

The Alberta Lake Management Society Volunteer Lake Monitoring Program

# 2011 Isle Lake Report

Completed with Support From:



**Beaver River Watershed Alliance** 

Government





# 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

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# ISLE LAKE:

Isle Lake is located in the counties of Lac Ste. Anne and Parkland, 80 km west of the City of Edmonton. The Hamlet of Gainford, established in 1942, is situated on the southwest shore. In 1879, the Hudson Bay Company set up a trading post at nearby Lac Ste. Anne, and settlers began arriving in 1905 as agricultural lands became available.<sup>1</sup> Today, several subdivisions are registered along the shoreline and the lake is heavily used for recreation. Sport fishing is popular, and species include northern pike (*Esox lucius*), yellow perch (*Perca flavescens*), burbot (*Lota lota*), white suckers (*Catostomus commersoni*), and walleye (*Sanders vitreus*).<sup>1</sup>

Isle Lake is long and moderately shallow (Fig 1; maximum depth 7.5 m). Dominant phytoplankton in the spring are dinoflagellates (*Peridiniun cinctum*) and diatoms (*Stephanodiscus hantzschia* and *Asterionella formosa*).<sup>1</sup> During the summer, cyanobacteria (*Gleotrichia echinulata* and *Aphanizomenon flos-aquae*) are dominant until late fall when again diatoms such as *Stephanodiscus nigarie* dominate the biomass composition.<sup>1</sup> Emergent aquatic plants such as *Scirpus validus, Typha latifolia*, and *Carex* sp. are common. Submergent plants are found between 1-5 m depths and include northern watermilfoil and Richardson pondweed.<sup>1</sup> Such aquatic vegetation is important in supporting a healthy fishery by providing cover, food, and spawning beds for fish. However, excessive vegetation creates conflict with recreational use and treatments have been applied to remove some of the vegetation.



Figure 1 – Bathymetry and shoreline features of Isle Lake.<sup>1</sup>

# WATER LEVELS:

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.

Water levels at Isle Lake have changed little since monitoring began in 1972. Between the historical maximum of 730.5 in 1989 meters above sea level (m asl) and the historical minimum of 729.2 in 2010 m asl, water levels have only changed by 1.3 m (Figure 2). With a drainage basin area approximately 11 times the size of the lake, Isle Lake receives large amounts of input in the form of runoff. The Sturgeon River runs into Isle Lake from the West and exits the lake to the East, which then flows into neighbouring Lac St. Anne.



Figure 2 – Water levels at Lake Isle measured in meters above sea level (m asl) from Eureka Beach. Data obtained from Environment Canada.

# 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.

<sup>&</sup>lt;sup>1</sup> Mitchell, P. and E. Prepas. 1990. Atlas of Alberta Lakes, University of Alberta Press. Retrieved from http://sunsite.ualberta.ca/projects/alberta-lakes/

Average Secchi disk depth at Isle Lake in 2011 was 0.66 m. A value of 0.66 m falls into the hypereutrophic, or extremely productive, classification. This value also suggests that, on average, no surface light remained for photosynthesis beyond 1.32 m. Decreased water clarity can impair the growth of macrophytes and make foraging difficult for fish. High concentrations of algae/cyanobacteria are likely the biggest impairments to water clarity at Isle Lake. Water clarity remained below 1.00 m throughout the summer until September 7<sup>th</sup>, when it measured 1.25 m.

# 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.

Thermal stratification was observed only once throughout the summer, and occurred on June  $22^{nd}$  between 1.0-2.0m (Figure 3a). Short periods of stratification can contribute to the depletion of dissolved oxygen in deeper waters. After June, the lake became mixed, causing water temperatures to remain uniform throughout the water column. Water temperatures were high from the surface to the lakebed, measuring as much as 19.13 °C at the lakebed on August 16<sup>th</sup>.



Figure 3 – a) Temperature (°C) and b) dissolved oxygen (mg/L) profiles for Lake Isle measured in 2011.

Dissolved oxygen levels at Lake Isle were poor in 2011 (Figure 3b). The Canadian Council for Ministers of the Environment recommends 6.5 mg/L for the Protection of Aquatic Life, and on both August 16<sup>th</sup> and September 7<sup>th</sup>, more than half of the water column fell below this guideline. Low oxygen levels are likely a result of the decomposition of algae/cyanobacteria which is an oxygen-consuming process. A combination of high water temperatures and low dissolved oxygen concentrations may lead to summer fish kills, which have been observed at Isle Lake.

# 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.

Average Total Phosphorous (TP) measured during 2011 was 225.2  $\mu$ g/L, which falls into the hypereutrophic, or extremely productive, classification. Sediment core analysis suggests that Isle Lake has always been nutrient rich, though it is likely becoming moreso due to developments in its watershed<sup>2</sup>. High levels of runoff in 2011 likely contributed to increased amounts of TP in the lake, as in 1996, a high runoff year, as much as 53% of the lakes TP came from watershed runoff.<sup>2</sup> Internal sources contribute large amounts of phosphorous to the lake, and it is likely that internal loading was high in 2011 due to low dissolved oxygen concentrations. In 2011, TP ranged from a minimum of 24.0  $\mu$ g/L on June 22 to 300  $\mu$ g/L on August 2<sup>nd</sup>. Mitchell (1999) suggests that the management of septic systems and development in the watershed may result in noticeable improvements in lake water quality.

Average Total Kjeldahl Nitrogen (TKN) also fell into the hypereutrophic classification with a value of 2930  $\mu$ g/L, the highest TKN average recorded at Lake Isle. TKN changed greatly throughout the summer, ranging from 2410  $\mu$ g/L on September 7<sup>th</sup> to 4110  $\mu$ g/L on August 2<sup>nd</sup>.

Average chlorophyll-*a* concentration at Isle Lake measured 113  $\mu$ g/L in 2011. This is the highest value recorded at Lake Isle, and falls into the hypereutrophic classification. The largest bloom of algae/cyanobacteria was observed on August 2<sup>nd</sup>, with chlorophyll-*a* values measuring 156  $\mu$ g/L. In 2011, a Blue-Green Algae Advisory was posted by Alberta Health Services on August 17<sup>th</sup> and lifted on October 26<sup>th</sup>.

Average pH measured at Isle Lake was 8.32, which is well above neutral. Similar to many other lakes in Alberta, Isle Lake has high bicarbonate concentration (203 mg/L HCO<sub>3</sub>) and alkalinity (171 mg/L CaCO<sub>3</sub>) which help to buffer the lake against changes



Figure 4 – Cyanobacteria bloom on Isle Lake. September 7<sup>th</sup> 2011. Photo by Jessica Davis.

<sup>&</sup>lt;sup>2</sup> Mitchell, P. 1999. Water Quality Management in Lac St. Anne and Lake Isle: A Diagnostic Study. Retrieved from http://environment.gov.ab.ca/info/library/5804.pdf

to pH. Concentrations of ions in the lake have not changed appreciably over time, and remain low, as evidenced by Isle Lake's low conductivity (364  $\mu$ S/cm). The absence of changes to the ion concentration in Isle Lake suggests that there have been few changes to the lake's hydrology.

Parameter	1983 <sup>2</sup>	1984 <sup>2</sup>	1996 <sup>2</sup>	1997 <sup>2</sup>	1998 <sup>2</sup>	1996-1998 <sup>2</sup>	2002	2011
TΡ (μg/L)	140	166	94	178	367	/	147	225.2
TDP (µg/L)	72	115	37	116	285	/	95	85
Chlorophyll-a (µg/L)	64.7	47.5	48.6	65.6	67.1	/	20	113
Secchi depth (m)	1.4	1.3	3.1	1.7	2.1	/	2.1	0.66
TKN (μg/L)	1798	1838	1288	1675	2130	/	1623	2930
$NO_2$ and $NO_3$ (µg/L)	/	/	/	/	/	/	25	24.5
NH <sub>3</sub> (μg/L)	/	/	/	/	/	/	52	78.2
DOC (mg/L)	/	/	/	/	/	/	/	17.9
Ca (mg/L)	/	/	/	/	/	30.6	30	25.3
Mg (mg/L)	/	/	/	/	/	8.6	10	10.8
Na (mg/L)	/	/	/	/	/	19	26	32.8
K (mg/L)	/	/	/	/	1	7	9	9.3
SO <sub>4</sub> <sup>2-</sup> (mg/L)	/	/	/	/	1	30.6	8.9	4
Cl <sup>-</sup> (mg/L)	/	/	/	/	/	5	6.6	10.3
CO <sub>3</sub> (mg/L)	/	/	/	/	/	7.6	6.2	3.2
HCO₃ (mg/L)	/	/	/	/	/	165	189	203
pH	/	/	/	/	/	7.7-9.0	/	8.32
Conductivity (µS/cm)	/	/	/	/	/	308	/	364
Hardness (mg/L)	/	/	/	/	/	112	/	108
TDS (mg/L)	/	/	/	/	/	166	/	196
Microcystin (µg/L)	/	/	/	/	/	/	1	0.96
Total Alkalinity (mg/L CaCO <sub>3</sub> )	/	/	/	/	/	148	153	171

Table 1 – Average Secchi depth and water chemistry values for Isle Lake. Previous years averages are provided for comparison.

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

# **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



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

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  $4^{\circ}$  C water at the bottom and near  $0^{\circ}$  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•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  $25 \mu g/L$ ) 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.

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

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