

Lake Hayes Trophic Level Index (TLI)

Two water years: July 2024 – June 2025, and July 2025 – June 2026

1. Background — the Burns et al. TLI method

The Trophic Level Index is the standard method used in New Zealand to classify the nutrient and algal status of lakes (*Burns, Bryers & Bowman, 2000, building on Burns et al. 1999, produced for the Ministry for the Environment*). It combines four separate water quality signals into a single score:

- Water clarity (Secchi depth)
- Total nitrogen (TN)
- Total phosphorus (TP)
- Chlorophyll a (algal biomass)

Each variable is converted to a sub-index on a common 0–7+ scale using an empirically derived logarithmic equation, and the four sub-indices are averaged to give the overall TLI. Higher values indicate greater nutrient enrichment / lower water quality.

Trophic class	TLI range	Description
Microtrophic	1 – 2	Very low nutrient status
Oligotrophic	2 – 3	Low nutrient status
Mesotrophic	3 – 4	Moderate nutrient status
Eutrophic	4 – 5	High nutrient status
Supertrophic	5 – 6	Very high nutrient status
Hypertrophic	> 6	Extremely high nutrient status

2. Formulae

$$\text{TLI} = (\text{TLc} + \text{TLn} + \text{TLp} + \text{TLchl a}) / 4$$

where (all logarithms are base 10):

$$\text{TLc (clarity)} = 5.10 + 2.60 \times \log_{10}(1/\text{SD} - 1/40) - \text{SD} = \text{Secchi depth, metres}$$

$$\text{TLn (nitrogen)} = -3.61 + 3.01 \times \log_{10}(\text{TN}) - \text{TN, mg/m}^3 \text{ (equivalent to micrograms/L)}$$

$$\text{TLp (phosphorus)} = 0.218 + 2.92 \times \log_{10}(\text{TP}) - \text{TP, mg/m}^3 \text{ (equivalent to micrograms/L)}$$

$$\text{TLchl a (chlorophyll a)} = 2.22 + 2.54 \times \log_{10}(\text{Chl a}) - \text{Chl a, mg/m}^3 \text{ (equivalent to micrograms/L)}$$

Annual TLI method (*Burns 2000, "log of means"*): the arithmetic mean of each raw variable is calculated first across the 12 monthly samples in a water year; the four annual means are then substituted into the equations above once to give the four sub-indices, which are averaged for that year's TLI. This is repeated separately for each water year.

3. Input data – ORC Tropic Lake Data Sample FA 864 Lake Hayes at mid Lake 10m

2024/25 (rows 1–12, Jul–24 to Jun–25):

Month	Secchi (m)	TN (g/m ³)	TP (g/m ³)	Chl a (g/m ³)
Jul-24	4.35	0.36	0.052	0.01660
Aug-24	5.00	0.47	0.054	0.01770
Sep-24	3.60	0.43	0.046	0.04300
Oct-24	2.45	0.54	0.046	0.05000
Nov-24	2.20	0.43	0.037	0.04400
Dec-24	2.30	0.57	0.047	0.06300
Jan-25	2.60	0.53	0.032	0.08000
Feb-25	2.70	0.38	0.023	0.03500
Mar-25	3.10	0.41	0.026	0.03200
Apr-25	8.10	0.32	0.017	0.00380
May-25	5.40	0.28	0.017	0.01030
Jun-25	7.50	0.34	0.044	0.00360

2025/26 (rows 13–24, Jul–25 to Jun–26):

Month	Secchi (m)	TN (g/m ³)	TP (g/m ³)	Chl a (g/m ³)
Jul-25	8.65	0.44	0.070	0.00069
Aug-25	5.70	0.48	0.052	0.00144
Sep-25	7.20	0.49	0.049	0.00270
Oct-25	4.90	0.49	0.029	0.00600
Nov-25	2.95	0.44	0.031	0.01500
Dec-25	2.70	0.36	0.014	0.00960
Jan-26	6.15	0.30	0.010	0.00360
Feb-26	3.50	0.38	0.014	0.00490
Mar-26	4.60	0.34	0.015	0.01670
Apr-26	8.00	0.26	0.012	0.00103
May-26	8.90	0.26	0.012	0.00200
Jun-26	8.50	0.36	0.041	0.00145

Unit conversion note: the TLI formulae require TN, TP and chlorophyll a in mg/m³ (equivalent to micrograms/L). Data is in g/m³, so each annual mean below is multiplied by 1000 before being substituted into the equations. This conversion is shown explicitly at each step so the calculation can be traced back to original figures.

4. Calculation 2024/25 (July 2024 – June 2025)

Step 1: annual mean of raw values (as supplied, g/m³):

Variable	Annual mean
Secchi depth	4.108 m
TN	0.4217 g/m ³
TP	0.0368 g/m ³
Chlorophyll a	0.03325 g/m ³

Step 2: convert TN, TP, Chl a to mg/m³ (× 1000):

Variable	× 1000 → mg/m ³ (used in formula)
TN	$0.4217 \times 1000 = 421.67 \text{ mg/m}^3$
TP	$0.0368 \times 1000 = 36.75 \text{ mg/m}^3$
Chlorophyll a	$0.03325 \times 1000 = 33.250 \text{ mg/m}^3$

Step 3: sub-indices:

$$TLc = 5.10 + 2.60 \times \log_{10}(1/4.108 - 1/40) = \mathbf{3.382}$$

$$TLn = -3.61 + 3.01 \times \log_{10}(421.67) = \mathbf{4.291}$$

$$TLp = 0.218 + 2.92 \times \log_{10}(36.75) = \mathbf{4.789}$$

$$TLchla = 2.22 + 2.54 \times \log_{10}(33.250) = \mathbf{6.085}$$

Step 4: overall TLI:

$$TLI = (3.382 + 4.291 + 4.789 + 6.085) / 4 = \mathbf{4.64}$$

Sub-index	Value
TLc (clarity)	3.38
TLn (nitrogen)	4.29
TLp (phosphorus)	4.79
TLchla (chlorophyll a)	6.08
Overall TLI (2024/25 = Eutrophic)	4.64

5. Calculation – 2025/26 (July 2025 – June 2026)

Step 1: annual mean of raw values (as supplied, g/m³):

Variable	Annual mean
Secchi depth	5.979 m
TN	0.3833 g/m³
TP	0.0291 g/m³
Chlorophyll a	0.00543 g/m³

Step 2: convert TN, TP, Chl a to mg/m³ (× 1000):

Variable	× 1000 → mg/m³ (used in formula)
TN	$0.3833 \times 1000 = 383.33 \text{ mg/m}^3$
TP	$0.0291 \times 1000 = 29.08 \text{ mg/m}^3$
Chlorophyll a	$0.00543 \times 1000 = 5.426 \text{ mg/m}^3$

Step 3: sub-indices:

$$TLc = 5.10 + 2.60 \times \log_{10}(1/5.979 - 1/40) = \mathbf{2.898}$$

$$TLn = -3.61 + 3.01 \times \log_{10}(383.33) = \mathbf{4.167}$$

$$TLp = 0.218 + 2.92 \times \log_{10}(29.08) = \mathbf{4.492}$$

$$TLchla = 2.22 + 2.54 \times \log_{10}(5.426) = \mathbf{4.086}$$

Step 4: overall TLI:

$$TLI = (2.898 + 4.167 + 4.492 + 4.086) / 4 = \mathbf{3.91}$$

Sub-index	Value
TLc (clarity)	2.90
TLn (nitrogen)	4.17
TLp (phosphorus)	4.49
TLchla (chlorophyll a)	4.09
Overall TLI (2025/26 – Mesotrophic)	3.91

6. Results summary and year-on-year comparison

Sub-index	2024/25	2025/26	Change
TLc (clarity)	3.38	2.90	0.48 (clarity improved)
TLn (nitrogen)	4.29	4.17	0.12 (slightly improved)
TLp (phosphorus)	4.79	4.49	0.30 (improved)
TLchla (chlorophyll a)	6.09	4.09	2.00 (large improvement)
Overall TLI	4.64 (Eutrophic)	3.91 (Mesotrophic)	0.73 (improved, one full trophic class)

Lake Hayes' TLI improved from approximately 4.64 in 2024/25 (Eutrophic) to approximately 3.91 in 2025/26 (Mesotrophic – the mesotrophic band runs 3.0–4.0, so 3.91 sits clearly within it, just under the eutrophic threshold of 4.0). This represents a full trophic class improvement between the two years. The improvement is driven mainly by a large drop in chlorophyll a (algal biomass) and a corresponding gain in water clarity, with more modest improvements in nitrogen and phosphorus.

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Source: Burns, N.M., Bryers, G., Bowman, E. (2000). Protocol for Monitoring Trophic Levels of New Zealand Lakes and Reservoirs. Ministry for the Environment, New Zealand.