2024

Lake Water Quality in Tāmaki Makaurau: Annual Data Summary

Auckland Council's online interactive Water Quality and River Ecology Data Explorer presents State of the Environment (SoE) monitoring data for rivers, lakes, groundwater and the coast. Lake water quality can be compared across the region, by season, throughout the lakes' depths and over time.[1]

This report provides a summary of **lake water quality** monitoring results for **July 2020 to June 2024**.

Key findings

Most lakes in Auckland are in poor health

- 12 out of 13 (92%) of the monitored lakes in the Auckland region were in poor health.

Lake health differs between lake types

- Shallow, polymictic (well-mixed) lakes were in worse health than deeper, seasonally stratified lakes (where the water separates into layers between October and May).
- Nutrients, algae and turbidity were higher in polymictic lakes than in seasonally stratified lakes.

Stratification results in low oxygen and nutrient release from sediments

- Seasonally stratified lakes have prolonged periods with low oxygen and high nutrient concentrations in the bottom waters, suggesting nutrient release from lakebed sediments (internal loading) is occurring.

Risks to human health were low

- Cyanobacteria counts were low in publicly accessed lakes, but higher in other lakes.
- There are low levels of *E. coli* across all lakes in the region, but with episodic high results in lakes with high numbers of waterfowl.

[1] This does not include the detailed statistical analysis that is required to assess trends in water quality over time and is reported in our five-yearly State of the Environment reports.

Our lake water quality monitoring programme

Where	When	How	What
•13 lakes. •Split into five distinct spatial areas. •Two lake types (polymictic and seasonally-stratified).	•Monthly measurements and samples throughout the year.	•Water quality measured throughout the depth profile using a hand held meter. •Bottles of surface and bottom water collected and sent for laboratory analysis.	•Different measures of water quality including physical factors, nutrients, algae, bacteria, sediments and water clarity.

See the '[Water Quality and River Ecology Data Explorer Methodology]' report for more information on the water quality parameters we monitor, how we collect and analyse samples, how we analysed the data, and how to use the data explorer.

Figure 1: Lake type and location of sites monitored around the region from 2020 to 2024.

Lake health – Trophic Level Index

Lake water quality data for the 2020-2024 period shows that several lakes in the Auckland region are currently in a degraded state, with elevated concentrations of nutrients and algae, and low water clarity.

The ecological health of lakes is summarised using the Lake Trophic Level Index (TLI). This indicator is only displayed in the table tab of lake water quality on the data explorer. For the most recent reporting year (July 2023 – June 2024), 12 out of 13 of the region's monitored lakes show signs of nutrient enrichment (eutrophication) and are classed as being in poor, or very poor health, as shown using the lake TLI. Lake Rototoa had the lowest TLI score (3.3 - fair) and Lake Spectacle had the highest TLI score (6.1 – very poor).

Figure 2 shows no lakes are in the very good or good categories, and most are in a poor (eutrophic) state. This suggests there are elevated levels of nutrients and algae in Auckland's lakes, which reduce water clarity and can result in summer algal blooms.

Across the four years, Lake Rototoa had the lowest TLI score (3.0 - fair) in 2020-2021 and Lake Keretā had the highest TLI (7.7 – very poor) in 2021-2022.

As lake TLI is a score calculated annually, there are slight fluctuations in the proportion of lakes within each category over the 2020 to 2024 time period.

Lakes surrounded by pastoral land generally have poorer lake health compared to those surrounded by native bush.[2] Of the nine lakes surrounded by rural catchments, eight are in a degraded state, and five of these lack sufficient riparian zones to buffer surface contaminants (see Table 4 in methodology report for lake characteristics). However, even Lakes Wainamu and Kawaupaku which are predominantly surrounded by native bush do not have good water quality. Therefore, surrounding catchment land cover may not always be a good predictor of lake water quality.

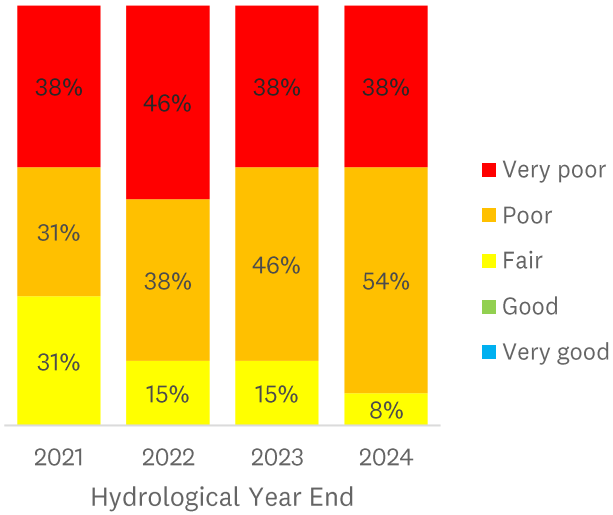

Figure 2: Proportion of Lake Trophic Level Index (TLI) scores for Auckland's lakes for each hydrological year within the 2020 – 2024 reporting period.

Comparisons between lakes

When comparing the surface waters of all lakes, the shallow polymictic lakes showed higher nutrient concentrations than the deeper, seasonally stratified lakes. In particular, the highest concentrations of nutrients were observed in Lakes Pokorua, Spectacle, Keretā (all polymictic lakes) and in the bottom waters of Lakes Kawaupaku and Kuwakatai. Polymictic lakes also had higher algal concentrations,[3] total suspended solids and turbidity levels than the deeper, seasonally stratified lakes. The greatest levels were observed in Lake Keretā (median total suspended solids 30 mg/L, median turbidity 22 NTU), which aligns with the lowest water clarity[4] in this lake (0.61 m). The lowest nutrient concentrations, total suspended solids and turbidity were found in Lake Rototoa and Lake Pupuke and these two lakes had the highest median water clarity (both 5.1 m).

[2] Verburg, P., Hamill, K., Unwin, M., and Abell, J. 2010. Lake water quality in New Zealand 2010: Status and trends. NIWA Client report for the Ministry for the Environment. NIWA Client report number: HAM2010-107

[3] Algae concentrations are shown on the dashboard as chlorophyll parameter, which is a photosynthetic pigment in plants and algae and is used as a measure of algal biomass in the water column.

[4] As shown by the Secchi depth parameter.

Most lakes showed elevated cyanobacteria concentrations, indicating potential risks to human health from exposure to cyanobacteria. The risk is low in Lakes Rototoa, Pupuke, Wainamu and Ōkaihau which are publicly accessible and recreationally used lakes (except Lake Ōkaihau which is on private land).

Generally, there were low levels of *E. coli* in lakes across the region, although there were occasional higher values recorded. Lakes that are surrounded by a rural catchment or with high numbers of (a known source of *E. coli* and nutrients)[5] had higher median *E. coli*. For example Lake Pokorua had the highest median *E. coli* concentration at 37 cfu/100mL, and waterfowl are more prevalent at this lake than at the others we monitor. Despite the presence of waterfowl and being in an urban catchment, *E. coli* remained low in Lake Pupuke (median 1 cfu/100mL).

Across the region's lakes, surface waters had higher pH and temperatures, while bottom waters of seasonally stratified lakes had elevated conductivity and salinity levels. Notably, Lake Keretā had the highest dissolved oxygen levels, with median concentrations exceeding 100% saturation, suggesting there are large amounts of algae photosynthesising and producing oxygen.

Peaks in lake water level around February / March 2023 show lakes were affected by Auckland Anniversary flooding in January 2023 and Cyclone Gabrielle in late February 2023. Shallow polymictic lakes such as Lakes Spectacle, Slipper and Pokorua experienced peaks in nutrient concentrations, whilst West Coast lakes including Lakes Kawaupaku, Wainamu and Ōkaihau showed peaks in both nutrients and turbidity, especially in the bottom waters. This timing aligns with flooding and landslides in the region during these weather events, suggesting these peaks could be from sediment and organic matter entering the lake.

Differences in water quality by lake type

Depth profiles help to reveal differences between lake types and provide insights into stratification patterns of each lake. Eight of the 13 monitored lakes are seasonally stratified, where stratification typically starts in late September/October and lasts until May. These lakes displayed a U-shape in temperature profiles, with warmer surface waters and cooler, deeper water in summer. In winter, temperatures became more uniform, resembling the year-round pattern in polymictic (fully mixed) lakes.

The pH depth profiles were less distinct than temperature but also showed higher values near the surface when stratified, especially in Lakes Kuwakatai, Kawaupaku, and Pupuke.

Anoxic (low oxygen) conditions were common near the bottom of all seasonally stratified lakes and even occurred closer to the surface (e.g. at four metres depth in Lakes Kawaupaku, Whatihua, and Okaihau). In Lake Pupuke, the deepest and only volcanic lake, there were layers of anoxic and oxic (at the surface and ~20-40 metres deep) zones throughout the year. The patterns of anoxia in these lakes increase the likelihood of potential internal nutrient loading where nutrients are released from lakebed sediments. Stratification and anoxic conditions are expected to be longer and more intense with climate-change driven temperature increases, which may exacerbate release of nutrients from sediments.[6] Higher nutrient concentrations in the bottom waters during stratified conditions, supports this theory of nutrient release from lake bed sediments. This release promotes further algal growth throughout

[5] Perrie & Milne (2012) Lake water quality and ecology in the Wellington region: State and trends. Greater Wellington Regional Council report.

[6] Woolway, R. et al. (2021) Phenological shifts in lake stratification under climate change. Nature Communications 12:2318.

the lake.[7] However, in some lakes (e.g. Lake Rototoa) the concentrations of algae and nutrients were higher during isothermal (well-mixed) periods, particularly in the surface waters, which does not support the theory of internal loading. For other parameters such as water clarity, variability between stratified and isothermal conditions was less obvious.

Polymictic lakes show little variation in pH and dissolved oxygen throughout the water column, though anoxic conditions do occasionally occur at depth in some lakes (e.g. Lakes Slipper, Spectacle, Tomorata). When oxygen is low throughout the water column there is less habitat available for aquatic species.[8]

Disclaimer

Find out more:

Visit the Data Explorer: https://environmentauckland.org.nz/Data/Dashboard/456

Read the methodology report: https://www.knowledgeauckland.org.nz/publications/water-quality-and-river-ecology-data-explorer-methodology-supplementary-report/

For more information and data, contact: EnvironmentalData@aucklandcouncil.govt.nz

[7] Graham, E., Woodward, B., Dudley, B., Stevens, L., Verberg, P., Zeldis, J., Hofstra, D., Matheson, F. and Elliott, S. (2020) Consequences of inaction: Potential ramifications of delaying proposed nutrient source reductions for New Zealand rivers, lakes and estuaries. Report prepared for Ministry for the Environment. NIWA Client Report No: 2020046HN.

[8] Rowe, D. & Graynoth, E (2002) Lake managers handbook. Fish in New Zealand lakes. Ministry for the Environment, Wellington.

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