THE ALBERTA LAKE MANAGEMENT SOCIETY
VOLUNTEER LAKE MONITORING PROGRAM

2014 Little Beaver Lake Report

LAKEWATCH IS MADE POSSIBLE WITH SUPPORT FROM:

Beaver River Watershed Alliance

Alberta Government

LICA Lakeland Industry & Community 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 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 thank Sandy McGregor and Doug Jensen for their assistance with sampling Little Beaver Lake in 2014. We would also like to thank Jackson Woren, Brittany Kereliuk, and Kara MacAulay who were summer technicians with ALMS in 2014. Program Coordinator 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 Jackson Woren and Bradley Peter. Alberta Environment, the Beaver River Watershed Alliance (BRWA), the Lakeland Industry and Community Association (LICA), and Environment Canada, were major sponsors of the program.

LITTLE BEAVER LAKE:

Figure 1 – Little Beaver Lake, Alberta. Photo taken by Jackson Woren, 2014.

Little Beaver Lake is a quiet, scenic lake 35 km south of Camrose and 107 km south of Edmonton. This shallow lake is approximately 3.5 km long and 500 m wide, and is surrounded by forested rolling hills and agricultural development. The county subdivision of Little Beaver Lake Estates lies on its west shore, and the village of Ferintosh lies on its east shore. It is within the Battle River watershed.

Little Beaver Lake was historically a meeting place for aboriginal peoples, who called it 'Amiskoogis Saskihigan', meaning 'little lake belonging to the beaver'. During the 1880's European fur traders hunted buffalo in the area, and in the 1890's ranchers established in the watershed discovered rich soils suitable for agriculture.

The first non-aboriginal settlers arrived in the early 1900's by rail from the Edmonton-Calgary railway to establish homesteads. In 1910, the Grand Trunk Pacific Railway arrived, and the village was incorporated in 1911. The village of Ferintosh was originally known as Lassen, named after the first settlement of homesteads in the area belonging to J. J. Lassen. The village was renamed Ferintosh by Dr. J. R. McLeod in 1910, because a nearby town with a similar name created confusion for the postal service.

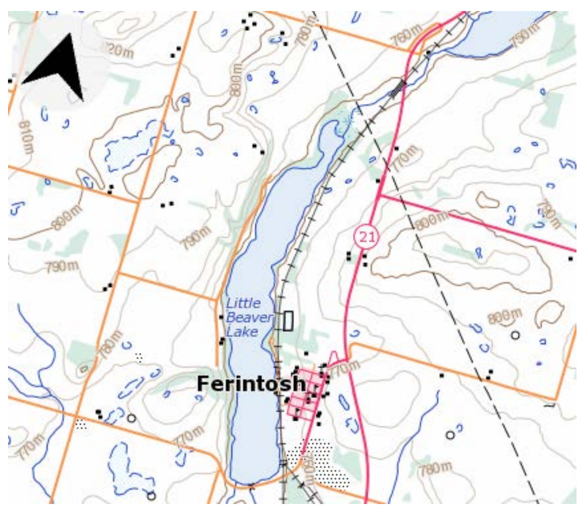

Figure 2 – Topographical map of Little Beaver Lake, Alberta. From the Atlas of Canada, 2009.

WATER LEVELS:

Water levels in Little Beaver Lake have been recorded since 1971 (Figure 3). In 1973, a historical maximum was achieved of 746.8 meters above sea level (m asl), though levels quickly dropped to 745.7 m asl in 1978. Since 1978, water levels increased and fluctuated around 746.2 m.

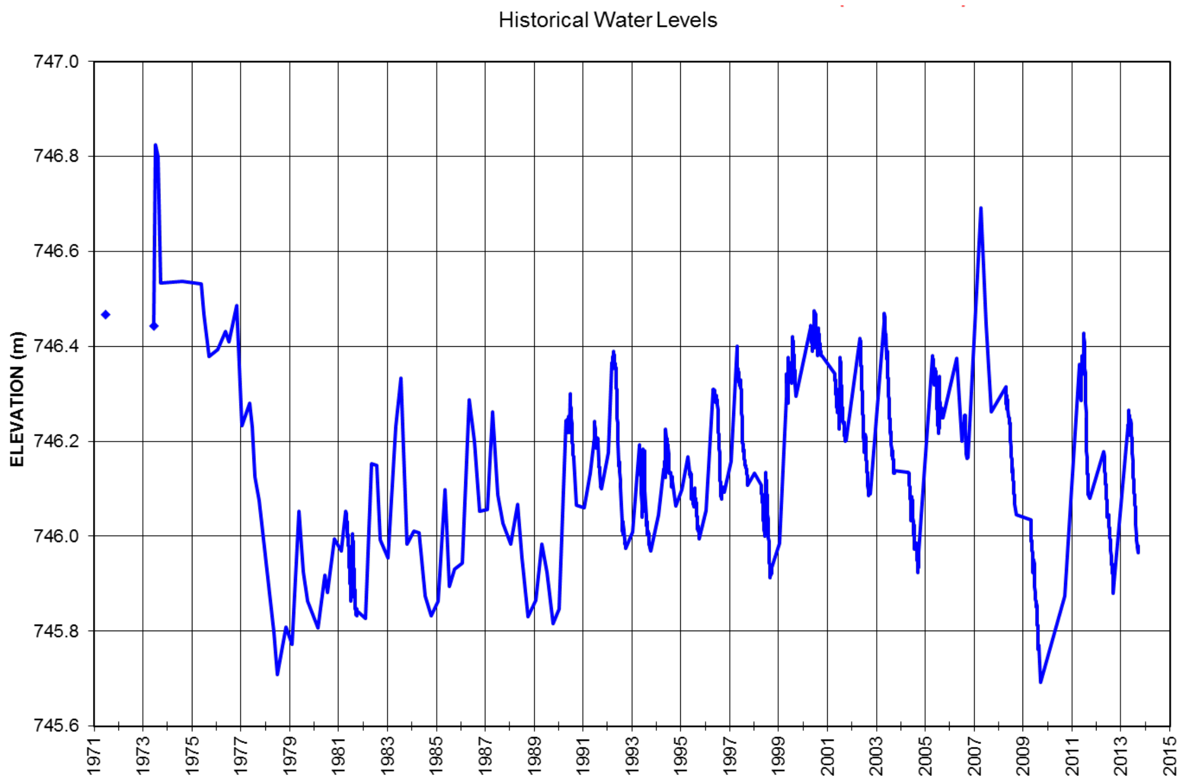

Figure 3 – Water levels in meters above sea level (m asl) for Little Beaver Lake, 2014. Data retrieved from Alberta Environment and Sustainable Resource Development.

SECCHI DISC 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 disk depth in Little Beaver Lake was poor (Figure 4, Table 1) - on August 1st and September 16th, Secchi disc depth measured a seasonal maximum of 0.25 m, and on July 14th and August 25th, Secchi disc depth measured a seasonal minimum of 0.15 m. Secchi disk depths followed the trend of increased chlorophyll-*a* concentrations with August 25th having the lowest Secchi depth and highest chlorophyll-*a* concentration. In addition, as a shallow lake, it is likely that suspended sediments from the lakebed contribute to reduced water clarity at Little Beaver Lake. Average secchi disc depth during 2014 was 0.2 m.

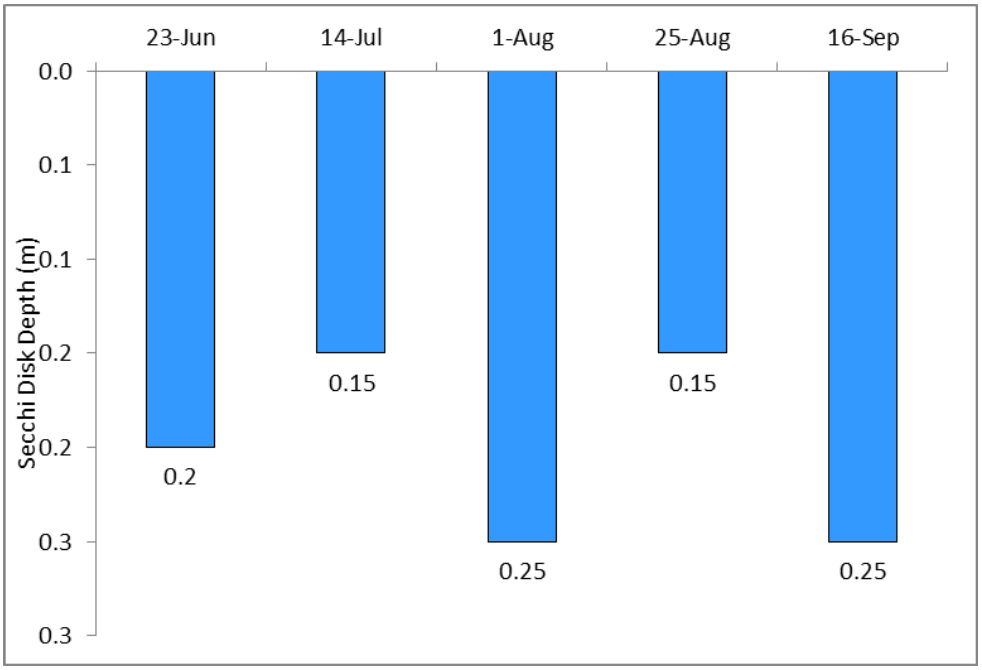

Figure 4 – Secchi disk depths recorded at the profile spot at Little Beaver Lake in 2014.

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.

Surface water temperature varied greatly throughout the season (Figure 5a). On July 14th, surface water temperature was recorded at a seasonal maximum of 22.56 °C. On September 16th, surface water temperature was recorded at a seasonal minimum of 11.84 °C. On all trips, Little Beaver Lake remained isothermal – temperature remaining consistent throughout the water column. Due to its depth, Little Beaver Lake is polymictic, mixing many times throughout the year.

Dissolved oxygen was also highly variable throughout the season (Figure 5b). On June 23rd as well as September 16th, dissolved oxygen was supersaturated at the surface with concentrations of 12.75 mg/L and 12.79 mg/L, respectively. On August 25th, dissolved oxygen was 5.96 mg/L at the surface, which means the entire water column fell below the Canadian Council for Ministers of the Environments (CCME) Guidelines for the Protection of Aquatic Life (PAL) of 6.5 mg/L. For the remainder of the trips, the water column remained above the CCME guidelines. During the July, August, and September trips, dissolved oxygen concentrations rapidly declined to zero at the lake bed. This is indicative of large amounts of algal biomass present during the summer which was likely decomposing on the lakebed in September, resulting in oxygen depletion.

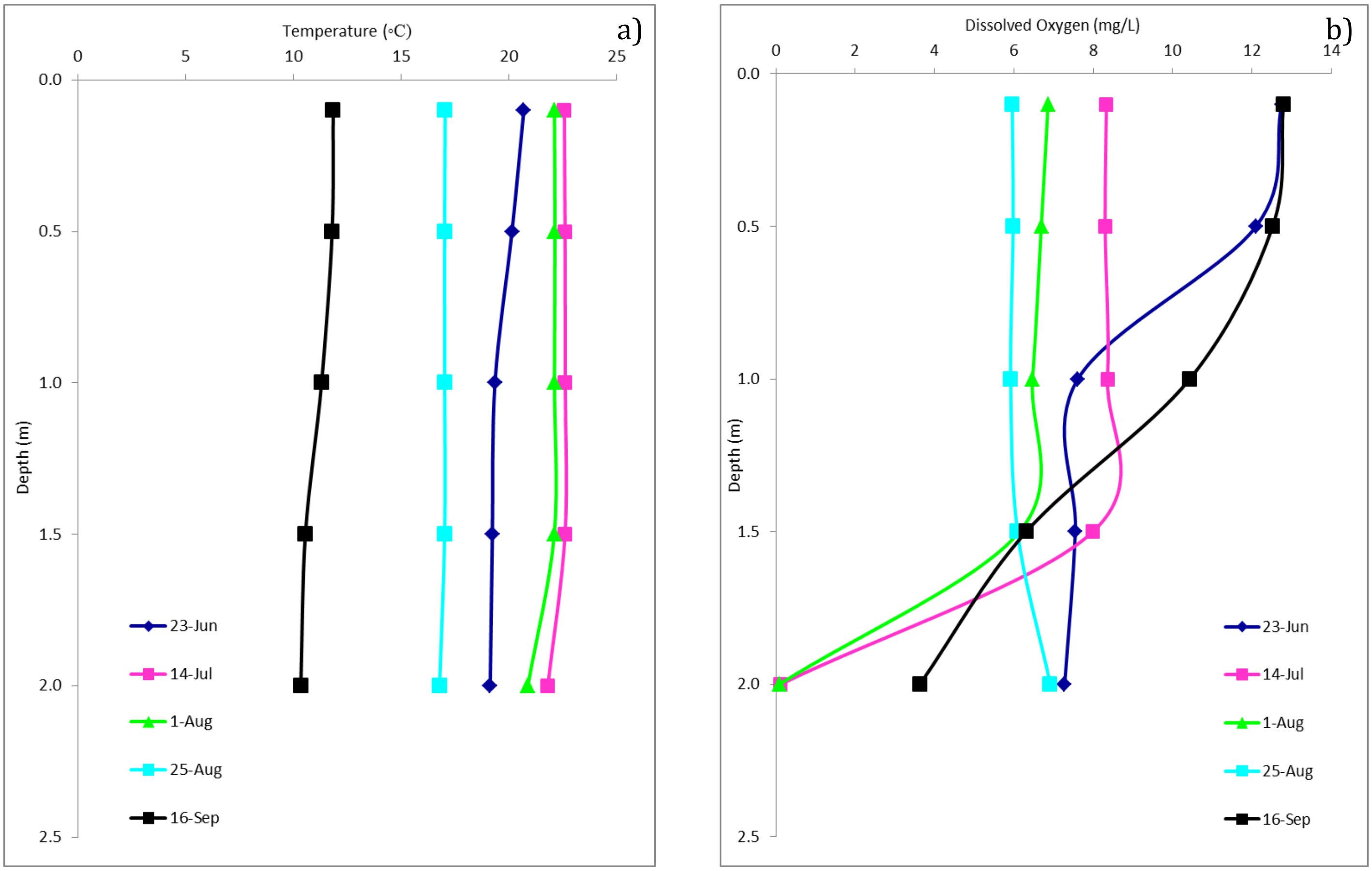

Figure 5 – a) Temperature (°C) and b) dissolved oxygen (mg/L) profiles for Little Beaver Lake measured during the summer of 2014.

WATER CHEMISTRY:

ALMS measures a suite of water chemistry parameters. Phosphorous, 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.

Based on all trophic status criteria (Table A), Little Beaver Lake would be considered hypereutrophic, or extremely productive (Table 1). Average total phosphorous (TP) in 2014 was 1300.8 μg/L, well above the 100 μg/L required for hypereutrophic classification. This value is the highest recorded since 2009 (Table 1) of 516.5 μg/L. On August 1st, total phosphorus measured a seasonal minimum of 660 μg/L, and on September 16th, total phosphorus measured a seasonal maximum of 2320 μg/L (Figure 6). Developments and activities in Little Beaver Lake's watershed should limit their contribution of phosphorus to the lake.

Total Kjeldahl nitrogen also greatly exceeded the minimum concentration requirement for a hypereutrophic classification with an average of 8342 μg/L in 2014. Total Kjeldahl nitrogen ranged greatly throughout the season from a minimum of 920 μg/L on August 1st to a maximum of 30,600 μg/L on September 16th. The seasonal average of TKN remains close to the average observed in 2009 (Figure 6, Table 1). This large spike in

September correlated with a large spike in phosphorus, and may be related to a rainfall event experienced earlier in the week.

Finally, average chlorophyll-*a* concentration in 2014 was 173 µg/L. This is the highest average observed at all the lakes monitored by ALMS in 2014. On September 16th, chlorophyll-*a* concentration measured a seasonal low of 95 µg/L, and on August 25th, chlorophyll-*a* concentration measured a maximum of 340 µg/L (Figure 6).

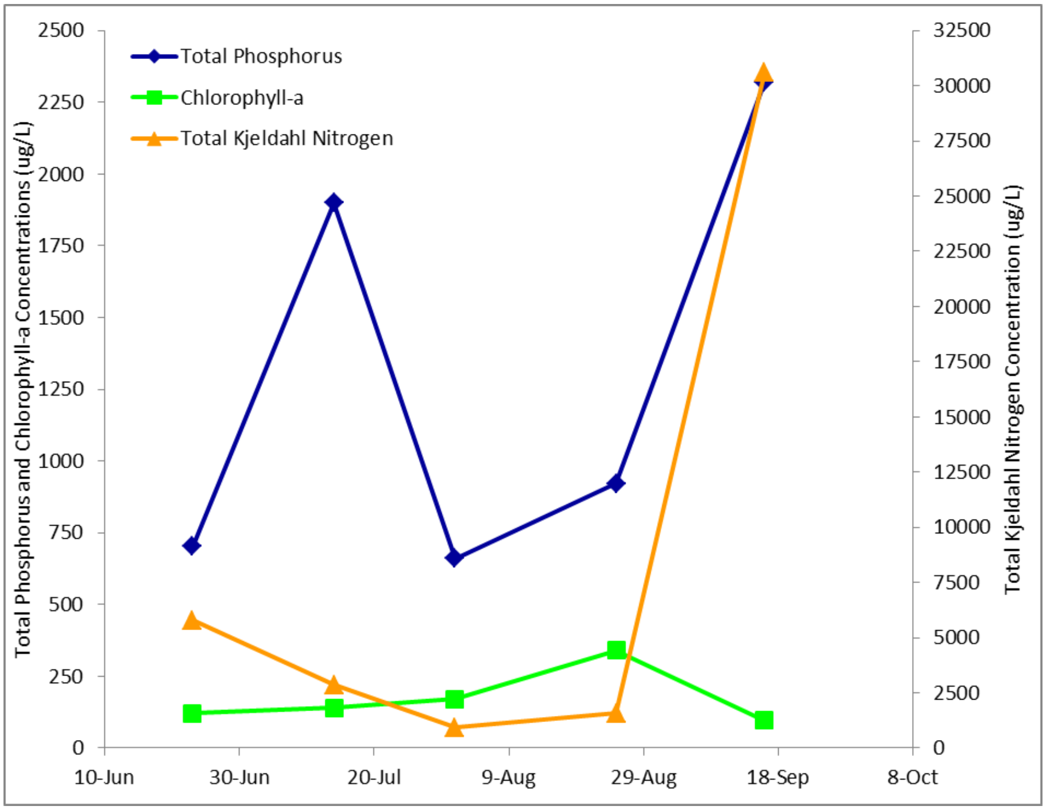

Figure 6 – Total phosphorus (µg/L), chlorophyll-*a* (µg/L), and total Kjeldahl nitrogen (mg/L) measured twice during the summer of 2014.

Average pH measured at Little Beaver Lake was 8.908, well above neutral (Table 1). This may be due to high alkalinity (326.8 mg/L $CaCO_3$) and bicarbonate (398.8 µg/L HCO_3), which helps to buffer the lake against changes in pH. Dominant ions in Little Beaver Lake include sulfate (163.33 mg/L), sodium (160 mg/L), and magnesium (31.5 mg/L) contributing to an average conductivity of 1040 µS/cm (Table 1). More data is required to determine if there are any trends in changing ion concentrations.

Metals were sampled twice in 2014 and all values except for aluminum and iron fell within their guidelines. High aluminum and iron values indicate that there may have been some sediment contamination which is very common in very shallow lakes (Table 2). Sediment contamination may influence the concentrations of phosphorus in water quality samples.

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 2014, concentrations of microcystin reached an observed maximum of 39.32 µg/L on August 25th which exceeds the recreational guideline of 20 µg/L. Seasonal average of Microcystin concentrations were recorded at 16.136 µg/L (Table 1). This is the highest average observed at all the lakes monitored by ALMS in 2014. Field notes suggest that *Gloeotrichia* spp., *Anabaena spp.,* and *Microcystis spp.* were the most dominant at Little Beaver Lake– species of these genera are known to produce microcystin toxins. Caution should always be taken when recreating in waters experiencing cyanobacteria blooms.

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 2014, no zebra or quagga mussels were detected in Little Beaver Lake.

Table 1 – Average secchi depth and water chemistry values for Little Beaver Lake in 2014. Historical values are provided for comparison.

Parameter	2009	2010	2014
TP (µg/L)	516.5	421.5	1300.8
TDP (µg/L)	83.5	91.5	178.2
Chlorophyll-*a* (µg/L)	195.7	107.9	173
Secchi depth (m)	0.2	0.38	0.2
TKN (µg/L)	7990	5970	8342
NO_2 and NO_3 (µg/L)	99	11	32
NH_3 (µg/L)	65.5	58.5	628.2
DOC (mg/L)	52.4	49.1	42.17
Ca (mg/L)	16.3	13.5	25.57
Mg (mg/L)	30.8	38.7	31.5
Na (mg/L)	181.3	169	160
K (mg/L)	32.6	26.7	27.02
SO_4^{2-} (mg/L)	140.7	146	163.33
Cl^- (mg/L)	31.3	32.1	29.23
CO_3 (mg/L)	64.3	55	39.3
HCO_3 (mg/L)	385.3	430	398.8
pH	9.29	9.16	8.91
Conductivity (µS/cm)	1066.7	1140	1040
Hardness (mg/L)	167.7	193	193.3333
TDS (mg/L)	686.3	693	675.6667
Microcystin (µg/L)	/	0.77	16.14
Total Alkalinity (mg/L $CaCO_3$)	423	444	326.8

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

Table 2. Average concentrations of metals measured in Little Beaver Lake on August 1st and September 16th 2014. The CCME heavy metal Guidelines for the Protection of Freshwater Aquatic Life (unless otherwise indicated) are presented for reference.

Metals (Total Recoverable)	**2014**	**Guidelines**
Aluminum μg/L	751	100[a]
Antimony μg/L	0.2375	6[e]
Arsenic μg/L	3.61	5
Barium μg/L	94.5	1000[e]
Beryllium μg/L	0.0223	100[d,f]
Bismuth μg/L	0.0005	/
Boron μg/L	58.85	5000[ef]
Cadmium μg/L	0.0151	0.085[b]
Chromium μg/L	1.905	/
Cobalt μg/L	0.5515	1000[f]
Copper μg/L	1.7	4[c]
Iron μg/L	553.5	300
Lead μg/L	0.519	7[c]
Lithium μg/L	81.05	2500[g]
Manganese μg/L	79	200[g]
Molybdenum μg/L	0.772	73[d]
Nickel μg/L	1.41	150[c]
Selenium μg/L	0.652	1
Silver μg/L	0.003	0.1
Strontium μg/L	311.5	/
Thallium μg/L	0.006915	0.8
Thorium μg/L	0.1078	/
Tin μg/L	0.03265	/
Titanium μg/L	16.6	/
Uranium μg/L	3.29	100[e]
Vanadium μg/L	2.34	100[f,g]
Zinc μg/L	3.11	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.
Red font indicates value exceeding 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:

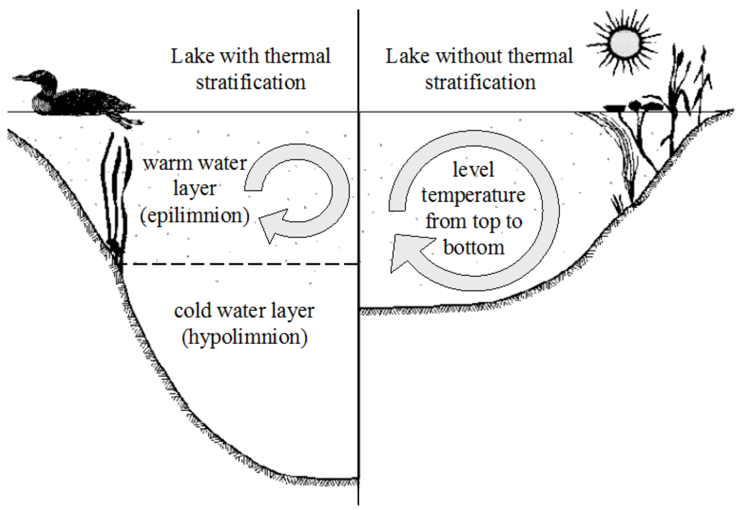

Figure A: Difference in the circulation of the water column depending on thermal stratification.

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.

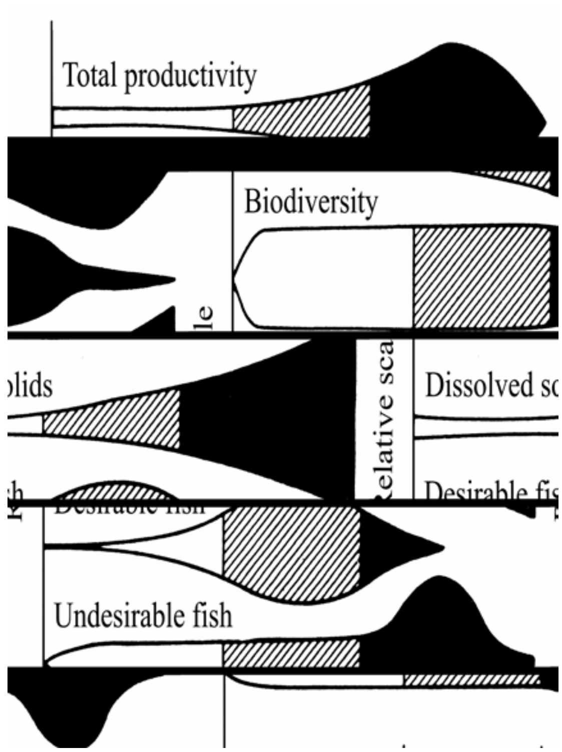

Figure B: Suggested changes in various lake characteristics with eutrophication. From "Ecological Effects of Wastewater", 1980.

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

Trophic state	Total Phosphorus (µg•L^{-1})	Total Nitrogen (µg•L^{-1})	Chlorophyll *a* (µg•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

Note: These values are from a detailed study of global lakes reported in Nurnberg 1996. Alberta Environment uses slightly different values for TP and CHL based on those of the OECD reported by Vollenweider (1982). The AENV and OECD cutoffs for TP are 10, 35 and 100; for CHL are 3, 8 and 25. AENV does not have TN or Secchi depth criteria. The corresponding OECD exists for Secchi depth and the cutoffs are 6, 3 and 1.5 m.