The Alberta Lake Management Society
Volunteer Lake Monitoring Program

Sandy Lake

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2006 Report

Completed with support from:

Alberta Lake Management Society

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> *Water is integral to supporting and maintaining life on this planet as it moderates the climate, creates growth and shapes the living substance of all of Earth's creatures. It is the tide of life itself, the sacred source.* David Suzuki (1997). The Sacred Balance.

Alberta Lake Management Society's Lakewatch Program

Lakewatch has several important objectives, one of which is to collect and interpret water quality 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 these sources.

ALMS would like to thank all who express interest in Alberta's aquatic environments and particularly those who have participated in the Lakewatch program. These people prove that ecological apathy can be overcome and give us hope that our water resources will not be the limiting factor in the health of our environment.

Acknowledgements

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Sandy Lake

Sandy Lake is a shallow, extensively developed recreational lake northwest of Edmonton. At one time it was known for having a good yellow perch fishery with some northern pike. The name derives from the sand that dominates surface geology throughout the region. Likely important to nomadic Plains Cree, Treaty No. 6 established the Alexander Indian Reserve east of Sandy Lake in 1876. Agriculture developed around Sandy Lake throughout the 1800s as European settlers arrived. However, recreation became the primary use for Sandy Lake in the 1900s and by 1988 there were over 1000 lots within 1.5 km of the shoreline. In addition to permanent and summer inhabitants, there are two commercial campgrounds, a day use area, two public boat launches and a Girl Guides camp at Sandy Lake.

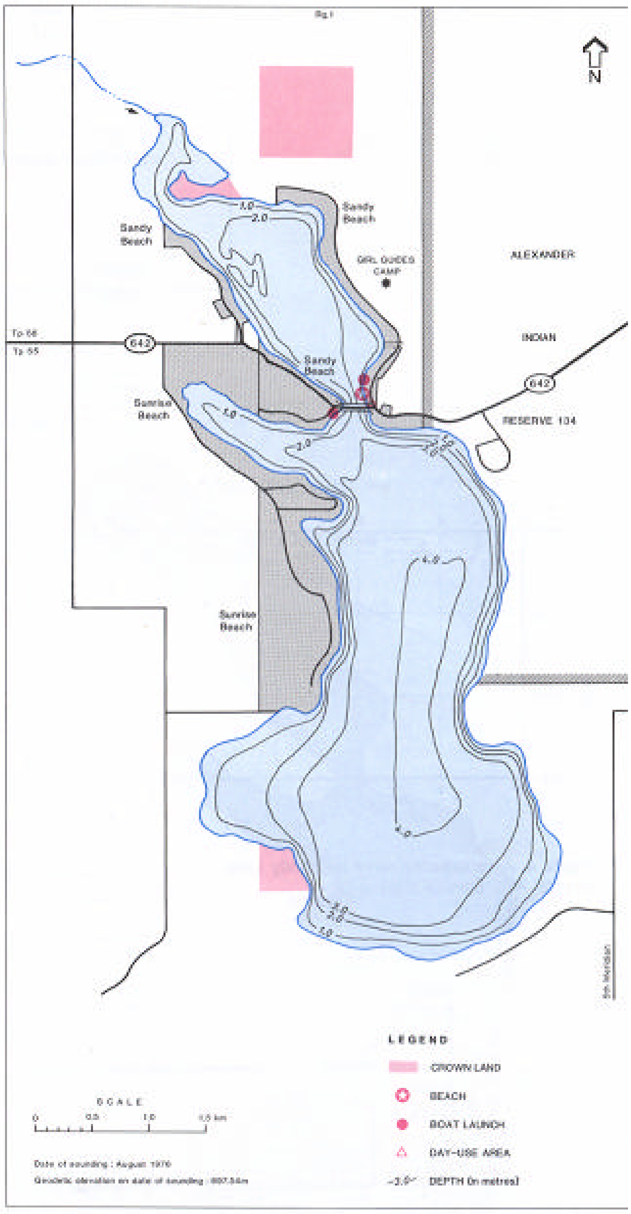


Figure 1:. Bathymetry of Sandy Lake. From Mitchell and Prepas 1990.

Sandy Lake is split into two basins with a causeway over the constriction. The north basin is small and about 2 m deep. The south basin is much larger and about 4 m deep (**Figure 1**). Sandy Lake is monomictic or polymictic becoming stratified in the winter but remaining completely mixed through the summer. Regular mixing of water has large implications on the fertility of the lake. The lake has become hypereutrophic and dense algal blooms are known to occur during summer months due to the lakes natural fertility. Sandy Lake has received extensive scrutiny compared to other lakes in Alberta, likely because of its recreational importance and its water quality problems. Detailed studies have been done on the nutrient budget for Sandy Lake.

Water Level

Water levels have been monitored at Sandy Lake since 1959 (**Figure 2**). Water levels are measured as the elevation in meters above sea level (m asl) of the surface of the lake. Prior to recent years, the lowest lake level on record occurred in 1970, measuring 696.8 m asl, and the maximum occurred in 1974, measuring 698.06 m asl. The water level was relatively stable and high through the late 70s and 80s. After 1992 the water level began to decline, reaching a historic low in 1995 of 696.9 m asl. The water level rose quickly in the two years following, with a peak in 1997 of 697.8 m asl. There has been a constant decline in water level in Sandy Lake since this 1997 peak. Dry conditions have resulted in a lack of surface runoff and may have reduced inputs from groundwater springs. The water level of Sandy Lake is now at a historic minimum of 696.33 m asl. The low lake level has resulted in a change in surface area of over 20% compared to historic maximum size. Considering the lake's shallow depth, it is behaving like a prairie pothole lake that is losing much of its water during this period of water shortage.

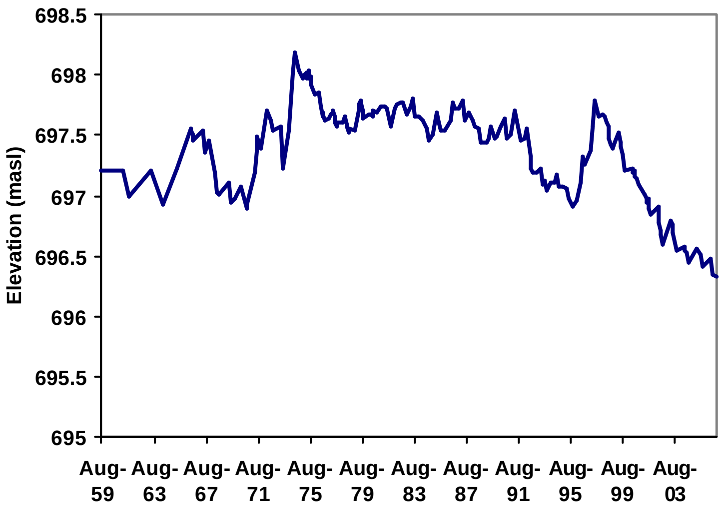
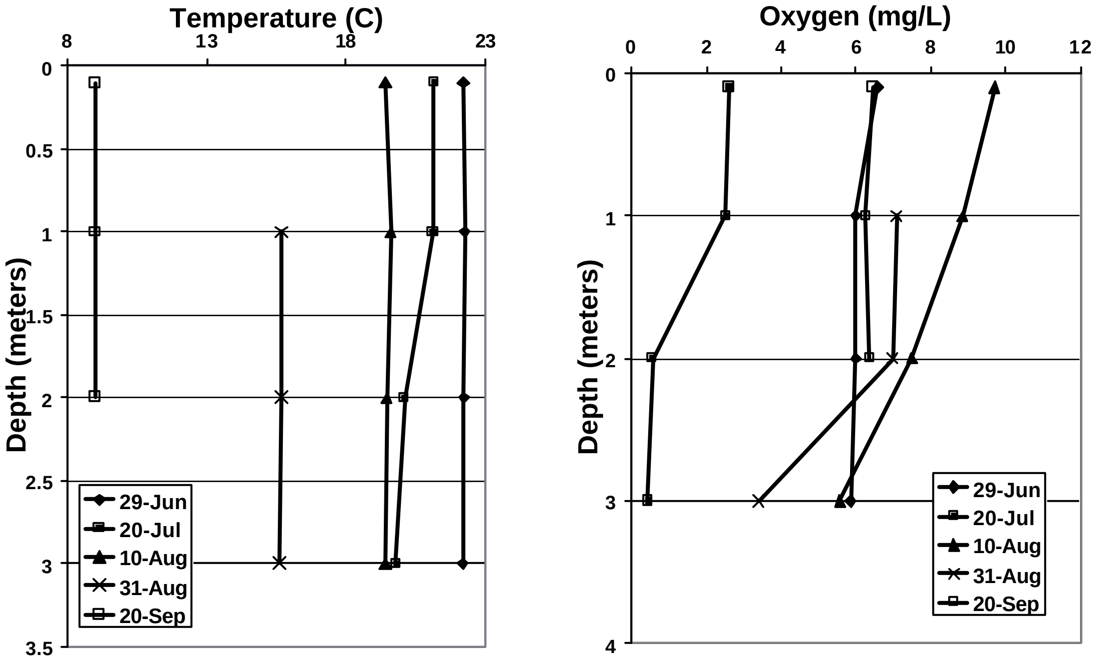


Figure 2: Historical water levels for Sandy Lake, 1959 to 2006.

Nutrient budget

The high concentration of nutrients in Sandy Lake has long been known to contribute to concerns about the poor water quality of this lake. As a result, a detailed investigation of phosphorus loading to Sandy Lake was undertaken in recent years. The total phosphorus load from the Sandy Lake basin is approximately 1100 kg/yr. Roughly three-quarters of the total external phosphorus load to Sandy Lake come from cottages and agriculture, each supplying about equal proportions. Point-source inputs from sewage were later estimated to account for approximately 7% of the total external load (Mitchell and Prepas 1990). By far the largest contributor to phosphorus concentrations, and hence poor water quality in Sandy Lake, is derived from lake bottom sediments. Recycling from bottom sediments may contribute about 3000 kg/yr of phosphorus, which is 3 times more than all other sources combined!



Figures 3: Temperature and dissolved oxygen profiles in Sandy Lake, summer

Water Temperature and Dissolved Oxygen

Water temperature and dissolved oxygen profiles in the water column can provide information on water quality and fish habitat. Please refer to the end of this report for descriptions of technical terms.

Temperature readings taken between June and September in Sandy Lake show no thermal stratification during the summer months (**Figure 3**). Measures of dissolved oxygen taken simultaneously, however, exhibit a general trend of decline in oxygen levels with increasing depth (**Figure 3**). The decline in June was only slight, while that experienced in July was more pronounced; the lowest 1 m experiencing low oxygen conditions. There was a decreasing trend in oxygen levels with depth at both the beginning and end of August, never falling below 3 mg/L. However, and in September there appears to have been little change in oxygen throughout the water column; all three depths measured just above 6 mg/L of oxygen. With the exception of the reading taken in July, Sandy Lake was within the provincial surface water quality guidelines for dissolved oxygen (5.0 mg/L or greater) for the duration of the summer.

Water clarity and Secchi Depth

Water clarity is influenced by suspended materials, both living and dead, as well as dissolved coloured 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 more turbid as algae grow throughout the summer.*

Water clarity is low in Sandy Lake. During the 2006 open water season, the average Secchi disk depth of the south basin of the lake was 0.62 m. There was a slight increase in Secchi depth to 0.9 m in July, which was concurrent with a decline in algal biomass.

Water chemistry

Based on the trophic status of lake water characteristics, Sandy Lake is considered to be hypereutrophic, with an average total phosphorus concentration of 227 ?g/L in the summer of 2006 (see *A Brief Introduction to Limnology* at the end of this report). It is considered high in nutrient concentration and algal biomass compared to lakes throughout Canada. In the context of the province of Alberta, Sandy Lake is nutrient rich, and has one of the highest algal biomasses of lakes sampled by ALMS.

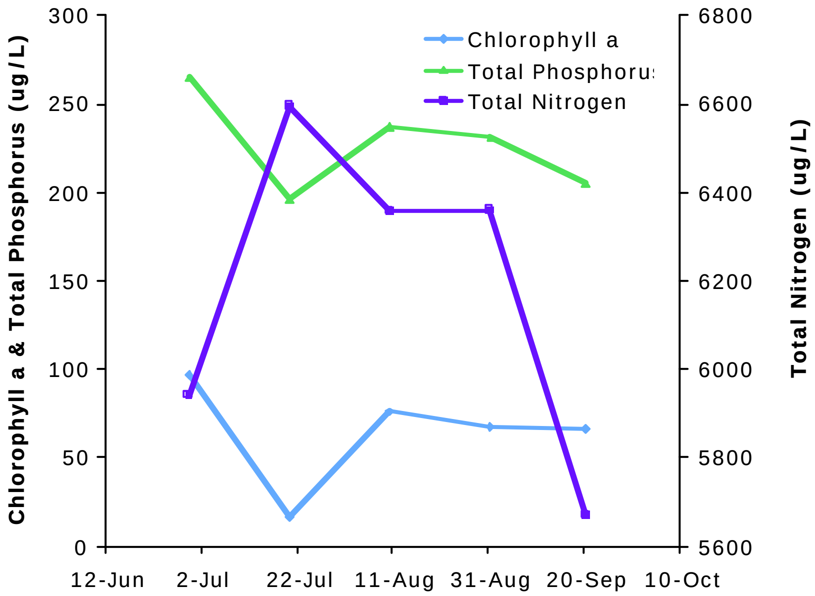


Figure 4: Total phosphorus, Chlorophyll *a* and Total Nitrogen for Sandy Lake, summer 2006.

Hypereutrophic lakes represent a relatively small fraction of lakes in Alberta and they are generally considered to have water quality that impairs recreational activity. Phosphorus concentrations have largely increased in the south basin when compared to 1988 values (**Table 1**). Phosphorus concentrations in the north basin, however, seem to have declined since 1988. Nitrogen concentrations on the other hand have increased substantially in both basins since 1988. Chlorophyll *a* concentrations increased markedly between the 1988 and 2001 sampling dates, but decreased in 2006 (data only available for the south basin). Total phosphorus concentrations decreased drastically from the end of June to mid-July (295 to 196 ?g/L, respectively), and remained relatively stable for the rest of the open water season (ranging between 237 and 205 ?g/L) (**Figure 4**). Chlorophyll *a*, which is a measure of algal biomass and water greenness, followed patterns in total phosphorus concentrations.

Sandy Lake is a classic example of problems encountered in extremely productive lakes. Shallow depth is one contributing factor that has been exacerbated by recent dry conditions. However, recent low water levels have been approached at other periods in the history of Sandy Lake and may be part of natural fluctuations. Future studies on algal community composition may be helpful in determining if algal blooms contain potentially toxin-producing cyanobacteria. Additional analyses of water samples for the toxins microcystin or cyanotoxin may be warranted during bloom periods in September.

Mineral ions such as calcium and sulfate are supplied by weathering in the watershed and from groundwater inflows. The fairly stable ion concentrations from the 1988 to 2001 period suggested that Sandy Lake was in equilibrium with its hydrology. Sulphate concentrations, however, have slightly increased over the past 5 years (when comparing the 2001 and 2006 sampling dates), as have sodium and chloride. Acid deposition from power plants, oil and gas processing plants, and human disturbance typically cause increases in these ions. In addition, reduced water level can also lead to the concentration of these ions. Sandy Lake is well protected from acidification as its pH of 9.1 is well above that of pure water (i.e., pH 7; **Table 1**).

Table 1: Mean values from summer 2001 and 2006 compared to values reported in the Atlas of Alberta Lakes.

Parameter	**1988 North**	**1988 South**	**2000 North**	**2000 South**	**2001 North**	**2001 South**	**2006 South**
TP (µg/L)	221	88	140	132	137	135	227
Chl-*a* (µg/L)	68	30	123	113	118	82	64.7
Secchi (m)	0.6	1.5	-	-	0.29	0.44	0.62
TKN (µg/L)	3736	2876	4962*	4962*	4963	4657	6180
TDN (µg/L)	-	-	-	-	3621	3731	-
NO_{2+3} (µg/L)	3	9	-	-	3	6	11.5
NH_4 (µg/L)	111	105	-	-	20	129	343
Ca (mg/L)	13	13	7*	7*	17	8	8.5
Mg (mg/L)	10	11	9*	9*	10	10	8.9
Na (mg/L)	109	114	128*	128*	79	134	227
K (mg/L)	13	14	16*	16*	11	18	21
SO_4 (mg/L)	?8	?5	-	-	6	3	10
Cl (mg/L)	3	3	-	-	6	8	12
Total Alkalinity (mg/L $CaCO_3$)	304	322	-	-	255	374	534*
CO_3 (mg/L)	-	-	-	-	-	-	550
HCO_3 (mg/L)	-	-	-	-	-	-	50
pH	-	-	-	-	-	-	9.1
Cond (µS/cm)	-	-	-	-	-	-	998
TDS (mg/L)	-	-	-	-	-	-	609*

Note: TP = total phosphorus, Chla = chlorophyll *a*, NO_{2+3} = nitrate+nitrite, NH_4 = ammonium, Ca = calcium, Mg = magnesium, Na = sodium, K = potassium, SO_4 = sulphate, Cl = chloride, CO_3 = carbonate, HCO_3 = bicarbonate, Cond = Specific Conductivity, TDS = Total dissolved solids.
* Original ALMS data not specified to basin level for these summer 2000 values.

Works Cited

Mitchell, P. and E. Prepas. 1990. Atlas of Alberta Lakes. University of Alberta Press.

A Brief Introduction to Limnology

Indicators of water quality

The goal of **Lakewatch** is to collect water samples necessary to determine the water quality of lakes. Though not all encompassing, the variables measured in **Lakewatch** are sensitive to human activities in watersheds that may cause impacts to 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 affected (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 fish habitat and production of noxious odors. Large increases in nutrients over time may also indicate sewage inputs, which in turn, may result in other human health concerns such as harmful bacteria or protozoans (e.g. *Cryptosporidium*).

Temperature and mixing

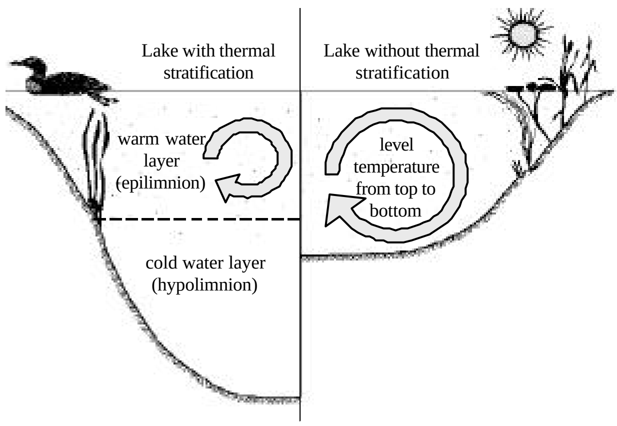


Figure 5 : Difference in the circulation of the water column depending on thermal stratification.

Water temperature in a lake dictates the behavior of many chemical parameters responsible for water quality (Figure 5). 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. A third layer, known as the metalimnion, provides an effective barrier between the epi- and hypolimnion**.** The metalimnion reflects a rapid transition in water temperature known as the **thermocline**. A thermocline typically occurs when water temperature changes by several degrees within one-meter of depth. The thermocline acts as an effective physico-chemical barrier to mixing between the hypolimnion and epilimnion, restricts downward movement of elements, such as oxygen, from the surface 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 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 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 state dissolved oxygen concentrations (in the epilimnion) must not decline below 5 mg/L and should not average less than 6.5 mg/L over a seven-day period. However, the guidelines also require that dissolved oxygen concentrations remain above 9.5 mg/L 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 terrestrial plants and plants and algae of tropical lakes, phosphorus is usually in shortest supply in temperate 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. Larger aquatic plants, known as macrophytes, rather than algae, dominate some highly productive lakes. In these lakes, chlorophyll-a and nutrient values taken from water samples do not include productivity from large aquatic plants. As a result, lakes like Chestermere, which are dominated by macrophytes, reflect lower-nutrient trophic states than would otherwise result if macrophyte-based chlorophyll were 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 Depth

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. Secchi disk depth is the oldest, simplest, and quickest quantitative measure of water clarity. A Secchi disk is a black and white disk that is lowered down through the water column until it can no longer be seen. Secchi disk depth is the midpoint between the depth at which it disappears when lowered and reappears when it is pulled up again. The Secchi disk depth in lakes with high algal biomass will generally be low. Secchi disk depth, however, is not only affected by algae, high concentrations of suspended sediments, particularly fine clays or glacial till common in plains or mountain reservoirs of Alberta, also impact water clarity. Mountain reservoirs may have exceedingly shallow Secchi disk depths despite low algal growth and nutrient concentrations.

The euphotic zone, calculated as twice the Secchi disk depth, is the portion of the water column that has sufficient light for aquatic plants to grow. Murky waters, with shallow Secchi depths, can prevent aquatic plants from growing on the lake bottom. Aquatic plants are important because they ensure clear lake water by reducing shoreline erosion and stabilizing lake bottom sediments. Many lakes in Alberta are shallow and have bottom sediments with 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 fish, depend on aquatic plants for food and shelter.

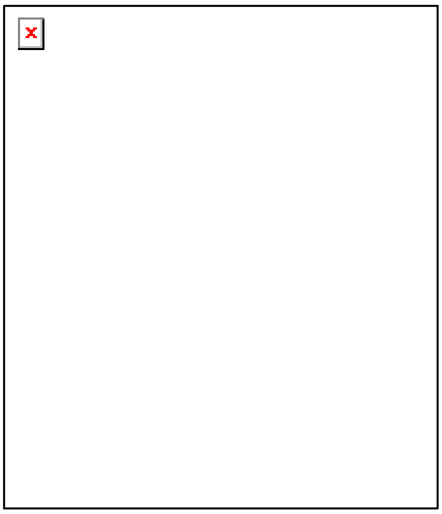


Figure 6: Suggested changes in various lake characteristics with eutrophication. From "Ecological Effects of Wastewater", 1980.

Trophic State

Trophic state is a classification system for lakes that depends on fertility and is a useful index for rating and comparing lakes. From low to high nutrient and algal biomass (as chlorophyll-a) concentrations, the trophic states are: oligotrophic, mesotrophic, eutrophic and hypereutrophic. The nutrient and algal biomass concentrations that define these categories are shown in Table 2 and a graph of Alberta lakes compared by trophic state can be found on the ALMS website. A majority of lakes in Alberta are meso- to eutrophic because they naturally contain high nutrient concentrations due to our deep fertile soils. Thus, lakes in Alberta are susceptible to human impacts because they are already nutrient-rich; any further nutrient increases can bring about undesirable conditions illustrated in Figure. 6.

Table 2: Trophic status based on lake water characteristics

Trophic state	Total Phosphorus (µg/L)	Total Nitrogen (µg/L)	Chlorophyll a (µg/L)	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 and Kerekes (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.

References

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