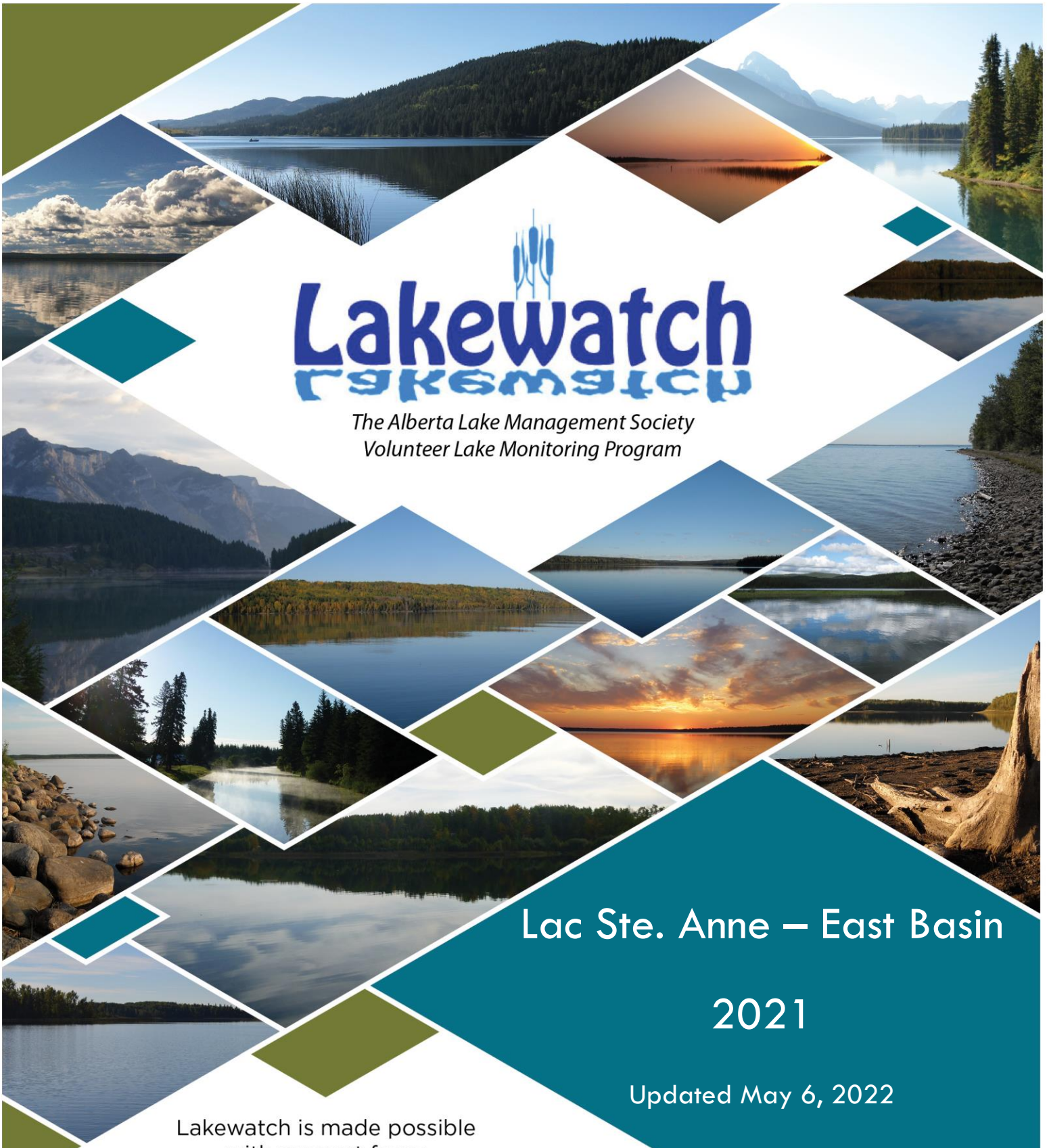

Lakewatch

The Alberta Lake Management Society
Volunteer Lake Monitoring Program

Lac Ste. Anne – East Basin

2021

Updated May 6, 2022

Lakewatch is made possible with support from:

Alberta
LICA Environmental Stewards
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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 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 Connie Stonehouse for her commitment to collecting data at Lac Ste. Anne. We would also like to thank Keri Malanchuk and Brittany Onysyk, who were summer technicians in 2021. 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.

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

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, and 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]

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 ago, 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]

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.

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[1] University of Alberta. 2005. Atlas of Alberta Lakes. University of Alberta Press.

[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 –

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 East Basin was 24 µg/L (Table 2), falling into the mesotrophic, or moderately productive trophic classification. This value falls below all previous historical averages. TP ranged from a minimum of 17 µg/L on the June 7th sampling event, and was highest during the August 31st sampling event, at 32 µg/L (Figure 1).

Average chlorophyll-*a* concentration in 2021 was 13.3 µg/L (Table 2), falling into the eutrophic, or highly productive trophic classification. Chlorophyll-*a* was lowest during the July 5th sampling event at 8.1 µg/L, and peaked late in the season at 18.4 µg/L during the September 20th sampling event (Figure 1).

The average TKN concentration was 1.3 mg/L (Table 2) and varied little through the season, ranging between 1.2 – 1.7 mg/L (Figure 1).

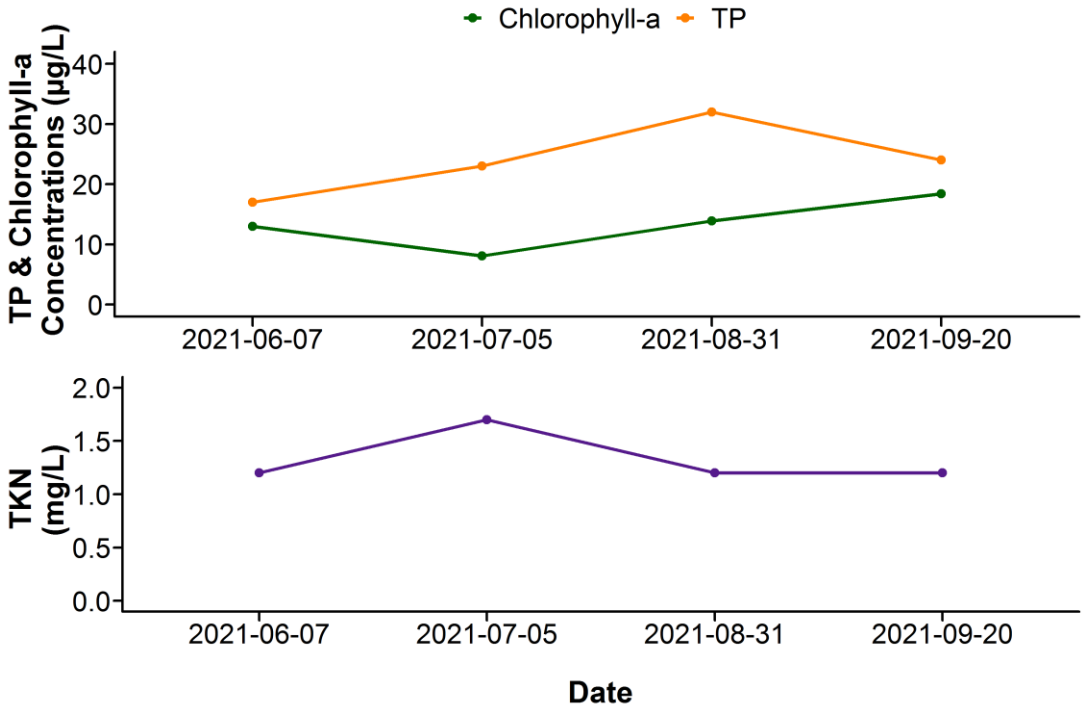

Figure 1. Total Phosphorus (TP), Total Kjeldahl Nitrogen (TKN), and Chlorophyll-*a* concentrations measured four times over the course of the summer at Lac Ste. Anne East Basin.

Average pH was measured as 8.37 in 2021, buffered by moderate alkalinity (182 mg/L $CaCO_3$) and bicarbonate (218 mg/L HCO_3). Aside from bicarbonate, sodium and calcium were slightly higher than all other major ions, and together contributed to a moderate conductivity of 405 µS/cm (Figure 2, top; Table 2). Lac Ste. Anne's East Basin is in the moderate range of ion levels compared to other LakeWatch lakes sampled in 2021 (Figure 2, bottom).

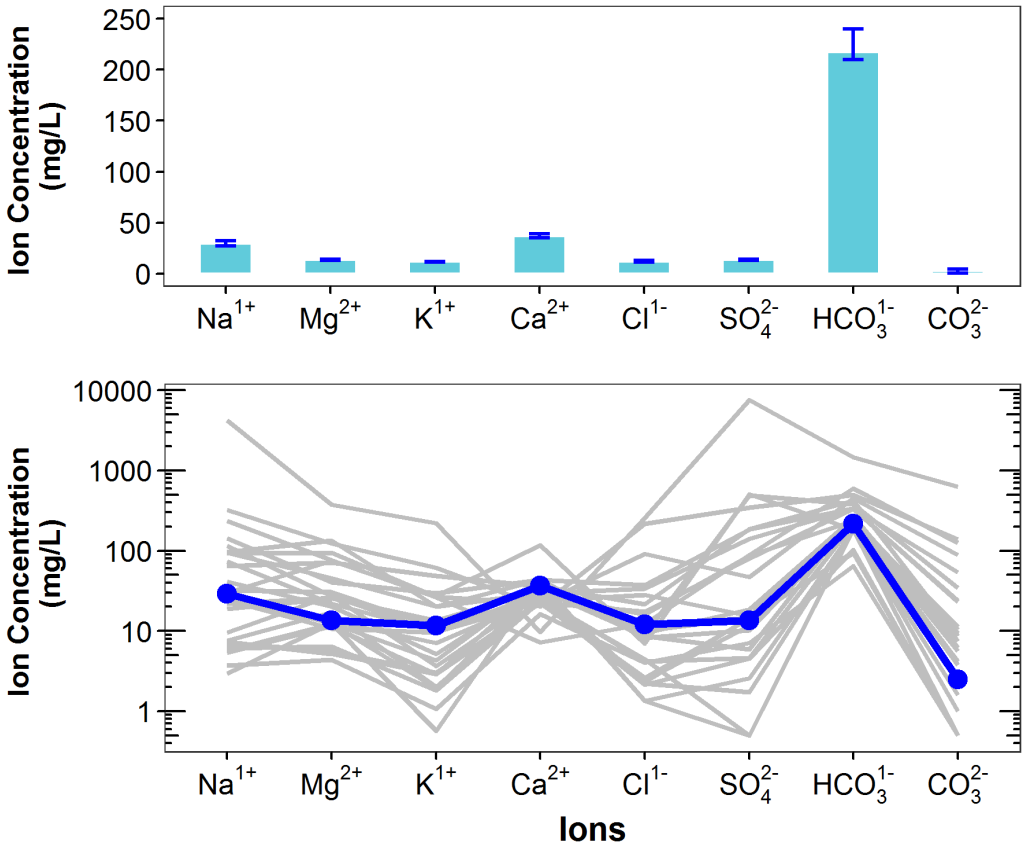

Figure 2. Average levels of cations (sodium = Na^{1+}, magnesium = Mg^{2+}, potassium = K^{1+}, calcium = Ca^{2+}) and anions (chloride = Cl^{1-}, sulphate = SO_4^{2-}, bicarbonate = HCO_3^{1-}, carbonate = CO_3^{2-}) from four measurements over the course of the summer at Lac Ste. Anne East Basin. Top) bars indicate range of values measured, and bottom) Schoeller diagram of average ion levels at Lac Ste. Anne East Basin (blue line) compared to 25 lake basins (gray lines) sampled through the LakeWatch program in 2021 (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 Lac Ste. Anne in 2021, but Table 3 displays historical metal concentrations.

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 Lac Ste. Anne East Basin in 2021 was 6.23 m, corresponding to an average Secchi depth of 0.30 m (Table 2). The euphotic depth on June 5th was adjusted to equal the lake's bottom depth, as light was able to reach the bottom of the lake on that day. The date with the highest euphotic depth was July 5th, when it was equal to lake bottom, and the lowest euphotic depth was present on September 20th, at 5.0 m.

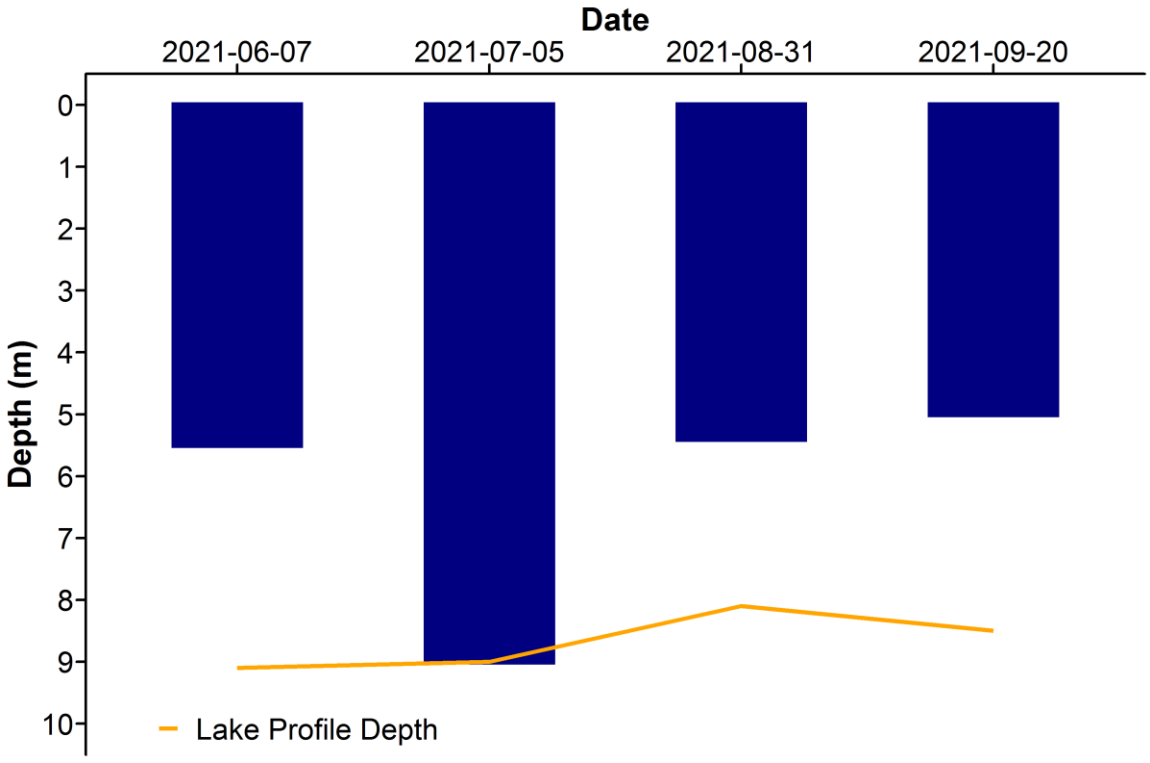

Figure 3. Euphotic depth values measured four times over the course of the summer at Lac Ste. Anne East Basin in 2021.

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 Lac Ste. Anne East Basin varied throughout the summer, with the July 5th sampling event having the warmest temperatures at 22.3°C (Figure 4a). The lake was well mixed during all sampling trips, as indicated by the relatively consistent temperatures from top to bottom each day. The temperature profile from the June 7th sampling event indicates very slight stratification near the bottom, at about 8 m.

The lake was well oxygenated in the surface waters only during the June, August, and September sampling events, measuring above the CCME guidelines of 6.5 mg/L dissolved oxygen (Figure 4b). Oxygen levels on July 5th were at 6.5 mg/L from the surface to 3.5 m, below which levels were less than 6.5 mg/L. These reduced levels could be due to the high water temperatures present throughout the lake, following a heat wave event in late June (Figure 6), since warmer water will hold less oxygen. The interaction of high winds, mixing of low oxygen bottom waters evident (as present during June 7th sampling event), and decreased solar radiation leading up to the sampling event were likely important as well.

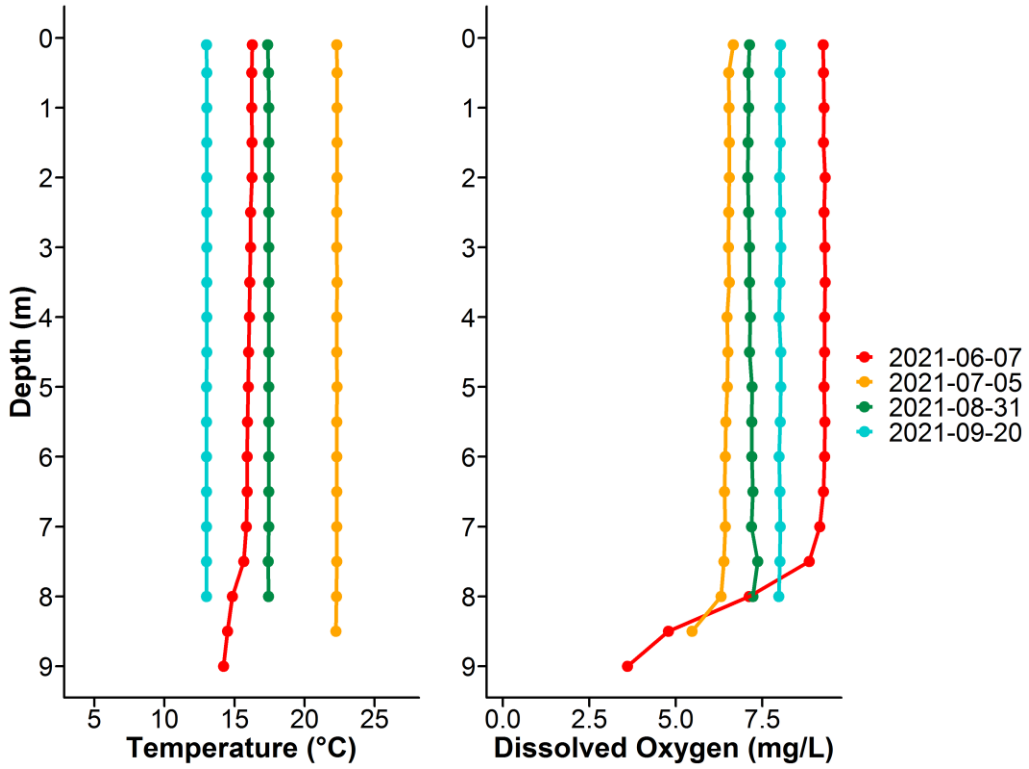

Figure 4. a) Temperature (°C) and b) dissolved oxygen (mg/L) profiles for Lac Ste. Anne East Basin measured four times over the course of the summer of 2021.

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 Lac Ste. Anne East Basin fell below the recreational guideline of 10 µg/L during every sampling event in 2021. Levels on June 7th and July 5th were below the laboratory detection limit of 0.1 µg/L, and a value of 0.05 µg/L was used to calculate the season average value. Even though low levels of microcystin were detected, caution should always be observed when recreating around cyanobacteria.

Table 1. Microcystin concentrations measured four times at Lac Ste. Anne East Basin in 2021.

Date	Microcystin Concentration (µg/L)
7-Jun-21	<0.10
5-Jul-21	<0.10
31-Aug-21	0.34
20-Sep-21	0.26
Average	0.18

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 involved sampling with a 63 µm plankton net at three sample sites to look for juvenile mussel veligers and spiny water flea in each lake sampled. In 2021, no mussels or spiny water flea were detected at Lac Ste. Anne East Basin.

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.

A watermilfoil specimen was collected from Lac Ste. Anne on June 15th, and was confirmed to be the native Northern Watermilfoil.

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 Ste. Anne in 2021 dropped below the historical average, and were at the lowest level seen in the previous 10 years (Figure 5).

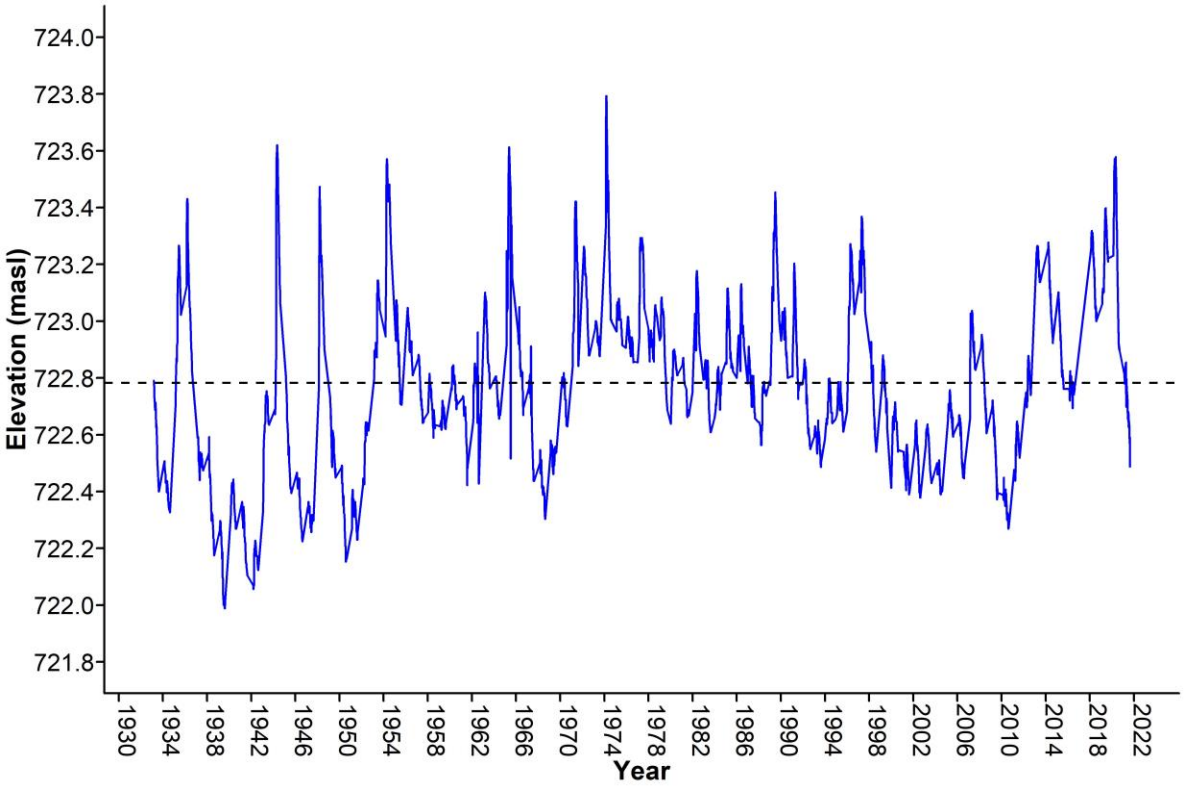

Figure 5. Water levels measured at Lac Ste. Anne East Basin in metres above sea level (masl) from 1934-2021. Data retrieved from Environment Canada and Alberta Environment and Parks. Black dashed line represents historical yearly average water level.

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.

Lac Ste. Anne East Basin experienced a warmer, drier, windier summer with slightly more solar radiation compared to normal (Figure 6). A warm spell prior to the July 5th sampling resulted in relatively high surface temperatures. The whole lake cooled by nearly 4.5°C between the August 31st and September 20th sampling events, due to decreasing average air temperatures and high winds.

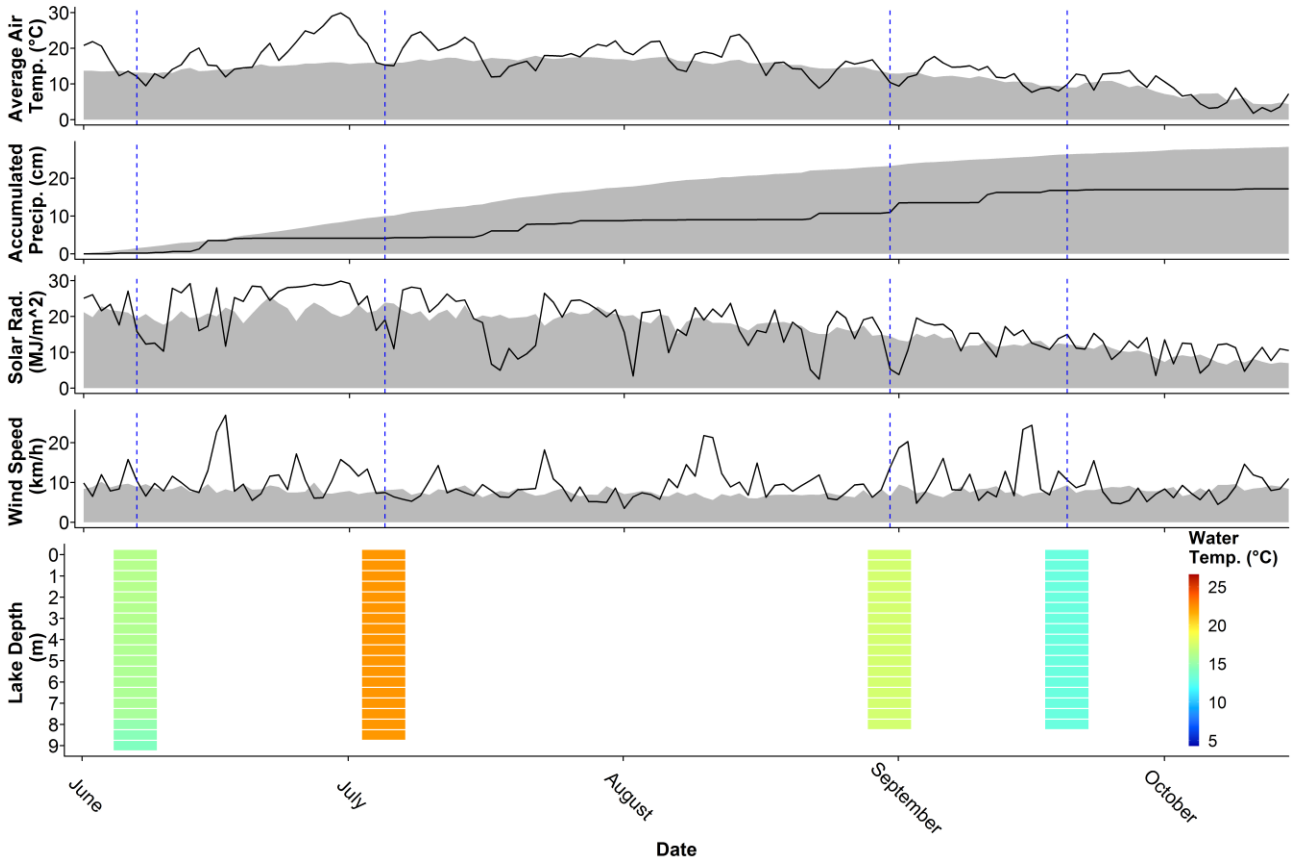

Figure 6. Average air temperature (°C), accumulated precipitation (cm), and wind speed (km/h) measured from Glenevis AGCM, as well as solar radiation (MJ/m^2) measured from Edmonton Stony Plain CS, with Lac Ste. Anne East Basin temperature profiles (°C) at the bottom. Black lines indicate 2021 levels, gray indicates long-term normals, and blue lines indicate sampling dates for Lac Ste. Anne East Basin over the summer. Further information about the weather data provided is available in the LakeWatch 2021 Methods report. Weather data provided by Agriculture, Forestry and Rural Economic Development, Alberta Climate Information Service (ACIS) https://acis.alberta.ca (retrieved April 2022).

Table 2. Average Secchi depth and water chemistry values for Lac Ste. Anne East Basin and Whole Lake (marked with '*'). Historical values are given for reference. Number of sample trips are inconsistent between years.

Parameter	1984	1985	1988	1996	1997	1998	2012*	2013*	2014*	2021
TP (µg/L)	52	25	53	46	88	44	111	78	129	24
TDP (µg/L)	20	7	/	14	20	13	20	26	49	9
Chlorophyll-*a* (µg/L)	19.2	15	44.5	30.4	85.2	20.5	62.2	34	45.2	13.3
Secchi depth (m)	2.27	2.4	1.24	2.19	2.33	2.22	1.77	3.1	1.68	3.3
TKN (mg/L)	0.9	0.9	/	1.3	1.6	1.1	1.9	1.5	1.9	1.3
NO_2-N and NO_3-N (µg/L)	65	2	10	13	48	14	17	3	30	7
NH_3-N (µg/L)	24	12	/	78	33	72	48	152	113	27
DOC (mg/L)	8	10	/	12	12	12	/	17	16	14
Ca^{2+} (mg/L)	30	32	28	/	29	35	/	/	/	37
Mg^{2+} (mg/L)	9	9	10	/	10	10	/	/	/	14
Na^{+} (mg/L)	15	16	17	18	17	17	30	29	32	29
K^{+} (mg/L)	7	7	7	/	7	8	/	15	13	12
SO_4^{2-} (mg/L)	10	9	7	9	9	11	5	5	5	14
Cl^{-} (mg/L)	2	3	2	4	5	5	8	8	9	12
CO_3^{2-} (mg/L)	5.4	2.5	7.7	5.2	9.6	4.9	11	4.9	5.5	2.5
HCO_3^{-} (mg/L)	174	181	163	172	155	185	178	198	198	218
pH	8.47	8.49	8.52	8.52	8.66	8.43	8.73	8.44	8.45	8.37
Conductivity (µS/cm)	303	308	289	313	297	334	338	367	364	405
Hardness (mg/L)	113	117	111	118	114	131	104	116	112	148
TDS (mg/L)	164	166	158	169	161	181	186	198	211	238
Microcystin (µg/L)	/	/	/	/	/	/	1.22	0.70	1.36	0.18
Total Alkalinity (mg/L $CaCO_3$)	150	150	144	149	141	157	164	170	171	182

Table 3. Concentrations of metals measured in Lac Ste. Anne. 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	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	0.17[b]
Chromium µg/L	0.14985	0.3445	/
Cobalt µg/L	0.01345	0.0085	50,1000[c,d]
Copper µg/L	0.237	0.222	2.61[b]
Iron µg/L	13.45	22.1	300
Lead µg/L	0.01925	2.8865	3.68[b]
Lithium µg/L	16.9	16.1	2500[d]
Manganese µg/L	66.05	98.1	220[e]
Molybdenum µg/L	0.3355	0.278	73
Nickel µg/L	0.05225	0.004	104[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[c,d]
Zinc µg/L	0.415	0.8435	30[f]

Values represent means of total recoverable metal concentrations.

[a] Based on pH ≥ 6.5

[b] Based on 2014 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 2014 avg. water hardness (as CaCO3) and avg. pH

[f] Based on 2014 avg. water hardness (as CaCO3), avg. pH, and avg. DOC with CCME equation

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