Lakewatch

The Alberta Lake Management Society
Volunteer Lake Monitoring Program

Lac Ste. Anne Report
West Basin
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. Special thanks to Bridget Bull and Duane Kootenay for their help in sampling Lac Ste. Anne in 2019. 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.

LAC STE. ANNE

Emergent vegetation at the shoreline of Lac Ste. Anne, 2014.

Lac Ste. Anne is a large lake of cultural significance. It is a special lake for many people because of its long history and spiritual symbolism as well as its recreational attributes. The lake is 80 km west of the city of Edmonton and lies within the county of Lac Ste. Anne. Alexis Nakota Sioux Nation reserve is located on the northern shore of the lake, and Alberta Beach is located on the southeastern shore. The Summer Villages of Ross Haven and Yellowstone, along with the subdivision of Corsair Cove, and the unincorporated hamlet of Gunn, lie along the northern shore. The Summer Villages of Castle Island, Sunset Point, and Val Quentin lie to either side of Alberta Beach. The Summer Village of West Cove lies on the southern shore of the west basin. The lake has a total area of 54.5 km^2, a maximum depth of 9 m, and an average depth of 4.8 m. It is separated into two basins by a narrows spanned by a bridge. Two islands are found in the centre of the western basin, Farming Island and Horse Island, while the small Castle Island and tiny Rock Island lie at the eastern tip of the lake.[1] Lac Ste. Anne is a eutrophic lake.

The recorded history of Lac Ste. Anne goes back to 1843 when Father Jean Baptiste Thibault established a mission on the south shore where Mission Creek enters the lake. Before Father Thibault renamed the lake for Ste. Anne, it was called by the Cree name Manitou Sakhahigan, which means "Lake of the Spirit".[2] Long before Europeans arrived, the Cree and other native people visited the lake because the water was thought to have healing properties. Now, every year, tens of thousands of people journey in July to experience the healing properties and the spiritual awareness of the lake. The site of the pilgrimage was designated a National Historic Site in 2004 as “an important place of spiritual, cultural and social rejuvenation, central aspects of summer gatherings of Aboriginal people.”[3]

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[1] University of Alberta. 2005. Atlas of Alberta Lakes. University of Alberta Press. Available at: http://sunsite.ualberta.ca/Projects/Alberta-Lakes/

[2] Holmgren, E.J. and P.M. Holmgren. 1976. Over 2000 place names of Alberta. 3rd ed. West. Producer Prairie Books, Saskatoon.

[3] Parks Canada. 2005. News Release: Minister Anderson announces new historic designations in Canada. Available at: http://www.pc.gc.ca/APPS/CP-NR/release_e.asp?id=805&andor1=nr Figure 1 –

Lac Ste. Anne has high sport fishing pressure and populations of walleye have collapsed. Currently a Special Fish Harvest License must be obtained to catch walleye.[4] Perch, lake whitefish, and burbot, are also found in the lake. Other popular recreational activities include sightseeing, swimming, power boating, sailing, water skiing and wind surfing in summer, and snowmobiling and cross-country skiing in winter. The watershed has an area of 619 km^2, 11 times greater than the lake, and includes both Isle and Birch Lakes.[1] It is formed along the Sturgeon River through which it drains into the North Saskatchewan River. Land-use in the watershed is dominated by agriculture and cottage development. Remaining forested areas are representative of the dry mixedwood natural sub-region of the boreal forest natural region of Alberta.

METHODS

Profiles: Profile data is measured at the deepest spot in the West 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). This report examines data collected only from the West Basin of Lac Ste. Anne.

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 Lac Ste. Anne's West Basin was 176 µg/L (Table 2), falling into the hypereutrophic, or very highly productive trophic classification. This value falls slightly below the range of historical averages. Detected TP was lowest when first sampled in June at 75 µg/L, and rose throughout the season until the final sampling at 270 µg/L in late August (Figure 1).

Average chlorophyll-*a* concentrations in 2018 was 70.9 µg/L (Table 2), falling into the hypereutrophic, or very high productivity trophic classification. Like TP, Chlorophyll-*a* rose throughout the season, from a minimum of 14.4 µg/L in June to a maximum of 158 µg/L in late August.

Finally, the average TKN concentration was 2.53 mg/L (Table 2) with concentrations increasing over the course of the sampling season.

Average pH was measured as 8.44 in 2018, buffered by moderate alkalinity (172.5 mg/L $CaCO_3$) and bicarbonate (202.5 mg/L HCO_3). Calcium and sodium were the dominant ion contributing to a low conductivity of 375 µS/cm (Table 2).

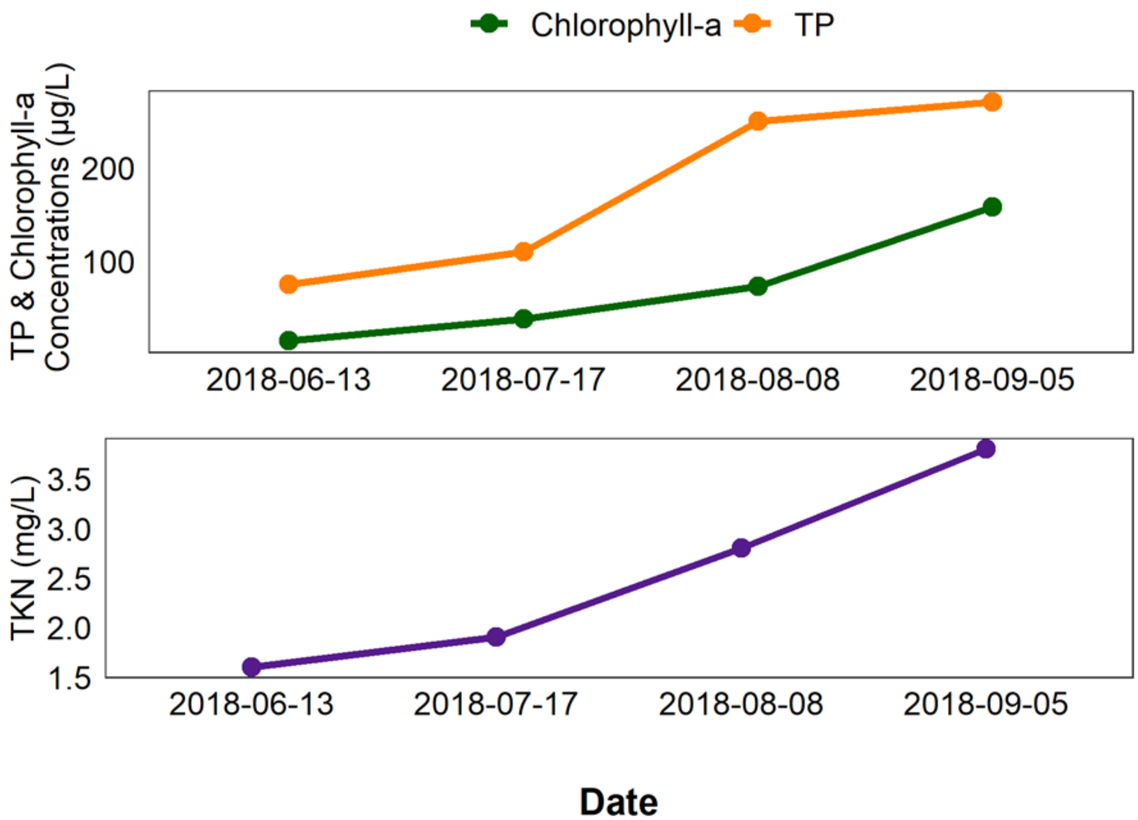

Figure 1- Total Phosphorus (TP), Total Kjeldahl Nitrogen (TKN), and Chlorophyll-*a* concentrations measured four times over the course of the summer in Lac Ste. Anne's West Basin.

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 Lac Ste. Anne in 2018. Table 3 presents historical values from years in which metal concentrations were tested.

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 Lac Ste. Anne's West Basin in 2018 was 1.60 m (Table 2). Secchi depth decreased by over 50% over the sampling season. This steady decrease in water clarity may have been due steadily increasing algae concentrations over the season, as indicated by increasing chlorophyll-a levels (Figure 1).

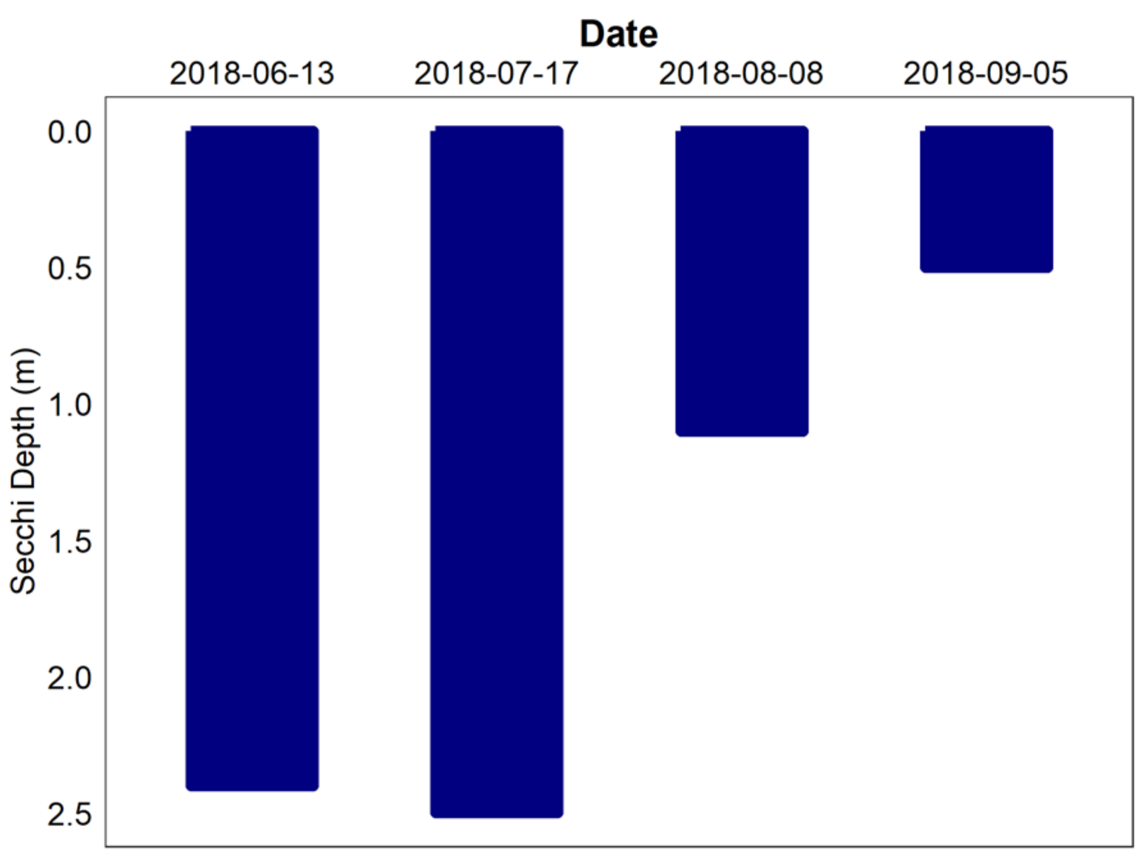

Figure 2 – Secchi depth values measured four times over the course of the summer at Lac Ste. Anne in 2018.

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 Lac Ste. Anne's West Basin varied throughout the summer, with a maximum temperature of 21.0°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 partial or complete mixing throughout the season.

Lac Ste. Anne 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 3.5 meters on July 17 and August 8, likely a result of decomposition of organic matter on the lake bottom.

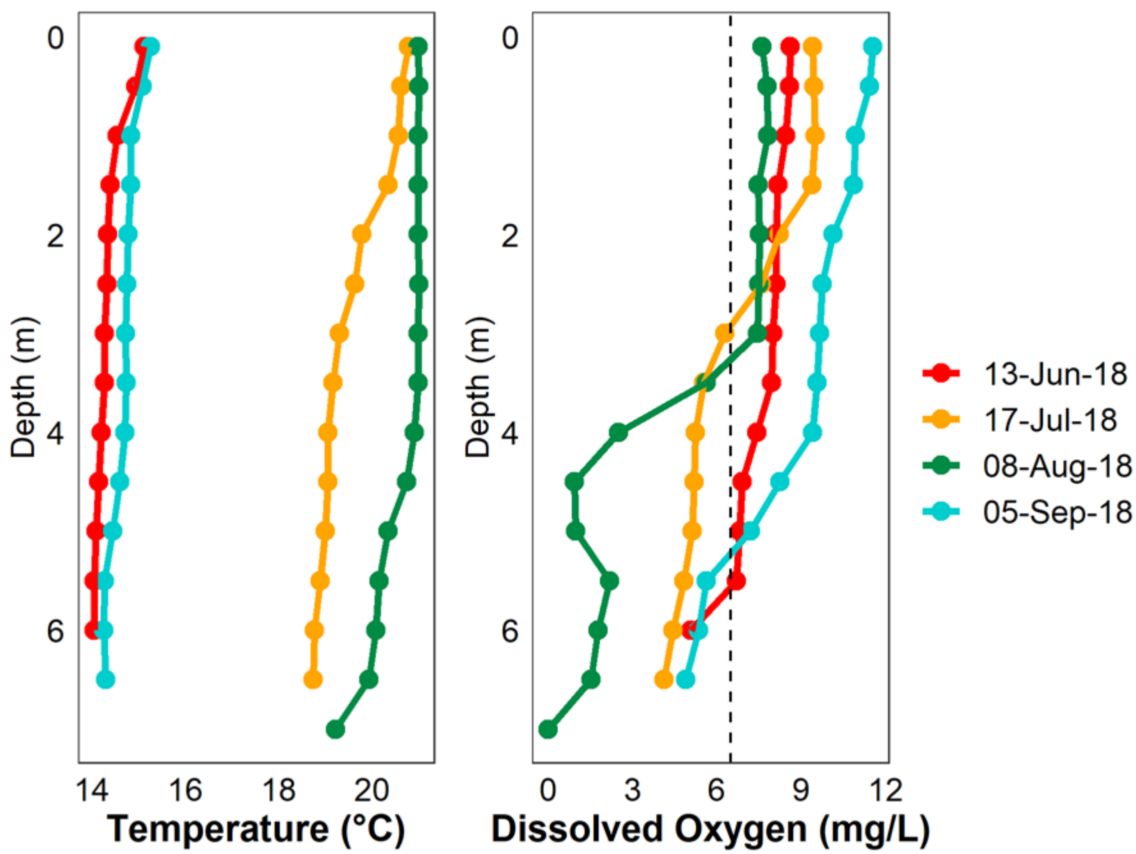

Figure 3 – a) Temperature (°C) and b) dissolved oxygen (mg/L) profiles for Lac Ste. Anne's West Basin measured four times over the course of the summer of 2018.

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 Lac Ste. Anne's West Basin fell below the recreational guideline of 20µg/L for at the locations and times sampled in Lac Ste. Anne in 2018. However, microcystins were detectable, an individual sampling locations may have higher concentrations of toxins. Recreating in cyanobacteria blooms is not advised.

Table 1 – Microcystin concentrations measured four times at Lac Ste. Anne in 2018.

Date	Microcystin Concentration (µg/L)
13-Jun-18	0.12
17-Jul-18	0.31
08-Aug-18	0.77
05-Sep-18	3.05
Average	1.1

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 Lac Ste. Anne.

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 Lac St. Anne have been measured by both Alberta Environment and Parks and Environment Canada. While there are large year to year fluctuations, average water levels in 2018 are well within the range of historical levels (Figure 4). Due to the gradual slope of the lake, small losses in volume can result in large losses in lake area.

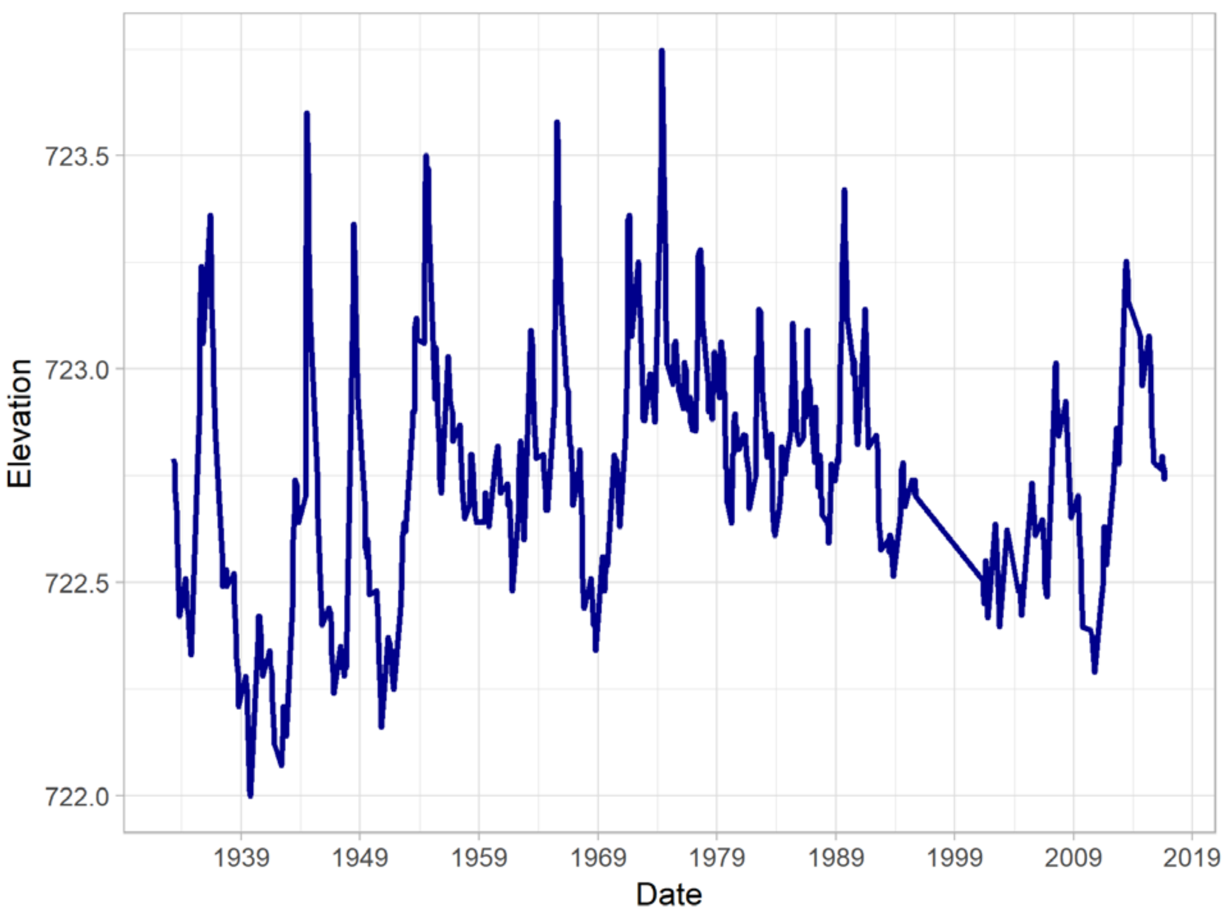

Figure 4: Water levels in Lac Ste. Anne from 1932-2011. No data was collected from 1996 to 2000. Data retrieved from Environment and Climate Change Canada and Alberta Environment and Parks.

Table 2: Average historical Secchi depth and water chemistry values for Lac Ste. Anne’s West Basin

Parameter	1996	1997	1998	2018
TP (µg/L)	182.2	204.0	310.2	176.3
TDP (µg/L)	/	130.4	235.7	85.5
Chlorophyll-a (µg/L)	39.2	70.1	101.3	70.9
Secchi depth (m)	2.8	2.3	2.0	1.625
TKN (µg/L)	1.8	/	/	2.525
NO2 and NO3 (µg/L)	/	/	/	13.775
NH3 (µg/L)	216	/	/	200
DOC (mg/L)	14.47	14.7	15	19.3
Ca (mg/L)	/	34.2	32.1	31.5
Mg (mg/L)	/	9.2	9.8	11.5
Na (mg/L)	17.8	15.1	18.5	29.75
K (mg/L)	/	6.4	7.7	11.5
SO42- (mg/L)	7.74	8.49	5.03	6.08
Cl- (mg/L)	3.81	5.21	4.48	12.25
CO3 (mg/L)	7.60	12.00	12.50	4.23
HCO3 (mg/L)	165.9	159.1	165.0	202.5
pH	8.42	8.66	8.75	8.44
Conductivity (µS/cm)	296	300	313	375
Hardness (mg/L)	108.60	123.29	120.75	127.50
TDS (mg/L)	159.6	166.71	171.25	215
Microcystin (µg/L)	/	/	/	1.06
Total Alkalinity (mg/L CaCO3)	142.0	146.9	156.0	172.5

Table 3: Concentrations of metals were last measured in Lac Ste. Anne (Whole Lake Composite) in 2014. The CCME heavy metal Guidelines for the Protection of Freshwater Aquatic Life (unless otherwise indicated) are presented for reference.

Metals (Total Recoverable)	2013	2014	Guidelines
Aluminum µg/L	9.19	9.4	100[a]
Antimony µg/L	0.03975	0.1473	/
Arsenic µg/L	1.345	1.58	5
Barium µg/L	69.4	68.55	/
Beryllium µg/L	0.0015	0.009	100[c,d]
Bismuth µg/L	0.0005	0.00325	/
Boron µg/L	61.2	61.9	1500
Cadmium µg/L	0.0362	0.007715	0.26[b]
Chromium µg/L	0.14985	0.3445	/
Cobalt µg/L	0.01345	0.0085	1000[d]
Copper µg/L	0.237	0.222	4[b]
Iron µg/L	13.45	22.1	300
Lead µg/L	0.01925	2.8865	7[b]
Lithium µg/L	16.9	16.1	2500[e]
Manganese µg/L	66.05	98.1	200[e]
Molybdenum µg/L	0.3355	0.278	73[c]
Nickel µg/L	0.05225	0.004	150[b]
Selenium µg/L	0.076	0.115	1
Silver µg/L	0.02075	0.001	0.25
Strontium µg/L	183	182.5	/
Thallium µg/L	0.00125	0.001675	0.8
Thorium µg/L	0.00015	0.003945	/
Tin µg/L	0.0226	0.0376	/
Titanium µg/L	1.645	1.045	/
Uranium µg/L	0.1525	0.151	15
Vanadium µg/L	0.196	0.2095	100[d,e]
Zinc µg/L	0.415	0.8435	30

Values represent means of total recoverable metal concentrations.

[a] Based on pH ≥ 6.5

[b] Based on water hardness > 180mg/L (as $CaCO_3$)

[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.