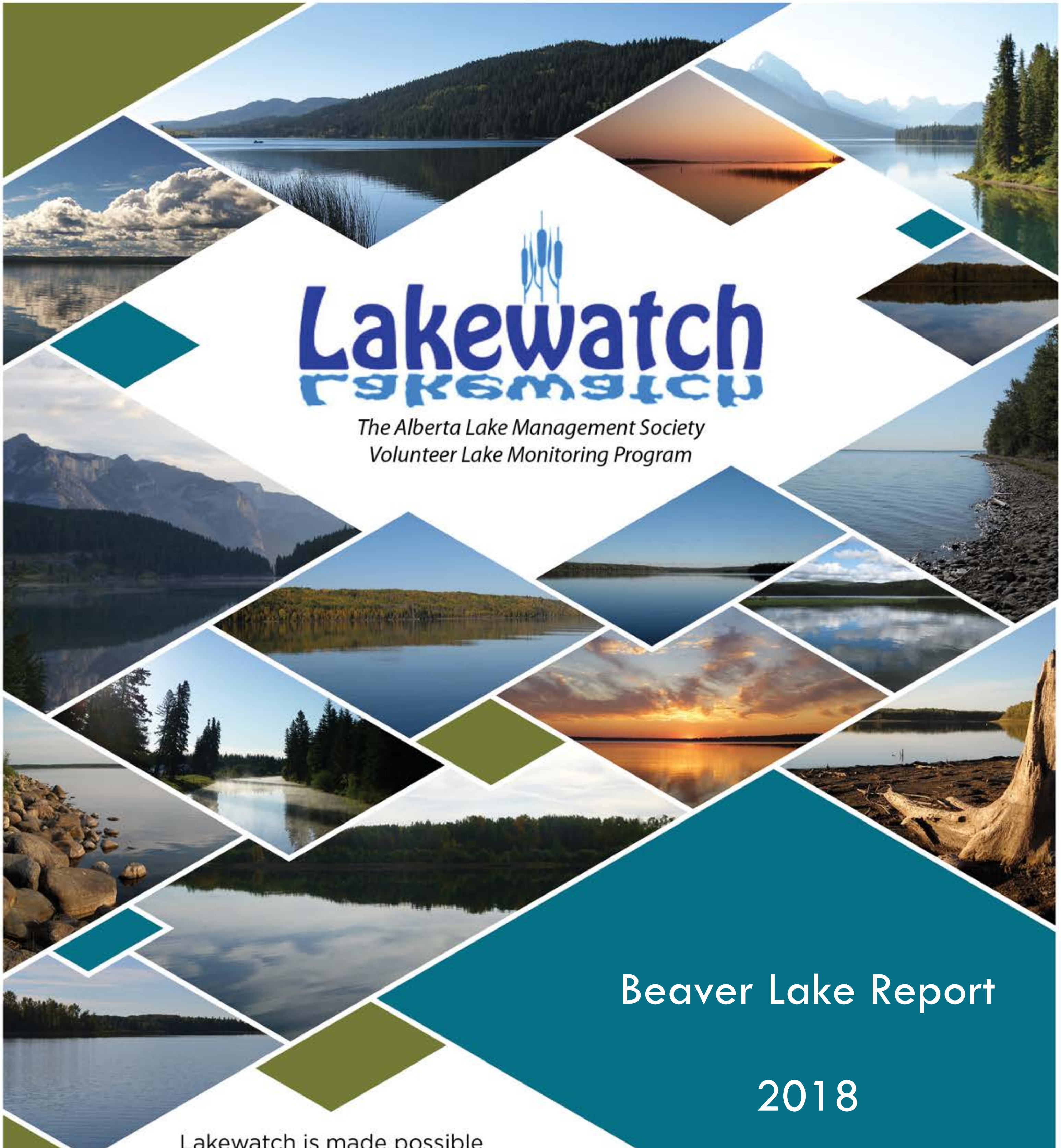

Lakewatch

The Alberta Lake Management Society
Volunteer Lake Monitoring Program

Beaver Lake Report

2018

Lakewatch is made possible
with support from:

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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.

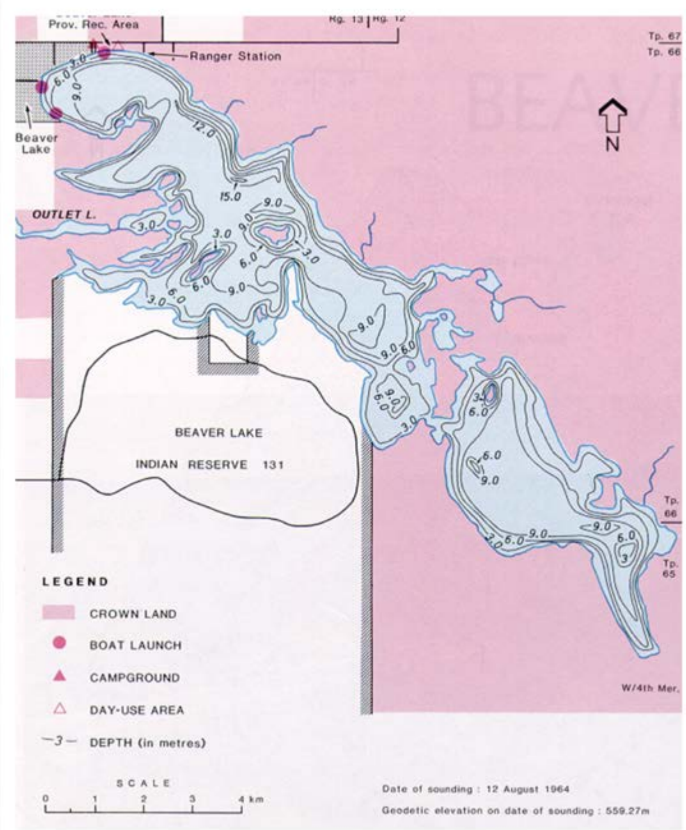
ACKNOWLEDGEMENTS

The LakeWatch program is made possible through the dedication of its volunteers. A special thanks to Evan Tichonuk for his efforts in collecting data from Beaver Lake in 2018. 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.

BEAVER LAKE

Beaver Lake is a large lake located near the Town of Lac La Biche (east on secondary highway 663 from highway 36). Beaver Lake lies within the Lakeland region, which is rich in history including various missions, hunting, trapping, and both European and Native settlements. In 1919, a settler named Max Huppie purchased a large tract of land on the northwest corner of Beaver Lake, an area that, today, supports a provincial campground, a forest firefighter base camp and one large residential sub-division.

Beaver Lake is popular for fishing. Nine species of fish have been reported in Beaver Lake including: northern pike (*Esox lucius*), walleye (*Sander vitreus*), yellow perch (*Perca flavescens*), lake whitefish (*Coregonus clupeaformis*), burbot (*Lota lota*), white sucker (*Catostomus commersoni*), brook stickleback (*Culaea inconstans*), Iowa darter (*Etheostoma exile*), and spottail shiner (*Notopis hudsonius*).



Depth contours (3m intervals) and shoreline features of Beaver Lake (Mitchell and Prepas 1990).

Beaver Lake is a large body of water with a surface area of 33 km^2. It consists of two large basins linked by a shallow, narrow channel, with a northwest to southeast orientation. Depth is generally 6 to 9 m in both basins, with a narrow trough reaching 15 m in depth on the northeast side of the north basin. Access to the south basin is limited to boats with very shallow draft or times of higher water. Beaver Lake contains several islands, the number of which varies with the water level. Both basins slope quite steeply to their greatest depth; the bottom of each basin is quite flat, except in the vicinity of the islands.

The area of Beaver Lake's watershed is 9 times larger than that of the lake itself. The terrain surrounding Beaver Lake is gently rolling and heavily forested. Trembling aspen (*Populus tremuloides*) is dominant in areas with well-drained soils while trembling aspen and balsam poplar (*Populus balsamifera*) co-dominate in less well-drained areas. Jack pine (*Pinus banksiana*) grows on well-drained ridges near wetlands and black spruce (*Picea mariana*) and tamarac (*Larix laricina*) grow on poorly drained organic soils. Soil in the drainage basin is most commonly Orthic Gray Luvisol of a clay or loamy type.

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 Alberta Innotech, 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 Beaver Lake was 31.75 µg/L (Table 2), falling just above threshold for eutrophic, or highly productive trophic classification. This value falls within the range of historical averages. Detected TP was lowest when first sampled in June at 15 µg/L, and rose throughout the season until the final sampling at 57 µg/L in late August (Figure 1).

Average chlorophyll-*a* concentrations in 2018 was 16.025 µg/L (Table 2), falling into the oligotrophic, or low productivity trophic classification. Like TP, Chlorophyll-*a* rose throughout the season, from a minimum of 5 µg/L in June to a maximum of 30 µg/L in late August.

Finally, the average TKN concentration was 1.47 mg/L (Table 2) with concentrations increasing over the course of the sampling season.

Average pH was measured as 8.59 in 2018, buffered by moderate alkalinity (220 mg/L $CaCO_3$) and bicarbonate (248 mg/L HCO_3). Calcium was the dominant ion contributing to a medium conductivity of 563 µS/cm (Table 2).

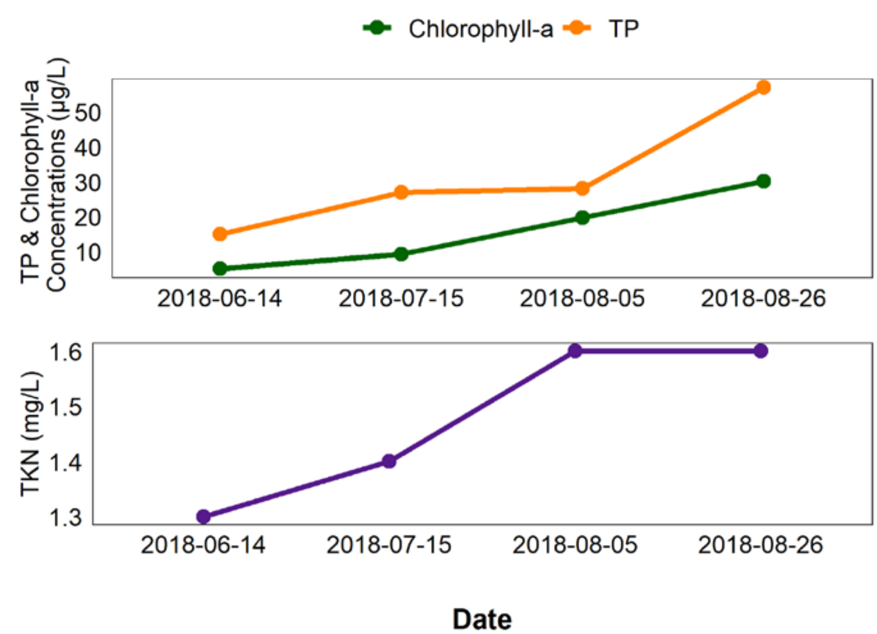

Figure 1- Total Phosphorus (TP), Total Kjeldahl Nitrogen (TKN), and Chlorophyll-*a* concentrations measured five times over the course of the summer at Beaver Lake.

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 measured once on August 5 at Beaver Lake at the surface and all measured values fell within their respective guidelines (Table 3).

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 Beaver Lake in 2018 was 2.15 m (Table 2). Secchi depth decreased by over 50% over the sampling season. This steady decrease in water clarity may have been due to steadily increasing algae concentrations over the season, as indicated by increasing chlorophyll-a levels (Figure 1).

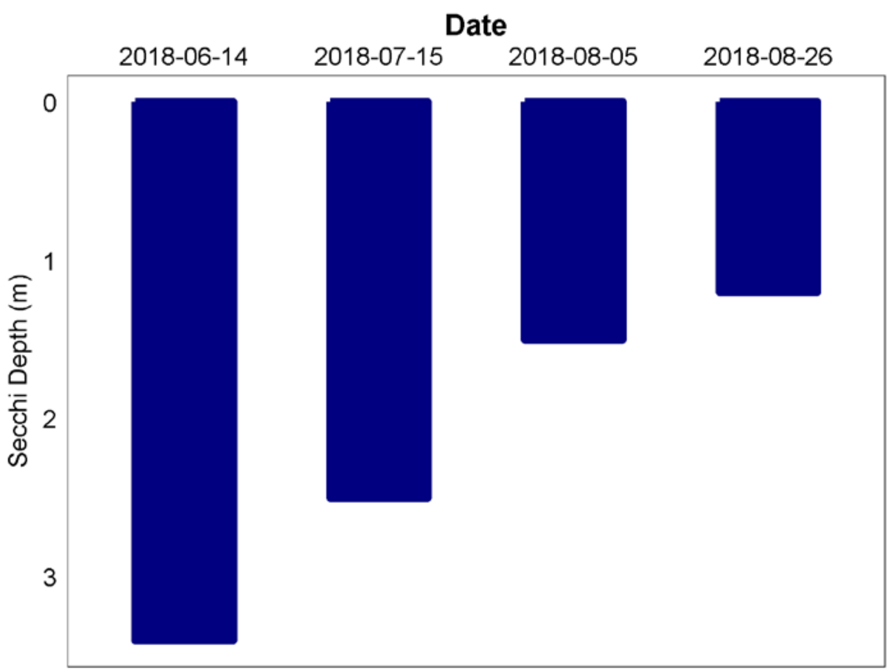

Figure 2 – Secchi depth values measured five times over the course of the summer at Beaver Lake in 2018.

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 Beaver Lake varied throughout the summer, with a minimum temperature of 14.7°C at 8.5m on June 14, and a maximum temperature of 21.1°C measured at the surface on August 5 (Figure 3a). The lake was not stratified during any of the sampling trips, with temperatures fairly constant from top to bottom, which indicates complete mixing throughout the season.

Beaver Lake remained well oxygenated through most 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 fell below this guideline in the bottom 2.5 meters on August 5.

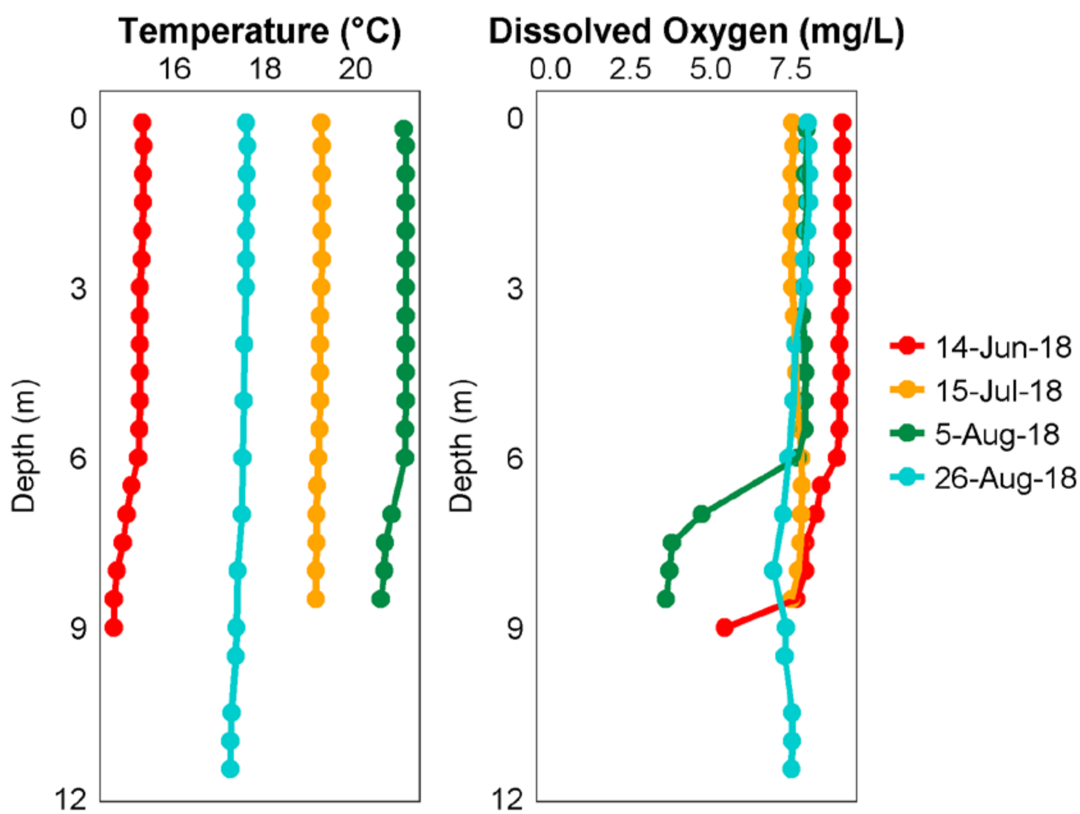

Figure 3 – a) Temperature (°C) and b) dissolved oxygen (mg/L) profiles for Beaver Lake measured four times over the course of the summer of 2018.

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 Beaver Lake fell below the recreational guideline of 20µg/L for at the locations and times sampled in Beaver Lake in 2018.

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

Date	**Microcystin Concentration (µg/L)**
14-Jun-2018	<0.10
15-Jul-2018	0.16
5-Aug-2018	0.43
26-Aug-2018	1.14
Average	0.46

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 Beaver 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.

Water levels in Beaver Lake were monitored by Environment Canada between 1972 and 2016 under the joint Federal-Provincial Hydrometric agreement. Water levels were quite stable during the 1970s and reached a maximum of 559.4 m in August 1975 (Figure 4). Since then, water levels have declined steadily, except for an increase in 1997, one of the wettest years on record. The lowest water level occurred in October 2016 when it dropped to 556.1 m. Compared to 30 years ago, the surface area of Beaver Lake has been reduced by approximately 4 km^2.

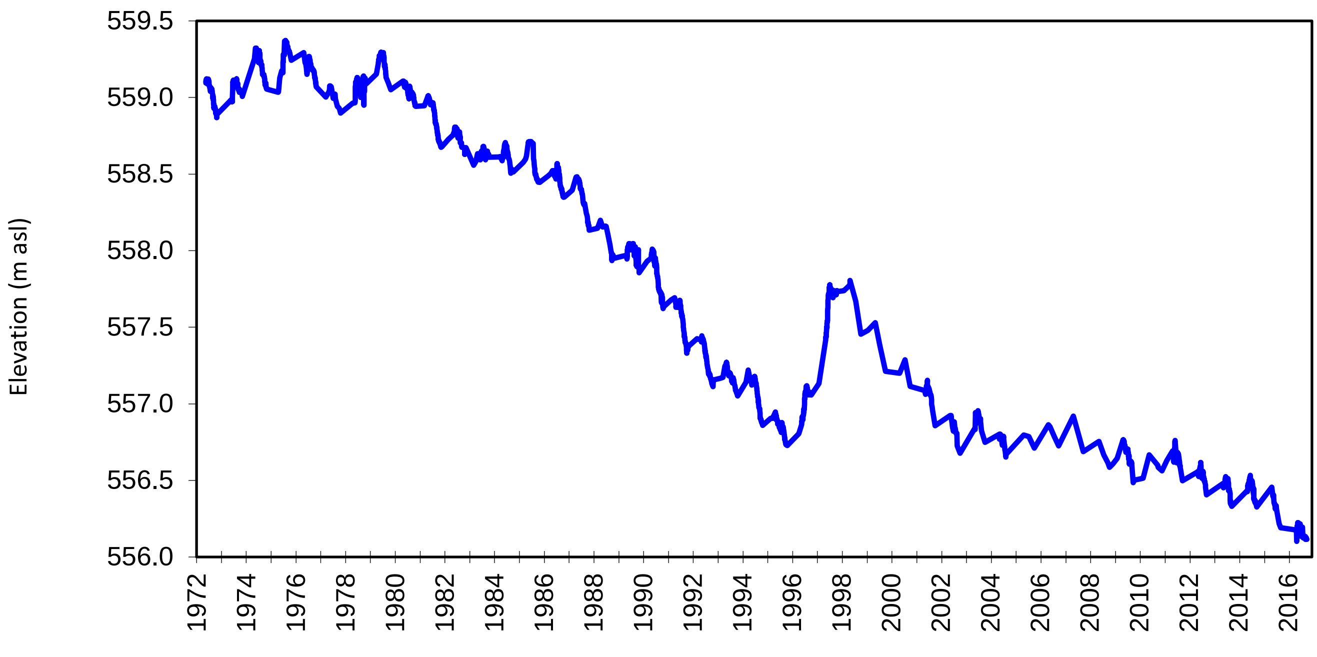

Figure 4: Water levels in Beaver Lake in meters above sea level (m asl), from 1972 to 2016. Data retrieved from Alberta Environment and Parks.

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

Parameter	1986	2003	2004	2008	2010	2018
TP (µg/L)	33	47	56	36.6	50.8	31.75
TDP (µg/L)	12	17	13	14.4	21.6	6.875
Chlorophyll-*a* (µg/L)	11	18	24	6.09	9.316	16.03
Secchi disk depth (m)	2.9	2.4	1.8	5.6	3.2	2.15
TKN (µg/L)	1137	1358	1510	1292	1510	1475
$NO_{2,3}$ (µg/L)	5.6	17	13	32	6	5.125
NH_4 (µg/L)	3	2.8	3.1	31.8	44.4	24.75
Dissolved organic C (mg/L)	-	-	-	17.3	18.1	18.5
Ca (mg/L)	35	31	32	32.5	27	34
Mg (mg/L)	23	31	30	32.3	34.97	39.25
Na (mg/L)	13	13	21	22.5	24.23	26.25
K (mg/L)	10	10	14	13.4	14.77	17
SO_4^{2-} (mg/L)	29	42	62	65.7	72	84
Cl^- (mg/L)	0.5	1.6	2.3	2.77	3.07	4.58
TDS (mg/L)	-	-	-	294.3	298	345
pH	8.5	8.7	8.5	8.4	8.54	8.59
Conductivity (µS/cm)	409	492	499	1171	518	562.5
Hardness (mg/L)	-	-	-	213.7	211	247.5
HCO_3 (mg/L)	222	222	239	242.7	237	247.5
CO_3 (mg/L)	6.3	15	10	6	5.67	10.2
Total Alkalinity (mg/L $CaCO_3$)	191	206	499	208.7	204	220
Microcystin (µg/L)	-	-	-	0.15	0.3	0.3

Table 3: Concentrations of metals measured in Beaver Lake on in each sampling year since 2004. The CCME heavy metal Guidelines for the Protection of Freshwater Aquatic Life (unless otherwise indicated) are presented for reference.

Metals (total)	2004	2008	2010	2018	Guidelines
Aluminum (µg/L)	10.7	10.9	17.2	1.9	100[a]
Antimony (µg/L)	0.068	0.051	0.048	0.06	6[e]
Arsenic (µg/L)	1.47	1.75	1.680	1.75	5
Barium (µg/L)	57.1	58.2	52.8	57	1000[e]
Beryllium (µg/L)	<0.003	<0.003	0.003	0.003	100[d,f]
Bismuth (µg/L)	<0.001	0.003	0.002	0.003	-
Boron (µg/L)	79.6	81.5	74.1	87.3	5000[e,f]
Cadmium (µg/L)	<0.002	0.0029	0.004	0.01	0.085[b]
Chromium (µg/L)	0.14	0.165	0.090	0.1	-
Cobalt (µg/L)	0.019	0.0186	0.021	0.036	1000[f]
Copper (µg/L)	0.42	0.23	0.227	0.11	4[c]
Iron (µg/L)	8	7.4	10.8	4.2	300
Lead (µg/L)	0.0278	0.0221	0.030	0.005	7[c]
Lithium (µg/L)	32.3	31.4	31.800	40.6	2500[g]
Manganese (µg/L)	138	26.9	36.700	46.6	200[g]
Molybdenum (µg/L)	0.169	0.249	0.207	0.157	73[d]
Nickel (µg/L)	<0.005	<0.005	0.013	0.16	150[c]
Selenium (µg/L)	<0.1	0.121	0.090	0.3	1
Silver (µg/L)	<0.0005	0.0022	0.005	0.001	-
Stronium (µg/L)	231	235.5	211.50	256	-
Thallium (µg/L)	0.0007	0.0014	0.002	0.002	0.8
Thorium (µg/L)	0.00071	0.0127	0.008	0.002	-
Tin (µg/L)	0.036	0.0854	0.015	0.06	-
Titanium (µg/L)	1.07	1.4	0.906	0.94	-
Uranium (µg/L)	0.162	0.223	0.199	0.19	100[e]
Vanadium (µg/L)	0.285	0.377	0.300	0.28	100[f,g]
Zinc (µg/L)	4.85	0.693	0.441	0.8	30

Values represent means of total recoverable metal concentrations.

[a] Based on pH ≥ 6.5

[b] Based on water hardness > 180mg/L (as CaCO3)

[c] CCME interim value.

[d] Based on CCME Guidelines for Agricultural use (Livestock Watering).

[e] Based on CCME Guidelines for Agricultural Use (Irrigation).

A forward slash (/) indicates an absence of data or guidelines