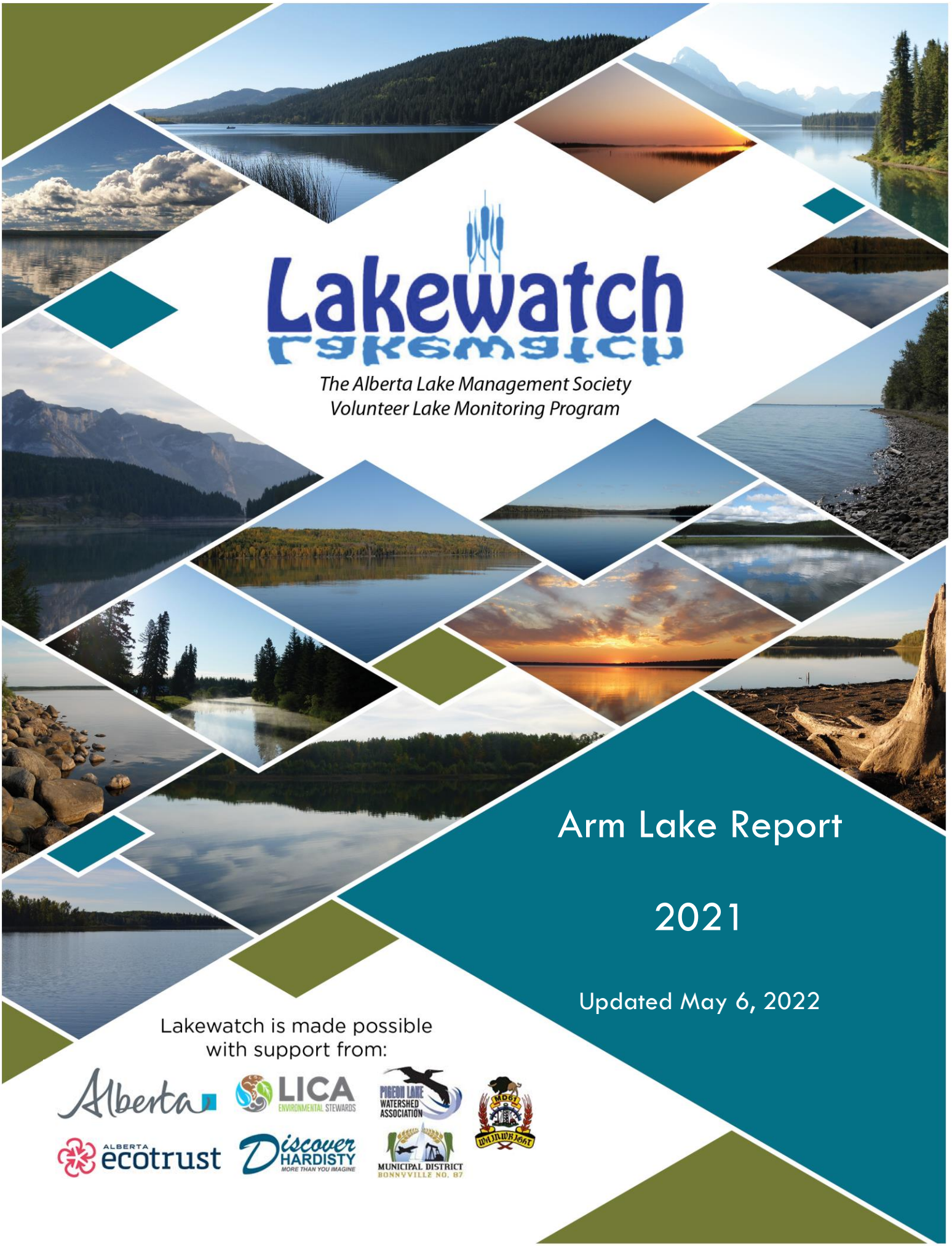

Lakewatch

The Alberta Lake Management Society
Volunteer Lake Monitoring Program

Arm Lake Report

2021

Updated May 6, 2022

Lakewatch is made possible with support from:

Alberta
LICA Environmental Stewards
Pigeon Lake Watershed Association
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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

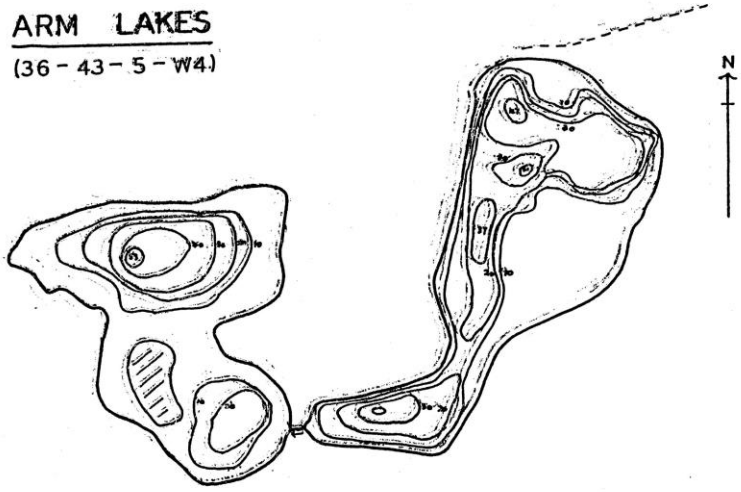
The LakeWatch program is made possible through the dedication of its volunteers. A special thanks to Rick Lapierre for his commitment to collecting data at Arm Lake. We would also like to thank Keri Malanchuk and Brittany Onysyk, who were summer technicians in 2021. Executive Director Bradley Peter and Program Manager Caleb Sinn were instrumental in planning and organizing the field program. This report was prepared by Caleb Sinn and Bradley Peter.

ARM LAKE

Arm Lake is situated in the North Saskatchewan River drainage basin in east-central Alberta, near the Battle River valley. The lake consists of two distinct arms, though the East arm, which has buildings along the northern shore, is the site of sampling. In the mid 1970's, the narrows joining the two arms was dug out, allowing water to flow from the West arm into the East arm. After lobbying by the Arm Lake Cabin Owners Association, the narrows were restored, now allowing no water to flow between the two arms. The town of Wainwright, with a population of 5,775, and the Canadian Forces Base Wainwright are located approximately 20 km northwest of Arm Lake. Arm Lake, along with its larger neighbour Clear (Barnes) Lake, together make up a popular recreation area for the region. Arm Lake hosts a campground, golf course, public beach, and picnic area. Popular activities on the lake include swimming, boating, and fishing for northern pike and yellow perch.

Dense growth of small-leaf pondweed was observed in 2010. The plant is considered non-invasive in Alberta and populations have seemingly declined in the past few years.

The watershed area for Arm Lake is 3.42 km^2 and the lake area is 0.28 km^2. The lake to watershed ratio of Arm Lake is 1:12. A map of the Arm Lake watershed area can be found at http://alms.ca/wp-content/uploads/2016/12/Arm.pdf.



Bathymetric map of Arm Lake (anglersatlas.com)

Arm lake from above (MD of Wainwright)

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 Arm Lake was 15 µg/L (Table 2), falling into the mesotrophic, or moderately productive trophic classification. This value falls within the range of observed historical averages. TP ranged from a minimum of 7.3 µg/L on the July 14th sampling, to a maximum of 27 µg/L on September 1st (Figure 1).

Average chlorophyll-*a* concentration in 2021 was 5.2 µg/L (Table 2), falling into the mesotrophic, or moderately productive trophic classification. Chlorophyll-*a* was lowest earliest in the season, at 2.5 µg/L on June 24th and peaked at 5.8 µg/L on September 1st – chlorophyll-a displayed little variation through the season (Figure 1). However, residents did observe what appeared to be a bloom of cyanobacteria in the Spring of 2021.

The average TKN concentration was 1.2 mg/L (Table 2). TKN also displayed very little variation through the season (Figure 1).

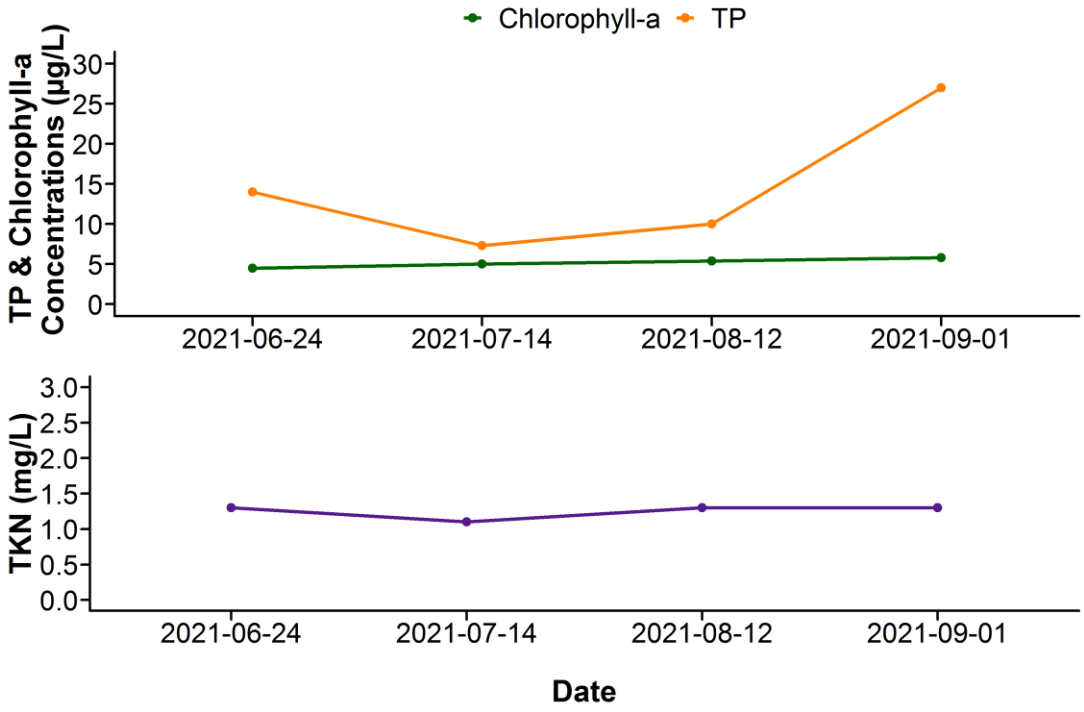


Figure 1. Total Phosphorus (TP), Total Kjeldahl Nitrogen (TKN), and Chlorophyll-*a* concentrations measured four times over the course of the summer at Arm Lake.

Average pH was measured as 8.37 in 2021, buffered by moderate alkalinity (190 mg/L $CaCO_3$) and bicarbonate (222 mg/L HCO_3). Aside from bicarbonate, magnesium and calcium were higher than all other major ions, and together contributed to a low conductivity of 380 µS/cm (Figure 2, top; Table 2). Arm Lake is in the average to low end range of ion levels, compared to other LakeWatch lakes sampled in 2021 (Figure 2, bottom).

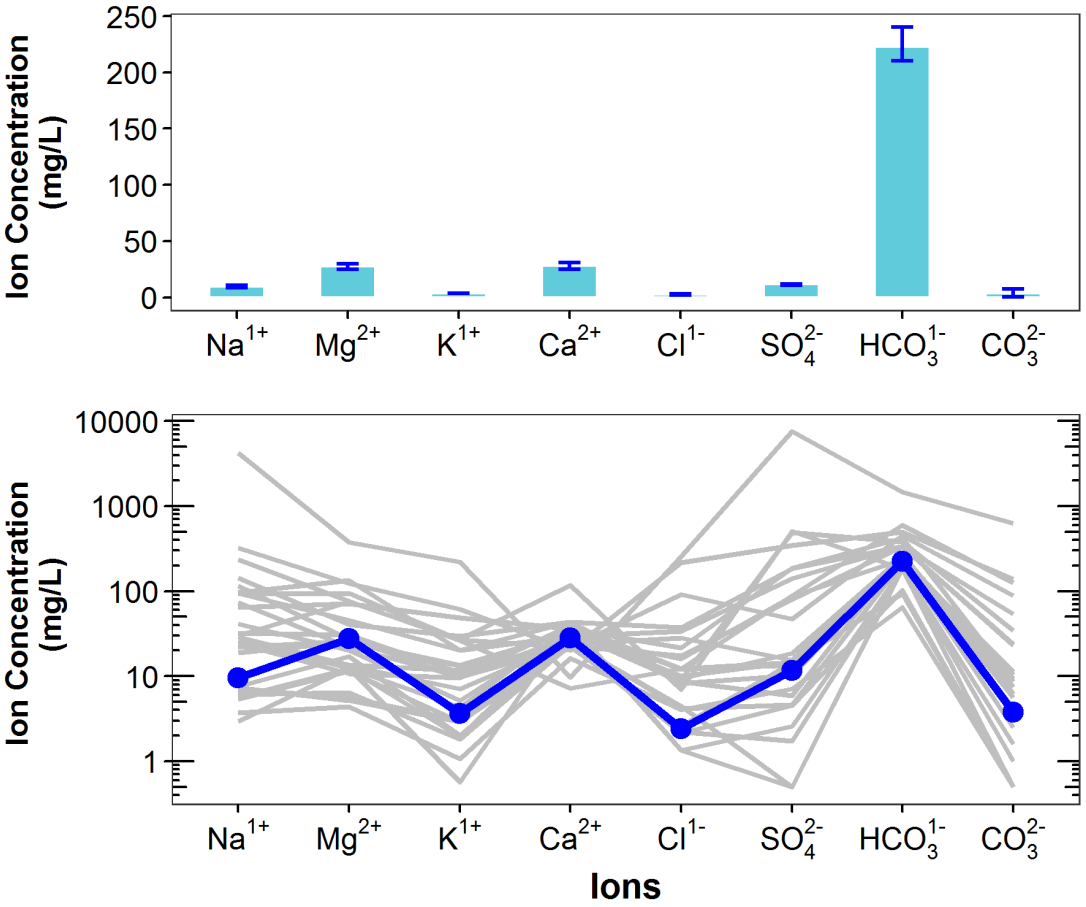


Figure 2. Average levels of cations (sodium = Na^{1+}, magnesium = Mg^{2+}, potassium = K^{1+}, calcium = Ca^{2+}) and anions (chloride = Cl^{1-}, sulphate = SO_4^{2-}, bicarbonate = HCO_3^{1-}, carbonate = CO_3^{2-}) from four measurements over the course of the summer at Arm Lake. Top) bars indicate range of values measured, and bottom) Schoeller diagram of average ion levels at Arm Lake (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 Arm Lake 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 Arm Lake in 2021 was 6.08 m, corresponding to an average Secchi depth of 3.04 m (Table 2). Euphotic depth varied over the season, ranging from as deep as 8.2 m on June 24th to 4.2 m on August 12th (Figure 3). Interestingly, algal growth, as indicated by chlorophyll-a levels, did not change proportionally through the season to the changes seen in water clarity, as indicated by euphotic depth.

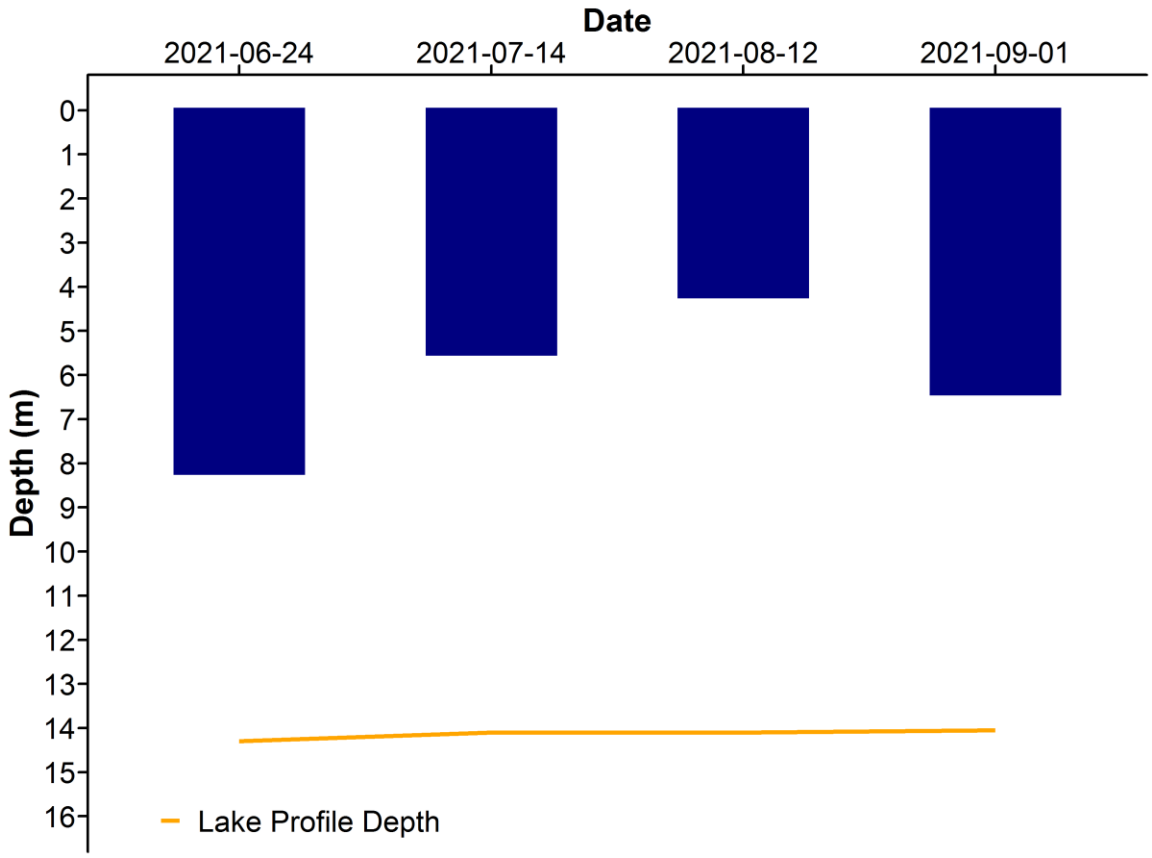


Figure 3. Euphotic depth values measured four times over the course of the summer at Arm Lake in 2021.

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 Arm Lake varied throughout the summer, with the July 14th sampling date having the warmest temperatures at 23.6°C (Figure 4a). The lake was stratified during all sampling trips, with the largest changes in temperature (thermocline) beginning between 4 and 8 m, depending on the sampling date.

Arm 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 were appreciable reductions in surface oxygen during the July 14th and August 12th sampling events – these dates also had small increases at 5 m depth. All dates displayed sharp decreases in oxygen between 6 and 8m depth, below which oxygen was 0 mg/L.

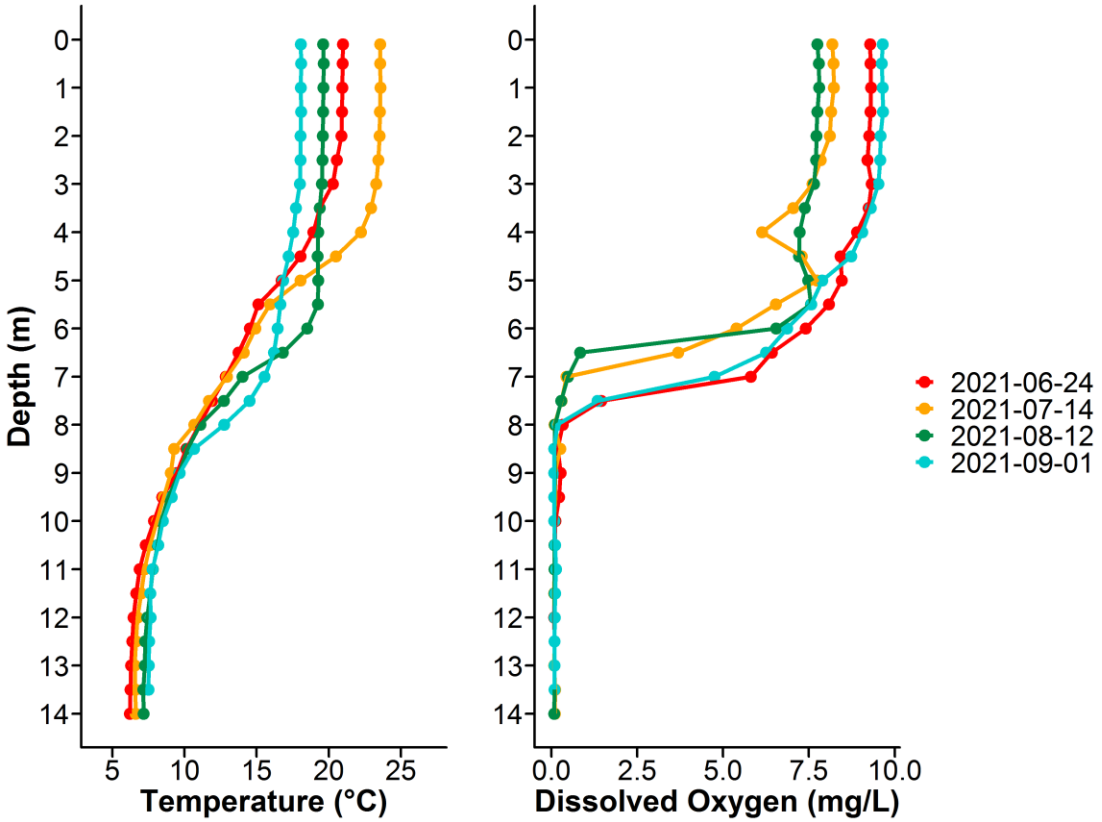


Figure 4. a) Temperature (°C) and b) dissolved oxygen (mg/L) profiles for Arm Lake measured four times over the course of the summer of 2021.

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 Arm Lake fell below the recreational guideline of 10 µg/L during every sampling event in 2021. 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 Arm Lake in 2021.

Date	Microcystin Concentration (µg/L)
24-Jun-21	0.10
14-Jul-21	0.13
12-Aug-21	0.15
1-Sep-21	0.14
Average	0.13

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 2021, no mussels or spiny water flea were detected at Arm 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 Arm Lake in 2021.

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 level data for Arm Lake is unavailable.

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.

Arm Lake experienced a warmer, drier, and windier summer than normal (Figure 5). A warm spell during the July 14th sampling resulted in relatively high surface temperatures. The profile measured on August 12th indicated a deeper thermocline, and well-mixed surface layer of the lake, likely due to following a windy spell.

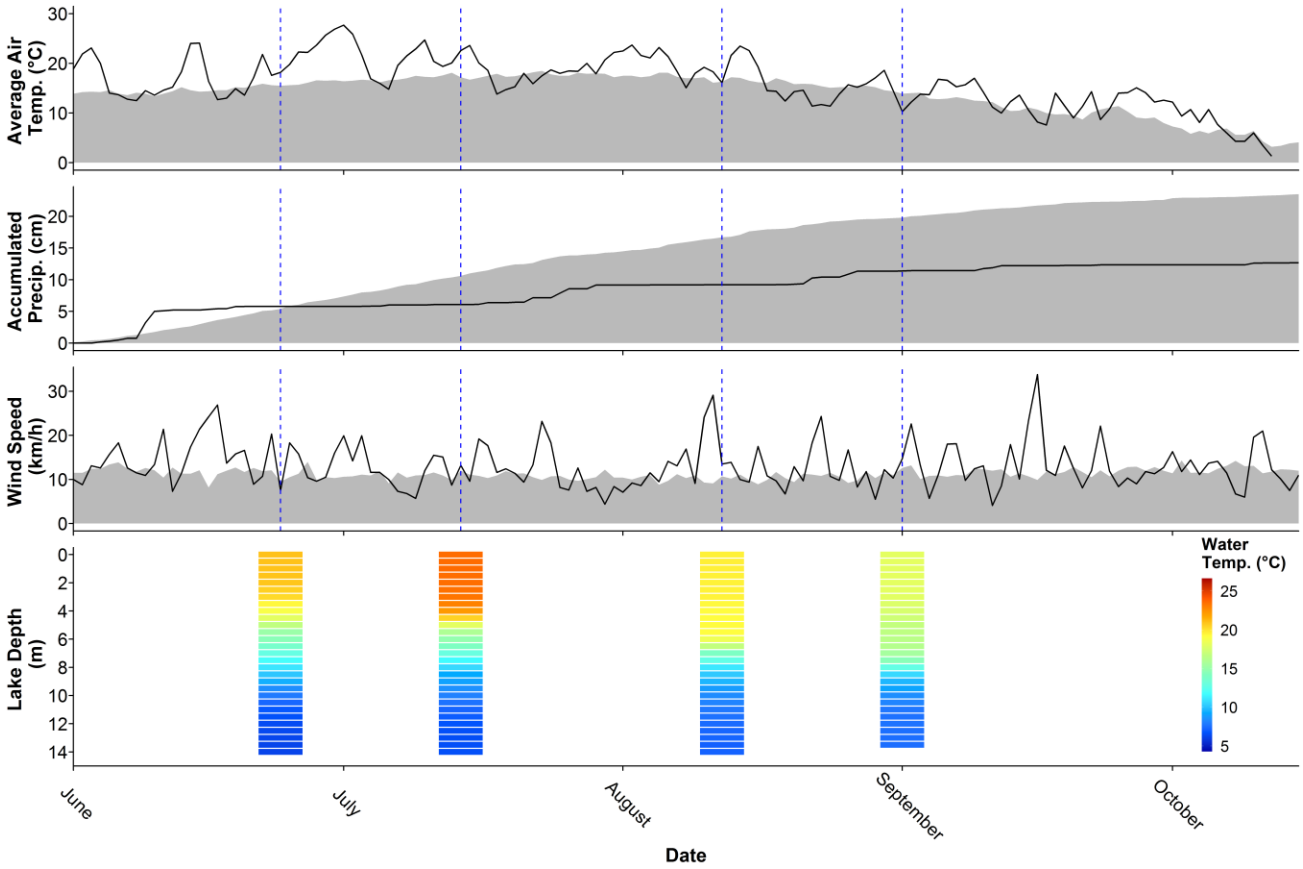


Figure 5. Average air temperature (°C), accumulated precipitation (cm), and wind speed (km/h) measured from Edgerton AGCM, as well as Arm Lake temperature profiles (°C). Black lines indicate 2021 levels, gray indicates long-term normals, and blue lines indicate sampling dates for Arm Lake over the summer. 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). *Note: Solar Radiation not available at Edgerton AGCM.

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

Parameter	2009	2010	2011	2016	2021
TP (µg/L)	22	17	19	10	15
TDP (µg/L)	9	10	8	3	2
Chlorophyll-*a* (µg/L)	3.2	3.0	3.2	6.2	5.2
Secchi depth (m)	3.56	3.85	4.55	3.82	3.04
TKN (mg/L)	1.0	1.1	1.0	1.0	1.2
NO_2-N and NO_3-N (µg/L)	7	8	5	3	3
NH_3-N (µg/L)	22	14	24	31	17
DOC (mg/L)	13	13	12	13	12
Ca^{2+} (mg/L)	28	24	29	28	28
Mg^{2+} (mg/L)	27	28	29	30	28
Na^{+} (mg/L)	10	10	9	10	10
K^{+} (mg/L)	3	4	4	4	4
SO_4^{2-} (mg/L)	16	17	14	13	12
Cl^{-} (mg/L)	2	2	1	1	2
CO_3^{2-} (mg/L)	8	3	3	3	4
HCO_3^{-} (mg/L)	215	225	226	216	222
pH	8.53	8.51	8.41	8.45	8.37
Conductivity (µS/cm)	367	363	375	356	380
Hardness (mg/L)	183	176	193	190	188
TDS (mg/L)	200	199	221	198	202
Microcystin (µg/L)	\	0.08	0.06	0.08	0.13
Total Alkalinity (mg/L $CaCO_3$)	189	190	191	182	190

Table 3. Concentrations of metals measured once in Arm 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)	2016	Guidelines
Aluminum µg/L	6.8	100[a]
Antimony µg/L	0.046	/
Arsenic µg/L	2.32	5
Barium µg/L	86.9	/
Beryllium µg/L	0.004	100[c,d]
Bismuth µg/L	5.00E-04	/
Boron µg/L	37.8	1500
Cadmium µg/L	0.001	0.27[b]
Chromium µg/L	0.06	/
Cobalt µg/L	0.005	50,1000[c,d]
Copper µg/L	0.48	4[b]
Iron µg/L	8.7	300
Lead µg/L	0.019	7[b]
Lithium µg/L	28.1	2500[d]
Manganese µg/L	24.1	240[e]
Molybdenum µg/L	0.582	73
Nickel µg/L	0.171	150[b]
Selenium µg/L	0.03	1
Silver µg/L	0.001	0.25
Strontium µg/L	179	/
Thallium µg/L	0.00045	0.8
Thorium µg/L	0.00045	/
Tin µg/L	0.018	/
Titanium µg/L	0.8	/
Uranium µg/L	0.968	15
Vanadium µg/L	0.09	100[c,d]
Zinc µg/L	0.9	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