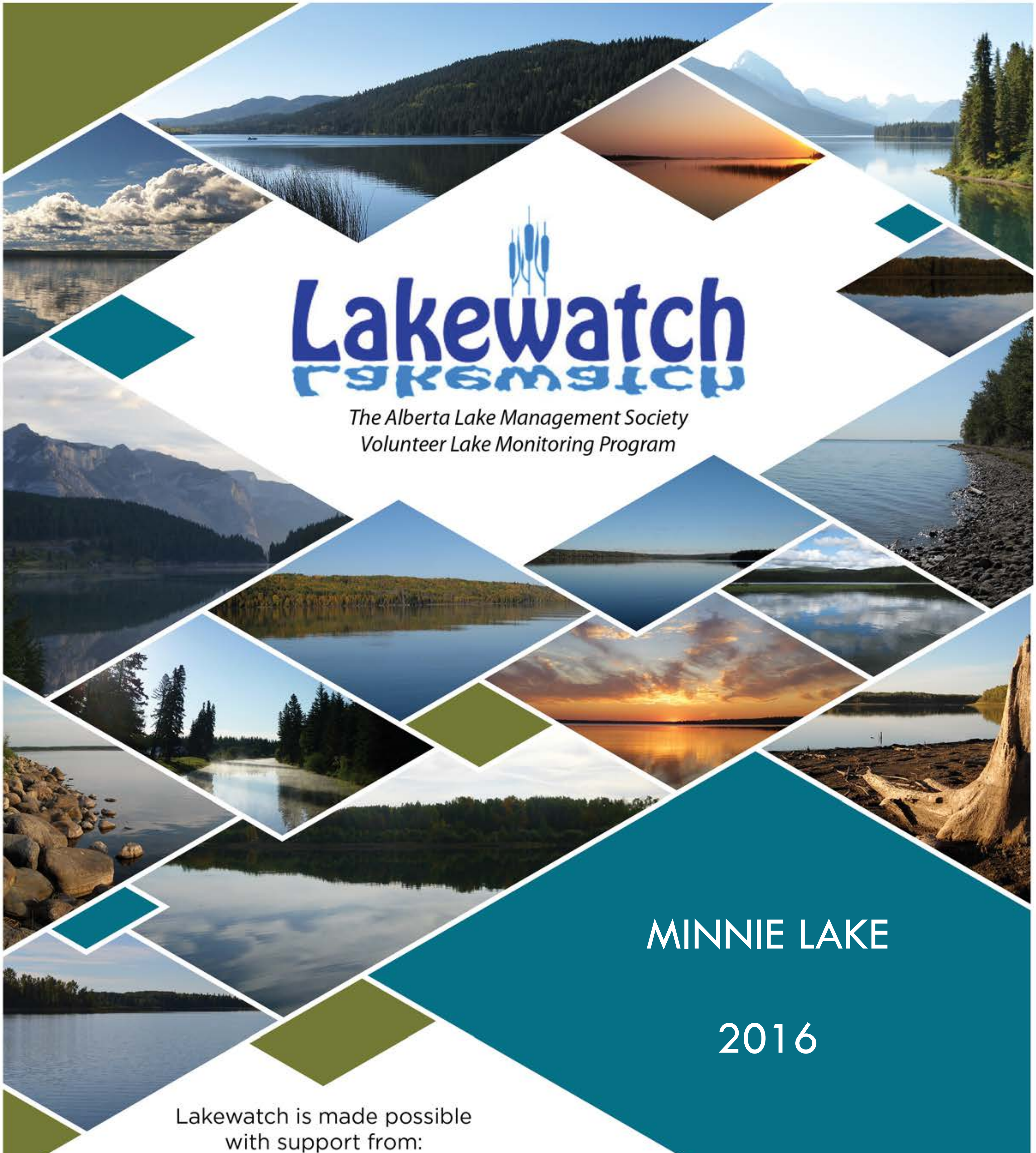

Lakewatch

The Alberta Lake Management Society
Volunteer Lake Monitoring Program

MINNIE LAKE

2016

Lakewatch is made possible
with support from:

This project was undertaken with the financial support of:
Ce projet a été réalisé avec l'appui financier de :

Environment and Climate Change Canada / Environnement et Changement climatique Canada

Alberta Environment and Parks

Pigeon Lake Watershed Association

Cargill

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 Garry & Nadine Kissel for the time and energy put into sampling Minnie 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.

MINNIE LAKE

Minnie Lake is a small lake located west of Bonnyville and northeast of Glendon within the Beaver River Watershed. The lake is 2 km long and 0.6 km wide, with a surface area of 0.84 km^2. Mean depth is 8.3 m and maximum depth is 21.45 m, though water levels have decreased since these values were calculated.
The shoreline of the lake hosts two municipal campsites, private cabins and recreational properties, agricultural land, and boreal forest. Minnie Lake is spring-fed by the Beverly channel aquifer and surface runoff from precipitation. In 2006-2007 the lake experienced a winterkill, which decimated stocks of northern pike and yellow perch that previously supported a recreational fishery. Fish populations have not recovered to date.

Minnie Lake- photo by Pauline Pozsonyi 2011

The watershed area for Minnie Lake is 4.43 km^2 and the lake area is 0.67 km^2. The lake to watershed ratio of Minnie Lake is 1:7. A map of the Minnie Lake watershed area can be found here.

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.

Total phosphorus (TP) in Minnie Lake had an average concentration of 19 µg/L in 2016, putting it in the mesotrophic classification (Table 2). TP levels in Minnie Lake in 2016 were historically low, and fell within a lower trophic classification than in previous years. TP decreased throughout the summer, with the maximum concentration of 26 µg/L on June 27 (Figure 1).

Chlorophyll-*a* concentrations remained relatively stable over the course of the summer, with an average concentration of 7 µg/L in 2016 (Table 2). This puts Minnie Lake in the mesotrophic trophic status class. A maximum concentration of 8.7 µg/L was reached on August 24 (Figure 1).

Minnie Lake had an average TKN concentration of 1.48 mg/L over five sampling dates in 2016 (Table 2). On June 27, TKN concentrations were at a seasonal maximum of 1.6 mg/L , and decreased throughout the sampling season(Figure 1).

Average pH measured as 8.86 in 2016, buffered by moderate alkalinity (356 mg/L $CaCO_3$) and bicarbonate (360 mg/L HCO_3). Magnesium, sodium and sulphate were the dominant ions contributing to a relatively high conductivity measure of 1400 uS/cm (Table 2).

METALS

Samples were analyzed for metals once in 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 Minnie Lake and most measured values fell within their respective guidelines (Table 3). However, arsenic fell above its recommended guideline of 5 mg/L, measuring 8.34 mg/L in Minnie Lake in 2016. This is a typical result for Minnie Lake as previous records have confirmed high arsenic concentrations. High arsenic levels are well known in the Beaver River Watershed area due to the region's natural geology.

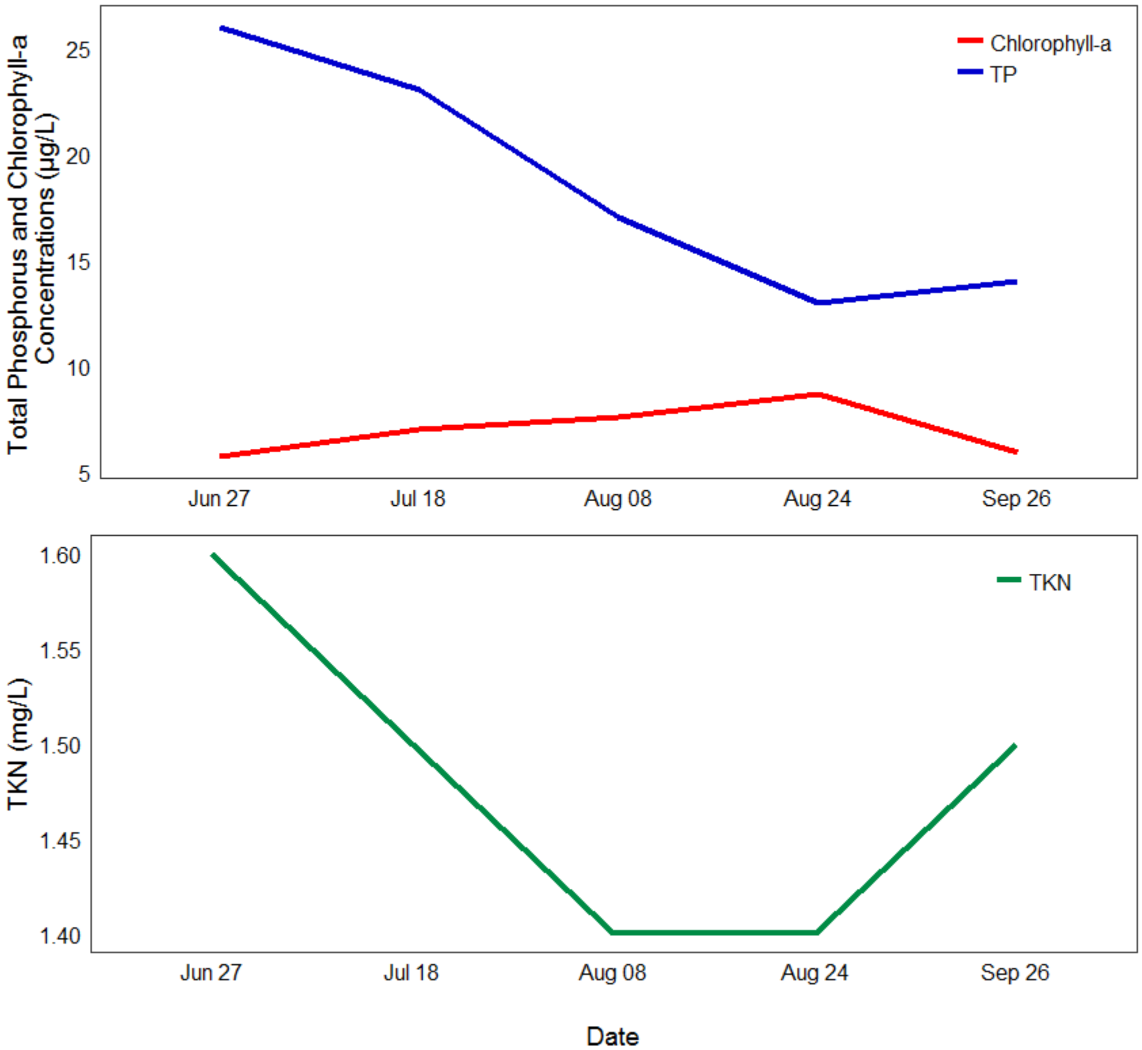

Figure 1- Total Phosphorus (TP), Total Kjeldahl Nitrogen (TKN), and Chlorophyll-*a* concentrations measured five times over the course of the summer at Minnie Lake.

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.

Average Secchi depth in 2016 was 1.90 m, classifying Minnie Lake as eutrophic, or productive (Figure 2). This is historically low for Minnie Lake. A maximum Secchi depth of 2.75 m was recorded on September 26, but it is unclear what caused the fluctuations in water quality over the course of the sampling season.

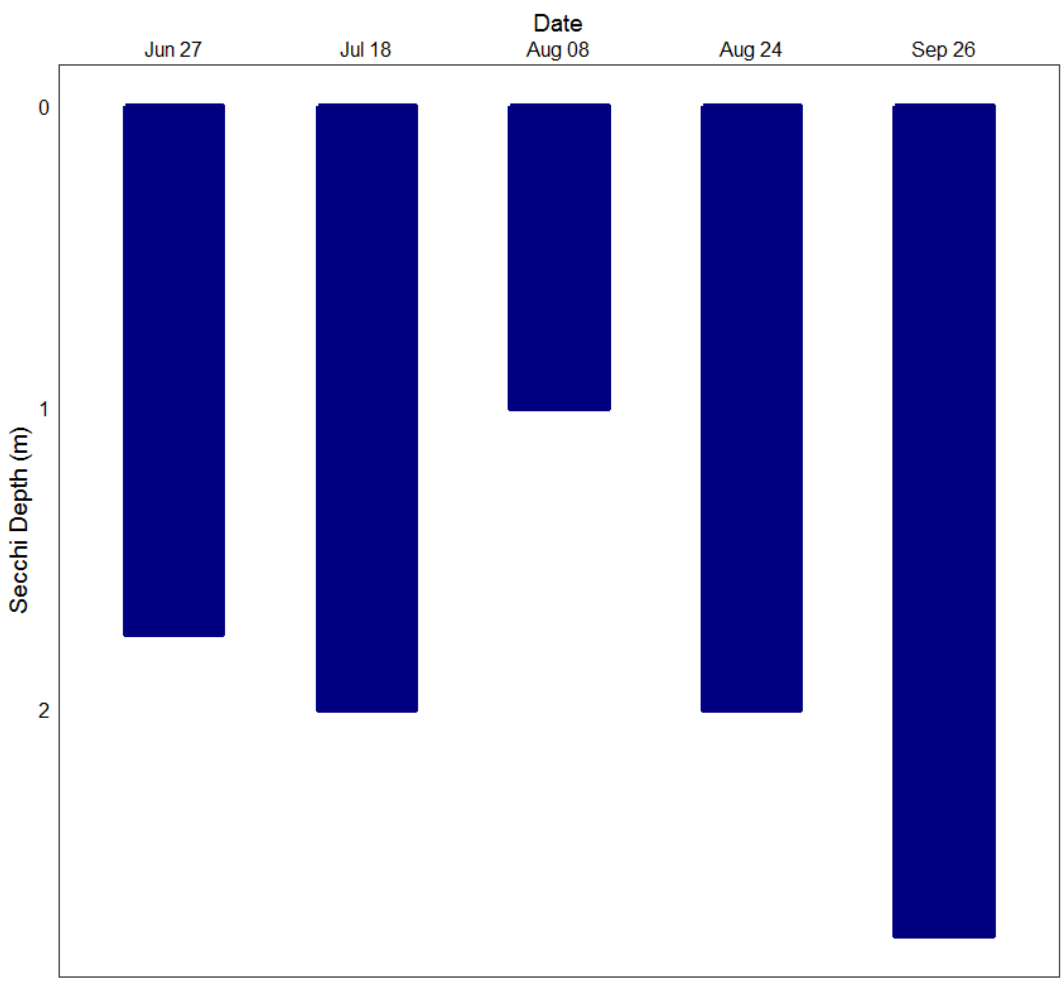

Figure 2 – Secchi depth values measured five times over the course of the summer at Minnie Lake in 2016.

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.

Minnie Lake water temperatures varied throughout the summer (Figure 3a). A maximum temperature of 22.46 °C was observed on July 18. Given the depth of Minnie Lake, it remains strongly thermally stratified for the entire sampling season, with the thermocline remaining around 5 m until it deepens to closer to 8 m on September 26.

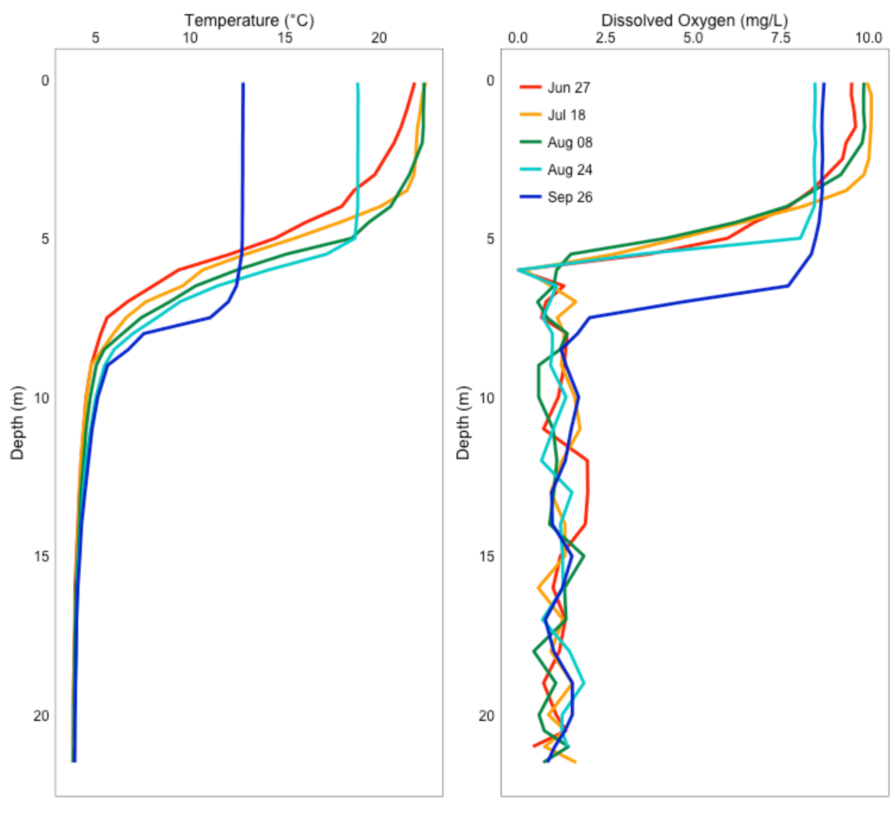

Figure 3 – a) Temperature (°C) and b) dissolved oxygen (mg/L) profiles for Minnie Lake measured five times over the course of the summer of 2016.

Minnie 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). Minnie Lake reached anoxic conditions at the bottom on all sampling occasions. This is due to the separation of atmospheric oxygen from the surface by way of thermal stratification. Oxygen levels are choppy below the thermocline, possibly due to decomposition or photosynthetic activity near the bottom.

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 Minnie Lake in 2016. Measured concentrations remained below the recommended guidelines at all visits in 2016.

Date	Microcystin Concentration (μg/L)
Jun 27	0.13
Jul 18	0.11
Aug 8	0.05
Aug 24	0.14
Sep 26	0.12
Average	0.11

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 Minnie 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 Minnie Lake have declined since Alberta Environment began monitoring the lake in 1981 (Figure 4). Since 1981, Minnie Lake water levels have fluctuated and declined 3.3 m between 551.2 m asl and 554.5 m asl. Data from Alberta Environment was only available until 2014.

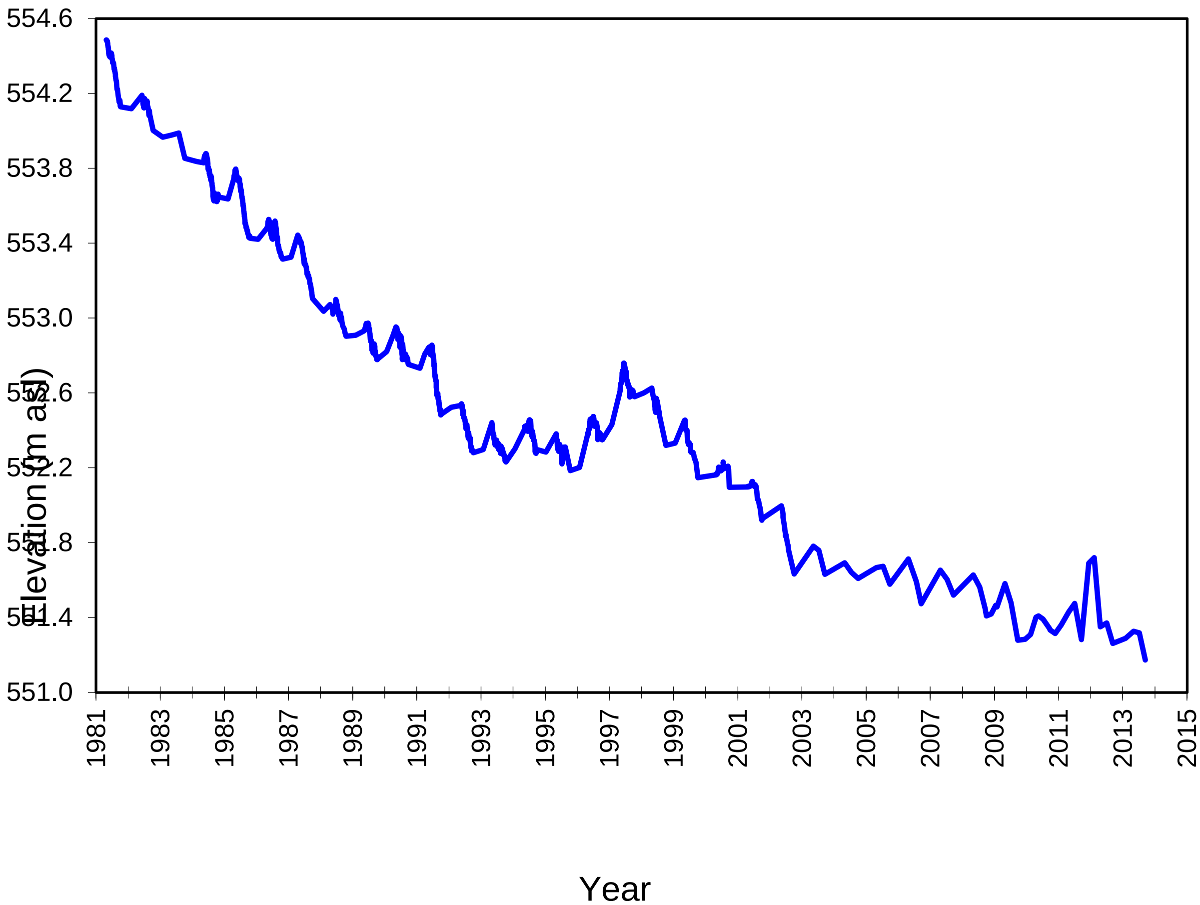

Figure 4- Water levels measured in meters above sea level (m asl) from 1981- 2014. Data retrieved from Alberta Environment.

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

Parameter	1978	1979	1985	2008	2009	2010	2011	2012	2013	2014	2015	2016
TP (µg/L)	/	/	21	40	42.25	38.8	52.4	44.75	32.2	33.75	24.4	19
TDP (µg/L)	/	/	11	23.8	22.5	27	25.6	22	21.2	24.25	10.6	8
Chlorophyll-*a* (µg/L)	/	/	6	5.26	4.03	3.44	5.16	6.42	3.02	4.1*	4.76	7
Secchi depth (m)	/	/	/	4.5	2.19	4.7	3.85	3.81	3.32	3.67	2.55	1.9
TKN (mg/L)	/	/	1.153	1.504	1.533	1.608	1.834	1.655	1.644	1.460	1.520	1.48
NO_2 and NO_3 (µg/L)	/	/	6	21	7.625	12.1	13.9	11.38	2.5	38	2.5	2.5
NH_3 (µg/L)	/	/	50	6.2	35.75	99.2	35	42.25	23.6	50.2	31	25
DOC (mg/L)	/	/	13.2	18.27	19.5	19.6	19	19.4	22.03	17.7	18	18.6
Ca (mg/L)	29	30	19.4	26.6	25.73	21.8	25.6	24.2	22.93	22.67	26.4	22.6
Mg (mg/L)	90	87	91	120.3	121.3	123.3	131.3	121	143.67	124	144	142
Na (mg/L)	62	61	68	94.23	96.6	97.2	95.8	95.63	98.9	103.33	95.5	96.6
K (mg/L)	11.7	9.4	13.1	23.3	19.07	18.57	18.5	19.87	21.03	20.17	20	20
SO_4^{2-} (mg/L)	223	211	197	398.7	421	408.67	400	450.7	391	433.33	440	428
Cl^- (mg/L)	3	3	4.4	7.13	6.93	7.47	7.3	7.6	6.8	7.5	7.95	7.86
CO_3 (mg/L)	/	/	21	25.67	31.33	23	29	28	44.8	37.94	36.8	37.8
HCO_3 (mg/L)	340	398	368	408.3	389.67	412	393.4	398	358.6	424.6	376	360
pH	8.9	8.6	8.6-8.9	8.627	8.8	8.65	8.77	8.73	8.88	8.78	8.82	8.86
Conductivity (µS/cm)	922	981	992	1340	1323.3	1370	1350	1367.5	1418	1360	1400	1400
Hardness (mg/L)	442	435	422	561.67	563.67	562.3	605	558.3	648.67	567	660	634
TDS (mg/L)	614	611	595	897.3	914	902.67	902	943.3	906	948.33	962	932
Microcystin (µg/L)	/	/	/	0.1275	0.1125	0.076	0.11	0.135	0.088	0.076	0.07	0.11
Total Alkalinity (mg/L $CaCO_3$)	324	316	338	378.3	371.67	376	371.2	373	369	352	370	356

*Incorrect value has been replaced with a corrected value April 11 2019.

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

Metals (Total Recoverable)	**2008**	**2009**	**2010**	**2011**	**2013**	**2014**	**2015**	**2016**	**Guidelines**
Aluminum µg/L	13.7	13	14.26	14.84	22.55	17.4	9.95	7.1	100[a]
Antimony µg/L	0.382	0.375	0.392	0.3725	0.3685	0.349	0.3985	0.415	6[d]
Arsenic µg/L	9.15	9.33	9.56	9.07	9.83	9.875	10.36	8.34	5
Barium µg/L	20.6	18.7	18.5	18.25	12.65	12.35	14.9	12	1000[d]
Beryllium µg/L	<0.003	<0.003	0.005	0.0015	0.0057	0.004	0.004	0.004	100[c,e]
Bismuth µg/L	0.0073	0.0057	0.00385	0.0005	0.00795	0.0005	0.0005	5.00E-04	/
Boron µg/L	162	205.5	159.5	204.5	186.5	185	185	187	1500
Cadmium µg/L	0.0124	0.0187	0.01725	0.01385	0.0036	0.00186	0.002	0.001	0.26[b]
Chromium µg/L	0.494	0.394	0.169	0.2575	0.3065	0.292	0.125	0.07	/
Cobalt µg/L	0.111	0.092	0.0972	0.07485	0.09775	0.0687	0.0875	0.102	1000[e]
Copper µg/L	0.332	2.09	0.6815	1.0825	1.3	0.9025	1.665	1.48	4[b]
Iron µg/L	10.9	43.6	16.1	8.9	29.3	16.85	13.1	10.7	300
Lead µg/L	0.0274	0.0544	0.0851	0.03275	0.0617	0.01115	0.029	0.03	7[b]
Lithium µg/L	74.1	101.5	84.05	106.5	93.95	92.95	89.3	101	2500[f]
Manganese µg/L	8.61	6.36	5.905	15.75	4.515	6.78	7.38	2.94	200[f]
Molybdenum µg/L	0.799	0.727	0.746	0.735	0.6685	0.5695	0.6185	0.597	73[c]
Nickel µg/L	0.271	0.665	0.3805	0.15125	0.5225	0.3475	0.3825	0.775	150[b]
Selenium µg/L	0.2	0.292	0.232	0.228	0.089	0.123	0.085	0.12	1
Silver µg/L	0.0022	0.0082	0.0029	0.00025	0.01125	0.001	0.001	0.001	0.25
Strontium µg/L	74	69.7	55	73.25	49.7	58.7	76	50.1	/
Thallium µg/L	0.0026	0.0029	0.00555	0.000275	0.0015	0.00085	0.00045	9.0E-04	0.8
Thorium µg/L	0.0628	0.00215	0.01825	0.01015	0.0321	0.011375	0.002225	0.0086	/
Tin µg/L	0.0308	<0.03	0.015	0.015	0.015	0.00825	0.0135	0.01	/
Titanium µg/L	0.667	0.691	1.0995	0.686	1.1145	0.685	0.875	0.54	/
Uranium µg/L	2.3	2.08	2.16	2.14	2.1	2.165	2.26	2.31	15
Vanadium µg/L	1.31	1.22	1.165	1.06	1.035	1.04	1.265	1.36	100[e,f]
Zinc µg/L	1.58	1.34	1.165	1.48	1.465	1.58	1.55	2.3	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 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.