



*THE ALBERTA LAKE MANAGEMENT SOCIETY
VOLUNTEER LAKE MONITORING PROGRAM*

2014 Bear Lake Report

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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 Kase DeVries and the Bear Lake Bible Camp for their assistance with sampling Bear 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.

BEAR LAKE:

Bear Lake is a pothole lake found in the County of Grande Prairie in northwestern Alberta. It is located 10 km northwest of the town of Grande Prairie. The shoreline of Bear Lake is somewhat developed, with a small county park on the north shore of the lake. On the south shore lies Lake Pointe Properties which has been subdivided into 23 residential lots. Municipal and environmental reserves border the lake and the properties¹. Trilogy Energy Corp. has a station on the south shore of Bear Lake. Within the watershed, conventional oil and gas exploration is a common occurrence with active sites and wells surrounding Bear Lake¹. The watershed also contains an active pig feeding operation facility and a Hutterite colony.



Figure 1 –LakeWatch technician Brittany Kereliuk collecting a mussel veliger haul at Bear Lake. 2015.

Bear Lake is thought to be named for the animal that is found in the area, or because the First Nations groups that inhabited the area described the shape of the lake to resemble a bear³. There are three main First Nations groups that are located in the Grande Prairie area: Duncan's First Nation, Horse Lake First Nation, and Sturgeon Lake Cree Nation⁴.

Bear Lake has a length of about 10.2 km and a maximum width of about 5.8 km. The maximum depth of Bear Lake is 2.5 m. Bear River is a major inflow into Bear Lake; other inflows are more ephemeral, contributing intermittently after major rain events and during spring runoff. Bear Creek represents the lake's main outflow, which flows through Grande Prairie and finally to the Smoky River. The city of Grande Prairie in partnership with Environment and Sustainable Resource Development (ESRD) are currently conducting work under the Wapiti River Water Management Plan to examine Bear Creek's water quality.

Bear Lake is used for motorized recreational water sports as well as swimming, canoeing, wind surfing, and kayaking. Sport fishing is not known to be a popular activity at Bear Lake since it is believed that there are no sportfish in the lake. Other activities in the area include hiking, bird watching, and picnicking.

¹ Grande Prairie County. 2012. Available at: <http://www.countygp.ab.ca/EN/index.html>

² Personal communication Kase DeVries

³ Personal communication Mona, Bear Lake Campground.

⁴ Western Cree Website. Available at: <http://www.westerncree.ca/index.php>

⁵ University of Alberta. 2005. Atlas of Alberta Lakes. University of Alberta Press. Available at: <http://sunsite.ualberta.ca/Projects/Alberta-Lakes/>

⁶ Government of Alberta. 2014. Alberta Parks. Available at: <http://www.albertaparks.ca/saskatoon-island.aspx>

Bear Lake is found in the Aspen Parkland ecoregion of Alberta, though much of the land has been converted for agricultural use. Primary crops include wheat, barley, oats, canola, pasture, and hay⁵.

The macrophyte composition at Bear Lake is largely unknown, though the lake perimeter includes species such as the common cattail (*Typha latifolia*) and bulrushes (*Scirpus spp.*). Submerged macrophytes cover a large surface area of the lake throughout most of the summer and are especially prominent when lake levels are low. Bear Lake is located close to Saskatoon Lake and shares many of the same wildlife species which includes large numbers of grassland, forest, and shore birds⁶. Rare species such as the trumpeter swan may also be observed at Bear Lake. Larger vertebrates that can be found around the lake are snowshoe hares, weasels, woodchucks, muskrats, coyotes, and deer⁶.

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. Requests for water quantity monitoring should go through Environment and Sustainable Resource Developments Monitoring and Science division.

Water quantity data has not been consistently collected at Bear Lake. Lake level trends and the relationship between surface water and groundwater are therefore not yet understood (Figure 2).

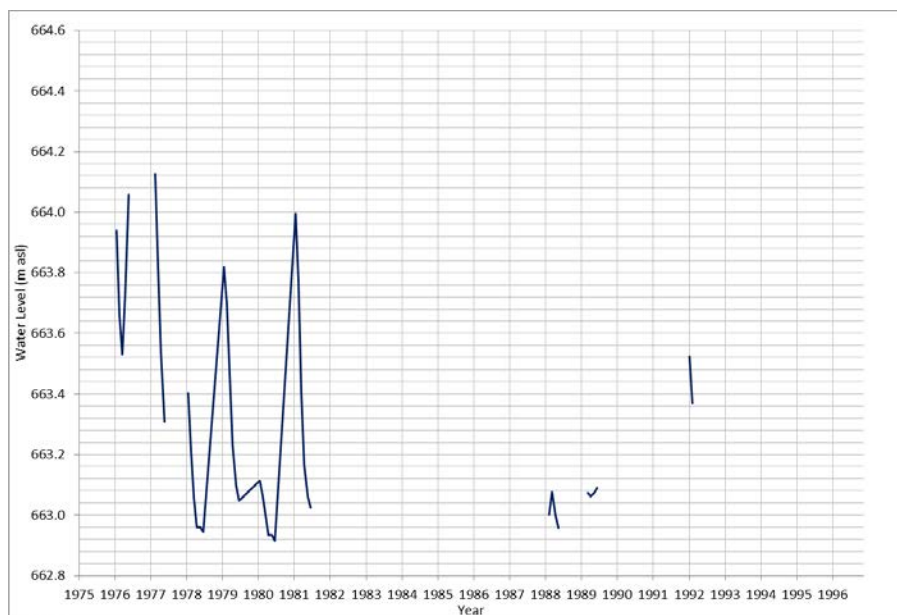


Figure 2 - Water quantity data collected at Bear Lake from 1976 to 1992.

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.

Throughout the sampling season, Secchi disk depth changed dramatically at Bear Lake (Figure 3). On July 13th, Secchi disk depth measured a seasonal maximum of 1.35 m, while on September 22nd, Secchi disk depth measured a seasonal minimum of 0.20 m. This decrease in water clarity correlated closely with increases in chlorophyll-*a* concentration, suggesting phytoplankton is the primary factor impeding water clarity at Bear Lake. Due to the lack of historical data on Bear Lake it is unknown how this compares to historical averages. The average Secchi disk depth in 2014 measured 0.66 m in 2014.

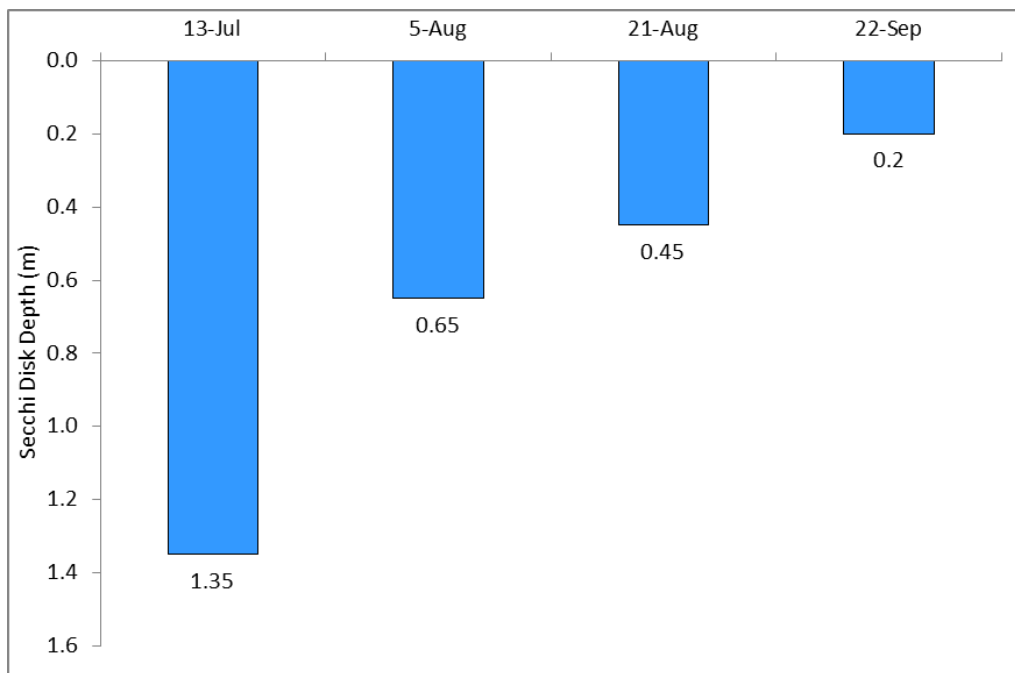


Figure 3 - Secchi disk depths recorded from the profile spot at Bear Lake in 2014.

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 temperatures varied greatly throughout the sampling season ranging from a minimum of 12.02 °C on September 22nd to a maximum of 24.75 °C on July 13th (Figure 4a). Slight thermal stratification was observed on two sampling trips at Bear Lake, beginning as early as 0.1 m on July 13th. As Bear Lake is very shallow, strong permanent thermal stratification is unlikely to develop; however, high air temperatures and calm days, will likely lead to intermittent stratification which may affect dissolved oxygen concentrations and nutrient release from the sediment.

Surface dissolved oxygen concentrations varied greatly at Bear Lake during 2014 (Figure 4b). On July 13th and August 5th, dissolved oxygen concentrations were supersaturated at the surface (13.53 mg/L and 17.67 mg/L, respectively) due to a large surface bloom of cyanobacteria. Below the surface, however, concentrations dropped dramatically with depth, falling below the Canadian Council for Ministers of the Environment (CCME) Guidelines for the Protection of Aquatic Life (PAL) of 6.5 mg/L by the lakebed. On August 21st, the *entire* water column fell below the CCME PAL guidelines for dissolved oxygen concentration. Low dissolved oxygen concentrations coupled with warm water temperatures can create a stressful environment for fish. These conditions are likely due to the oxygen-consuming decomposition process which occurs due to the large amounts of cyanobacterial biomass. .

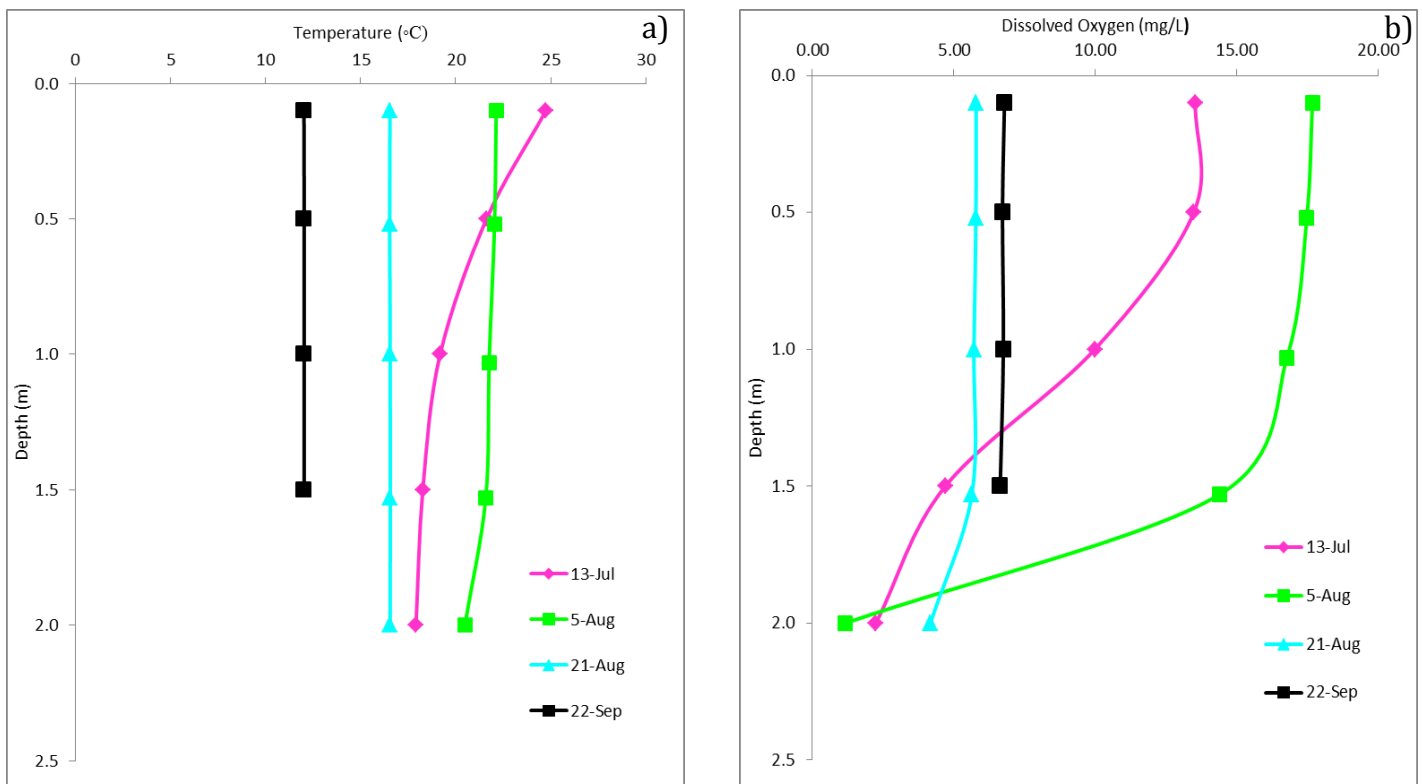


Figure 4 – a) Temperature (°C) and b) dissolved oxygen (mg/L) profiles from Bear Lake, 2014.

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 more complete list of parameters.

Average Total Phosphorus (TP) measured 246.75 µg/L in 2014 (Table 1). This value falls well into the hypereutrophic, or very nutrient rich, classification. Throughout the summer, TP ranged from a seasonal minimum of 71 µg/L on July 13th to a seasonal maximum of 353 µg/L on August 5th (Figure 5).

Chlorophyll-*a* concentration measured an average of 70.75 µg/L in 2014 (Table 1). This value falls well into the hypereutrophic, or extremely productive, classification. Throughout the summer, chlorophyll-*a* concentration ranged from a minimum of 51 µg/L on July 13th to a maximum of 94 µg/L on August 21st (Figure 5). More data is required to better understand the relationship between nutrients and chlorophyll-*a* concentration at Bear Lake.

Finally, total Kjeldahl nitrogen (TKN) measured an average of 1735 µg/L in 2014 (Figure 5, Table 1). Similar to chlorophyll-*a*, average TKN falls into the hypereutrophic classification. Throughout the summer, TKN ranged from a minimum of 970 µg/L on August 21st to a maximum of 2410 µg/L on September 22nd.

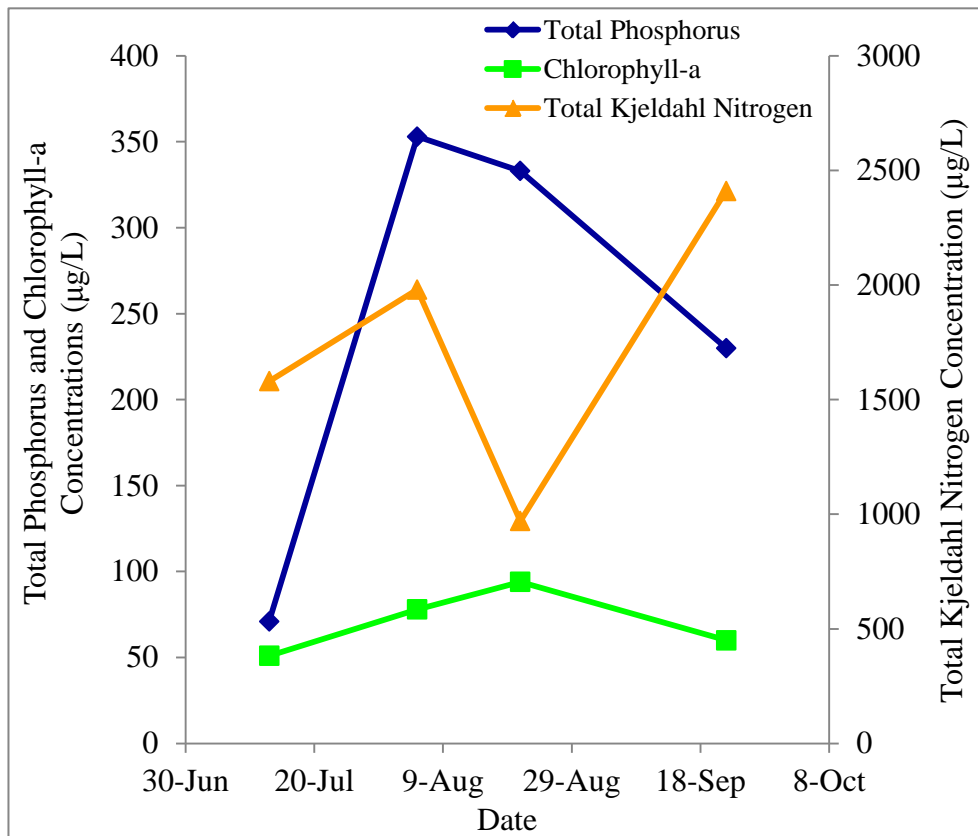


Figure 5 – Total phosphorus (µg/L), chlorophyll-*a* (µg/L), and total Kjeldahl nitrogen (µg/L) concentrations measured four times over the course of the summer of 2014.

Average pH measured 8.133 in 2014. Bear Lake has moderate to low alkalinity (81.78 mg/L CaCO₃) and bicarbonate (99.75 mg/L HCO₃) concentration which may help to buffer the lake against changes to pH (Table 1). Sulphate (25 mg/L), calcium (18.1 mg/L), and sodium (15.27 mg/L) are the dominant ions in Bear Lake, contributing to a conductivity of 230 µS/cm.

Metals were collected twice at Bear Lake and, with exception of aluminium and iron, all concentrations fell within their respective guidelines (Table 2). Because Bear Lake is shallow, contamination of samples from sediments likely caused the spikes in aluminium and iron concentrations.

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 a seasonal maximum of 15.31 µg/L on August 21st (Table 1). Though this value falls below the recommended recreational guidelines (20 µg/L), it represents the average from a 10-point composite sample, suggesting concentrations across the lake are very high. Caution should be taken when recreating in Bear Lake, particularly when blooms are visible.

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 Bear Lake.

Table 1 – Average Secchi disk depth and water chemistry values for Bear Lake in 2014

Parameter	2014
TP ($\mu\text{g/L}$)	246.75
TDP ($\mu\text{g/L}$)	94.25
Chlorophyll- <i>a</i> ($\mu\text{g/L}$)	70.75
Secchi depth (m)	0.66
TKN ($\mu\text{g/L}$)	1735
NO ₂ and NO ₃ ($\mu\text{g/L}$)	42.5
NH ₃ ($\mu\text{g/L}$)	83.5
DOC (mg/L)	13.3
Ca (mg/L)	18.1
Mg (mg/L)	5.49
Na (mg/L)	15.27
K (mg/L)	8.23
SO ₄ ²⁻ (mg/L)	25
Cl ⁻ (mg/L)	4.8
CO ₃ (mg/L)	3.45
HCO ₃ (mg/L)	99.75
pH	8.13
Conductivity ($\mu\text{S/cm}$)	230
Hardness (mg/L)	67.8
TDS (mg/L)	138.33
Microcystin ($\mu\text{g/L}$)	5.86
Total Alkalinity (mg/L CaCO ₃)	81.78

Note: TP = total phosphorus, TDP = total dissolved phosphorus, Chl-*a* = chlorophyll-*a*, TKN = total Kjeldahl nitrogen. NO₂₊₃ = nitrate+nitrite, NH₃ = ammonia, Ca = calcium, Mg = magnesium, Na = sodium, K = potassium, SO₄ = sulphate, Cl = chloride, CO₃ = carbonate, HCO₃ = bicarbonate. A forward slash (/) indicates an absence of data.

Table 2 - Concentrations of metals measured in Bear Lake on August 5th and September 22nd, 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	1193.5	100 ^a
Antimony µg/L	0.1	6 ^e
Arsenic µg/L	1.8185	5
Barium µg/L	67.05	1000 ^e
Beryllium µg/L	0.04705	100 ^{d,f}
Bismuth µg/L	0.008275	/
Boron µg/L	44.4	5000 ^{ef}
Cadmium µg/L	0.01155	0.085 ^b
Chromium µg/L	1.44	/
Cobalt µg/L	0.4575	1000 ^f
Copper µg/L	1.61	4 ^c
Iron µg/L	1200	300
Lead µg/L	0.474	7 ^c
Lithium µg/L	3.855	2500 ^g
Manganese µg/L	101.75	200 ^g
Molybdenum µg/L	0.748	73 ^d
Nickel µg/L	2.7	150 ^c
Selenium µg/L	0.1785	1
Silver µg/L	0.0088	0.1
Strontium µg/L	107.5	/
Thallium µg/L	0.01535	0.8
Thorium µg/L	0.1583	/
Tin µg/L	0.0167	/
Titanium µg/L	13.44	/
Uranium µg/L	0.185	100 ^e
Vanadium µg/L	3.575	100 ^{f,g}
Zinc µg/L	4.215	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 CaCO₃)

^c Based on water hardness > 180mg/L (as CaCO₃)

^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 that exceeds CCME 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:

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.

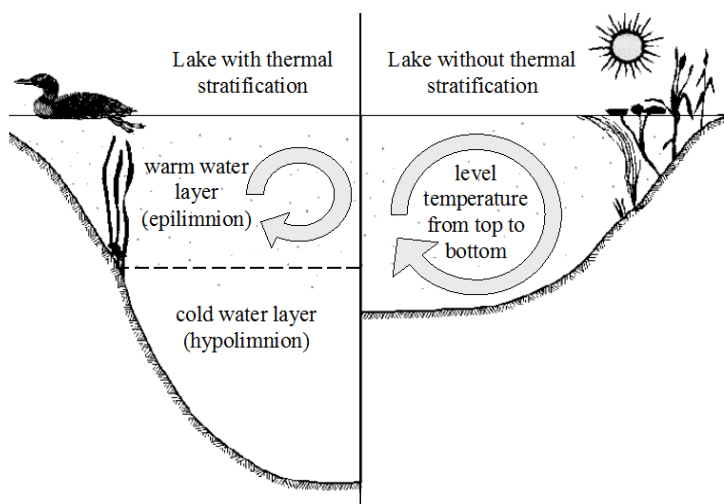


Figure A: Difference in the circulation of the water column depending on thermal stratification.

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•L⁻¹ and should not average less than 6.5 mg•L⁻¹ over a seven-day period. However, the guidelines also require that dissolved oxygen concentrations remain above 9.5 mg•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.

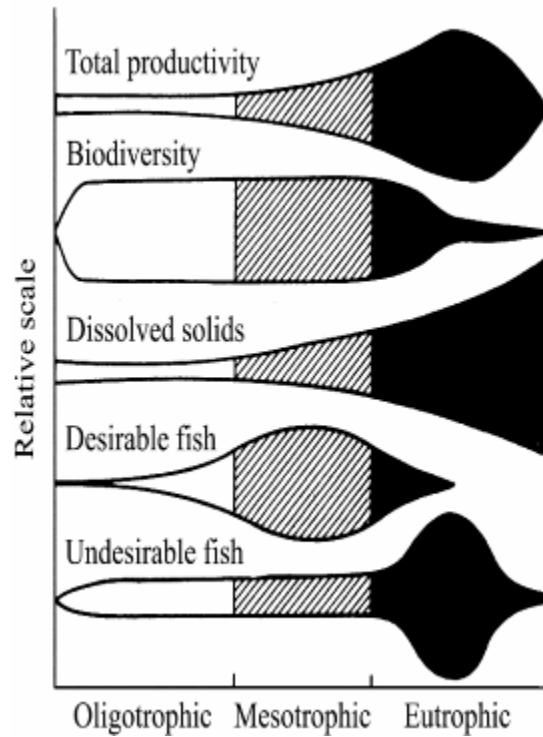


Figure B: Suggested changes in various lake characteristics with eutrophication. From “Ecological Effects of Wastewater”, 1980.

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