



# Lakewatch

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*THE ALBERTA LAKE MANAGEMENT SOCIETY  
VOLUNTEER LAKE MONITORING PROGRAM*

## 2015 Laurier Lake Report

*LAKEWATCH IS MADE POSSIBLE WITH SUPPORT FROM:*



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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.

Data in this report has been published before the completion of the data validation process.

## **Acknowledgements**

The LakeWatch program is made possible through the dedication of its volunteers. We would like to thank Bev Smith for his assistance with sampling Laurier Lake in 2015. Bev was named volunteer of the Year in 2015. We would also like to thank Ageleky Bouzetos, Laticia McDonald, and Mohamad Youssef who were summer technicians with ALMS in 2015. 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 Ageleky Bouzetos 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.

## LAURIER LAKE:

Laurier Lake is one of four beautiful lakes that were left behind 10,000 years ago when glaciers carved a hummocky terrain of kettles, eskers, and lake basins. Archaeological evidence indicates that the area was inhabited 7000 years ago, with Europeans arriving in 1754 by way of the nearby North Saskatchewan River.

The Whitney Lakes Provincial Park adjacent to Laurier Lake was established in 1982. It boasts a diverse setting of jack pine (*Pinus banksiana*) meadows, aspen (*Populus spp.*) groves, willow (*Salix spp.*) thickets, marshes, fens, and mixed wood forests. As many as 148 bird species have been observed in the park with an excellent viewing

point on the west side of Laurier Lake. The land surrounding Laurier Lake includes a mixture of recreational cottage development, cleared agricultural land, and natural deciduous forest. Protected Crown Land makes up the north shore of the lake and the remainder is privately owned.

The lake is enjoyed through recreational activities including hiking, wildlife viewing, and water-based recreation such as wind surfing, water-skiing, sailing, swimming, and fishing. Yellow perch (*Perca flavescens*) and northern pike (*Esox lucius*) are the sport fish of Laurier Lake. Fish stocking occurred in 1953 with sport and forage fish transferred from Moose Lake to Laurier Lake. The lake has not been managed for commercial or domestic fisheries.



Figure 1 – LakeWatch Coordinator Bradley Peter and volunteer Bev Smith at Laurier Lake. Photo by Pauline Pozsonyi, 2011.

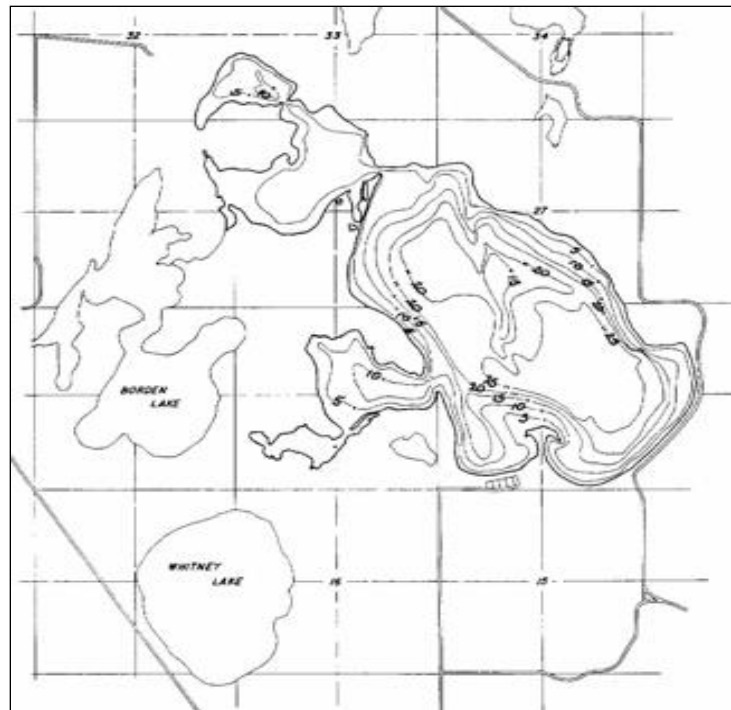


Figure 2 – Bathymetric map of Laurier Lake showing five-foot depth contour intervals.

## 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.*

Laurier Lake has a surface area of 6.42 km<sup>2</sup>, a maximum of depth of approximately 7.5 m, and a drainage basin of 92.0 km<sup>2</sup> (which is shared with Ross, Borden, and Whitney Lakes; Figure 2). One intermittent and three permanent streams feed into Laurier Lake. The outflow, on the northwest end, drains into Borden Lake and subsequently into the North Saskatchewan River. Between 1968-2004 water levels at Laurier Lake have shown a general trend towards decline (Figure 3). Maximum water elevation was observed in 1974 at 567.2 meters above sea level (m asl), and a minimum of 564.0 m asl was observed in 2004. However, since 2004 water levels have shown an increasing trend, reaching 566.146 m asl in 2015 – a value this high has not been observed since 1988. High water levels have reconnected Laurier Lake to bays which were previously separated in dryer years (Bev Smith, pers. comm.).

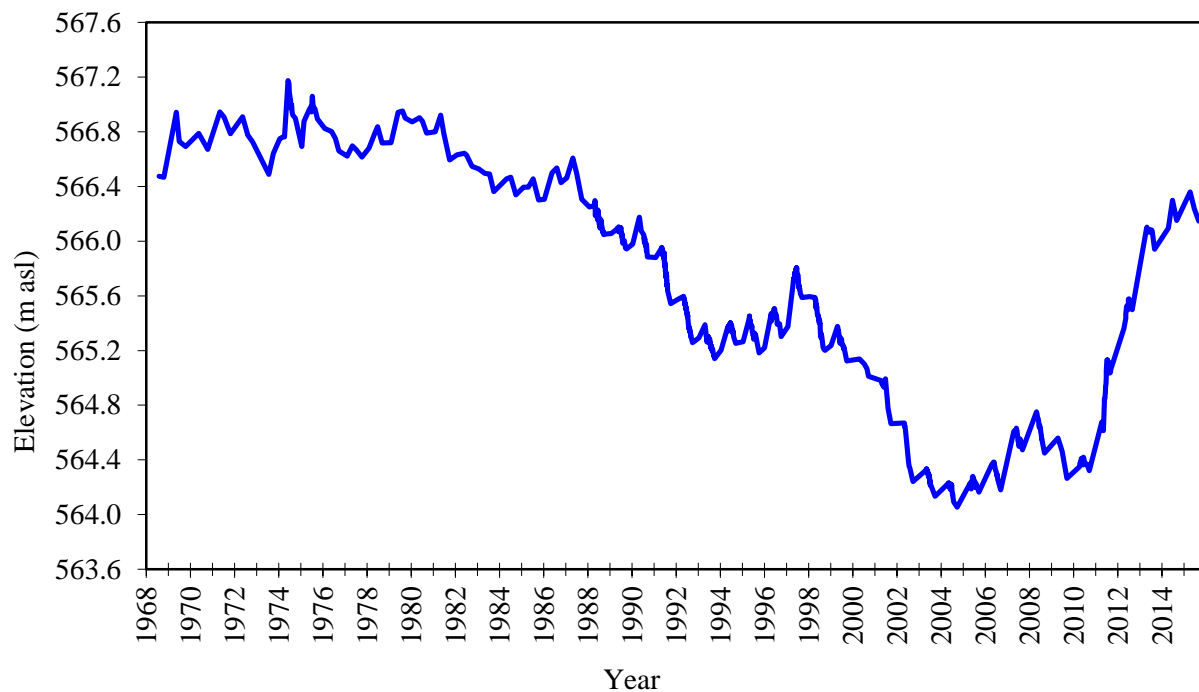


Figure 3 – Historical water levels for Laurier Lake recorded in meters above sea level (m asl) from 1968 to 2015. Data retrieved from Alberta Environment.

## WATER CLARITY & 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 Laurier Lake measured an average of 2.67 m in 2015 (Table 2; Figure 3). This average was comprised of a maximum water clarity of 4.10 m on June 1<sup>st</sup> and a minimum water clarity of 2.00 m on July 29<sup>th</sup>. An average value of 2.67 m is one of the highest Secchi disk depths when compared to Laurier Lake's historical variation.

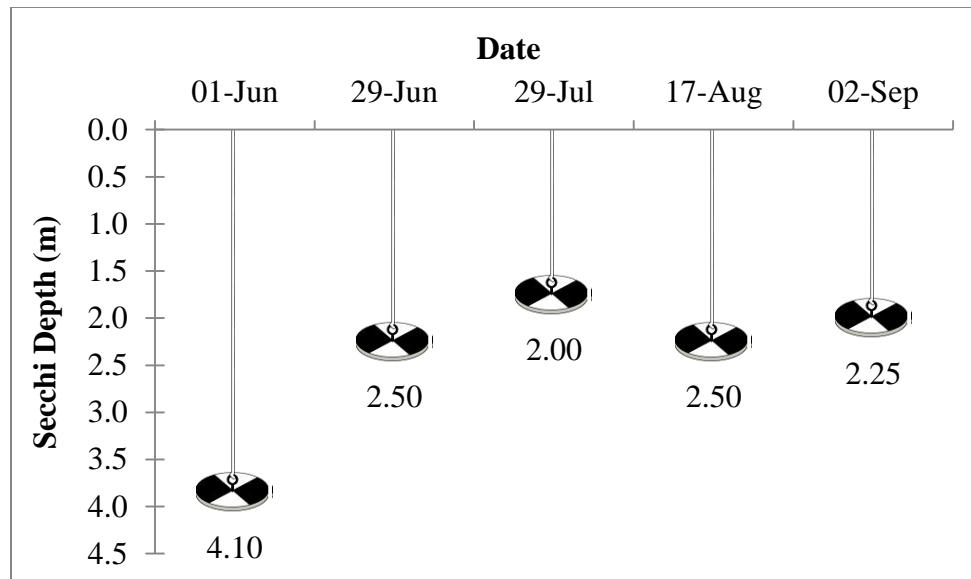


Figure 4 – Secchi disk depth values (m) measured five times at Laurier Lake during the summer of 2015.

#### **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.*

Temperature in Laurier Lake reached a maximum surface temperature of 23.10 °C on June 29<sup>th</sup> and a maximum bottom temperature of 20.59 °C on July 29<sup>th</sup> (Figure 5a). Warm waters throughout the water column have the potential to stress fish populations. Thermal stratification was observed on June 29<sup>th</sup> between 2.5-4.5 m, but was not observed again during the summer. Thermal stratification has the potential to impact dissolved oxygen concentrations throughout the water column.

**b)**

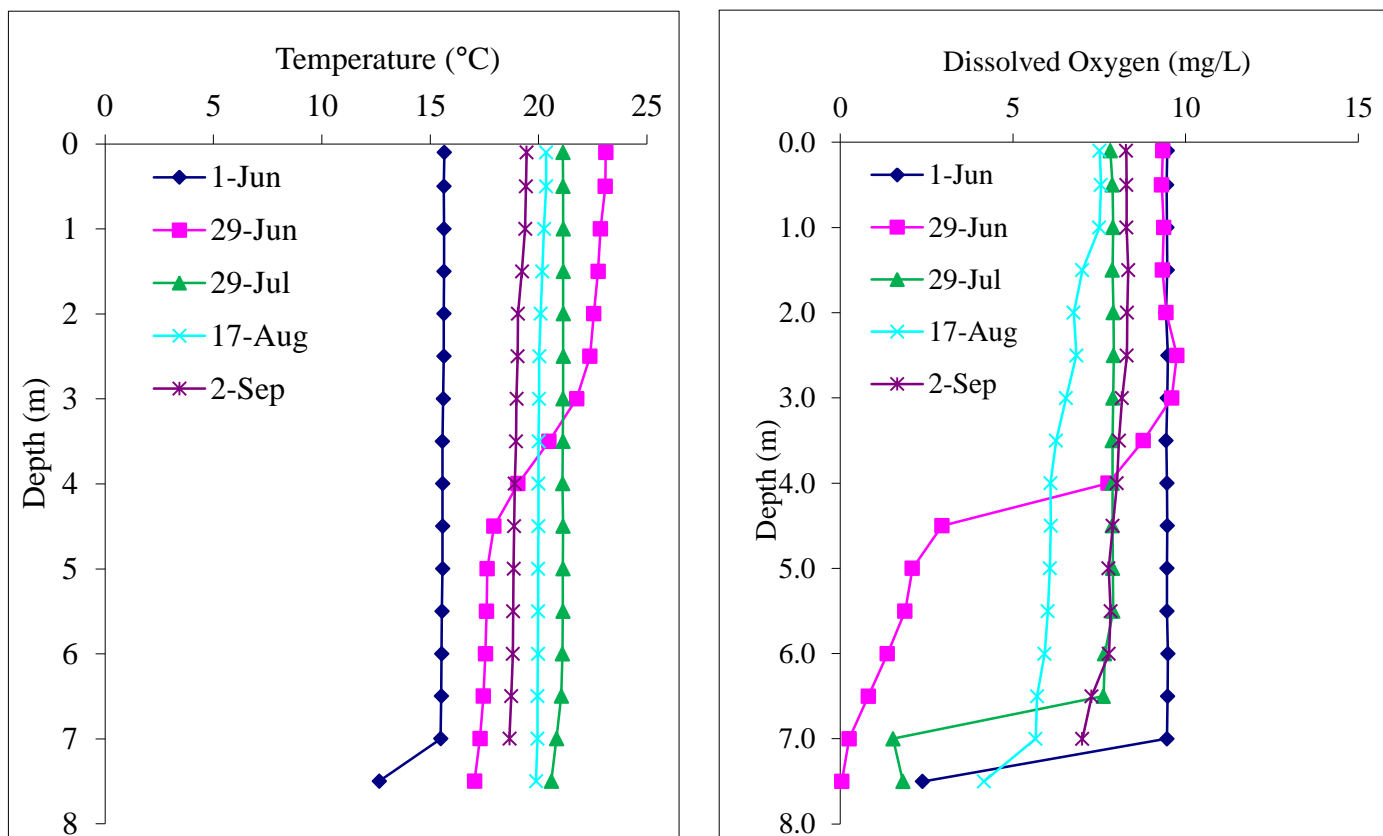


Figure 5 – a) Temperature (°C) and b) dissolved oxygen (mg/L) profiles for Laurier Lake measured five times over the course of the summer of 2015.

Dissolved oxygen varied throughout the summer of 2015 (Figure 5b). On June 1<sup>st</sup> a maximum dissolved oxygen concentration of 9.47 mg/L was recorded at the surface of the lake. Low concentrations of dissolved oxygen were detected near the lake sediments on each sampling trip with the exception of September 2<sup>nd</sup> when the entire water column was well oxygenated. Concentrations below the Canadian Council for Ministers of the Environment guideline for the Protection of Aquatic Life were observed for more than half the water column on August 17<sup>th</sup>.

**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) measured 39 µg/L in 2015. This average falls into the eutrophic, or nutrient rich, classification, and lies well within the historical variation previously observed at Laurier Lake. Throughout the summer, TP showed little fluctuations, measuring a minimum of 37 µg/L on June 1<sup>st</sup> and a maximum of 45 µg/L on June 29<sup>th</sup>.



Average chlorophyll-*a* concentration measured 7.8 µg/L in 2015 – similar to TP, this concentration lies well within the historical variation previously observed at Laurier Lake (Table 2). Throughout the summer there were no observed significant cyanobacteria blooms, and chlorophyll-*a* fluctuated between a minimum of 5.4 µg/L on June 1<sup>st</sup> and a maximum of 9.2 µg/L on both July 29<sup>th</sup> and August 17<sup>th</sup> (Figure 7).

Average total Kjeldahl nitrogen (TKN) measured 2.2 mg/L in 2015 (Table 2, Figure 7). This average falls on the low end of the historical observations recorded at Laurier Lake, and lies within the hypereutrophic, or very productive, trophic classification.

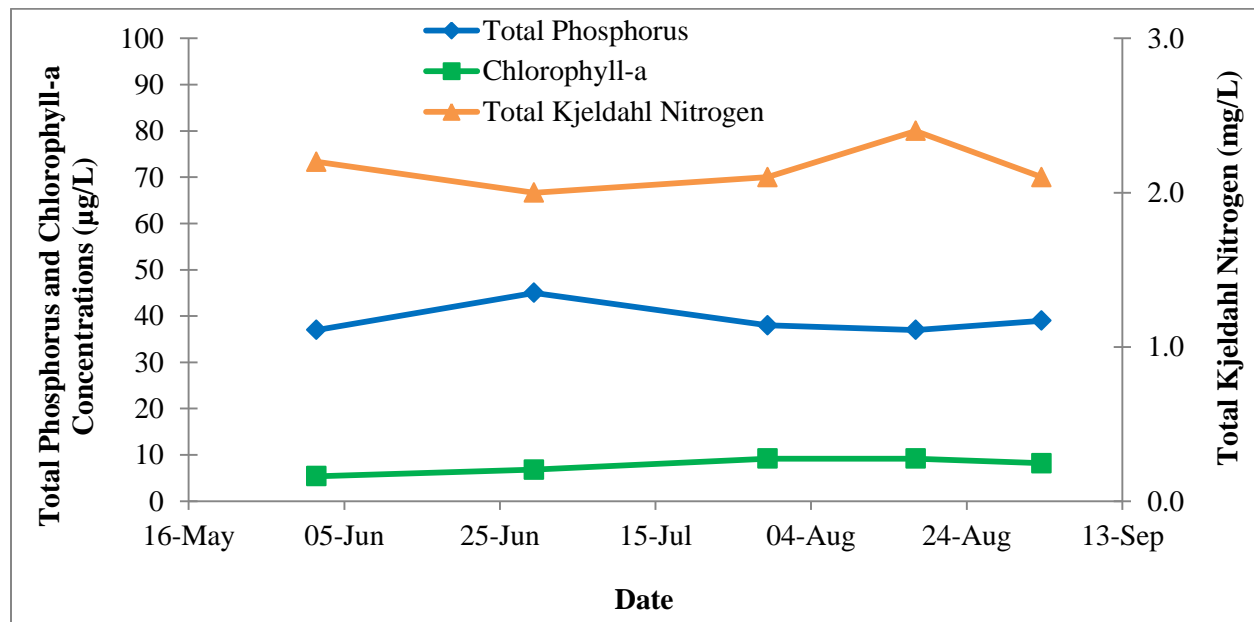


Figure 7 - Total phosphorus (µg/L), chlorophyll-*a* concentration (µg/L), and total Kjeldahl nitrogen (µg/L) measured five times over the course of the summer at Laurier Lake.

Average pH in Laurier Lake measured 8.85, well above neutral. Laurier Lake consistently has a high pH, and is well buffered against changes to pH due to its high alkalinity (524 mg/L CaCO<sub>3</sub>) and bicarbonate concentration (536 mg/L HCO<sub>3</sub><sup>-</sup>; Table 2). In 2014, major ions in Laurier Lake were sodium (98 mg/L), magnesium (87 mg/L), sulphate (120 mg/L), and potassium (30 mg/L). Overall, concentration of dissolved solids measured an average of 698 mg/L and conductivity measured 1100 µS/cm.

Metals were measured twice at Laurier Lake and only arsenic on July 29<sup>th</sup> (5.6 µg/L) narrowly exceeded the Canadian Council for Ministers of the Environment guidelines for the Protection of Aquatic Life of 5.0 µg/L (Table 3). A number of lakes across the province have exceeded arsenic guidelines simply due to the natural geology which exists in their watersheds.

**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.*

Despite its low chlorophyll-*a* concentrations, microcystin was still detectable in Laurier Lake in very small quantities. A maximum concentration of 0.75 µg/L was detected on September 2<sup>nd</sup>, which falls well below the recreational guidelines of 20 µg/L. All cyanobacteria blooms should be treated with caution when recreating as they may produce toxins not sampled for, and single grab samples may have higher concentrations of microcystin than the composite samples collected by ALMS.

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

<b>Date</b>	<b>Microcystin Concentration (µg/L)</b>
01-Jun-15	0.25
29-Jun-15	0.58
29-Jul-15	0.34
17-Aug-15	0.53
02-Sep-15	0.75
<b>Average</b>	<b>0.49</b>

**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 Laurier Lake.



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

Parameter	1978	1980	1987	1997	1998	2000	2002	2003	2004	2007	2008	2009	2010	2012	2013	2014	2015
TP (µg/L)	/	/	/	32.0	48.0	37.0	36.0	27.2	33.2	41.6	51.2	50.5	37.6	36.4	73.4	48	39.2
TDP (µg/L)	/	/	/	/	/	/	15	15	18	22	18.8	20.5	16.4	19.4	31	26.2	13.4
Chlorophyll-a (µg/L)	/	/	/	5.3	8.9	5.5	5.8	2.56	4.9	4.29	11.93	9.13	6.96	5.85	14.37	19.6	7.8
Secchi depth (m)	/	1.30	1.20	4.60	1.30	1.80	2.50	4.36	3.17	2.40	1.30	2.00	1.80	3.10	1.72	1.42	2.67
TKN (µg/L)	/	/	/	/	/	/	2.5	2.4	2.6	2.2	2.7	2.8	2.6	2.2	2.3	2.2	2.2
NO <sub>2</sub> and NO <sub>3</sub> (µg/L)	<50	50	<1	/	/	/	3.8	211	6.7	5	6	5.75	9.6	3.4	2.5	24	5.4
NH <sub>3</sub> (µg/L)	/	/	/	/	/	/	23	40.8	74.4	46.2	39.2	39.3	33.2	33	26.4	32.8	74
DOC (mg/L)	/	/	/	/	/	/	/	/	44.3	37.9	37.9	39	37.5	32.2	34.1	35.17	33
Ca (mg/L)	23	27	19	20	21	13	12	10.3	10.6	16.3	14.5	12.1	12.2	20.2	23.13	23.13	26
Mg (mg/L)	48	54	52	73	81	83	99	106	105.1	97.8	92.9	88.1	98.6	84.6	83.3	71.67	87
Na (mg/L)	49	45	59	86	92	98	77	127.5	130.3	122.7	120.7	132.3	136	101.9	100.9	108.33	98
K (mg/L)	14	14	17	24	25	25	26	31.25	33.87	32.83	31.9	38	34.47	31.3	35.2	32.57	30
SO <sub>4</sub> <sup>2-</sup> (mg/L)	36	40	41	62	66	73	94	99	103.7	111.7	121.3	135.7	148.7	118.3	107.3	102.67	120
Cl <sup>-</sup> (mg/L)	5	6	9	12	13	15	12	18.4	20.1	19.5	20.2	21.2	22.7	18.7	16.6	18.23	20
CO <sub>3</sub> (mg/L)	/	/	/	39	62	66	102	112	83.7	86	84.7	70	85	45	55.6	63.66	52
HCO <sub>3</sub> (mg/L)	/	/	/	493	468	469	515	522	601.3	535.7	544.3	582.3	568	546.8	500.2	614.6	536
pH	/	/	/	8.8	8.9	8	9.2	9.24	9.06	9.11	9.03	9	9.1	8.84	8.88	8.90	8.85
Conductivity (µS/cm)	/	/	/	/	/	/	/	/	1196.7	1163.3	1196.7	1246.7	1257	1143.6	1098.6	1100	1100
Hardness (mg/L)	/	/	/	351	387	376	/	462.5	459	443.3	418.7	392.7	436.3	399	401	353	422
TDS (mg/L)	/	/	/	562	598	602	/	764.5	783.7	750.3	754.3	784.3	817	690.7	669	709.667	698
Microcystin (µg/L)	/	/	/	/	/	/	/	/	/	0.53	0.236	0.39	0.174	0.4692	/	3.514	0.49
Total Alkalinity (mg/L CaCO <sub>3</sub> )	310	329	360	470	488	493	592	615	633	583	588	594	607.7	523.8	503	504	524

Note: TP = total phosphorous, TDP = total dissolved phosphorous, Chl-*a* = chlorophyll-*a*, TKN = total Kjeldahl nitrogen. NO<sub>2+3</sub> = nitrate+nitrite, NH<sub>3</sub> = ammonia, DOC = dissolved organic carbon, Ca = calcium, Mg = magnesium, Na = sodium, K = potassium, SO<sub>4</sub> = sulphate, Cl = chloride, CO<sub>3</sub> = carbonate, HCO<sub>3</sub> = 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 Laurier Lake on July 29<sup>th</sup> and September 2<sup>nd</sup>. 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.

<b>Metals (Total Recoverable)</b>	<b>2007</b>	<b>2008</b>	<b>2010</b>	<b>2011</b>	<b>2012</b>	<b>2013</b>	<b>2014</b>	<b>2015</b>	<b>Guidelines</b>
Aluminum µg/L	29.4	9.69	20.65	17.2	7.61	7.265	16.05	10.05	100 <sup>a</sup>
Antimony µg/L	0.137	0.117	0.131	0.1245	0.115	0.0931	0.094	0.1415	6 <sup>e</sup>
Arsenic µg/L	2.6	3	3.185	2.825	2.435	2.35	2.165	3.89	5
Barium µg/L	20.2	16.95	17.8	19.15	29.6	35.8	37.85	23.225	1000 <sup>e</sup>
Beryllium µg/L	<0.003	<0.003	0.0015	0.00275	0.00975	0.0015	0.004	0.004	100 <sup>d,f</sup>
Bismuth µg/L	<0.005	0.0051	0.00205	0.0028	0.0067	0.00075	0.0005	0.0145	/
Boron µg/L	175.5	182	188.5	189	221.5	163	171	280	5000 <sup>ef</sup>
Cadmium µg/L	0.008	0.0038	0.00425	0.00345	0.00325	0.0019	0.002	0.0015	0.085 <sup>b</sup>
Chromium µg/L	0.611	0.56	0.441	0.465	0.2955	0.526	0.695	0.185	/
Cobalt µg/L	0.099	0.058	0.07075	0.081	0.05905	0.0482	0.0255	0.071	1000 <sup>f</sup>
Copper µg/L	0.613	0.555	0.278	2.9	0.6815	0.373	0.2425	1.085	4 <sup>c</sup>
Iron µg/L	37.1	15.8	16.855	21.05	9.5	17.15	13.4	14	300
Lead µg/L	0.057	0.023	0.0208	0.05535	0.01625	0.02645	0.00975	0.043	7 <sup>c</sup>
Lithium µg/L	102.9	100.2	114	114.5	111.5	87.05	75.8	149.35	2500 <sup>g</sup>
Manganese µg/L	5.15	7.97	4.125	8.335	13	19.9	20.3	12.61	200 <sup>g</sup>
Molybdenum µg/L	0.661	0.587	0.8645	0.7775	0.5875	0.4565	0.316	0.7825	73 <sup>d</sup>
Nickel µg/L	0.275	0.127	0.12845	0.199	0.0025	0.2175	0.004	0.164	150 <sup>c</sup>
Selenium µg/L	0.547	0.372	0.416	0.312	0.302	0.2395	0.49	0.11	1
Silver µg/L	<0.003	0.0086	0.001425	0.043125	0.00235	0.02525	0.018	0.0015	0.1
Strontium µg/L	84.5	62.9	58.85	72.35	114.5	134	145	89.2	/
Thallium µg/L	<0.001	0.0024	0.00115	0.001275	0.000425	0.00015	0.002975	0.02225	0.8
Thorium µg/L	<0.01	0.017	0.01245	0.0379	0.01295	0.0067	0.002225	0.029725	/
Tin µg/L	<0.06	<0.03	0.015	0.015	0.0337	0.015	0.01475	0.0215	/
Titanium µg/L	1.24	1.36	1.38	0.7535	0.69	1.4	1.935	2.01	/
Uranium µg/L	0.811	0.808	1.085	0.875	0.6825	0.677	0.5495	2.77	100 <sup>e</sup>
Vanadium µg/L	0.742	0.512	0.807	0.563	0.4275	0.3265	0.44	0.845	100 <sup>f,g</sup>
Zinc µg/L	1.53	0.916	0.326	1.0925	1.031	0.6225	1.1	1.25	30

Values represent means of total recoverable metal concentrations.

<sup>a</sup> Based on pH ≥ 6.5; calcium ion concentrations [Ca<sup>2+</sup>] ≥ 4 mg/L; and dissolved organic carbon concentration [DOC] ≥ 2 mg/L.

<sup>b</sup> Based on water Hardness of 300 mg/L (as CaCO<sub>3</sub>)

<sup>c</sup> Based on water hardness > 180mg/L (as CaCO<sub>3</sub>)

<sup>d</sup> CCME interim value.

<sup>e</sup> Based on Canadian Drinking Water Quality guideline values.

<sup>f</sup> Based on CCME Guidelines for Agricultural use (Livestock Watering).

<sup>g</sup> 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:

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.

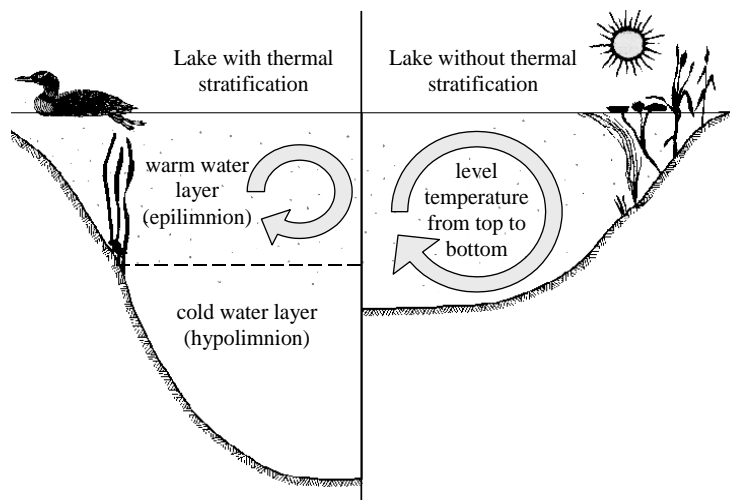


Figure A: Difference in the circulation of the water column depending on thermal stratification.

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

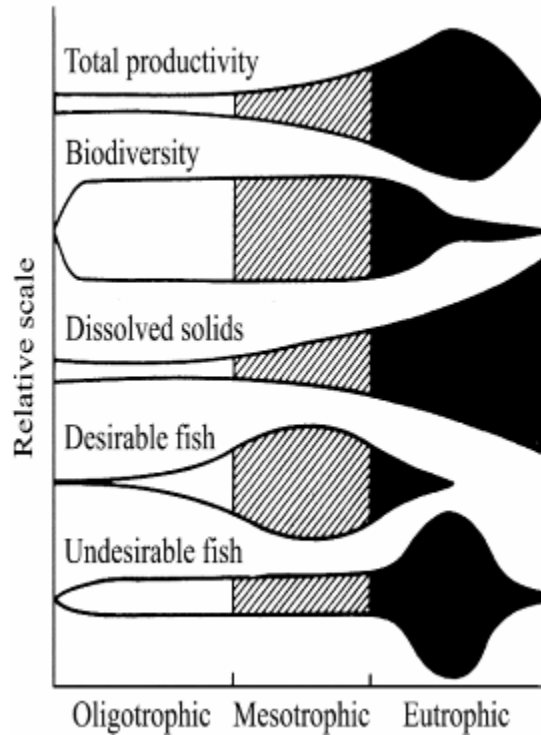


Figure B: Suggested changes in various lake characteristics with eutrophication. From “Ecological Effects of Wastewater”, 1980.

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

Trophic state	Total Phosphorus (µg•L <sup>-1</sup> )	Total Nitrogen (µg•L <sup>-1</sup> )	Chlorophyll a (µg•L <sup>-1</sup> )	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