Lakewatch

THE ALBERTA LAKE MANAGEMENT SOCIETY
VOLUNTEER LAKE MONITORING PROGRAM

2015 Gull Lake Report

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Beaver River Watershed Alliance

aemera.org

LICA
Lakeland Industry & Community Association

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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.

Historical data has been re-queried and summarized for the 2012 report.

Acknowledgements

The LakeWatch program is made possible through the dedication of its volunteers. We would like to thank Norval Horner, Craig MacLeod, Glenn Fraser, Derek Robertson, and Paul Qneski for their assistance with sampling Gull Lake in 2015. We would also like to thank Laticia McDonald, Ageleky Bouzetos, and Mohamad Youssef who were summer technicians with ALMS in 2015. Executive Director Bradley Peter was instrumental in planning and organizing the field program. Mike Bilyk was involved in the training aspects of the program. Lisa Reinbolt was responsible for data management. This report was prepared by Bradley Peter and Alicia Kennedy. The Beaver River Watershed Alliance (BRWA), the Lakeland Industry and Community Association (LICA), the Alberta Environmental Monitoring Evaluation and Reporting Agency (AEMERA), and Environment Canada, were major sponsors of the program.

GULL LAKE:

Gull Lake has a large surface area (80.6 km^2) and is considered to be a shallow lake (mean depth = 5.4 meters; Figure 1). The lake is situated approximately 17 km east of the town of Lacombe and 136 km south from the city of Edmonton. As this lake is situated between two large cities (Edmonton and Calgary), it is heavily populated and visited frequently.

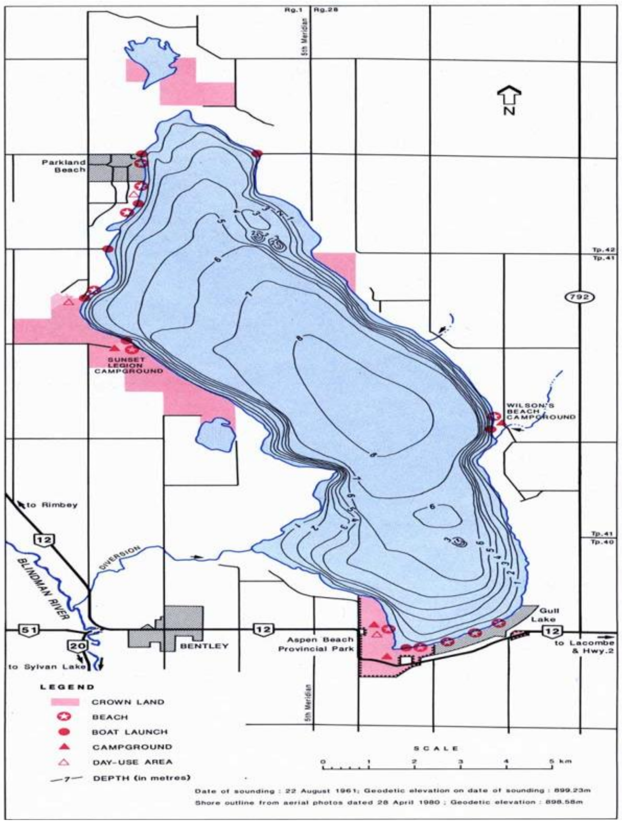

Figure 1 – Bathymetric map of Gull Lake obtained from Alberta Environment.

The surrounding region of Gull Lake was settled in 1805. At the turn of the 20th century, a lumber industry was established at the lake. A steamboat was used for the sawmill operation as well as for the transportation of passengers. By 1908, the lake served as a hydroelectric reservoir; however, in 1910, the dam was destroyed. Following the destruction of the dam, Gull Lake water levels continually decreased and were a cause for concern. Although the community of Gull Lake had a dam built at the outlet in 1921, the water level nonetheless continued to decrease. The dam is now located approximately 1.6 km from shore, and the water level dropped, on average, ~6 cm/yr from 1924 to 1968. By 1977, a pipeline and canal was built, diverting water from the Blindman River to increase water levels when they fell below a specified target. The diversion pumps were operated in 2010 and water was transferred into Gull Lake.

The lake is renowned for its clear water and sandy beaches. It also supports moderate sport fishing of predominantly northern pike, walleye, and whitefish. It supports many recreational activities such as boating, swimming, fishing, and sailing. There are many cottages along the lake's shoreline and new subdivisions and commercial campgrounds are being proposed in upland areas within the watershed. Aspen Beach Provincial Park lies on the southwest shore of the lake, which was established in 1932, making it one of the first parks of the Alberta park system. The Provincial Park contains two campgrounds, a boat launch, beaches, and day use areas. There are marinas and boat launches located in various subdivisions around the lakeshore. The remaining majority of the watershed is used for agricultural activities and cattle production.

Gull Lake lies within two of Alberta's natural subregions: the Boreal Forest natural region on the northern half and the Parkland natural region on the southern half, they are within the Dry Mixedwood and Central Parkland sub-regions respectively. The dominant trees are trembling aspen, balsam poplar, white spruce, and willow in between large cultivated areas.

WATER QUANTITY:

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.

The drainage basin of Gull Lake is approximately two-times the lake's surface area. There are presently only minor inlets and no outlet streams (the outlet has been completely dry for decades), which in part explains why Gull Lake is prone to decreasing lake levels. The pumping from Blindman Creek adds water to the lake in order to reach a target elevation of 899.16 metres above sea level (m asl). In 2012, Gull Lake measured an average of 899.3044 m asl.

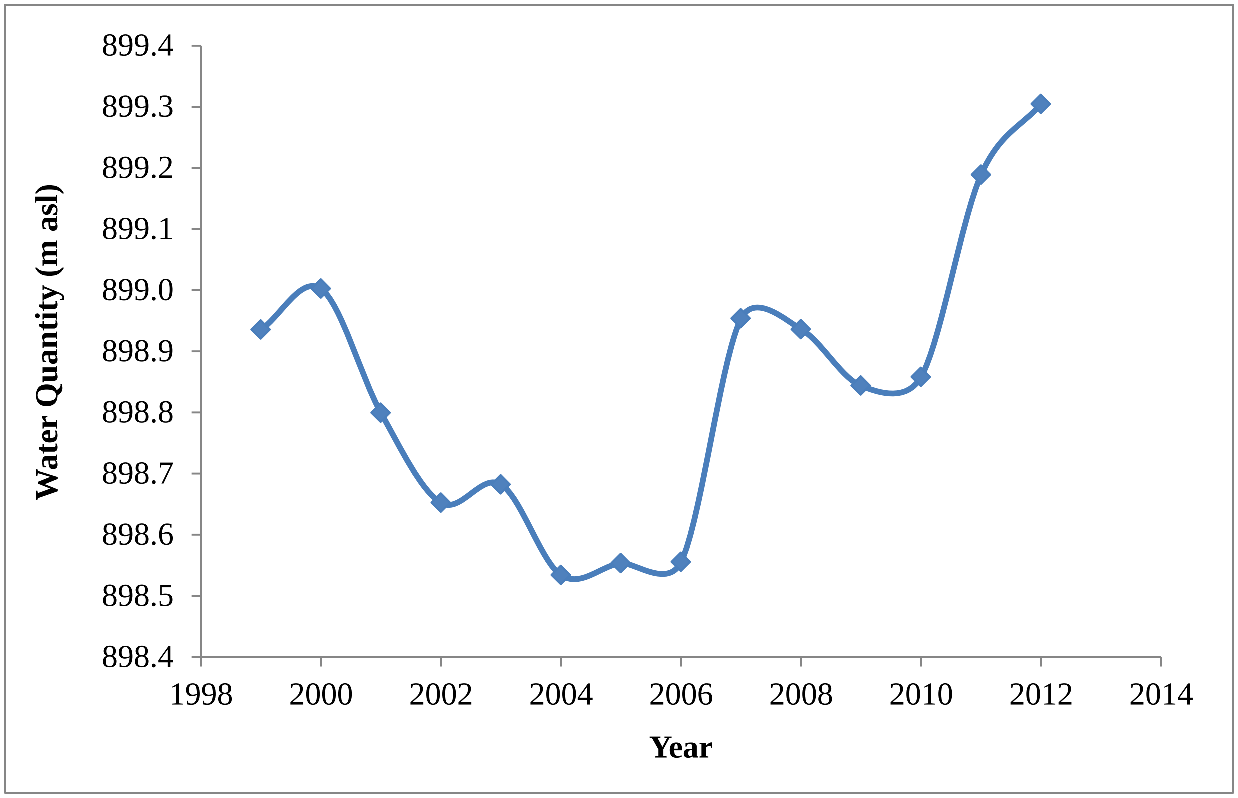

Figure 2 – Historical water levels measured as water quantity in meters above sea level (m asl) for Gull Lake from 1999-2012. Data retrieved from Environment Canada.

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.

Secchi depth at Gull Lake averaged 1.68 m in the summer of 2015 (Table 2). This value is comprised of a maximum water clarity measurement of 2.30 m on June 17th and a minimum water clarity measurement of 1.40 m on August 14th (Figure 3). At many lakes across Alberta, Secchi depth decreases as water temperatures increase and phytoplankton populations become denser. An average value of 1.68 m falls on the low end of historical observations (Table 2) – though Gull Lake shows little variance in its water clarity.

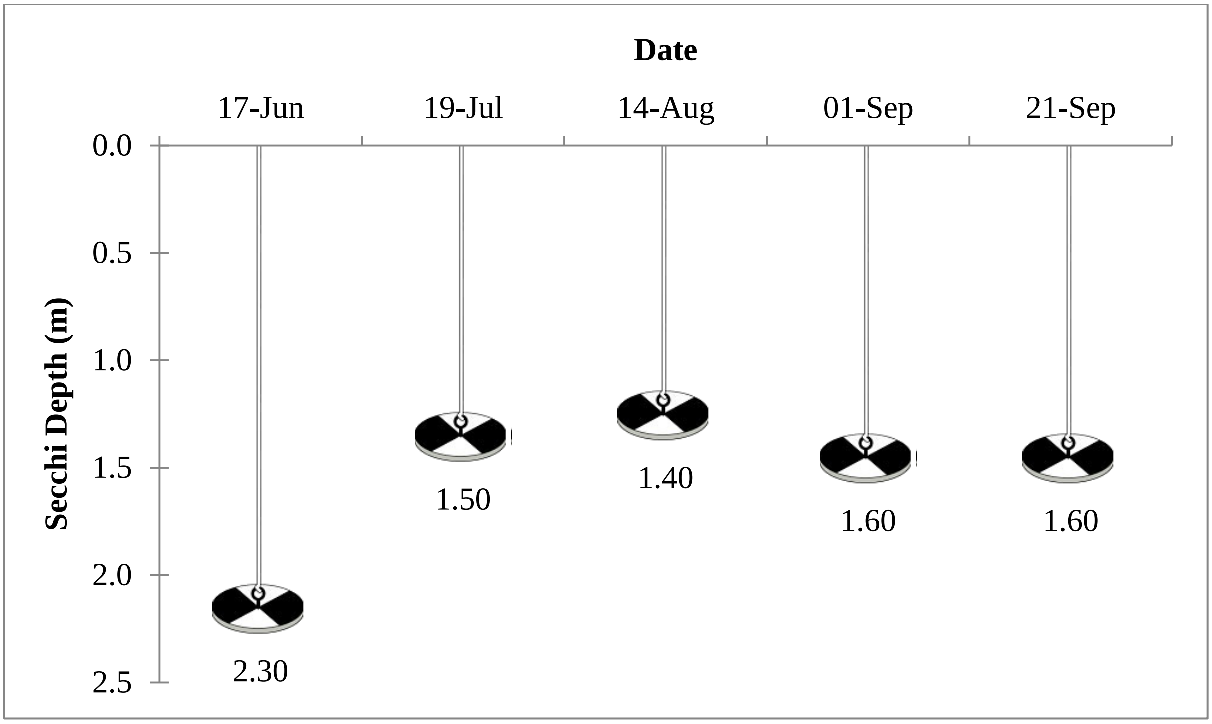

Figure 3 – Secchi depth values measured five times over the course of the summer at Gull Lake in 2015.

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.

Due to its large size and shallow depth, Gull Lake was well mixed for much of the summer. Thermal stratification was observed only once on Gull Lake, on August 14th, between 5.0-6.0 m depth (Figure 4a). This stratification has important implications for dissolved oxygen concentrations. A maximum surface water temperature of 21.50 °C was observed on August 14th while a minimum surface water temperature of 12.74 °C was observed on September 21st. Gull Lake was warm throughout the water column on both July 19th and August 14th, when it measured over 19 °C at the lake sediments.

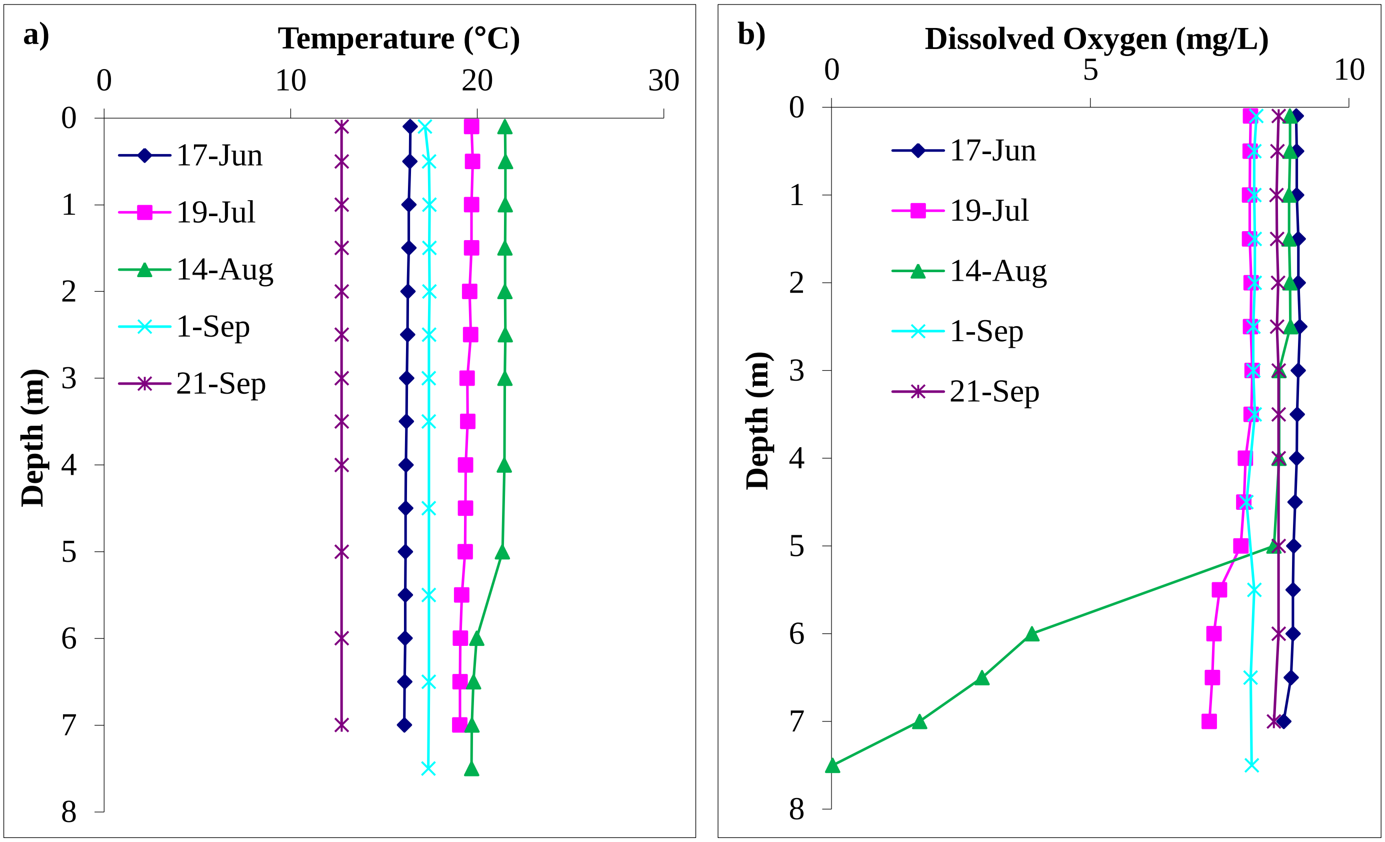

Figure 4 – a) Temperature (°C) and b) dissolved oxygen (mg/L) profiles for Gull Lake measured five times over the course of the summer of 2015.

Gull Lake was well oxygenated throughout the summer of 2015 (Figure 4b). Concentrations regularly measured above the Canadian Council for Ministers of the Environment guidelines for the Protection of Aquatic Life of 6.5 mg/L. Gull Lake only proceeded below the recommended guidelines on August 15th when thermal stratification likely prevented the mixing of atmospheric oxygen into deeper waters.

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 1 for a complete list of parameters.

Average Total Phosphorus (TP) in 2015 measured 26 μg/L (Table 2). This value falls on the low end of the historical variation previously observed at Gull Lake and results in a classification of mesotrophic, or moderately productive. TP concentration reached a maximum of 32 μg/L on July 19th and a minimum of 20 μg/L on June 17th (Figure 5).

Average Total Kjeldahl Nitrogen (TKN) measured 1.4 mg/L in 2015. Similar to TP, this value falls on the low end of the historical variation observed at Gull Lake (Table 2).

Average chlorophyll-*a* concentration measured 8.54 μg/L in 2015 (Table 2). This value falls well within the historical variation observed at Gull Lake – in addition, a value of 8.54 μg/L results in a trophic classification of mesotrophic or moderately productive. Chlorophyll-*a* concentration fluctuated little throughout the summer, measuring a minimum of 4.0 μg/L on June 17th and a maximum of 11.6 μg/L (Figure 5). Surface blooms of *Lyngbya* spp. which were observed in 2012 were not observed in 2015. Low concentrations of microcystin toxin were detected in Gull Lake – suggesting a small portion of the phytoplankton community is comprised of microcystin producing species of cyanobacteria.

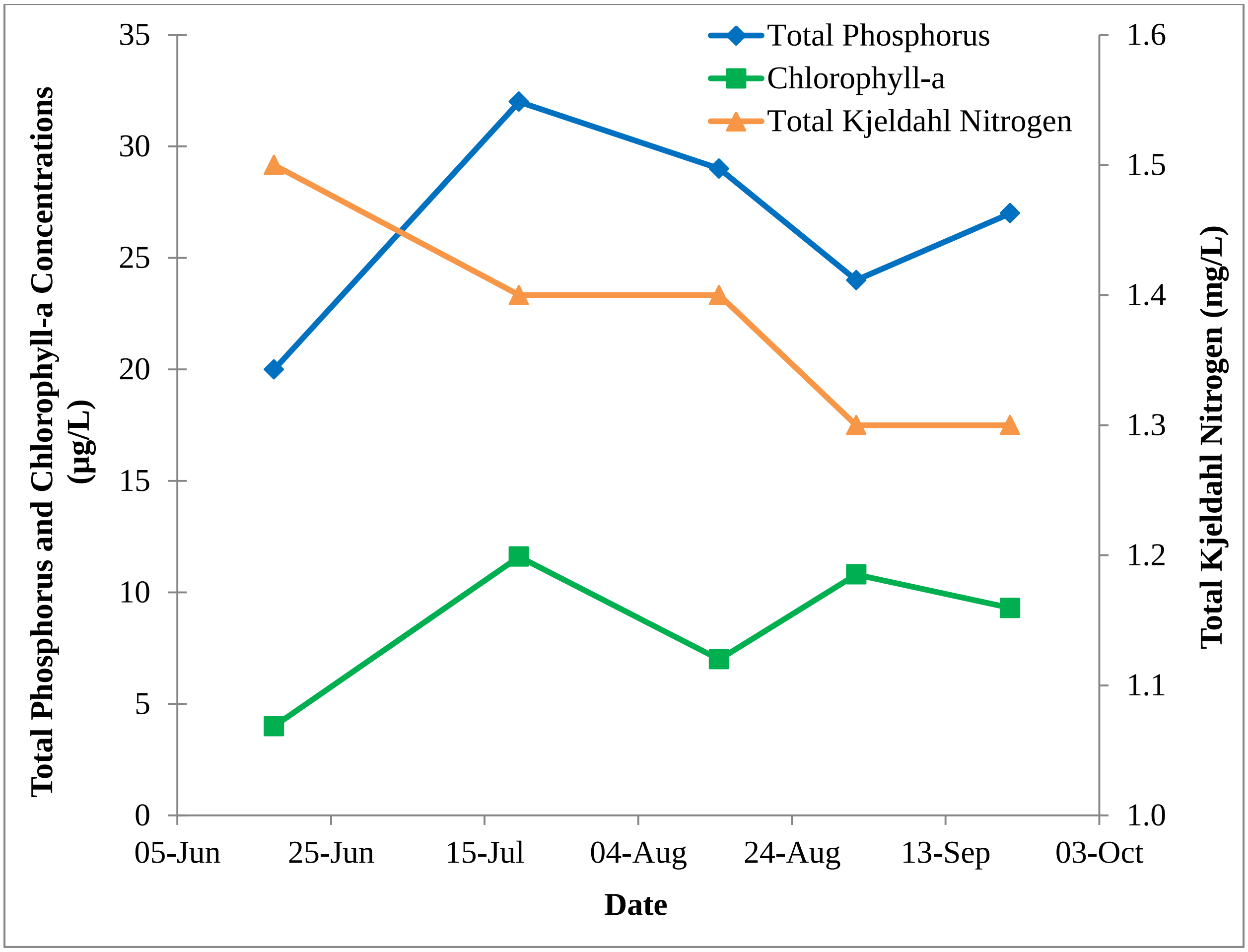

Figure 5 – Total Phosphorus (TP), Total Kjeldahl Nitrogen (TKN), and Chlorophyll-*a* concentration measured five times over the course of the summer at Gull Lake.

Average pH in Gull Lake measured 9.08 - this value is well above neutral (Table 2). Gull Lake has high alkalinity (666 mg/L $CaCO_3$) which helps to buffer the lake against changes to pH. Gull Lake has high conductivity (1280 uS/cm). Dominant ions contributing to Gull Lake's conductivity include sodium (194 mg/L) magnesium (64.4 mg/L) and sulphate (81.6 mg/L).

Metal concentrations were measured twice over the summer at Gull Lake and all concentrations, with the exception of arsenic (7.05 μg/L), fell within their respective guidelines (Table 3). In certain parts of the province, the geology surrounding a lake can contribute to elevated arsenic concentration (e.g. the Beaver River watershed).

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.

In 2015, low concentrations of microcystin were detected in Gull Lake and all values fell below the recommended recreational guidelines of 20 μg/L (Table 1). An average concentration of 0.21 μg/L was observed over five sampling trips (Table 1). Little variation existed in microcystin concentrations: a minimum concentration of 0.16 μg/L was observed on June 17th while a maximum concentration of 0.26 was observed on September 1st. As microcystin is not the only cyanobacterial toxin, caution should always be observed when recreating in visible cyanobacteria.

Table 1 – Microcystin concentrations measured five times at Gull Lake in 2015.

Date	Microcystin Concentration (μg/L)
17-Jun-15	0.16
19-Jul-15	0.20
14-Aug-15	0.16
01-Sep-15	0.26
21-Sep-15	0.25
Average	**0.21**

INVASIVE SPECIES:

Quagga and Zebra mussels are invasive species which, if introduced to our lakes, will have significant negative ecological, economical, and recreational impacts. ALMS collects water samples which are analyzed for mussel veligers (juveniles) and monitors substrates for adult mussels. In order to prevent the spread of invasive mussels, always clean, drain, and dry your boat between lakes. To report mussel sightings or mussel-fouled boats, call the confidential Alberta hotline at 1-855-336-BOAT.

In 2015, no zebra or quagga mussels were detected in Gull Lake.

Table 2 - Average Secchi disk depth and water chemistry values for Gull Lake. Previous years averages are provided for comparison.

Parameter	**2006**	**2008**	**2010**	**2012**	**2015**
TP (µg/L)	40.3	56.8	41.7	42.6	26
TDP (µg/L)	17.5	17.3	14.0	17.2	9
Chl-*a* (µg/L)	9.39	9.81	6.99	10.046	8.54
Secchi depth (m)	1.65	2.00	2.83	1.95	1.68
TKN (mg/L)	1668	1800	1680	1490	1380
NO_2 and NO_3 (µg/L)	2.5	3	8.17	2.5	2.5
NH_3 (µg/L)	28.5	19.75	26	17.6	25
DOC (mg/L)	23.20	/	20.45	20.27	21
Ca (mg/L)	8.33	10.03	10.7	12.63	9
Mg (mg/L)	67.85	66.05	63.95	56.07	64
Na (mg/L)	233.5	205.5	228.5	194.3	194
K (mg/L)	21.7	19.75	21.95	21.4	21
SO_4^{2-} (mg/L)	90	79	95	94.7	82
Cl^- (mg/L)	5.85	7.5	7.5	7.6	9.0
CO_3 (mg/L)	103.5	98	76	77.6	93
HCO_3 (mg/L)	657.5	614.5	688.5	630.4	624
pH	9.17	9.1	9.01	9.09	9.08
Conductivity (µS/cm)	1323.3	1270	1297.5	1226.6	1280
Hardness (mg/L)	310.5	297	290	262.7	288
TDS (mg/L)	844.5	788	841.5	774.7	788
TSS	/	/	/	5.2	/
Microcystin (µg/L)	0.085	0.24	0.14	0.21	0.21
Total Alkalinity (mg/L $CaCO_3$)	712	666.75	691	646.6	666

Note: TP = total phosphorous, TDP = total dissolved phosphorous, Chl-*a* = chlorophyll-*a*, TKN = total Kjeldahl nitrogen. NO_{2+3} = nitrate+nitrite, NH_3 = ammonia, DOC = dissolved organic carbon, Ca = calcium, Mg = magnesium, Na = sodium, K = potassium, SO_4 = sulphate, Cl = chloride, CO_3 = carbonate, HCO_3 = bicarbonate, TDS = total dissolved solids, TSS = total suspended solids. A forward slash (/) indicates an absence of data.

Table 3 - Average concentrations of metals measured in Gull Lake on August 14th and September 21st. Values shown for 2015 are an average of those dates. The CCME heavy metal Guidelines for the Protection of Freshwater Aquatic Life (unless otherwise indicated) are presented for reference.

Metals (Total Recoverable)	**2012**	**2015**	**Guidelines**
Aluminum µg/L	45.2	84	100[a]
Antimony µg/L	0.2735	0.300	6[e]
Arsenic µg/L	7.085	7.05	5
Barium µg/L	48.3	35.05	1000[e]
Beryllium µg/L	0.0015	0.004	100[d,f]
Bismuth µg/L	0.0021	0.0005	/
Boron µg/L	161.5	156	5000[ef]
Cadmium µg/L	0.018	0.009	0.085[b]
Chromium µg/L	0.2445	0.205	/
Cobalt µg/L	0.07665	0.0895	1000[f]
Copper µg/L	0.881	0.84	4[c]
Iron µg/L	32.6	59.7	300
Lead µg/L	0.10525	0.132	7[c]
Lithium µg/L	42.95	42.35	2500[g]
Manganese µg/L	2.535	3.425	200[g]
Molybdenum µg/L	4.065	3.965	73[d]
Nickel µg/L	0.28	0.5	150[c]
Selenium µg/L	0.146	0.03	1
Silver µg/L	0.0034	0.002	0.1
Strontium µg/L	109	65.65	/
Thallium µg/L	0.000775	0.001775	0.8
Thorium µg/L	0.005775	0.010275	/
Tin µg/L	5	0.0095	/
Titanium µg/L	1.415	2.94	/
Uranium µg/L	2.61	2.74	100[e]
Vanadium µg/L	1.49	1.12	100[f,g]
Zinc µg/L	0.995	0.85	30

Values represent means of total recoverable metal concentrations.

[a] Based on pH ≥ 6.5; calcium ion concentrations $[Ca^{+2}]$ ≥ 4 mg/L; and dissolved organic carbon concentration [DOC] ≥ 2 mg/L.

[b] Based on water Hardness of 300 mg/L (as $CaCO_3$)

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

[d] CCME interim value.

[e] Based on Canadian Drinking Water Quality guideline values.

[f] Based on CCME Guidelines for Agricultural use (Livestock Watering).

[g] Based on CCME Guidelines for Agricultural Use (Irrigation).

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

A BRIEF INTRODUCTION TO LIMNOLOGY

INDICATORS OF WATER QUALITY:

Water samples are collected in LakeWatch to determine the chemical characteristics that characterize general water quality. Though not all encompassing, the variables collected in LakeWatch are sensitive to human activities in watersheds that can cause degraded water quality. For example, nutrients such as phosphorus and nitrogen are important determinants of lake productivity. The concentrations of these nutrients in a lake are impacted (typically elevated) by land use changes such as increased crop production or livestock grazing. Elevated nutrient concentrations can cause increases in undesirable algae blooms resulting in low dissolved oxygen concentrations, degraded habitat for fish and noxious smells. A large increase in nutrients over time may also indicate sewage inputs which in turn may result in other human health concerns associated with bacteria or the protozoan *Cryptosporidium*.

TEMPERATURE AND MIXING:

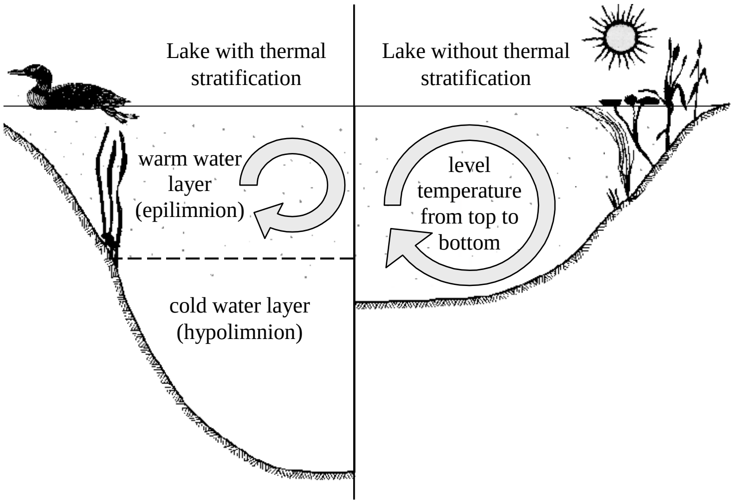

Figure A: Difference in the circulation of the water column depending on thermal stratification.

Water temperature in a lake dictates the behavior of many chemical parameters responsible for water quality. Heat is transferred to a lake at its surface and slowly moves downward depending on water circulation in the lake. Lakes with a large surface area or a small volume tend to have greater mixing due to wind. In deeper lakes, circulation is not strong enough to move warm water to depths typically greater than 4 or 5 m and as a result cooler denser water remains at the bottom of the lake. As the difference in temperature between warm surface and cold deeper water increases, two distinct layers are formed. Limnologists call these layers of water the **epilimnion** at the surface and the **hypolimnion** at the bottom. The layers are separated by a transition layer known as the **metalimnion** which contains the effective wall separating top and bottom waters called a **thermocline**. A thermocline typically occurs when water temperature changes by more than one degree within one meter depth. The hypolimnion and epilimnion do not mix, nor do elements such as oxygen supplied at the surface move downward into the hypolimnion. In the fall, surface waters begin to cool and eventually reach the same temperature as hypolimnetic water. At this point the water mixes from top to bottom in what is often called a **turnover** event. Surface water cools further as ice forms and again a thermocline develops this time with 4° C water at the bottom and near 0° C water on the top.

In spring another turnover event occurs when surface waters warm to 4° C. Lakes with this mixing pattern of two stratification periods and two turnover events are called **dimictic** lakes. In shallower lakes, the water column may mix from top to bottom most of the ice-free season with occasional stratification during periods of calm warm conditions. Lakes that mix frequently are **termed polymictic** lakes. In our cold climate, many shallow lakes are **cold monomictic meaning a thermocline develops every winter, there is one turnover event in spring but the remainder of the ice free season the lake is polymictic.**

DISSOLVED OXYGEN:

Oxygen enters a lake at the lake surface and throughout the water column when produced by photosynthesizing plants, including algae, in the lake. Oxygen is consumed within the lake by respiration of living organisms and decomposition of organic material in the lake sediments. In lakes that stratify (see temperature above), oxygen that dissolves into the lake at the surface cannot mix downward into the hypolimnion. At the same time oxygen is depleted in the hypolimnion by decomposition. The result is that the hypolimnion of a lake can become **anoxic**, meaning it contains little or no dissolved oxygen. When a lake is frozen, the entire water column can become anoxic because the surface is sealed off from the atmosphere. Winter anoxic conditions can result in a fish-kill which is particularly common during harsh winters with extended ice-cover. Alberta Surface Water Quality Guidelines suggest dissolved oxygen concentrations (in the epilimnion) must not decline below 5 $mg\bullet L^{-1}$ and should not average less than 6.5 $mg\bullet L^{-1}$ over a seven-day period. However, the guidelines also require that dissolved oxygen concentrations remain above 9.5 $mg\bullet L^{-1}$ in areas where early life stages of aquatic biota, particularly fish, are present.

GENERAL WATER CHEMISTRY:

Water in lakes always contains substances that have been transported by rain and snow or have entered the lake in groundwater and inflow streams. These substances may be dissolved in the water or suspended as particles. Some of these substances are familiar minerals, such as sodium and chloride, which when combined form table salt, but when dissolved in water separate into the two electrically charged components called **ions**. Most dissolved substances in water are in ionic forms and are held in solution due to the polar nature of the water molecule. **Hydrophobic** (water-fearing) compounds such as oils contain little or no ionic character, are non-polar and for this reason do not readily dissolve in water. Although hydrophobic compounds do not readily dissolve, they can still be transported to lakes by flowing water. Within individual lakes, ion concentrations vary from year to year depending on the amount and mineral content of the water entering the lake. This mineral content can be influenced by the amount of precipitation and other climate variables as well as human activities such as fertilizer and road salt application.

PHOSPHORUS AND NITROGEN:

Phosphorus and nitrogen are important nutrients limiting the growth of algae in Alberta lakes. While nitrogen usually limits agricultural plants, phosphorus is usually in shortest supply in lakes. Even a slight increase of phosphorus in a lake can, given the right conditions, promote algal blooms causing the water to turn green in the summer and impair recreational uses. When pollution originating from livestock manure and human sewage enters lakes not only are the concentrations of phosphorus and nitrogen increased but nitrogen can become a limiting nutrient which is thought to cause blooms of toxic algae belonging to the cyanobacteria. Not all cyanobacteria are toxic, however, the blooms can form decomposing mats that smell and impair dissolved oxygen concentrations in the lake.

CHLOROPHYLL-*A*:

Chlorophyll *a* is a photosynthetic pigment that green plants, including algae, possess enabling them to convert the sun's energy to living material. Chlorophyll *a* can be easily extracted from algae in the laboratory. Consequently, chlorophyll *a* is a good estimate of the amount of algae in the water. Some highly productive lakes are dominated by larger aquatic plants rather than suspended algae. In these lakes, chlorophyll *a* and nutrient values taken from water samples do not include productivity from large aquatic plants. The result, in lakes like Chestermere which are dominated by larger plants known as macrophytes, can be a lower trophic state than if macrophyte biomass was included. Unfortunately, the productivity and nutrient cycling contributions of macrophytes are difficult to sample accurately and are therefore not typically included in trophic state indices.

SECCHI DISK TRANSPARENCY:

Lakes that are clear are more attractive for recreation, whereas those that are turbid or murky are considered by lake users to have poor water quality. A measure of the transparency or clarity of the water is performed with a Secchi disk with an alternating black and white pattern. To measure the clarity of the water, the Secchi disk is lowered down into the water column and the depth where the disk disappears is recorded. The Secchi depth in lakes with a lot of algal growth will be small while the Secchi depth in lakes with little algal growth can be very deep. However, low Secchi depths are not caused by algal growth alone. High concentrations of suspended sediments, particularly fine clays or glacial till, are common in plains or mountain reservoirs of Alberta. Mountain reservoirs may have exceedingly low Secchi depths despite low algal growth and nutrient concentrations.

The euphotic zone or the maximum depth that light can penetrate into the water column for actively growing plants is calculated as twice the Secchi depth. Murky waters, with shallow Secchi depths, can prevent aquatic plants from growing on the lake bottom. Conversely, aquatic plants can ensure lakes have clear water by reducing shoreline erosion and stabilizing lake bottom sediments. In Alberta, many lakes are shallow and bottom sediments contain high concentrations of nutrients. Without aquatic plants, water quality may decline in these lakes due to murky, sediment laden water and excessive algal blooms. Maintaining aquatic plants in certain areas of a lake is often essential for ensuring good water clarity and a healthy lake as many organisms, like aquatic invertebrates and insects, depend on aquatic plants for food and shelter.

TROPHIC STATE:

Trophic state is classification of lakes into four categories of fertility and is a useful index for rating and comparing lakes. From low to high nutrient and algal biomass (as chlorophyll) concentrations, the trophic states are; **oligotrophic**, **mesotrophic**, **eutrophic** and **hypereutrophic (Table 2)**.

A majority of lakes in Alberta contain naturally high levels of chlorophyll *a* (8 to 25 µg/L) due to our deep fertile soils. These lakes are usually considered fertile and are termed eutrophic. The nutrient and algal biomass concentrations that define these categories are shown in the following table, a figure of Alberta lakes compared by trophic state can be found on the ALMS website.

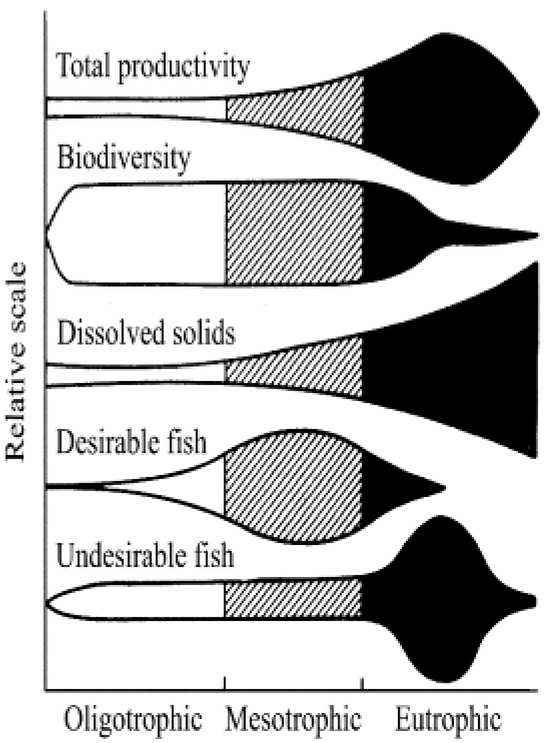

Figure B: Suggested changes in various lake characteristics with eutrophication. From "Ecological Effects of Wastewater", 1980.

Table A - Trophic status classification based on lake water characteristics.

Trophic state	Total Phosphorus ($\mu g \bullet L^{-1}$)	Total Nitrogen ($\mu g \bullet L^{-1}$)	Chlorophyll a ($\mu g \bullet L^{-1}$)	Secchi Depth (m)
Oligotrophic	< 10	< 350	< 3.5	> 4
Mesotrophic	10 – 30	350 - 650	3.5 - 9	4 - 2
Eutrophic	30 – 100	650 - 1200	9 - 25	2 - 1
Hypereutrophic	> 100	> 1200	> 25	< 1