Lakewatch

THE ALBERTA LAKE MANAGEMENT SOCIETY
VOLUNTEER LAKE MONITORING PROGRAM

2015 Matchayaw Lake Report

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Beaver River Watershed Alliance

aemera.org

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.

Data in this report is still in the validation process.

Acknowledgements

The LakeWatch program is made possible through the dedication of its volunteers. We would like to thank Brenda & Keith McNicol, Donna & Jamie & Megan Crow, and Randy Parish for their assistance with sampling Matchayaw Lake in 2015. We would also like to thank Laticia McDonald, Ageleky Bouzetos, and Mohamad Youssef who were summer technicians with ALMS in 2015. Executive Director 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 Bradley Peter and Alicia Kennedy. The Beaver River Watershed Alliance (BRWA), the Lakeland Industry and Community Association (LICA), the Alberta Environmental Monitoring Evaluation and Reporting Agency (AEMERA), and Environment Canada, were major sponsors of the program.

MATCHAYAW (DEVIL'S) LAKE:

This lake is located in Lac Ste. Anne County, approximately 60 km northwest of Edmonton, near the town of Onoway. The lake's official name is a Cree term, however, it may also be referred to by the English translation. The name *Matchayaw* is Cree for "devil", or "place of evil".

Figure 1 – Matchayaw Lake. Photo by Laticia McDonald 2015.

Matchayaw Lake lies in the Dry Mixedwood natural subregion, and the lakeshore is mostly undeveloped with the exception of some private residential lots. The hamlet of Bilby is located on the south shore, and, just south of Bilby is the Bilby Natural Area which is a popular destination for day-hikes and birding.

Imrie Park, located just east of Onoway on the shores of the lake, is a 216 acre park donated by Mary Louise Imrie, one of Edmonton's first female architects. The park is operated by the Onoway Fish & Game Association, and in the summer provides camping facilities, a day-use area, and walking trails. In the winter, the walking trails are groomed for cross-country skiiers. No ATV usage is permitted in the park. Boating is permitted on the lake, and a boat launch is located at the northeast end of the lake, shortly after the bridge crossing the Sturgeon River.

The lake has a surface area measuring 2.11 km^2, and its maximum depth has been recorded as 8 m. The lake is fed by Kilini Creek from the southwest and the Sturgeon River from the north. The Sturgeon River exits the lake from the northwest shore. Matchayaw Lake lies within the Athabasca River Basin, and also lies within the smaller Sturgeon River watershed, which includes areas surrounding Isle Lake and Lac Ste. Anne (Fig. 2).

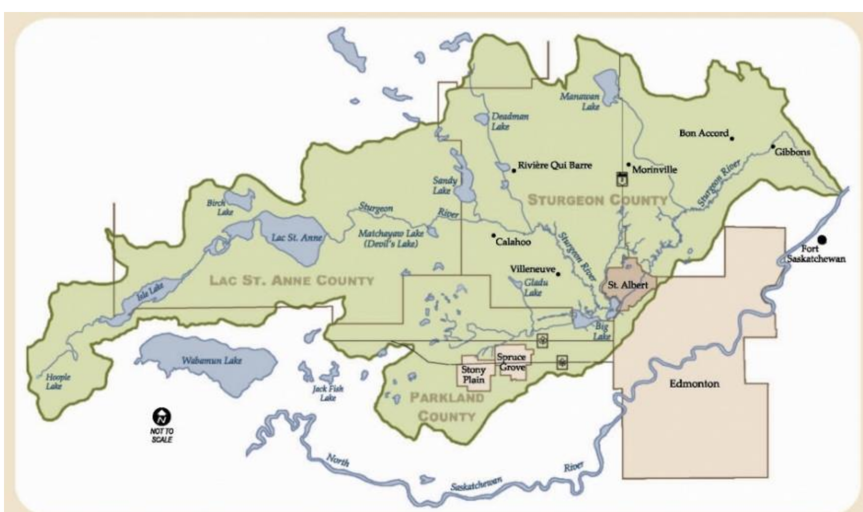

***Figure 2** – Sturgeon River Watershed; red circle marks Matchayaw Lake. Map from the City of St. Albert.*

Common recreational activities at the lake include canoeing, waterskiing and wakeboarding. The lake and its surrounding wetlands are home to many types of birds, including grebes, terns, and pelicans. Fishing at the lake takes place year-round, and recorded sportfish species are burbot (*Lota lota*), lake whitefish (*Coregonus clupeaformis*), northern pike (*Esox lucius*), walleye (*Stizostedion viteum*), and yellow perch (*Perca flavescens*). Dense macrophyte cover has been observed along parts of the shoreline, and some residents mechanically remove plants in front of their property.

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.

Average Secchi disk depth in 2015 measured 0.95 m. Maximum Secchi depth observed in 2015 was 1.5 m, while the minimum observed Secchi depth was 0.75 m. 2015's average Secchi depth falls at the low end of the historical variation observed at Matchayaw Lake (Table 1) – meaning water clarity was less than that in previous years. Phytoplankton (including cyanobacteria) and suspended sediments are often the major factors contributing to changes in water clarity.

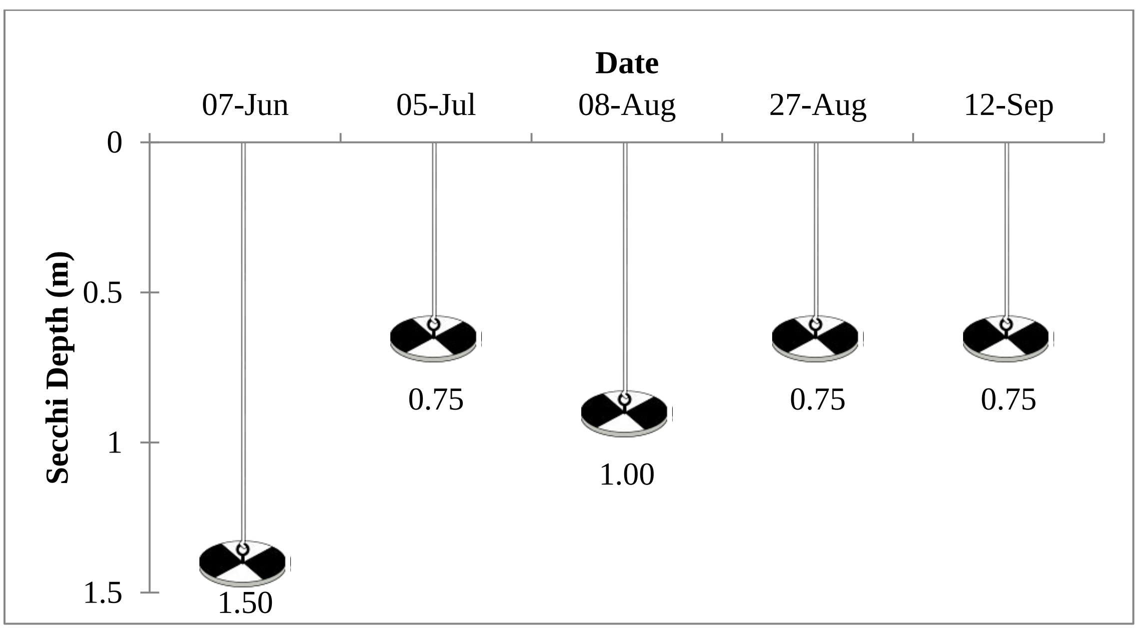

Figure 3 – Secchi disk depth measured five times over the course of the summer in 2015 at Matchayaw Lake.

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.

Water temperature at Matchayaw Lake peaked on August 8th at 22.78 °C and measured a minimum of 16.62 °C on September 12th (Figure 4a). Thermal stratification, the change in water temperature by one degree Celcius within a meter of depth, was observed three times on Matchayaw Lake: June 7th, July 5th, and August 8th. This stratification can prevent the mixing of dissolved oxygen deep into the water column, though is common and normal in lakes across the province. This stratification can also maintain cool bottom waters. By August 27th, stratification had begun to fade, though a temperature gradient was still observed (Figure 4a).

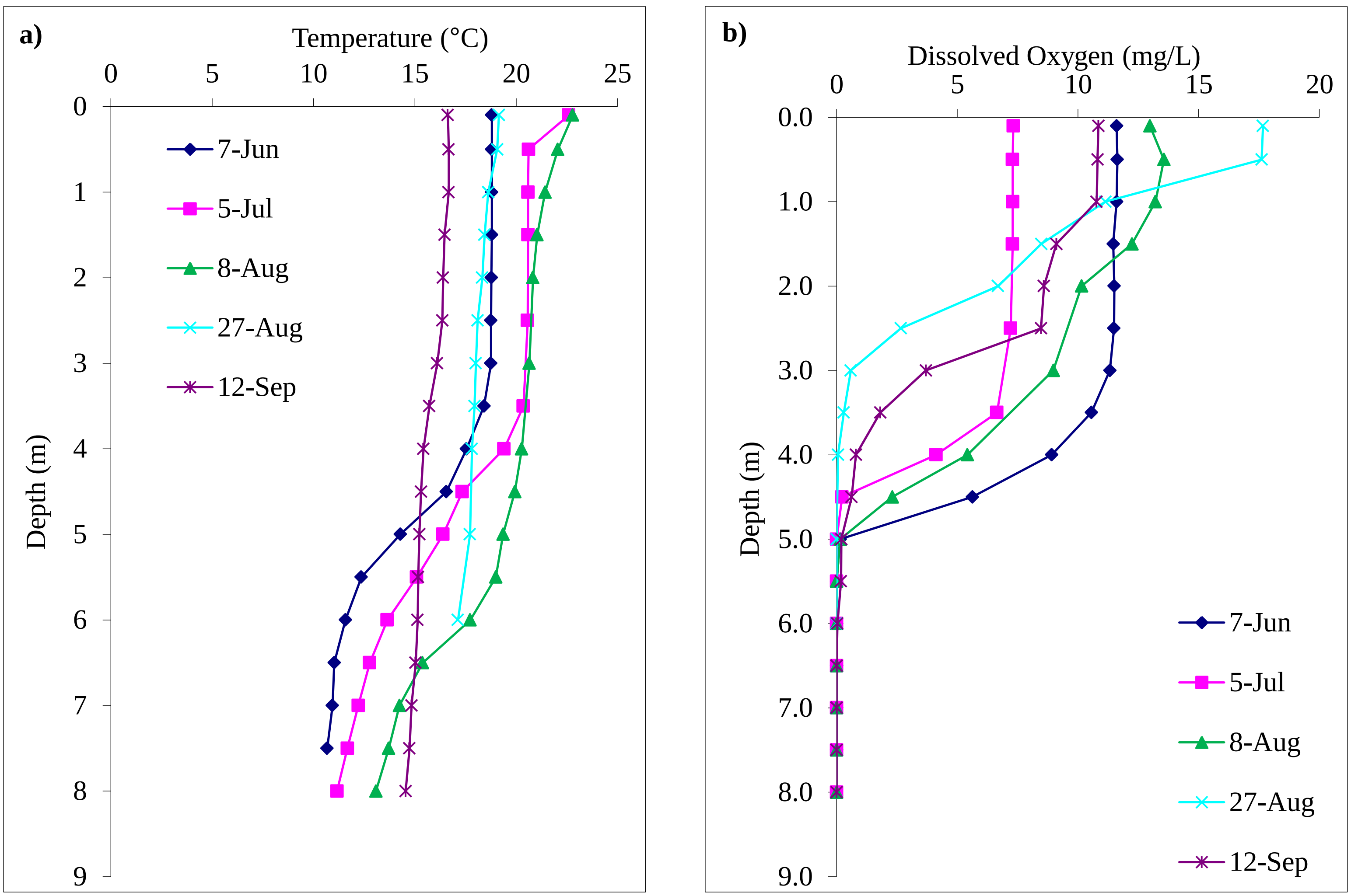

Figure 4 – Temperature (°C) and dissolved oxygen (mg/L) measured five times over the course of the summer at Matchayaw Lake in 2015.

Dissolved oxygen concentrates fluctuated greatly over the course of the summer at Matchayaw Lake (Figure 4b). At the surface, concentrations were highly elevated on August 27th at 17.66 mg/L. This super-saturation of surface waters often coincides with the photosynthesis associated with dense phytoplankton blooms. In contrast, surface water dissolved oxygen concentration measured a minimum of 10.85 mg/L on September 12th. The effects of thermal stratification on dissolved oxygen concentrations were also evident: oxygen proceeded to anoxia on each trip to Matchayaw Lake. The Canadian Council for Ministers of the Environment recommends 6.5 mg/L for the Protection of Aquatic Life. Anoxia is normal for lakes with thermal stratification and may contribute to the release of nutrients from the lake sediments.

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.

In 2015, Total Phosphorus (TP) concentration was at a historical minimum of 59 μg/L. An average of 59 μg/L puts Matchayaw Lake into the eutrophic, or nutrient rich classification. Historically, Matchayaw has been classified as hypereutrophic based on its TP concentrations. Within the season, phosphorus concentrations varied from a minimum of 30 μg/L on July 15th to a maximum of 85 μg/L on September 12th. Increasing TP concentrations are not unexpected as nutrients from deep waters may have been mixed with surface waters as thermal stratification broke down in late August.

Compared to historical averages, the 2015 chlorophyll-*a* average was moderate at 43.9 μg/L and concentration of algae peaked on August 27th at 68.8 μg/L. An early season bloom was observed on June 7th, and high concentrations were not observed again until August 8th. Community shifts of phytoplankton are common in lakes across Alberta: in some lakes, diatoms may bloom early in the season. As this bloom dies off, it may be overtaken by cyanobacteria. Data on cyanobacteria species from 2015 is not yet available.

Average Total Kjeldahl Nitrogen (TKN) measured 1.7 mg/L in 2015. Some cyanobacteria species have the ability to fix atmospheric nitrogen in their cells which can cause increases in a lake's nitrogen. High concentrations of TKN are frequently observed at lakes throughout the province.

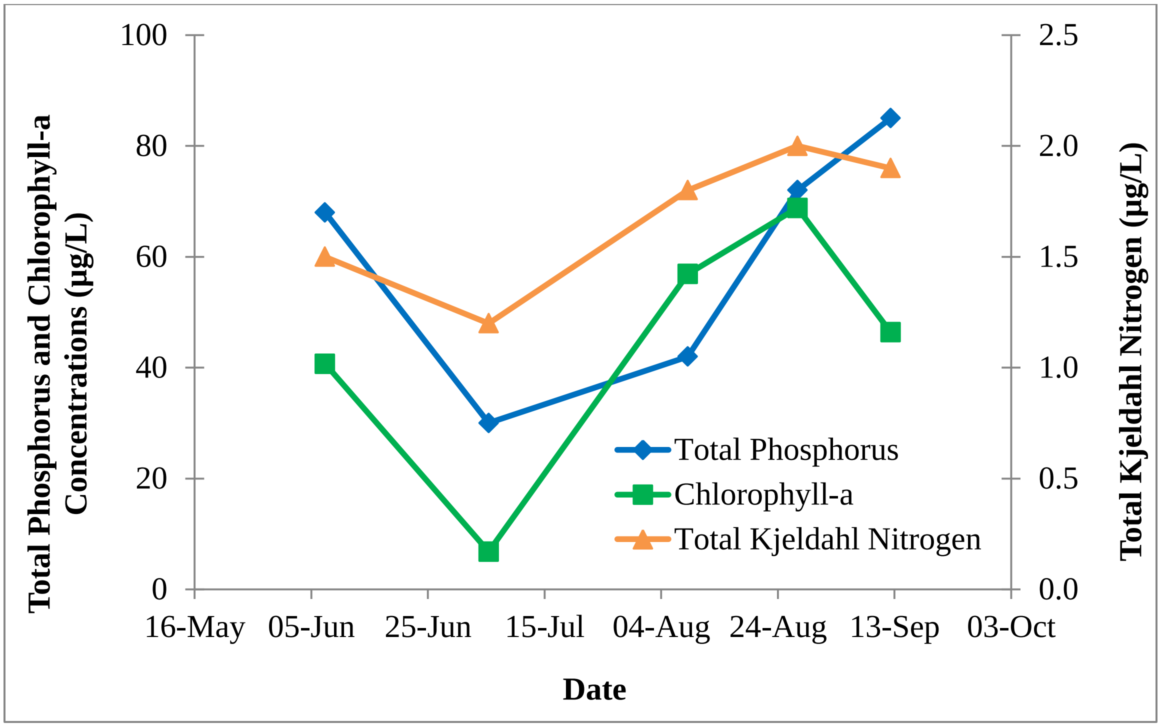

Figure 5 – Average total phosphorus (μg/L), chlorophyll-*a* (μg/L), and total Kjeldahl nitrogen (mg/L) concentrations measured five times over the course of the summer at Matchayaw Lake.

Average pH at Matchayaw Lake measured 8.516, well above neutral (Table 1). Matchayaw Lake has moderate alkalinity (228 mg/L $CaCO_3$) and bicarbonate (264 mg/L) concentrations which help to buffer the lake against changes to pH. Similarly, conductivity at Matchayaw Lake is moderate, measuring 596 uS/cm. Dominant ions contributing to conductivity in Matchayaw Lake include sodium (69 mg/L) and sulphate (62 mg/L).

Metals were measured twice at Matchayaw Lake and all metals sampled for 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 2015, microcystin concentrations were below the detection limit on every sampling trip to Matchayaw Lake. Not all species of cyanobacteria, notably *Aphanizomenon* spp., are capable of producing microcystin toxin. Caution should always be observed when recreating in cyanobacteria blooms as other toxins may be present.

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 Matchayaw Lake.

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

Parameter	1995	1996	2001	2007	2015
TP (µg/L)	135.19	110.03	102	100	59
TDP (µg/L)	23.6	113	/	42.8	17
Chlorophyll-*a* (µg/L)	24.75	28.4	71	40.4	43.9
Secchi depth (m)	3.35	2.54	2.11	1.11	0.95
TKN (mg/L)	/	1.4	1.3	1.7	1.7
NO_2 and NO_3 (µg/L)	55.1	13	10	7.75	2.3
NH_3 (µg/L)	/	90	51	126	85
DOC (mg/L)	/	/	/	18	15
Ca (mg/L)	37	41	27	49.6	29
Mg (mg/L)	18.2	14.1	18	19.6	17.4
Na (mg/L)	73	36.6	76	74.2	69
K (mg/L)	6.3	7.5	6	7.3	8
SO_4^{2-} (mg/L)	56	30.15	72	81.75	62
Cl^- (mg/L)	7.96	6.88	9	19.48	19.8
CO_3 (mg/L)	10.5	3.95	19	16	6.25
HCO_3 (mg/L)	309.4	230.5	246	289	264
pH	8.22	8.31	9.00	8.44	8.52
Conductivity (µS/cm)	597.8	439.75	605	635.75	596
Hardness (mg/L)	167	160.5	/	204.75	144
TDS (mg/L)	355	240.3	7	402.3	344
Microcystin (µg/L)	/	/	/	0.798	0.05
Total Alkalinity (mg/L $CaCO_3$)	260.8	195.5	233	6.875	228

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

Table 2 - Average concentrations of metals measured in Matchayaw Lake on June 7th, August 8th, and September 12th. 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.

Metals (Total Recoverable)	2007	2015	Guidelines
Aluminum µg/L	/	52.3	100[a]
Antimony µg/L	/	0.081	6[e]
Arsenic µg/L	/	1.547	5
Barium µg/L	/	54.33	1000[e]
Beryllium µg/L	/	0.0073	100[d,f]
Bismuth µg/L	/	0.0023	/
Boron µg/L	/	95.83	5000[ef]
Cadmium µg/L	/	0.005	0.085[b]
Chromium µg/L	/	0.2200	/
Cobalt µg/L	/	0.082	1000[f]
Copper µg/L	/	0.653	4[c]
Iron µg/L	9.6	18.23	300
Lead µg/L	/	0.135	7[c]
Lithium µg/L	/	28.67	2500[g]
Manganese µg/L	/	34.13	200[g]
Mercury @ Surface ng/L		0.45	26
Mercury @ Sediment ng/L		2.17	26
Molybdenum µg/L	/	0.6840	73[d]
Nickel µg/L	/	0.406	150[c]
Selenium µg/L	/	0.073	1
Silver µg/L	/	0.0027	0.1
Strontium µg/L	/	278	/
Thallium µg/L	/	0.0014	0.8
Thorium µg/L	/	0.0107	/
Tin µg/L	/	0.021	/
Titanium µg/L	/	1.160	/
Uranium µg/L	/	1.203	100[e]
Vanadium µg/L	/	0.310	100[f,g]
Zinc µg/L	/	0.77	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:

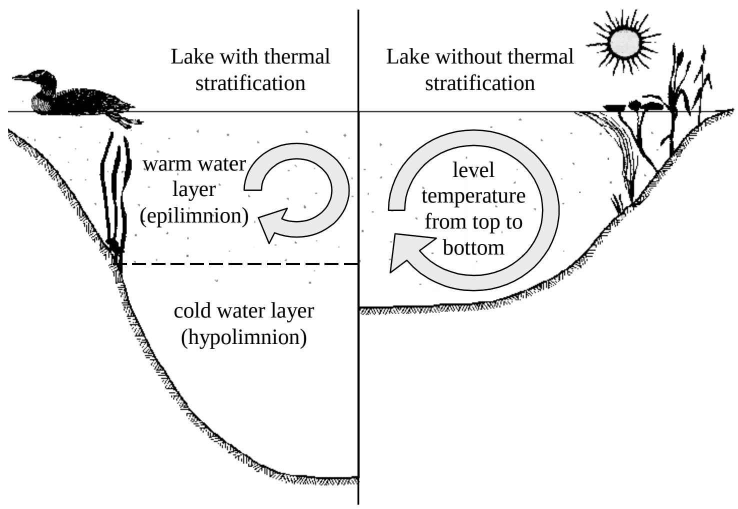

Figure A: Difference in the circulation of the water column depending on thermal stratification.

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.

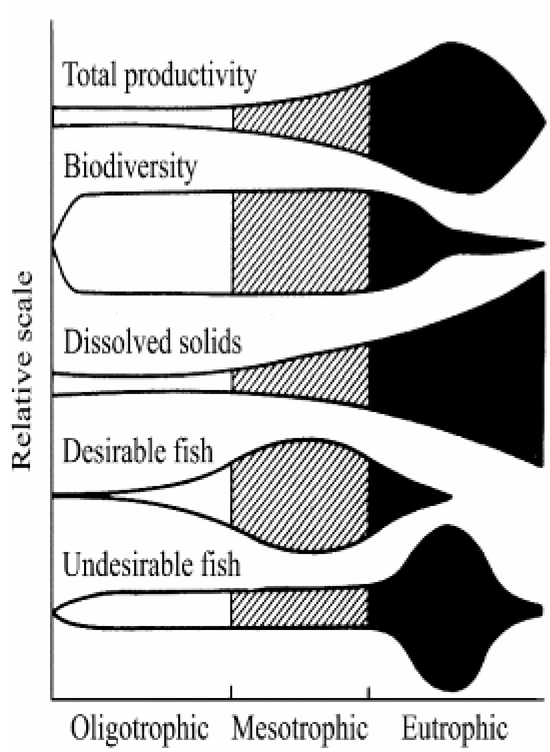

Figure B: Suggested changes in various lake characteristics with eutrophication. From "Ecological Effects of Wastewater", 1980.

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