

2022/23 Lake water quality and ecology monitoring



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Disclaimer

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For the latest available results go to the [GW environmental data hub](#).

Overview

Greater Wellington (GW) routinely monitors water quality in two lakes in the Wellington Region, Lake Wairarapa and Lake Ōnoke. Monitoring in Lake Wairarapa commenced in 1994 and the programme remained largely unchanged until 2012/13 when changes in monitoring frequency and some site locations and variables were implemented (see [Cockeram & Perrie 2013](#) and [Cockeram & Perrie 2014](#)). Water quality monitoring in Lake Ōnoke was established in 2009. Additional shorter-term targeted water quality monitoring and “one-off” sampling, including zooplankton communities, has also been undertaken in other lakes in the Wellington Region (see [Perrie & Milne 2012](#); [Perrie et al. 2015](#); [Duggan 2022](#); [Perrie & Royal 2022](#)).

In 2011 assessments of ecological condition, based on submerged macrophyte community structure and composition, were introduced for Lakes Kohangapiripiri, Kohangatera and Pounui. Assessments of macrophyte communities, termed LakeSPI (Submerged Plant Indicator) have since been expanded to other lakes and lagoons in the Wellington Region: Bartons Lagoon, Boggy Pond, Lake Nganoke, Lake Ngarara, Lake Waiorongomai, Matthews Lagoon and Turners Lagoon ([de Winton et al. 2022](#)). LakeSPI assessments are planned to occur every three-five years.

Monitoring network

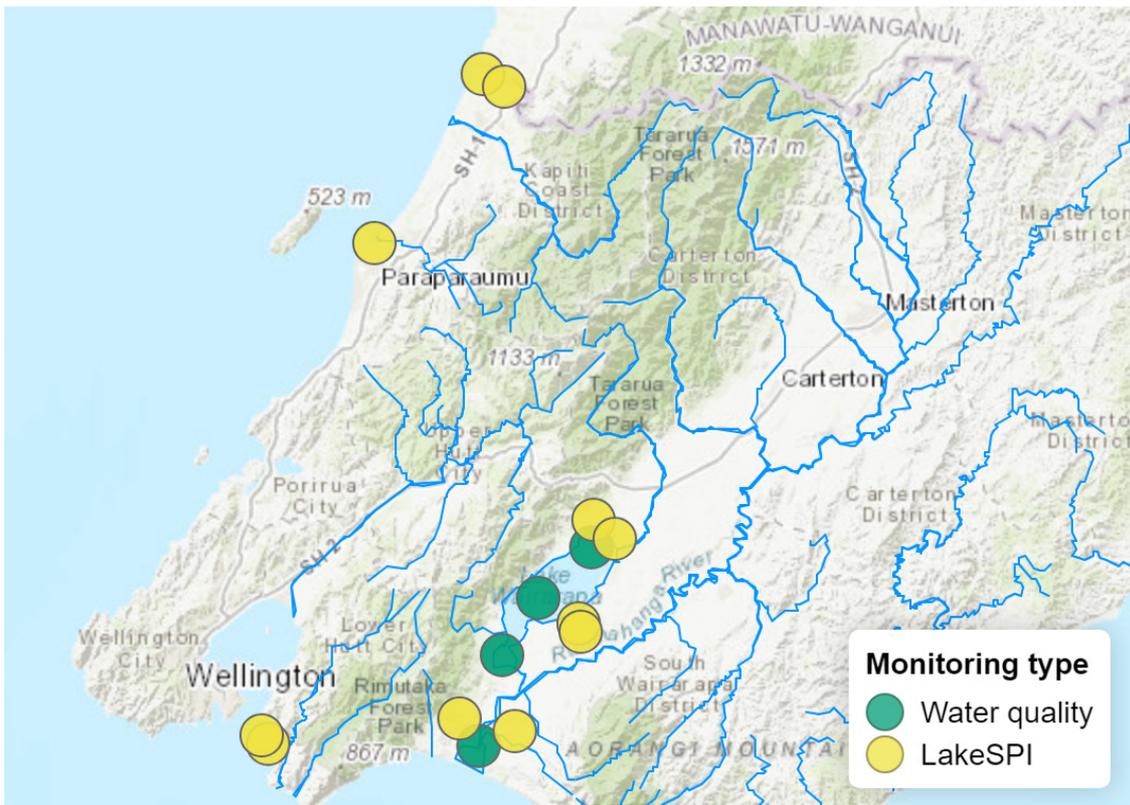


Figure 1: Locations of lake water quality and ecology monitoring sites.

Table 1: Lake attributes and catchment information.

Lake	Max depth (approx.)	Lake area	Catchment area	Catchment landcover
Wairarapa	2.5 m	7,850 ha	57,245 ha	<ul style="list-style-type: none"> • Pasture 54.0% • Indigenous forest and scrub 43.9% • Urban 0.4% • Other 1.7%
Ōnoke	5.5 m	622 ha	341,744 ha	<ul style="list-style-type: none"> • Pasture 64.0% • Indigenous forest and scrub 27.5% • Exotic forest 3.7% • Horticulture 1.0% • Urban 0.7% • Other 3.1%

Monitoring objectives

1. Assist in the detection of spatial and temporal changes in the condition of selected lakes;
2. Contribute to our understanding of freshwater biodiversity in the Wellington Region;
3. Determine the suitability of lakes for designated uses;
4. Provide information to assist in targeted investigations where remediation or mitigation of poor water quality or ecosystem health is desired; and
5. Provide information required to determine the effectiveness of regional plans and policies.

Monitoring results

State assessments presents current lake status as assessed by the Trophic Lake Index (TLI), GW Natural Resources Plan (NRP), and National Policy Statement for Freshwater Management National Objectives Framework (NOF). Links are provided with each for more information.

Trend assessments estimates the rate of change and direction of key lake water quality data at each site over periods of 5-, 10-, 15-, and all available- years.

Supplementary data provides annual summaries of dissolved oxygen, water temperature, pH, conductivity, visual clarity, turbidity, suspended solids, chlorophyll *a*, and dissolved and total nutrients.

Methods

Analytical methods for physicochemical and microbiological water quality

Lake Wairarapa monitoring sites are accessed by boat and the Lake Ōnoke monitoring sites (including the two upstream monitoring sites) are accessed by wading from the lake or river edge. Water samples are collected in accordance with the sub-surface grab method for sampling isothermal lakes described in [Smith et al. \(1989\)](#) and in the case of Lake Ōnoke, a 'grab pole' is used to collect water samples in an effort to minimise the potential effects of re-suspension of lake-bed sediments (caused by wading) on the samples. Note that the sub-surface grab method differs from protocols outlined in [Burns et al. \(2000\)](#) for the sampling of isothermal lakes.

Field measurements (conductivity, dissolved oxygen and temperature) are taken using a YSI DSS field meter which is calibrated on the day of sampling. Secchi disc measurement methodology is consistent with the procedure outlined in [Burns et al. \(2000\)](#) except that an underwater viewer is not used. Note that all field measurements collected from Lake Ōnoke (and upstream sites) are made from a 'wading position', although care is taken to minimise any disturbance of lakebed sediments.

Water samples requiring laboratory analysis are stored on ice upon collection and couriered overnight to RJ Hill Laboratories in Hamilton. The variables monitored and current analytical methods are summarised in [Appendix Table A1](#). All lake water samples collected for dissolved nutrient analysis are filtered in the laboratory.

State assessments

See [Hickson-Rowden and Perrie \(2018\)](#) for the finer details on the application of the assessments outlined below.

Trophic Level Index (TLI)

Table 2: Classification of lake trophic status using the TLI [Burns et al. \(1999\)](#).

Trophic status (nutrient enrichment)	TLI	Chlorophyll <i>a</i> (mg/m³)	Secchi depth (m)	Total phosphorus (g/m³)	Total nitrogen (g/m³)
Ultra-microtrophic (practically pure)	0.0- 1.0	0.13-0.33	33-25	0.00084-0.0018	0.016-0.034
Microtrophic (very low)	1.0- 2.0	0.33-0.82	25-13	0.0018-0.0041	0.034-0.073
Oligotrophic (low)	2.0- 3.0	0.82-2.0	15-7.0	0.0041-0.0090	0.073-0.157
Mesotrophic (medium)	3.0- 4.0	2.0-5.0	7.0-2.8	0.0090-0.0200	0.157-0.337
Eutrophic (high)	4.0- 5.0	5.0-12	2.8-1.1	0.0200-0.0430	0.337-0.725
Supertrophic (very high)	5.0- 6.0	12-31	1.1-0.4	0.0430-0.0960	0.725-1.558
Hypertrophic (extremely high)	>6.0	>31	<0.4	<0.0960	>1.558

Natural Resources Plan (NRP)

Table 3: Selected attributes and narratives from table 3.5 of GW's [NRP](#). Note that monitoring data should be analysed separately for closed periods and open periods for intermittently closed and open lakes or lagoons (ICOLs), such as Lake Ōnoke.

Attribute	Lake type	Annual summary	Threshold
Total Nitrogen (mg/m ³)	Seasonally stratified and brackish	Median	≤350
	Polymictic	Median	≤500
Total Phosphorus (mg/m ³)		Median	≤20
Phytoplankton (mg chl- <i>a</i> /m ³)		Median	≤5
		Max	≤25

National Policy Statement for Freshwater Management (NPS-FM)

Attribute states and guideline values taken from the [National Policy Statement for Freshwater Management 2020 National Objectives Framework \(NOF\)](#). For Lake Ōnoke that is intermittently open to the sea, monitoring data should be analysed separately for closed periods and open periods. Where there are multiple attributes for Chlorophyll *a* and ammoniacal nitrogen, the worst state determines the overall band in the maps above

Table 4: **Chlorophyll *a* (mg/m²)** NOF state bands.

Attribute state	Annual median	Annual maximum	Description
A	≤2	≤10	Lake ecological communities are healthy and resilient, similar to natural reference conditions.
B	>2 and >5	>10 and >25	Lake ecological communities are slightly impacted by additional algal and/or plant growth arising from nutrient levels that are elevated above natural reference conditions.
C	>5 and >12	>25 and >60	Lake ecological communities are moderately impacted by additional algal and plant growth arising from nutrient levels that are elevated well above natural reference conditions. Reduced water clarity is likely to affect habitat available for native macrophytes.
D	>12	>60	National bottom line. Lake ecological communities have undergone or are at high risk of a regime shift to a persistent, degraded state (without native macrophyte/seagrass cover), due to impacts of elevated nutrients leading to excessive algal and/or plant growth, as well as from losing oxygen in bottom waters of deep lakes.

Table 5: **Total phosphorus (g/m³)** NOF state bands.

Attribute state	Annual median	Description
A	≤10	Lake ecological communities are healthy and resilient, similar to natural reference conditions.
B	>10 and >20	Lake ecological communities are slightly impacted by additional algal and/or plant growth arising from nutrient levels that are elevated above natural reference conditions.
C	>20 and >50	Lake ecological communities are moderately impacted by additional algal and plant growth arising from nutrient levels that are elevated well above natural reference conditions.
D	>50	National bottom line. Lake ecological communities have undergone or are at high risk of a regime shift to a persistent, degraded state (without native macrophyte/seagrass cover), due to impacts of elevated nutrients leading to excessive algal and/or plant growth, as well as from losing oxygen in bottom waters of deep lakes.

Table 6: **Total nitrogen (g/m³)** NOF state bands. Attribute states are calculated differently for polymictic lakes (polymictic) and seasonally stratified & brackish lakes (brackish). See this Land Air Water Aotearoa (LAWA) [factsheet](#) for more information.

Attribute state	Annual median (polymictic)	Annual median (brackish)	Description
A	≤300	≤160	Lake ecological communities are healthy and resilient, similar to natural reference conditions.
B	>300 and >500	>160 and >350	Lake ecological communities are slightly impacted by additional algal and/or plant growth arising from nutrient levels that are elevated above natural reference conditions.
C	>500 and >800	>350 and >750	Lake ecological communities are moderately impacted by additional algal and plant growth arising from nutrient levels that are elevated well above natural reference conditions.
D	>800	>750	National bottom line. Lake ecological communities have undergone or are at high risk of a regime shift to a persistent, degraded state (without native macrophyte/seagrass cover), due to impacts of elevated nutrients leading to excessive algal and/or plant growth, as well as from losing oxygen in bottom waters of deep lakes.

Table 7: **Ammonia (pH adjusted mg/L)** NOF state bands. Numeric attribute state is based on pH 8 and temperature of 20°C.

Attribute state	Annual median	Annual 95 th percentile	Description
A	≤0.03	≤0.05	99% species protection level: No observed effect on any species tested.
B	>0.03 and >0.24	>0.05 and >0.4	95% species protection level: Starts impacting occasionally on the 5% most sensitive species.
C	>0.24 and >1.3	>0.4 and >2.2	National bottom line. 80% species protection level: Starts impacting regularly on the 20% most sensitive species (reduced survival of most sensitive species).
D	>1.3	>2.2	Starts approaching acute impact level (that is, risk of death) for sensitive species.

Trend assessments

Trends assessments are estimated at each site using monthly data over periods of 5-, 10-, and 15-years, where sufficient data is available. These results are then categorised into differing levels of trend direction likelihood. Series with too many censored values ([Appendix Table A1](#)) can still have a trend direction estimated but are unable to have a reliable trend rate estimated and this is shown as ‘N/A’ in the map hover labels and tables. Site-periods with too few data for reliable estimates of both direction and rate are shown as “not assessed”.

The trend methodology follows the approach as described in this [LAWA trends factsheet](#) with exceptions:

- Due to monitoring network interruptions, we use a slightly lower data requirement threshold of 85% (i.e., at least 85% of all possible months or quarters worth of data in that period) rather than the 90% threshold for trends on LAWA.
- Series with too many censored values ([below lab detection limits](#)) can still have a trend direction estimated on LAWA but are unable to have a reliable trend rate estimated. In this report we present such trends as “Indeterminate”.

LakeSPI assessments

Submerged aquatic plant communities are assessed using the nationally accepted LakeSPI (Submerged Plant Index) methodology developed by [Clayton and Edwards \(2006\)](#). This involves scuba divers assessing 11 metrics over a 2 m wide transect from the shore to the deepest vegetation limit at several sites which are representative of the lake.

The first LakeSPI surveys were carried out in autumn 2011 and are intended to be repeated at five-yearly intervals except where more frequent surveys are warranted.

Application of the LakeSPI method results in three indices expressed as a percentage of expected pristine state:

- A native condition index (ie, the diversity and quality of the indigenous flora);
- An invasive condition index (ie, the degree of impact by invasive weed species); and
- An overall LakeSPI index that synthesises components of both the native condition and invasive condition indices to provide an overall indication of lake ecological condition.

The LakeSPI index is used to place the lake vegetation into one of five categories of lake condition listed in the table below ([Verburg et al. 2010](#)):

Lake ecological condition	LakeSPI index (% of expected pristine state)
Non-vegetated	0
Poor	>0-20
Moderate	>20-50
High	>50-75
Excellent	>75

Each sub-component condition index is also rated against [National Policy Statement for Freshwater Management 2020](#) NOF guidelines:

Attribute state	Native Condition index	Invasive Impact index
A	>75	0*
B	>50 and >75	>1 and >25
C	>20 and >50	>25 and >90
D	≤20	≥90

**Note Invasive Impact index scores for non-vegetated lakes are not included in the A band.*

State assessment results

The following sections present maps of state assessments under each framework. Details on each assessment framework and calculations are available in [Hickson-Rowden and Perrie \(2018\)](#) and the [state assessments methods](#) section.

Trophic level index (TLI)

The Trophic Level Index (TLI) measures water quality status of New Zealand lakes using four variables; chlorophyll *a*, Secchi depth (water clarity), total phosphorus and total nitrogen. The maps show the overall mean TLI score for each lake and the table includes each of the four TLI variables. These values are calculated for the periods July 2022 to June 2023 and the three-year rolling mean period July 2020 to June 2023 (note the variable number of samples between sites).

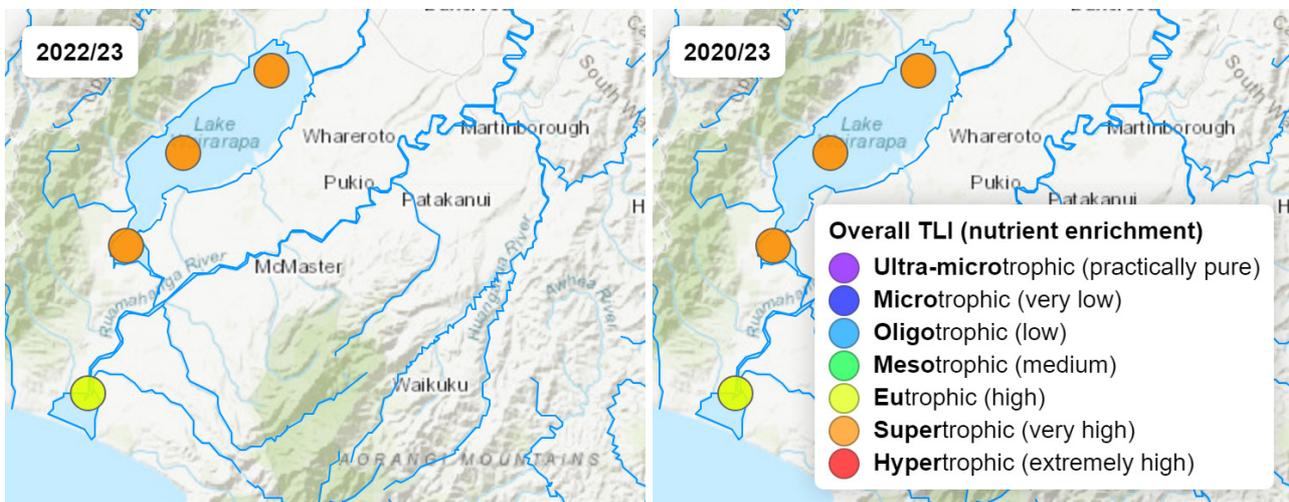


Figure 2: TLI states for the three year period 2020/21 to 2022/23 and latest one year period 2022/23

Table 8: TLI overall and variable scores, abbreviated trophic level classes are provided in brackets.

Lake	Site	Years	No. samples	Overall TLI	Chlorophyll <i>a</i>	Secchi depth	Total phosphorus	Total nitrogen
Wairarapa	Site 2 - stump	2020/23	31	5.3 (Super)	4.9 (Eu)	6.5 (Hyper)	5.7 (Super)	4.3 (Eu)
Wairarapa	Site 2 - stump	2022/23	9	5.4 (Super)	5.3 (Super)	6.3 (Hyper)	5.8 (Super)	4.3 (Eu)
Wairarapa	Middle	2020/23	31	5.2 (Super)	4.8 (Eu)	6.4 (Hyper)	5.6 (Super)	4.1 (Eu)
Wairarapa	Middle	2022/23	9	5.3 (Super)	5.1 (Super)	6.2 (Hyper)	5.7 (Super)	4.2 (Eu)
Wairarapa	Alsops Bay	2020/23	23	5.3 (Super)	4.9 (Eu)	6.4 (Hyper)	5.6 (Super)	4.3 (Eu)
Wairarapa	Alsops Bay	2022/23	8	5.3 (Super)	5.2 (Super)	6.1 (Hyper)	5.6 (Super)	4.2 (Eu)
Ōnoke	Site 1	2020/23	33	4.8 (Eu)	3.7 (Meso)	6.1 (Hyper)	5.1 (Super)	4.5 (Eu)
Ōnoke	Site 1	2022/23	11	5.0 (Eu)	3.8 (Meso)	6.0 (Hyper)	5.5 (Super)	4.7 (Eu)

Natural Resources Plan thresholds (NRP)

Comparison of lake data against NRP outcomes for the one-year period July 2022 to June 2023.

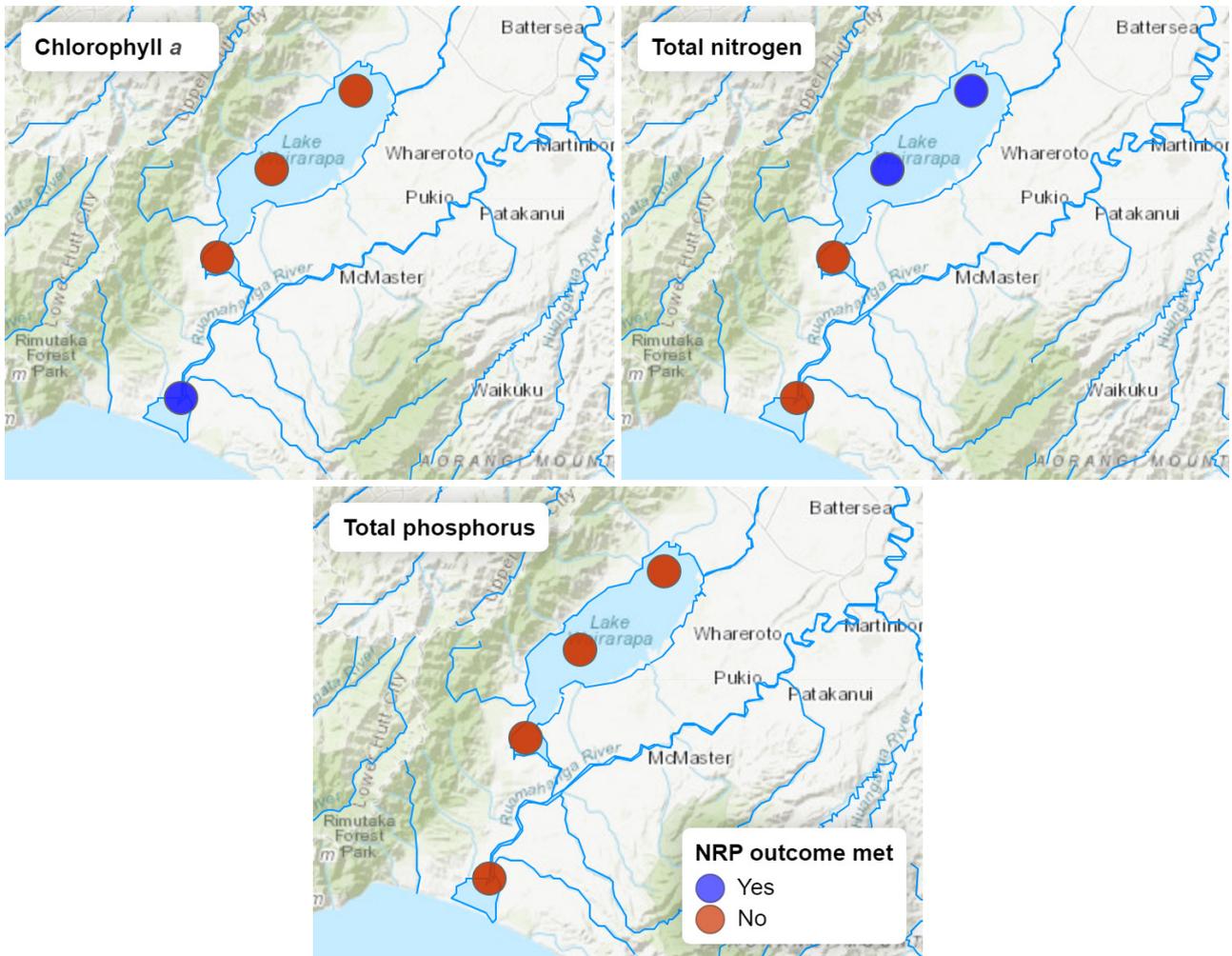


Figure 3: NRP results for the three attributes assessed: Chlorophyll *a*, Total nitrogen, and Total phosphorus.

Table 9: NRP attribute scores, values with asterisks (*) indicating exceedances of PNRP thresholds.

Note Lake Ōnoke data is assessed separately when the lake mouth was open versus closed at the time of sampling; only data for when the lake mouth is open is presented on the map.

Lake	Site	No. samples	Chlorophyll <i>a</i> median	Chlorophyll <i>a</i> max	Total nitrogen median	Total phosphorus median
Wairarapa	Site 2 - stump	9	22.0*	58.0*	390	78*
Wairarapa	Middle	9	17.0*	43.0*	380	65*
Wairarapa	Alsops Bay	7	11.0*	56.0*	365*	65*
Ōnoke	Site 1 (closed)	3	4.0	35.0*	710*	77*
Ōnoke	Site 1 (open)	8	3.5	12.0	405*	68*

National objectives framework (NOF)

Comparison of lake data annual summaries against NPS-FM NOF attribute states for the one-year period July 2022 to June 2023.

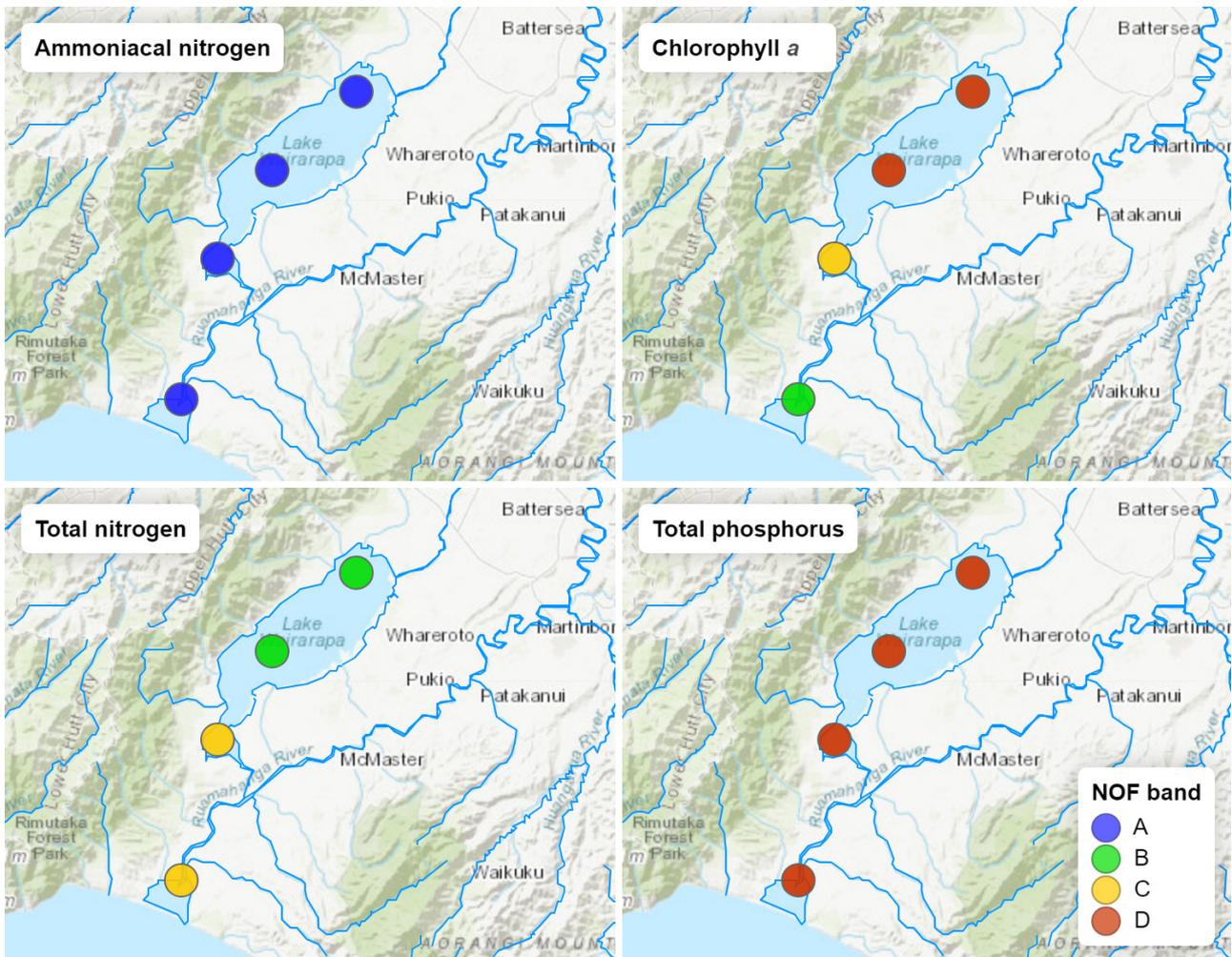


Figure 4: NOF states for the four attributes assessed: Ammoniacal nitrogen, Chlorophyll *a*, Total nitrogen, and Total phosphorus.

Table 10: Individual NOF attribute scores with states provided in brackets. **Note** Lake Ōnoke data is assessed separately when the lake mouth was open versus closed at the time of sampling; only data for when the lake mouth is open is presented on the map.

Lake	Site	No. samples	Type	Ammoniacal nitrogen median	Ammoniacal nitrogen 95 th percentile	Chlorophyll <i>a</i> median	Chlorophyll <i>a</i> max	Total nitrogen median	Total phosphorus median
Wairarapa	Site 2 - stump	9	Polymictic	<0.005 (A)	0.037 (A)	22 (D)	58 (C)	390 (B)	78 (D)
Wairarapa	Middle	9	Polymictic	<0.005 (A)	0.018 (A)	17 (D)	43 (C)	380 (B)	65 (D)
Wairarapa	Alsops Bay	8	Brackish	0.006 (A)	0.012 (A)	11 (C)	56 (C)	365 (C)	65 (D)
Ōnoke	Site 1 (closed)	3	Brackish	0.009 (A)	0.026 (A)	4 (B)	35 (C)	710 (C)	77 (D)
Ōnoke	Site 1 (open)	8	Brackish	<0.005 (A)	0.019 (A)	4 (B)	12 (B)	405 (C)	68 (D)

Trend assessment results

Trends assessments are estimated at each site using data over periods of 5-, 10-, and 15- years, where sufficient data is available, and presented in the following maps. See the [trend assessments methods](#) section for more information.

In the following tables, the confidence in trend direction is marked by:

- ↑↑: very likely improving
- ↑: likely improving
- →: indeterminate
- ↓: likely degrading
- ↓↓: very likely degrading

Note Lake Ōnoke NOF & NRP states in the following tables are only included for when the lake mouth was open at the time of sampling. Trends use all available data.

Ammoniacal nitrogen

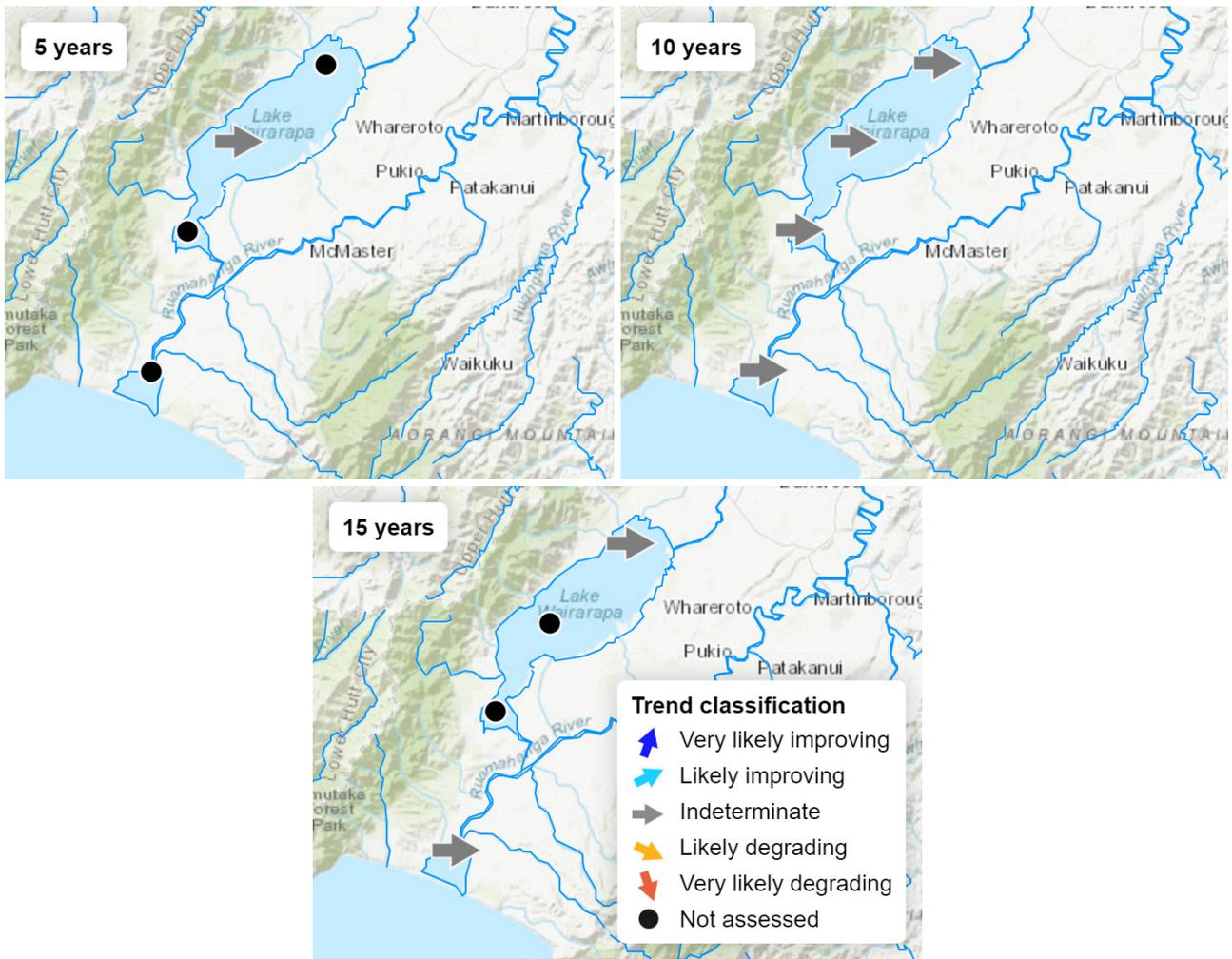


Figure 5: Ammoniacal nitrogen (mg/L) 5, 10, and 15 year trends

Table 11: Ammoniacal nitrogen (mg/L) trend results and applicable state assessments, see the [National Objectives Framework \(NOF\)](#) methods section for full details on assessment criteria.

Lake	Site	Median (3-yr)	NOF state	Trend classification		
				5 yr	10 yr	15 yr
Ōnoke	Site 1	0.014	A		→	→
Wairarapa	Alsops Bay	0.005	A		→	
Wairarapa	Middle	<0.005	A	→	→	
Wairarapa	Site 2 - stump	<0.005	A		→	→

Total nitrogen

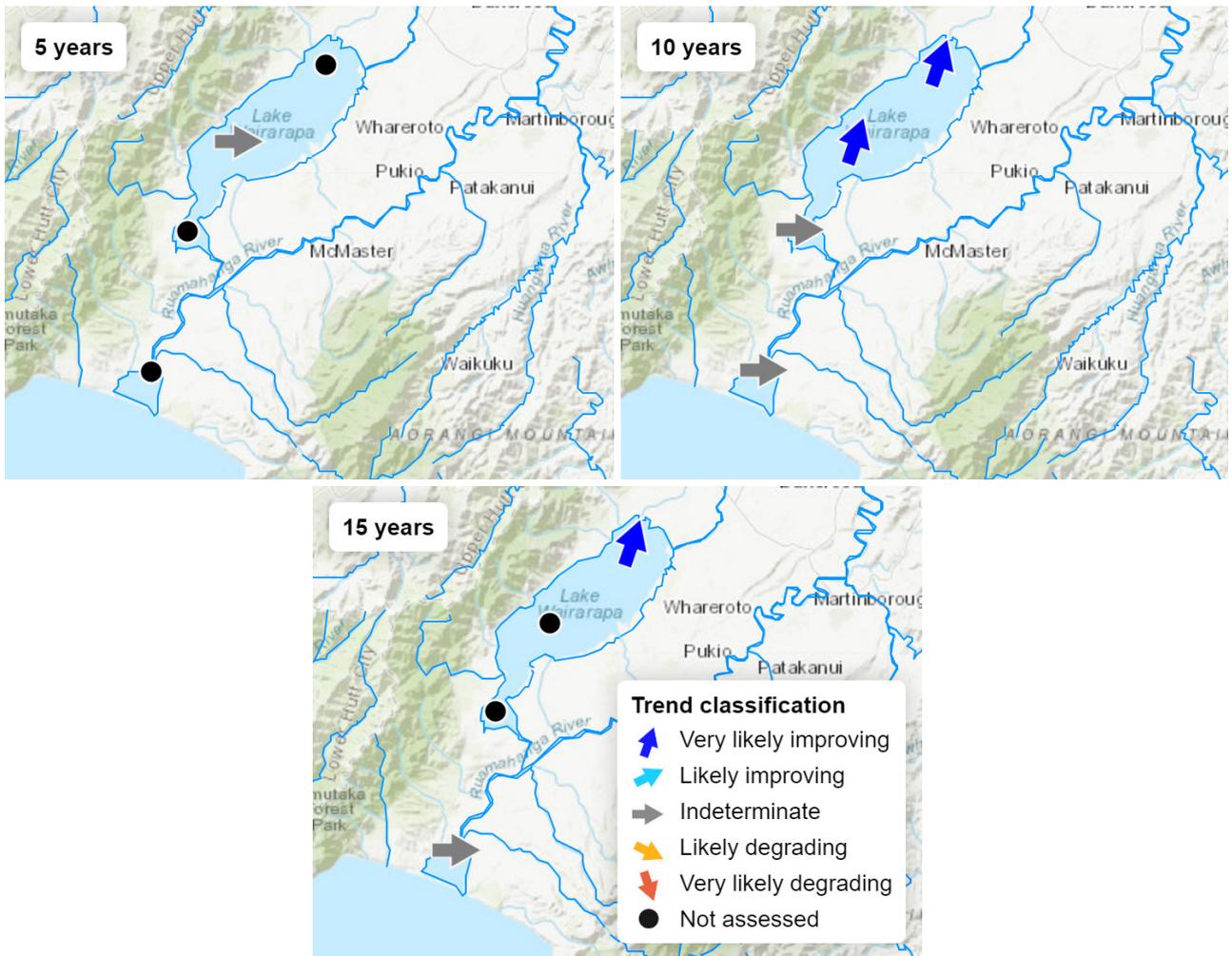


Figure 6: Total nitrogen (mg/m³) 5, 10, and 15 year trends

Table 12: Total nitrogen (mg/m³) trend results and applicable state assessments, see the [National Objectives Framework \(NOF\)](#), [Trophic Level Index \(TLI\)](#), and [Natural Resource Plan \(RNP\)](#) methods sections for full details on assessment criteria.

Lake	Site	Median (3-yr)	NOF state	TLI (3-yr)	Meets NRP	Trend classification		
						5 yr	10 yr	15 yr
Ōnoke	Site 1	500	C	Eutrophic (high)	No		→	→
Wairarapa	Alsops Bay	370	C	Supertrophic (very high)	No		→	
Wairarapa	Middle	330	B	Supertrophic (very high)	Yes	→	↑↑ -27.4	
Wairarapa	Site 2 - stump	390	B	Supertrophic (very high)	Yes		↑↑ -23.1	↑↑ -15.0

Total phosphorus

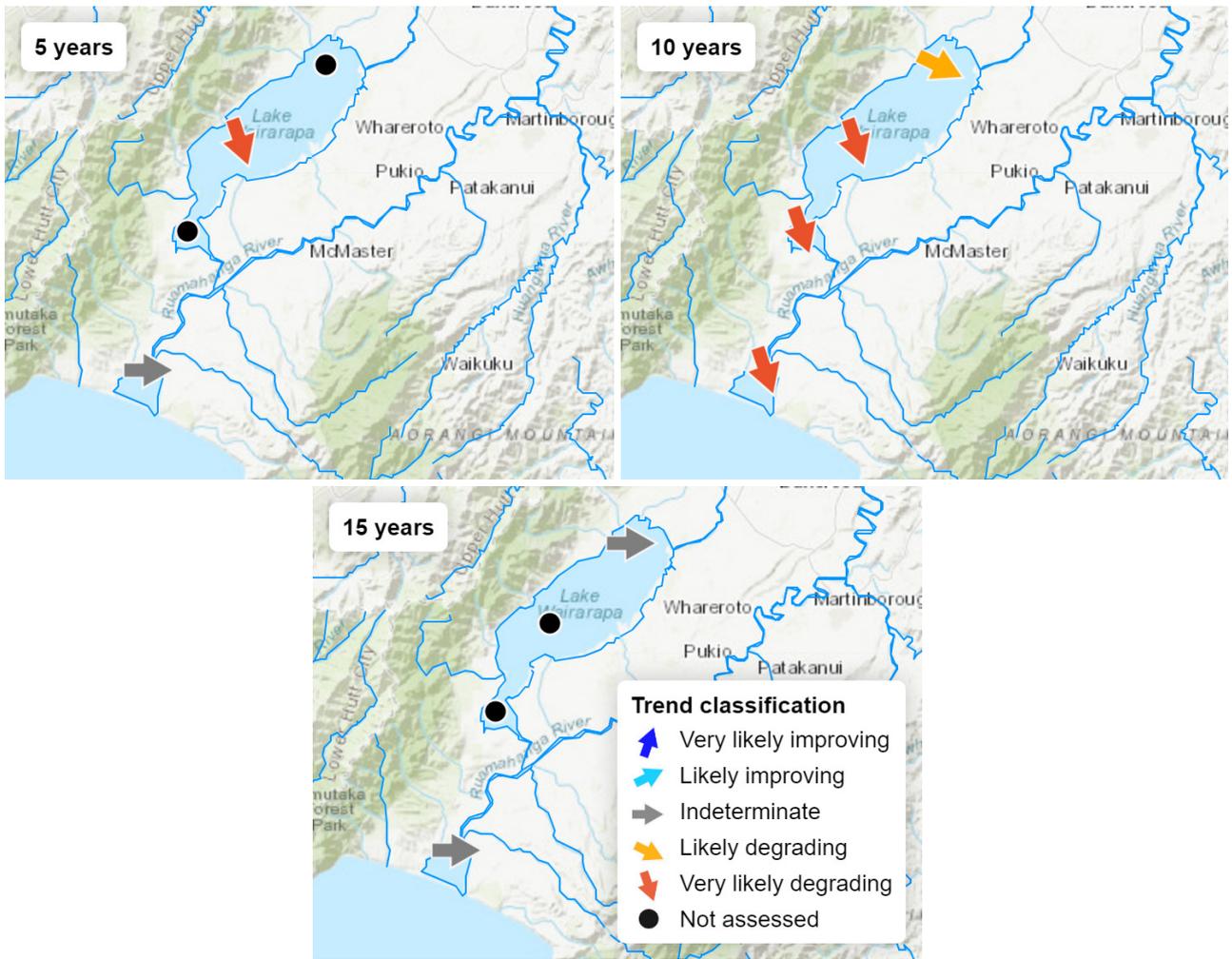


Figure 7: Total phosphorus (mg/m³) 5, 10, and 15 year trends

Table 13: Total phosphorus (mg/m³) trend results and applicable state assessments, see the [National Objectives Framework \(NOF\)](#), [Trophic Level Index \(TLI\)](#), and [Natural Resource Plan \(RNP\)](#) methods sections for full details on assessment criteria.

Lake	Site	Median (3-yr)	NOF state	TLI (3-yr)	Meets NRP	Trend classification		
						5 yr	10 yr	15 yr
Ōnoke	Site 1	41	D	Eutrophic (high)	No	→	↓↓ 1.0	→
Wairarapa	Alsops Bay	71	D	Supertrophic (very high)	No		↓↓ 2.0	
Wairarapa	Middle	66	D	Supertrophic (very high)	No	↓↓ 5.5	↓↓ 2.2	
Wairarapa	Site 2 - stump	77	D	Supertrophic (very high)	No		↓ 1.3	→

Visual clarity

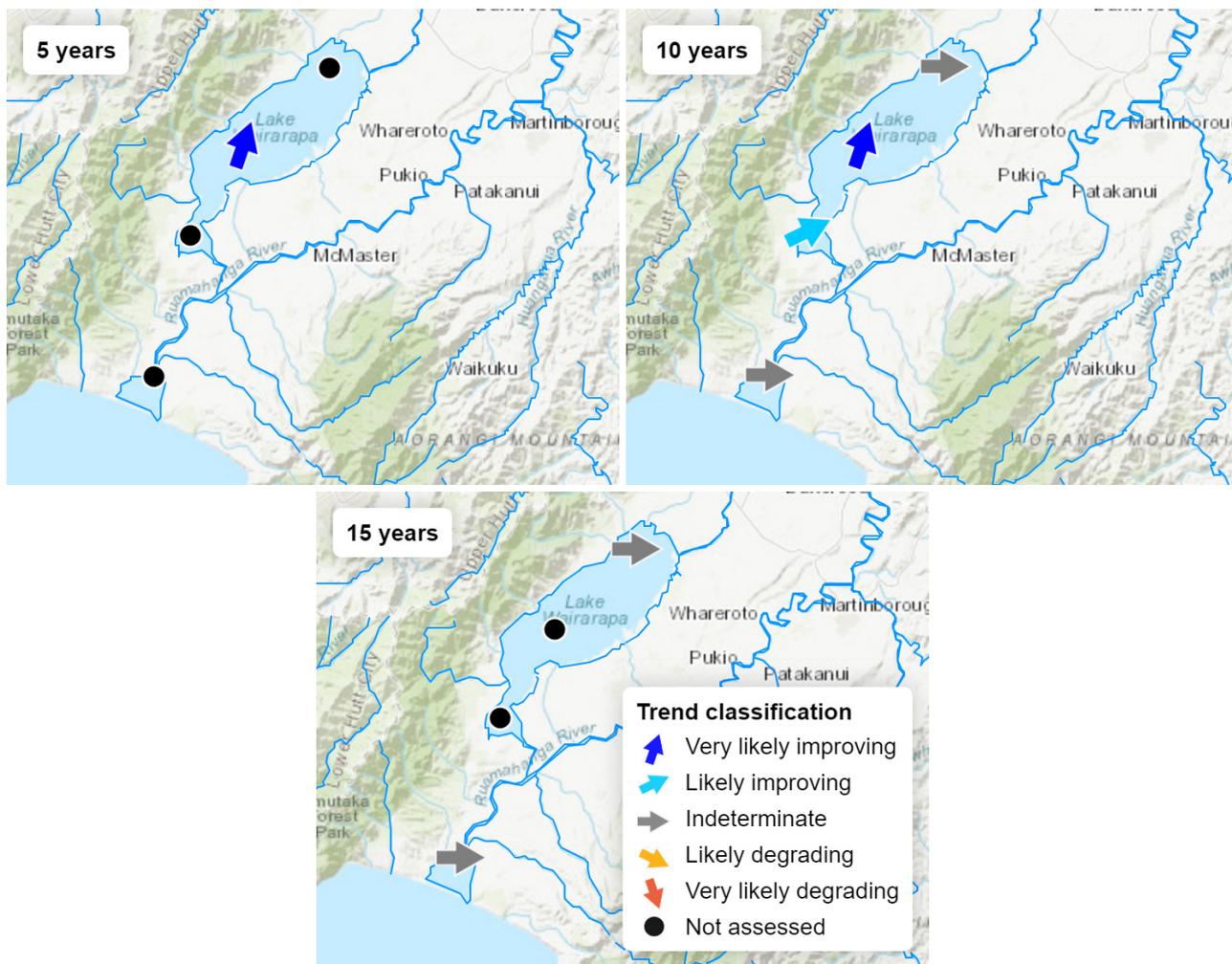


Figure 8: Visual clarity (m) 5, 10, and 15 year trends

Table 14: Visual clarity (m) trend results and applicable state assessments, see the [Trophic Level Index \(TLI\)](#) methods section for full details on assessment criteria.

Lake	Site	Median (3-yr)	TLI (3-yr)	Trend classification		
				5 yr	10 yr	15 yr
Ōnoke	Site 1	0.39	Eutrophic (high)		→	→
Wairarapa	Alsops Bay	0.34	Supertrophic (very high)		↑ 0.01	
Wairarapa	Middle	0.25	Supertrophic (very high)	↑↑ 0.02	↑↑ 0.01	
Wairarapa	Site 2 - stump	0.23	Supertrophic (very high)		→	→

Chlorophyll *a*

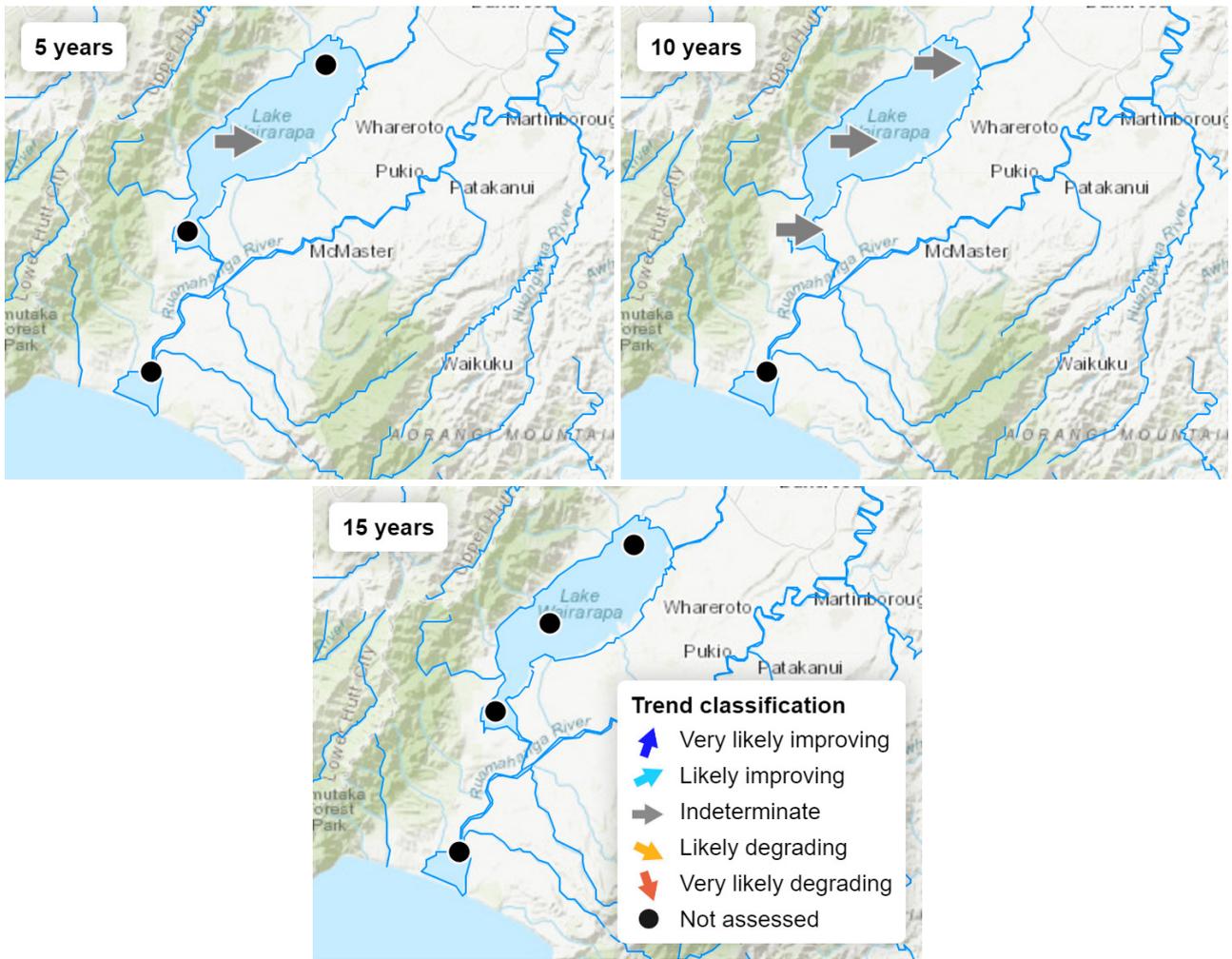


Figure 9: Chlorophyll *a* (mg/m³) 5, 10, and 15 year trends

Table 15: Chlorophyll *a* (mg/m³) trend results and applicable state assessments, see the [National Objectives Framework \(NOF\)](#), [Trophic Level Index \(TLI\)](#), and [Natural Resource Plan \(RNP\)](#) methods sections for full details on assessment criteria.

Lake	Site	Median (3-yr)	NOF state	TLI (3-yr)	Meets NRP	Trend classification		
						5 yr	10 yr	15 yr
Ōnoke	Site 1	3.5	B	Eutrophic (high)	No			
Wairarapa	Alsops Bay	11.5	C	Supertrophic (very high)	No		→	
Wairarapa	Middle	14.0	D	Supertrophic (very high)	No	→	→	
Wairarapa	Site 2 - stump	12.0	D	Supertrophic (very high)	No		→	

LakeSPI assessment results

Submerged aquatic plant communities are assessed using the LakeSPI methodology. Metrics include measures of diversity from the presence of key plant communities, the depth of vegetation growth, and the extent that invasive weeds are represented. See the [LakeSPI assessments methods section](#) for more information, and the [technical report](#) for additional results.

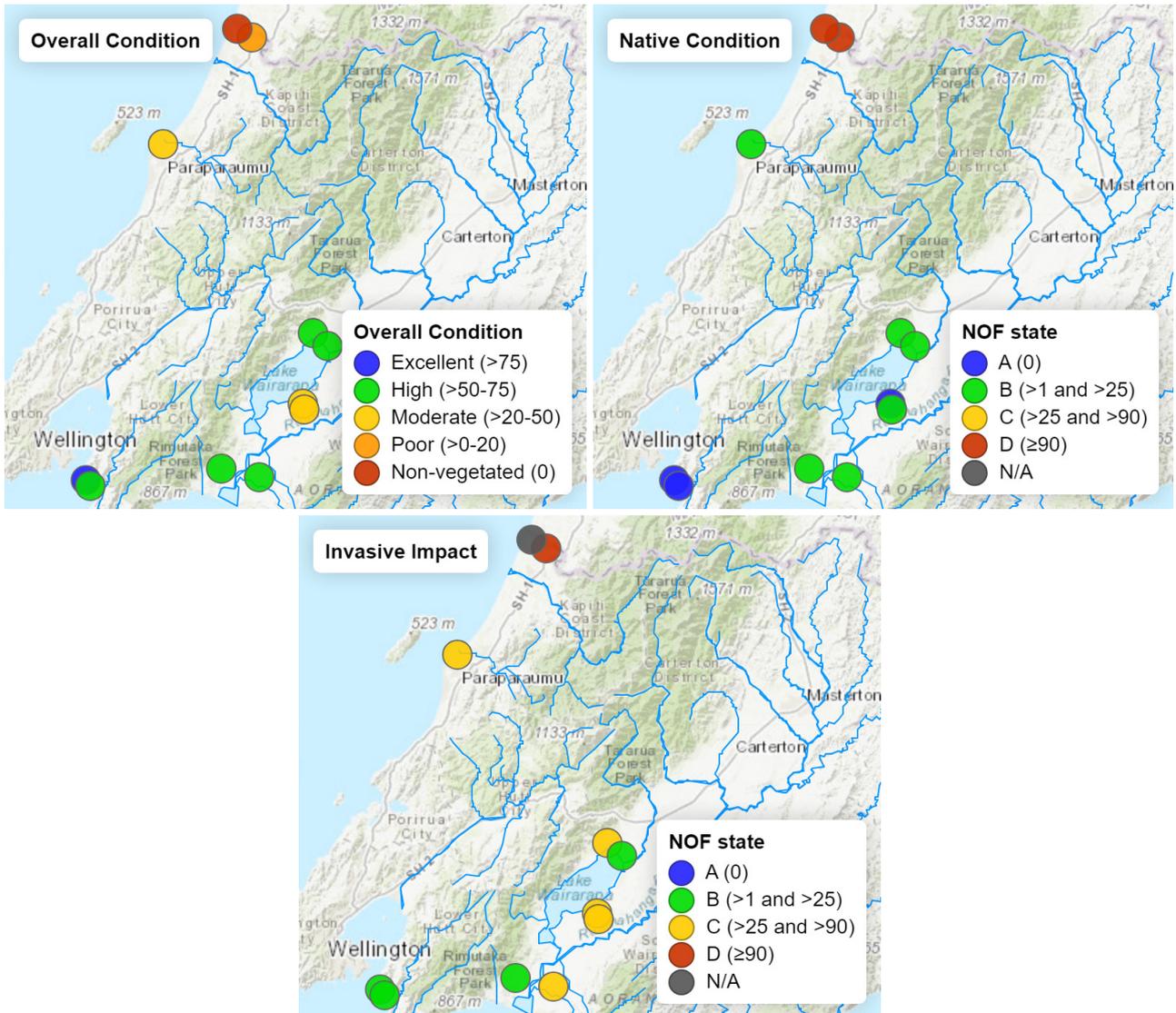


Figure 10: LakeSPI assessments from the latest surveys. Legend values in brackets correspond to: % of best possible for Overall Condition & Native Condition, and % of highest possible Invasive Impact.

Table 16: LakeSPI assessments from the latest surveys. Values refer to index scores (% of best possible for LakeSPI and Native Condition, and % of worst possible for Invasive Impact). NOF state letters, A (best) to D (worst), are included in brackets where applicable.

Area	Waterbody	Latest survey	Overall condition	LakeSPI	Native Condition	Invasive Impact
Ōtaki	Lake Waitawa	2022	Poor	6	0 (D)	96 (D)
Ōtaki	Lake Waiorongomai	2022	Non-vegetated	0	0 (D)	N/A
Waikanae	Lake Ngarara	2022	Moderate	45	64 (B)	58 (C)
Wainuiomata	Lake Kohangapiripiri	2023	Excellent	88	81 (A)	7 (B)
Wainuiomata	Lake Kohangatera	2023	High	87	79 (A)	6 (B)
Wairarapa	Lake Pounui	2023	High	72	52 (B)	7 (B)
Wairarapa	Lake Nganoke	2022	High	68	69 (B)	30 (C)
Wairarapa	Boggy Pond	2022	Moderate	44	79 (A)	67 (C)
Wairarapa	Matthew's Lagoon	2022	Moderate	34	62 (B)	73 (C)
Wairarapa	Turner's Lagoon	2022	High	68	74 (B)	31 (C)
Wairarapa	Barton's Lagoon	2022	High	74	71 (B)	22 (B)

Supplementary data results

Nitrogen

Total nitrogen

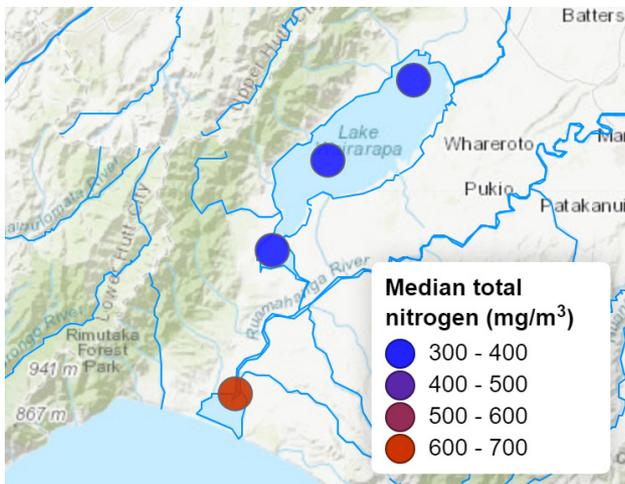


Figure 11: Median total nitrogen (mg/m³) results.

Table 17: Total nitrogen results, all units are mg/m³ unless otherwise noted.

Lake	Site	No. samples	Min	Median	Max
Wairarapa	Site 2 - stump	9	200	390	850
Wairarapa	Middle	9	150	380	810
Wairarapa	Alsops Bay	8	160	365	900
Ōnoke	Site 1	11	340	700	1,050

Ammoniacal nitrogen

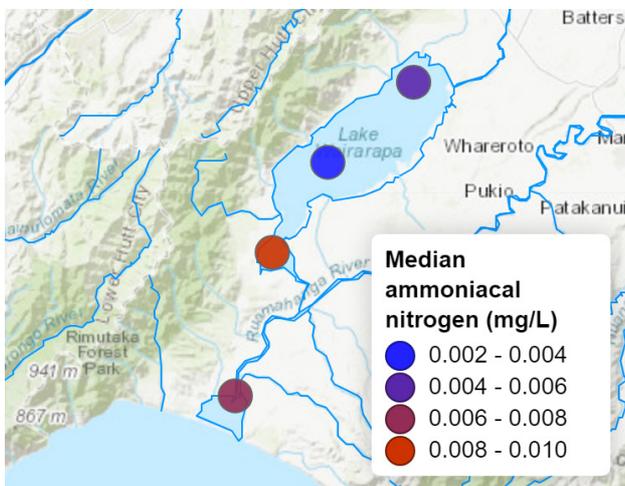


Figure 12: Median ammoniacal nitrogen (mg/L) results.

Table 18: Ammoniacal nitrogen results, all units are mg/L unless otherwise noted.

Lake	Site	No. samples	Min	Median	Max
Wairarapa	Site 2 - stump	9	<0.005	0.006	0.056
Wairarapa	Middle	9	<0.005	<0.005	0.041
Wairarapa	Alsops Bay	8	<0.005	0.010	0.015
Ōnoke	Site 1	11	<0.005	0.007	0.048

Total Kjeldahl nitrogen

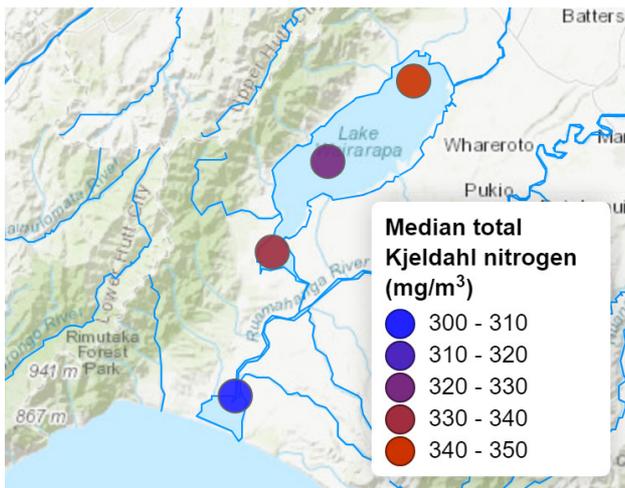


Figure 13: Median total Kjeldahl nitrogen (mg/m³) results.

Table 19: Total kjeldahl nitrogen results, all units are mg/m³ unless otherwise noted.

Lake	Site	No. samples	Min	Median	Max
Wairarapa	Site 2 - stump	9	200	350	830
Wairarapa	Middle	9	<200	320	720
Wairarapa	Alsops Bay	8	<200	330	830
Ōnoke	Site 1	11	<200	300	510

Nitrite-nitrate nitrogen

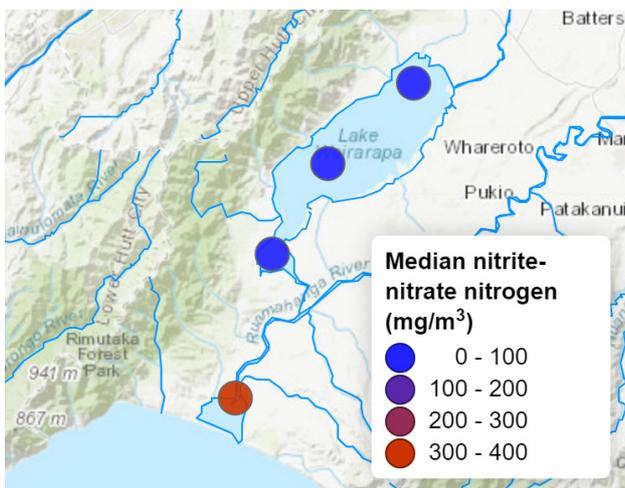


Figure 14: Median nitrite-nitrate nitrogen (mg/m³) results.

Table 20: Nitrite-nitrate nitrogen results, all units are mg/m³ unless otherwise noted.

Lake	Site	No. samples	Min	Median	Max
Wairarapa	Site 2 - stump	9	<1.0	1.0	570.0
Wairarapa	Middle	9	<1.0	2.4	490.0
Wairarapa	Alsops Bay	8	1.0	2.6	570.0
Ōnoke	Site 1	11	124.0	360.0	650.0

Phosphorus

Total phosphorus

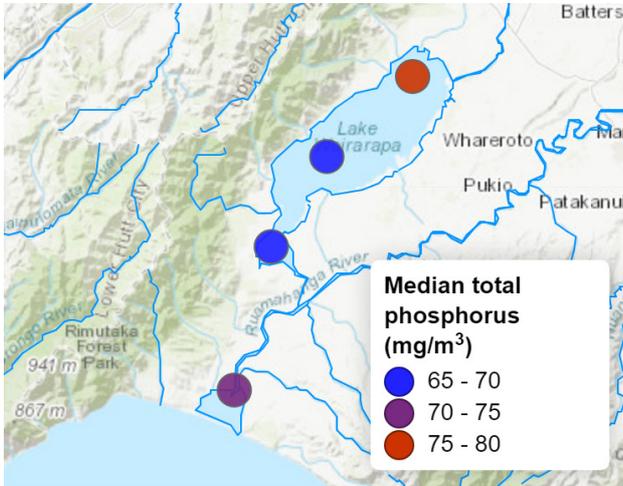


Figure 15: Median total phosphorus (mg/m³) results.

Table 21: Total phosphorus results, all units are mg/m³ unless otherwise noted.

Lake	Site	No. samples	Min	Median	Max
Wairarapa	Site 2 - stump	9	37	78	330
Wairarapa	Middle	9	29	65	169
Wairarapa	Alsops Bay	8	38	65	172
Ōnoke	Site 1	11	22	71	146

Dissolved reactive phosphorus

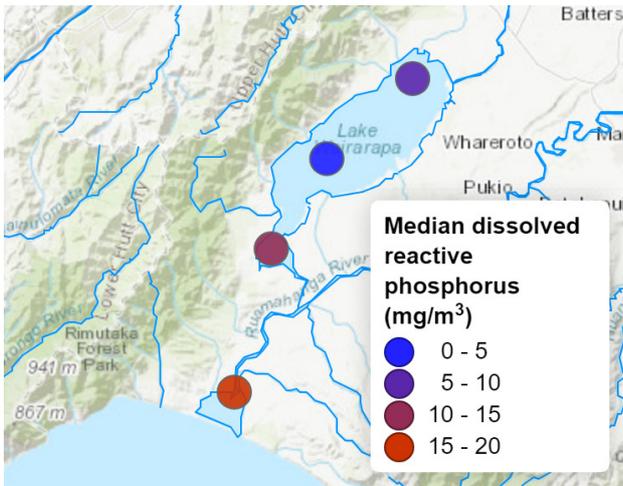


Figure 16: Median dissolved reactive phosphorus (mg/m³) results.

Table 22: Dissolved reactive phosphorus results, all units are mg/m³ unless otherwise noted.

Lake	Site	No. samples	Min	Median	Max
Wairarapa	Site 2 - stump	9	3.0	9.0	33.0
Wairarapa	Middle	9	1.2	2.1	27.0
Wairarapa	Alsops Bay	8	2.0	14.1	28.0
Ōnoke	Site 1	11	1.2	15.1	30.0

Phytoplankton

Chlorophyll *a*

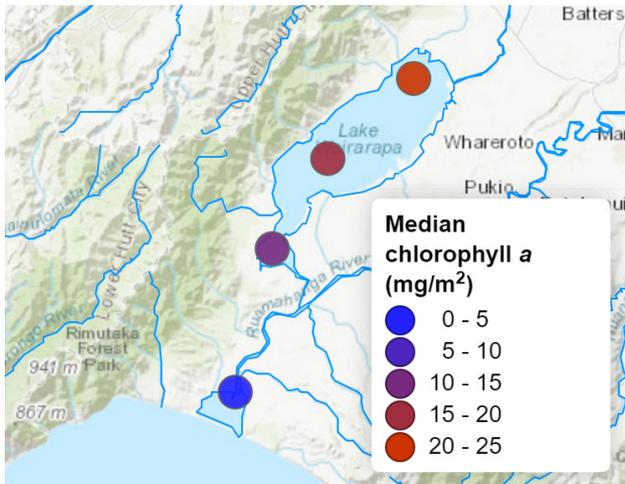


Figure 17: Median chlorophyll *a* (mg/m³) results.

Table 23: Chlorophyll *a* results, all units are mg/m² unless otherwise noted.

Lake	Site	No. samples	Min	Median	Max
Wairarapa	Site 2 - stump	9	3.0	22.0	58.0
Wairarapa	Middle	9	<3.0	17.0	43.0
Wairarapa	Alsops Bay	7	3.0	11.0	56.0
Ōnoke	Site 1	11	<3.0	4.0	35.0

Water clarity

Secchi depth

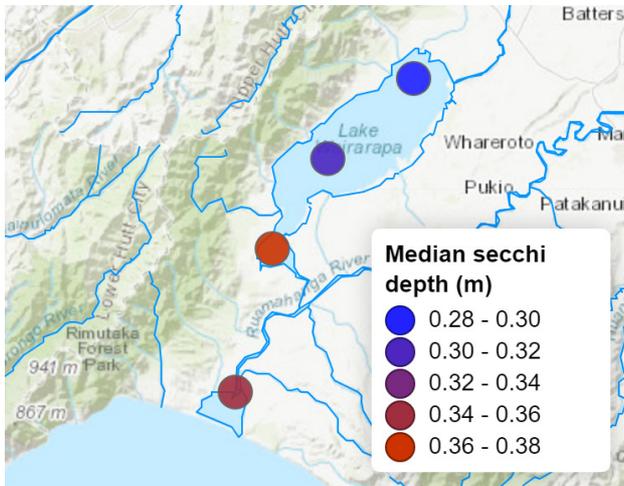


Figure 18: Median secchi depth (m) results.

Table 24: Secchi depth results, all units are m unless otherwise noted.

Lake	Site	No. samples	Min	Median	Max
Wairarapa	Site 2 - stump	9	0.15	0.29	0.60
Wairarapa	Middle	9	0.18	0.31	0.63
Wairarapa	Alsops Bay	8	0.20	0.37	0.50
Ōnoke	Site 1	11	0.19	0.35	1.00

Sediment

Turbidity

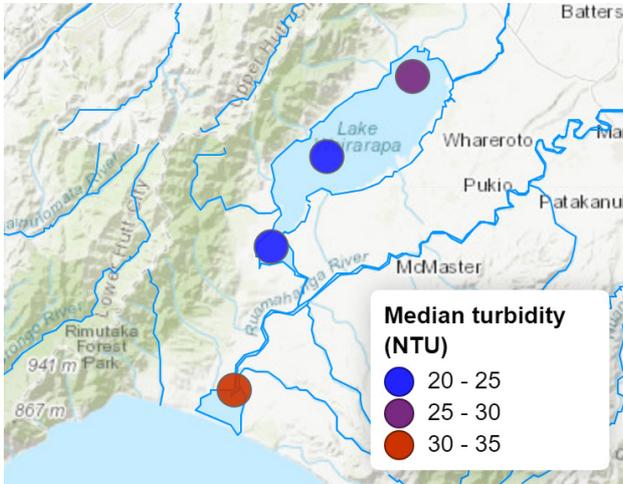


Figure 19: Median turbidity (NTU) results.

Table 25: Turbidity results, all units are NTU unless otherwise noted.

Lake	Site	No. samples	Min	Median	Max
Wairarapa	Site 2 - stump	9	10.4	27.0	136.0
Wairarapa	Middle	9	6.9	24.0	122.0
Wairarapa	Alsops Bay	8	13.9	23.0	124.0
Ōnoke	Site 1	11	1.6	35.0	138.0

Total suspended solids

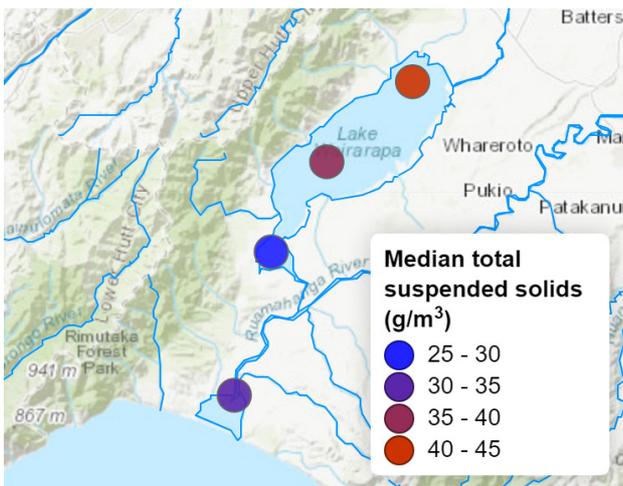


Figure 20: Median total suspended solids (g/m³) results.

Table 26: Total suspended solids results, all units are g/m³ unless otherwise noted.

Lake	Site	No. samples	Min	Median	Max
Wairarapa	Site 2 - stump	9	17.0	41.0	163.0
Wairarapa	Middle	9	13.0	37.0	132.0
Wairarapa	Alsops Bay	8	17.0	28.0	120.0
Ōnoke	Site 1	11	5.0	32.0	160.0

Volatile suspended solids

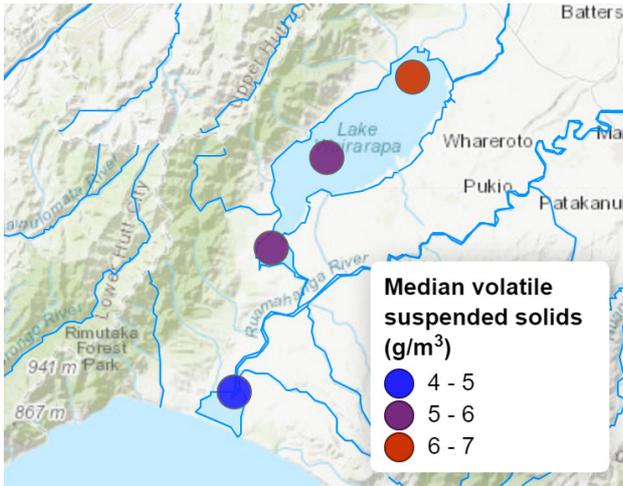


Figure 21: Median volatile suspended solids (g/m³) results.

Table 27: Volatile suspended solids results, all units are g/m³ unless otherwise noted.

Lake	Site	No. samples	Min	Median	Max
Wairarapa	Site 2 - stump	9	2.0	7.0	21.0
Wairarapa	Middle	9	<2.0	5.0	26.0
Wairarapa	Alsops Bay	8	<2.0	5.0	44.0
Ōnoke	Site 1	11	<2.0	4.0	11.0

Other water quality variables

Water temperature

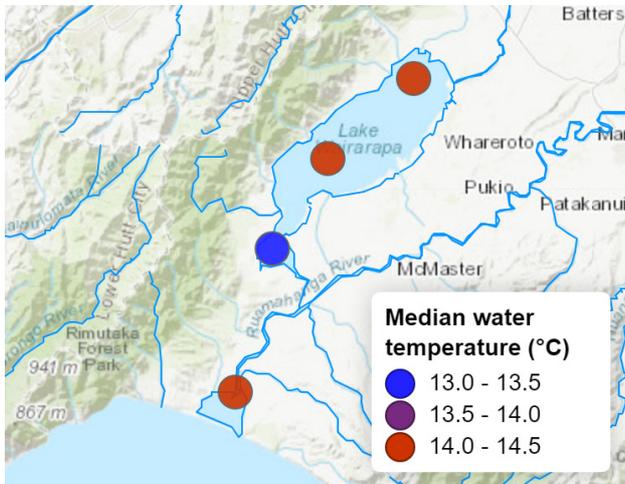


Figure 22: Median water temperature (°C) results.

Table 28: Water temperature results, all units are °C unless otherwise noted.

Lake	Site	No. samples	Min	Median	Max
Wairarapa	Site 2 - stump	9	9.3	14.0	20.1
Wairarapa	Middle	9	9.1	14.1	20.7
Wairarapa	Alsops Bay	8	9.3	13.1	19.4
Ōnoke	Site 1	11	8.6	14.2	21.4

pH

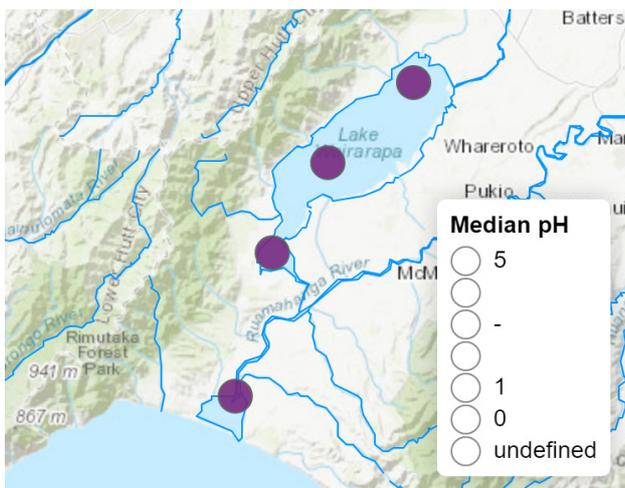


Figure 23: Median pH results.

Table 29: pH results, all units are pH units unless otherwise noted.

Lake	Site	No. samples	Min	Median	Max
Wairarapa	Site 2 - stump	9	7.3	7.6	8.7
Wairarapa	Middle	9	7.2	7.6	8.4
Wairarapa	Alsops Bay	8	7.2	7.6	8.1
Ōnoke	Site 1	11	7.2	7.6	8.6

Dissolved oxygen mg/L

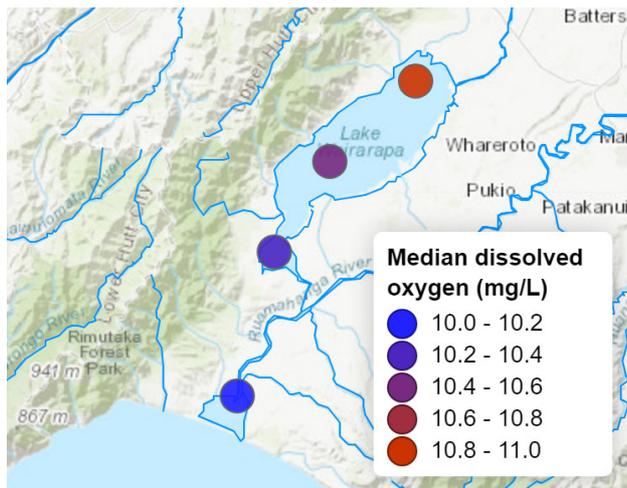


Figure 24: Median dissolved oxygen (mg/L) results.

Table 30: Dissolved oxygen results, all units are mg/L unless otherwise noted.

Lake	Site	No. samples	Min	Median	Max
Wairarapa	Site 2 - stump	9	8.66	10.86	12.55
Wairarapa	Middle	9	8.59	10.58	11.98
Wairarapa	Alsops Bay	8	8.63	10.36	11.76
Ōnoke	Site 1	11	8.22	10.05	12.30

Dissolved oxygen % saturation

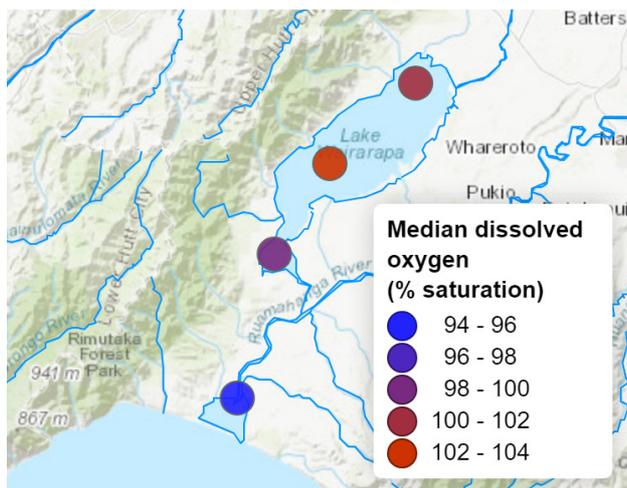


Figure 25: Median dissolved oxygen (% saturation) results.

Table 31: Dissolved oxygen % sat results, all units are % saturation unless otherwise noted.

Lake	Site	No. samples	Min	Median	Max
Wairarapa	Site 2 - stump	9	95.4	100.7	116.2
Wairarapa	Middle	9	94.6	103.4	111.0
Wairarapa	Alsops Bay	8	93.8	99.0	109.0
Ōnoke	Site 1	11	94.0	95.8	122.5

Conductivity

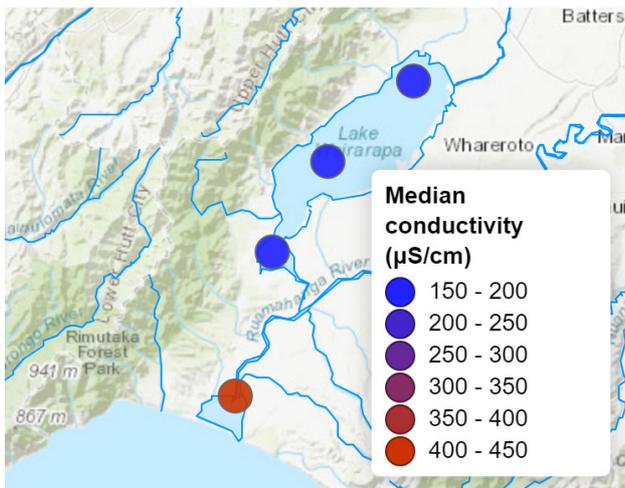


Figure 26: Median conductivity (µS/cm) results.

Table 32: Conductivity results, all units are µS/cm unless otherwise noted.

Lake	Site	No. samples	Min	Median	Max
Wairarapa	Site 2 - stump	9	128.0	156.5	374.3
Wairarapa	Middle	9	124.9	172.0	337.5
Wairarapa	Alsops Bay	8	125.7	160.5	342.2
Ōnoke	Site 1	11	183.4	433.0	3744.0

Resources

Useful Links

[Australian and New Zealand Guidelines for Fresh and Marine Water Quality](#)

[Greater Wellington Natural Resources Plan](#)

[National Policy Statement for Freshwater Management 2020](#)

[2017/18 Lake water quality and ecology report](#)

[Land Air Water Aotearoa \(LAWA\)](#)

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Appendix

Monitoring details

Table A1: Water quality sampling methods and detection limits.

Variable	Method	Detection limit
pH	pH meter. APHA 4500-H+ B 22nd ed. 2012	0.1 pH units
Turbidity	Analysis using a Hach 2100N, Turbidity meter. APHA 2130 B 22nd Ed. 2012	0.05 NTU
Total suspended solids	Filtration using Whatman 934 AH, Advantec GC-50 or 1-2 equivalent filters (nominal pore size 1.2 - 1.5µm), gravimetric determination. APHA 2540 D 22nd Ed. 2012	2 g/m ³
Volatile suspended solids	Filtration (GF/C, 1.2 µm). Ashing 550°C, 30 min. Gravimetric. APHA 2540 E 22nd Ed. 2012	2 g/m ³
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - Nitrite-N	0.001 g/m ³
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO 3 - I (modified) 22nd Ed. 2012	0.001 g/m ³
Nitrate-N + Nitrite-N (NNN)	Total oxidised nitrogen. Automated cadmium reduction, Flow injection analyser. APHA 4500-NO 3 - I (modified) 22nd Ed. 2012	0.001 g/m ³
Ammoniacal nitrogen	Phenol/hypochlorite colorimetry. Flow injection analysers. (NH ₄ -N = NH ₄ ⁺ -N + NH ₃ -N) APHA 4500-NH 3 F 22nd Ed. 2012	0.005 g/m ³
Total Kjeldahl nitrogen	Kjeldahl digestion, phenol/hyperchlorite colorimetry (Discrete Analysis). APHA 4500-N Org C. (modified) 4500- F (modified) 22nd Ed. 2012	0.1 g/m ³
Total nitrogen	Calculation: TKN + Nitrate-N + Nitrite-N	0.05 g/m ³
Dissolved reactive phosphorus	Filtered sample. Molybdenum blue colorimetry. Flow injection analyser. APHA 4500-P G 22nd Ed. 2012	0.001 g/m ³
Total phosphorus	Total Phosphorus digestion, ascorbic acid colorimetry. Discrete Analyser. APHA 4500-P B & E (modified from manual analysis) 22nd Ed. 2012	0.004 g/m ³
Chlorophyll <i>a</i>	Acetone extraction. Spectroscopy. APHA 10200 H (modified) 22nd Ed. 2012	0.003 mg/m ²
Pheophytin <i>a</i>	Acetone extraction. Spectroscopy. APHA 10200 H (modified) 22nd Ed. 2012	0.003 g/m ³
Absorbance at 340 nm	Filtered sample. Spectrophotometry, 1cm cell. APHA 5910 B 22nd Ed. 2012	0.002 AU/cm
Absorbance at 440 nm	Filtered sample. Spectrophotometry, 1cm cell. APHA 5910 B 22nd Ed. 2012	0.002 AU/cm
Absorbance at 780 nm	Filtered sample. Spectrophotometry, 1cm cell. APHA 5910 B 22nd Ed. 2012	0.002 AU/cm

Table A2: Water quality monitoring site information.

Lake	Site	Type	Lat	Lng
Wairarapa	Site 2 - stump	Polymictic	-41.176	175.285
Wairarapa	Middle	Polymictic	-41.227	175.214
Wairarapa	Alsops Bay	Brackish	-41.282	175.168
Ōnoke	Site 1	Brackish	-41.371	175.139

Table A3: LakeSPI monitoring site information.

Area	Waterbody	Depth (m)	Lat	Lng
Ōtaki	Lake Waiorongomai	1.5	-40.712	175.143
Ōtaki	Lake Waitawa	6.9	-40.725	175.173
Waikanae	Lake Ngarara	2.5	-40.877	175.005
Wairarapa	Turner's Lagoon	0.4	-41.151	175.287
Wairarapa	Barton's Lagoon	1.0	-41.168	175.314
Wairarapa	Boggy Pond	1.1	-41.251	175.267
Wairarapa	Matthew's Lagoon	1.3	-41.260	175.269
Wairarapa	Lake Nganoke	1.6	-41.356	175.186
Wairarapa	Lake Pounui	9.8	-41.344	175.114
Wainuiomata	Lake Kohangatera	2.3	-41.368	174.867
Wainuiomata	Lake Kohangapiripiri	1.5	-41.361	174.857