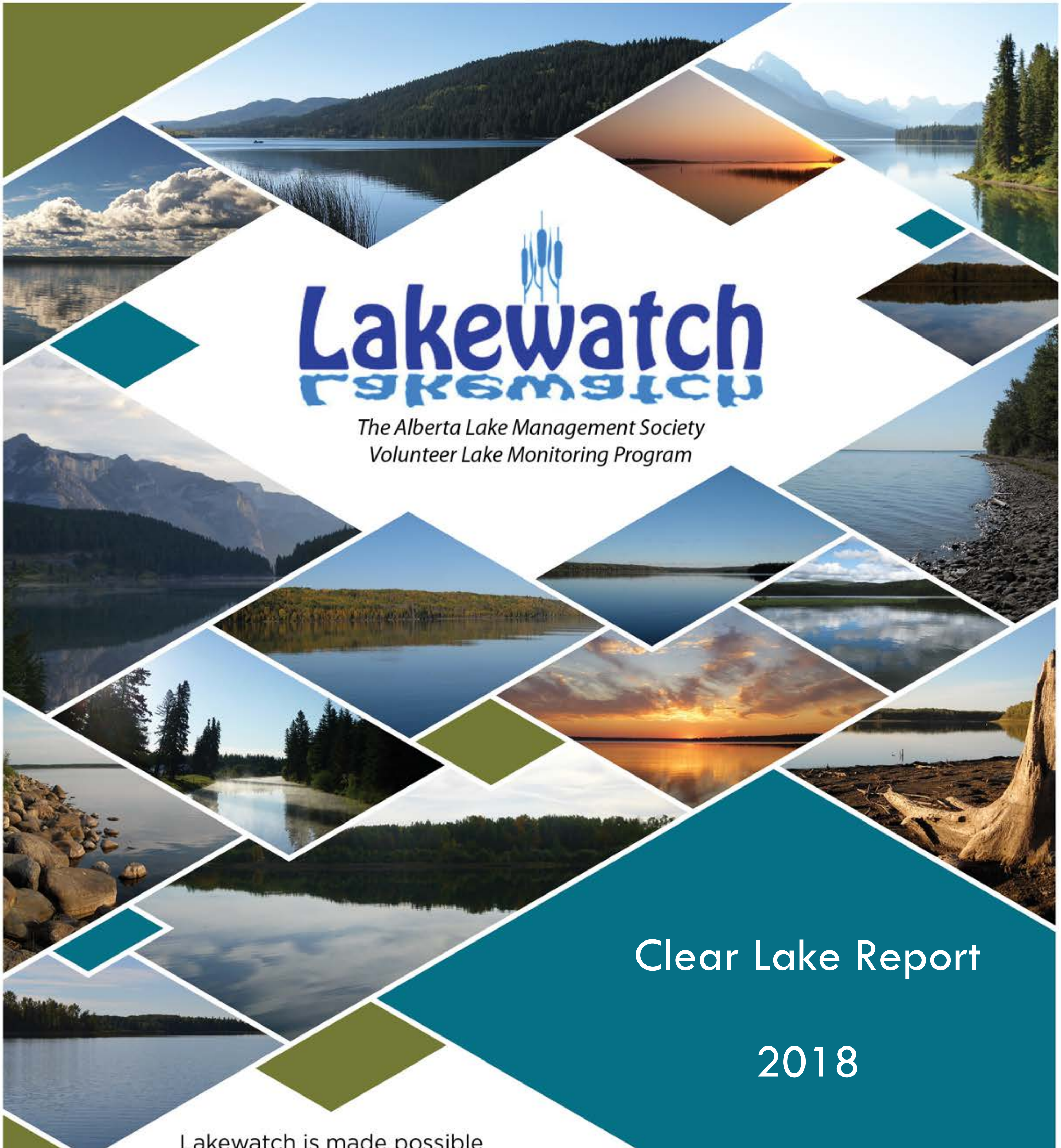

Lakewatch

The Alberta Lake Management Society
Volunteer Lake Monitoring Program

Clear Lake Report

2018

Lakewatch is made possible with support from:

Alberta
Pigeon Lake Watershed Association
Jackfish Lake
MD 61 Wainwright
LICA Environmental Stewards
Red Deer River Watershed Alliance
Cargill

ALBERTA LAKE MANAGEMENT SOCIETY'S LAKEWATCH PROGRAM

LakeWatch has several important objectives, one of which is to collect and interpret water quality data on Alberta Lakes. Equally important is educating lake users about their aquatic environment, 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 a lay 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 Doug Jackson for his commitment to collecting data at Clear Lake. We would also like to thank Alanna Robertson, Lindsay Boucher and Shona Derlukewich, who were summer technicians in 2018. Executive Director Bradley Peter and Program Coordinator Laura Redmond were instrumental in planning and organizing the field program. This report was prepared by Caitlin Mader and Bradley Peter.

CLEAR LAKE

Known as "Barne's Lake" until 1993, Clear Lake is located in the North Saskatchewan River drainage basin in east-central Alberta, near the Battle River valley. The lake sits at an elevation of 663 m above sea level and has a length of approximately 1.2 km and a width of 0.9 km. The maximum depth of this lake is ~18 m.

Figure 1 – Technician Elynne Murray and volunteer Mary Smith monitoring Clear Lake in 2013.

Clear Lake is located in the M.D. of Wainwright which has a population of ~4400. The M.D.'s main industries are agriculture, oil and natural gas production, and the Canadian Forces Base Wainwright. Clear Lake and its larger neighbour Arm Lake are a popular recreation area in the region. Clear Lake has roughly 135 cottages, of which 10 are permanent homes, a public beach, and a picnic area. Popular activities on the lake include swimming, boating, sailing, water skiing, and fishing.

METHODS

Profiles: Profile data is measured at the deepest spot in the main basin of the lake. At the profile site, temperature, dissolved oxygen, pH, conductivity and redox potential are measured at 0.5- 1.0 m intervals. Additionally, Secchi depth is measured at the profile site and used to calculate the euphotic zone. On one visit per season, metals are collected at the profile site by hand grab from the surface and at some lakes, 1 m off bottom using a Kemmerer.

Composite samples: At 10-sites across the lake, water is collected from the euphotic zone and combined across sites into one composite sample. This water is collected for analysis of water chemistry, chlorophyll-a, nutrients and microcystin. Quality control (QC) data for total phosphorus was taken as a duplicate true split on one sampling date. ALMS uses the following accredited labs for analysis: Routine water chemistry and nutrients are analyzed by Maxxam Analytics, chlorophyll-*a* and metals are analyzed by Innotech Alberta, and microcystin is analyzed by the Alberta Centre for Toxicology (ACTF). In lakes where mercury samples are taken, they are analyzed by the Biogeochemical Analytical Service Laboratory (BASL).

Invasive Species: Monitoring for invasive quagga and zebra mussels involved two components: monitoring for juvenile mussel veligers using a 63 µm plankton net at three sample sites and monitoring for attached adult mussels using substrates installed at each lake.

Data Storage and Analysis: Data is stored in the Water Data System (WDS), a module of the Environmental Management System (EMS) run by Alberta Environment and Parks (AEP). Data goes through a complete validation process by ALMS and AEP. Users should use caution when comparing historical data, as sampling and laboratory techniques have changed over time (e.g. detection limits). For more information on data storage, see AEP Surface Water Quality Data Reports at aep.alberta.ca/water.

Data analysis is done using the program R.[1] Data is reconfigured using packages tidyr [2] and dplyr [3] and figures are produced using the package ggplot2 [4]. Trophic status for each lake is classified based on lake water characteristics using values from Nurnberg (1996)[5]. The Canadian Council for Ministers of the Environment (CCME) guidelines for the Protection of Aquatic Life are used to compare heavy metals and dissolved oxygen measurements. Pearson's Correlation tests are used to examine relationships between TP, chlorophyll-*a,* TKN and Secchi depth, providing a correlation coefficient (r) to show the strength (0-1) and a p-value to assess significance of the relationship.

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[1] R Core Team (2016). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

[2] Wickman, H. and Henry, L. (2017). tidyr: Easily Tidy Data with 'spread ( )' and 'gather ( )' Functions. R package version 0.7.2. https://CRAN.R-project.org/package=tidyr.

[3] Wickman, H., Francois, R., Henry, L. and Muller, K. (2017). dplyr: A Grammar of Data Manipulation. R package version 0.7.4. http://CRAN.R-project.org/package=dplyr.

[4] Wickham, H. (2009). ggplot2: Elegant Graphics for Data Analysis. Springer-Verlag New York.

[5]Nurnberg, G.K. (1996). Trophic state of clear and colored, soft- and hardwater lakes with special consideration of nutrients, anoxia, phytoplankton and fish. Lake and Reservoir Management 12: 432-447.

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 Clear Lake was 12 µg/L (Table 2), falling just above threshold for mesotrophic, or moderately productive trophic classification. This value falls below the range of historical averages. Detected TP was lowest when sampled on July 4 at 10 µg/L, and generally rose throughout the season until the final sampling at 15 µg/L in late August (Figure 1).

Average chlorophyll-*a* concentrations in 2018 was 4.0 µg/L (Table 2), falling into the mesotrophic, or moderately productive trophic classification. Chlorophyll-*a* remained fairly constant throughout the season, reaching its maximum of 5.2 µg/L in late August.

Finally, the average TKN concentration was 0.89 mg/L (Table 2) with concentrations peaking on August 25 at 0.92 mg/L.

Average pH was measured as 8.65 in 2018, buffered by moderate alkalinity (258 mg/L $CaCO_3$) and bicarbonate (288 mg/L HCO_3). Magnesium was the dominant ion contributing to a low conductivity of 472 µS/cm (Table 2).

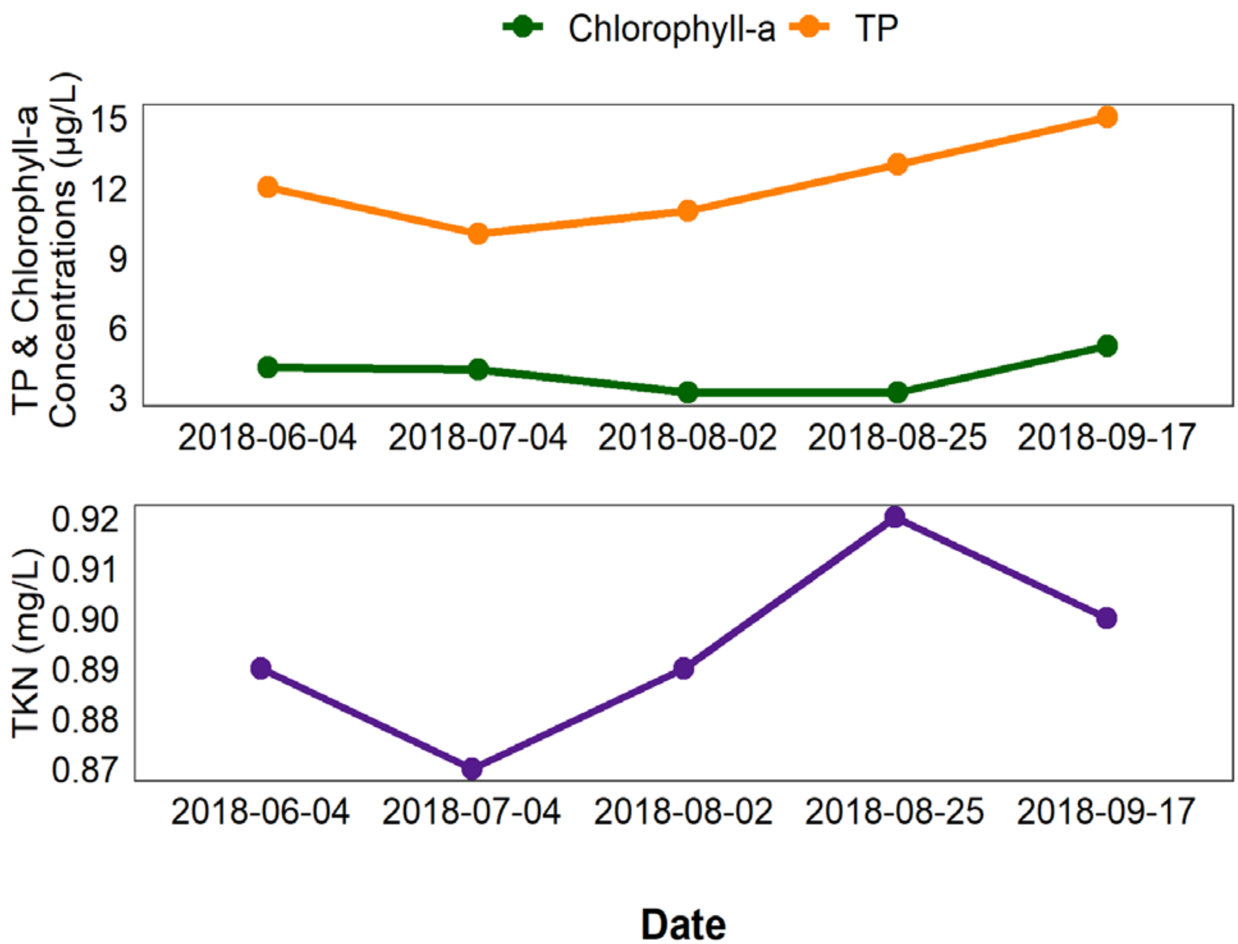

Figure 1- Total Phosphorus (TP), Total Kjeldahl Nitrogen (TKN), and Chlorophyll-*a* concentrations measured five times over the course of the summer at Clear Lake.

METALS

Samples were analyzed for metals once throughout the summer (Table 3). In total, 27 metals were sampled for. It should be noted that many metals are naturally present in aquatic environments due to the weathering of rocks and may only become toxic at higher levels.

Metals were not measured at Clear Lake in 2018. Table 3 presents historical concentrations of metals from previously sampled years.

WATER CLARITY AND SECCHI 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 Secchi depth of Clear Lake in 2018 was 3.40 m (Table 2). Secchi depth increased slightly over the sampling season, but overall water clarity is fairly steady throughout the season (Figure 2).

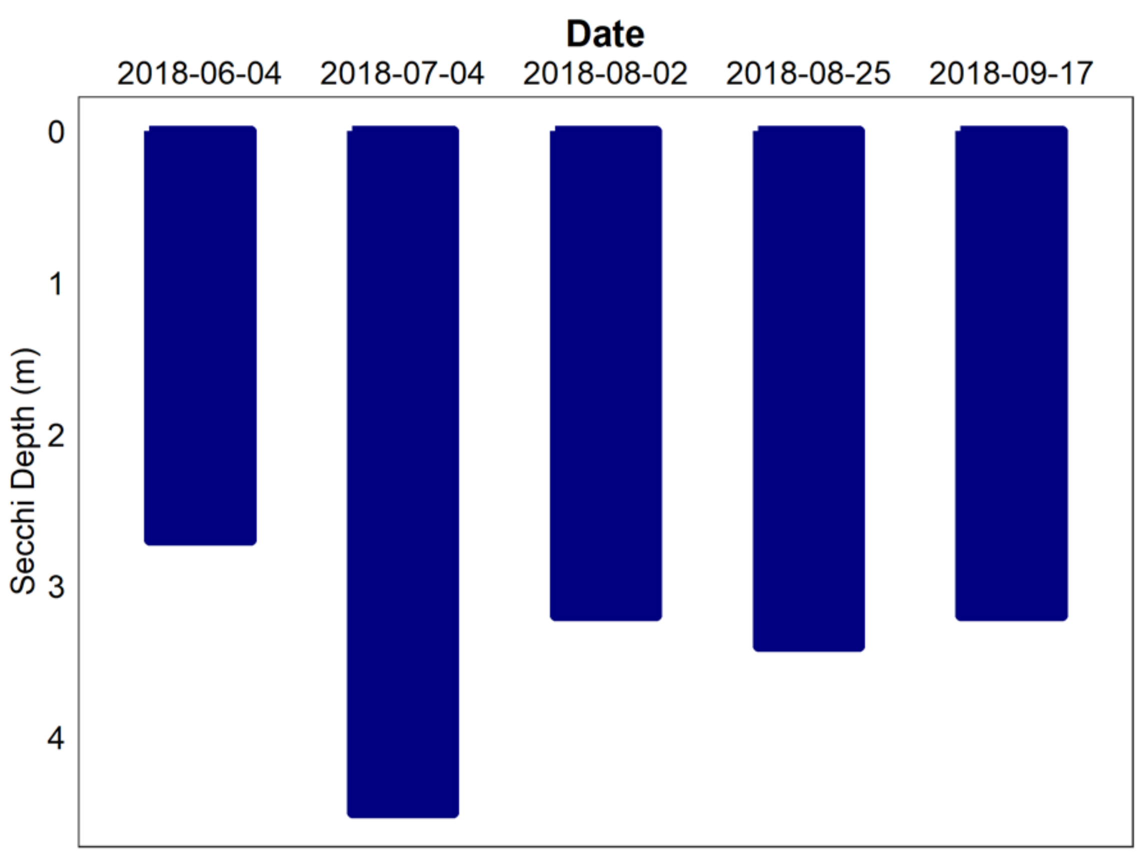

Figure 2 – Secchi depth values measured five times over the course of the summer at Clear Lake in 2018.

WATER TEMPERATURE AND DISSOLVED OXYGEN

Water temperature and dissolved oxygen 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.

Temperatures of Clear Lake varied throughout the summer, with a minimum temperature of 3.8°C at 14.5 m on June 4, and a maximum temperature of 21.1°C measured at the surface on August 5 (Figure 3a). The lake was strongly stratified during all of the sampling trips, with a steep drop in temperature and dissolved oxygen between 5 and 13 meters deep. This indicates that the top and bottom of the water column mix little throughout the open water season.

Clear Lake remained well oxygenated through the upper layer of the water column throughout the summer, measuring above the CCME guidelines of 6.5 mg/L for the Protection of Aquatic Life (Figure 3b). The oxygen level dropped significantly below the thermocline due to a lack of mixing with the warmer water on the surface. This is typical for a stratified lake such as Clear Lake.

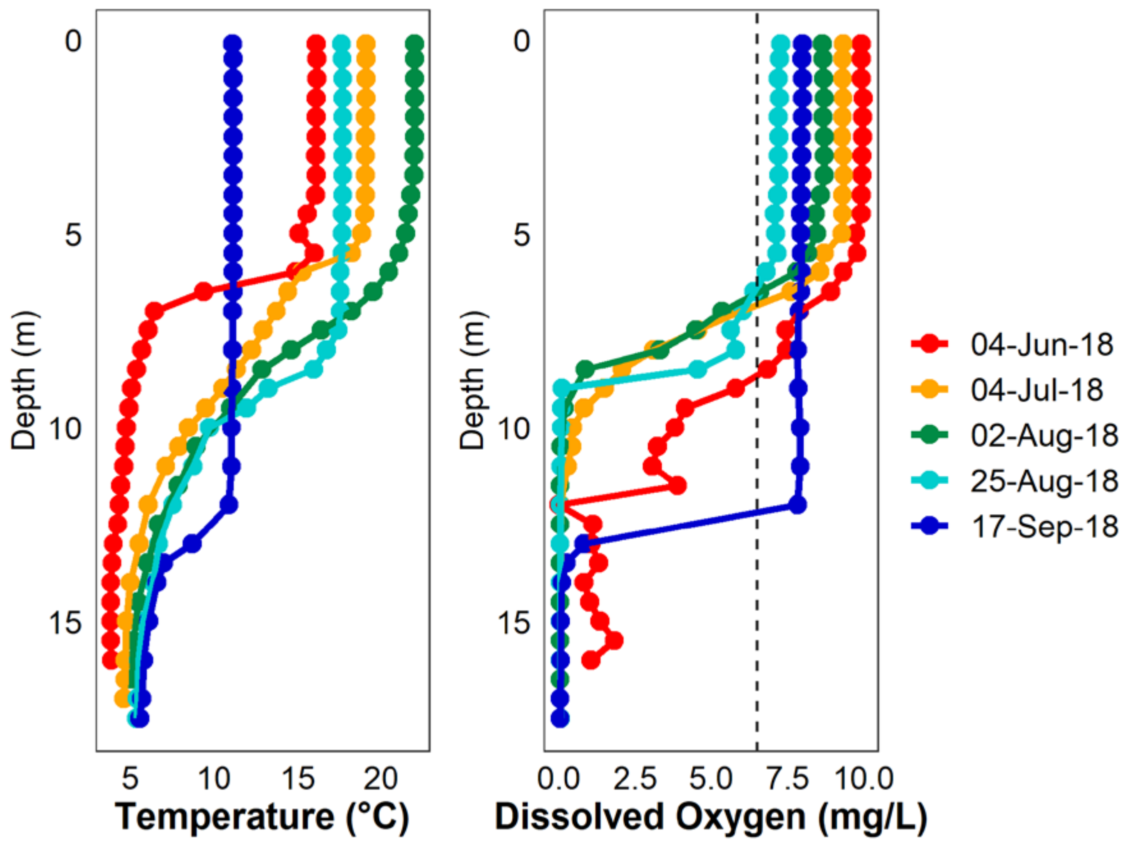

Figure 3 – a) Temperature (°C) and b) dissolved oxygen (mg/L) profiles for Clear Lake measured five times over the course of the summer of 2018.

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 the one of the most common cyanobacteria toxins. In Alberta, recreational guidelines for microcystin are set at 20 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 Clear Lake fell below the recreational guideline of 20 μg/L in 2018. Individual sample sites may have higher concentrations of microcystin, therefore recreation in cyanobacteria blooms should be avoided.

Table 1 – Microcystin concentrations measured four times at Clear Lake in 2018.

Date	Microcystin Concentration (μg/L)
04-Jun-18	<0.10
04-Jul-18	<0.10
02-Aug-18	<0.10
25-Aug-18	0.11
17-Sep-18	<0.10
Average	0.06

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 have been linked to creating toxic algae blooms, decreasing the amount of nutrients needed for fish and other native species, and causing millions of dollars in annual costs for repair and maintenance of water-operated infrastructure and facilities.

Monitoring involved two components: monitoring for juvenile mussels (veligers) using a plankton net and monitoring for attached adult mussels using substrates installed in each lake. No mussels have been detected in Clear Lake.

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.

There is no water level data for Clear lake.

Table 2: Average historical Secchi depth and water chemistry values for Clear Lake.

Parameter	2006	2007	2008	2013	2018
TP (μg/L)	24	22	27	24	12
TDP (μg/L)	9.4	10	13.8	9.7	5.9
Chlorophyll-*a* (μg/L)	5.4	1.8	2.6	3.4	4.0
Secchi depth (m)	3.2	5.5	5.7	3.1	3.40
TKN (mg/L)	0.94	0.87	0.88	0.88	0.89
NO_2 and NO_3 (μg/L)	2.5	8	2.5	3.8	4.2
NH_3 (μg/L)	29	37.3	36.8	13.8	21
DOC (mg/L)	9.8	10.9	9.6	13.1	10.5
Ca (mg/L)	18	19.6	20.5	21.4	20.6
Mg (mg/L)	43	43.5	43.7	47.9	43.4
Na (mg/L)	21	21.1	21	20.8	21
K (mg/L)	6.2	6.5	6.1	5.97	6.32
SO_4^{2-} (mg/L)	10.7	/	7.7	8	10.1
Cl^- (mg/L)	1.7	1.9	2	2.27	2.54
CO_3 (mg/L)	18	26.5	18	21.2	13.2
HCO_3 (mg/L)	292	300	294	283	288
pH	8.7	8.7	8.7	8.76	8.65
Conductivity (μS/cm)	479	470	479	493	472
Hardness (mg/L)	240	273	284	251	232
TDS (mg/L)	261	259	264	268	262
Microcystin (μg/L)	/	5.06	0.15	0.05	0.10

Table 3: Concentrations of metals were last measured in Clear Lake in 2013. The CCME heavy metal Guidelines for the Protection of Freshwater Aquatic Life (unless otherwise indicated) are presented for reference.

Metals (Total Recoverable)	2013	Guidelines
Aluminum µg/L	14.17	100[a]
Antimony µg/L	0.065	6[e]
Arsenic µg/L	3.97	5
Barium µg/L	47.3	1000[e]
Beryllium µg/L	0.0015	100[d,f]
Bismuth µg/L	0.0063	/
Boron µg/L	97.5	5000[ef]
Cadmium µg/L	0.0046	0.085[b]
Chromium µg/L	0.20	/
Cobalt µg/L	0.027	1000[f]
Copper µg/L	2.69	4[c]
Iron µg/L	15.55	300
Lead µg/L	0.061	7[c]
Lithium µg/L	55.75	2500[g]
Manganese µg/L	5.62	200[g]
Molybdenum µg/L	1.56	73[d]
Nickel µg/L	0.23	150[c]
Selenium µg/L	0.086	1
Silver µg/L	0.017	0.1
Strontium µg/L	99.95	/
Thallium µg/L	0.0003	0.8
Thorium µg/L	0.008	/
Tin µg/L	0.03	/
Titanium µg/L	0.65	/
Uranium µg/L	1.48	100[e]
Vanadium µg/L	0.51	100[f,g]
Zinc µg/L	0.43	30

Values represent means of total recoverable metal concentrations.
[a] Based on pH ≥ 6.5; calcium ion concentrations [Ca^{+2}] ≥ 4 mg/L; and dissolved organic carbon concentration [DOC] ≥ 2 mg/L.
[b] Based on water Hardness of 300 mg/L (as $CaCO_3$)
[c] Based on water hardness > 180mg/L (as $CaCO_3$)
[d] CCME interim value.
[e] Based on Canadian Drinking Water Quality guideline values.
[f] Based on CCME Guidelines for Agricultural use (Livestock Watering).
[g] Based on CCME Guidelines for Agricultural Use (Irrigation).
A forward slash (/) indicates an absence of data or guidelines.