THE ALBERTA LAKE MANAGEMENT SOCIETY
VOLUNTEER LAKE MONITORING PROGRAM

2015 Iosegun Lake Report

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Beaver River Watershed Alliance

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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.

Acknowledgements

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IOSEGUN LAKE:

Iosegun Lake is a medium sized lake located 8 km north of Fox Creek and 90 km North West of Whitecourt. Iosegun Lake is found in the Peace River watershed. The name originates from Cree or Stoney word for the Iosegun River that either means ‘tail’ or ‘hash’. Before being named Iosegun Lake it was called Hash Lake by the fur traders and First Nations groups that inhabited the area in the early 1900s[1]. A lake management plan was created for Iosegun Lake in 1988 which assessed the potential commercial and public recreational development of the lake and was used to guide the expansion of the SemCAMS oil and gas projects in the area[2].

The lake is 8 km long and 2 km wide, with a water surface of 13.4 km^2.[1] Average depth of Iosegun Lake is 4.1 m and maximum depth may be as deep as 11.2 m. Raspberry Lake and several intermittent and permanent streams flow into Iosegun Lake. Water flows from the lake at the north end in Outlet Creek which then flows into the Iosegun River and eventually the Little Smoky River.

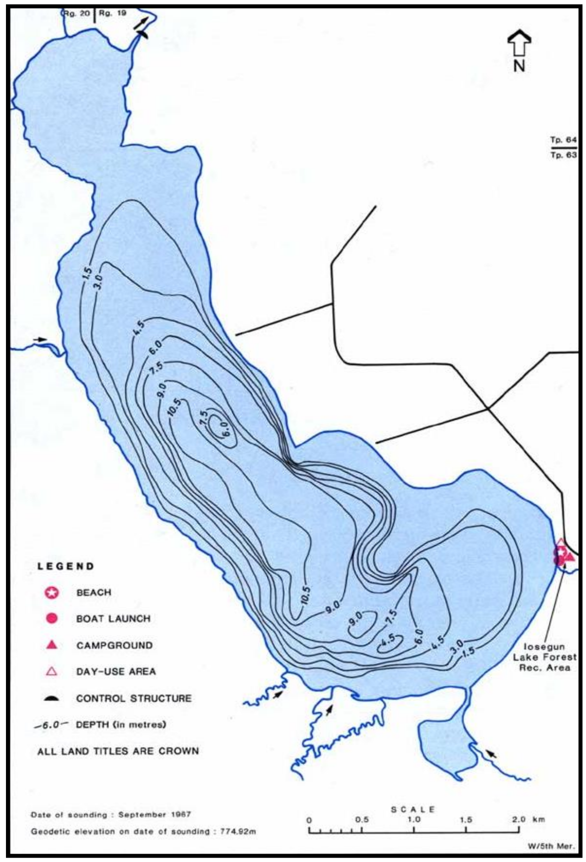

Figure 1 –Bathymetric map of Iosegun Lake[1].

Iosegun Lake was used by Chevron between 1981 and 1988 for water extraction. Water withdrawal in those years ranged between $0.5884 \times 10^6\ m^3$ and $1.056 \times 10^6\ m^3$. Currently, there are two active water licenses issued to Trilogy Resources Ltd. for oilfield injection from the lake without an expiry date[4]. Iosegun Lake is also used by the Fox Creek wastewater treatment plant which releases treated effluent in spring and fall, into an unnamed creek which flows into Iosegun Lake[1]. The lake is also used for recreational activities such as power boating, swimming, fishing, cross-country skiing, as well as snowmobiling.

Sport fish include northern pike, lake whitefish, walleye, burbot, and yellow perch. Other fish species include trout-perch, longnose sucker, and spottail shiners.[3] There is currently no data on the macrophytes populations in and around Iosegun Lake. Iosegun Lake is an important staging

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[1] University of Alberta. 2005. Atlas of Alberta Lakes. University of Alberta Press. Available at: http://sunsite.ualberta.ca/Projects/Alberta-Lakes/

[2] SemCAMS. 2013. Available at: www.semcams.com

[3] Envirocon Limited. 1983. Iosegun Lake outlet control structure: Fisheries impact. Prep. For. Alta. Envir., Plan. Div., Edmonton.

[4] Personal communication with Alina Wolanski

area for waterfowl, and species such as the common loon, grebes, buffleheads, and goldeneye can be spotted at the lake.

Iosegun Lake has a large watershed (248 km^2), 19 times the size of the lake, which is largely forested. The watershed is located in the Moist Mixedwood subregion of the Boreal Mixedwood ecoregion of Alberta with trembling aspen and balsam poplar being the most common trees in the area. There is very little agricultural development in the area (1%), however there is forestry and natural gas activity in the area. Iosegun is located on the Kaybob Oil and Gas Field and there are many wells located surrounding the lake with pipelines that carry oil and gas to processing plants[1].

In 2014, it was announced that Shell is looking into a 5 year water extraction license for hydraulic fracturing. It is estimated that they would draw 5,000,000 m^3/y during those five years. At the same time they are exploring other water sources in the area of Fox Creek[4].

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 fluctuated at Iosegun Lake (Figure 2). On June 14th, Secchi disk depth measured a seasonal maximum of 2.00 m, while on July 6th and September 28th Secchi disk depth measured a seasonal minimum of 1.25 m. The pattern of water clarity at Iosegun Lake was not clearly correlated with chlorophyll-*a* concentrations, suggesting additional factors such as suspended sediment may be an important factor determining water clarity at Iosegun Lake. On average, Iosegun Lake had a Secchi disk depth of 1.57 m. More data is required to better understand the factors affecting water clarity at Iosegun Lake.

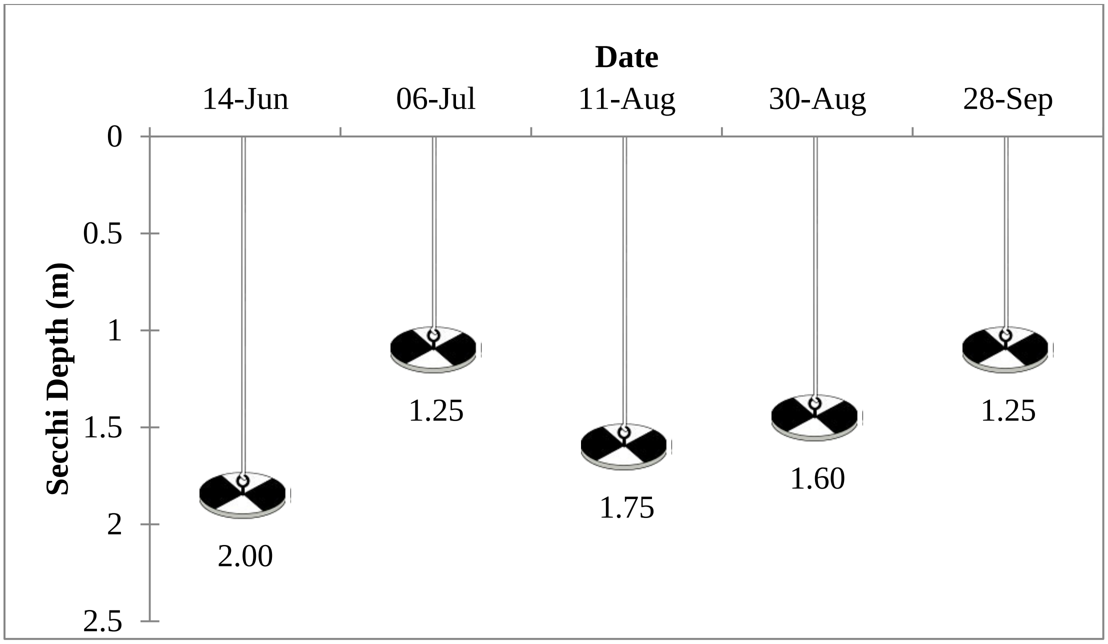

Figure 2 - Secchi disk depths recorded at the profile spot at Iosegun Lake, 2015.

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.

Surface water temperatures ranged from a minimum of 10.94 °C on September 28nd to a maximum of 21.10 °C on August 11th (Figure 3a). Weak thermal stratification was observed only on the July 6th – this was split between two temperature gradients between the depths of 4.5-5.5m and 9.00-10.0 m. By August 30th, Iosegun Lake was isothermal, measuring 17°C throughout the water column. This mixing of the lake is also evident in the lake's oxygen concentration dynamics. The presence/absence of thermal stratification has important implications for nutrient cycling and dissolved oxygen concentrations in Iosegun Lake.

Oxygen concentrations at Iosegun Lake were poor in 2015. On July 6th, August 11th, and August 30th much of the water column fell below the Canadian Council for Ministers of the Environment (CCME) recommended guidelines for the Protection of Aquatic Life (PAL) of 6.5 mg/L. The effect of weak thermal stratification combined with decomposition at the lake bed (an oxygen consuming process) are apparent on July 6th, when concentrations at the surface are well above 6.5 mg/L, but by 5.0 m, concentrations fall below the recommended guidelines. Anoxic conditions at the lake bed may promote the release of phosphorus from the lake sediments.

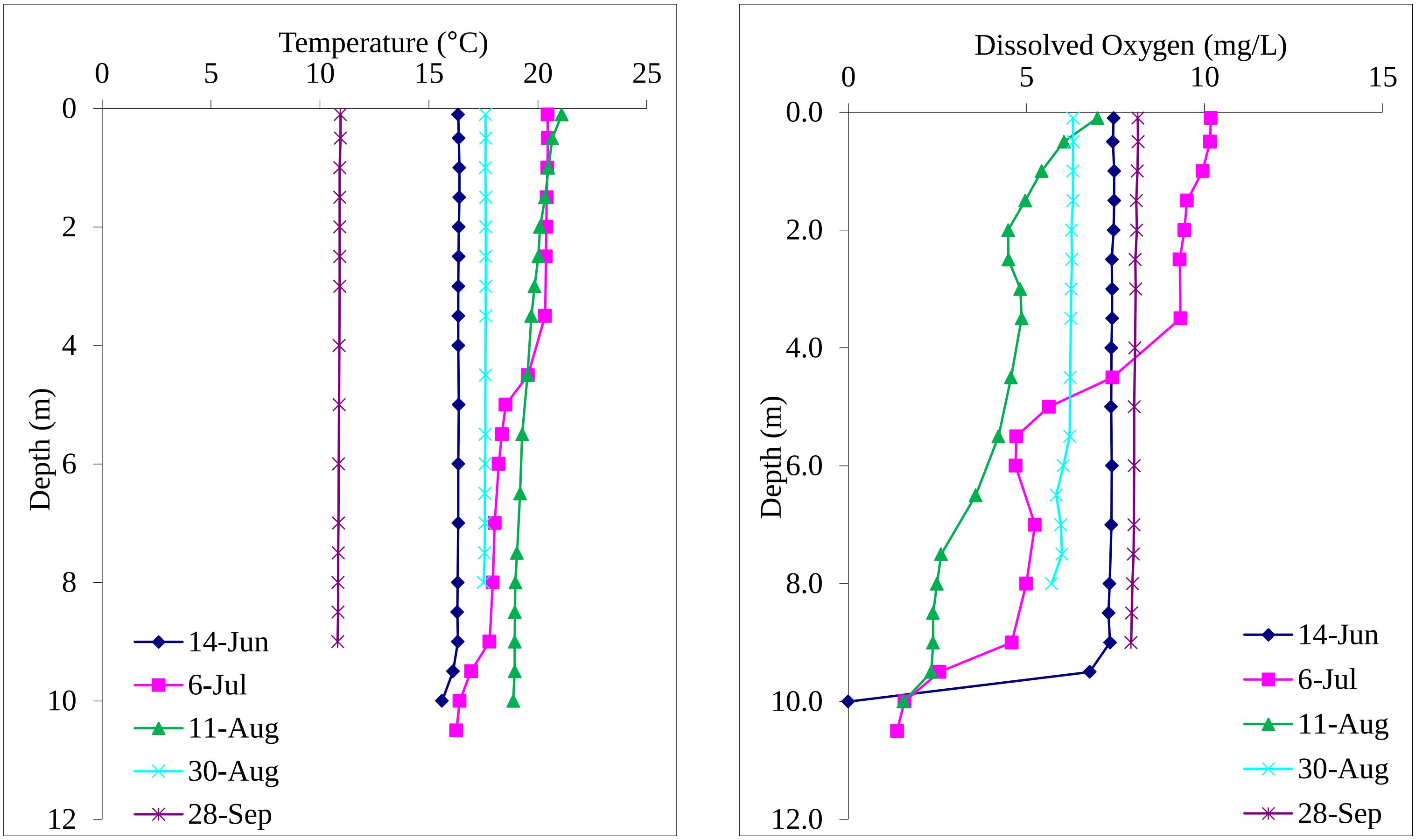

Figure 3 – Temperature (°C) and dissolved oxygen profiles measured at Iosegun Lake in the summer of 2015.

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 more complete list of parameters.

Average Total Phosphorus (TP) measured 52 μg/L in 2015 (Table 2). This value falls into the eutrophic, or nutrient rich, classification. Throughout the summer, TP ranged from a seasonal minimum of 32 μg/L on June 14th to a seasonal maximum of 52 μg/L on September 28th (Figure 4). The mixing of the water column at the end of the season can result in an increase in available phosphorus.

Chlorophyll-*a* concentration measured an average of 17.1 μg/L in 2015 (Table 2). This value falls just into eutrophic classification – in contrast, in 2014, Iosegun Lake fell into the hypereutrophic classification with an average chlorophyll-*a* concentration of 25.2 μg/L. Throughout the summer, chlorophyll-*a* concentration ranged from a minimum of 4.2 μg/L on June 14th to a maximum of 35.9 μg/L on July 6th. More data is required to better understand the relationship between nutrients and chlorophyll-*a* concentration at Iosegun Lake.

Finally, Total Kjeldahl Nitrogen (TKN) measured an average of 1.1 mg/L in 2015 (Table 2). Average TKN concentration for 2015 falls just into the hypereutrophic classification. Throughout the summer, TKN ranged from a minimum of 0.72 mg/L on June 14th to a maximum of 1.5 mg/L on August 11th (Figure 4).

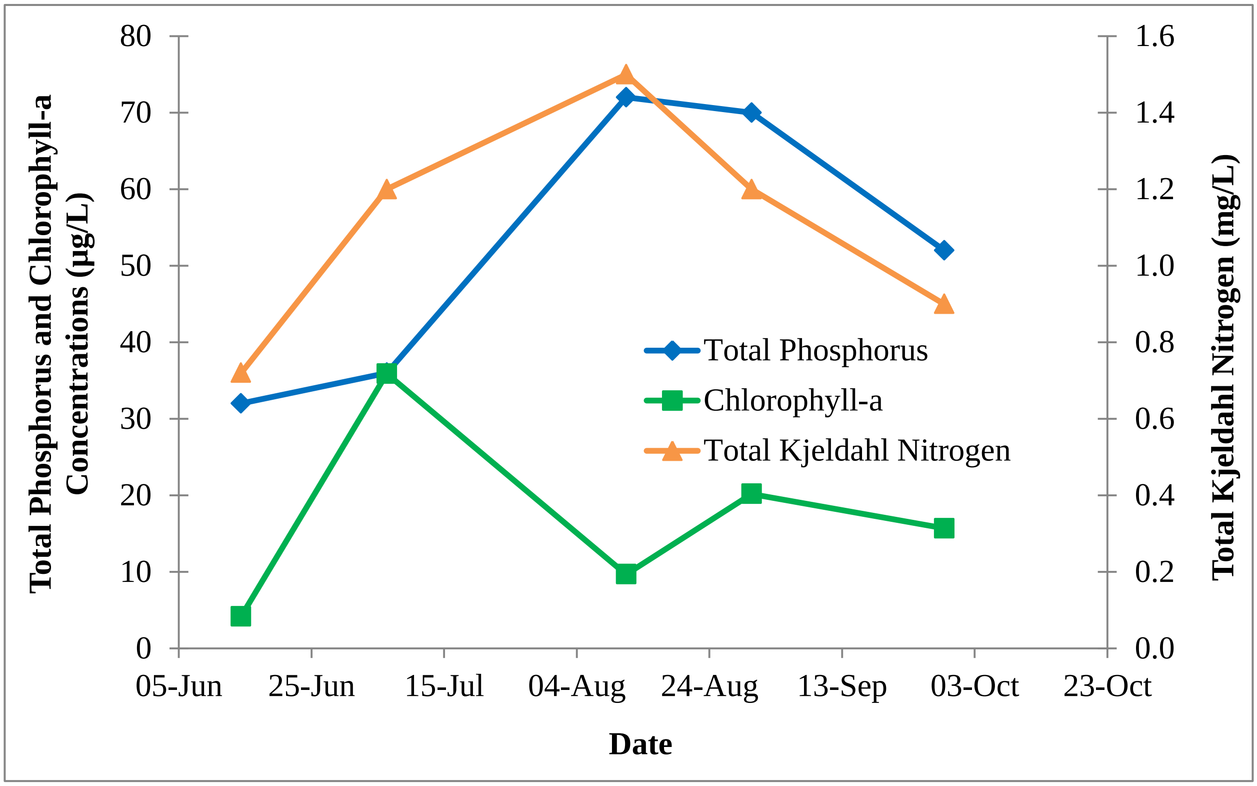

Figure 4 - Total phosphorus (µg/L), chlorophyll-*a* (µg/L), and total Kjeldahl nitrogen (µg/L) concentrations measured five times over the course of the summer of 2015.

Average pH measured 7.57 in 2015 – this value is above neutral. Iosegun Lake has low level of alkalinity (60.84 mg/L CaCO3) and bicarbonate (74 mg/L HCO_3) concentration which would help to buffer the lake against changes to pH (Table 2). The maximum pH value recorded was 8.0 on July 17th, while the minimum was 6.44 recorded on August 28th. Calcium (17.47 mg/L), chloride (13.833 mg/L), and sodium (12.13 mg/L) are the dominant ions in Iosegun Lake, contributing to a conductivity of 174.4 µS/cm.

Metals were collected twice at Iosegun Lake and all concentrations fell within their respective guidelines (Table 3).

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, concentrations of microcystin reached an observed maximum of 2.69 μg/L on August 30th. Average microcystin concentration measured 0.97 μg/L which falls well below the recommended guidelines of 20 μg/L (Table 1). Caution should always be taken when recreating in waters experiencing cyanobacteria blooms.

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

Date	Microcystin Concentration (μg/L)
14-Jun-15	0.05
06-Jul-15	0.05
11-Aug-15	0.86
30-Aug-15	2.69
28-Sep-15	1.21
Average	**0.97**

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 Iosegun Lake.

Table 2. Average Secchi disk depth and water chemistry values for Iosegun Lake in 2015.

Parameter	1983	1985	2014	2015
TP (µg/L)	49*	48*	81	55
TDP (µg/L)	29*	17*	38	22
Chlorophyll-a (µg/L)	29.2	31.0	25.2	17.1
Secchi depth (m)	/	/	1.52	1.57
TKN (mg/L)	0.94	0.97	1.3	1.1
NO2 and NO3 (µg/L)	7.25	15	36	19
NH3 (µg/L)	/	/	58	48
DOC (mg/L)	19	17	22	16
Ca (mg/L)	19	17	17	19
Mg (mg/L)	3.8	3.8	4.4	4.9
Na (mg/L)	7	7	12	12
K (mg/L)	1.2	1.4	1.7	1.7
SO42- (mg/L)	5.0	4.6	3.3	4.0
Cl- (mg/L)	3	4	14	16
CO3 (mg/L)	/	/	0.20	0.25
HCO3 (mg/L)	72	72	74	76
pH	7.91	7.72	7.57	7.83
Conductivity (µS/cm)	139	144	174	186
Hardness (mg/L)	55	57	62	69
TDS (mg/L)	71	74	97	104
Microcystin (µg/L)	/	/	0.25	0.97
Total Alkalinity (mg/L CaCO3)	59	59	61	62

Note: TP = total phosphorus, TDP = total dissolved phosphorus, 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.
*Historical data included duplicate values. Total phosphorus VMV 15421 & dissolved phosphorus 15105

Table 3. Average concentrations of metals measured in Iosegun Lake on June 14th, August 11th, and September 28th, 2015. The CCME heavy metal Guidelines for the Protection of Freshwater Aquatic Life (unless otherwise indicated) are presented for reference.

Metals (Total Recoverable)	2014	2015	Guidelines
Aluminum µg/L	25.9	39.6	100[a]
Antimony µg/L	0.069	0.060	6[e]
Arsenic µg/L	1.285	0.778	5
Barium µg/L	34.7	42.5	1000[e]
Beryllium µg/L	0.013	0.010	100[d,f]
Bismuth µg/L	0.01725	0.00383	/
Boron µg/L	13.3	14.0	5000[ef]
Cadmium µg/L	0.006	0.006	0.085[b]
Chromium µg/L	0.27	0.37	/
Cobalt µg/L	0.150	0.115	1000[f]
Copper µg/L	0.87	0.60	4[c]
Iron µg/L	341	245	300
Lead µg/L	0.225	0.237	7[c]
Lithium µg/L	3.0	3.6	2500[g]
Manganese µg/L	101	63	200[g]
Mercury ng/L	/	1.08	26
Mercury ng/L	/	0.95	26
Molybdenum µg/L	0.255	0.237	73[d]
Nickel µg/L	2.115	0.727	150[c]
Selenium µg/L	0.17	0.07	1
Silver µg/L	0.001	0.003	0.1
Strontium µg/L	87.0	85.3	/
Thallium µg/L	0.0015	0.0053	0.8
Thorium µg/L	0.0048	0.0058	/
Tin µg/L	0.021	0.016	/
Titanium µg/L	0.85	1.62	/
Uranium µg/L	0.080	0.073	100[e]
Vanadium µg/L	0.34	0.30	100[f,g]
Zinc µg/L	2.4	0.5	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:

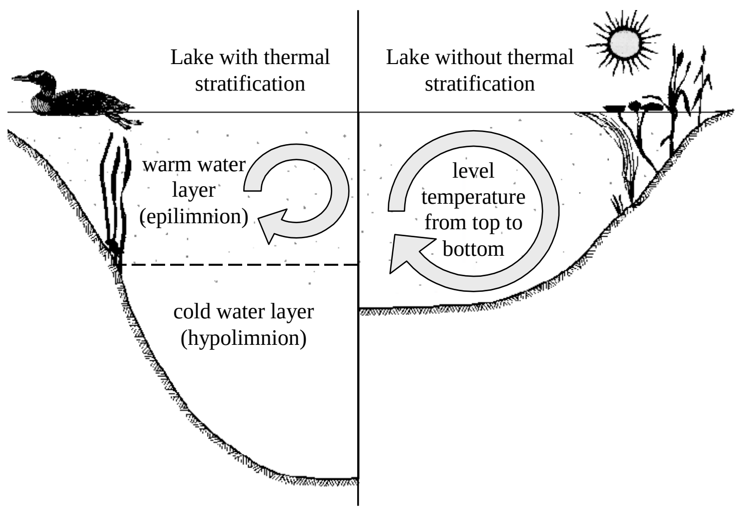

Figure A: Difference in the circulation of the water column depending on thermal stratification.

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.

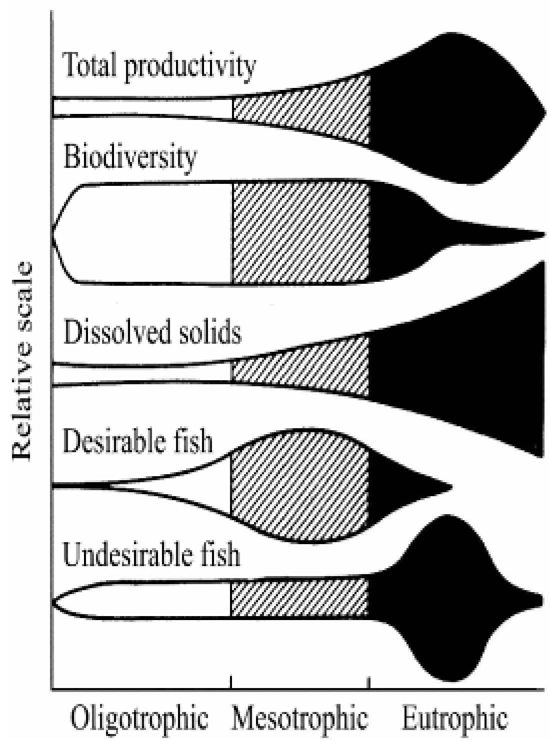

Figure B: Suggested changes in various lake characteristics with eutrophication. From “Ecological Effects of Wastewater”, 1980.

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

Trophic state	Total Phosphorus (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