



Preston McEachern
9637 – 81 Ave.
Edmonton, AB, T6C 0X6
(780) 427-1197
prestonm@telusplanet.net

Lakewatch

Muriel 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. Mike Bilyk, John Willis, Doreen LeClair and Dave Trew from Alberta Environment were instrumental in funding, training people and organizing with Lakewatch data. Comments on this report by Dave Trew were appreciated. Alberta Lake Management Society members and the board of directors helped in many facets of water collection and management. Sophie Lewin and Lucille Kowalchuk were summer field coordinators and were an excellent addition to the program. Without the dedication of these people and the interest of cottage owners, Lakewatch would not have occurred.

Muriel Lake

Muriel Lake is located 13 km south of the town of Bonnyville and 250 km northeast of Edmonton. The first non-native establishment in the area was a fur-trading post in 1781 by the North West Company near the present-day hamlet of Beaver Crossing, about 35 km northeast of Muriel Lake. The first settlers came to the Bonnyville area in 1907, and established an economy based on the timber industry. Two sawmills were located at Muriel Lake, one at the northeastern tip and the other on the large island/peninsula on the eastern shore. In the 1920s, a large fire forced the economic base to switch to agriculture. There are several subdivisions (391 lots) around the lakeshore, mostly on the south and east sides of the lake. Much of the watershed is occupied by the Kehiwin Indian Reserve 123, located on 8200 ha of land in southwest of the lake. The largest recreational facility on Muriel Lake is Muriel Lake Park, which is operated by the Municipal District of Bonnyville. Muriel Lake is managed for domestic, sport and commercial fisheries. Northern pike, yellow perch, lake whitefish, and walleye are the sport fish found in the lake. Lake whitefish were stocked in 1937 (Alta. For. Ld. Wild. N.d.) and walleye are stocked periodically. The primary commercial species is lake whitefish, which generally has formed about 95% of the total catch (Alta. Rec. Parks Wild. 1976).

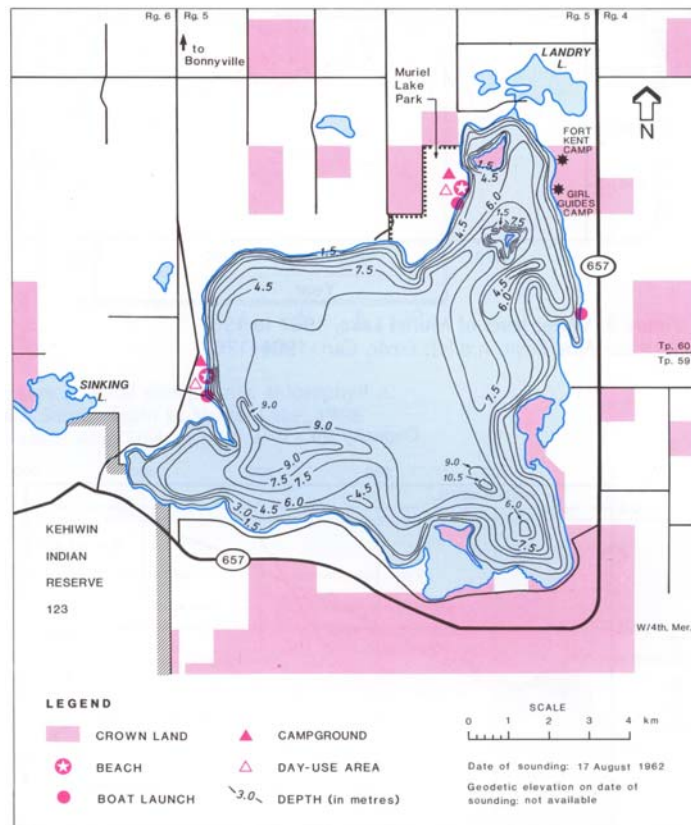


Fig. 1: Bathymetry of Muriel Lake. From Mitchell and Prepas 1990.

Muriel Lake is a large (64.1 km²) but relatively shallow (mean and maximum depth 6.6 and 10.7 m, respectively) water body. The shoreline consists primarily of steep rocky slopes, but there are also several attractive sandy beaches (Alta. Mun. Aff. 1979). Water levels have been monitored since the late 1960s and since then, have fluctuated by as much as 1.5 m. Muriel Lake is mesotrophic, with a moderate supply of nutrients and relatively low concentration of algae, and mixes periodically throughout the summer.

Phytoplankton succession during the summer goes from golden-brown algae (*Dinobryon* sp.) in May, to diatoms (*Fragilaria crotonensis*) and dinoflagellates (*Ceratium hirundinella*) in June, and diatoms (*Fragilaria crotonensis*), blue-green, and green algae (*Closterium* sp.) in late summer. Emergent aquatic vegetation is not abundant in most areas. Because of its clear waters (Secchi disk depth 2.2 m), aquatic plants can grow to a depth of 7 m in Muriel Lake and the littoral zone can cover almost 50% of the lake's area. Emergent vegetation is largely restricted to areas sheltered from the wind. The northwest shore, although somewhat protected has no emergent stands because

of its rocky or sandy substrate. The dominant emergent species in 1978 were common great bulrush (*Scirpus validus*), and common cattail (*Typha latifolia*) and sedges (*Carex* spp.) closer to shore. The dominant submergent species was large-sheath pondweed (*Potamogeton vaginatus*).

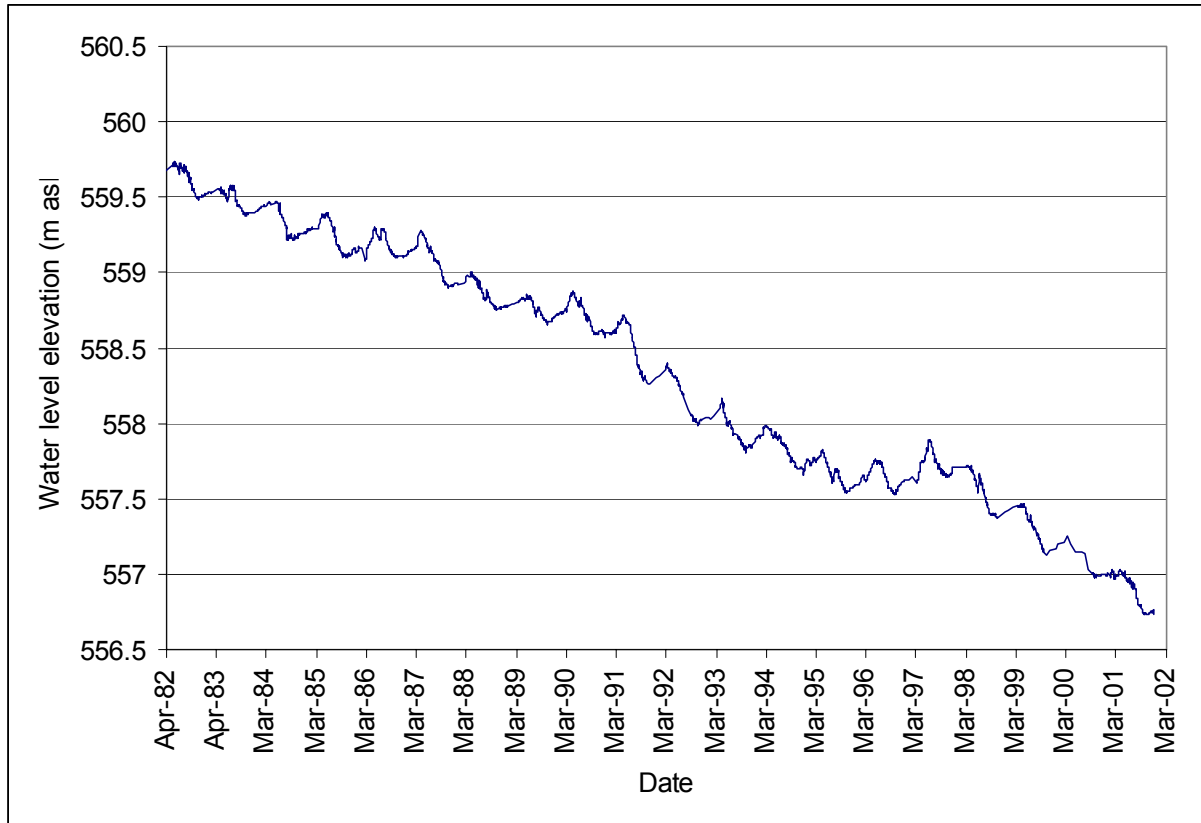


Fig. 2: Water levels in Muriel Lake from 1982 through January 2002.

Water Levels

Water levels in Muriel Lake have declined steadily since the maximum level in 1975 of 560.5 m. Figure 2 does not include data prior to 1982; however, water levels remained relatively steady at 559.5 m from 1967 to 1970 then rose steadily over the next five years. The 3 m decline since 1982 (or 4 m decline since 1975) is unprecedented for natural lakes in Alberta despite declining lake levels observed across the Province. In many lakes, the wet years of 1996 and 1997 resulted in peak water levels within the context of historical records (last 3 decades). These wet years barely registered at Muriel Lake. While climate may be an important factor in the water level decline, it seems unlikely that it is the only factor as patterns in Muriel Lake are not consistent with other lakes in the region.

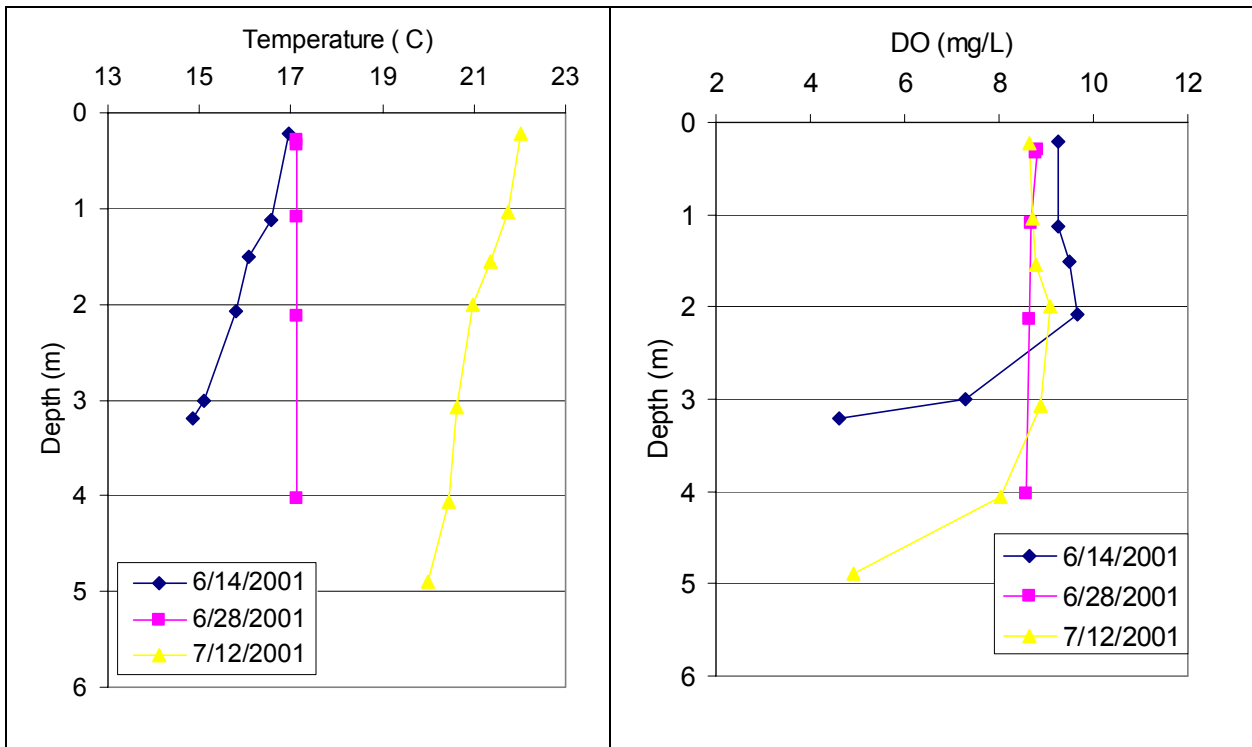


Fig. 3: Temperature and dissolved oxygen profiles for Muriel Lake for the summer 2001.

Results

Water Temperature and Dissolved Oxygen

Muriel Lake is considered dimictic, a term describing lakes that stratify and mix twice per year. However, like many lakes in Alberta it is more likely that the lake is polymictic meaning it may stratify and mix additional times through the summer. In early spring, surface waters warm from 0° C and eventually reached the same temperature as deeper waters (around 4° C). This period of uniform temperature induces a spring mixing event. In mid June, the surface waters of the lake were already warm with the potential for a weak thermocline at 1.5 m depth. Surface waters subsequently mixed downward maintaining a uniform temperature with depth through late June. Weak stratification was apparent in mid June at 1.5 m but this must have been temporary as it did not influence dissolved oxygen concentrations. Except for June, dissolved oxygen concentrations remained relatively constant through the water column. Slight increases in dissolved oxygen at 2 m depth may indicate a layer of algae concentrated in the metalimnion. Metalimnetic algal peaks are common in stratified lakes and are important for fish production. Patterns following mid July were not available.

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 late spring

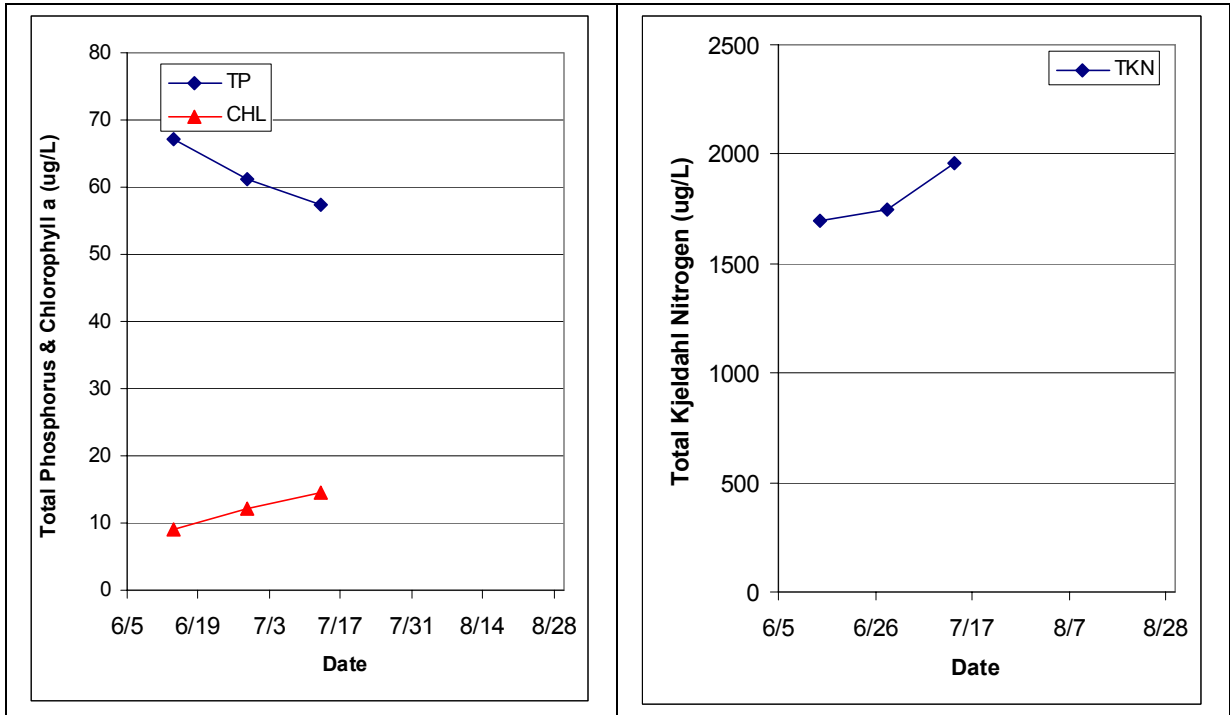


Fig. 4 & 5: Total phosphorus, chlorophyll *a* and Kjeldahl nitrogen for Muriel Lake, summer 2001.

but then becomes less clear as algae grow through the summer. In Muriel Lake, Secchi depths were generally poor, ranging between 0.8 and 1 m.

Water chemistry

Declining water levels in Muriel Lake and reduced inflow are likely responsible for rising phosphorus and chlorophyll concentrations in Muriel Lake. Total and dissolved phosphorus have both roughly doubled. Chlorophyll has also doubled. Unfortunately, we lost our volunteer at Muriel Lake in July and did not collect samples from which ion concentrations were to be analyzed. More information is required for Muriel Lake. Fortunately, Muriel Lake has been the focus of additional work through other groups. Hopefully their data can be used to augment those presented here.

Table 1: Mean values from summer 2001 samples compared to values from those reported in the Atlas of Alberta Lakes.

Parameter	1988	2001
TP (µg/L)	36	62
TDP (µg/L)	12	29
Chl (µg/L)	6.7	12
Secchi (m)	2.2	0.9
TN (µg/L)	1534	1832
TKN (µg/L)	1532	1826
NO ₂₊₃ N (µg/L)	<2	6
NH ₄ ⁺ N (µg/L)	21	< 1
Ca (mg/L)	11	-
Mg (mg/L)	98	-
Na (mg/L)	118	-
K (mg/L)	21	-
SO ₄ ²⁻ (mg/L)	116	-
Cl ⁻ (mg/L)	17	-
HCO ₃ (mg/L)	535	-
CO ₃ (mg/L)	70	-
Total Alkalinity (mg/L CaCO ₃)	556	-
Conductivity (µS/cm)	1143	-
pH	8.2-9.6	-
Color (mg/L Pt)	-	-
TSS (mg/L)	-	-

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 $5 \text{ mg}\cdot\text{L}^{-1}$ and should not average less than $6.5 \text{ mg}\cdot\text{L}^{-1}$ over a seven-day period. However, the guidelines also require that dissolved oxygen concentrations remain above $9.5 \text{ mg}\cdot\text{L}^{-1}$ 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 (µg•L ⁻¹)	Total Nitrogen (µg•L ⁻¹)	Chlorophyll a (µg•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.