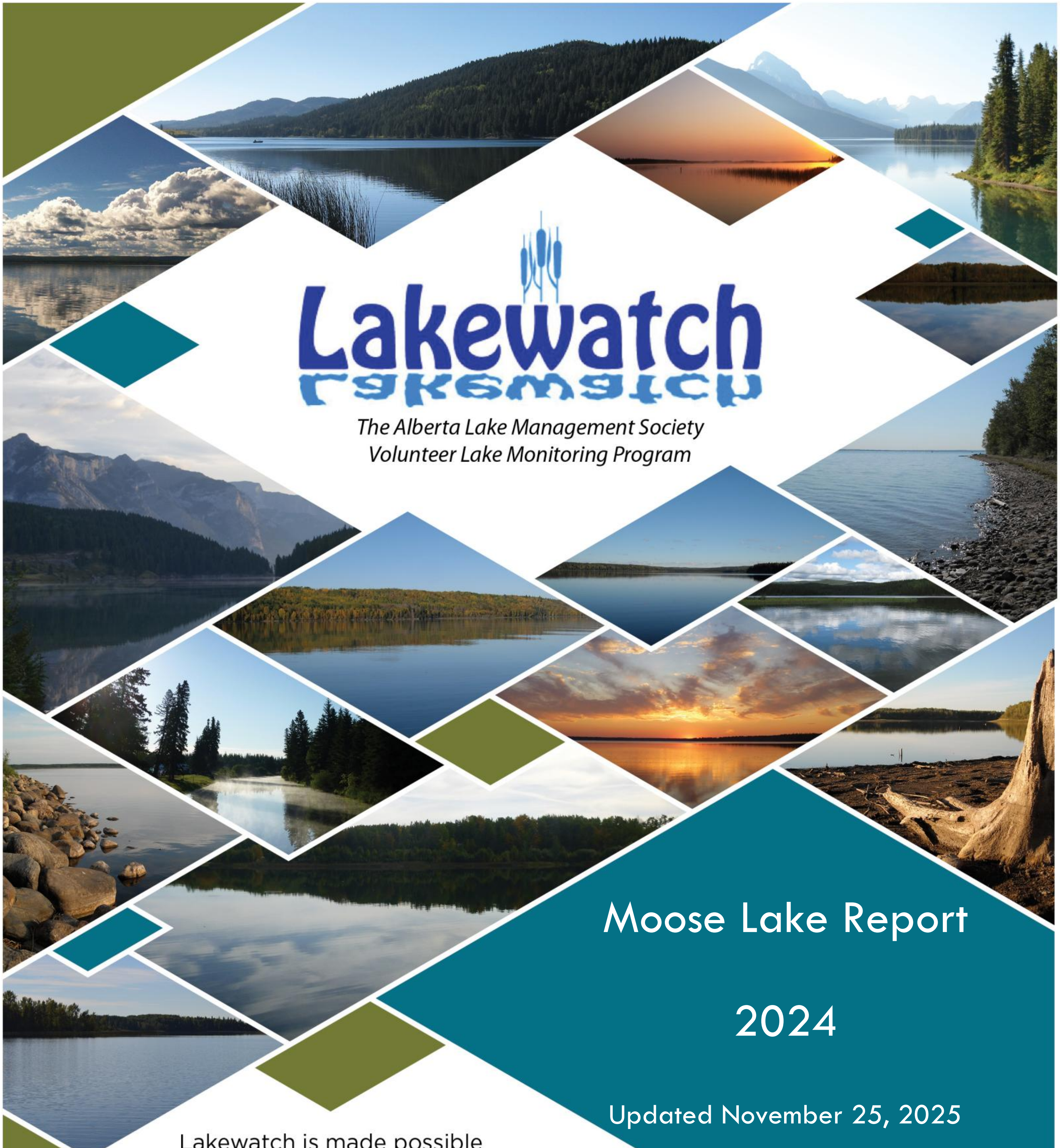


Lakewatch

The Alberta Lake Management Society
Volunteer Lake Monitoring Program

Moose Lake Report

2024

Updated November 25, 2025

Lakewatch is made possible with support from:

Alberta
Lac La Biche County welcoming by nature.
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.

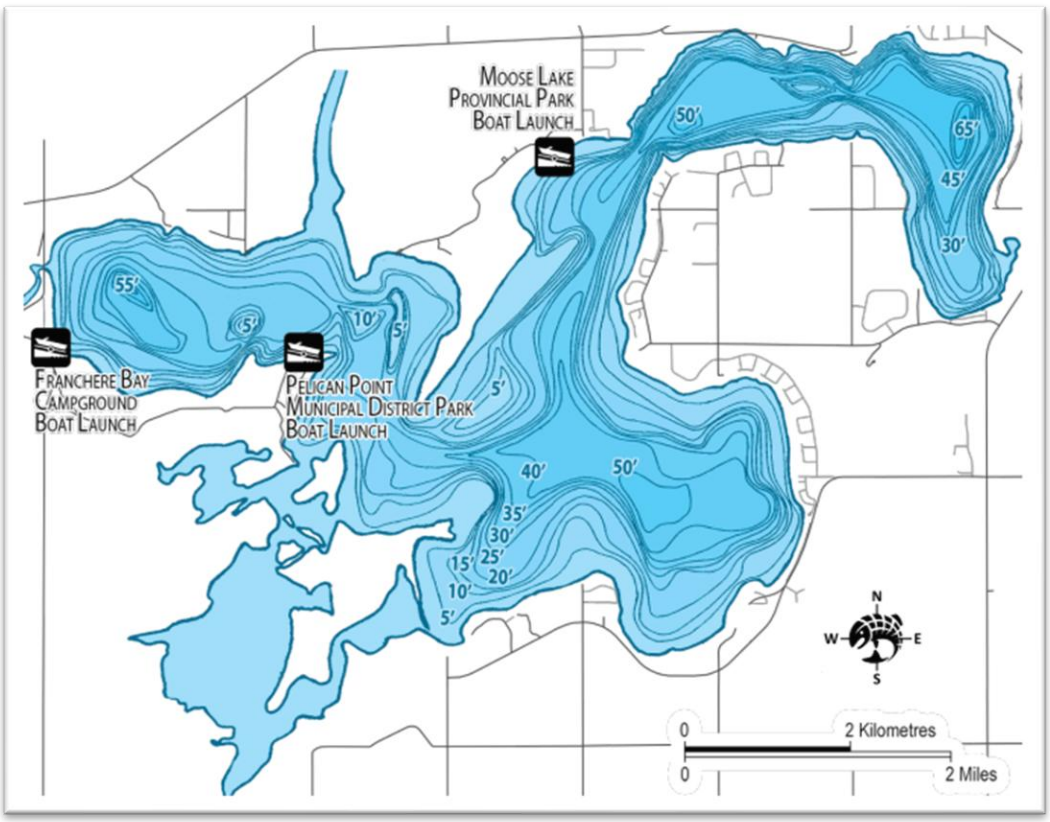
ACKNOWLEDGEMENTS

The LakeWatch program is made possible through the dedication of its volunteers. A special thanks to Daniel Lastiwka for their commitment to collecting data at Moose 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]

MOOSE LAKE

Moose Lake is a shallow, uniquely shaped lake located near the Town of Bonnyville, approximately 240 km northeast of Edmonton. Moose Lake has over 64 km of irregular shoreline and a surface area of 40 km^2.[1] The lake is comprised of four main bays with a maximum depth of 19 m and a mean depth of 5.6 m. The lake was once known by its French name Lac d'Orignal, which was likely inspired by the abundance of moose in the area.[1]



Bathymetric map of Moose Lake obtained from The Angler's Atlas.

The lake is very popular for locals and tourists alike, and the most popular sport fish species include walleye, northern pike, and yellow perch.[1] The shoreline has been heavily developed and includes cottage subdivisions, campgrounds, and summer villages. The southwest bay of Moose Lake, Island Bay, is shallower than the rest of the lake, and the shoreline and riparian wetland area remain intact, providing excellent habitat to a variety of waterfowl.

The watershed area for Moose Lake is just over 800 km^2. The lake area is approximately 40 km^2. The watershed ratio of Moose Lake is 20:1, indicating that a large area of land drains to the lake. The watershed of Moose Lake has been highly developed, with nearly 60% of the landscape altered.[2] The majority of the watershed is agricultural land, including grazing and cropland. A phosphorus budget for the Moose Lake Watershed Society was completed by Associated Environmental in 2021, revealing that although the bottom sediments contribute to the phosphorus levels in the lake (internal loading), the surrounding watershed delivers 50-70% of phosphorus to Moose Lake and best management practices should be followed throughout the watershed to improve water quality.[3]

Moose Lake is regularly issued cyanobacteria (previously referred to as "blue-green algae") advisories during the summer. Algal blooms and low water quality issues have been documented throughout the historical literature of Moose Lake.[1,4]

Moose Lake on September 4, 2024.

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[1]Mitchell, P. and E. Prepas. 1990. Atlas of Alberta Lakes.
[2] Fiera Biological Consulting Ltd. 2025. Beaver River State of the Watershed Assessment and Reporting.
[3]Associated Environmental. 2021. Moose Lake Watershed Society, Moose Lake Phosphorus Budget.
[4]Mitchell, P. (Alberta Government). 1992. Status report on the water quality of Moose Lake.

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 Moose Lake was 37 (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 6 µg/L on July 3 to a maximum of 58 µg/L on September 4 (Figure 1).

The average chlorophyll-*a* concentration in 2024 was 22.5 µg/L (Table 2), similarly falling into the eutrophic classification. Chlorophyll-*a* was lowest at 9.5 mg/L on July 3 and peaked at 33.3 mg/L on September 4 (Figure 1).

The average total Kjeldahl nitrogen (TKN) concentration was 1.3 mg/L (Table 2). TKN increased over the summer (Figure 1).

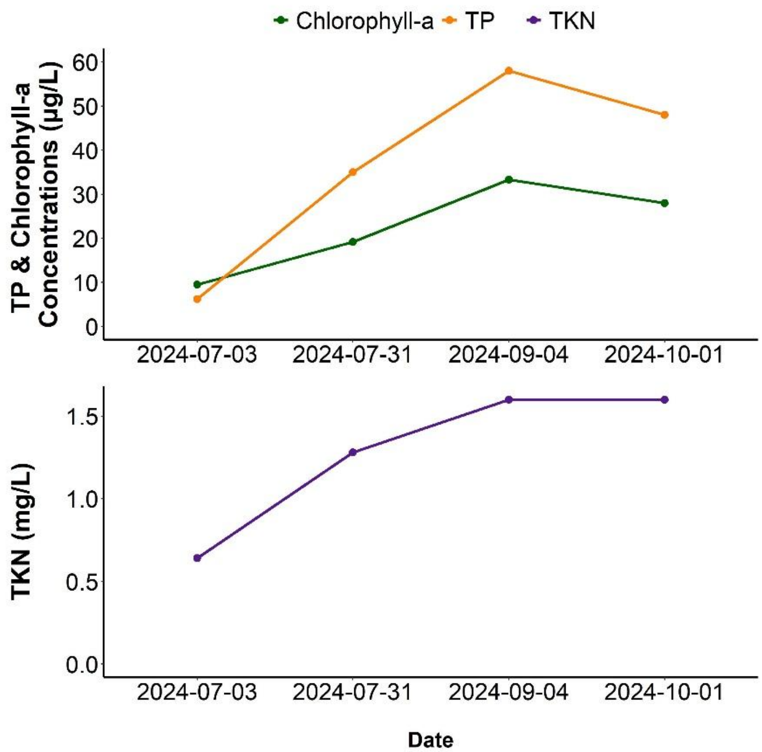

Figure 1. Total Phosphorus, Chlorophyll-*a*, and Total Kjeldahl Nitrogen concentrations measured over the course of the summer at Moose Lake in 2024.

Average pH was measured as 8.76 in 2024, buffered by alkalinity (342 mg/L $CaCO_3$) and bicarbonate (365 mg/L HCO_3). Aside from bicarbonate, sulphate and sodium were higher than all other major ions, and contributed to an average conductivity of 980 µS/cm (Figure 2, top; Table 2).

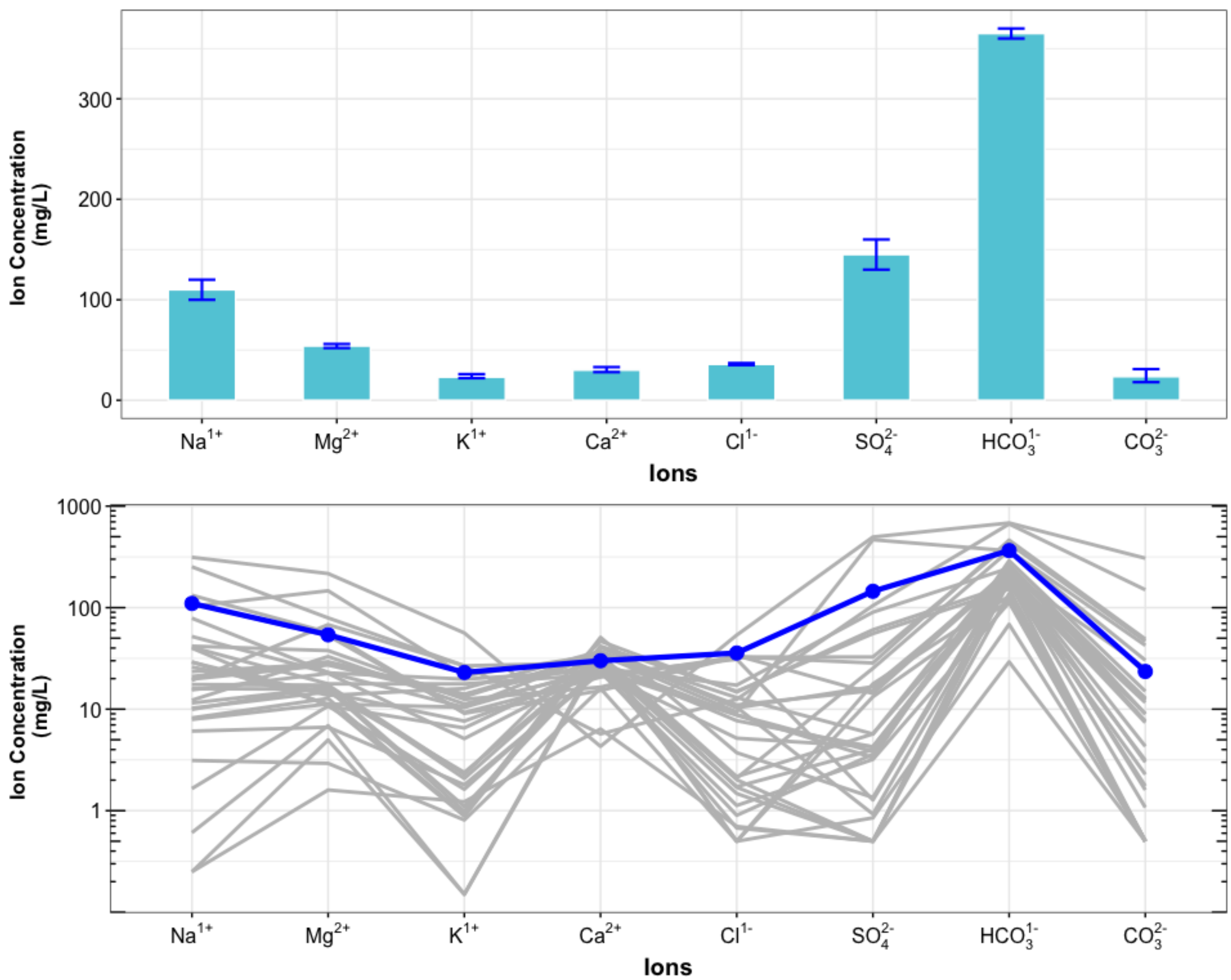

Figure 2. Average levels of cations (sodium = Na^{1+}, magnesium = Mg^{2+}, potassium = K^{1+}, calcium = Ca^{2+}) and anions (chloride = Cl^{1-}, sulphate = SO_4^{2-}, bicarbonate = HCO_3^{1-}, carbonate = CO_3^{2-}) from 4 measurements over the course of the summer at Moose Lake. Top) bars indicate range of values measured, and bottom) Schoeller diagram of average ion levels at Moose 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).

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 Moose Lake in 2024 (Table 3). No metals exceeded the CCME chronic guideline for the protection of aquatic life in 2024.[5]

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[5] Canadian Water Quality Guidelines. 2019. Canadian Council of Ministers of the Environment.

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 Moose Lake in 2024 was 4 m (Table 2). Euphotic depth varied over the season, ranging from as shallow as 2.6 m on September 4 to as deep as 6.6 m on July 3 (Figure 3). This trend follows the chlorophyll-*a* concentration trend over the summer (Figure 1). Chlorophyll-*a* is an indicator of algal growth (including cyanobacteria). As algae and cyanobacteria grow and reproduce, chlorophyll-*a* levels will increase, and the euphotic depth will decrease.

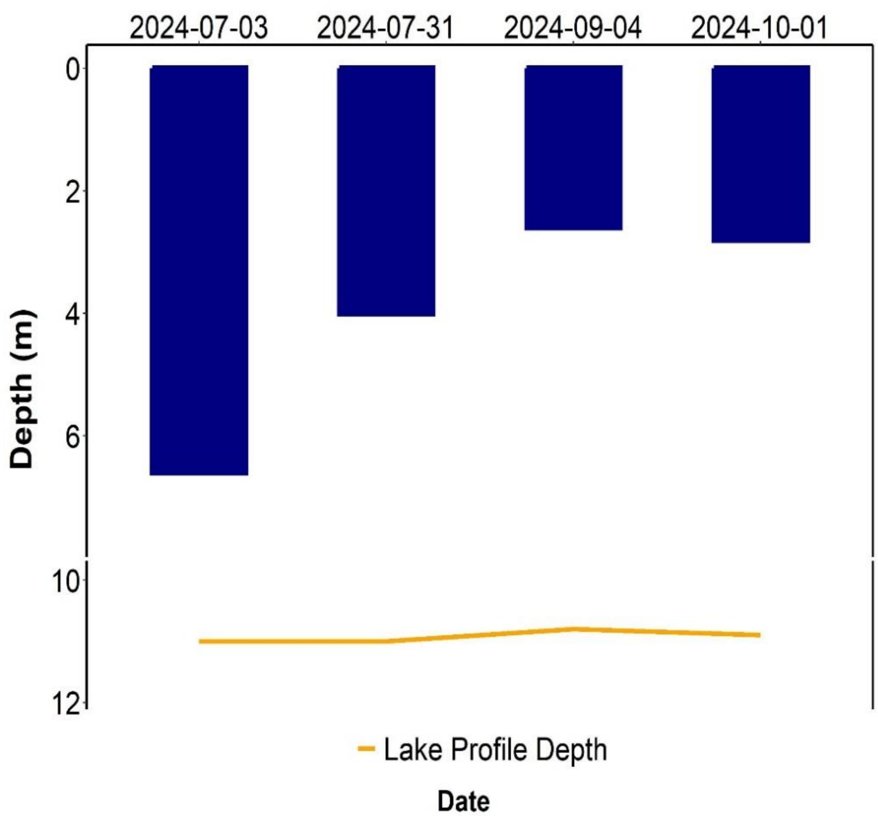

Figure 3. Euphotic depth values measured over the course of the summer at Moose Lake in 2024.

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 Moose Lake showed minimal variation throughout the summer. The July 31 sample trip had the warmest temperatures at 20.92°C (Figure 4). The Main Basin of Moose Lake was well mixed during all sampling events, reflected by a steady temperature Profile to the bottom of the lake (Figure 4). Thermal stratification was not observed throughout the summer, and the water column remained well mixed. Colder water temperatures overall were observed during the October 1 sampling event, which would be expected for fall sampling.

Due to the lack of thermal stratification, the water column remained relatively well oxygenated throughout the summer, measuring above the CCME guidelines of 6.5 mg/L dissolved oxygen[6] (Figure 4). There was a slight decrease of oxygen at 5 m on the July 31 sampling event, as well as near the bottom of the lake on the July and August sampling trips. Oxygen was likely being utilized for biological processes (decomposition) and removed from the water column.

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

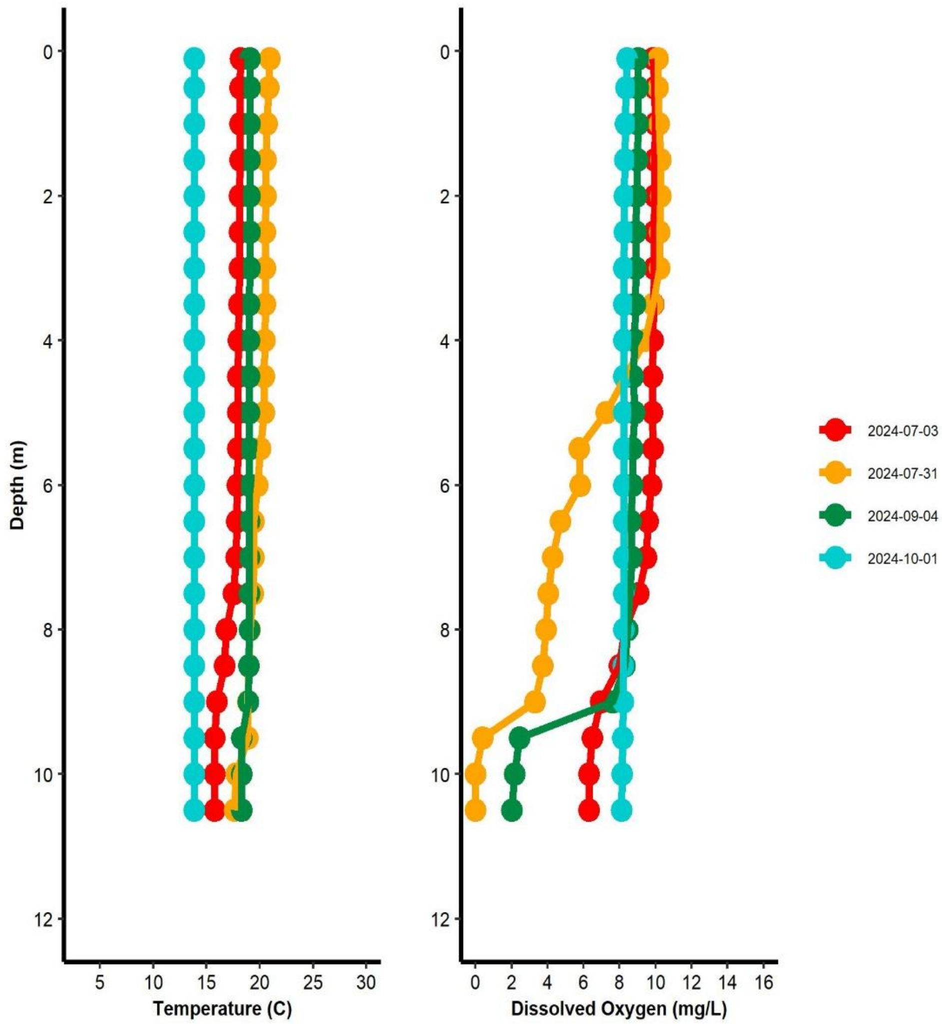


Figure 4. Temperature (°C) and dissolved oxygen (mg/L) profiles for Moose Lake measured over the course of the summer of 2024.

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 Moose Lake fell below the recreational guideline of 10 µg/L[7] during every sampling event in 2024. The average concentrations from across the lake were as high as 4.49 ug/L on September 4, indicating the cyanobacteria in the lake are capable of producing significant amounts of cyanotoxins.

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

Date	Microcystin Concentration (µg/L)
07/03/2024	0.16
07/31/2024	1.18
09/04/2024	4.49
10/01/2024	3.93
Average	**2.44**

[7] 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 zebra mussels, quagga mussels, or spiny water flea were detected 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 collected from Moose Lake in 2024. The specimen was confirmed to be Northern Watermilfoil (*Myriophyllum sibiricum*).

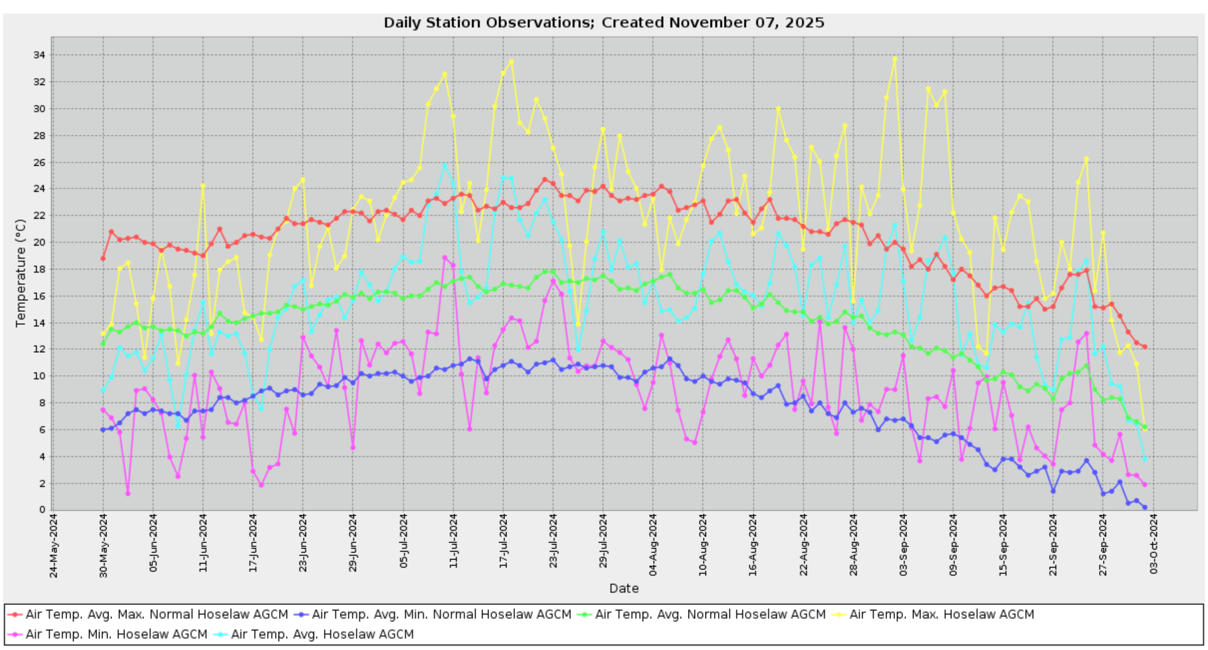
WEATHER AND LAKE STRATIFICATION

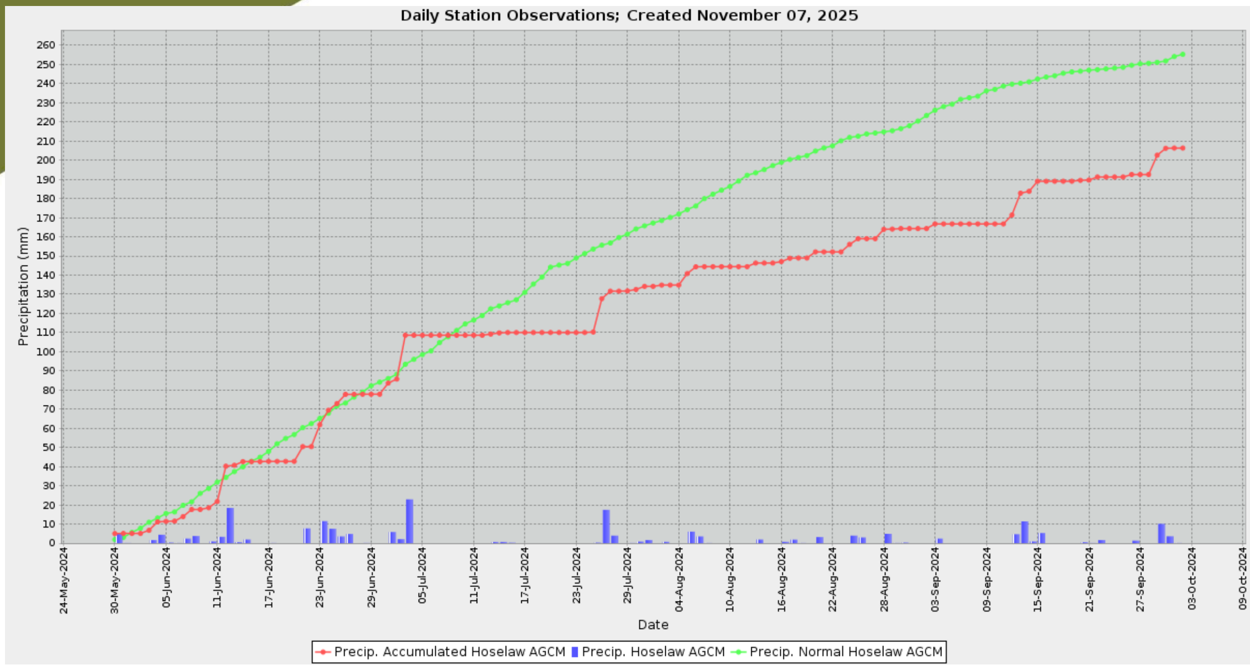
Air temperature will directly impact lake temperatures, and result in different temperature layers (stratification) throughout the lake, depending on its depth. Wind will also impact the degree to which a lake mixes, and how it will stratify. The amount of precipitation that falls within a lake's watershed 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, Moose 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.

Moose 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.





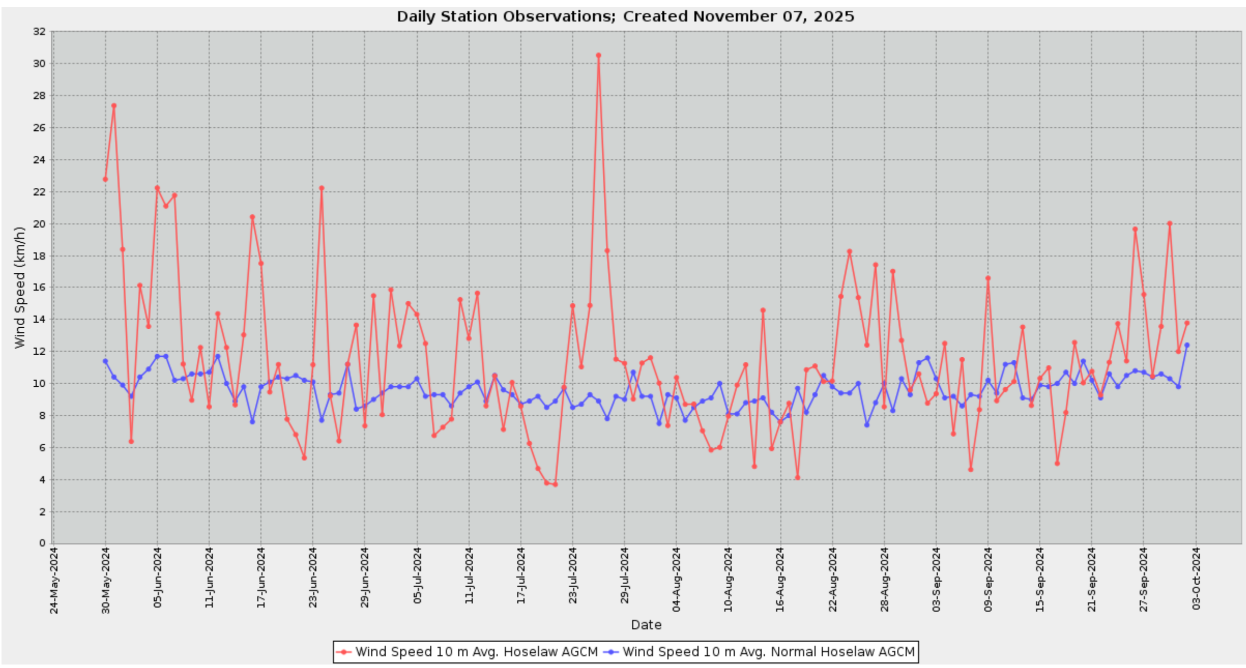


Figure 5. Air temperature (°C), wind speed (km/h), and precipitation (cm) measured from Hoselaw weather station south of Moose Lake. Weather data provided by Agriculture, Forestry and Rural Economic Development, Alberta Climate Information Service (ACIS) https://acis.alberta.ca.

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 at Moose Lake have fluctuated by about 2 m since the 1950s, with an overall decreasing trend (Figure 7). Due to its large watershed area (about 20:1), Moose Lake receives most water inputs via surface water.[4]

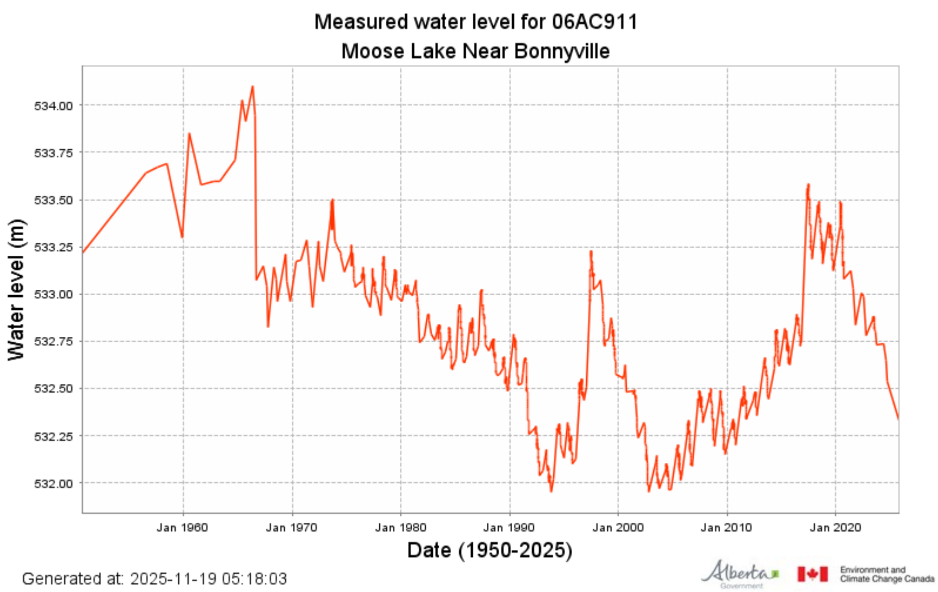


Figure 7. Water levels measured at Moose Lake in metres above sea level (masl) from 1950-2025. Data retrieved from Environment Canada and Alberta Environment and Parks Real-Time Hydrometric Data (https://wateroffice.ec.gc.ca/).

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[4] Mitchell, P. (Alberta Government). 1992. Status report on the water quality of Moose Lake.

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

Parameter	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
TP (µg/L)	36	46	25	40	50	41	51	54	44	40	41	43
TDP (µg/L)	-	-	-	-	-	-	-	-	-	-	12	-
Chlorophyll-a (µg/L)	13.7	16.2	10.5	17.6	21.5	16.0	22.3	31.1	15.7	21.0	22.7	14.6
Secchi depth (m)	2.25	1.92	3.75	2.53	2.31	2.48	2.18	3.35	2.69	3.00	2.11	2.28
TKN (mg/L)	-	-	1.3	-	-	-	-	-	-	-	1.4	-
NO_2-N and NO_3-N (µg/L)	25	25	87	25	10	8	5	10	2	4	3	7
NH_3-N (µg/L)	-	-	-	-	-	-	-	-	-	-	-	-
DOC (mg/L)	-	-	-	-	-	-	-	-	-	-	18	-
Ca^{2+} (mg/L)	24	24	27	27	28	27	22	23	22	26	24	22
Mg^{2+}(mg/L)	32	34	35	36	36	40	40	42	44	44	44	45
Na^{+} (mg/L)	62	64	65	66	62	74	78	74	76	82	84	85
K^{+} (mg/L)	12	11	12	12	12	12	12	12	13	13	14	14
SO_4^{2-} (mg/L)	82	84	89	92	94	102	107	106	112	117	115	117
Cl^{-} (mg/L)	12	12	13	13	14	13	14	15	14	16	16	17
CO_3^{2-} (mg/L)	-	-	-	-	-	-	-	-	-	-	-	-
HCO_3^{2-} (mg/L)	-	-	-	-	-	-	-	-	-	-	-	-
pH	8.40	8.68	8.54	8.63	8.65	8.58	8.70	8.93	8.70	8.84	8.99	8.99
Conductivity (µS/cm)	656	641	683	678	681	715	708	706	736	780	787	790
Hardness (mg/L)	-	198	210	216	216	234	218	228	235	245	242	238
TDS (mg/L)	370	381	397	400	399	429	435	432	444	472	474	474
Microcystin (µg/L)	-	-	-	-	-	-	-	-	-	-	-	-
Total Alkalinity (mg/L CaCO3)	244	252	259	257	256	267	262	268	272	289	295	292

Parameter	1995	1996	1997	2003	2004	2005	2006	2009	2010	2011	2012
TP (µg/L)	43	31	48	52	38	50	59	43	46	49	53
TDP (µg/L)	17	-	-	14	15	13	17	20	17	18	18
Chlorophyll-a (µg/L)	17.6	5.2	16.8	39.5	22.6	27.3	35.5	15.7	19.0	46.1	26.8
Secchi depth (m)	1.98	3.45	2.75	2.25	2.69	2.15	1.30	3.06	1.56	2.88	1.84
TKN (mg/L)	1.6	-	-	1.7	1.5	1.6	1.8	1.6	1.7	1.6	1.7
NO_2-N and NO_3-N (µg/L)	6	-	-	16	3	2	2	8	8	4	2
NH_3-N (µg/L)	-	-	-	33	38	16	23	-	-	-	-
DOC (mg/L)	18	-	-	-	18	18	18	18	18	17	18
Ca^{2+} (mg/L)	23	32	28	-	-	-	-	-	-	-	-
Mg^{2+}(mg/L)	45	45	42	-	-	-	-	-	-	-	-
Na^{+} (mg/L)	87	84	84	111	112	114	115	117	124	114	107
K^{+} (mg/L)	15	14	15	12	17	20	17	20	19	20	21
SO_4^{2-} (mg/L)	125	124	118	149	156	151	155	165	164	156	161
Cl^{-} (mg/L)	18	17	19	23	25	25	25	28	29	27	28
$CO\sim_3^{2-}$ (mg/L)	-	14.5	16.2	29.3	28.5	35	31.7	30.3	27.5	18	28.8
HCO_3^{2-} (mg/L)	-	322	313.5	342.67	350	334.5	345.67	348	357.5	371.5	358.5
pH	8.76	8.56	8.64	8.87	8.86	8.99	8.81	8.90	8.85	8.69	8.87
Conductivity (µS/cm)	793	808	776	-	934	868	947	954	964	974	993
Hardness (mg/L)	241	-	-	-	-	-	-	-	-	-	-
TDS (mg/L)	489	493	480	573	584	580	587	604	610	599	597
Microcystin (µg/L)	-	-	-	-	-	0.42	0.05	0.59	0.11	1.18	1.01
Total Alkalinity (mg/L CaCO3)	295	288	284	330	334	333	336	336	338	335	342

Parameter	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
TP (µg/L)	109	74	33	34	69	91	49	64	54	40	54	37
TDP (µg/L)	41	31	10	12	12	18	15	13	11	10	12	11
Chlorophyll-a (µg/L)	50.0	14.3	14.6	29.6	40.7	94.0	38.0	51.9	48.1	32.9	45.0	22.5
Secchi depth (m)	0.96	3.66	2.60	1.75	1.10	1.32	2.47	1.01	1.48	1.62	0.99	2.00
TKN (mg/L)	2	1.6	1.6	1.5	2.1	2.2	1.7	2	2.1	1.8	1.8	1.3
NO_2-N and NO_3-N (µg/L)	2	36	-	2	10	14	2	2	3	5	2	6
NH_3-N (µg/L)	-	87	-	38	52	104	24	37	28	28	30	18
DOC (mg/L)	24	18	16	16	17	18	18	18	17	18	19	18
Ca^{2+} (mg/L)	-	-	25	27	28	29	31	32	30	31	28	30
Mg^{2+}(mg/L)	-	-	52	57	54	49	47	45	45	50	52	54
Na^{+} (mg/L)	116	128	110	120	110	102	99	97	94	101	104	110
K^{+} (mg/L)	24	21	18	22	21	21	20	20	20	22	21	23
SO_4^{2-} (mg/L)	151	150	168	160	148	145	138	128	140	135	140	145
Cl^{-} (mg/L)	28	32	32	32	31	31	31	32	34	34	36	36
$CO\sim_3^{2-}$ (mg/L)	36.2	29.2	26.2	24.8	22.6	27	21.2	24.4	23.8	16.5	25.2	23.5
HCO_3^{2-} (mg/L)	341.7	353.4	366	368	348	337.5	347.5	307.5	332.5	347.5	365	365
pH	8.90	8.71	8.80	8.79	8.75	8.81	8.75	8.80	8.79	8.66	8.75	8.76
Conductivity (µS/cm)	989	996	990	994	934	918	905	875	925	918	930	980
Hardness (mg/L)	-	-	-	302	294	272	268	262	260	282	280	300
TDS (mg/L)	602	628	618	628	586	575	558	528	555	565	590	610
Microcystin (µg/L)	0.23	0.6	0.54	1.59	1.04	3.72	1.96	1.97	3.64	0.42	0.34	2.44
Total Alkalinity (mg/L CaCO3)	341	339	344	342	322	325	320	295	312	312	340	342

Table 3. Concentrations of metals measured in Moose 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	2003	2004	2005	2006	2009	2010	2011	2012	2013	2014	Guidelines
Aluminum (µg/L)	-	4.95	3.34	5.54	16.05	10.7	4.08	5.18	17.65	7.22	100[a]
Antimony (µg/L)	-	0.065	0.065	0.062	0.058	0.053	0.056	0.058	0.056	0.047	/
Arsenic (µg/L)	-	2.03	2.19	2.11	2.12	2.16	2.08	2.21	2.07	2.06	5
Barium (µg/L)	-	50.2	47.8	47.8	45.3	44.9	46	47	49.2	48.9	/
Beryllium (µg/L)	-	0.0015	0.0015	0.0015	0.003	0.0015	0.0039	0.0037	0.0057	0.004	100[c,d]
Bismuth (µg/L)	-	0.0011	0.0033	0.0029	0.006	0.0012	5e-04	5e-04	0.0036	5e-04	/
Boron (µg/L)	-	172	176	177.5	197	185	202	191	181.5	189	1500
Cadmium (µg/L)	-	0.007	0.005	0.003	0.005	0.005	0.004	0.01	0.003	0.002	0.36[b]
Chromium (µg/L)	-	0.87	0.606	0.424	0.2975	0.22	0.2175	0.351	0.3245	0.817	/
Cobalt (µg/L)	-	0.014	0.0206	0.01795	0.01065	0.0067	0.03045	0.0027	0.01295	0.007285	500, 1000[c,d]
Copper (µg/L)	-	0.75	0.607	0.716	0.492	0.263	0.499	0.663	0.638	0.554	4[b]
Iron (µg/L)	-	1	19	6.78	7.55	7.65	22.8	1	17.1	9.03	300
Lead (µg/L)	0.079	0.047	0.08	0.064	0.022	0.011	0.013	0.048	0.027	0.065	7[b]
Lithium (µg/L)	-	53.4	57.3	52.05	61.2	53.1	70.75	55.05	52.45	52.85	2500[d]
Manganese (µg/L)	-	8.14	7.26	7.76	7.55	7.2	5.62	7.99	9.02	8.51	130[e]
Molybdenum (µg/L)	-	0.846	0.705	0.657	0.597	0.556	0.627	0.625	0.57	0.523	73
Nickel (µg/L)	-	0.002	0.056	0.024	0.002	0.002	0.163	0.002	0.076	0.04	150[b]
Selenium (µg/L)	-	0.27	0.376	0.513	0.396	0.375	0.358	0.254	0.353	0.528	1
Silver (µg/L)	-	3e-04	0.0013	0.0034	0.0014	0.0018	0.0077	0.004	0.0453	0.001	0.25
Strontium (µg/L)	-	309	307.5	302.5	303	281	287.5	242	290.5	297	/
Thallium (µg/L)	-	0.0019	0.0293	0.0071	0.0042	0.0021	4e-04	1e-04	7e-04	0.0014	0.8
Thorium (µg/L)	-	0.009	0.019	0.012	0.002	0.008	0.012	0	0.009	0	/
Tin (µg/L)	-	0.01	0.01	0.01	0.04	0.01	0.03	0.04	0.01	0.01	/
Titanium (µg/L)	-	0.67	0.862	1.023	1.129	0.756	0.488	0.647	1.38	1.025	/
Uranium (µg/L)	-	0.437	0.591	0.492	0.454	0.433	0.463	0.445	0.42	0.446	15
Vanadium (µg/L)	-	0.388	0.384	0.25	0.29	0.244	0.26	0.3	0.256	0.386	100[c,d]
Zinc (µg/L)	-	7.9	4.34	2.16	0.72	0.5	0.68	1.05	0.94	0.81	30[f]

Metals	2015	2016	2017	2018	2020	2021	2022	2023	2024	Guidelines
Aluminum (µg/L)	4	6.6	19.4	1.3	3.7	5.9	7.9	2.5	5.4	100[a]
Antimony (µg/L)	0.052	0.05	0.055	0.055	0.054	0.045	0.051	0.047	0.047	/
Arsenic (µg/L)	1.93	1.78	1.83	2.18	2.03	2	1.84	2.05	2.03	5
Barium (µg/L)	45.9	44	47.8	50.6	51.8	50.8	52.4	50.4	54.4	/
Beryllium (µg/L)	0.004	0.004	0.0075	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	100[c,d]
Bismuth (µg/L)	0.0033	5e-04	0.0075	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	/
Boron (µg/L)	187.5	192	181	172	151	154	178	164	162	1500
Cadmium (µg/L)	0.001	0.001	0.025	0.005	0.005	0.005	0.005	0.005	0.005	0.36[b]
Chromium (µg/L)	0.34	0.04	0.25	0.05	0.05	0.1	0.05	0.05	0.05	/
Cobalt (µg/L)	0.012	0.001	0.026	0.036	0.032	0.068	0.017	0.036	0.02	500, 1000[c,d]
Copper (µg/L)	0.46	0.73	0.91	0.3	0.04	0.16	0.15	0.17	0.16	4[b]
Iron (µg/L)	8.15	6.6	9.6	12.6	8.7	7.7	9.9	4.5	7	300
Lead (µg/L)	0.015	0.014	0.051	0.036	0.007	0.007	0.014	0.044	0.031	7[b]
Lithium (µg/L)	53.45	60.7	52.5	54.1	44.6	49.7	47.4	47.6	47.9	2500[d]
Manganese (µg/L)	5.35	7.96	8.72	11.1	21	22.6	22.2	11.2	15.2	130[e]
Molybdenum (µg/L)	0.517	0.461	0.484	0.555	0.458	0.484	0.432	0.353	0.333	73
Nickel (µg/L)	0.004	0.277	4.82	0.41	0.11	0.16	0.13	0.15	0.1	150[b]
Selenium (µg/L)	0.045	0.58	0.5	0.4	0.5	0.5	0.1	0.7	0.5	1
Silver (µg/L)	0.001	0.001	0.0025	0.002	5e-04	5e-04	5e-04	0.003	0.001	0.25
Strontium (µg/L)	275.5	272	249	305	293	279	282	298	342	/
Thallium (µg/L)	0.0019	0.0016	0.005	0.001	0.001	0.001	0.001	0.001	0.001	0.8
Thorium (µg/L)	0.004	0.006	0.005	0.001	0.003	0.003	0.006	0.006	0.002	/
Tin (µg/L)	0.02	0.01	0.15	0.03	0.03	0.03	0.03	0.03	0.03	/
Titanium (µg/L)	0.81	0.66	1.11	0.69	0.57	0.5	0.23	0.6	0.75	/
Uranium (µg/L)	0.494	0.423	0.382	0.44	0.324	0.343	0.337	0.337	0.335	15
Vanadium (µg/L)	0.16	0.19	0.13	0.282	0.582	0.267	0.162	0.145	0.189	100[c,d]
Zinc (µg/L)	0.35	1.5	15.2	5.4	0.5	0.9	1.3	1.7	1.1	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 Moose Lake. In sum, a significant increasing trend was detected in chlorophyll-*a* and total dissolved solids, while a significant decreasing trend was detected in Secchi disk depth. Secchi depth can be subjective and is sensitive to variation in weather; therefore, trend analysis must be interpreted with caution. No significant trend was detected in total phosphorus. 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 Moose Lake data from 1984 to 2024.

Parameter	Date Range	Direction of Significant Change
Total Phosphorus	1984-2024	No Change
Chlorophyll-*a*	1984-2024	Increasing
Total Dissolved Solids	1984-2024	Increasing
Secchi Depth	1984-2024	Decreasing

Definitions

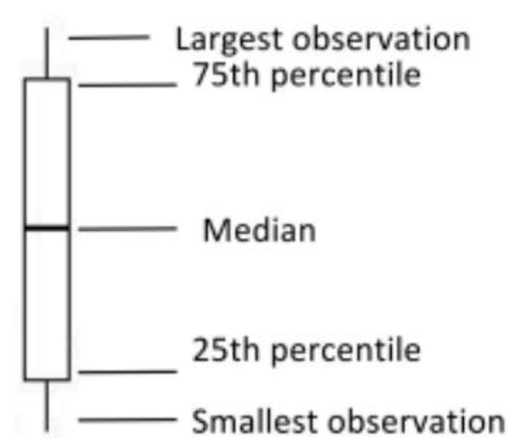
Median: the value in a range of ordered numbers that falls in the middle.

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 no significant upward or downward trend in Moose Lake TP data 1984 to 2024 (Tau = 0.1158, p = 0.079).

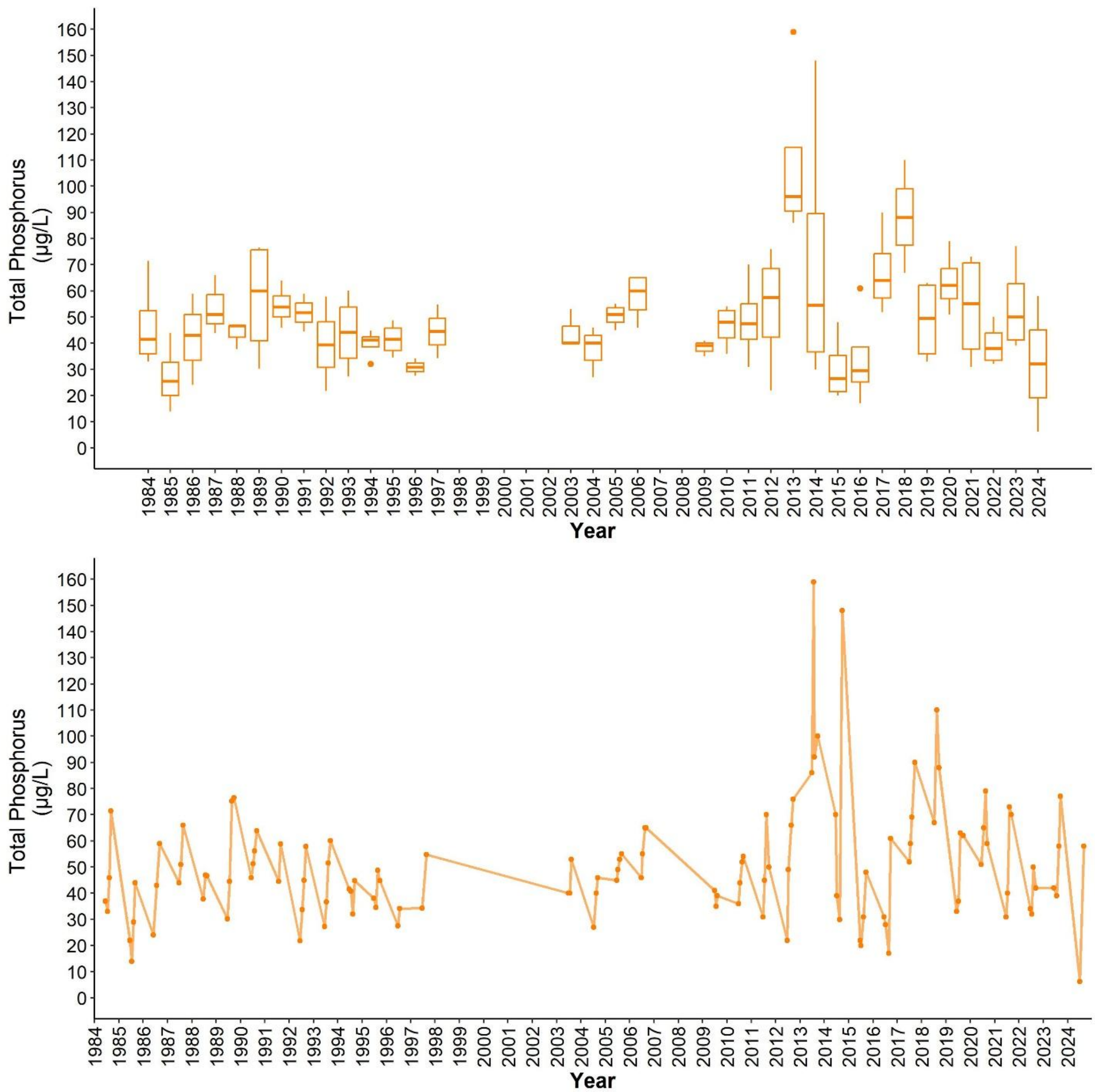
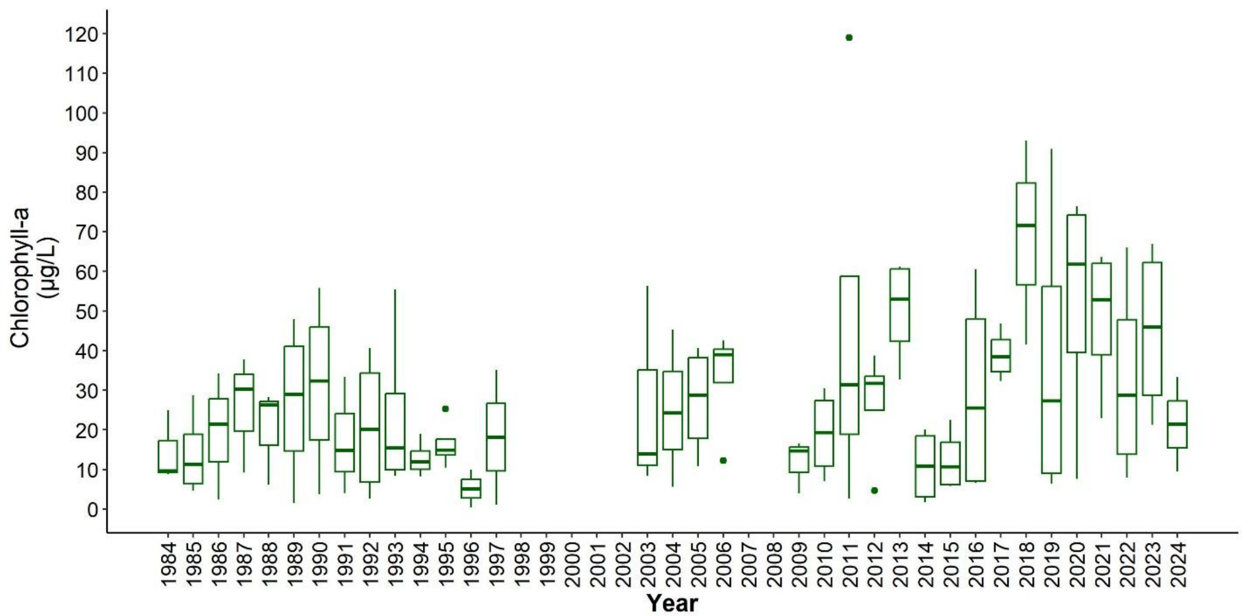


Figure 8. Monthly total phosphorus (TP) concentrations measured between June and September over the long term sampling dates between 1984 and 2024 (n = 121). The value closest to the 15th day of the month was chosen to represent the monthly value in cases with multiple monthly samples.

Chlorophyll-*a*

Trend analysis of chlorophyll-*a* over time suggests a significantly increasing trend over time at Moose Lake since 1984 (Tau = 0.2279, p = <0.001).



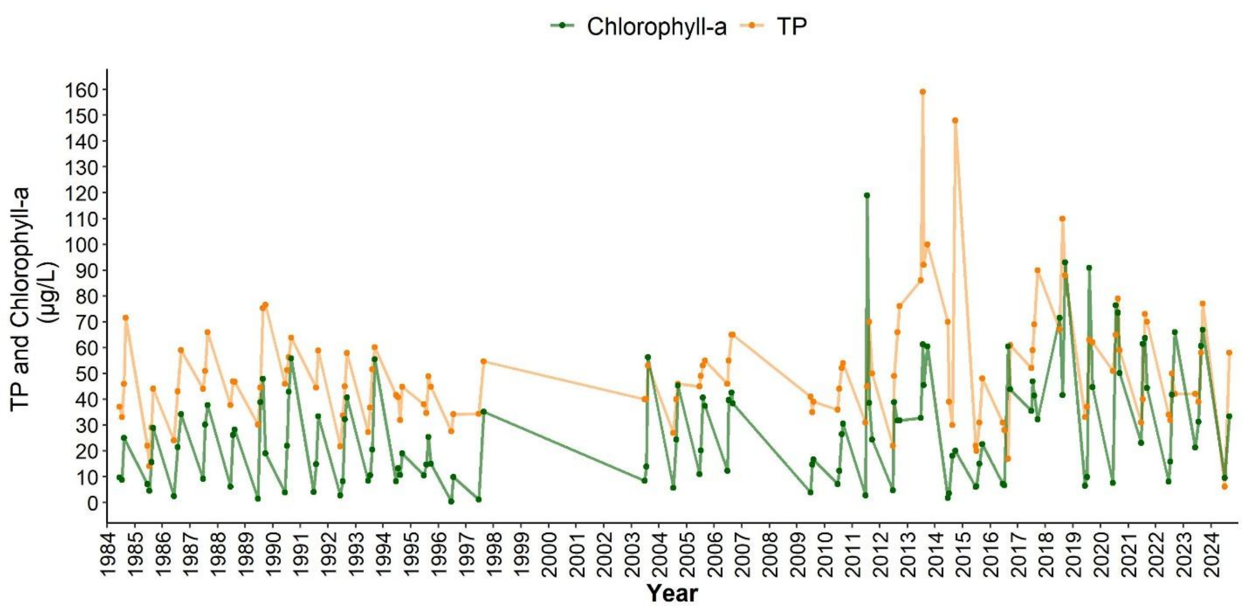


Figure 9. Monthly chlorophyll-*a* concentrations measured between June and September over the long term sampling dates between 1984 and 2024 (n = 121). The value closest to the 15th day of the month was chosen to represent the monthly value in cases with multiple monthly samples. Line graph is overlain by TP concentrations.

Total Dissolved Solids (TDS)

Trend analysis suggests a significantly increasing trend in TDS in Moose Lake since 1984 (Tau = 0.431, *p* = <0.001).

Figure 10. Monthly TDS values measured between June and September over the long term sampling dates between 1984 and 2024 (n = 89). 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 Moose Lake, exploring significance in trends in individual major ions can help explain an overall trend in TDS.

Trend analysis of major ions at Moose Lake indicates that all ions demonstrated a significantly increasing trend (Figure 11). Due to the consistent trend across major ions, it is likely that evaporative loss associated with declining water levels is largely driving the trend in TDS.

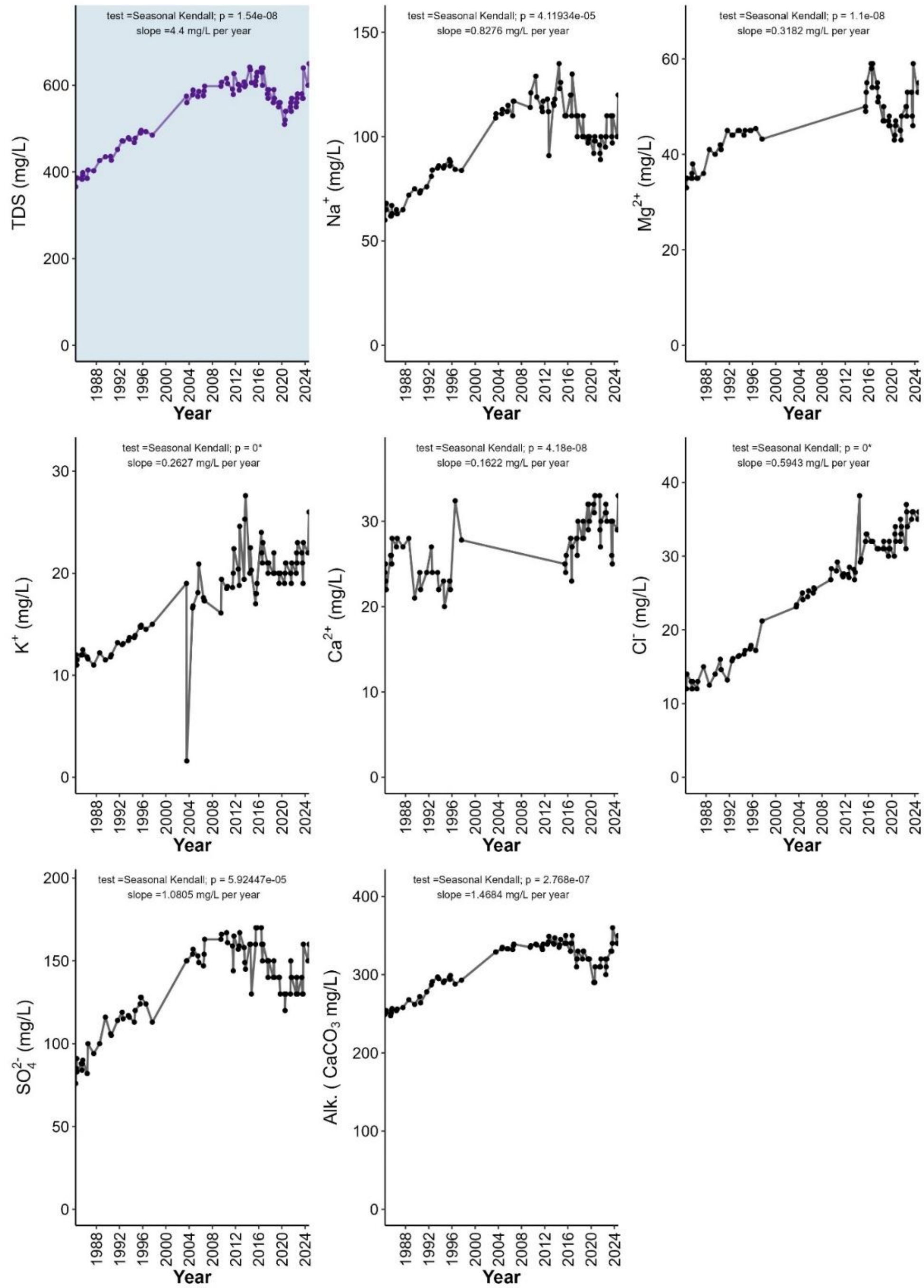
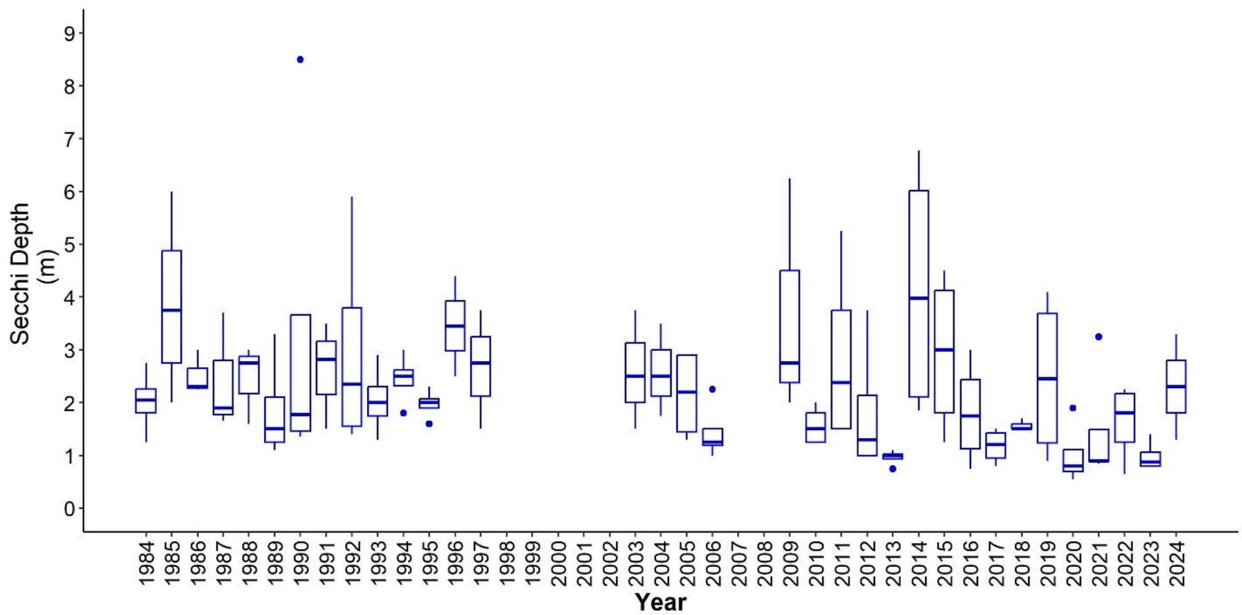


Figure 11. Concentrations of TDS (top left, blue panel), major ions (sodium = Na^+, magnesium = Mg^{2+}, potassium = K^+, calcium = Ca^{2+}, chloride = Cl^-, sulphate = SO_4^{2-}), and total alkalinity (Alk., as mg/L $CaCO_3$) measured monthly between June and September on sampling dates between 1984 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. A value of $p = 0^*$ indicates an extremely small p value. 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 suggests it has significantly decreased (the lake has become less clear) in Moose Lake since 1984 (Tau = -0.2763, *p* = <0.001).



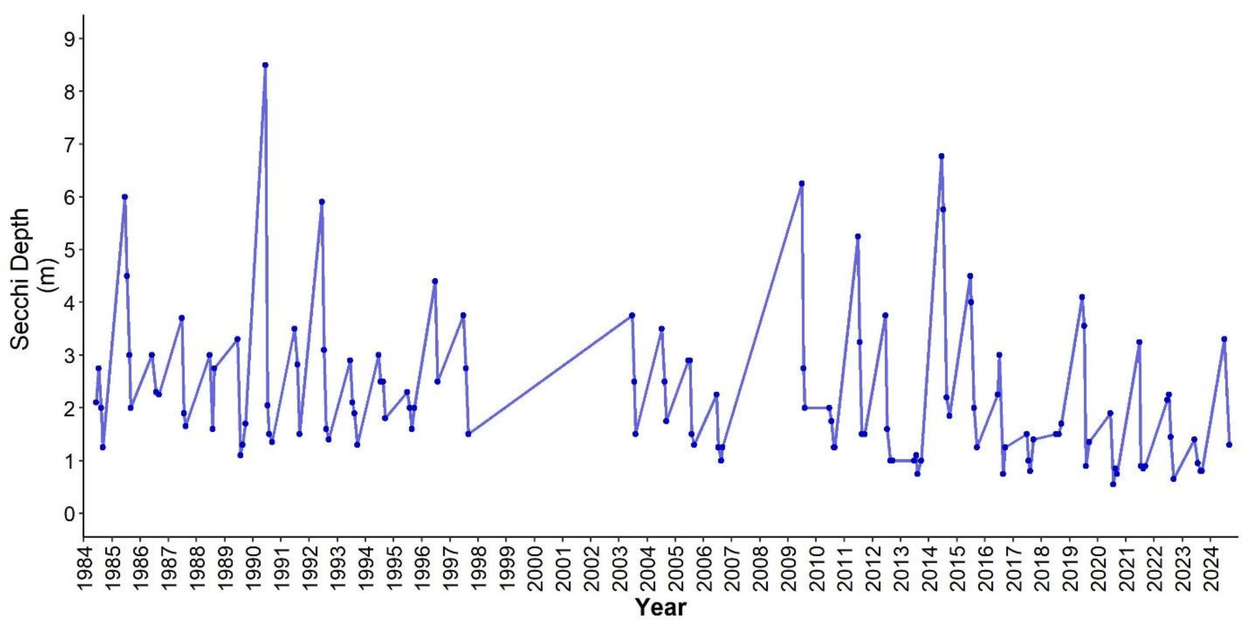


Figure 12. Monthly Secchi depth values measured between June and September over the long term sampling dates between 1984 and 2024 (n = 123). The value closest to the 15th day of the month was chosen to represent the monthly value in cases with multiple monthly samples.

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 1984-2024 on Moose 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	0.1158	0.2279	0.431	-0.2763
The extent of the trend	Slope (units per Year)	0.1667	0.3	4.4	-0.0228
The statistic used to find significance of the trend	Z	1.7592	3.4978	5.6575	-4.207
Number of samples included	n	121	121	89	123
The significance of the trend	*p*	0.0785	<0.0005*	1.54e-08*	2.588e-05*

*$p < 0.05$ is significant within 95%