Lakewatch

THE ALBERTA LAKE MANAGEMENT SOCIETY
VOLUNTEER LAKE MONITORING PROGRAM

2014 Marie Lake Report

LAKEWATCH IS MADE POSSIBLE WITH SUPPORT FROM:

Beaver River Watershed Alliance

Alberta
Government

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

The LakeWatch program is made possible through the dedication of its volunteers. We would like to thank Cal Sikstrom, Jim Ross, Karen & Mike Brown, and Diane Grainger for their assistance with sampling Marie 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.

MARIE LAKE:

Marie Lake is located in the Beaver River Drainage Basin and lies approximately 26 km northeast of the Town of Cold Lake, in the central mixed wood natural subregion of Alberta.[1] Marie Lake is named after the Cree word *Methae* or *Merai* meaning “a fish”, and may specifically refer to the burbot (*Lota lota*) prevalent throughout most of Alberta.[2] The Cree arrived in the late eighteenth century during the growth of the fur trade via a popular trade route from Waterhen, Saskatchewan. Their arrival resulted in the displacement of the Beaver, Blackfoot, and Slavey tribes that were common in the area.[2]

Figure 1 – The view from a dock on Marie Lake. Photo by Randi Newton 2012.

Marie Lake is over 26.0 m deep (Figure 2) with a slow flushing rate (a residence time of 14.5 years). It is mesotrophic and has a small littoral zone for its surface area of 36 km². The shoreline is primarily sandy with macrophytes (rooted aquatic plants) limited to a couple areas. A large macrophyte bed is located along the west shore stretching towards the north, and another lies on the western edge of the south bay. Macrophyte beds are dominated by bulrush, pondweed, and northern watermilfoil[1]. The low productivity of the shoreline does not provide suitable habitat for semi-aquatic wildlife; however, the macrophytes beds are very important for maintaining a productive fishery.

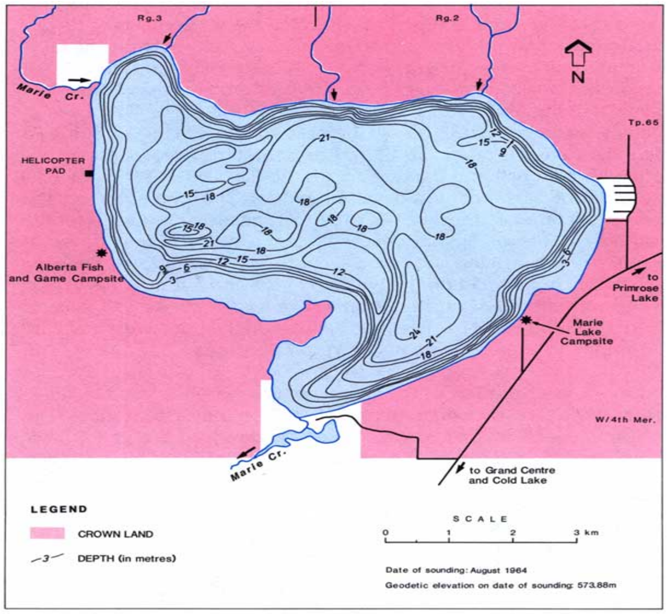

Figure 2 – Bathymetric map of Marie Lake obtained from Alberta Environment.

Currently, Marie Lake supports a domestic fishery - commercial fishing licenses have not been issued in the past decade. Sport fish include lake whitefish, walleye, northern pike, yellow perch, and burbot.

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[1] Nat. Regions Committee, 2006. Nat. Regions and Subregions of AB. Compiled by D.J. Downing and WW Pettapiece. GoA Pub. No. T/852

[2] Mitchell, P. and E. Prepas. 1990. Atlas of Alberta Lakes, University of Alberta Press. Retrieved from http://sunsite.ualberta.ca/projects/alberta-lakes/

Although largely undeveloped, Marie Lake has individual private cottages along the southern shore and a subdivision on the eastern shore on private land. Also on the east shore is a members only National Defense/RCMP recreational campground. Additional private property and a campground are located at Shelter Bay on the north shore. Within the watershed, forestry, oil, and gas extraction industries are the main land uses. The Marie Lake Air and Watershed Society is spearheading the protection and enhancement of the lake's watershed.

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 Marie Lake have changed little since monitoring began in 1980 (Figure 3). There have, however, been large fluctuations, namely in 1992-1993 when water levels reached a minimum of 573.1 m above sea level (m asl), and in 2007, when water levels reached a maximum of 573.9 m asl. In a historical context, the 2011 water levels (573.89 m asl) at Marie Lake sit at the high end of the historical variation. More data will need to be collected to update lake current lake levels.

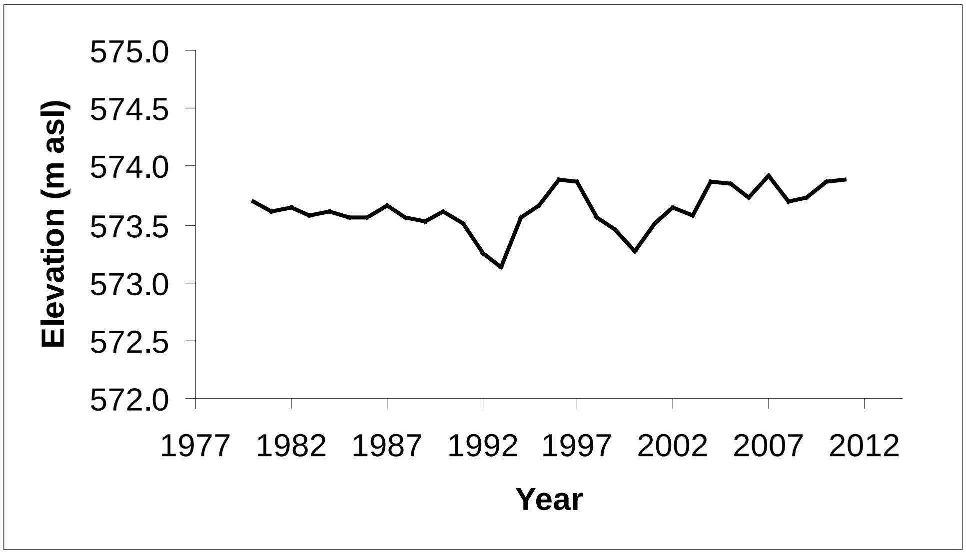

Figure 3 – Water levels at Marie Lake measured in meters above sea level (m asl). Data obtained from Environment Canada

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.*

Average Secchi disk depth measured 5.00 m during the summer of 2014; this average is on the high end of the historical variation measured at Marie Lake since monitoring began in 1980 (Table 1). Throughout the summer, Secchi disk depth ranged from a maximum of 6.60 m on July 26th to a minimum of 4.0 m on June 30th (Figure 4). High winds during sampling on June 30th can explain the low Secchi disk reading. Low levels of algae/cyanobacteria measured in 2014 are the most likely reason for the high level of water clarity.

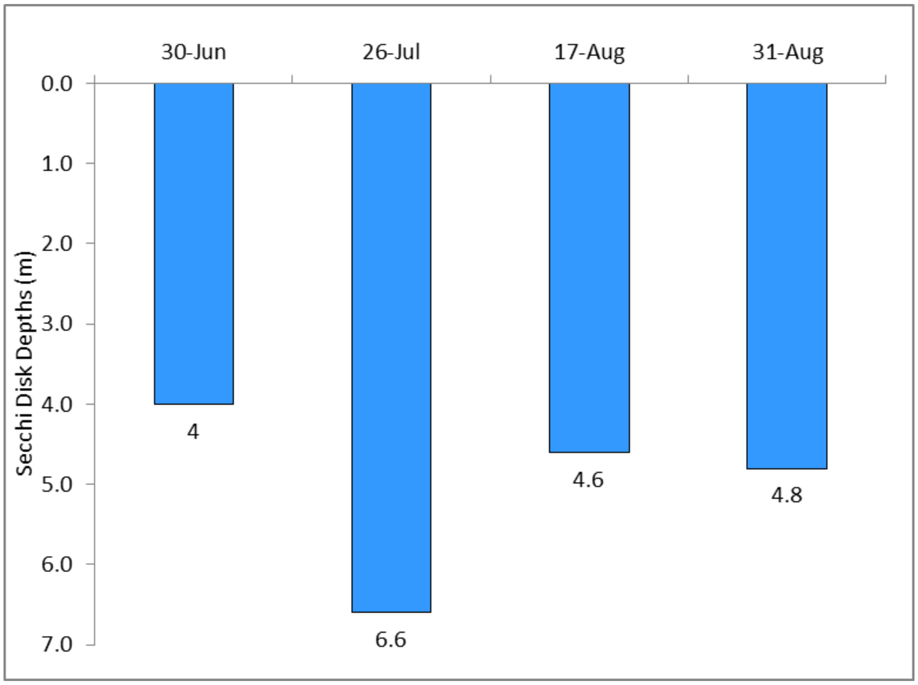

Figure 5 – Secchi disk depths measured four times throughout the summer of 2014 at Marie Lake.

WATER TEMPERATURE AND DISSOLVED OXYGEN:

Water temperature and dissolved oxygen profiles in the water column can provide information on water quality and fish habitat. The depth of the thermocline is important in determining the depth to which dissolved oxygen from the surface can be mixed. Please refer to the end of this report for descriptions of technical terms.

Surface water temperature measured at Marie Lake changed little throughout the course of the summer (Figure 5a). A minimum water temperature of 17.65 °C was measured on June 30th, while a maximum water temperature of 22.04 °C was recorded on August 17th. Strong thermal stratification was observed on all four sampling trips. Although no data was collected in September, previous year's data suggests that by September 30th the water column begins to mix and temperatures became more uniform. The presence of thermal stratification has important implications for dissolved oxygen concentrations as the density difference created by the temperature change can act as a barrier to mixing.

The water column remained well oxygenated above the thermocline for the length of the summer, consistently measuring above the Canadian Council for Ministers of the Environment (CCME) guidelines for the Protection of Aquatic Life of 6.5 mg/L. Surface dissolved oxygen concentrations ranged from a minimum of 8.86 mg/L on July 26th and a maximum of 9.44 on June 30th. Increases in dissolved oxygen concentrations just above the thermocline suggest that there may have been a metalimnetic bloom of phytoplankton. Below the thermocline, however, there were dramatic reductions in dissolved oxygen concentrations. This is typical in stratified lakes, as the oxygen rich surface waters are separated from deeper waters by the thermocline. In addition, the thermocline acts to isolate the oxygen-consuming decomposition process that occurs at the lake sediments. Reductions in dissolved oxygen concentrations were least dramatic during the June sample, as the lake had likely only just begun to stratify.

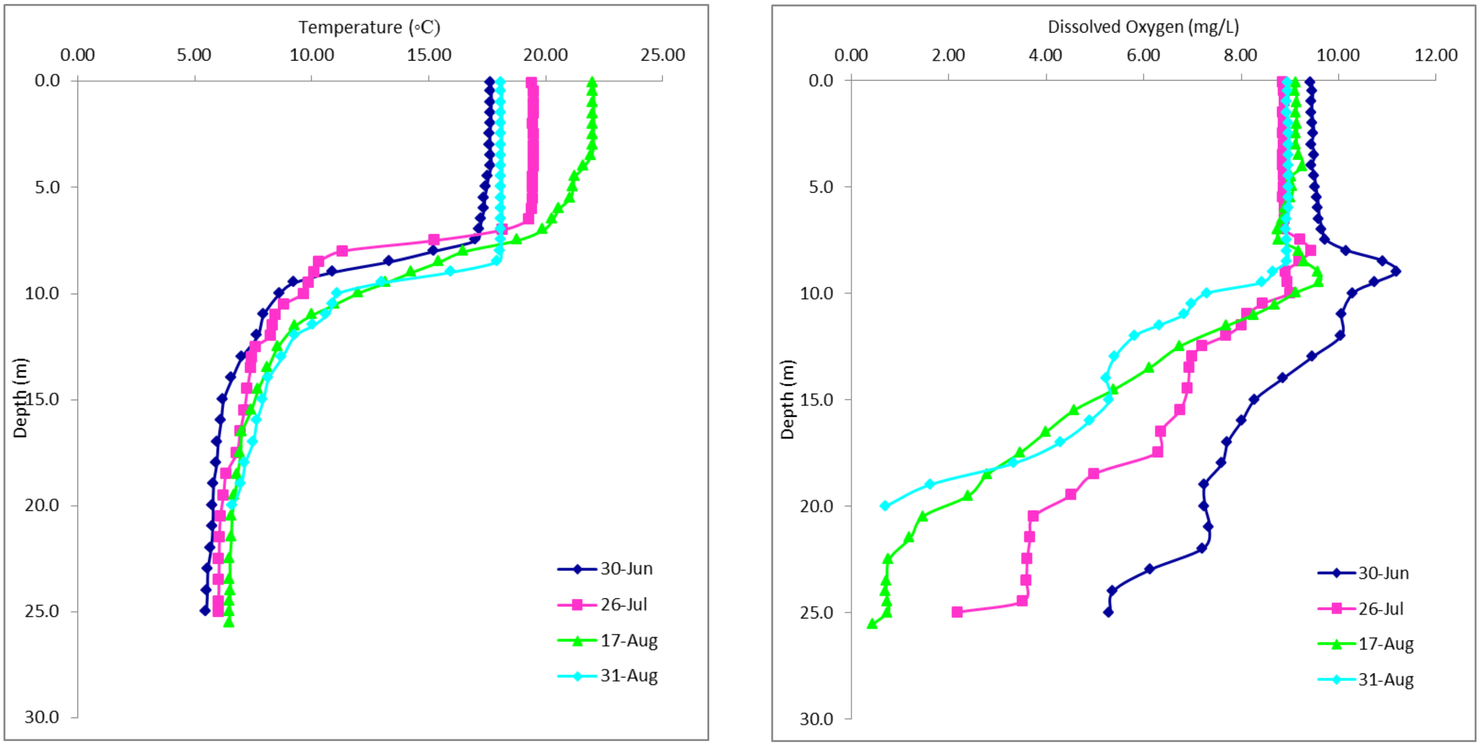

Figure 5 – a) Temperature (◦C) and b) dissolved oxygen (mg/L) profiles of Marie Lake in 2014.

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 complete list of parameters.

Total Phosphorus (TP) measured an average of 12.75 µg/L during the summer of 2014 which falls into the mesotrophic, or moderately productive, classification. Compared to previous years, this value is one of the lowest measured at Marie Lake since 1981. According to a long term trends report released by the Government of Alberta, Marie Lake has shown no trends in terms of total phosphorus concentration.[3] Throughout the summer, TP increased from a minimum of 8 µg/L on June 30th and July 26th to a maximum of 22 µg/L on August 17th (Figure 6).

Possibly as a result of low TP concentrations, the chlorophyll-*a* concentration measured in 2014 (1.85 µg/L) was the second lowest value historically recorded at Marie Lake next to what was recorded in 2012. This value falls into the oligotrophic, or low productivity, classification. Long term trend analysis suggests that chlorophyll-*a* concentrations have an overall downward trend. Throughout the summer chlorophyll-*a* concentration changed very little, ranging between a minimum of 1.5 µg/L on August 17th to a maximum of 2.3 µg/L on August 31st (Figure 6). Such low concentrations of chlorophyll-*a* likely contributed to the high Secchi disk depth values measured in 2014. Historical trends have been graphed for reference (Figure 7).

Finally, average Total Kjeldahl Nitrogen (TKN) measured 515 mg/L in 2014 – compared to historical measurements, the 2014 average is the second lowest on record, with only the 2003 average measuring less at 495 µg/L. As was the case with chlorophyll-*a*, TKN changed very little throughout the summer, ranging between 420 µg/L on August 17th and 570 µg/L on July 26th (Figure 6).

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[3] Casey, R. 2012. Water Quality Conditions and Long Term Trends in Alberta Lakes. Retrieved from: http://environment.gov.ab.ca/info/library/8544.pdf

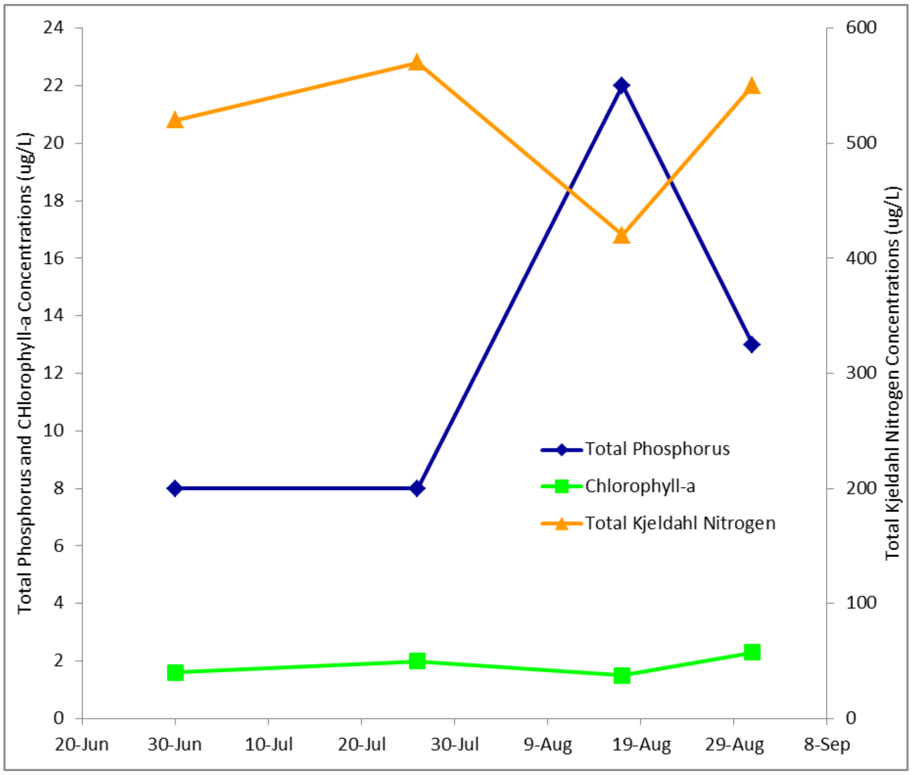

Figure 6 – Total phosphorus (ug/L), chlorophyll-*a* (ug/L), and Total Kjeldahl Nitrogen (ug/L) measured four times throughout the summer of 2014 at Marie Lake.

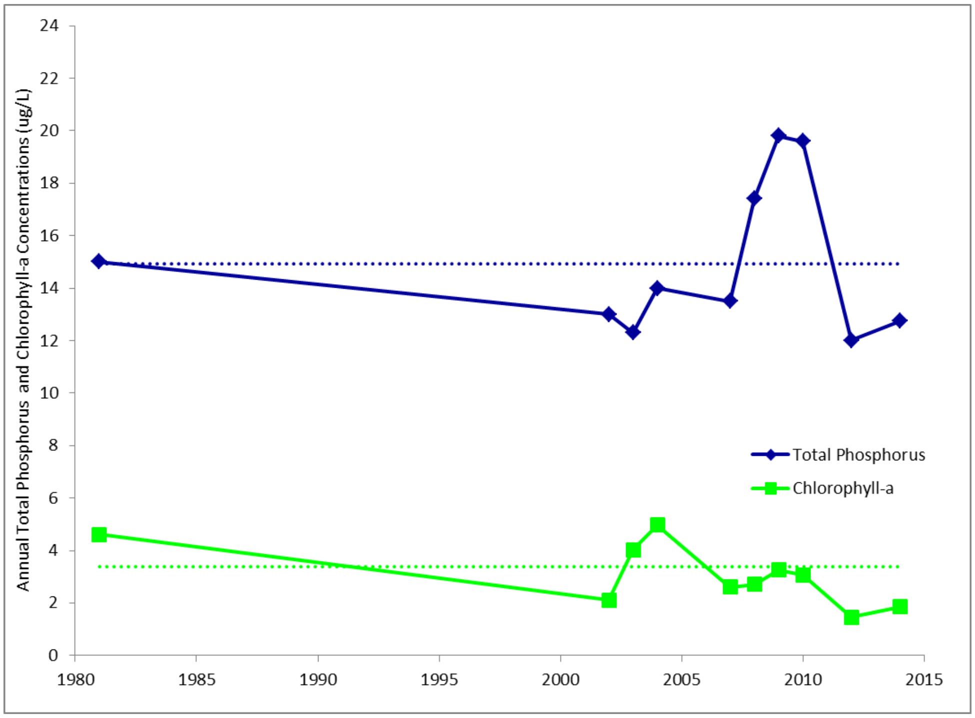

Figure 7 – Historical total phosphorus (ug/L) and chlorophyll-*a* (ug/L) concentrations measured at Marie Lake from 1981 to 2014. Historical averages for total phosphorus is 14.93 ug/L and chlorophyll-*a* is 3.37 ug/L.

Average pH measured 8.387 in 2014, well above neutral (Table 1). High levels of both bicarbonate (173.5 mg/L HCO_3) and alkalinity (142.25 mg/L $CaCO_3$) likely help to buffer Marie Lake against changes to pH. Marie Lake has relatively low concentrations of dissolved ions, with calcium (32.9 mg/L), magnesium (13 mg/L), and sodium (6.75 mg/L) being the dominant dissolved ions contributing to a conductivity of 262 µS/cm.

Metal concentrations were measured once throughout the summer and all values fell within their respective guidelines (Table 2).

MICROCYSTIN:

Microcystins are toxins produced by cyanobacteria (blue-green algae) which, when ingested, can cause severe liver damage. Microcystins are produced by many species of cyanobacteria which are common to Alberta's Lakes, and are thought to be the one of the most common cyanobacteria toxins. In Alberta, recreational guidelines for microcystin are set at 20 µg/L.

In 2014, concentrations of microcystin reached an observed maximum of 0.05 µg/L on August 17th and August 31st. On average, Marie Lake had a Microcystin concentration of 0.0375 µg/L. It is not known what cyanobacteria species is most prevalent at Marie Lake. Caution should always be taken when recreating in waters experiencing cyanobacteria blooms.

INVASIVE SPECIES:

Quagga and Zebra mussels are invasive species which, if introduced to our lakes, will have significant negative ecological, economical, and recreational impacts. ALMS collects water samples which are analyzed for mussel veligers (juveniles) and monitors substrates for adult mussels. In order to prevent the spread of invasive mussels, always clean, drain, and dry your boat between lakes. To report mussel sightings or mussel-fouled boats, call the confidential Alberta hotline at 1-855-336-BOAT.

In 2014, no zebra or quagga mussels were detected in Marie Lake.

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

Parameter	**1980**	**1981**	**2002**	**2003**	**2004**	**2007**	**2008**	**2009**	**2010**	**2012**	**2014**
TP (μg/L)	/	15	13	12.3	14	13.5	17.4	19.8	19.6	12	12.75
TDP (μg/L)	/	8	5	4	3.6	4.5	6.6	11.3	5.6	8	6.13
Chlorophyll-*a* (μg/L)	6.5	4.6	2.1	4.03	4.96	2.61	2.71	3.26	3.07	1.45	1.85
Secchi depth (m)	2.50	3.00	4.60	5.13	3.70	3.57	3.80	3.38	2.95	5.95	5
TKN (μg/L)	/	/	517	495	554	510	552	617.5	654	542	515
NO_2 and NO_3 (μg/L)	<1	/	1.8	4.75	3.2	2.5	6.5	5	6.2	2.5	20
NH_3 (μg/L)	/	<22	9.3	6.5	7.1	12.25	15.2	16.3	11.2	16.6	13
DOC (mg/L)	/	/	/	/	9.67	10.57	11.43	10.43	11.37	10.3	23.05
Ca (mg/L)	30	/	35	33.97	33.03	33.5	32.87	31.5	26.95	32.7	32.9
Mg (mg/L)	12	/	12	14.37	12.25	12.2	12.17	11.7	12.78	12.5	13
Na (mg/L)	6	/	6	6.23	4.58	7.47	6.4	6.5	6.38	5.8	6.75
K (mg/L)	2	/	2	2.03	2	1.97	1.93	1.87	1.9	1.63	1.89
SO_4^{2-} (mg/L)	<3	/	0.69	6.3	1.5	1.5	2.3	2.67	4.75	1.5	1.5
Cl^- (mg/L)	<1	/	0.56	0.47	0.57	0.77	0.58	0.83	0.8	0.87	0.8
CO_3 (mg/L)	/	/	/	4.33	6.33	7	4	9	0.5	14.7	1.775
HCO_3 (mg/L)	/	/	/	176	171	165.7	173	165.7	174	148.2	173.5
pH	/	/	/	8.44	8.44	8.42	8.41	8.51	8.33	8.58	8.39
Conductivity (μS/cm)	/	/	/	276	273.7	265.7	266.3	263.7	263	267.8	262
Hardness (mg/L)	/	/	/	143.7	132.7	134	132.3	127	119.75	142.3	135.5
TDS (mg/L)	/	/	/	154.7	144.7	146.3	144.3	143	139	133.3	145
TSS (mg/L)	/	/	/	/	1.5	/	/	/	/	1.16	/
Microcystin (μg/L)	/	/	/	/	/	0.125	0.0675	0.115	0.056	0.0695	0.0375
Total Alkalinity (mg/L $CaCO_3$)	135	/	147	151.7	150.7	147.3	146.3	145.7	143	145.6	142.25

Note: TP = total phosphorous, TDP = total dissolved phosphorous, Chl-*a* = chlorophyll-*a*, TKN = total Kjeldahl nitrogen. NO_{2+3} = nitrate+nitrite, NH_3 = ammonia, DOC = dissolved organic carbon, Ca = calcium, Mg = magnesium, Na = sodium, K = potassium, SO_4 = sulphate, Cl = chloride, CO_3 = carbonate, HCO_3 = bicarbonate TDS = total dissolved solids. A forward slash (/) indicates an absence of data.

Table 2 - Concentrations of metals measured in Marie Lake on August 17th. The CCME heavy metal Guidelines for the Protection of Freshwater Aquatic Life (unless otherwise indicated) are presented for reference.

Metals (Total Recoverable)	**2007**	**2008**	**2010**	**2012**	**2014**	**Guidelines**
Aluminum µg/L	9.1	4.2	12.25	3.705	16.5	100[a]
Antimony µg/L	0.012	0.024	0.0232	0.0201	0.019	6[e]
Arsenic µg/L	0.51	0.67	0.6575	0.619	0.635	5
Barium µg/L	33.3	32.1	32.2	33.6	31.6	1000[e]
Beryllium µg/L	<0.003	<0.003	0.0062	0.0039	0.004	100[d,f]
Bismuth µg/L	<0.001	0.0013	0.00195	0.0075	0.0005	/
Boron µg/L	17.7	23	18.95	38.65	22.2	5000[ef]
Cadmium µg/L	<0.002	0.0029	0.01085	0.0018	0.002	0.085[b]
Chromium µg/L	0.08	0.139	0.05285	0.04935	0.09	/
Cobalt µg/L	<0.001	0.0073	0.0009	0.0005	0.001	1000[f]
Copper µg/L	0.13	<0.05	0.1555	0.276	0.29	4[c]
Iron µg/L	39.9	3.28	23.15	2	12.9	300
Lead µg/L	0.021	0.0674	0.0161	0.003	0.047	7[c]
Lithium µg/L	4.37	7.25	6.31	6.75	7.01	2500[g]
Manganese µg/L	21.9	9.07	19.785	11.41	4.3	200[g]
Molybdenum µg/L	0.154	0.172	0.19	0.173	0.164	73[d]
Nickel µg/L	<0.005	0.086	0.0025	0.0025	0.004	150[c]
Selenium µg/L	0.06	<0.1	0.05	0.05	0.03	1
Silver µg/L	<0.0005	<0.0005	0.00655	0.00025	0.001	0.1
Strontium µg/L	90.8	91	84.35	88.7	84.7	/
Thallium µg/L	<0.0003	<0.003	0.002575	0.00015	0.00045	0.8
Thorium µg/L	0.007	<0.003	0.00545	0.00015	0.001	/
Tin µg/L	0.03	0.0315	0.015	0.015	0.014	/
Titanium µg/L	1.38	1.03	1.095	0.4205	0.5	/
Uranium µg/L	0.08	0.0662	0.0676	0.0606	0.051	100[e]
Vanadium µg/L	0.14	0.112	0.12055	0.08575	0.1	100[f,g]
Zinc µg/L	0.64	0.175	0.798	0.2915	1.2	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:

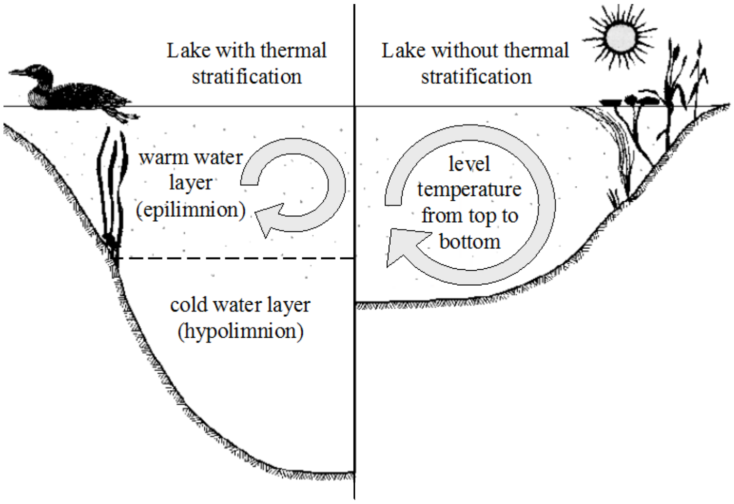

Figure A: Difference in the circulation of the water column depending on thermal stratification.

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.

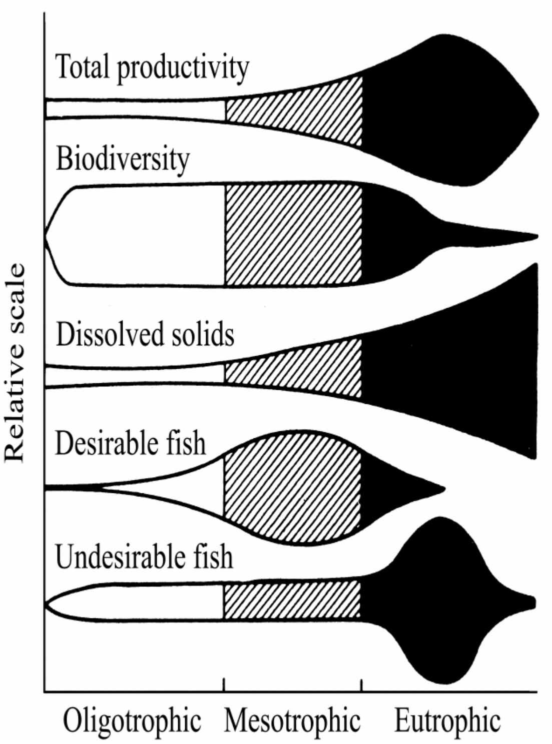

Figure B: Suggested changes in various lake characteristics with eutrophication. From “Ecological Effects of Wastewater”, 1980.

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

Trophic state	Total Phosphorus ($\mu g \bullet L^{-1}$)	Total Nitrogen ($\mu g \bullet L^{-1}$)	Chlorophyll *a* ($\mu g \bullet L^{-1}$)	Secchi Depth (m)
Oligotrophic	< 10	< 350	< 3.5	> 4
Mesotrophic	10 – 30	350 - 650	3.5 - 9	4 - 2
Eutrophic	30 – 100	650 - 1200	9 - 25	2 - 1
Hypereutrophic	> 100	> 1200	> 25	< 1

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