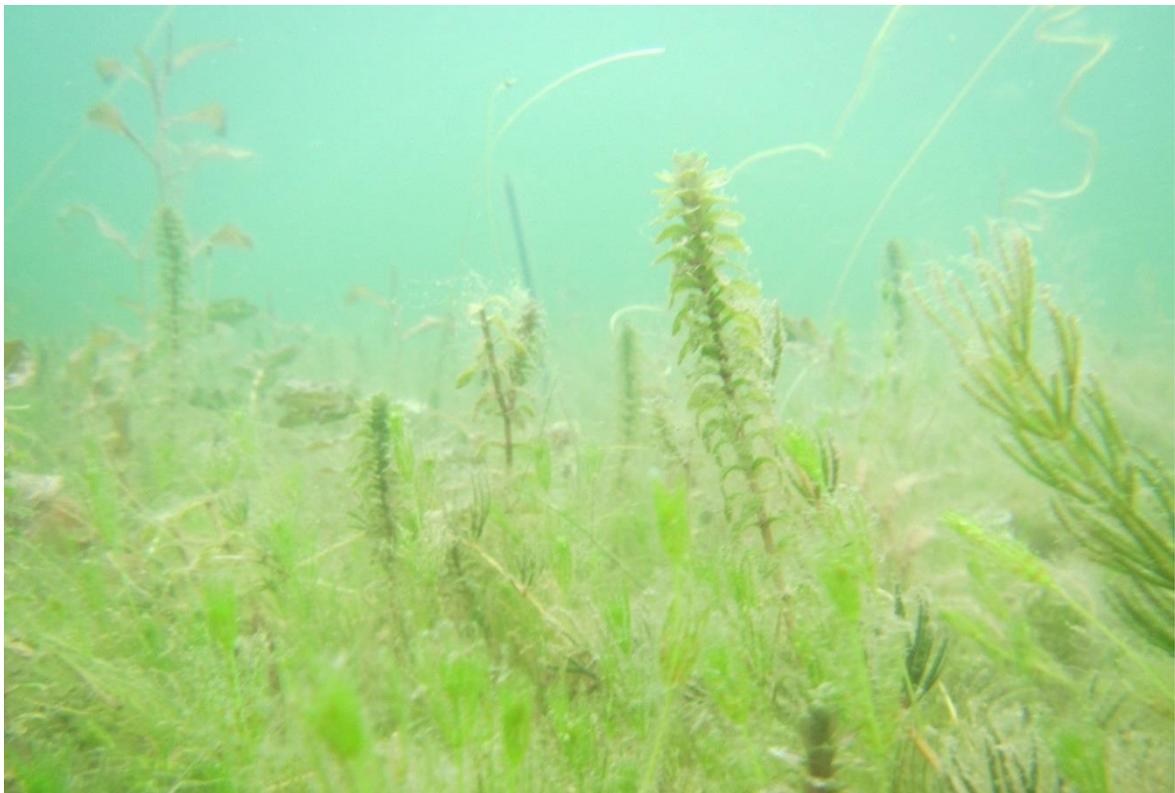


Figure 3-7: Elodea shoots (centre) and hornwort shoot (right) growing amongst native species in the shallows of Lake Rotonuiaha.

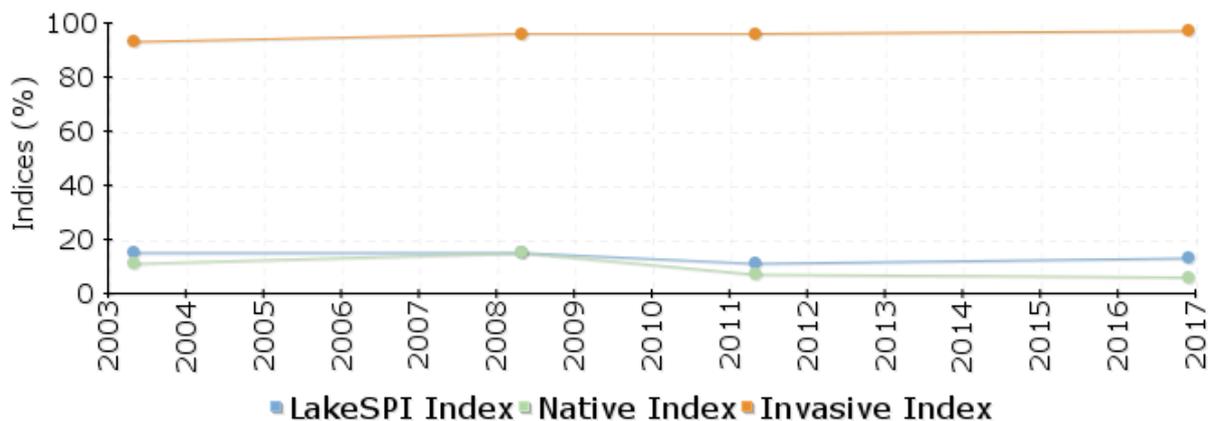
3.4 Lake Rotoroa

3.4.1 Results



Lake condition: Poor
 Lake ranking: 4th
 Lake maximum depth: 16 m
 Max depth of vegetation: 9.5 m

Rotoroa Lake Submerged Plant Indicators



Survey Date	Status	LakeSPI %	Native Condition %	Invasive Impact %
November 2016	Poor	13%	6%	97%
April 2011	Poor	11%	7%	96%
April 2008	Poor	15%	15%	96%
April 2003	Poor	15%	11%	93%

* The 2003, 2008 and 2011 assessments were based on a limited assessment of only one site.

Figure 3-8: LakeSPI results for Lake Rotoroa.

Lake Rotoroa is categorised as being in poor condition with a LakeSPI Index of 13% (Figure 3-8).

Hornwort formed a dense band of weed at all five baseline sites around Lake Rotoroa growing up to 3 m high and extending down to a depth of between c. 8 and 9.5 m. Other invasive species included *Elodea canadensis* (Figure 3-9), and the invasive pondweed *Potamogeton crispus* (Figure 3-10) which formed dense clumps through the profiles.

Native submerged plants included a native milfoil (*Myriophyllum propinquum*), and two charophyte species (*Chara globularis* and *Nitella hyalina*). *Chara globularis* formed a meadow (>75% cover) at

one of the five baseline sites down to a maximum depth of only 1 m contributing to a very low Native Condition Index of 6% (Figure 3-8).

The total cover of submerged vegetation (native and invasive species) at selected LakeSPI sites in Lake Rotoroa, over the depth range occupied by vegetation, was estimated to be 100%.

A thick covering of epiphytic algae was noted during the recent survey (Figure 3-11), in particular over the native species in shallow water (<1 m). The through-water visibility was estimated by divers to be between 2 – 4 m. A Secchi disk measurement of 1.95 m was recorded from the lake centre. No freshwater mussels were observed.

Historic notes: A survey of the submerged plants in Lake Rotoroa carried out in 1983 (Howard-Williams et al. 1983), recorded only three plant species in the lake. These included a native charophyte (*Nitella leonhardtii*), milfoil (*Myriophyllum triphyllum*); and the invasive pondweed *Potamogeton crispus*. A quick survey of the vegetation was also undertaken at one site (near the end of drive) by NIWA in April 2003, and again in 2008 and 2011 (Figure 3-8). Elodea dominated the submerged vegetation in 2003 down to a maximum depth of 3.5m, with only occasional plants of hornwort noted as present. By 2008 hornwort formed a dense cover of weed down to 7.6 m, displacing much of the elodea. The through-water visibility was estimated by divers in 2003 to be only 1 m.

3.4.2 Discussion

Lake Rotoroa has remained in a poor but stable condition since 2003. A high Invasive Impact Index of 97% (Figure 3-8), the highest recorded for any of the Hawke's Bay lakes, reflects the major impact the invasive species hornwort and elodea are having on the lake. However, a maximum depth of plants to around 9 m is consistent with the good water clarity noted at the time of the recent survey.

The presence of some native plants still growing in shallower areas around the lake, although under thick cover of epiphytic algae (Figure 3-11), is encouraging should the lake undergo any restoration efforts in the future.



Figure 3-9: Elodea growing in Lake Rotoroa.



Figure 3-10: The invasive pondweed (*Potamogeton crispus*) growing in clumps through the elodea in Lake Rotoroa.



Figure 3-11: Native charophytes in Lake Rotoroa covered by thick layer of algae.

3.5 Lake Oingo

3.5.1 Results



Lake condition:	Poor
Lake ranking:	5 th
Lake maximum depth:	2.9 m
Max depth of vegetation:	2.9 m

Oingo Lake Submerged Plant Indicators

Survey Date	Status	LakeSPI %	Native Condition %	Invasive Impact %
November 2016	Poor	12%	0%	89%

Figure 3-12: LakeSPI results for Lake Oingo.

Lake Oingo is categorised as being in poor condition with a LakeSPI Index of 12% (Figure 3-12).

Hornwort (*Ceratophyllum demersum*) and the invasive pondweed *Potamogeton crispus* were the only two submerged plants observed in Lake Oingo. *Potamogeton crispus* was the more prevalent of these two species forming a variable cover of low growing plants, c. 0.6 m in height, extending across the bottom of the lake to its maximum depth of 2.9 m. Hornwort was also recorded from each site but only at low covers, growing up to only 0.7 m high amongst the pondweeds (Figure 3-13).

The total cover of submerged vegetation (native and invasive species) at selected LakeSPI sites in Lake Oingo, over the depth range occupied by vegetation, varied between sites but overall was estimated to be low c. 15-25% and up to c.80% at one site.

At the time of the recent survey, water clarity was good with through-water visibility estimated by divers to be around 2 m. A Secchi disk measurement of 2.18 m was recorded from the lake centre. The sediment was a soft deep mud and no freshwater mussels were observed.

Historic notes: A survey of Lake Oingo over multiple sampling visits in 1984 described the lake as having a dense algal bloom that prevented the growth of any macrophytes (Hooper 1987). Lake Oingo was also visited by NIWA in April 2008 as part of a surveillance program looking for *Hydrilla* (Hofstra 2008). At this time the lake was dominated by hornwort over much of the lake surface leaving very little open water space (c. 3%). Germinating *Potamogeton crispus* plants were observed in thinly distributed patches.

3.5.2 Discussion

Potamogeton crispus was the dominant plant species recorded in the November 2016 survey but if this survey had been undertaken later in the season, it is likely that hornwort covers would have been a lot higher. This however, would have had only a small impact on overall LakeSPI scores since

hornwort was already present at all LakeSPI sites and the shallow depth of this lake means that invasive impact values from *Potamogeton crispus* were already high. While invasive species are not favourable in terms of overall lake condition, the presence of any submerged plants in a lake is preferable to none, in that they can help mitigate many of the symptoms of eutrophication (e.g., lock-up nutrients, maintain water clarity, compete with phytoplankton).



Figure 3-13: A shoot of hornwort growing up between *Potamogeton crispus* plants in Lake Oingo.

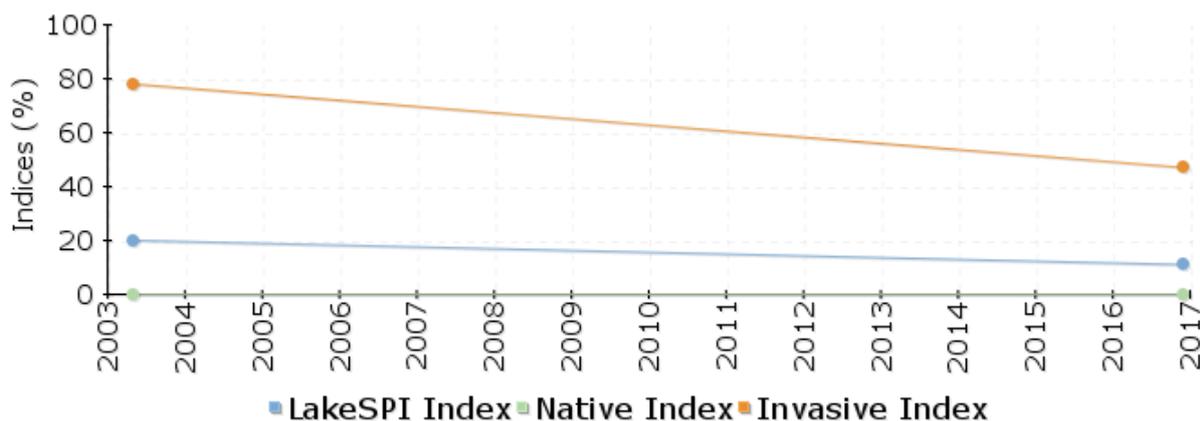
3.6 Lake Rotongaio

3.6.1 Results



Lake condition:	Poor
Lake ranking:	6 th
Lake maximum depth:	4.6 m
Max depth of vegetation:	3.2 m

Rotongaio Lake Submerged Plant Indicators



Survey Date	Status	LakeSPI %	Native Condition %	Invasive Impact %
November 2016	Poor	11%	0%	47%
April 2003	Poor	20%	0%	78%

* The 2003 assessments was based on a limited assessment of only one site.

Figure 3-14: LakeSPI results for Lake Rotongaio. LakeSPI Indices expressed as a percentage of lake maximum potential.

Lake Rotongaio is categorised as being in poor condition with a LakeSPI Index of 11% (Figure 3-14).

Elodea canadensis was the only submerged plant species found growing in Lake Rotongaio. *Elodea* formed variable covers around the lake exceeding a 10% cover at only three of the five LakeSPI sites. It formed high cover clumps up to 1.2 m tall at these sites and extended down to an average maximum depth of 2.6 m. No other submerged plants were found growing in the lake, however a fragment of the invasive pondweed *Potamogeton crispus*, and one of the native pondweed *Potamogeton ochreatus* were found washed onto the beach near the access point.

The total cover of submerged vegetation (native and invasive species) at selected LakeSPI sites in Lake Rotongaio, over the limited depth range occupied by vegetation, varied between sites from <5% (one site) to covers >70% (at three of the five sites). At the time of the recent survey, water clarity

was one of the lowest observed with through-water visibility estimated by divers as only 0.2 m. A Secchi disk measurement of 0.45 m was recorded from the lake centre. Plants did not appear healthy and had high covers of epiphytic algae. No freshwater mussels were observed.

Historic notes: Lake Rotongaio was surveyed at only one site (bottom of hill near access point) by NIWA in April 2003; and visited briefly again in April 2008 as part of a surveillance program looking for *Hydrilla* (Hofstra 2008). Both earlier surveys described elodea as being the only submerged plant present. In 2003, the water was noted as being very dark in colour and the elodea was described as being stressed with indications of sediment anoxia.

3.6.2 Discussion

Lake Rotongaio appears to be on the cusp of becoming non-vegetated as the recent survey found submerged plants exceeding a 10% cover at only three of the five baseline sites. Compared to the other two Putere lakes (Rotonuiaha and Rotoroa) Lake Rotongaio is noted to be in a poor condition.

Care should be taken when interpreting any decrease in lake condition between the 2003 and 2016 surveys because of the limited 2003 investigation.

3.7 Lake Poukawa

3.7.1 Results



Lake condition:	Non-vegetated
Lake ranking:	7 th
Lake maximum depth:	0.9 m
Max depth of vegetation:	0.5 m

Poukawa Lake Submerged Plant Indicators

Survey Date	Status	LakeSPI %	Native Condition %	Invasive Impact %
November 2016	Non-vegetated	0%	0%	0%

Figure 3-15: LakeSPI results for Lake Poukawa.

Lake Poukawa is categorised as being in a non-vegetated condition with a LakeSPI Index of 0% (Figure 3-15).

Submerged plants grew close to the lake margin or amongst emergent vegetation at four of the five LakeSPI sites, but exceeded a 10% cover at only one of these sites. No submerged plants were observed growing in the open water areas of Lake Poukawa.

Hornwort (*Ceratophyllum demersum*) was recorded at three of the five baseline sites but only as occasional plants. Hornwort was prolific in the drain used to access the lake. Other invasive species included one plant of *Elodea canadensis* at one site, the invasive pondweed *Potamogeton crispus* at four sites but at low covers, and a marginal plant *Ludwigia palustris*.

Ruppia polycarpa was the only native plant recorded from within Lake Poukawa, present at one of the five sites.

At the time of the survey, the water in Lake Poukawa was yellow/brown in colour but was clear enabling the survey team to see the lake bottom. The bottom sediments were soft and flocculent causing them to be easily suspended (Figure 3-17). A Secchi disk measurement of 0.8 m was recorded from the lake centre. No freshwater mussels were observed.

Historic notes: Dense beds of native charophytes were noted within Lake Poukawa in 1984 (Hooper 1987). Lake Poukawa was also visited by NIWA in April 2008 as part of a surveillance program looking for *Hydrilla* (Hofstra 2008). At the time of this visit the lake levels were very low and the bottom was described as deep mud. Low numbers of submerged plants were found at the site including *Potamogeton crispus*, a native *Callitriche* and a turf species *Limosella lineata*.

3.7.2 Discussion

Submerged plant covers did not exceed a 10% cover at the majority of sites assessed, generating a default LakeSPI Index of 0% (Figure 3-15).

The soft and very flocculent nature of the lake sediments would likely prevent any colonisation of submerged plants.



Figure 3-16: Diver identifying sparse plants growing amongst the emergents around Lake Poukawa.



Figure 3-17: Turbid water disturbed by the boat propeller.

3.8 Lake Runanga

3.8.1 Results



Lake condition:	Non-vegetated
Lake ranking:	7 th equal
Lake maximum depth:	1.7 m
Max depth of vegetation:	0 m

Runanga Lake Submerged Plant Indicators

Survey Date	Status	LakeSPI %	Native Condition %	Invasive Impact %
November 2016	Non-vegetated	0%	0%	0%

Figure 3-18: LakeSPI results for Lake Runanga.

Lake Runanga is categorised as being in a non-vegetated condition with a LakeSPI Index of 0% (Figure 3-18).

No submerged vegetation was recorded from any of the five LakeSPI sites.

At the time of the recent survey, water clarity was poor and a Secchi disk measurement of 0.45 m was recorded from the lake centre. The field team observed many (c. 8) large dead goldfish floating on the lake surface. No freshwater mussels were observed.

Of interest was a near-threatened (At Risk: Declining – de Lange et al. 2015) aquatic free-floating liverwort *Ricciocarpus natans* found growing amongst other free-floating species, *Azolla rubra* and duck weed (*Lemna minor*) on the outside of emergents near the access point.

Historic notes: Lake Runanga was described as having clear water with a diverse macrophyte community in the early summer of 1984/1985 (Hooper, 1987). By January 1985 however, this early report noted that the macrophytes had crashed and a blue green algae bloom was present in the lake. Lake Runanga was also visited by NIWA in April 2008 as part of a surveillance program looking for *Hydrilla* (Hofstra 2008). At the time of this visit the lake was described as unsuitable for submerged plant growth, due to high levels of suspended sediment. *Typha orientalis* dominated the margins with a *Potamogeton crispus* fragment found amongst it.

3.8.2 Discussion

No submerged vegetation was recorded from in Lake Runanga resulting in a LakeSPI Index of 0%.

Lake Runanga had low water clarity at the time of the recent survey and the presence of dead fish floating on the lake surface raises further concerns over anoxia.



Figure 3-19: Dead gold fish in Lake Runanga.



Figure 3-20: The near-threatened free-floating liverwort *Ricciocarpos natans* at the edge of Lake Runanga. (Photo: T. Burton)

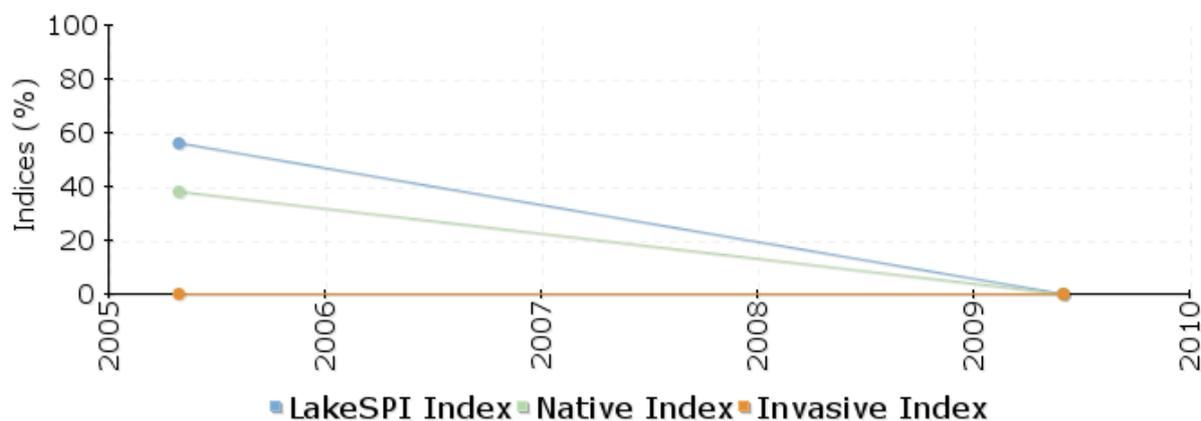
3.9 Lake Waikareiti

3.9.1 Results



Lake condition:	Non-vegetated
Lake ranking:	7 th equal
Lake maximum depth:	80 m
Max depth of vegetation:	Not recorded

Waikareiti Lake Submerged Plant Indicators



Survey Date	Status	LakeSPI %	Native Condition %	Invasive Impact %
May 2009	Non-vegetated	0%	0%	0%
April 2005	High	56%	38%	0%

**Both the 2005 and 2009 surveys were completed by DoC, Hawke's Bay dive team.*

Figure 3-21: LakeSPI results for Lake Waikareiti.

Lake Waikareiti is categorised as being in a non-vegetated condition with a LakeSPI Index of 0% (Figure 3-21). It was surveyed in 2005 and 2009 by the Department of Conservation dive team.

During the 2009 survey, charophytes and native pondweeds (species unknown) were recorded from in Lake Waikareiti but plant covers did not exceed a 10% cover at any of the five LakeSPI sites. No invasive species were recorded.

Freshwater mussels were observed during the 2009 survey.

Historic notes: Native charophytes were recorded at all five sites in a 2005 survey from between 3 and 11 m deep. Charophyte meadows (>75% cover) grew down to a maximum depth of 2 m at two sites and small patches of charophytes were recorded at low covers (<10%) down to a depth of c. 20 m at two of the five sites. Native pondweed and milfoil species (species unknown) were also recorded during the 2005 survey from most sites.

3.9.2 Discussion

The LakeSPI Index for Lake Waikareiti declined significantly between the 2005 (56%) and the 2009 (0%) survey (Figure 3-21). While similar native communities were identified in both surveys, submerged plant covers did not exceed a 10% cover in 2009, generating a default LakeSPI Index of 0%. We recommend a follow-up survey to confirm this unexpected result for a lake in a near pristine catchment.

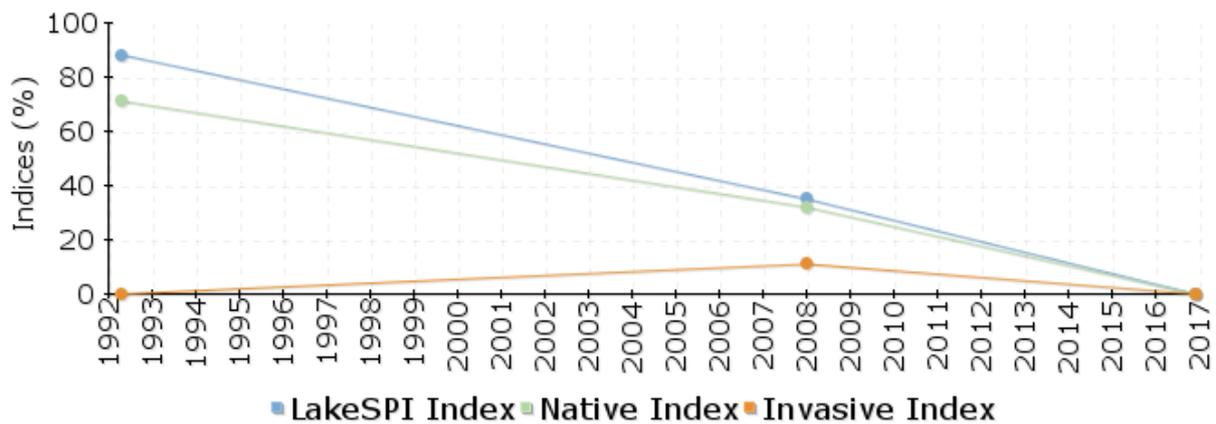
3.10 Lake Whakaki

3.10.1 Results



Lake condition: Non-vegetated
 Lake ranking: 7th equal
 Lake maximum depth: 1.5 m
 Max depth of vegetation: 0 m

Lake Whakaki Submerged Plant Indicators



Survey Date	Status	LakeSPI %	Native Condition %	Invasive Impact %
November 2016	Non-vegetated	0%	0%	0%
December 2007	Moderate	35%	32%	11%
April 1992	Excellent	88%	71%	0%

*2007 survey completed with funding from Ngā Whenua Rāhui for the Lake Whakaki Trust.

Figure 3-22: LakeSPI results for Lake Whakaki.

Lake Whakaki is categorised as being in a non-vegetated condition with a LakeSPI Index of 0% (Figure 3-22).

No submerged vegetation was found in Lake Whakaki.

Divers noted poor water clarity with a Secchi disk measurement of 0.17 m recorded from the lake centre. Lake sediments consisted of firm sand and mud with some fibrous/woody organic matter on top closer to the emergents at the lake margin (Figure 3-23). No freshwater mussels were observed.

Historic notes: The submerged aquatic vegetation in Lake Whakaki has been described by NIWA on two previous occasions, in 1992 (de Winton et al. 1992) and again in December 2007 (de Winton & Champion, 2008).

In 2007, submerged plant species included *Stuckenia pectinata* (formerly *Potamogeton pectinatus*), *Ruppia polycarpa*, *Potamogeton crispus* and *Lepilaena bilocularis*. The native pondweed *S. pectinata* was the dominant species and formed a low cover (1-5%) across the lagoon to its maximum depth at the time of 0.7m.

In addition to the species recorded in 2007, the 1992 survey found *Chara globularis*, *Zannichellia palustris* and *Lamprothamnium macropogon*, which formed high cover patches in the lagoon.

The marginal vegetation was similar on all occasions and is dominated by *Bolboschoenus fluviatilis* and *Juncus kraussii* (Figure 3-24).

3.10.2 Discussion

The LakeSPI method was not designed for brackish or estuarine waterbodies such as Lake Whakaki, on account of the quite different plant species and environment that exist in such systems. In 2016, the lagoon was in flood with a maximum depth of 1.5 m observed from the lake centre, compared to previous recorded maximum depths of c. 1 m. The temporary higher water levels in 2016 are unlikely to account for the absence of submerged plants at this time.

While care must be taken in interpreting LakeSPI scores for Lake Whakaki for the above reasons, LakeSPI is still a useful tool for monitoring vegetation changes over time. LakeSPI scores have declined significantly over the last 24 years (Figure 3-22) with the loss of submerged plants.

Following concerns about reduced submerged vegetation, including low amounts of drift deposits on the lagoon margin, Ngā Whenua Rāhui, and the lake Trustees engaged NIWA to undertake a survey of the lagoons submerged vegetation in 2007. LakeSPI results confirmed concerns that the submerged vegetation in the lagoon was decreasing. The LakeSPI Index had more than halved from 88% in 1992 to 35% in 2007 (Figure 3-22) and with no submerged plants recorded from the lagoon in 2016, Lake Whakaki now has a LakeSPI Index of 0%.



Figure 3-23: Bottom sediments in Lake Whakaki were compacted sand/mud with a layer of organic matter on top.



Figure 3-24: Emergents growing around the margin of Lake Whakaki dominated by *Bolboschoenus fluviatilis* (foreground).

3.11 Lake Hatuma (Whatumā)

3.11.1 Results



LakeSPI condition:	n/a
Lake ranking:	n/a
Lake maximum depth:	0.8 m
Max depth of vegetation:	0.8 m

Lake Hatuma (also known as Lake Whatumā) did not generate a LakeSPI result for this report based on its shallow overall depth of only 0.8 m (November 2017 survey).

An assessment of submerged vegetation at selected baseline sites around the lake found a mixed community of native and invasive plant species (Figure 3-25). A native plant, *Ruppia polycarpa*, formed grassy beds over the bottom at all sites down to the lakes maximum depth of 0.8 m. *Ruppia* reached high covers (76 – 95% cover) at most sites although overall covers were low (15% – 20%). Overall the estimated total cover of submerged vegetation at LakeSPI sites only, was very variable and ranged between 15 – 50%.

Other native vegetation in the lake was found growing closer to the lake margin and included a native milfoil (*Myriophyllum triphyllum*), two native pondweeds (*Potamogeton ochreatus* and *Potamogeton cheesemanii*), and a short growing turf species (*Lilaeopsis ruthiana*). A near-threatened (At Risk: Declining – de Lange et al. 2015) aquatic free-floating liverwort *Ricciocarpus natans* (Figure 3-20) was also found growing amongst another free-floating native species, *Azolla rubra*, at two of the four baseline sites.

Invasive weed species were present only at low covers, with the exception of the invasive pondweed *Potamogeton crispus* that reached >75% cover at one of the five LakeSPI sites. Hornwort (*Ceratophyllum demersum*), *Lagarosiphon major* and *Elodea canadensis* were also present but at only very low covers (<5%).

At the time of the survey, water clarity was relatively poor with the through-water visibility estimated by divers as only 0.2 m at the margins. A Secchi disk measurement of 0.45 m was recorded from the lake centre. No freshwater mussels were observed.

Historic notes: Lake Hatuma was visited by NIWA in April 2008 as part of a surveillance program for hydrilla (Hofstra 2008). During this visit water levels were described as very low (too shallow for access with a canoe) and the only submerged plants recorded at the time were the invasive pondweed *Potamogeton crispus* and a native milfoil *Myriophyllum propinquum*.

3.11.2 Discussion

Lakes less than one meter in depth, like Lake Hatuma, are not generally recommended for assessment using LakeSPI based on limitations in the methods metrics to detect change over time at shallow depths. The shallow nature of Lake Hatuma also makes it particularly vulnerable to change over a short time frame (e.g., vulnerability to drought).

Information collected from the survey still provides information to assess changes in lake condition over time. Should LakeSPI scores have been reported for Lake Hatuma, it would have indicated that the lake was in a high condition (LakeSPI Index of 63%) on account of native plants extending across the entire lake bottom down to the lakes maximum depth at the time of the survey.



Figure 3-25: Submerged vegetation in Lake Hatuma consisted of both native and invasive species. A handful of the bottom sediment shows elodea and *Ruppia polycarpa*. (Photo: T. Burton)

4 National comparison

Only a small cross-section of the regions lakes have been surveyed using LakeSPI, which may limit the following comparison.

Compared nationally, the Hawke's Bay Region has similar proportions of lakes in the 'excellent' and 'high' category, and greater proportions in the non-vegetated and poor categories (Figure 4-1 and Figure 4-2). The 'poor' condition group tends to represent those lakes with extensive invasion and dominance with little native vegetation character remaining. This is the case for all four of the Hawke's Bay lakes that fall within this group. The 'non-vegetated' group represents the most degraded state of a lake, where water quality conditions have deteriorated to the point where growth of submerged plants can no longer be supported, as is the case with Lakes Poukawa, Runanga and Whakaki.

The Hawke's Bay region has no lakes classified in 'moderate' condition which nationally contains the largest proportion of lakes and tends to represent those lakes that are impacted in varying degrees by invasive weeds but still retain some native vegetation character.

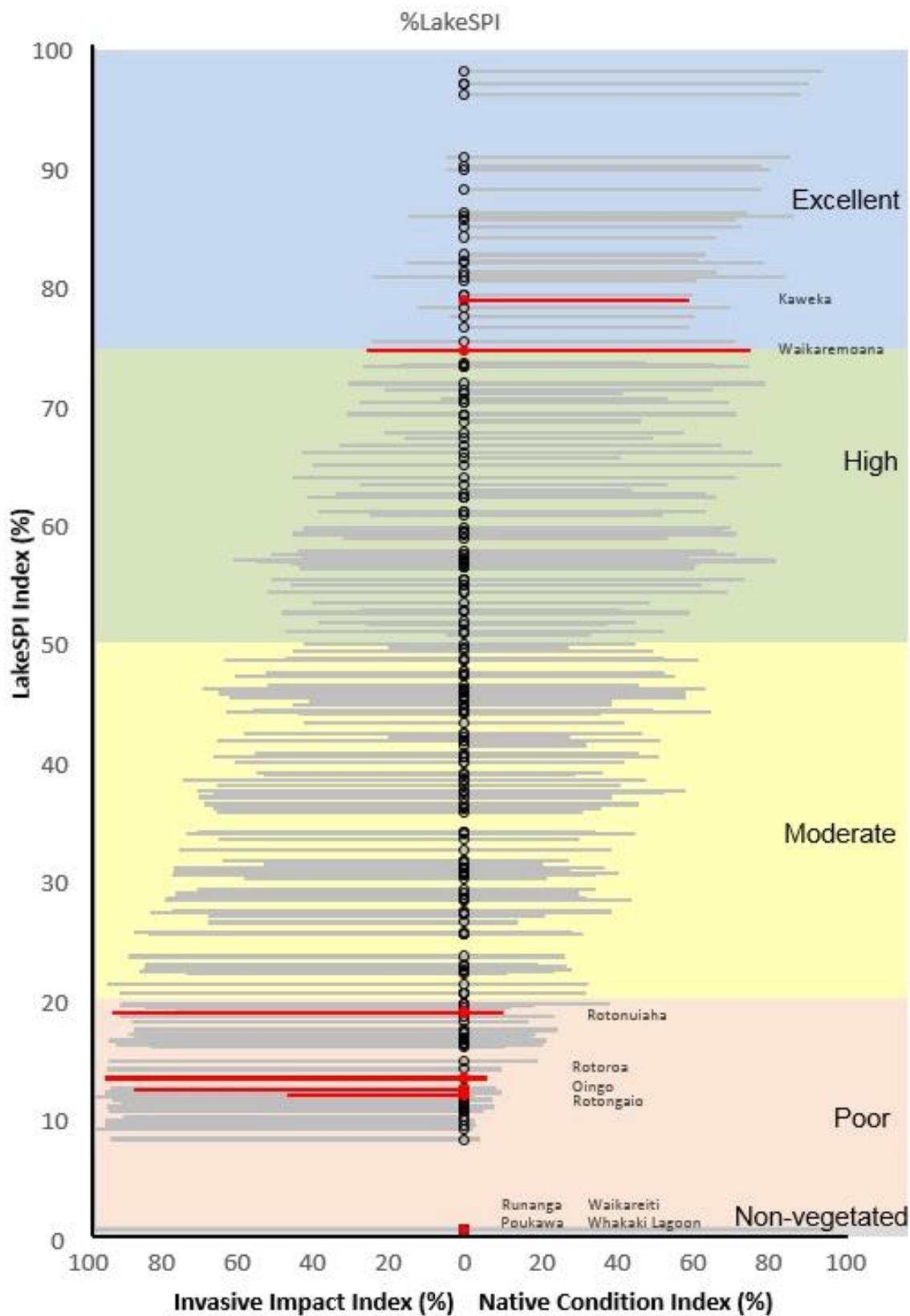


Figure 4-1: LakeSPI Indices based on the latest results of 283 lakes in grey, showing the scores for the lakes of the Hawke's Bay Region as a red line. LakeSPI scores are plotted on the vertical axis, with the Native Condition Index plotted on the right hand horizontal axis, and the Invasive Impact Index on the left hand to show the negative influence on the LakeSPI score.

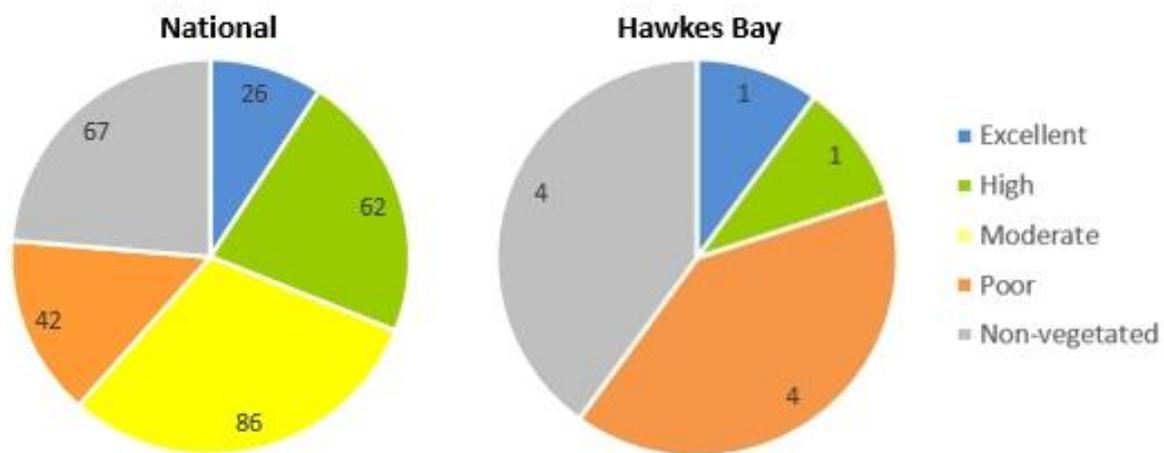


Figure 4-2: Proportion of lakes that fall into each of five categories of LakeSPI Index for the region (10) and nationally (283), with the number of lakes assessed shown in parenthesis.

5 Recommendations

It is recommended that a schedule for LakeSPI monitoring in the Hawke's Bay Region be developed in consultation with Hawke's Bay Council staff, with priorities and timing of re-survey based on lake value, stability and known threats to the lakes. In particular, we would suggest that this schedule includes:

- Lake Kaweka West. Resurvey to identify any changes in condition since last previous survey in 2007 (over ten years). Increase awareness by the surrounding land owners of the lakes value and maintain isolation where possible.
- Lake Waikaremoana. Resurvey in 2018 using LakeSPI to identify any changes in overall ecological condition. Genesis Energy Ltd are currently considering this monitoring timing.
- Lake Waikareiti. Resurvey to confirm results from 2009. Only four years prior, in 2005 (Figure 3-21), the lake had been in high ecological condition. Note plant species specific information was not collected for this lake.
- Prioritise lake for resurvey following management interventions, for those under pressure from new invasive pests, or following significant land-use changes in lake catchments.

6 Acknowledgements

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Appendix A Species list from LakeSPI surveys of eight Hawke's Bay Region lakes.

Table A-1: Submerged plant species recorded for eight lakes in the Hawke's Bay Region from LakeSPI survey sites in November 2017.

Species	Lake Hatuma	Lake Oingo	Lake Poukawa	Lake Rotongaio	Lake Rotoroa	Lake Rotonuiaha	Lake Runanga	Lake Whakaki
Invasive species								
<i>Elodea canadensis</i>	✓		✓	✓	✓	✓		
<i>Ceratophyllum demersum</i>	✓	✓	✓		✓	✓		
<i>Potamogeton crispus</i>	✓	✓	✓	✓*	✓	✓	✓	
<i>Ludwigia palustris</i>	✓		✓		✓			
Turf plants								
<i>Lilaeopsis ruthiana</i>	✓							
Tall native vascular plants								
<i>Myriophyllum propinquum</i>					✓	✓		
<i>Myriophyllum triphyllum</i>	✓							
<i>Potamogeton cheesemanii</i>	✓					✓		
<i>Potamogeton ochreatus</i>	✓			✓*				
<i>Ruppia polycarpa</i>	✓	✓*	✓			✓		
Charophytes								
<i>Chara globularis</i>					✓	✓		
<i>Nitella hyalina</i>					✓	✓		
Floating plants								
<i>Azolla rubra</i>		✓					✓	
<i>Lemna minor</i>		✓	✓				✓	
<i>Ricciocarpos natans</i>		✓					✓	

* Fragments only.

Appendix B Submerged plant cover ratios of eight Hawke’s Bay Region lakes.

Table B-1: Submerged plant cover ratio categories, as recorded on LakeSPI survey sheets, for eight lakes in the Hawke’s Bay Region in November 2017.

	*Total vegetation cover (%)					**Native ratio category (%)					**Invasive ratio category (%)				
	Site A	Site B	Site C	Site D	Site E	Site A	Site B	Site C	Site D	Site E	Site A	Site B	Site C	Site D	Site E
Lake Hatuma	26 - 50	6 - 25	6 - 25	6 - 25	-	100	> 95	>95	76 - 95	-	0	< 5	< 5	6 - 25	-
Lake Oingo	6 - 25	6 - 25	6 - 25	6 - 25	6 - 25	0	0	0	0	0	100	100	100	100	100
Lake Poukawa	< 10	0	< 10	< 1	< 1	< 5	0	0	0	0	> 95	100	100	100	100
Lake Rotongaio	5	5	5	5	5	0	0	0	0	0	100	100	100	100	100
Lake Rotoroa	100	100	100	100	100	< 5	0	< 5	0	0	> 95	100	> 95	100	100
Lake Rotonuiaha	100	100	100	100	100	< 5	0	< 5	0	< 5	> 95	100	> 95	100	> 95
Lake Runanga	< 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lake Whakaki	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

* **Total vegetation cover** provides an estimate of the total cover of submerged plants (native and invasive species) over the depth range occupied by vegetation, at LakeSPI sites.

** **Native ratio** and **Invasive ratio** categories provide a subjective estimate of the percentage of each vegetation type over the entire depth profile at a LakeSPI site. This LakeSPI metric does not take into account plant height, biomass or density, and ignores bare sediment patches.