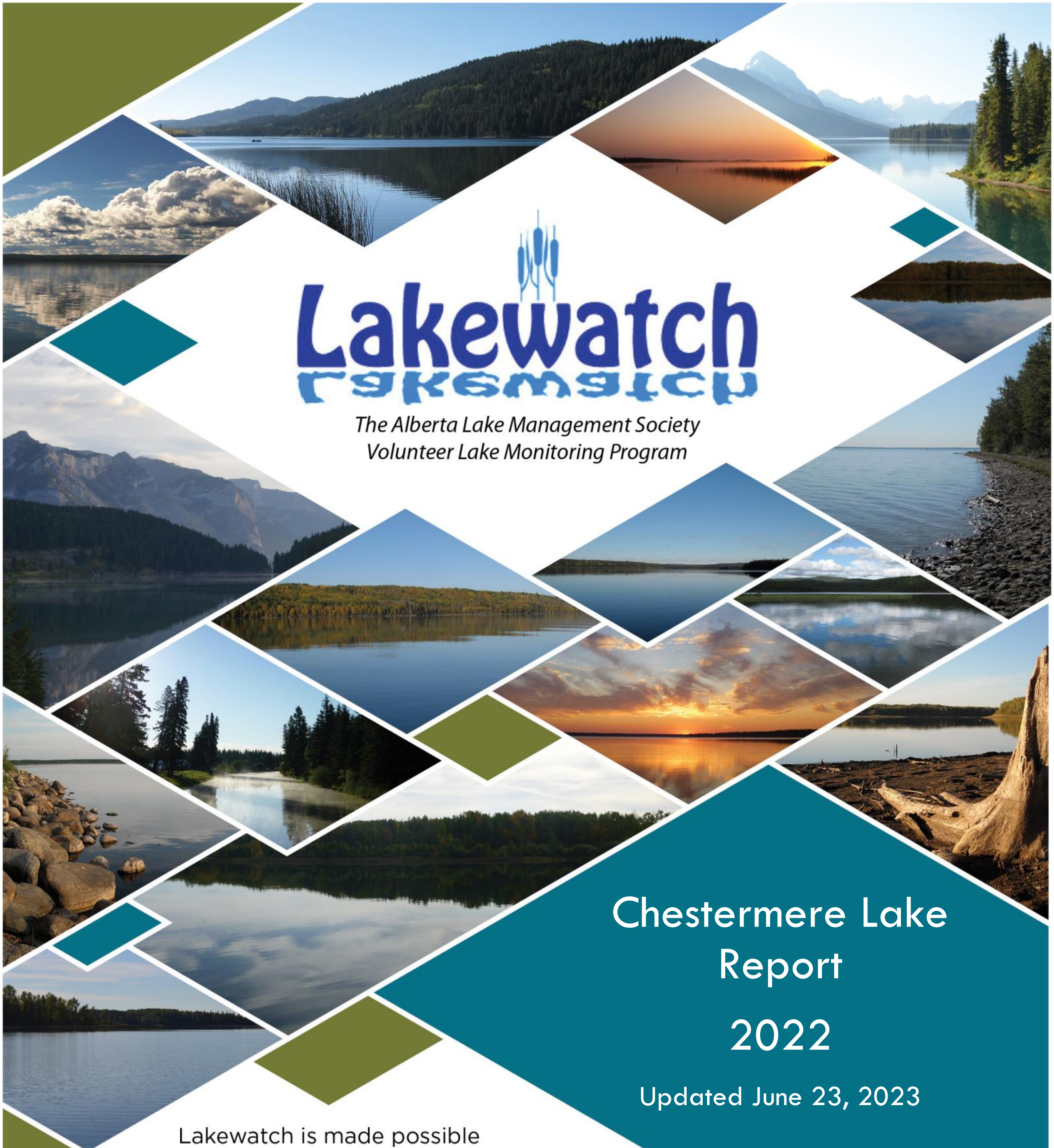


Lakewatch

The Alberta Lake Management Society
Volunteer Lake Monitoring Program

Chestermere Lake Report

2022

Updated June 23, 2023

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 Kathy Speck and Sonja LeDuc for their commitment to collecting data at Chestermere Lake. We would also like to thank Kurstyn Perrin and Dominic Wong, who were summer technicians in 2022. Executive Director Bradley Peter and Program Manager Caleb Sinn were instrumental in planning and organizing the field program. This report was prepared by Caleb Sinn and Bradley Peter.

CHESTERMERE LAKE

Situated in the Town of Chestermere just minutes East of Calgary, Chestermere Lake is a popular recreational lake and a highly developed, urban, man-made reservoir. Chestermere Lake was originally built by the Canadian Pacific Railroad (CPR) in the 1880's as a water-balancing reservoir, supplying water at 50 cents per acre to CPR land. In the 1940's, the CPR offered to forgive mortgages held on their land in return for settlers giving up their water rights. The irrigation system was turned over to the Western Irrigation District (WID), which currently owns and operates the structures feeding water to and from Chestermere Lake (Mitchell and Prepas, 1990). The drainage basin for the lake is only 7.65 km^2 including the 2.65 km^2 'reservoir' at its maximum capacity. Chestermere Lake is surrounded by urban development.

Chestermere Lake is shallow over most of its depth (<2.0 m over 50% of its area). During the original survey conducted by the Alberta Government, Chestermere Lake was more than seven meters deep. The deepest areas of the lake have accumulated little sediment as maximum depth still remains between five to seven meters depending on water levels. Sediment accumulation has been heaviest at the WID canal inflow (south) where as much as two meters of sediment has accumulated. Likely due to its shallow depth, aquatic weeds are prevalent in Chestermere Lake. Chestermere is an important site for recreational use and mechanical removal of weeds using harvesters is maintained on a continuous basis. Chestermere Lake receives a large volume of water during summer months, enough to replace the entire lake volume in eight days. Flushing of this magnitude may actually help to maintain the waters clarity and thus the success of weeds in comparison to other Alberta lakes of similar depth.

Chestermere Lake at sunset in 2019.

In 2016, two species of bryozoans were identified in Chestermere Lake: *Plumatella* sp. and *Cristatella mucedo*.

BEFORE READING THIS REPORT, CHECK OUT A BRIEF INTRODUCTION TO LIMNOLOGY AT ALMS.CA/REPORTS

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 Chestermere Lake was 7 µg/L (Table 2), falling into the oligotrophic, or minimally productive trophic classification. This value falls below all previously observed historical averages going back to 1983 (Table 2). TP ranged from a minimum of <3 µg/L on August 22nd, to a maximum of 11 µg/L on September 20th (Figure 1). Note that a value of 1.5 µg/L was used to calculate the average TP, and to plot in Figure 1, where the levels were below the detection limit of 3 µg/L.

Average chlorophyll-*a* concentration in 2022 was 4.6 µg/L (Table 2), falling into the mesotrophic, or moderately productive trophic classification. Chlorophyll-*a* was lowest during the July 19th sampling event at 3.1 µg/L, and peaked at 5.7 µg/L on September 20th.

The average TKN concentration was 0.3 mg/L (Table 2), and displayed little seasonal variation (Figure 1).

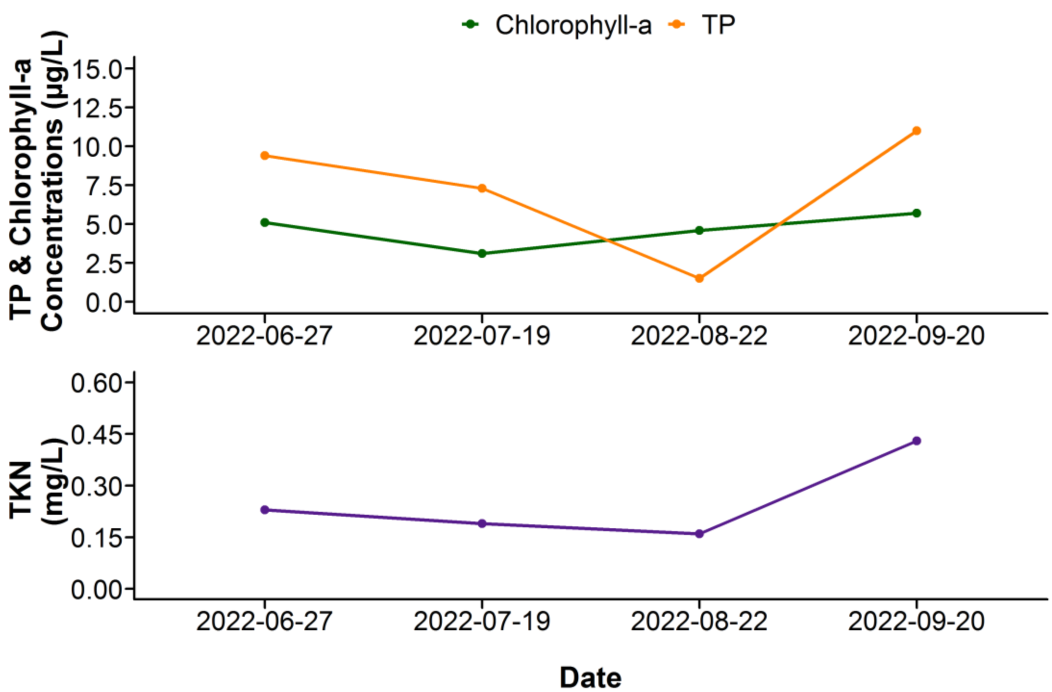


Figure 1. Total Phosphorus (TP), Total Kjeldahl Nitrogen (TKN), and Chlorophyll-*a* concentrations measured four times over the course of the summer at Chestermere Lake.

Average pH was measured as 7.96 in 2022, buffered by low alkalinity (128 mg/L $CaCO_3$) and bicarbonate (155 mg/L HCO_3). Aside from bicarbonate, calcium and sulphate were higher than all other major ions, and together contributed to a low conductivity of 355 µS/cm (Figure 2, top; Table 2). Sodium, chloride, sulphate and bicarbonate displayed high seasonal variability. The variability of sodium, chloride and sulphate is driven primarily from high values during the June sampling event, following many days with high precipitation (Figure 5), while the high bicarbonate value is from the August sampling event. Chestermere Lake is in the low end range of ion levels, compared to other LakeWatch lakes sampled in 2022, with the exception of calcium, chloride, and sulphate, being at moderate to higher levels. (Figure 2, bottom).

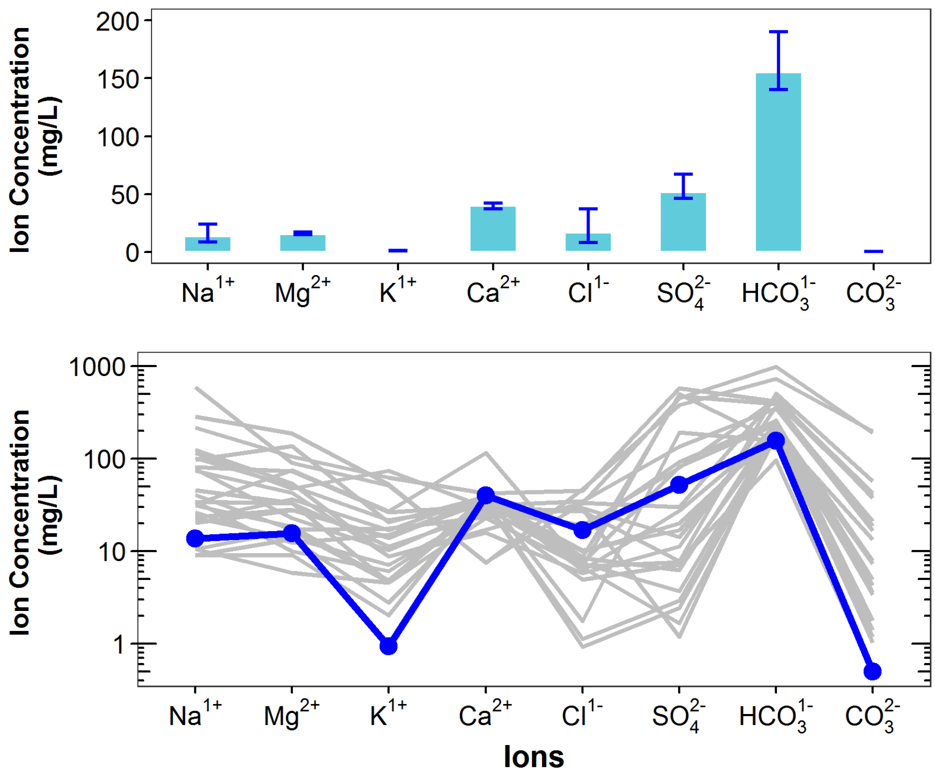


Figure 2. Average levels of cations (sodium = Na^{1+}, magnesium = Mg^{2+}, potassium = K^{1+}, calcium = Ca^{2+}) and anions (chloride = Cl^{1-}, sulphate = SO_4^{2-}, bicarbonate = HCO_3^{1-}, carbonate = CO_3^{2-}) from four measurements over the course of the summer at Chestermere Lake. Top) bars indicate range of values measured, and bottom) Schoeller diagram of average ion levels at Chestermere Lake (blue line) compared to 26 lake basins (gray lines) sampled through the LakeWatch program in 2022 (note $\log_{10}$ 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 not measured at Chestermere Lake in 2022, but historical levels are available in Table 3.

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 Chestermere Lake in 2022 was 5.63 m, corresponding to an average Secchi depth of 3.35 m (Table 2). Euphotic depth is not double the Secchi depth because euphotic depth was equal to the bottom depth during the June 27th and July 19th sampling events. Euphotic depth varied over the season, ranging from as deep as 6.20 m and 6.30 m on June 27th and July 19th (the measured bottom depths), to 4.90 m on September 20th (Figure 3). Euphotic depths that are equal to the bottom depth indicate that light was likely able to penetrate to all depths of the lake within June and July, which will impact the amount of habitat that could support the growth of rooted macrophytes, as well as sediment dwelling algae and cyanobacteria.

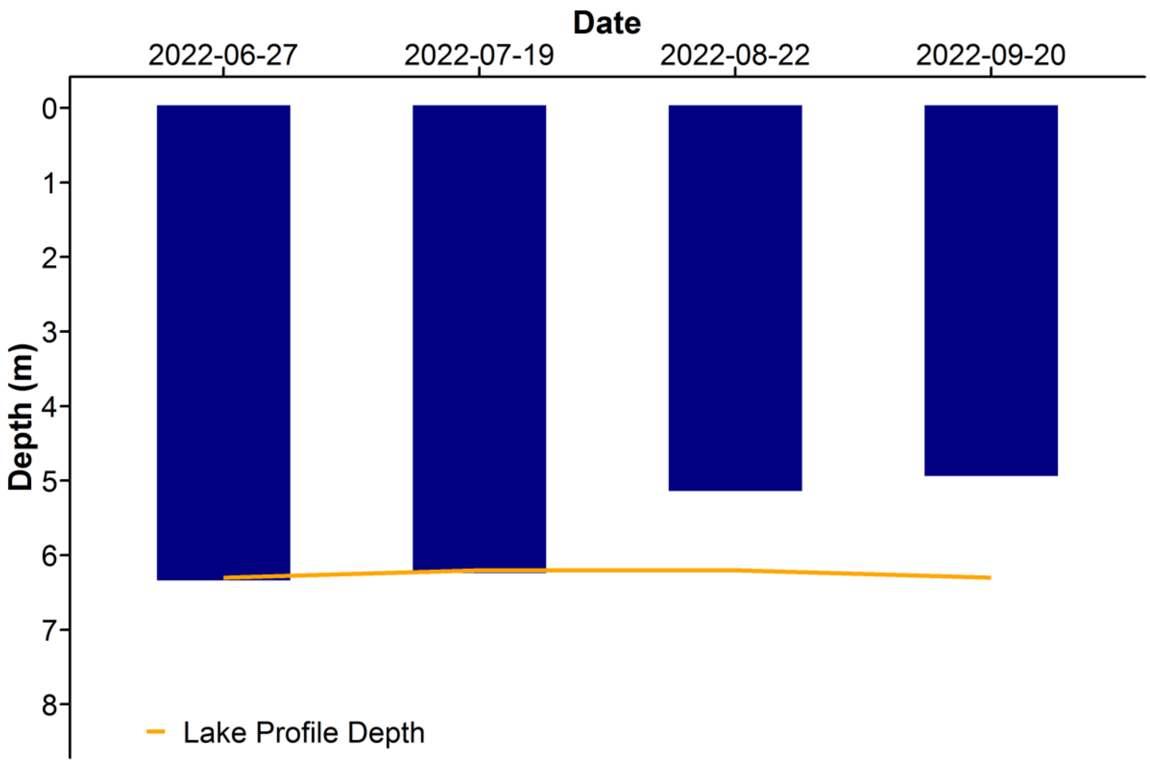


Figure 3. Euphotic depth values measured four times over the course of the summer at Chestermere Lake in 2022.

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 of Chestermere Lake varied throughout the summer, with the August 22nd sampling date having the warmest temperatures at 20.2°C (Figure 4a). The lake was primarily mixed during all sampling trips, but some slight stratification was observed during the June 27th and July 19thsampling events, and even more subtle stratification was observed during the August 22nd sampling event.

Chestermere Lake was well oxygenated in the surface waters on all sampling dates, measuring above the CCME guidelines of 6.5 mg/L dissolved oxygen (Figure 4b). There was an appreciable increase in surface oxygen during the June 27th sampling event, and an appreciable increase during the June 27th sampling event. Slight oxygen depletion was observed during the June 27th and August 22nd sampling events, below 4 m depth.

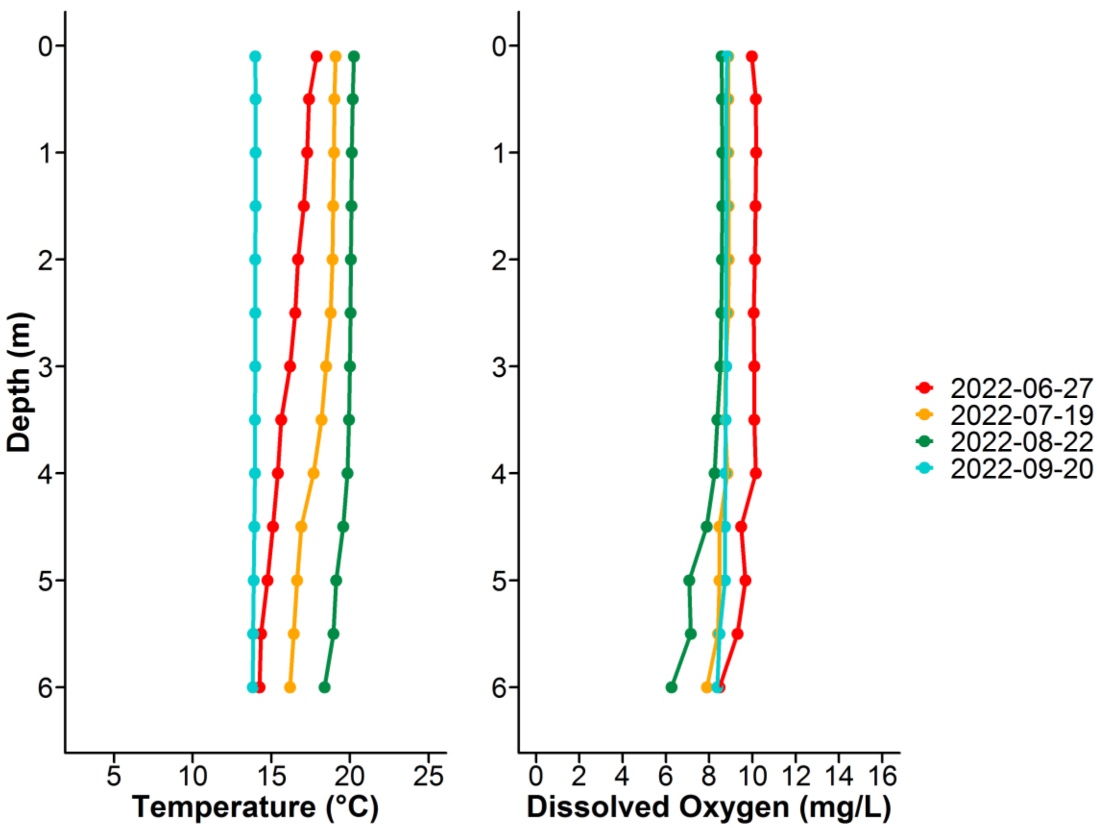


Figure 4. a) Temperature (°C) and b) dissolved oxygen (mg/L) profiles for Chestermere Lake measured four times over the course of the summer of 2022.

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 Chestermere Lake fell below the recreational guideline of 10 μg/L during every sampling event in 2022. In addition, microcystin levels from every sampling event were below the laboratory detection limit of 0.10 μg/L. A value of 0.05 μg/L is assigned to each date that is below detection, in order to calculate an average.

Table 1. Microcystin concentrations measured four times at Chestermere Lake in 2022.

Date	Microcystin Concentration (μg/L)
27-Jun-22	<0.1
19-Jul-22	<0.1
22-Aug-22	<0.1
20-Sep-22	<0.1
Average	0.05

INVASIVE SPECIES MONITORING

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 at three sample sites. This monitoring is designed to detect juvenile Dreissenid mussel veligers and spiny water flea. In 2022, no mussels or spiny water flea were detected at Chestermere Lake.

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.

No suspect watermilfoil was observed or collected from Chestermere Lake in 2022.

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 Protected Areas.

Water levels in Chestermere Lake are controlled and have remained relatively stable since water level monitoring began in 1991 (Figure 5). Water levels of the reservoir fluctuated each year between about 1023.5 masl and 1025.7 masl, and have seen a historical range of 3.9 m.

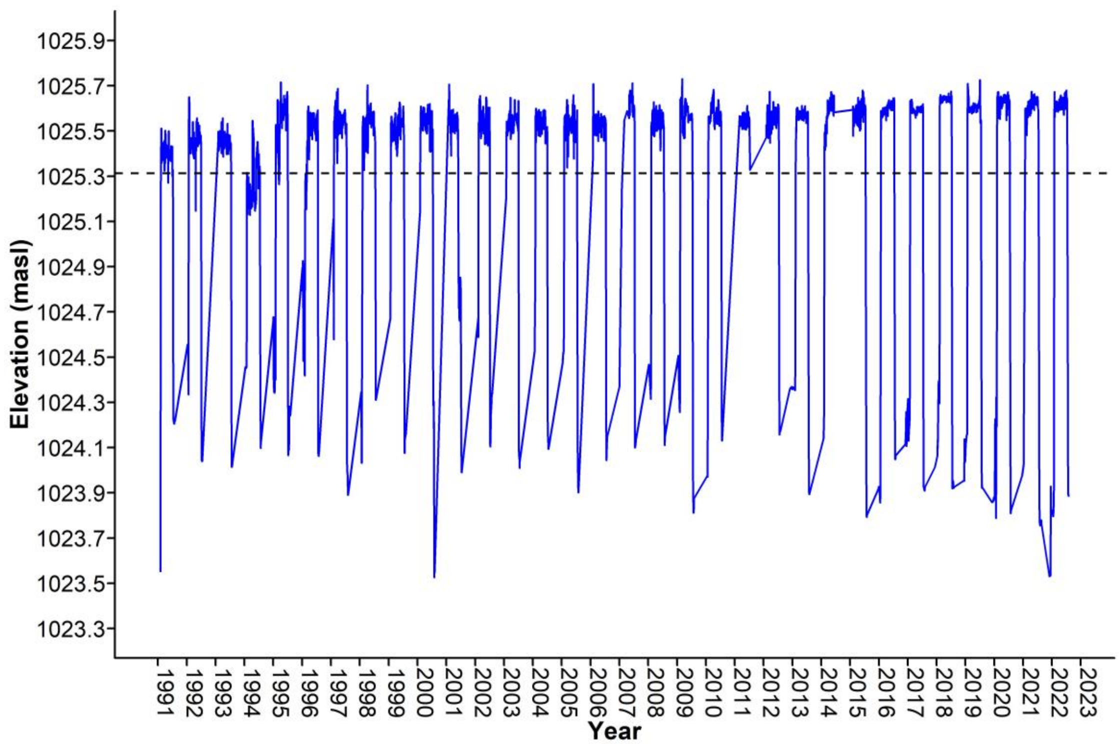


Figure 5. Water levels measured at Chestermere Lake in metres above sea level (masl) from 1991-2022. Data retrieved from Alberta Environment and Protected Areas and/or Environment and Climate Change Canada. Black dashed line represents historical yearly average water level.

WEATHER & 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.

Chestermere Lake experienced a warmer, slightly wetter, windier summer with higher solar radiation than normal (Figure 6). Despite a windy spell leading up the June 27th sampling event, stratification was observed likely due to the warm and calm conditions during that sampling event. A long spell of warmer than normal conditions leading up to the August 22nd sampling event culminated in high water temperatures throughout the lake.

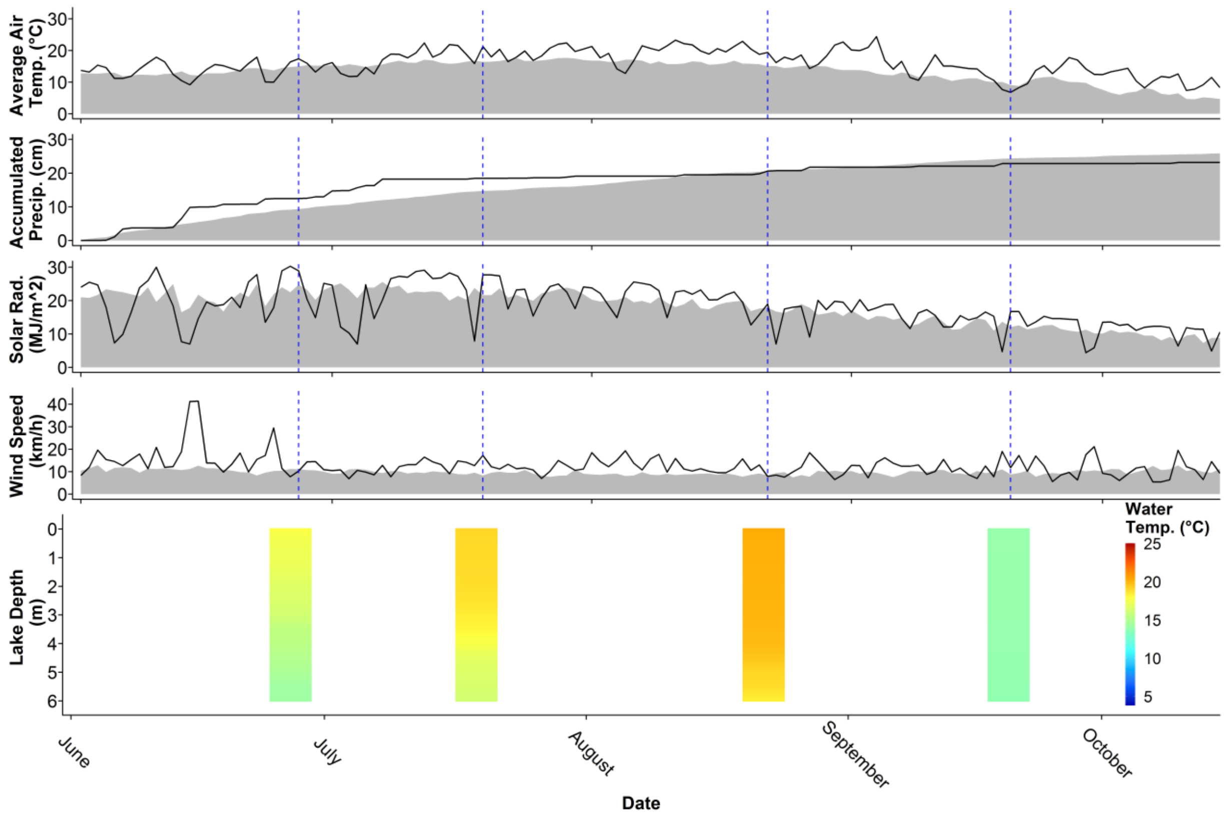


Figure 6. Average air temperature (°C), accumulated precipitation (cm), solar radiation (MJ/m²), and wind speed (km/h) measured from "Calgary Int'l CS", as well as Chestermere Lake temperature profiles, interpolated (°C). Black lines indicate 2022 levels, gray indicates long-term normals, and blue lines indicate sampling dates for Chestermere Lake over the summer. Further information about the weather data provided is available in the LakeWatch 2022 Methods report. Weather data provided by Agriculture, Forestry and Rural Economic Development, Alberta Climate Information Service (ACIS) https://acis.alberta.ca (retrieved March 2023).

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

Parameter	1983	1999	2000	2001	2007	2010	2011	2013	2015	2016	2019	2020	2022
TP (µg/L)	36	32	25	19	31	24	24	18	16	13	12	9	7
TDP (µg/L)	/	/	/	/	11	7	8	5	4	4	4	2	2
Chlorophyll-a (µg/L)	5.5	9.0	7.6	3.4	2.7	3.4	8.0	3.1	6.4	8.7	4.9	7.3	4.6
Secchi depth (m)	2.90	2.60	/	/	3.90	4.25	3.43	2.98	2.22	2.70	2.36	1.79	3.35
TKN (mg/L)	0.4	0.3	0.2	0.7	0.5	0.3	0.4	0.3	0.3	0.3	0.3	0.3	0.3
NO2 and NO3 (µg/L)	/	/	229	739	226	30	87	85	27	33	48	27	22
NH3 (µg/L)	/	/	/	/	/	18	18	14	25	25	17	18	10
DOC (mg/L)	/	/	/	/	4	2	3	3	2	2	3	2	3
Ca (mg/L)	35	37	37	37	42	32	43	43	39	42	41	43	40
Mg (mg/L)	12	15	13	14	15	17	18	16	16	18	16	18	16
Na (mg/L)	7	15	8	5	46	19	23	18	18	24	15	20	14
K (mg/L)	1	1	1	1	3	1	2	2	1	2	1	1	1
SO42- (mg/L)	38	/	43	38	100	58	66	49	60	74	51	60	52
Cl- (mg/L)	4	7	5	3	37	13	16	11	14	17	14	19	17
CO3 (mg/L)	/	/	/	/	2	1	2	2	1	1	1	1	0
HCO3 (mg/L)	/	/	/	/	158	146	162	175	142	150	148	160	155
pH	/	/	/	/	8.31	8.42	8.34	8.38	8.31	8.29	8.27	8.22	7.96
Conductivity (µS/cm)	/	/	/	/	563	149	432	421	392	430	375	413	355
Hardness (mg/L)	/	/	/	/	185	375	181	173	162	180	168	178	160
TDS (mg/L)	/	/	/	/	330	212	251	227	220	254	218	240	215
Microcystin (µg/L)	/	/	/	/	/	0.03	0.08	0.05	<0.1	0.05	0.05	0.05	0.05
Total Alkalinity (mg/L CaCO3)	111	/	116	110	132	120	135	147	116	122	123	133	128

Table 3. Concentrations of metals measured in Chestermere 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 (Total Recoverable)	2013	2015	2016	Guidelines
Aluminum µg/L	95.6	227	28.5	100[a]
Antimony µg/L	0.1165	0.148	0.145	/
Arsenic µg/L	0.5775	0.6335	0.802	5
Barium µg/L	54.45	51.25	46.7	/
Beryllium µg/L	0.0015	0.0065	0.004	100[c,d]
Bismuth µg/L	0.0077	0.00225	0.012	/
Boron µg/L	14.2	18.65	18.7	1500
Cadmium µg/L	0.0226	0.033	0.019	0.26[b]
Chromium µg/L	0.317	0.57	0.21	/
Cobalt µg/L	0.06575	0.1055	0.047	50,1000[c,d]
Copper µg/L	1.303	4.295	1.32	3.9[b]
Iron µg/L	90.15	298.5	73.7	300
Lead µg/L	0.136	0.338	0.107	6.7[b]
Lithium µg/L	4.89	5.125	6.21	2500[d]
Manganese µg/L	7.185	19.9	9.71	270[e]
Molybdenum µg/L	0.9945	1.08	1.08	73
Nickel µg/L	0.438	0.3875	0.302	149.4[b]
Selenium µg/L	0.9035	0.58	0.92	1
Silver µg/L	0.0255	0.0055	0.008	0.25
Strontium µg/L	237	225.5	239	/
Thallium µg/L	0.0057	0.0094	0.0528	0.8
Thorium µg/L	0.0208	0.025025	0.0348	/
Tin µg/L	0.02805	0.057	0.026	/
Titanium µg/L	1.35	4.875	0.91	/
Uranium µg/L	1.065	1.16	1.25	15
Vanadium µg/L	0.5045	0.655	0.36	100[c,d]
Zinc µg/L	1.58	3.35	1.5	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 guideline

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 Chestermere Lake. In sum, a significant decreasing trend was observed in TP, and a significant increasing trend was observed in TDS. No significant trends were detected in chlorophyll-*a* or Secchi disk 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 Chestermere Lake data from 1983 to 2022.

Parameter	Date Range	Direction of Significant Trend
Total Phosphorus	1983-2022	Decreasing
Chlorophyll-*a*	1983-2022	No Change
Total Dissolved Solids	1983-2022	Increasing
Secchi Depth	1983-2022	No Change

Definitions:

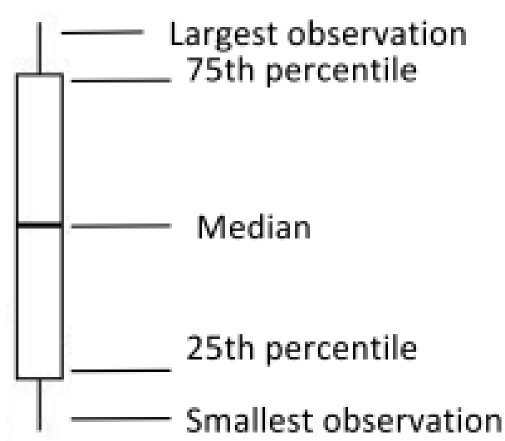
Median: the value in a range of ordered numbers that falls in the middle.

Trend: a general direction in which something is changing.

Monotonic trend: a gradual change in a single direction.

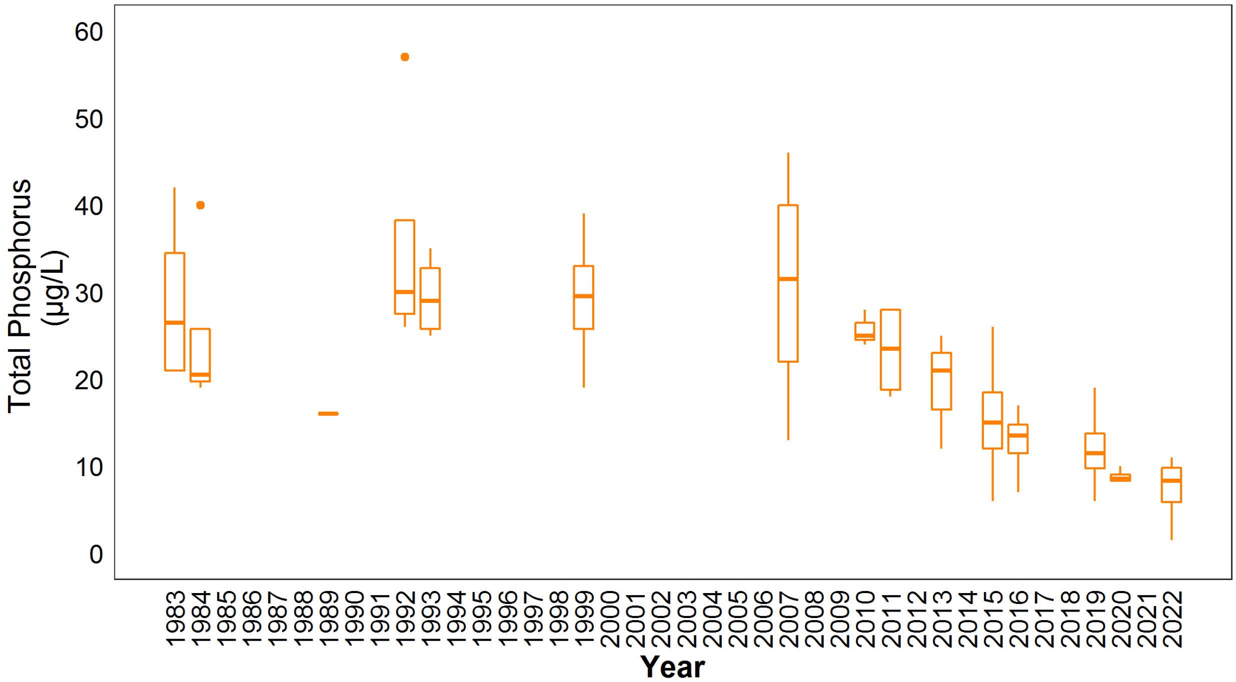
Statistically significant: The likelihood that a relationship between variables is caused by something other than random chance. This is indicated by a p-value of <0.05. Variability: the extent by which data is inconsistent or scattered.

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 showed that it has significantly decreased in Chestermere Lake since 1983 (Tau = -0.56, p = <0.001).



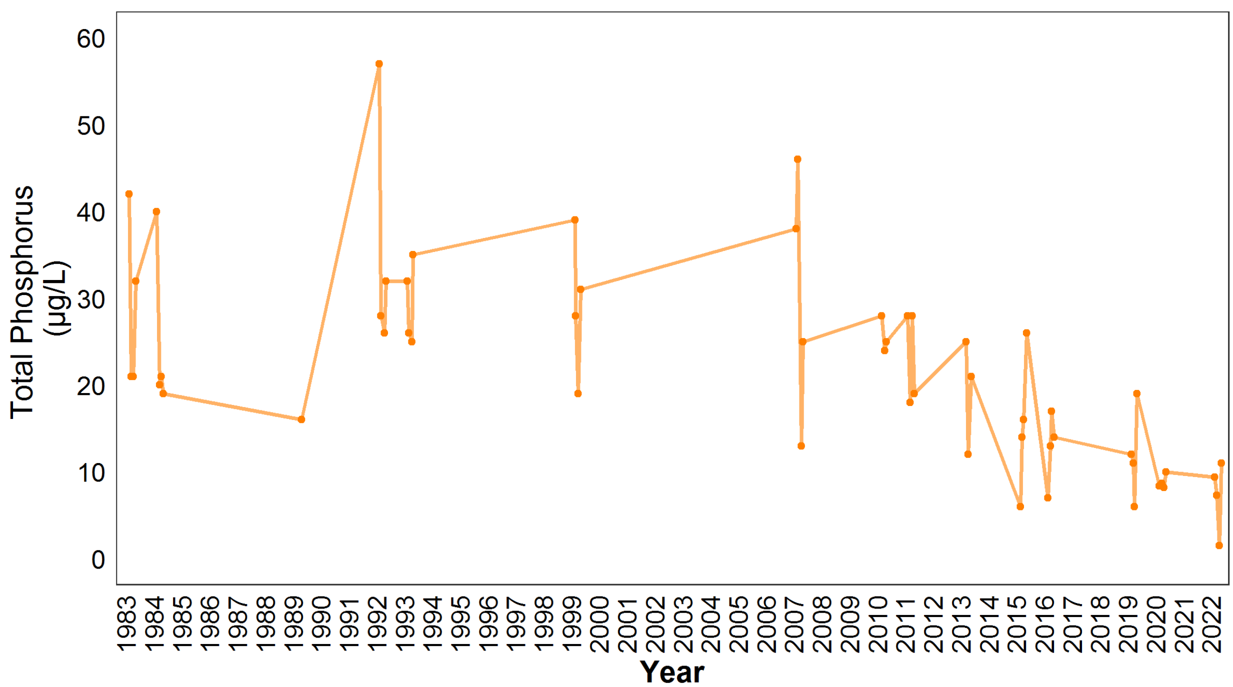
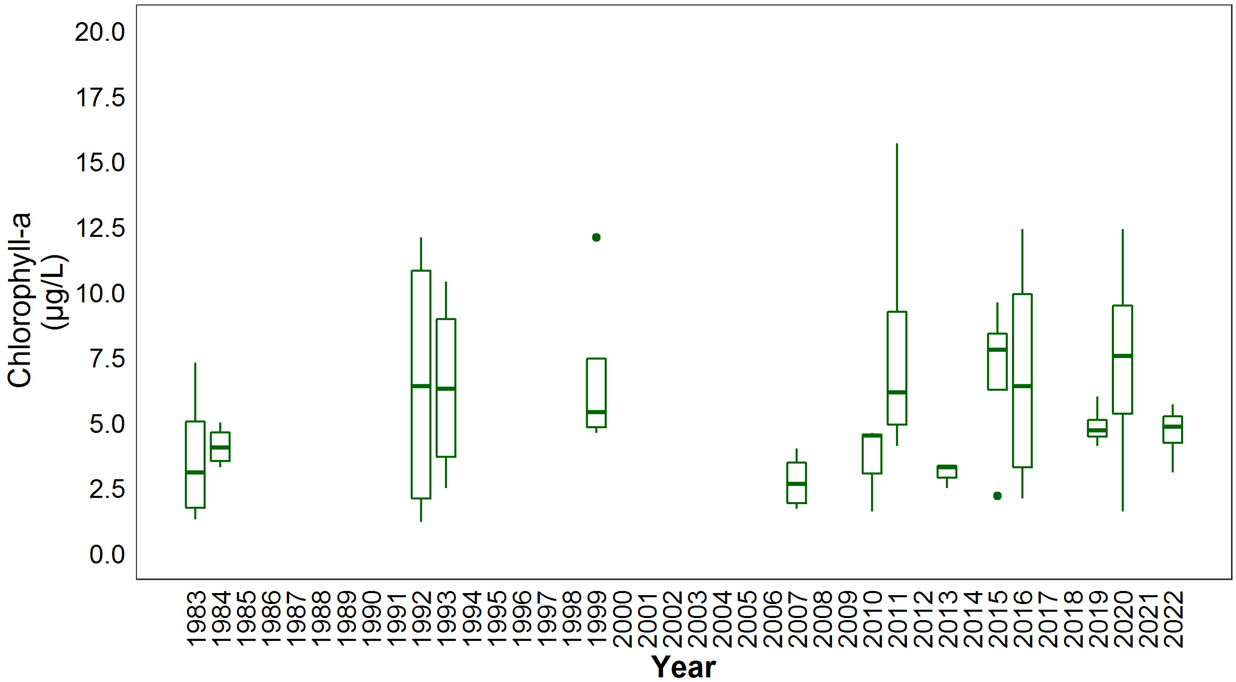


Figure 7. Monthly total phosphorus (TP) concentrations measured between June and September over the long term sampling dates between 1983 and 2022 (n = 55). The value closest to the 15th day of the month was chosen to represent the monthly value in cases with multiple monthly samples.

Chlorophyll-*a*

Chlorophyll-*a* has not significantly changed over time at Chestermere Lake (Tau = -0.12, p = 0.27).



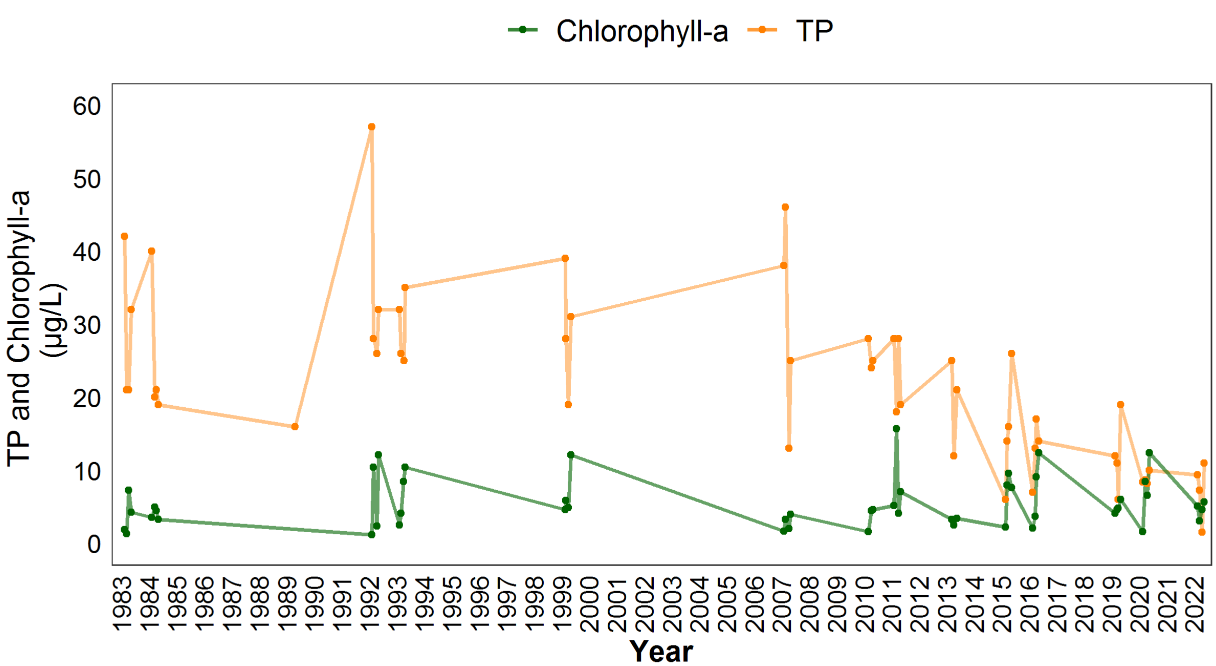


Figure 8. Monthly chlorophyll-*a* concentrations measured between June and September over the long term sampling dates between 1983 and 2022 (n = 54). The value closest to the 15th day of the month was chosen to represent the monthly value in cases with multiple monthly samples. Line graph is overlain by TP concentrations.

Total Dissolved Solids (TDS)

Trend analysis showed a significant increasing trend in TDS between 1983 and 2022 (Tau = 0.49, *p* = <0.001) in Chestermere Lake (Figure 9).

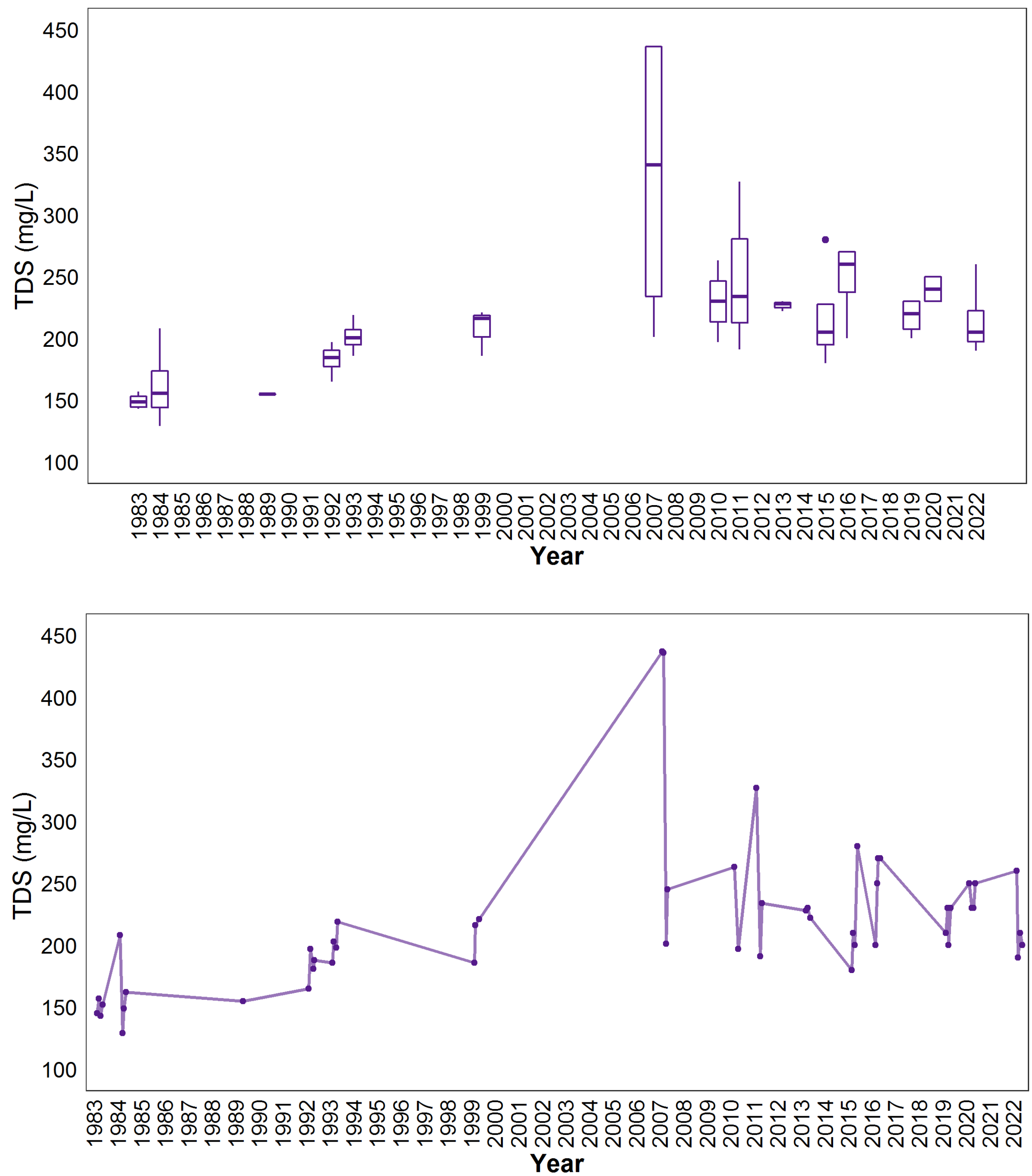


Figure 9. Monthly TDS values measured between June and September over the long term sampling dates between 1983 and 2022 (n = 52). The value closest to the 15th day of the month was chosen to represent the monthly value in cases with multiple monthly samples.

Due to the significant increasing trend of TDS in Chestermere Lake, exploring the specific major ions which may be driving this trend is important to determine. Trend analysis of major ions at Chestermere Lake indicates that alkalinity (bicarbonate, carbonate), sulphate, chloride, and sodium are the top parameters that drove the historical increase in TDS (Figure 10). However, all parameters analyzed for trends displayed significant, increasing trends over time.

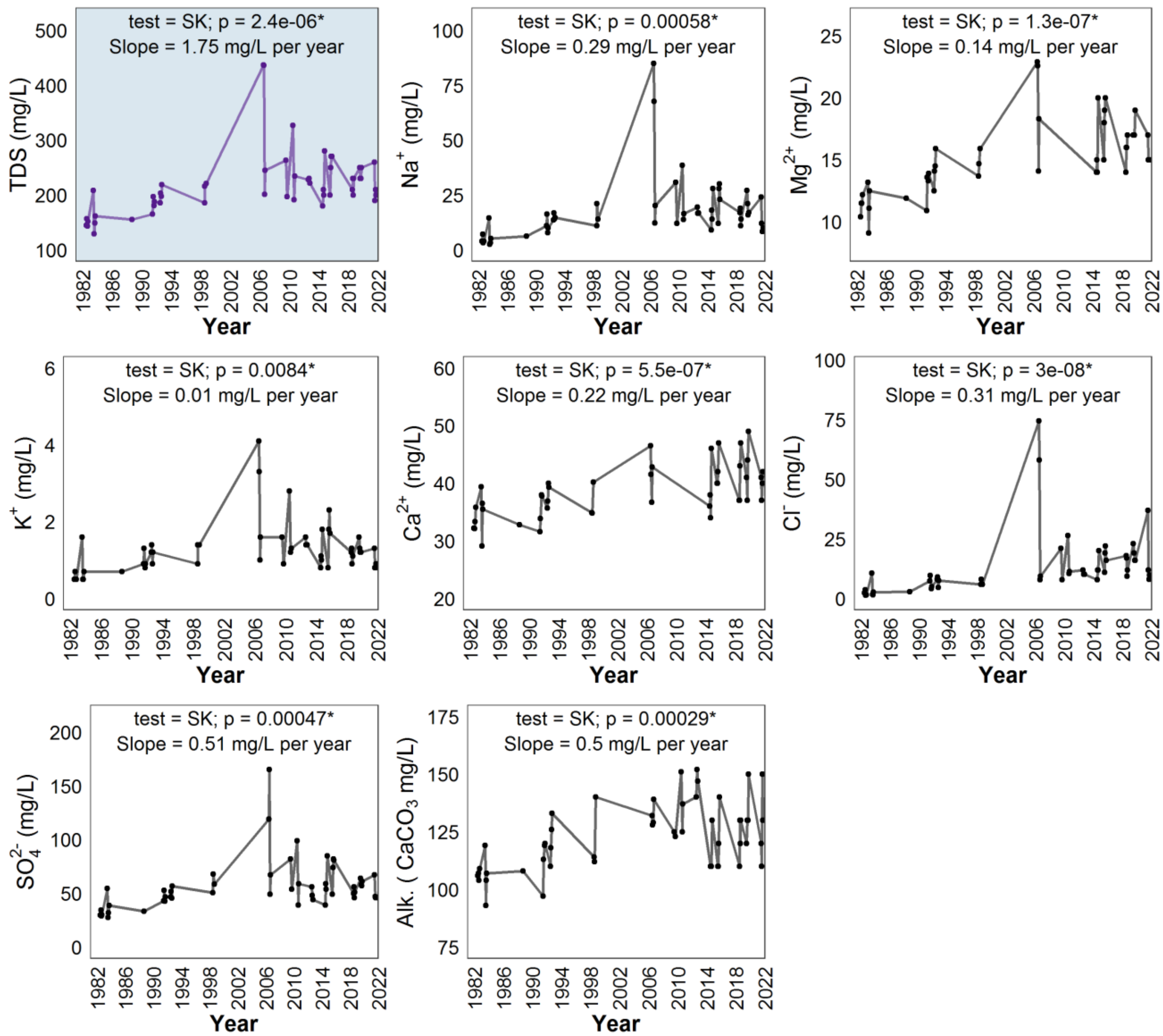
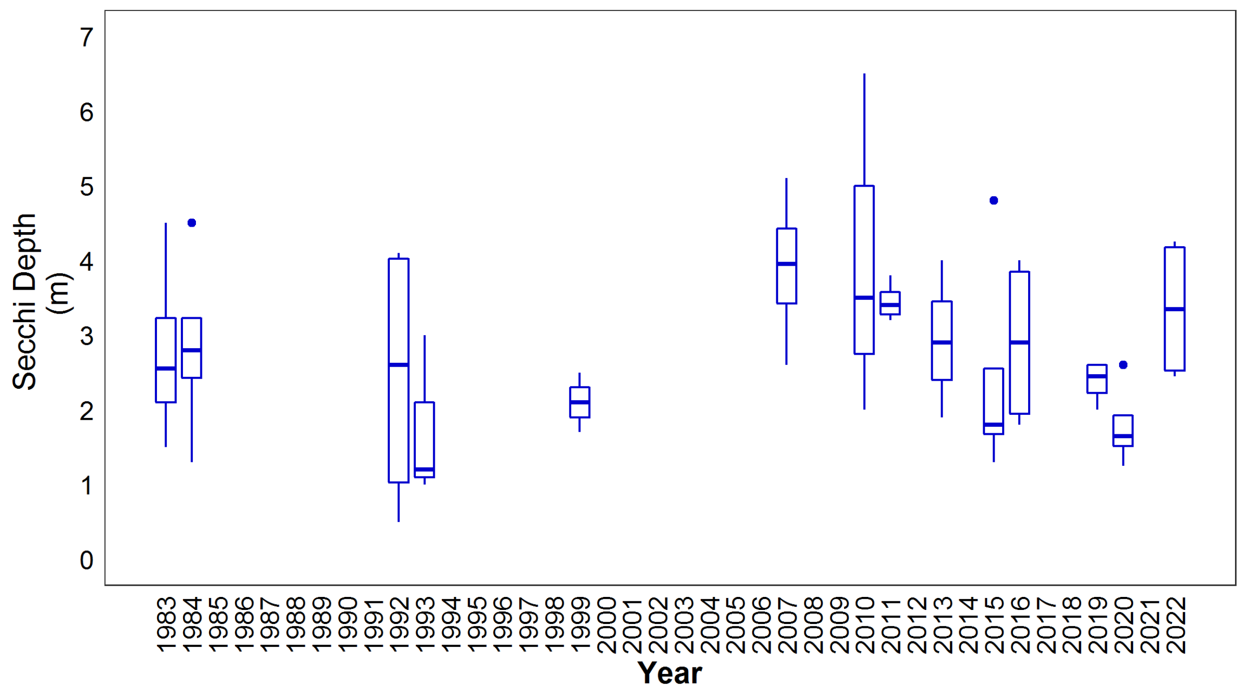


Figure 10. Concentrations of TDS (top left, blue panel), major ions (sodium = Na^+, magnesium = Mg^{2+}, potassium = K^+, calcium = Ca^{2+}, chloride = Cl^-, sulphate = SO_4^{2-}), and total alkalinity (Alk., as mg/L $CaCO_3$) measured monthly between June and September on sampling dates between 1983 and 2021. 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

Secchi depth has not significantly changed in Chestermere Lake since 1983 (Tau = -0.039, p = <0.623).



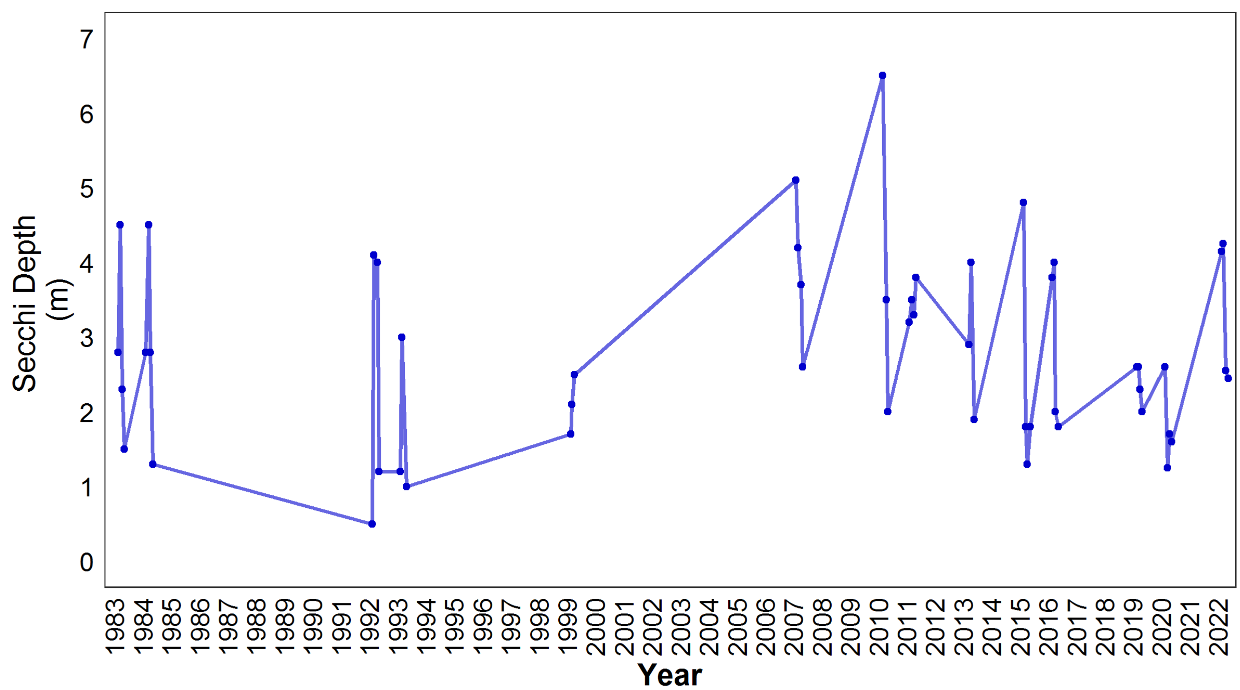


Figure 11. Monthly Secchi depth values measured between June and September over the long term sampling dates between 1983 and 2022 (n = 52). The value closest to the 15th day of the month was chosen to represent the monthly value in cases with multiple monthly samples.

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 1983-2022 on Chestermere 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	-0.56	0.12	0.49	-0.04
The extent of the trend	Slope (units per Year)	-0.63	0.03	1.75	-0.01
The statistic used to find significance of the trend	Z	-5.51	1.09	4.72	-0.49
Number of samples included	n	55	54	52	52
The significance of the trend	*p*	3.53×10^{-8}*	0.27	2.39×10^{-6}*	0.63

*$p < 0.05$ is significant within 95%