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Lakewatch

Matchayaw Lake

The Alberta Lake Management Society
Volunteer Lake monitoring report

And you really live by the river? What a jolly life!"

"By it and with it and on it and in it," said the Rat. "It's brother and sister to me. What it hasn't got is not worth having, and what it doesn't know is not worth knowing." *Kenneth Grahame The Wind in the Willows*

"The world's supply of fresh water is running out. Already one person in five has no access to safe drinking water." *BBC World Water Crisis Homepage*

A note from the Lakewatch Coordinator Preston McEachern

Lakewatch has several important objectives, one of which is to document and interpret water quality in Alberta Lakes. Equally important are the objectives of educating lake users about their aquatic environment; enhancing public involvement in lake management; and facilitating a link between aquatic scientists and lake users. The 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. Substantial additional information is generally available on the lakes that have participated in Lakewatch and readers requiring more information are encouraged to seek these sources.

The 2002 Lakewatch Report has undergone a substantial change in format from previous years. I am no longer the author as much as an editor including text and figures from others who have done an excellent job describing lakes throughout Alberta. I have attempted to give due credit to these outstanding people and apologize for blatant plagiarism where it occurs. As editor, feel free to castigate me for errors. I have included easily accessible information that is likely to have been updated in recent years and readers are encouraged to help update these reports by sending new information to me.

I would like to thank all people who share my love for aquatic environments and particularly those who have helped in the Lakewatch program. These people prove that ecological apathy can be overcome and give us hope that water will not be the limiting factor in the health of our planet.

Acknowledgements

The Lakewatch program is made possible through the dedication of its volunteers and Alberta Environment employees. Our volunteers, Donna and Jamie Crowe, Neil and Barb Warner, Don, Norma and Jeff Thurston were the engines behind our sampling success. Thanks to them for volunteering and making this possible at Matchayaw. Susan Cassidy was our summer field coordinator and was an excellent addition to the program. Her hard work made it possible for Lakewatch to expand to 17 lakes, more than triple the number in any previous year! Without the dedication of these people and the interest of cottage owners, Lakewatch would not have occurred.

Figure 1: Picture of Matchayaw Lake

Photo: Donna Crowe

Matchayaw Lake

Matchayaw Lake, which is known locally as Devil's Lake or Lake Matchayan, is located about 56 km northwest of Edmonton near Onoway. The Sturgeon River drains into Matchayaw at the northwest corner of the lake and continues out from the north shore. The lake is relatively small with an area of 2.11 km^2 but has a maximum depth of 10 m and a mean depth of 4.35 m, which is deep for its size. The drainage basin area for Matchayaw is 1018 km^2, providing a large drainage ratio of 482. The lake volume is estimated at 9.18 million cubic meters. The residence time for water in the lake is unknown, however, it is likely less than two or three months. The first water quality study on Matchayaw was conducted in 1995. A summary of the historical importance of this lake is not currently available.

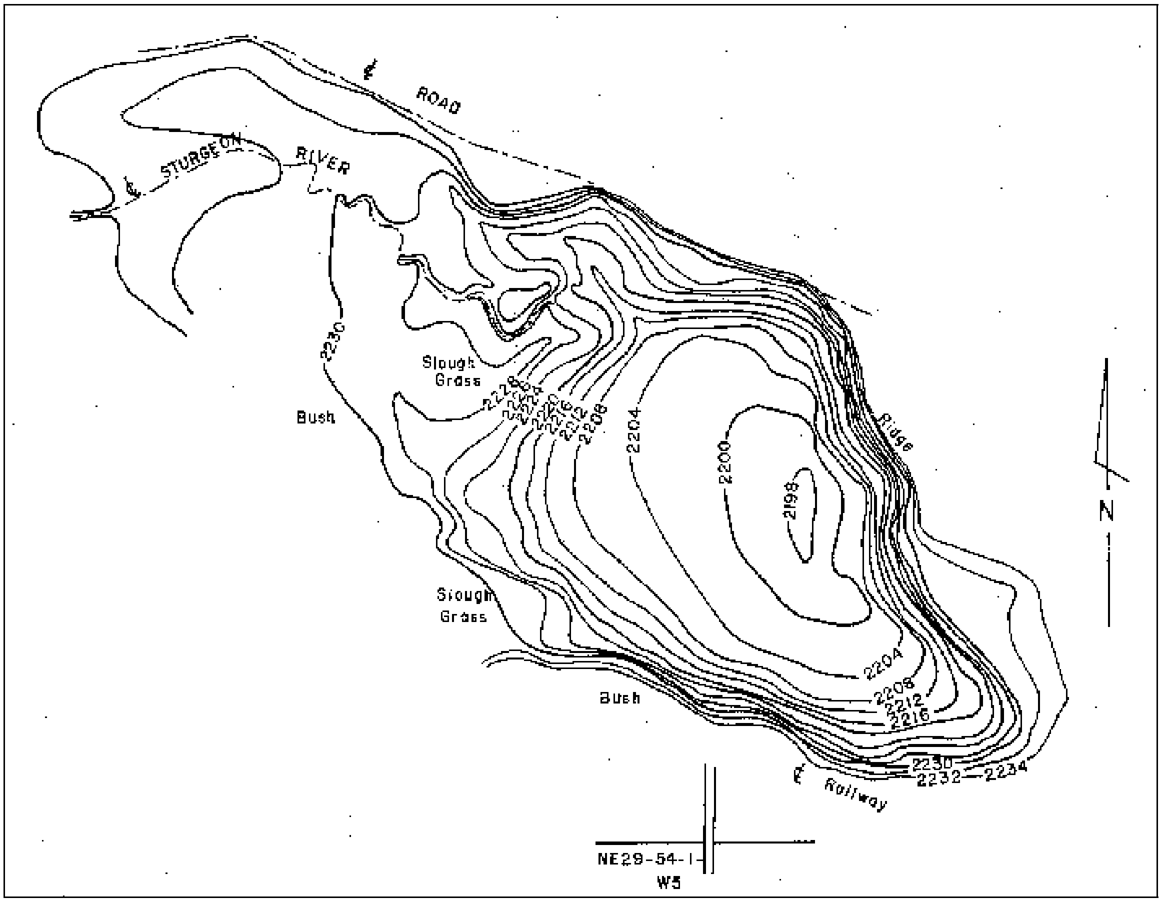


Fig. 2: Bathymetry of Matchayaw Lake. Contours are at 4 feet intervals. From Alberta Environment.

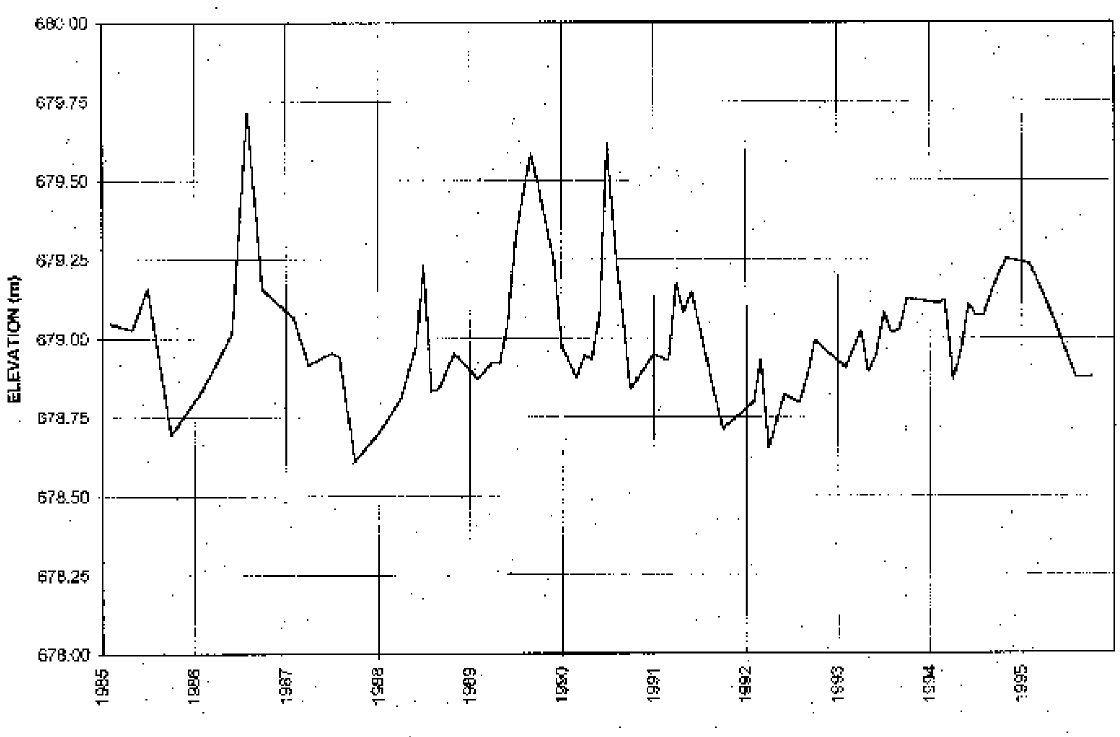


Fig. 3: Water level graph for Matchayaw Lake. Data from 2001 are currently not available.

Water Levels

Lake water levels in Matchayaw fluctuated between maximum and minimum values that differ by 1 m (Fig. 3). Though lake levels appear to fluctuate over a large range they have remained relatively consistent since 1985 and have not shown the drastic decline that is common for many lakes in Alberta. Relatively constant lake levels are undoubtedly a result of large flow through the lake from the Sturgeon River. Matchayaw Lake is relatively well protected from loss of lake levels due to the dry climatic conditions currently impacting other lakes in the region. Matchayaw has a relatively steep littoral zone; changes in lake level therefore do not overly influence shoreline habitat. This contrasts with nearby Sandy Lake where a small decline in lake level can expose several meters of littoral zone.

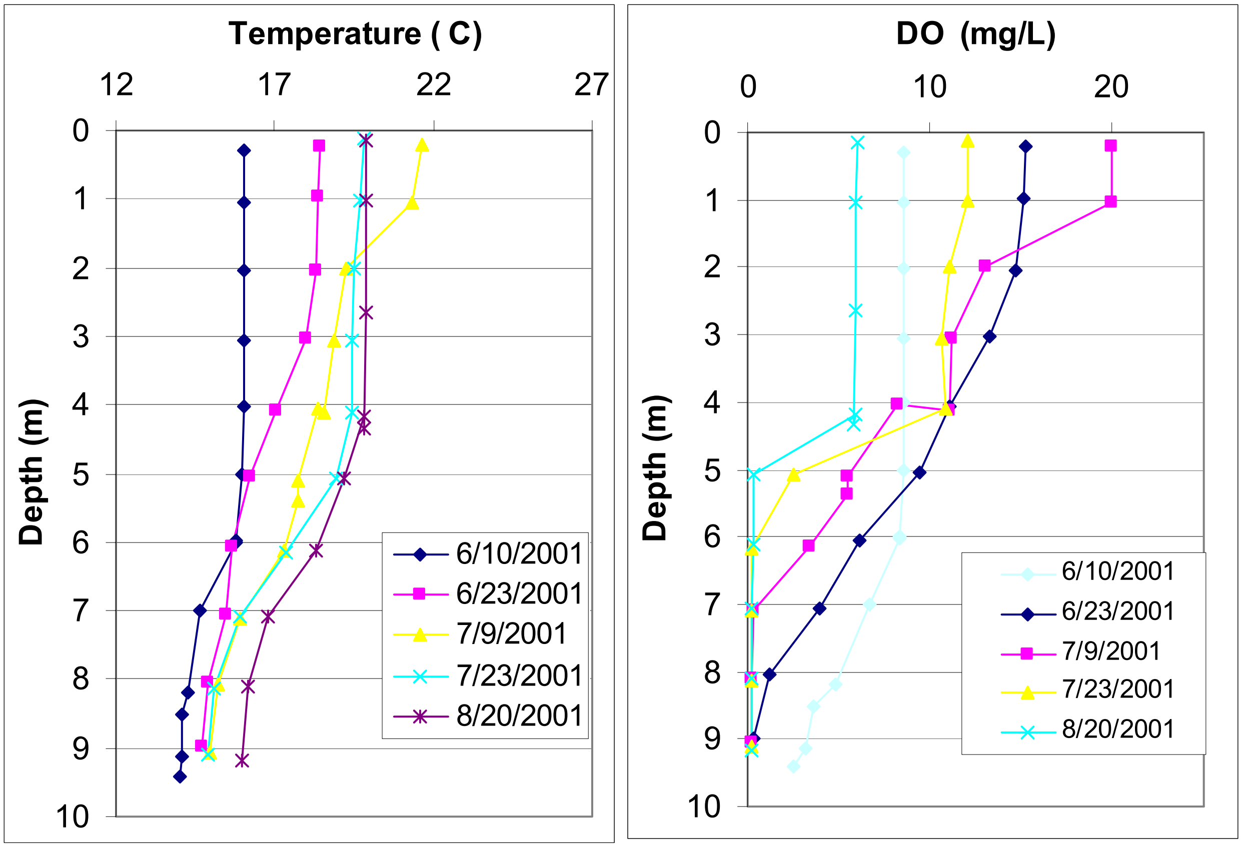


Fig. 4: Temperature and dissolved oxygen profiles for Matchayaw Lake.

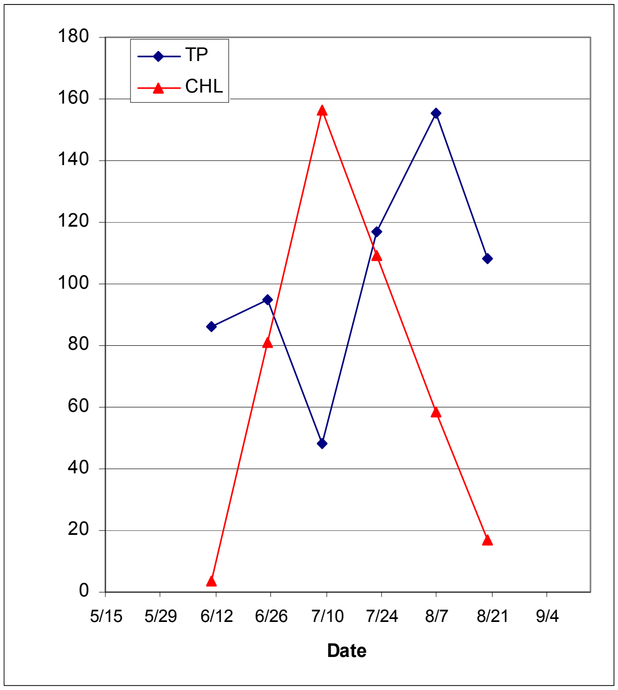
Results

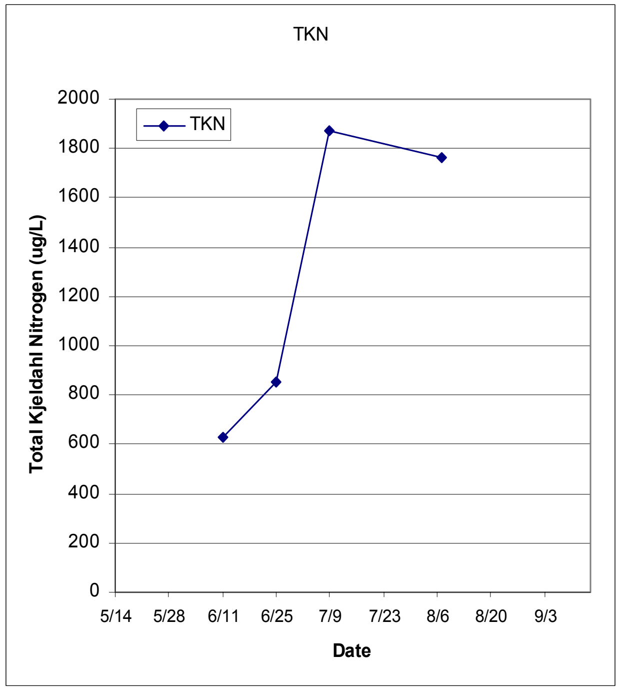
Water temperature and dissolved oxygen

The small area to depth ratio for Matchayaw was conducive to the onset of thermal stratification. The lake was already stratified in early June which continued to become more pronounced as the summer progressed and surface waters heated. As a result, dissolved oxygen concentrations declined rapidly below 4 m depth approaching anoxia by 5 or 6 m depth after June. Dissolved oxygen concentrations in the epilimnion (surface waters) during late August were surprisingly low (6 $mg \bullet L^{-1}$) compared to the general pattern in this lake. However, dissolved oxygen concentrations in the 7 $mg \bullet L^{-1}$ range were recorded in other lakes in the area over a three day period around August 20.

Water clarity and Secchi Depth

Water clarity is influenced by the suspended material, both living and dead, as well as some coloured dissolved compounds in the water column. The most widely used measure of lake water clarity is the Secchi depth. After ice and snowmelt a lake can have low clarity due to spring runoff and suspended sediments in the lake. Lake water usually clears in the spring but then becomes less clear as algae grow through the summer. In mid-May, Secchi depth was 3.5 m which is very clear for eutrophic Alberta lakes. Water clarity increased through May and early June with Secchi depth reaching 4.9 m in mid-June. Algal growth accelerated during the next week and Secchi depth declined to 1.1 m as an algal bloom occurred (Fig. 4). Secchi depths remained below 1 m through July, returned to 1.5 m by Aug 7 and increased to 2.1. m by the end of August. Mean Secchi depth for the summer was 2.1 m.





Figures 4: Total phosphorus, chlorophyll *a* and Kjeldahl nitrogen for Matchayaw Lake, summer 2001.

Table1: Mean values from summer 2001 samples compared to values from those reported in the Atlas of Alberta Lakes.

Parameter	1995	2001
TP ($\mu g \bullet L^{-1}$)	135	102
Chl ($\mu g \bullet L^{-1}$)	24.8	71
Secchi (m)	3.4	2.11
TKN ($\mu g \bullet L^{-1}$)	-	1280
TN ($\mu g \bullet L^{-1}$)	-	1290
$NO_{2+3}N$ ($\mu g \bullet L^{-1}$)	-	10
NH_4^+ N ($\mu g \bullet L^{-1}$)	-	51
Ca ($mg \bullet L^{-1}$)	37	27
Mg ($mg \bullet L^{-1}$)	18	18
Na ($mg \bullet L^{-1}$)	73	76
K ($mg \bullet L^{-1}$)	6.3	6
SO_4^{2-} ($mg \bullet L^{-1}$)	56	72
Cl^- ($mg \bullet L^{-1}$)	8.0	9
HCO_3^{-1} ($mg \bullet L^{-1}$)	309	246
CO_3^{2-} ($mg \bullet L^{-1}$)	< 3	19
Total Alkalinity ($mg \bullet L^{-1}$ $CaCO_3$)	261	233
Conductivity ($\mu S \bullet cm^{-1}$)	599	605
pH	8.3	9
Color ($mg \bullet L^{-1}$ Pt)	26	29
TSS ($mg \bullet L^{-1}$)	3	7

Water chemistry

Ion concentrations have not changed appreciably since 1995. The constant ion chemistry of this lake is in keeping with the high inflow from the Sturgeon River. As such, water chemistry in this lake is a reflection of the river. The inference from these data is that the general hydrology and ion chemistry in the Sturgeon River also has not changed appreciably over the six-year period.

Nutrient concentrations in Matchayaw are very high, but appear to be normal for the lake. Again this is likely the result of high loading from the Sturgeon River watershed. Peak total phosphorus concentrations in 2001 (0.16 mg•L^{-1}) are actually lower than those recorded in 1995 (0.2 mg•L^{-1}). However, 2001 sampling managed to catch the peak of particularly severe algal bloom with concentrations of chlorophyll *a* that were 60 mg•L^{-1} higher than those recorded in 1995. Blooms of the magnitude observed in July 2001 where chlorophyll *a* was more than three times the TP concentration are indicative of blooms where certain algae tend to release toxins into the water. These toxins are referred to generically as cyanotoxins and have been responsible for the deaths of waterfowl in lakes around Matchayaw. The occurrence of cyanotoxins should be monitored in Matchayaw in future years to estimate potential impacts both in the lake and the Sturgeon River.

Matchayaw is certainly impacted by excessive nutrient loading from the Sturgeon River watershed. Fortunately, the impacts from this nutrient load are reduced by the large volume of water flow through the lake. However, the nutrient concentrations in Matchayaw are indicative of a poorly managed basin as a whole. Watershed management of agricultural runoff into the Sturgeon River should be a priority for the area.

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.

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**. 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.

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.