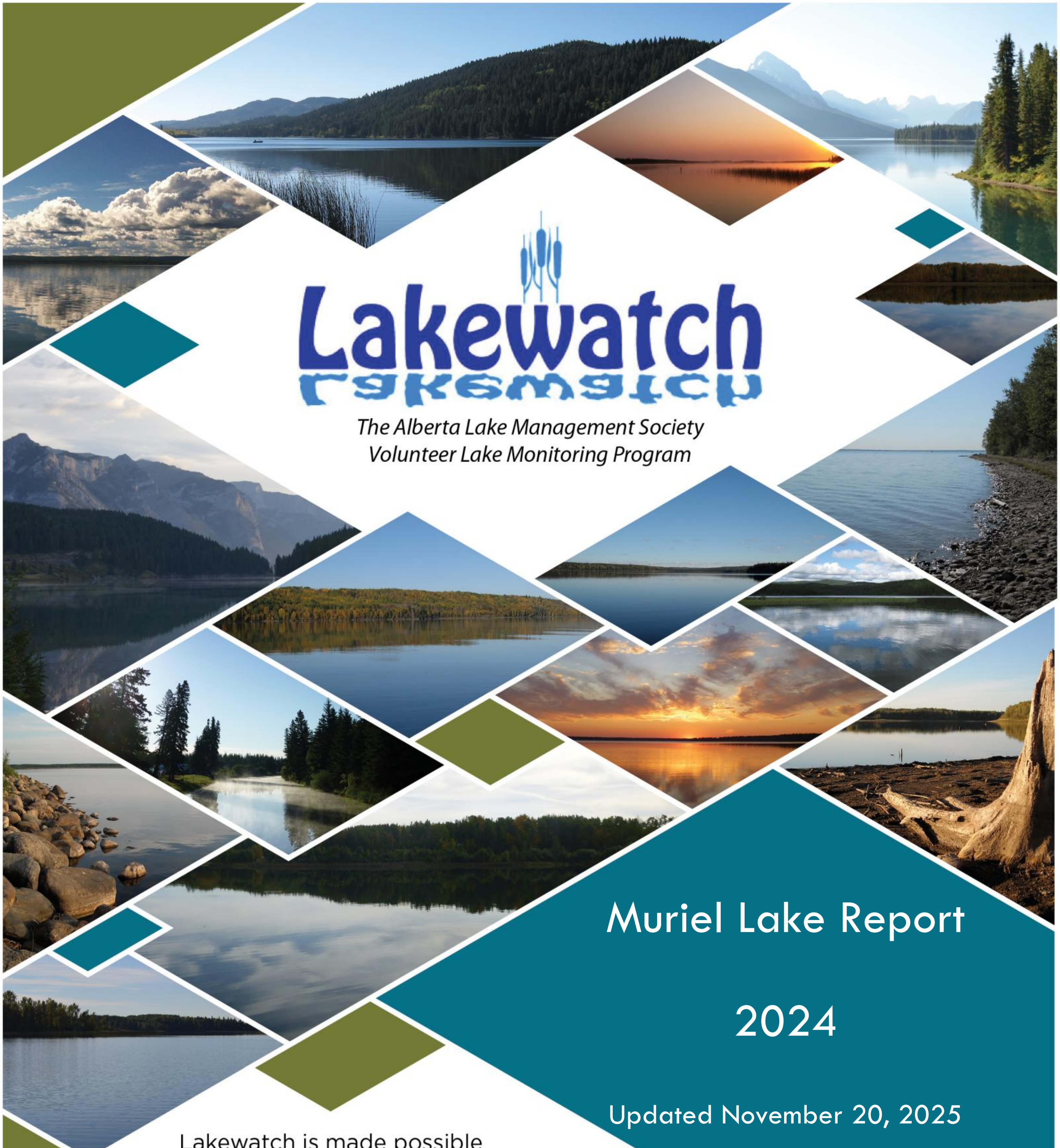


Lakewatch

The Alberta Lake Management Society
Volunteer Lake Monitoring Program

Muriel Lake Report

2024

Updated November 20, 2025

Lakewatch is made possible
with support from:

Alberta

LICA ENVIRONMENTAL STEWARDS

PIGEON LAKE WATERSHED ASSOCIATION

ALBERTA LAKE MANAGEMENT SOCIETY'S LAKEWATCH PROGRAM

LakeWatch has several important objectives, one of which is to collect and interpret water quality data from Alberta's Lakes. Equally important is educating lake users about aquatic environments, encouraging public involvement in lake management, and facilitating cooperation and partnerships between government, industry, the scientific community and lake users. LakeWatch reports are designed to summarize basic lake data in understandable terms for the widest audience, and are not meant to be a complete synopsis of information about specific lakes. Additional information is available for many lakes that have been included in LakeWatch, and readers requiring more information are encouraged to seek those sources.

ALMS would like to thank all who express interest in Alberta's aquatic environments, and particularly those who have participated in the LakeWatch program. These leaders in stewardship give us hope that our water resources will not be the limiting factor in the health of our environment.

If you require data from this report, please contact ALMS for the raw data files.

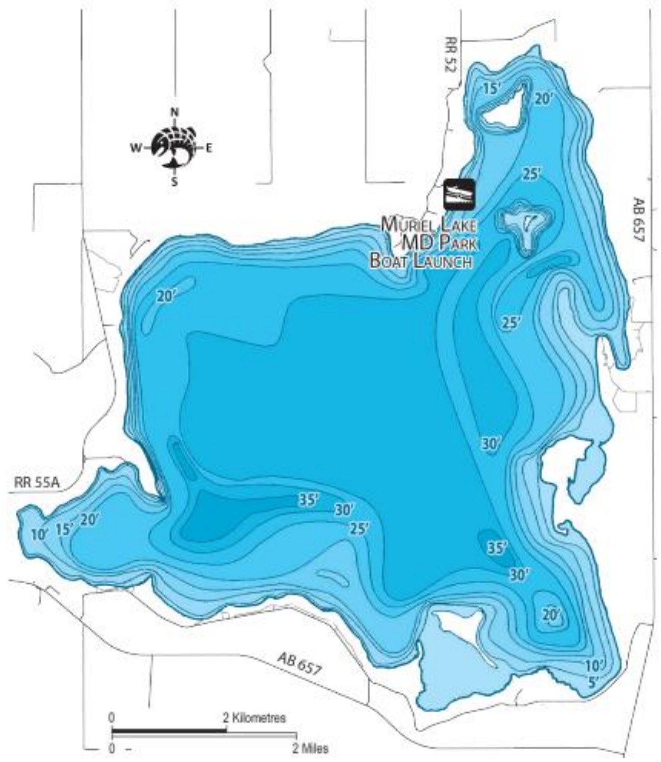
ACKNOWLEDGEMENTS

The LakeWatch program is made possible through the dedication of its volunteers. A special thanks to Jeff Hlewka for their commitment to collecting data at Muriel Lake. We would also like to thank Katherine Cundict and Jordyn Lajeunesse, who were summer technicians in 2024. Executive Director Bradley Peter and Program Manager Brittany Onysyk were instrumental in planning and organizing the field program. This report was prepared by Brittany Onysyk and Bradley Peter.

BEFORE READING THIS REPORT, CHECK OUT [A BRIEF INTRODUCTION TO LIMNOLOGY]

MURIEL LAKE

Muriel Lake is a large, shallow lake located 13 km south of the town of Bonnyville and 250 km northeast of Edmonton. The lake is approximately 69 km^2 and has a drainage basin of about 456 km^2, making the drainage basin about 6 times the size of the lake.[1] The average depth of Muriel Lake is 3.7 m. Muriel Lake lies within the dry mixedwood subregion[2], but the area surrounding the lake has been heavily developed. The lake is surrounded by agricultural, industrial, and recreational development, including public campgrounds, commercial resorts, and private residences mostly on the south and east sides of the lake.[3]



Historical bathymetric map of Muriel Lake obtained from the Angler's Atlas.

Water levels have been monitored since the late 1960's. Since then, Muriel Lake has faced steadily declining water levels. In 1974, lake levels were at their highest recorded level (560.43 m above sea level).[4] In 2000, lake levels reached 557 m (Figure 7). As of 2024, lake levels reached their lowest on record at 555.5 m (Figure 6). This loss of over 5 m of water in 50 years is substantial and has greatly increased the shoreline around the lake raising concerns from locals.

Although northern pike, yellow perch, lake whitefish, and walleye were once prevalent in the lake, these species have been extirpated or near extirpated from Muriel Lake.[5,6] Decreasing water levels, extremely low winter oxygen levels, as well as high pH and salinity are likely to have limited the survival of these species in the lake.[5]

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[1] Muriel Lake Basin Management Society. 2019. Muriel Lake Why the Water Level Dropped.

[2] Strong, W.L. and K.R. Leggat. 1981. Ecoregions of Alberta. Alta. En. Nat. Resour., Resour. Eval. Plan. Div., Edmonton.

[3] Government of Alberta. 2006. Cold Lake-Beaver River Basin Surface Water Quantity and Aquatic Resources State of the Basin Report.

[4] Government of Alberta. 2000. An Evaluation of Changes in Water Quality of Muriel Lake.

[5] Government of Alberta. 2013. Muriel Lake Fall Walleye Index Netting, 2012.

[6] Government of Alberta. 2023. Muriel Lake Fall Index Netting Summary, 2022.

WATER CHEMISTRY

ALMS measures a suite of water chemistry parameters. Phosphorus, nitrogen, and chlorophyll-a are important because they are indicators of eutrophication, or excess nutrients, which can lead to harmful algal/cyanobacteria blooms. One direct measure of harmful cyanobacteria blooms are Microcystins, a common group of toxins produced by cyanobacteria. See Table 2 for a complete list of parameters.

The average total phosphorus (TP) concentration for Muriel Lake was 62 µg/L (Table 2), falling into the eutrophic, or productive, trophic classification. This value falls on the higher end of all previously observed historical TP averages going back to 1988 (Table 2). TP ranged from a minimum of 55 µg/L on June 20, to a maximum of 66 µg/L on September 5 (Figure 1).

The average chlorophyll-*a* concentration in 2024 was 10.6 µg/L (Table 2), falling into the mesotrophic, or moderately productive trophic classification. Chlorophyll-*a* was lowest at 8.6 µg/L on September 5 and peaked at 11.8 µg/L on October 8 (Figure 1).

The average total Kjeldahl nitrogen (TKN) concentration was 3.2 mg/L (Table 2). A sharp drop in TKN levels was observed during the October 8 sampling event (Figure 1), where the algal community had likely died off.

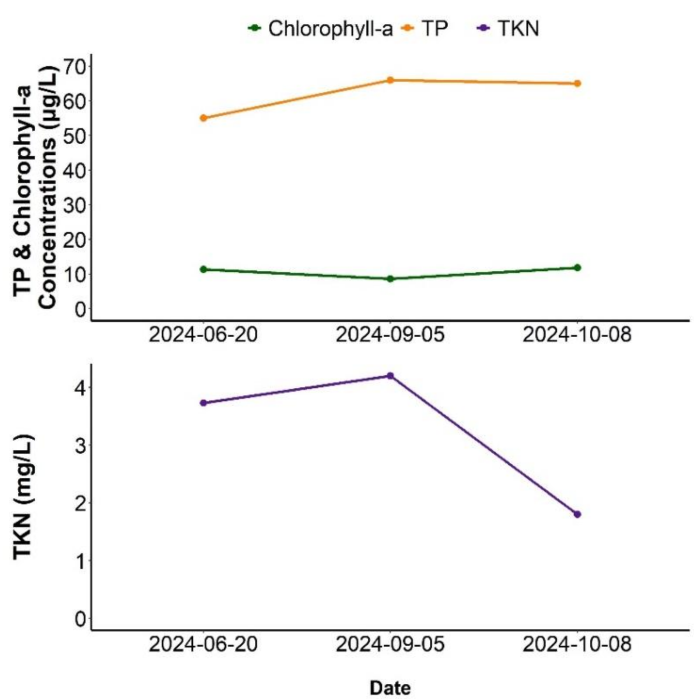

Figure 1. Total Phosphorus, Chlorophyll-a, and Total Kjeldahl Nitrogen concentrations measured over the course of the summer at Muriel Lake in 2024.

Average pH was measured as 9.37 in 2024, buffered by high alkalinity (1067 mg/L $CaCO_3$) and bicarbonate (683 mg/L HCO_3). Aside from bicarbonate, sulphate, sodium, and magnesium were higher than all other major ions (Figure 2, top). These major ions contributed to a high average conductivity of 2467 µS/cm (Table 2).

In 2024, Muriel Lake had the highest concentration of most ions measured, with the exception of calcium (Figure 2, bottom). Precipitation of calcium out of the water column may be encouraged by the lake's high pH. High conductance may inhibit the growth of algae/ cyanobacteria in Muriel Lake.[4]

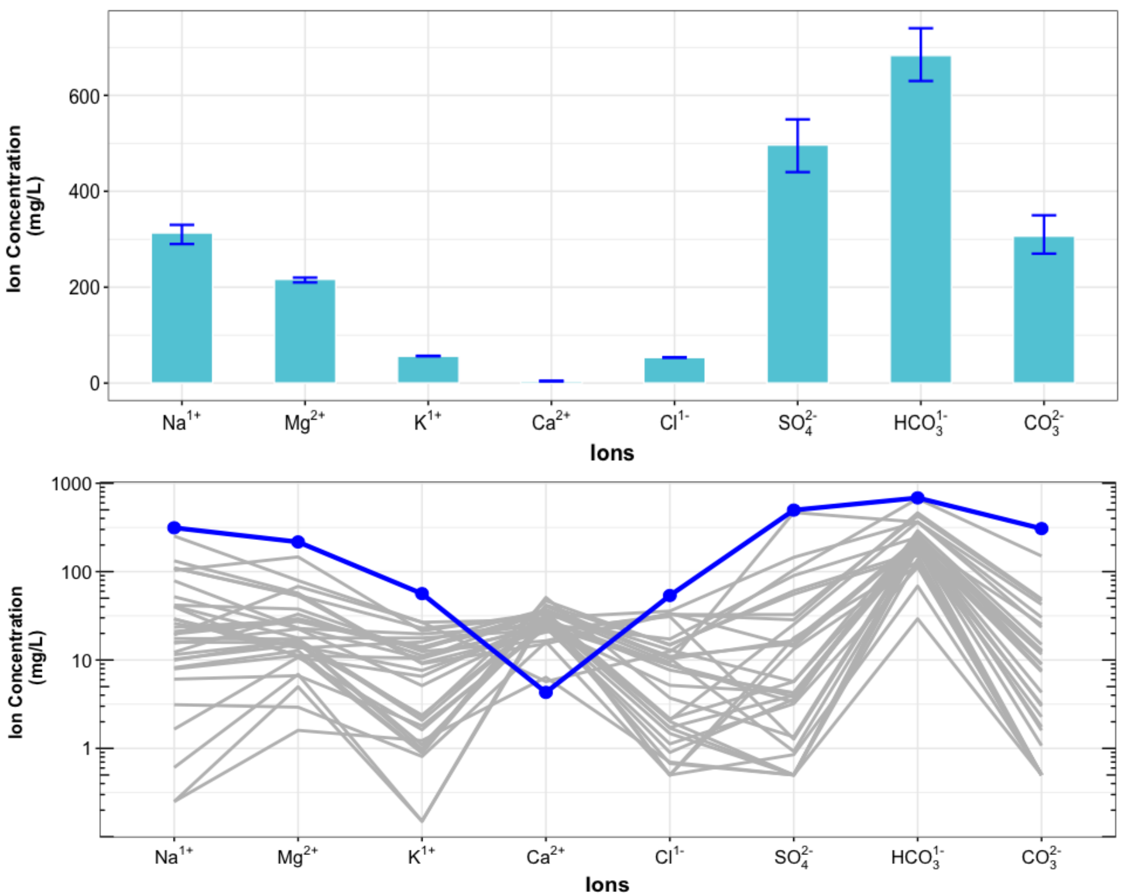

Figure 2. Average levels of cations (sodium = Na^{1+}, magnesium = Mg^{2+}, potassium = K^{1+}, calcium = Ca^{2+}) and anions (chloride = Cl^{1-}, sulphate = SO_4^{2-}, bicarbonate = HCO_3^{1-}, carbonate = CO_3^{2-}) from 3 measurements over the course of the summer at Muriel Lake. Top) bars indicate range of values measured, and bottom) Schoeller diagram of average ion levels at Muriel Lake (blue line) compared to 26 lake basins (gray lines) sampled through the LakeWatch program in 2024 (note log10 scale on y-axis of bottom figure).

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[4] Government of Alberta. 2000. An Evaluation of Changes in Water Quality of Muriel Lake.

Metals

Metals will naturally be present in aquatic environments due to in-lake processes or the erosion of rocks, or introduced to the environment from human activities such as urban, agricultural, or industrial developments. Many metals have a unique guideline as they may become toxic at higher concentrations. Where current metal data are not available, historical concentrations for 27 metals have been provided (Table 3).

Metals were measured at Muriel Lake in 2024 (Table 3). Arsenic and selenium exceeded the CCME chronic guideline for the Protection of Aquatic Life.[7] Arsenic has been measured above the CCME guidelines since LakeWatch sampling has occurred at Muriel Lake (2006), and selenium regularly exceeds guidelines (Table 3).

The elevated levels of arsenic and selenium are likely attributed to the prevalence of these metals in the landscape surrounding and beneath Muriel Lake.[8] In Northern Alberta, surface and groundwater is commonly found to be naturally high in arsenic and other heavy metals due to the local geology.[9]

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[7] Canadian Water Quality Guidelines. 2019. Canadian Council of Ministers of the Environment.
[8] Government of Alberta. 2006. Cold Lake Beaver River Basin Water Management Plan.
[9] Government of Alberta. 2000. Arsenic in Groundwater from Domestic Wells in Three Areas of Northern Alberta.

WATER CLARITY AND EUPHOTIC DEPTH

Water clarity is influenced by suspended materials, both living and dead, as well as dissolved colored compounds in the water column. During the melting of snow and ice in spring, lake water can become turbid (cloudy) from silt transported into the lake. Lake water usually clears in late spring, but then becomes more turbid with increased algal growth as the summer progresses. The easiest and most widely used measure of lake water clarity is the Secchi depth. Two times the Secchi depth equals the euphotic depth – the depth to which there is enough light for photosynthesis.

The average euphotic depth of Muriel Lake in 2024 was 1.3 m, corresponding to a Secchi depth of 0.65 m (Table 2). Euphotic depth varied over the season, ranging from as shallow as 1.2 m on June 6 to as deep as 1.5 m on October 8 (Figure 3).

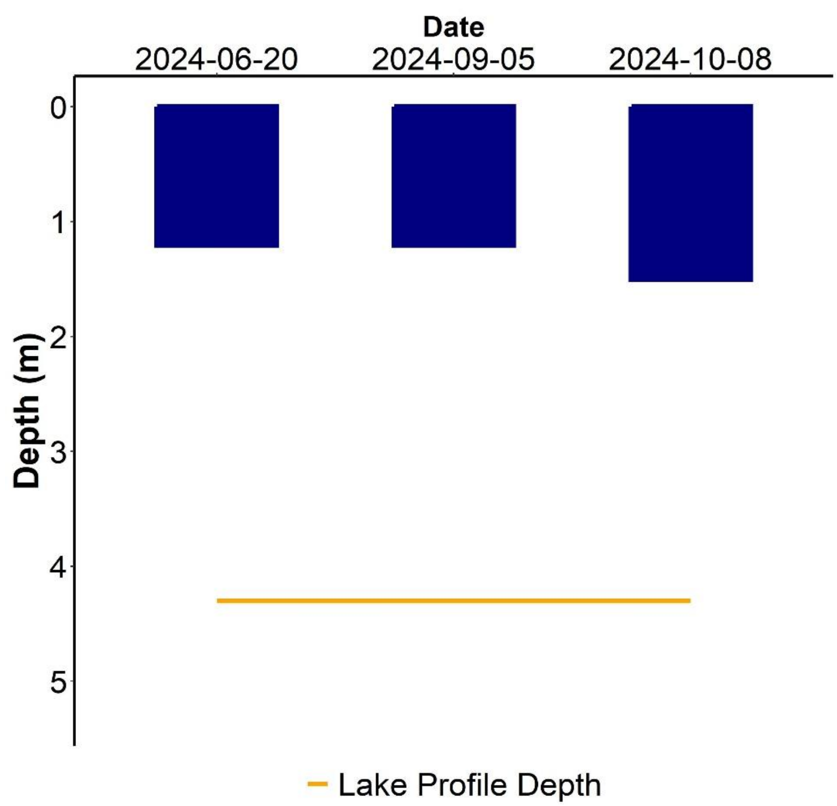

Figure 3. Euphotic depth values measured over the course of the summer at Muriel Lake in 2024.

WATER TEMPERATURE AND DISSOLVED OXYGEN

Water temperature and dissolved oxygen (DO) profiles in the water column can provide information on water quality and fish habitat. The depth of the thermocline is important in determining the depth to which dissolved oxygen from the surface can be mixed. Please refer to the end of this report for descriptions of technical terms.

Surface temperatures at Muriel Lake showed some variation throughout the summer, with the September 5 sampling having the warmest temperatures at 17.88°C (Figure 4). The lake was well mixed during all other sampling events, reflected by a steady temperature Profile to the bottom of the lake (Figure 4). Because thermal stratification was not observed, the water column remained well mixed throughout the summer.

Due to the lack of thermal stratification, the water column remained well oxygenated throughout the summer. Muriel Lake was well oxygenated in the surface waters on all sampling dates, measuring above the CCME guidelines of 6.5 mg/L dissolved oxygen[10] (Figure 4). Due to the lake being poorly stratified (well mixed), oxygen levels remained relatively stable during all sampling events. This is expected for a shallow, small lake.

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[10] Canadian Council of Ministers of the Environment. 1999. Canadian water quality guidelines for the protection of aquatic life: Dissolved oxygen (freshwater).

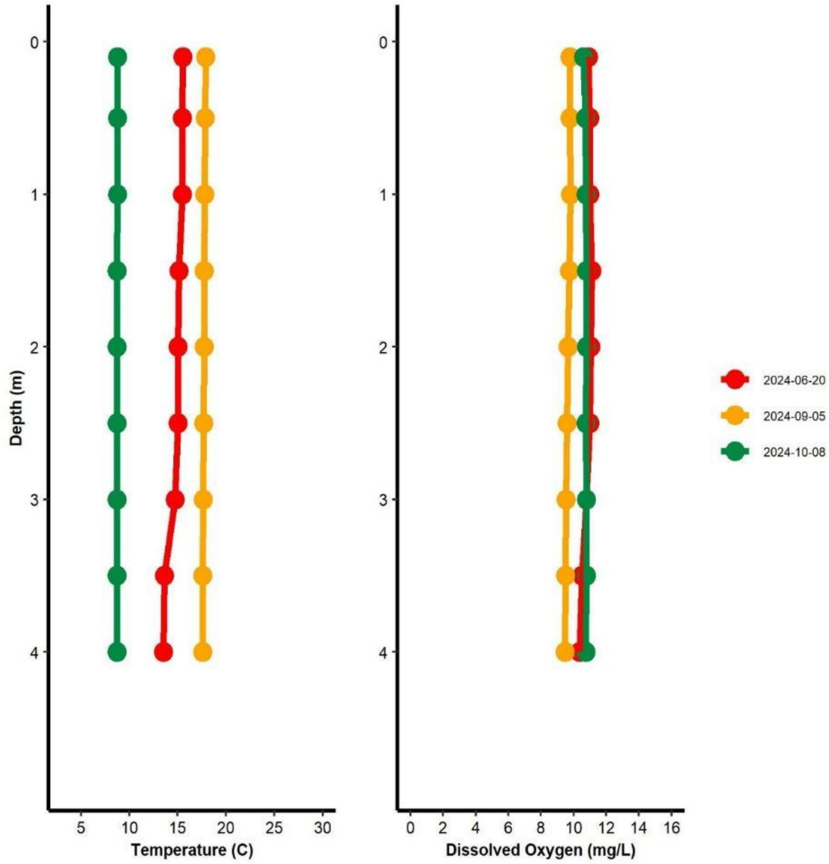


Figure 4. Temperature (°C) and dissolved oxygen (mg/L) profiles for Muriel Lake measured over the course of the summer of 2024.

MICROCYSTIN

Microcystins are toxins produced by cyanobacteria (blue-green algae) which, when ingested, can cause severe liver damage. Microcystins are produced by many species of cyanobacteria which are common to Alberta's Lakes, and are thought to be one of the most common cyanobacteria toxins. In Alberta, recreational guidelines for microcystin are set at 10 µg/L. Blue-green algae advisories are managed by Alberta Health Services. Recreating in algal blooms, even if microcystin concentrations are not above guidelines, is not recommended.

Microcystin levels in Muriel Lake fell below the recreational guideline of 10 µg/L[11] during every sampling event in 2024. Despite low levels of microcystin detected during the three sampling events, caution should be observed in areas of the lake where significant cyanobacteria accumulation occurs.

Table 1. Microcystin concentrations measured four times at Muriel Lake in 2024.

Date	Microcystin Concentration (µg/L)
06/20/2024	0.26
09/05/2024	0.18
10/08/2024	0.15
Average	0.2

[11] Health Canada. 2022. Guidelines for Canadian Recreational Water Quality.

INVASIVE SPECIES

Dreissenid mussels pose a significant concern for Alberta because they impair the function of water conveyance infrastructure and adversely impact the aquatic environment. These invasive mussels can change lake conditions which can then lead to toxic cyanobacteria blooms, decrease the amount of nutrients needed for fish and other native species, and cause millions of dollars in annual costs for repair and maintenance of water-operated infrastructure and facilities. Spiny water flea pose a concern for Alberta because they alter the abundance and diversity of native zooplankton, as they are aggressive zooplankton predators. Through over-predation, they will impact higher trophic levels such as fish. They also disrupt fishing equipment by attaching in large numbers to fishing lines.

Monitoring for aquatic invasive species involved sampling with a 63 µm plankton net. This monitoring is designed to detect juvenile Dreissenid mussel veligers and spiny water flea. No mussels or spiny water flea were detected in Muriel Lake in 2024.

Eurasian watermilfoil is a non-native aquatic plant that poses a threat to aquatic habitats in Alberta because it grows in dense mats preventing light penetration through the water column, reduces oxygen levels when the dense mats decompose, and outcompetes native aquatic plants. Eurasian watermilfoil can look similar to the native Northern watermilfoil, thus genetic analysis is ideal for suspect watermilfoil species identification.

Watermilfoil was not collected from Muriel Lake in 2024.

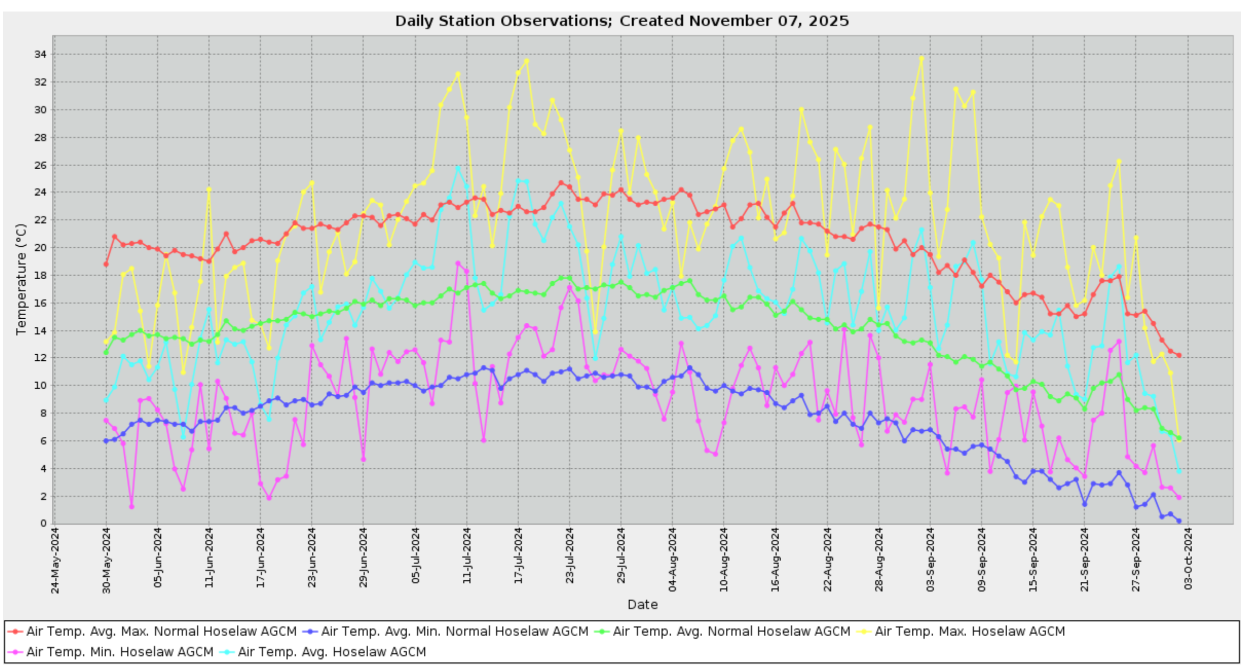
WEATHER AND LAKE STRATIFICATION

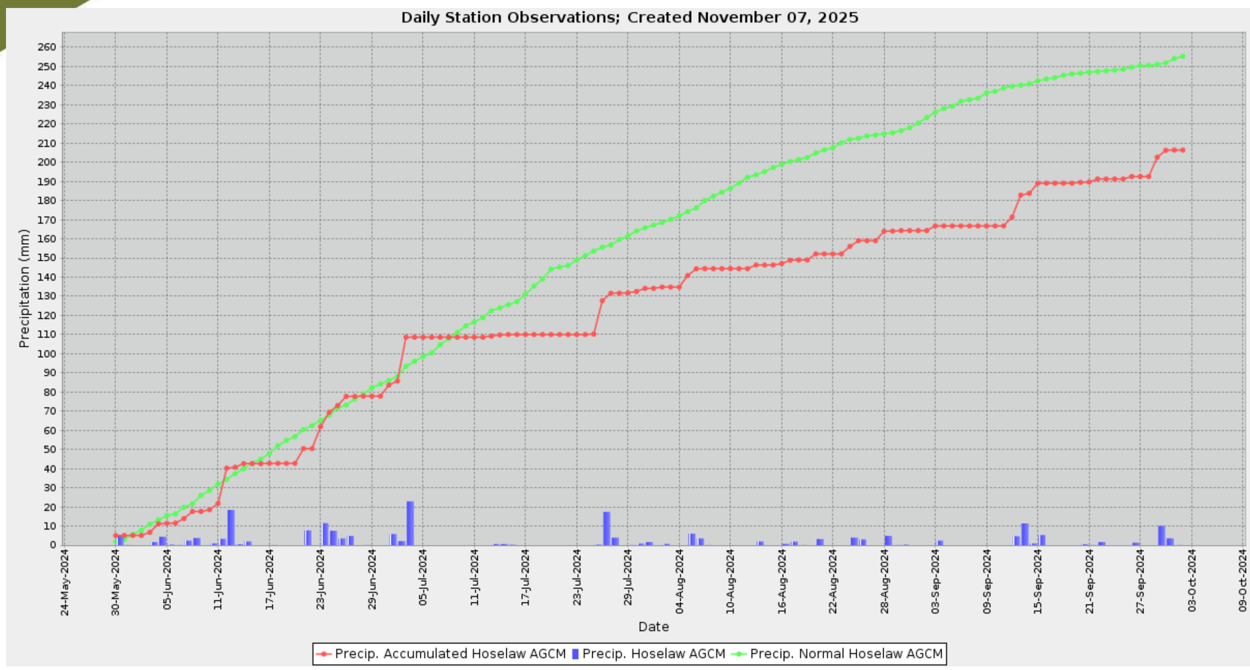
Air temperature will directly impact lake temperatures, and result in different temperature layers (stratification) throughout the lake, depending on its depth. Wind will also impact the degree to which a lake mixes, and how it will stratify. The amount of precipitation that falls within a lake's watershed will have important implications, depending on the context of the watershed and the amount of precipitation that has fallen. Solar radiation represents the amount of energy that reaches the earth's surface, and has implications for lake temperature & productivity.

In 2024, Muriel Lake experienced a warmer and windier summer compared to normal, with about normal accumulated precipitation (Figure 5). Although it was warmer overall, the beginning of the sampling season was unseasonably cold and wet, with the month of June near breaking the lowest temperatures on record on numerous days. The lowest temperature was recorded on June 2 at 1.2°C. July was the warmest month, with the average temperature being 19.5°C. 2024 also broke numerous heat records, including the hottest day recorded on September 2 at 33.7°C. September was also a warmer than average month, with the average temperature being 13.9°C.

Muriel Lake received less than normal precipitation in the summer of 2024 (206 mm total). Precipitation occurred in short bursts over the summer months, with nearly 20 mm of rain falling on numerous days over the summer (June 12, July 3, and July 26) followed by weeks of no precipitation. Very little precipitation fell in the months of August and September.

Strong winds were also observed throughout the sampling season.





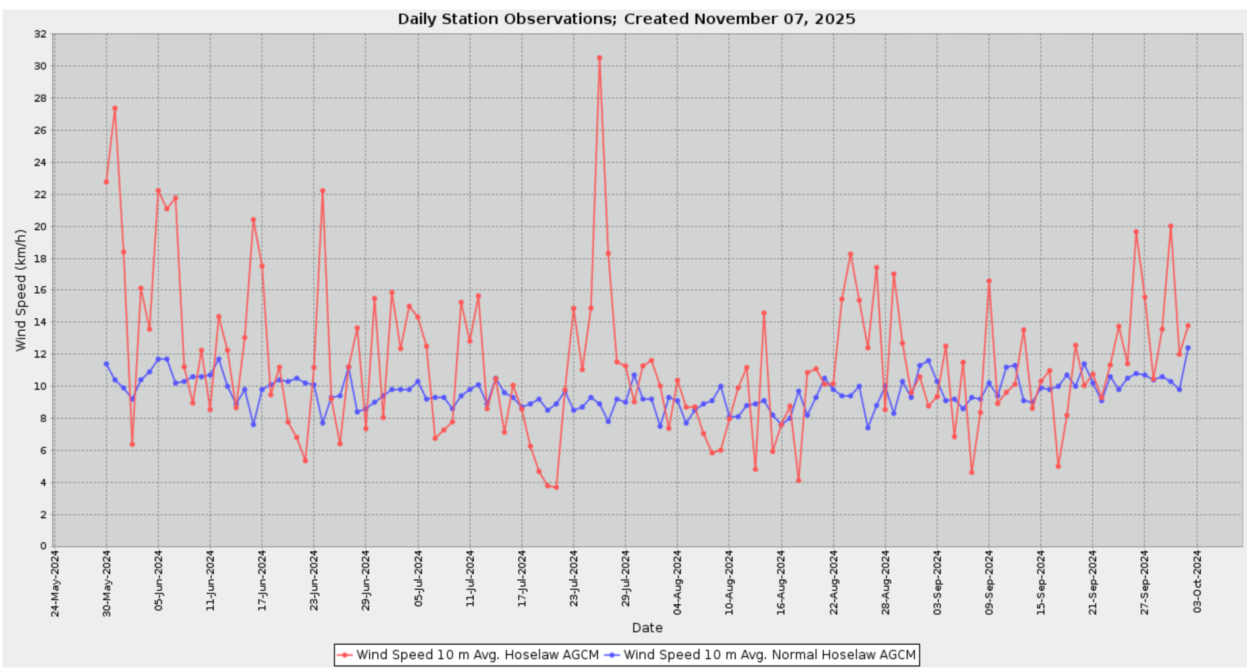


Figure 5. Air temperature (°C), wind speed (km/h), and precipitation (cm) measured from Hoselaw weather station northwest of Muriel Lake. Weather data provided by Agriculture, Forestry and Rural Economic Development, Alberta Climate Information Service (ACIS) https://acis.alberta.ca.

WATER LEVELS

There are many factors influencing water quantity. Some of these factors include the size of the lake's drainage basin, precipitation, evaporation, water consumption, ground water influences, and the efficiency of the outlet channel structure at removing water from the lake. Requests for water quantity monitoring should go through Alberta Environment and Parks Monitoring and Science division.

Water levels have been steadily decreasing at Muriel Lake since the 1970s (Figure 6). The lake has dropped by nearly 5 m since the beginning of the historical record in 1967 (Figure 7).

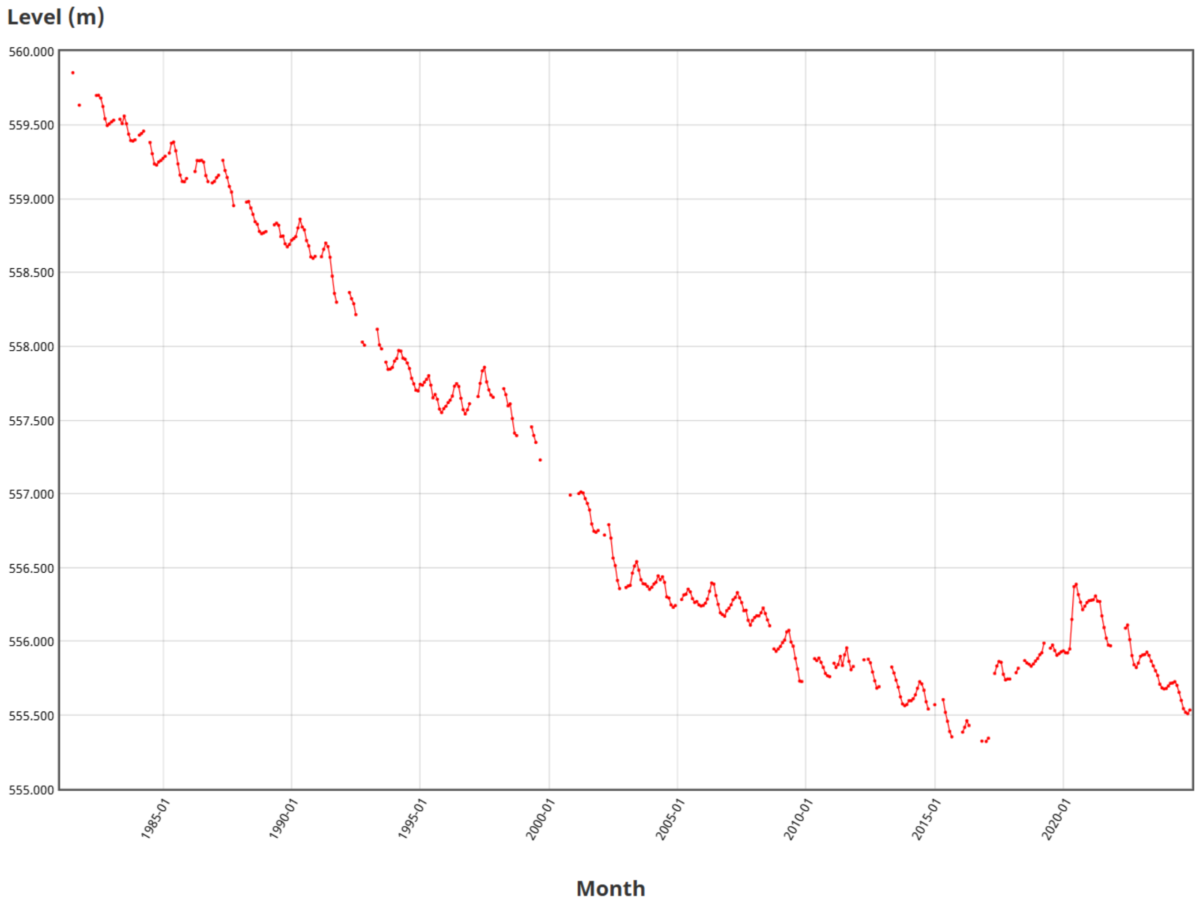


Figure 6. Water levels measured at Muriel Lake in metres above sea level (masl) from 1981-2024. Obtained from https://wateroffice.ec.gc.ca/).

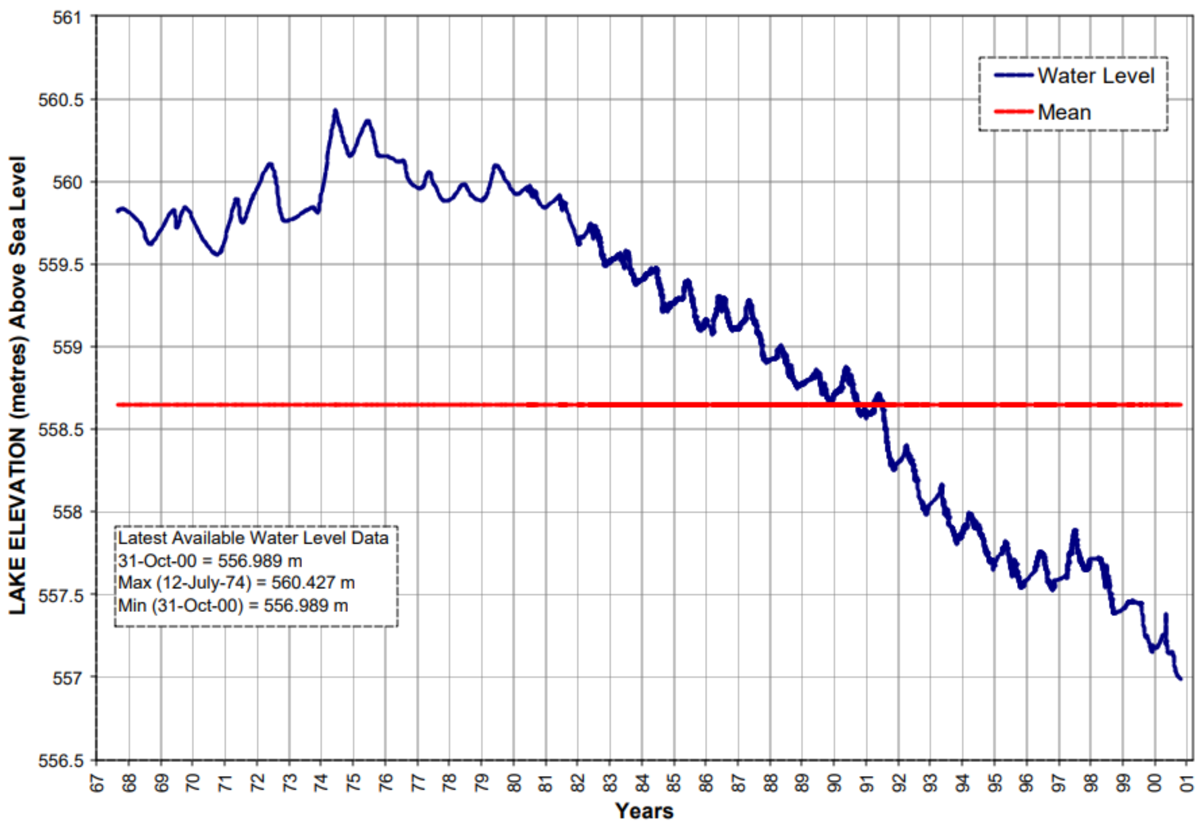


Figure 7. Historical water levels measured at Muriel Lake in metres above sea level (masl) from 1967-2001. Obtained from An Evaluation of Changes in Water Quality of Muriel Lake (https://sites.ualberta.ca/~ersc/water/climate/muriel/gov_qual.pdf).

Table 2. Average Secchi depth and water chemistry values for Muriel Lake.

Parameter	1988	1993	1997	2003	2006	2009	2012	2015	2017	2019	2020	2022	2024
TP (µg/L)	36	32	41	48	54	64	54	100	48	58	44	51	62
TDP (µg/L)	12	17	16	18	22	29	32	21	16	14	10	11	12
Chlorophyll-a (µg/L)	6.7	-	6.7	9.2	8.5	9.6	4.6	31.7	20.9	21.7	20.2	15.1	10.6
Secchi depth (m)	2.16	-	1.86	1.12	1.5	1.08	2.86	0.75	1.03	1.5	0.72	1.12	0.65
TKN (mg/L)	1.5	1.8	2.0	2.5	2.7	3.4	3.1	3.9	3.4	3.4	3.3	3.5	3.2
NO_2-N and NO_3-N (µg/L)	1	1	3	2	2	23	4	-	2	7	2	12	8
NH_3-N (µg/L)	21	111	23	20	45	-	64	-	44	43	48	34	38
DOC (mg/L)	26	32	28	-	45	47	48	62	53	51	41	51	58
Ca^{2+} (mg/L)	11	7	8	-	-	-	-	4	7	6	9	7	4
Mg^{2+}(mg/L)	98	115	126	-	-	-	-	210	208	175	155	188	217
Na^{+} (mg/L)	118	140	160	238	245	289	283	312	302	278	255	285	313
K^{+} (mg/L)	21	27	30	39	41	54	58	56	59	51	46	53	56
SO_4^{2-} (mg/L)	116	143	154	239	256	333	334	398	360	360	328	380	497
Cl^{-} (mg/L)	17	20	23	34	36	41	41	51	44	48	42	47	54
CO_3^{2-} (mg/L)	-	-	114.6	209.5	181	213.3	193.5	265	212.5	220	160	197.5	306.7
HCO_3^{2-} (mg/L)	-	-	620	746	800	858	878.25	872.5	782.5	725	680	730	683.33
pH	9.03	9.15	9.18	9.27	9.23	9.25	9.19	9.27	9.30	9.19	9.15	9.12	9.37
Conductivity (µS/cm)	1143	1350	1354	-	1925	2157	2212	2475	2200	2200	2000	2200	2467
Hardness (mg/L)	427	491	-	-	-	-	-	-	878	742	665	788	897
TDS (mg/L)	714	853	919	1305	1325	1510	1507	1725	1600	1500	1350	1525	1800
Microcystin (µg/L)	-	-	-	-	0.18	0.22	0.36	16.25	0.3	0.37	0.36	0.28	0.2
Total Alkalinity (mg/L CaCO3)	556	667	696	961	957	1060	1050	1175	998	965	822	932	1067

Table 3. Concentrations of metals measured in Muriel Lake. The CCME heavy metal Guidelines for the Protection of Freshwater Aquatic Life (unless otherwise indicated) are presented for reference. Note that metal sample collection method changed in 2016 from composite to single surface grab at the profile location.

Metals	2006	2009	2012	2015	2017	2018	2020	2022	2024	Guidelines
Aluminum (μg/L)	31.8	20.15	16.48	19.8	85.7	9.9	16.8	32.2	14.2	100[a]
Antimony (μg/L)	0.183	0.182	0.226	0.244	1.31	0.277	0.232	0.28	0.334	/
Arsenic (μg/L)	8.54	9.21	8.72	10.7	54.8	10.85	9.96	9.98	11.2	5
Barium (μg/L)	5.1	3.1	2.9	2.6	15.2	3.1	5.5	5.8	2.5	/
Beryllium (μg/L)	0.0015	0.0015	0.0063	0.004	0.0075	0.0015	0.0015	0.0015	0.015	100[c,d]
Bismuth (μg/L)	0.0032	0.0046	0.0024	0.008	0.0075	0.0015	0.004	0.0015	0.015	/
Boron (μg/L)	290	325.5	377.5	441	1760	372	305	388	419	1500
Cadmium (μg/L)	0.009	0.004	0.008	0.006	0.025	0.005	0.005	0.005	0.05	0.36[b]
Chromium (μg/L)	0.696	0.72	0.6335	0.265	0.25	0.05	0.05	0.05	0.5	/
Cobalt (μg/L)	0.23	0.0576	0.0489	0.055	0.364	0.079	0.125	0.088	0.119	500, 1000[c,d]
Copper (μg/L)	1.87	1.435	0.995	1.57	3.54	0.2	0.39	0.25	0.4	4[b]
Iron (μg/L)	26.3	14.59	23.3	20.3	63.8	19.6	37.6	45.9	11.5	300
Lead (μg/L)	0.094	0.049	0.044	0.1	0.174	0.065	0.103	0.087	0.073	7[b]
Lithium (μg/L)	132	154	195.5	227.5	819	199	155	182	221	2500[d]
Manganese (μg/L)	4.26	1.67	2.35	2.77	9.57	4.99	8.25	10.5	5.54	130[e]
Molybdenum (μg/L)	1.49	1.58	1.885	1.995	8.45	1.82	1.57	1.25	1.45	73
Nickel (μg/L)	0.206	0.132	0.125	0.174	1.33	0.255	0.39	0.25	1.05	150[b]
Selenium (μg/L)	1.41	0.759	0.466	0.055	12.8	1.95	1.4	0.1	1	1
Silver (μg/L)	0.0024	0.0058	0.0018	0.0015	0.018	5e-04	0.003	5e-04	0.005	0.25
Strontium (μg/L)	11	9.4	9.4	5.5	47.8	11.4	21.2	20.1	6.6	/
Thallium (μg/L)	0.0098	0.0015	5e-04	4e-04	0.018	0.001	0.002	0.001	0.01	0.8
Thorium (μg/L)	0.013	0.007	0.008	0	0.043	0.003	0.009	0.009	0.01	/
Tin (μg/L)	0.01	0.01	0.05	0.08	0.15	0.03	0.03	0.03	0.03	/
Titanium (μg/L)	2.58	2.12	1.211	2.13	6.38	1.255	1.72	1.05	2.28	/
Uranium (μg/L)	1.44	1.595	1.56	1.9	7.23	1.685	1.43	1.26	1.55	15
Vanadium (μg/L)	0.597	0.703	0.578	0.51	4.55	0.803	1.08	0.454	0.722	100[c,d]
Zinc (μg/L)	2.46	1.52	1.42	1.7	14.8	2.2	2.2	1.6	5.9	30[f]

Values represent means of total recoverable metal concentrations.
[a] Based on pH ≥ 6.5
[b] Based on 2016 avg. water hardness (as CaCO3) with CCME equation
[c] Based on CCME Guidelines for Agricultural use (Livestock).
[d] Based on CCME Guidelines for Agricultural Use (Irrigation).
[e] Based on CCME Manganese variable calculation (https://ccme.ca/en/chemical/129#_aql_fresh_concentration) using 2016 avg. water hardness (as CaCO3) and avg. pH
[f] Based on 2016 avg. water hardness (as CaCO3), avg. pH, and avg. DOC with CCME equation
A forward slash (/) indicates an absence of data or guidelines.

LONG TERM TRENDS

Trend analysis was conducted on the parameters total phosphorus (TP), chlorophyll-*a*, total dissolved solids (TDS), and Secchi depth to look for changes over time in Muriel Lake. In sum, increasing trends were detected in TP, chlorophyll-*a,* and TDS, while a decreasing trend was detected in Secchi depth. Secchi depth can be subjective and is sensitive to variation in weather; therefore, trend analysis must be interpreted with caution. Data is presented below as both line and box-and-whisker plots. Detailed methods are available in the ALMS Guide to Trend Analysis on Alberta Lakes.

Table 4. Summary table of trend analysis on Muriel Lake data from 1988 to 2024.

Parameter	Date Range	Direction of Significant Change
Total Phosphorus	1988-2024	Increasing
Chlorophyll-a	1988-2024	Increasing
Total Dissolved Solids	1988-2024	Increasing
Secchi Depth	1988-2024	Decreasing

Definitions

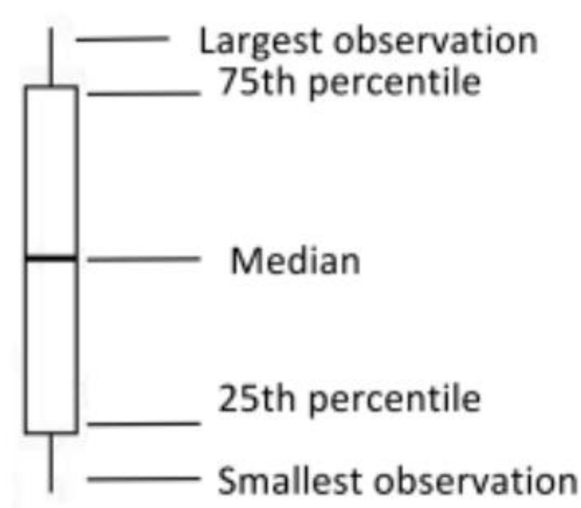
Median: the value in a range of ordered numbers that falls in the middle.

Trend: a general direction in which something is changing.

Monotonic trend: a gradual change in a single direction.

Statistically significant: The likelihood that a relationship between variables is caused by something other than random chance. This is indicated by a p-value of <0.05. Variability: the extent by which data is inconsistent or scattered.

Box and Whisker Plot: a box-and-whisker plot, or boxplot, is a way of displaying all of our annual data. The median splits the data in half. The 75th percentile is the upper quartile of the data, and the 25th percentile is the lower quartile of the data. The top and bottom points are the largest and smallest observations.



Total Phosphorus (TP)

Trend analysis of TP over time suggests it has significantly increased in Muriel Lake from 1988 to 2024 (Tau = 0.2725, p = 0.04).

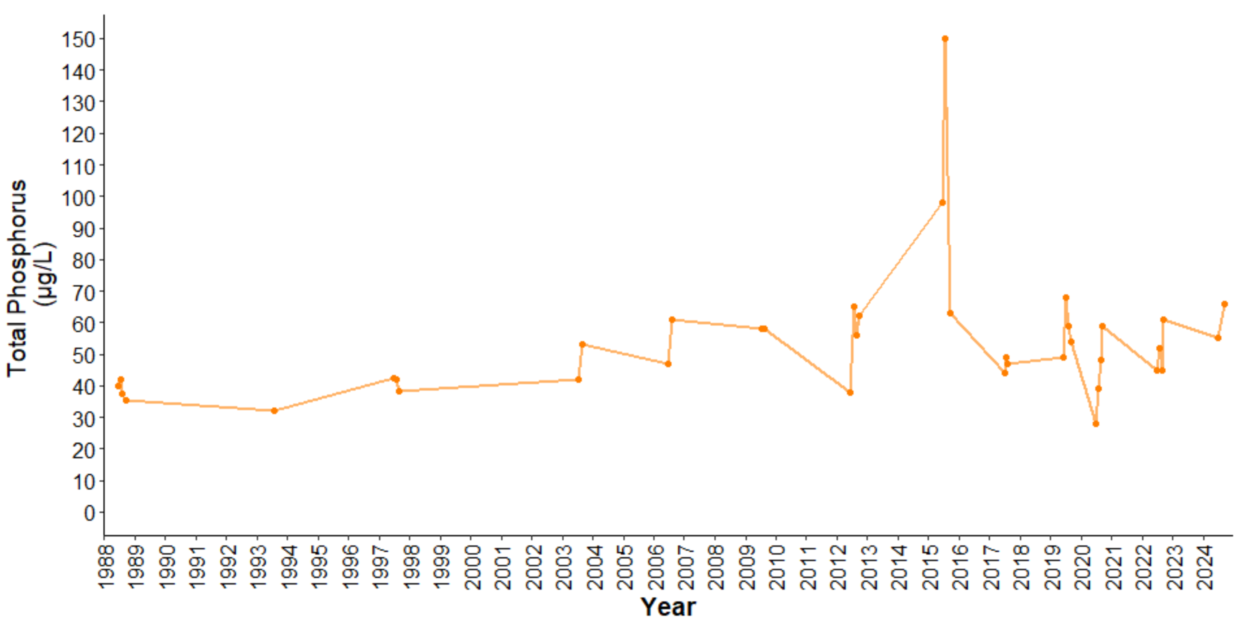
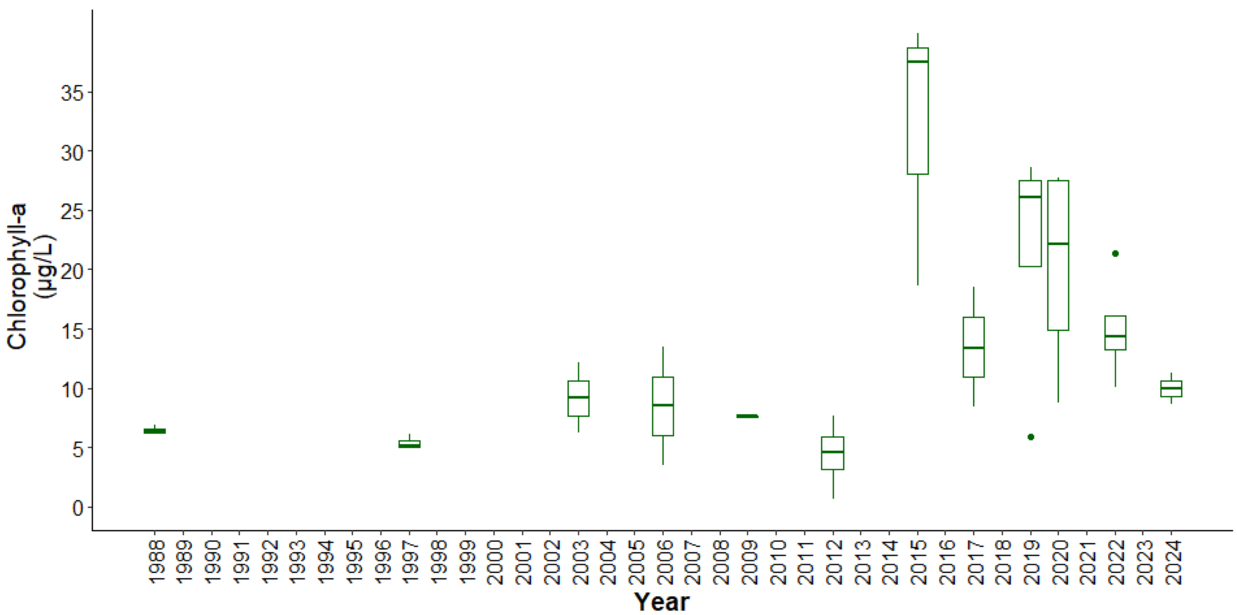


Figure 8. Monthly total phosphorus (TP) concentrations measured between June and September over the long term sampling dates between 1988 and 2024 (n = 38). The value closest to the 15th day of the month was chosen to represent the monthly value in cases with multiple monthly samples.

Chlorophyll-*a*

Trend analysis of chlorophyll-*a* over time suggests it has significantly increased over time at Muriel Lake from 1988 to 2024 (Tau = 0.4474, p = <0.001).



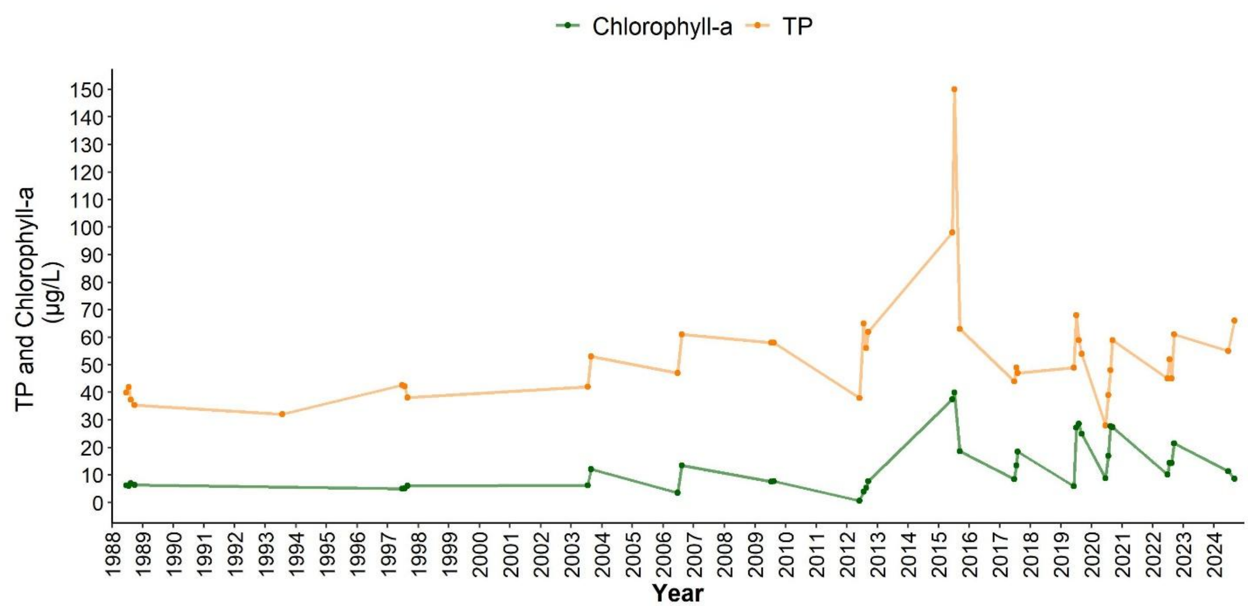


Figure 9. Monthly chlorophyll-*a* concentrations measured between June and September over the long term sampling dates between 1988 and 2024 (n = 37). The value closest to the 15th day of the month was chosen to represent the monthly value in cases with multiple monthly samples. Line graph is overlain by TP concentrations.

Total Dissolved Solids (TDS)

Trend analysis showed a significantly increasing trend in TDS in Muriel Lake since 1988 (Tau = 0.5165, *p* = <0.001).

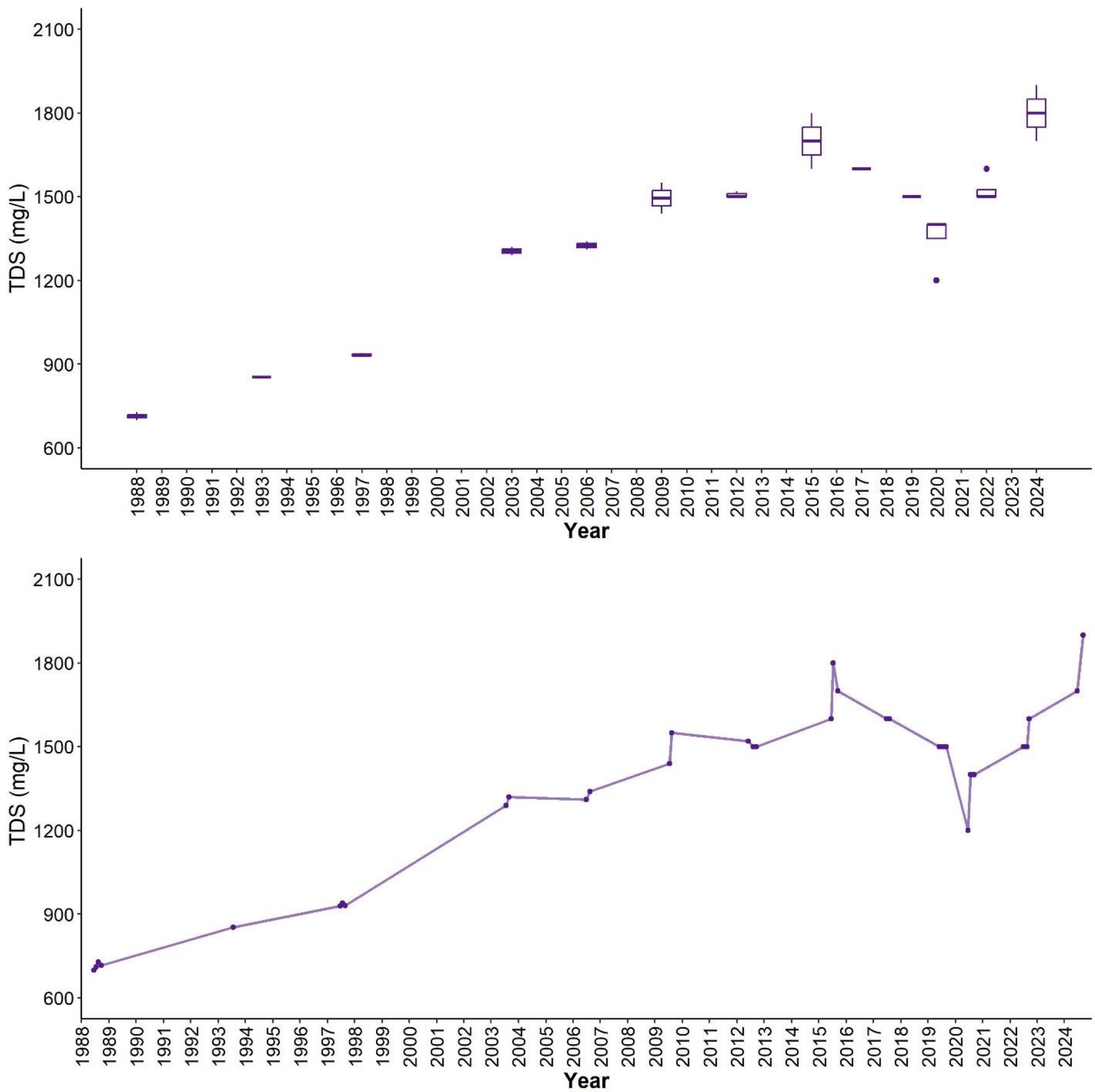


Figure 10. Monthly TDS values measured between June and September over the long term sampling dates between 1988 and 2024 (n = 37). The value closest to the 15th day of the month was chosen to represent the monthly value in cases with multiple monthly samples.

Due to the significant increasing trend of TDS in Muriel Lake, exploring the specific major ions which may be driving this trend is important to determine.

Trend analysis of major ions at Muriel Lake indicates that sodium, potassium, chloride, and sulphate are significantly increasing and are likely the key parameters that drove the historical increase in TDS (Figure 11). No trends were detected in calcium or alkalinity, likely related to the high pH of Muriel Lake causing precipitation of calcium from the water column (Table 2). Magnesium has insufficient data for trend analysis.

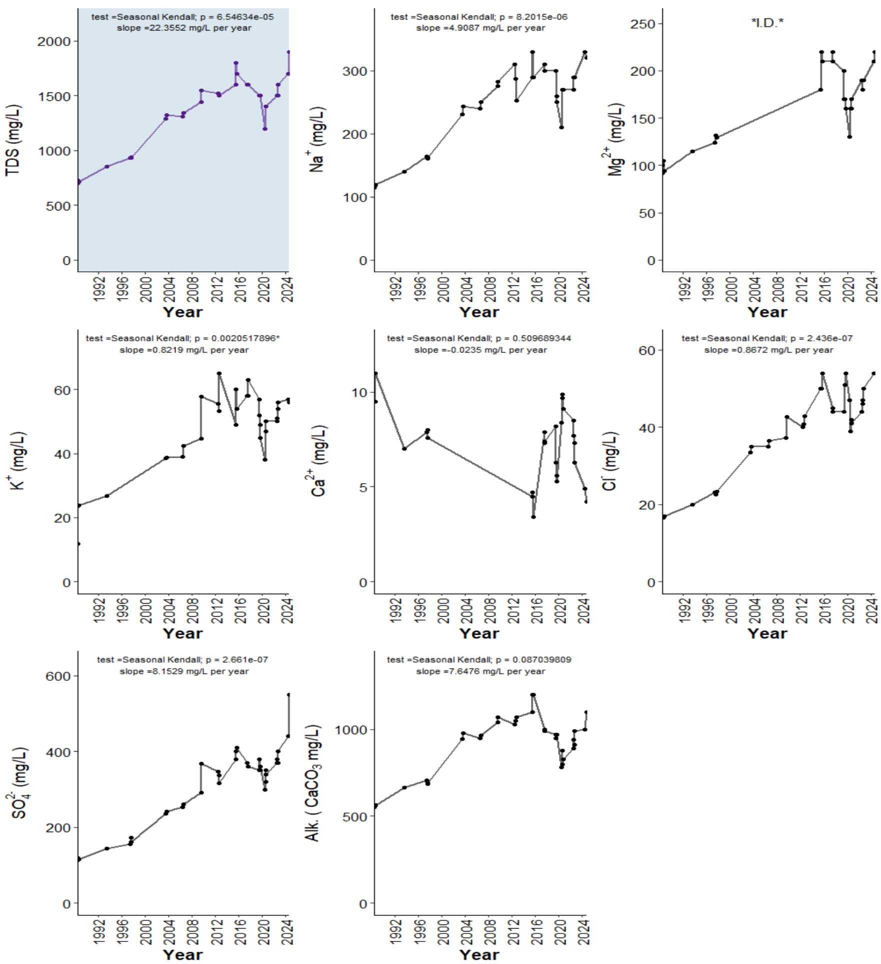


Figure 11. Concentrations of TDS (top left, blue panel), major ions (sodium = Na^+, magnesium = Mg^{2+}, potassium = K^+, calcium = Ca^{2+}, chloride = Cl^-, sulphate = SO_4^{2-}), and total alkalinity (Alk., as mg/L $CaCO_3$) measured monthly between June and September on sampling dates between 1988 and 2024. Also represented is the monotonic trend results for each parameter; test used (MK = Mann Kendall, SK = Seasonal Kendall), significance of test (p; assessed as significance when $p < 0.05$, marked with '*' if significant), and the slope of the trend. Test selection follows method outline in the ALMS Guide to Trend Analysis on Alberta Lakes. Note that some ions had insufficient data (I.D.) therefore trends were not calculated. The value closest to the 15th day of the month was chosen to represent the monthly value in cases with multiple monthly samples.

Secchi Depth

Trend analysis of Secchi depth over time showed that it has significantly decreased (the lake has become less clear) in Muriel Lake since 1988 (Tau = -0.4294, *p* = 0.001).

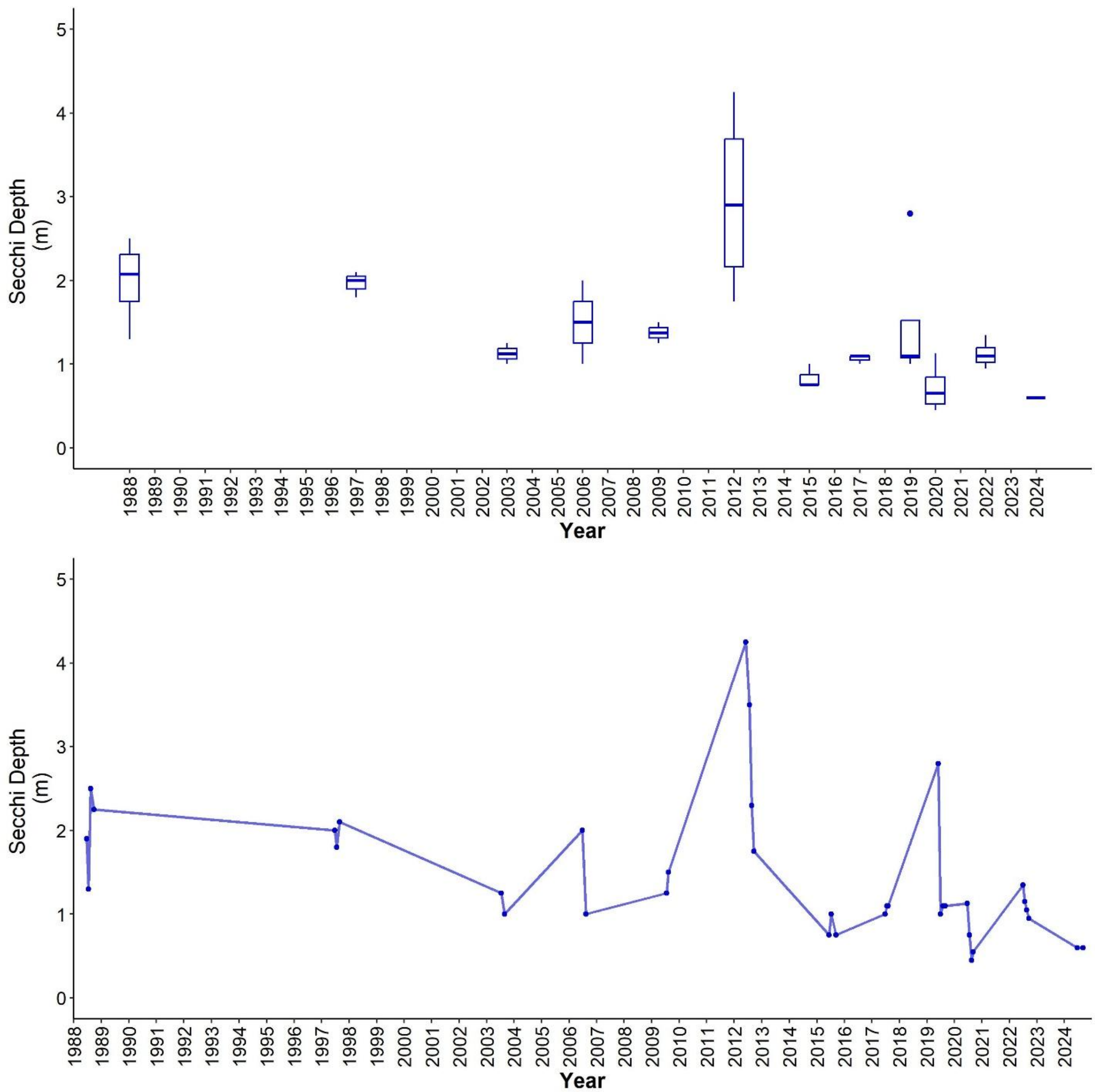


Figure 12. Monthly Secchi depth values measured between June and September over the long term sampling dates between 1988 and 2024 (n = 37). The value closest to the 15th day of the month was chosen to represent the monthly value in cases with multiple monthly samples.

Table 5. Results of trend tests using total phosphorus (TP), chlorophyll-*a*, total dissolved solids (TDS), and Secchi depth data from June to September for sampled years from 1988-2024 on Muriel Lake data.

Definition	Unit	Total Phosphorus (TP)	Chlorophyll-*a*	Total Dissolved Solids (TDS)	Secchi Depth
Statistical Method	-	Seasonal Kendall	Seasonal Kendall	Seasonal Kendall	Seasonal Kendall
The strength and direction (+ or -) of the trend between -1 and 1	Tau	0.2725	0.4474	0.5165	-0.4294
The extent of the trend	Slope (units per Year)	0.3333	0.4	22.3552	-0.0362
The statistic used to find significance of the trend	Z	2.053	3.4184	3.9922	-3.1933
Number of samples included	N	38	37	37	37
The signficance of the trend	*p*	0.040*	0.0006*	6.546e-05*	0.0014*

*$p < 0.05$ is significant within 95%