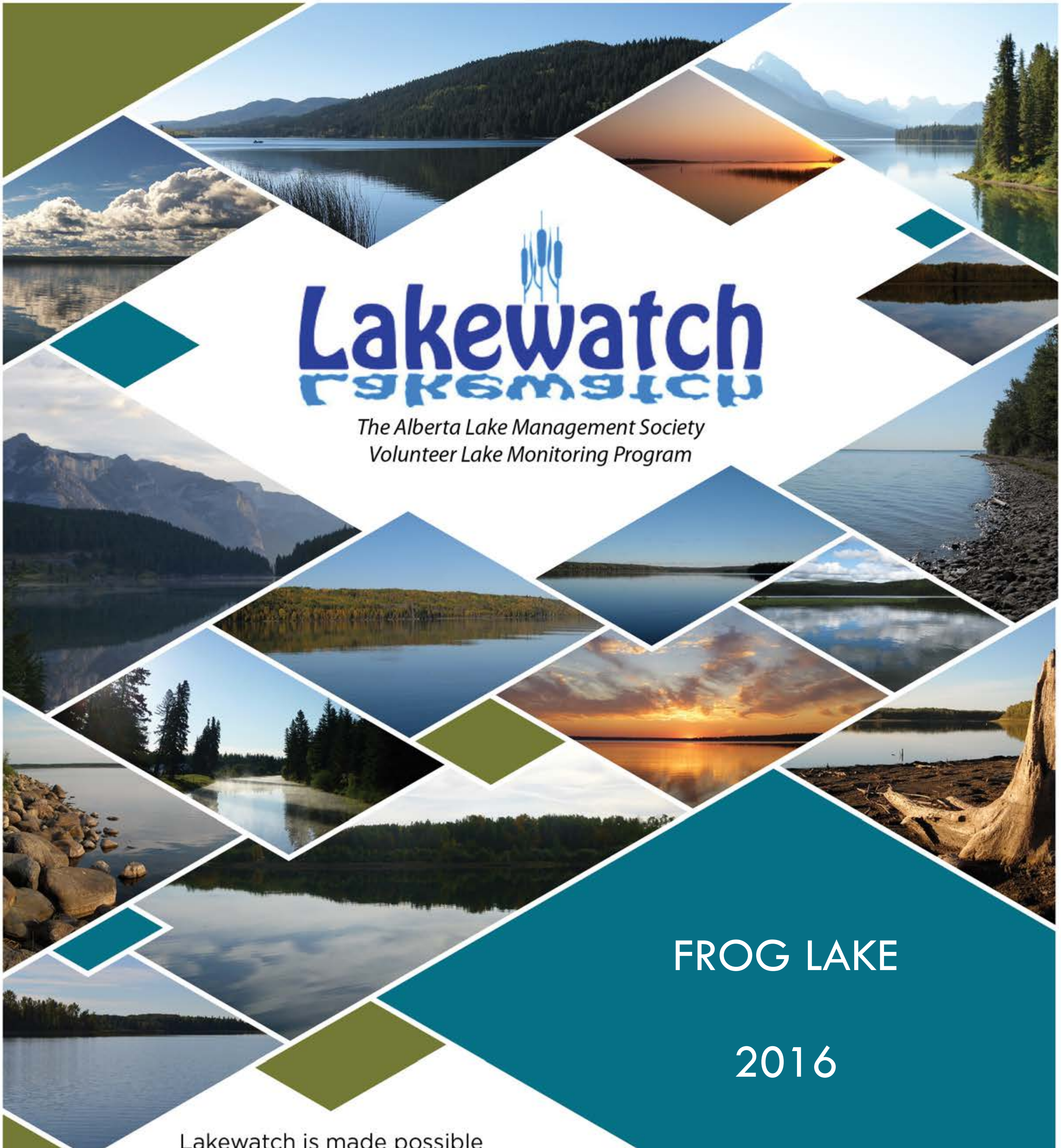

Lakewatch

The Alberta Lake Management Society
Volunteer Lake Monitoring Program

FROG LAKE

2016

Lakewatch is made possible
with support from:

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Environment and Climate Change Canada
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Pigeon Lake Watershed Association
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LICA Lakeland Industry & Community Association
Beaver River Watershed Alliance
Red Deer River Watershed Alliance
MD 61 Wainwright

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.

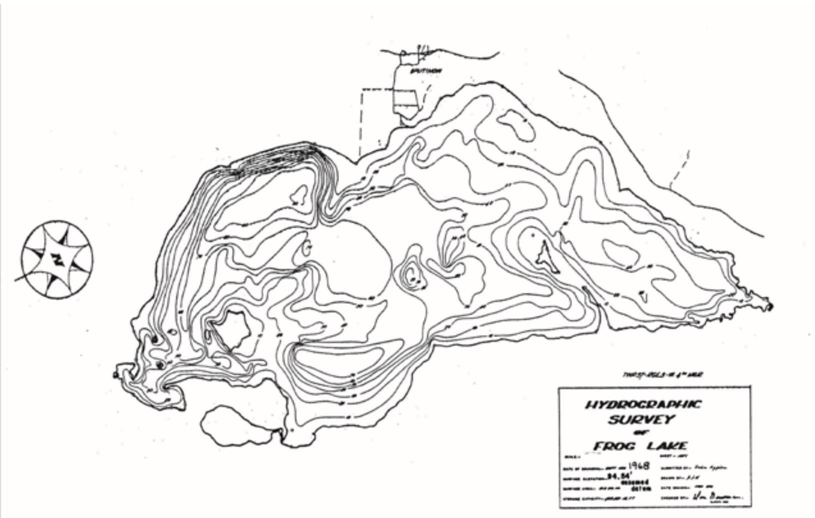
ALMS would like to thank all who express interest in Alberta's aquatic environments and particularly those who have participated in the LakeWatch program. These people prove that ecological apathy can be overcome and give us hope that our water resources will not be the limiting factor in the health of our environment.

ACKNOWLEDGEMENTS

The LakeWatch program is made possible through the dedication of its volunteers. We would like to extend a special thanks to Len Quinney, Kendra Quinney, Roy Quinney, Amanda Quinney, Mick Wacanta, and Jimmy Stanley for the time and energy put into sampling Frog Lake in 2016. We would also like to thank Alicia Kennedy, Ageleky Bouzetos, and Breda Muldoon who were summer technicians in 2016. Executive Director Bradley Peter was instrumental in planning and organizing the field program. Alicia Kennedy was instrumental in report design. This report was prepared by Bradley Peter and Laura Redmond. The Beaver River Watershed, the Lakeland Industry and Community Association, Environment Canada, and Alberta Environment and Parks are major sponsors of the LakeWatch program.

FROG LAKE

Frog Lake is a very large (surface area 58 km$^{2)}$ and deep (maximum depth 28 m) lake located about 200 km east of the city of Edmonton, in the Eastern North Saskatchewan River Basin. The 4 islands on Frog Lake are protected bird sanctuaries and provide nesting sites for one of the largest cormorant colonies in Alberta. Pelicans, various cranes, bald eagles, ducks, geese, and a whole host of other birds make Frog Lake their home. Frog Lake is surrounded by jack pine (*Pinus banksiana*), aspen (*Populus spp.*) groves, willow (Salix spp.) thickets, marshes, fens and mixed wood forests. Frog Lake's watershed is quite large (613 km^2) and about 10 times larger than the lake surface area. The majority of the land cover in the watershed is natural (86% of watershed area), and only about 14% of the watershed has been cleared. The land cover in Frog Lake's watershed has remained relatively unchanged over the past 15 years (Ducks Unlimited, unpublished 1986 and 1998 data). Frog Lake is a very important source of subsistence fisheries as it is almost completely surrounded by Indian reserves and Metis settlements. The Puskiakiwenin Indian Reserve 122 and Unipouheos Indian reserve 121 occupy the western shore of Frog Lake, whereas the Fishing Lake Metis Settlement occupies most of the eastern shore. Only a few anglers or campers enjoy the beauty of this lake.



Bathymetric map of Frog Lake

The watershed area for Frog Lake is 553 km^2 and the lake area is 58 km^2. The lake to watershed ratio of Frog Lake is 1:9. A map of the Frog Lake watershed area can be found here or at http://alms.ca/lake-watershed-maps/.

Alberta Environment. 1989. Moose Lake. Environmental Assessment Division, Environmental Quality Monitoring Branch, Edmonton.
Alberta Recreation, Parks and Wildlife Foundation. 1992.
Mitchell, P. and E. Prepas. 1990. Atlas of Alberta Lakes. University of Alberta Press.

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 of Frog Lake was 17 μg/L, putting it in the mesotrophic classification in 2016 (Table 2). TP concentrations fluctuated in 2016, peaking on July 19 at 28 μg/L (Figure 1). An average concentration of 17 ug/L falls on the low end of the historical variation observed at Frog Lake.

Chlorophyll-*a* concentrations remained stable over the course of the summer of 2016, and was highest on September 28 at 8 μg/L (Figure 1). The average chlorophyll-*a* concentration of 5.0 μg/L, also putting Frog Lake into the mesotrophic classification. This average falls well within Frog Lake's historical variation related to chlorophyll-*a* concentration.

Average TKN concentration was 1.1 mg/L in 2016, which lies within the average historical values of Frog Lake (Table 2). TKN values fluctuated throughout the summer, and increased between July and September (Figure 1). The maximum TKN concentration of 1.2 mg/L was measured on September 7.

Average pH measured as 8.9 in 2016, buffered by moderate alkalinity (400 mg/L $CaCO_3$) and bicarbonate (404 mg/L HCO_3). Magnesium, sodium and sulphate were the dominant ions contributing to a moderate conductivity measure of 950 μS/cm (Table 2).

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 at Frog Lake and all measured values fell within their respective guidelines (Table 3).

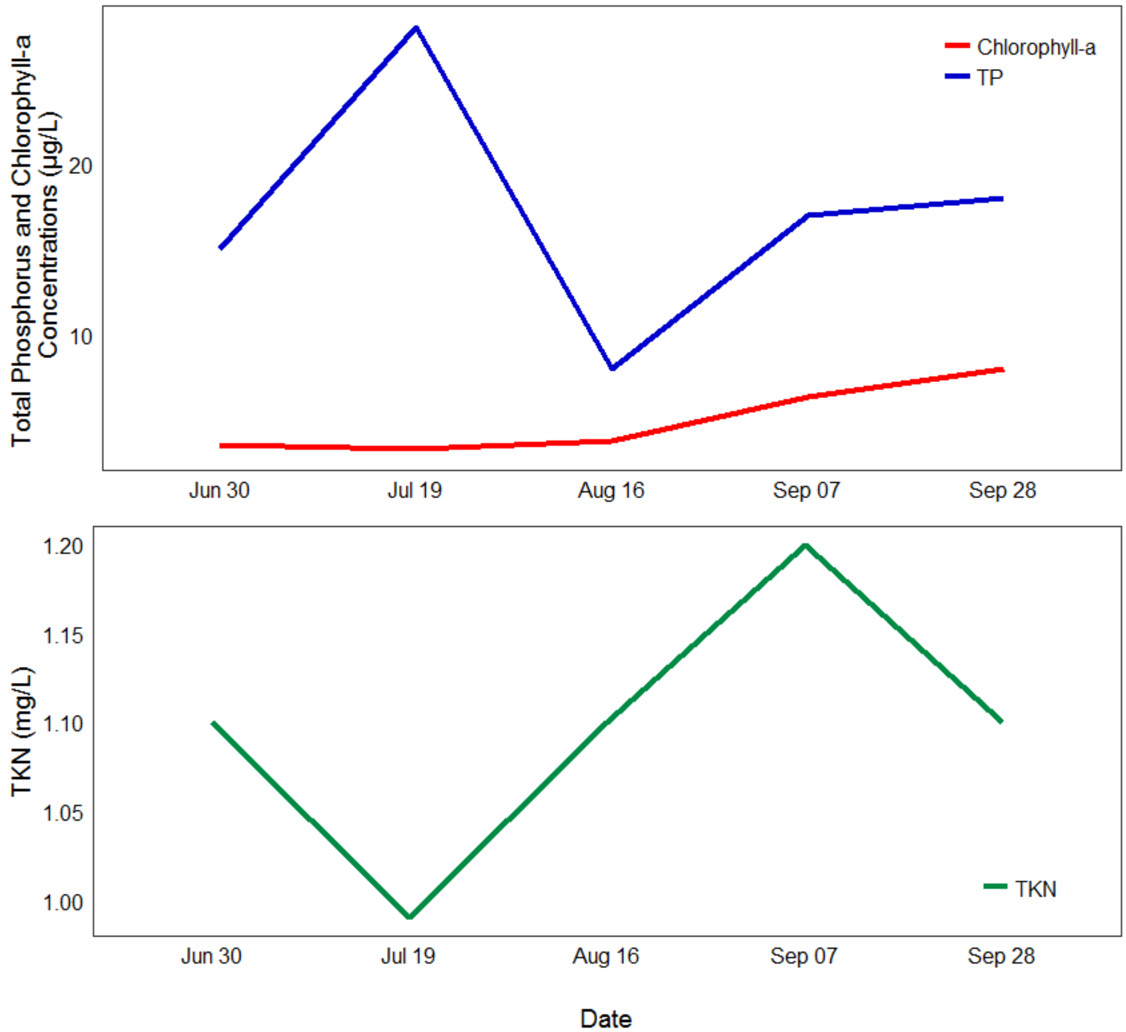


Figure 1- Total Phosphorus (TP), Total Kjeldahl Nitrogen (TKN), and Chlorophyll-*a* concentrations measured five times over the course of the summer at Frog Lake.

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 disk depth. Two times the Secchi disk depth equals the euphotic depth – the depth to which there is enough light for photosynthesis.

Secchi depth remained consistent for Frog Lake in 2016, with an average depth of 3.75 m (Table 2). This classifies Frog Lake as mesotrophic. Secchi depth was not significantly correlated with chlorophyll-*a;* therefore, changes in water quality may be attributed to other suspended materials.

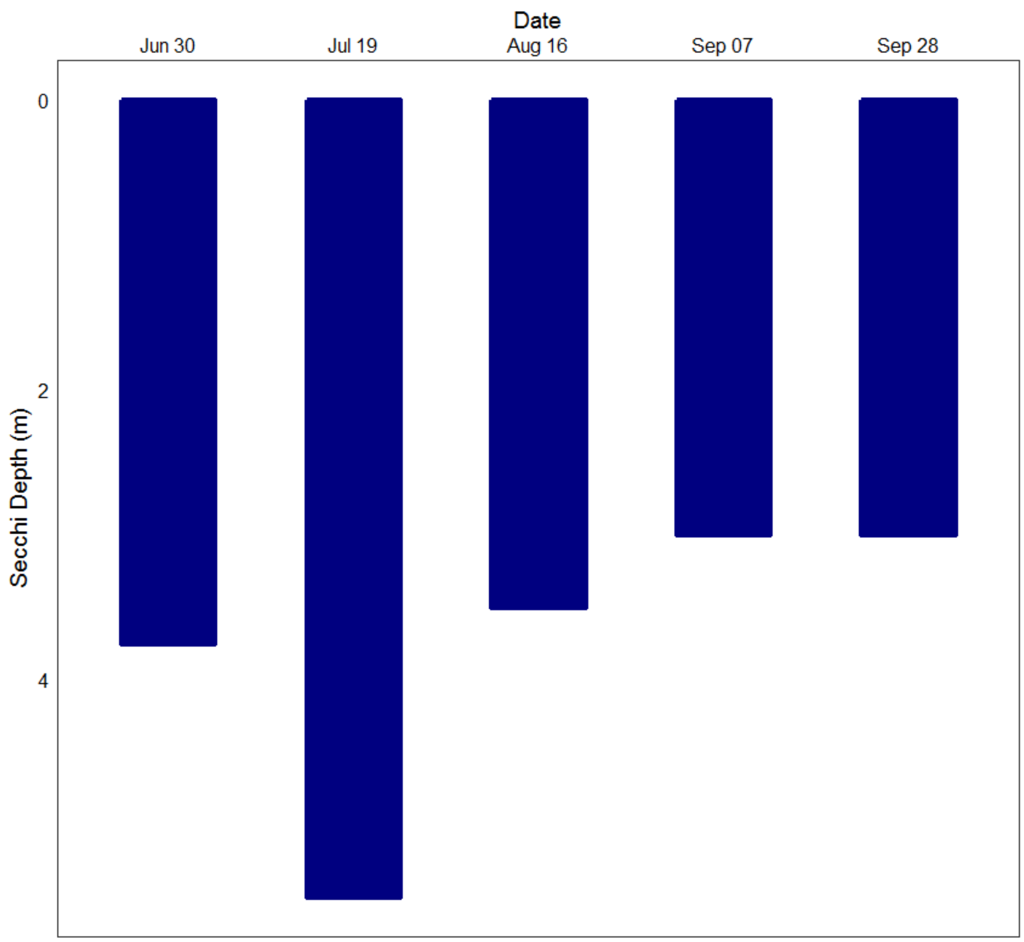


Figure 2 – Secchi depth values measured five times over the course of the summer at Frog Lake in 2016.

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.

Frog Lake was thermally stratified at each visit during 2016, and deepened over the course of the summer (Figure 3a). Surface temperature fluctuated, with a maximum temperature of 22.10 °C on August 16. The strong thermal stratification of Frog Lake consequently affected oxygen concentrations in the water column.

Frog Lake remained well oxygenated at the surface throughout the summer, measuring above the Canadian Council for Ministers of the Environment guidelines of 6.5 mg/L for the Protection of Aquatic Life (Figure 3b). Anoxic conditions were reached at the bottom of Frog Lake. Anoxic conditions are more likely under thermally stratified conditions, as it isolates oxygen-rich surface waters from oxygen-poor bottom waters. Further contributing to the oxygen decline is the process of decomposition which draws away oxygen at the lakebed.

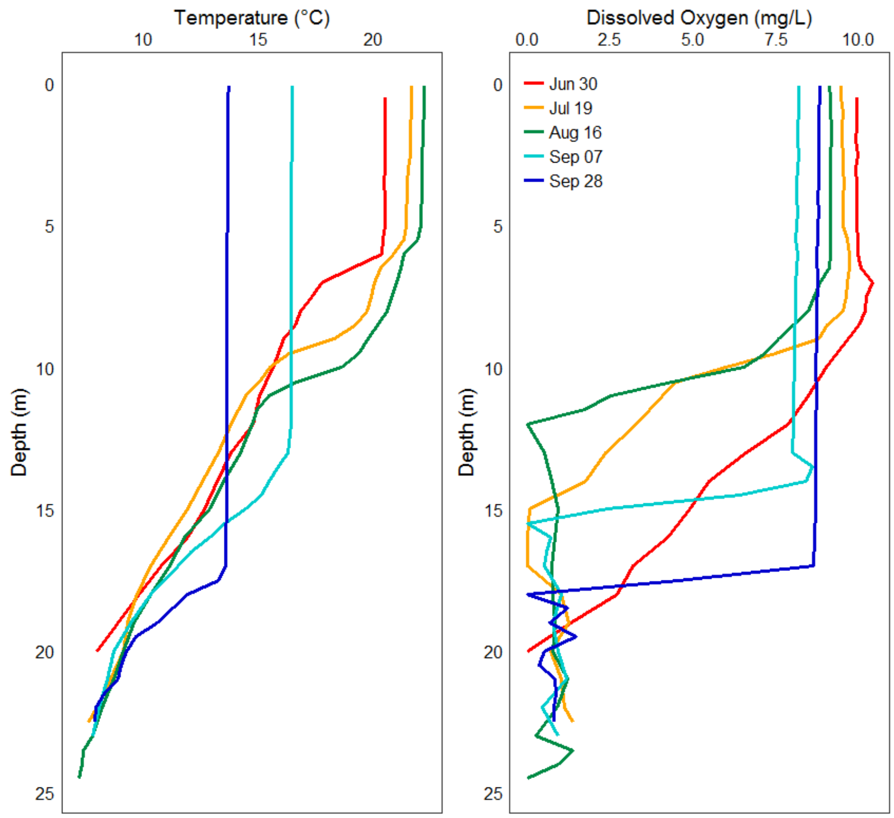


Figure 3 – a) Temperature (°C) and b) dissolved oxygen (mg/L) profiles for Frog Lake measured five times over the course of the summer of 2016.

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.

Table 1 – Microcystin concentrations measured five times at Frog Lake in 2016. Microcystin levels remained below the guideline for recreational use at all sampling dates.

Date	Microcystin Concentration (μg/L)
Jun 30	0.17
Jul 19	0.12
Aug 16	0.13
Sep 7	0.14
Sep 28	0.15
Average	0.142

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 mussel veligers using a plankton net and monitoring for attached adult mussels using substrates installed in each lake. In 2016, no invasive mussels were detected in Frog Lake.

WATER LEVELS

There are many factors influencing water quantity. Some of these factors include the size of the lakes 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 Frog Lake have declined since Alberta Environment began monitoring the lake in 1968 (Figure 4). Since 1968, Frog Lake water levels have fluctuated, but declined from a maximum of 575.3 m asl to a minimum of 570.9 m asl.

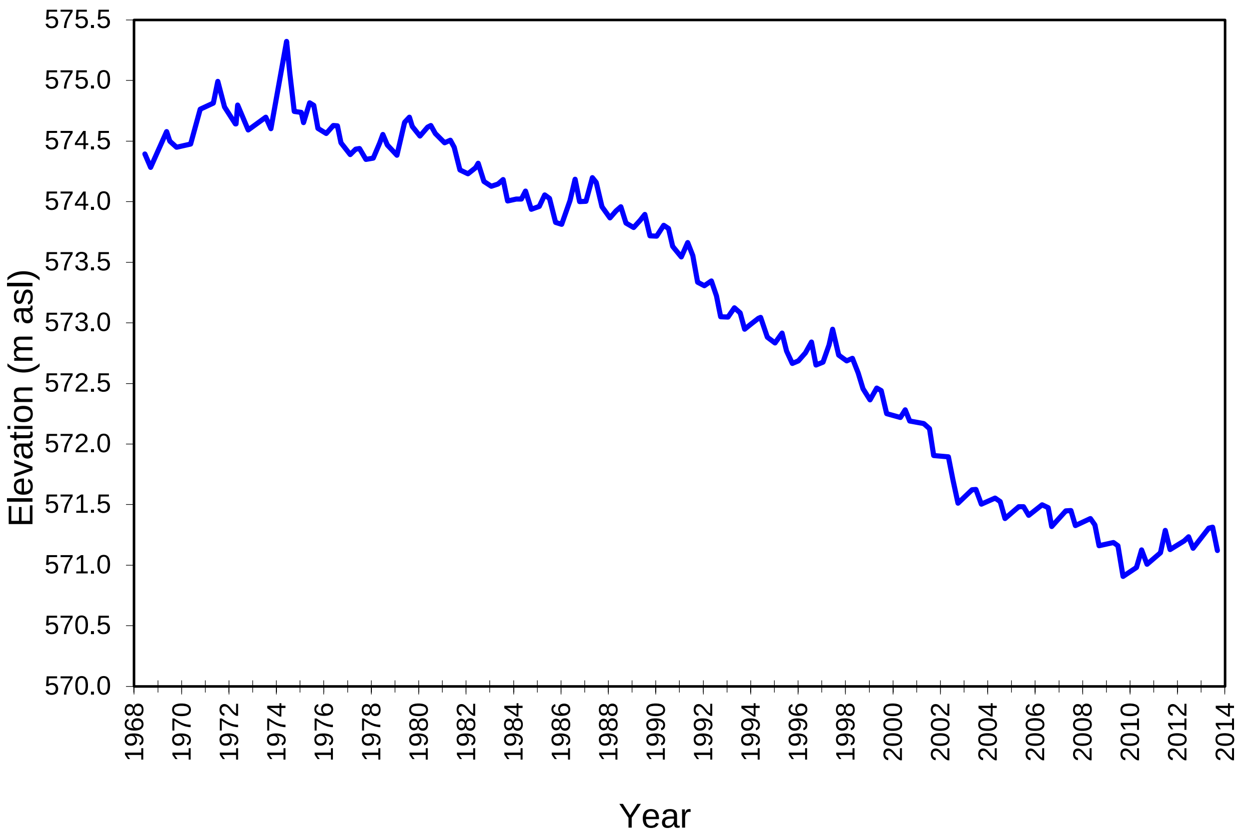


Figure 4- Water levels measured in meters above sea level (m asl) from 1968- 2014. Data retrieved from Alberta Environment.

Table 2: Average Secchi depth and water chemistry values for Frog Lake. Historical values are given as reference.

Parameter	May 1976	June 1978	March 1986	2003	2004	2005	2006	2016
TP (µg/L)	-	-	12	18	26	30	36	17
TDP (µg/L)	-	-	-	7.3	11	7.5	10.5	4
Chlorophyll-*a* (µg/L)	-	-	-	6.1	7.1	5.7	3.87	5.0
Secchi depth (m)	-	-	-	2.80	3.60	3.25	2.50	3.75
TKN (mg/L)	-	-	9.2	1.2	1.2	1.3	1.3	1.1
NO_2 and NO_3 (µg/L)	29	2	41	23	5.3	-	-	2.5
NH_3 (µg/L)	-	-	29	26	22	14.5	11.5	25
DOC (mg/L)	-	-	-	-	-	-	-	14.4
Ca (mg/L)	-	25	25	18	17	16	31	15
Mg (mg/L)	36	43	51	64	60	54	31	78
Na (mg/L)	41	73	55	75	78	80	19	94
K (mg/L)	12	12	14	17	17	17	11	21
SO_4^{2-} (mg/L)	48	73	67	91	90	92	24	132
Cl^- (mg/L)	7	28	7	11	11	10.3	1.7	14.6
CO_3 (mg/L)	-	11	14	35	35	36	11	42.6
HCO_3 (mg/L)	-	377	360	386	388	256	384	404
pH	8.7	8.6	8.7	8.9	8.9	8.9	8.6	8.9
Conductivity (µS/cm)	540	574	691	-	834	845	463	950
Hardness (mg/L)	-	-	-	-	-	-	-	360
TDS (mg/L)	347	413	410	500		494	255	600
Microcystin (µg/L)	-	-	-	-	-	-	-	0.142
Total Alkalinity (mg/L $CaCO_3$)	276	266	319	375	377	375	229	400

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

Metals (Total Recoverable)	2003	2004	2005	2006	2016	Guidelines
Aluminum µg/L	6.81	20.7	4.88	5.82	5.6	100[a]
Antimony µg/L	0.08	0.123	0.05	0.023	0.022	6[d]
Arsenic µg/L	1.89	1.78	1.5	1.1	0.585	5
Barium µg/L	15.27	14.8	27.7	39	31	1000[d]
Beryllium µg/L	0.02	0.002	0.003	0.003	0.004	100[c,e]
Bismuth µg/L	0.0043	0.0005	0.002	0.002	5.00E-04	/
Boron µg/L	152	143	104	55	21.3	1500
Cadmium µg/L	0.03	0.004	0.002	0.006	0.001	0.26[b]
Chromium µg/L	0.206	0.27	0.17	0.24	0.015	/
Cobalt µg/L	0.025	0.03	0.028	0.02	0.001	1000[e]
Copper µg/L	0.489	1.15	0.45	2.18	0.49	4[b]
Iron µg/L	1.5	8.0	14.9	-	25.9	300
Lead µg/L	0.151	0.19	0.08	0.08	0.03	7[b]
Lithium µg/L	40.17	46.7	32	18.2	7.33	2500[f]
Manganese µg/L	6.2	4.37	20	43.5	14.2	200[f]
Molybdenum µg/L	0.264	0.278	0.44	0.37	0.163	73[c]
Nickel µg/L	0.03	0.0025	0.23	0.005	0.004	150[b]
Selenium µg/L	0.25	0.32	0.14	0.33	0.12	1
Silver µg/L	0.0025	0.0011	0.0022	-	0.001	0.25
Strontium µg/L	106	98.3	133	166	85.9	/
Thallium µg/L	0.018	0.0006	0.0003	0.0003	0.001	0.8
Thorium µg/L	0.005	0.0042	0.007	0.002	0.00045	/
Tin µg/L	0.07	0.015	0.032	0.03	0.021	/
Titanium µg/L	1.0	0.45	0.93	1.5	0.65	/
Uranium µg/L	0.287	0.305	0.306	0.254	0.062	15
Vanadium µg/L	0.513	0.329	0.286	0.249	0.07	100[e,f]
Zinc µg/L	1.14	1.59	2.87	2.36	0.4	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 Canadian Drinking Water Quality guideline values.
[e] Based on CCME Guidelines for Agricultural use (Livestock Watering).
[f] Based on CCME Guidelines for Agricultural Use (Irrigation).
A forward slash (/) indicates an absence of data or guidelines.