The Alberta Lake Management Society Volunteer Lake monitoring report

Hastings Lake

2008 Report

Completed with support from:

Alberta Environment

Alberta Lake Management Society

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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

Alberta Lake Management Society's Lakewatch Program

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 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

The Lakewatch program is made possible through the dedication of its volunteers and Lakewatch Chairs, Théo Charette and Ron Zurawell. We would like to thank Curtis Perrott for his efforts in collecting data in 2008. We would also like to thank Lisa Brodziak and Sophie Damlencour who were summer interns with ALMS in 2008. Project Technical Coordinator, Jill Anderson was instrumental in planning and organizing the field program. Technologists, Shelley Manchur, Mike Bilyk, Brian Jackson and John Willis were involved in the logistics planning and training aspects of the program. Doreen LeClair and Chris Rickard were responsible for data management. Théo Charette (ALMS President) and Jill Anderson (Program Manager) were responsible for program administration and planning. This report was updated by Sarah Lord for 2008. Alberta Environment and the Beaver River Watershed Alliance (BRWA) were major sponsors of the Lakewatch program.

Hastings Lake

Hastings Lake (**Figure 1**), with its natural shoreline and many islands, is a popular lake for boating and bird watching. It is a regionally significant nesting, moulting, staging and migration area for diving ducks, and its islands provide nesting habitat for Canada Geese. The lake is located 40 km east of the city of Edmonton in the County of Strathcona. To reach the north side of the lake from Edmonton, take Highway 14 east to the hamlet of Sherwood Park, then continue east and southeast on Secondary Road 630, locally known as Wye Road. About 3 km southeast of the hamlet of Deville, turn south on Range Road 203 and drive 0.5 km to the lakeshore. Access is also available at the end of Range Road 204 on the north shore and in the hamlet of Hastings Lake on the south shore.

Figure 1. Hastings Lake, Alberta. Photo by D. Webb and E. E. Prepas.

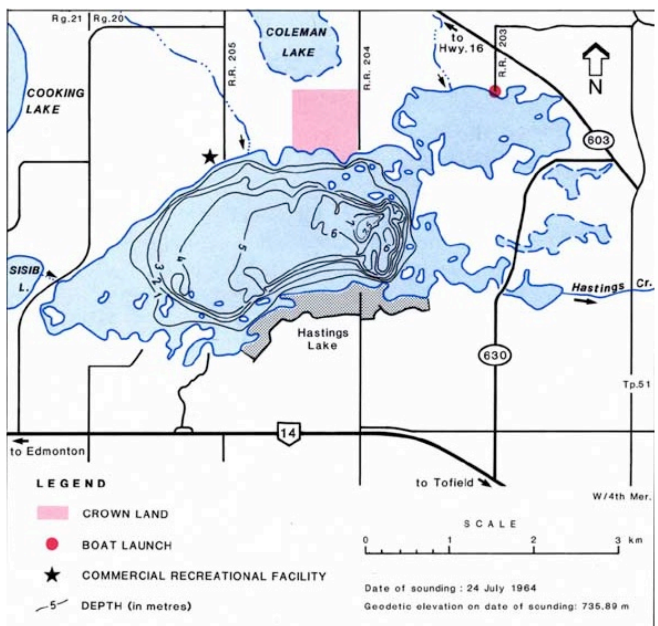

Figure 2. Bathymetric map of Hastings Lake, Alberta (Alta. Envir. n. d.).

The Cree name for the lake is *a-ka-ka-kwa-tikh*, which means "the lake that does not freeze" (Holmgren and Holmgren 1976). Apparently, springs that flow into the lake bottom prevent parts of the lake from icing over in winter (Bowick 1988). In 1884, the lake and its outlet were renamed by J.B. Tyrrell for Tom Hastings, a member of Tyrrell's geological survey party (Holmgren and Holmgren 1976).

Hastings Lake is a shallow, medium-sized water body that consists of two basins separated by a narrow channel. The smaller, northeast basin is known locally as Little Hastings Lake. The shoreline of the lake is irregular, and there are numerous bays along its length. The lake has more than 20 islands, mostly located in the main basin; their number and size vary with the water level. When the main basin was surveyed in July 1964, its maximum depth was 7.3 m (**Figure 2**).

The first settlers at Hastings Lake were Jonas Ward and August Gladue, who arrived sometime during the late 1800s (Touchings 1976). A Grand Trunk Railway station was built at the hamlet of Deville, 2.5 km north of the lake, in 1909, and a post office was established there soon after. In 1912, the school district of Deville was created, and a school was built in the hamlet.

By the late 1890s, most of the virgin timber had been removed from the area surrounding Hastings Lake, either by fire or by timber cutting. In 1893, a sawmill operated just south of the lake (Redecop and Gilchrist 1981). In 1899, Alberta's first forest reserve, the Cooking Lake Forest Reserve, was opened. It included all of Hastings Lake's drainage basin as well as land north and south of the drainage basin (Touchings 1976).

Most of the people who use Hastings Lake are local residents, and recreational facilities for visitors are limited. The only campground is Kawtikh Recreational Retreat on the north shore, a commercially operated facility that opened in 1988. There are 40 rustic campsites, a playground, a picnic area and a boat launch. The area is used for picnicking, bird watching and wildlife viewing. Grazing is permitted and the land is fenced, but access to the lakeshore is available and small boats can be launched at the end of the range road. The remainder of the shoreland, with the exception of some reserve land within the hamlet of Hastings Lake, is privately owned. West of the hamlet, there is a private camp owned by the Legion of Frontiersmen and a private sailing club, the Cutty Sark Club. Within the hamlet, there is a summer camp operated by the Hastings Lake and Lutheran Bible Camp Association. The most popular recreational activities at Hastings Lake are bird watching, sailing, canoeing, rowing and power boating.

Hastings lake is very fertile. During July and August, blue-green algae often reach bloom proportions. In some years, these blooms have been responsible for poisoning domestic animals and wildlife. The lake is marginal for overwinter fish survival, but yellow perch (*Perca flavens*) were stocked from 1982 to 1985, and by 1989, the perch catch rate was reported to be good. As of 1989, there were no plans to continue stocking.

Water Level

Lake levels were recorded from 1919 to 1922, and have been monitored regularly since 1956; as well, levels were estimated for 1939, 1941 and 1949. During the earlier period (1919 to 1922), the highest lake level recorded was 735.56 m in May 1920. The level declined continuously until 1949, when it reached its estimated historic minimum of 733.39 m. By 1956, when regular recording began, the level had risen by an estimated 2.57 m, to 735.96 m. The highest water level historically recorded in Hastings Lake was 736.53 m in July 1965, surpassed only during the exceptionally wet year of 1997 when water level reached 736.91 m. During the late 1960s and early 1970s the lake level declined again, to the second lowest recorded level of 735.22 m, in April 1971. Precipitation levels were high during 1974, and the lake level rose to 736.27 m in October. Since the mid-1970s, there has been no obvious long-term trend, either upward or downward, in the elevation of Hastings Lake (**Figure 3**). In 2008, the maximum elevation was 735.47 m in May.

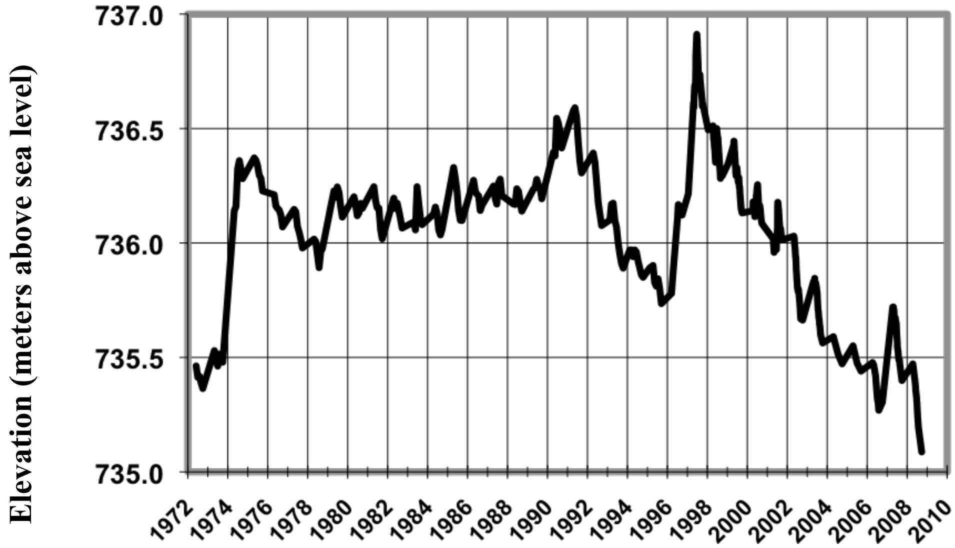

Figure 3. Historical water levels (meters above sea level (asl)) in Hastings Lake, Alberta 1972 – 2009.

Results

Water temperature and dissolved oxygen

Hastings Lake is typical of many shallow lakes: it is well mixed throughout most of the open-water season and becomes thermally stratified only during calm periods. Thermal stratification in Hastings Lake was not observed during the summer 2008 (**Figure 4**). On 12 June, surface water temperature was 19.3°C. Water temperature decreased slightly to 18.6°C at the surface on 16 July, and declined further to 16.3°C on 1 September and 10.8°C on 27 September. Lake waters were isothermic on all sampling dates.

Dissolved oxygen (DO) concentrations in upper layers of surface waters of Hastings Lake were ≥ 8 mg/L on all sampling dates through the summer, well within the acceptable range for surface water quality (DO ≥ 5.0 mg/L) (**Figure 4**). DO concentrations began a gradual decline at 3 m depth in early June, but by mid-July this chemocline had disappeared and all water layers were well-oxygenated. On 1 September, the weak chemocline had re-formed, but was lost by 27 September. On all sample dates, DO was near zero (e.g. anoxic) at the lakebed. Deep-water anoxia is common in summer, and the decomposition of organic matter produced during the open water season continues on into the winter months, which in turn, leads to low winter oxygen concentrations (as decomposition consumes oxygen).

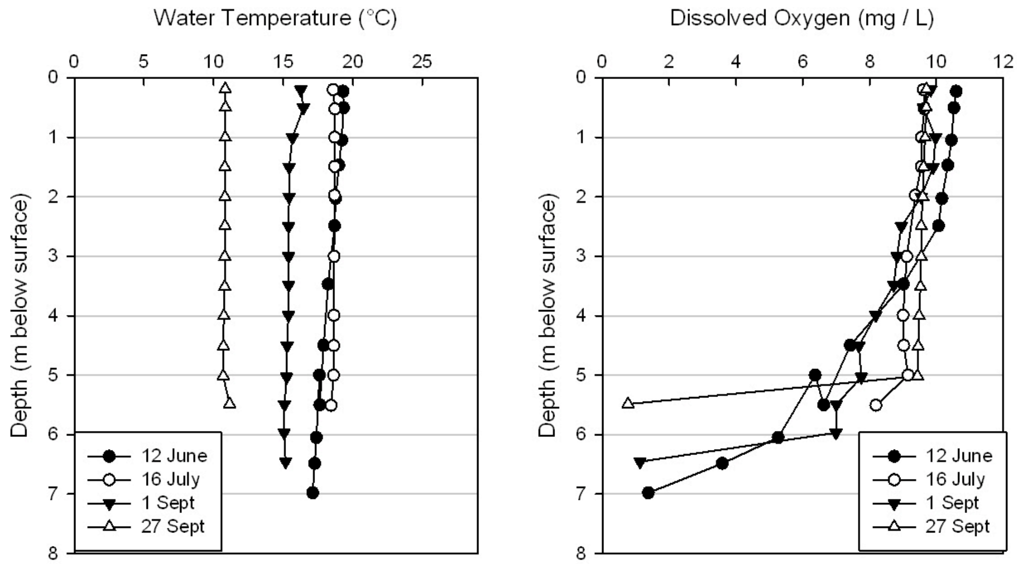

Figure 4. Water temperature (°C) and dissolved oxygen (mg/L) profiles for Hastings Lake during the summer of 2008.

Water clarity and Secchi Disk Depth

Water clarity is influenced by 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 disk depth. Following the period of ice and snowmelt, a lake can have low clarity due to spring runoff and the inflow of suspended sediments into the lake. Lake water usually clears in the spring but then becomes more turbid due to algal growth taking place throughout the summer open water season.

Water clarity on Hastings Lake was measured five times during the summer of 2008. Hastings Lake was relatively turbid compared to other lakes in Alberta, with average Secchi disk depth = 0.85 m (**Table 1**). On 12 June, light penetrated 1.0 m or ~14% of the total lake depth, which allowed for algal growth in the top 2.0 m of the lake. By 16 July, Secchi disk depth had decreased to 0.75 m, then recovered slightly to 0.9 m on 1 September. Water clarity declined back to a Secchi disk depth of 0.75 m by 27 September. This pattern of water clarity dynamics is typical of highly productive Alberta lakes, when algal growth during July and August causes reduced water clarity. Water clarity recovers in September as lower temperatures limit growth, and dying algae fall out of the water column and settle on the lakebed where they are decomposed by anaerobic bacteria. Fall turnover near 27 September may have resuspended particles back into the water column, causing reduced water clarity relative to early September.

Water chemistry

Based on lake water characteristics, Hastings Lake is considered hypereutrophic (see *A Brief Introduction to Limnology* at the end of this report). Average total phosphorus (TP = 77.5 μg/L) and total Kjeldahl nitrogen (TN = 3578 μg/L) concentrations were within the hypereutrophic range in 2008 (**Table 1**). Chlorophyll *a* (chl *a* = 30.4 μg/L) was also within the hypereutrophic range.

Total phosphorous varied over the summer, from a minimum of 70 μg/L on 12 June and 1 September, to a maximum of 88 μg/L on 27 September (**Figure 5**). Total nitrogen increased over the summer, from 2.91 mg/L on 12 June to a maximum of 4.0 mg/L on 27 September. Chlorophyll a (a measure of algal biomass) increased from 18.4 μg/L on 12 June to 45.2 μg/L by 27 September. It is likely that this late-summer algal bloom resulted from internal loading of phosphorus. In shallow lakes, phosphorus is frequently released from the deeper sediments during calm periods in summer, and from shallow sediments throughout the summer.

During the summer 2008, Hastings Lake was well buffered from acidification with an average pH = 8.5, which is well above that of pure water (i.e., pH 7). Water in Hastings lake is slightly saline, very hard and well-buffered. Dominant ions include bicarbonate, sulphate, and sodium (**Table 1**). Ion concentrations appear to have increased from 1987 levels, but it is not know if this change falls within normal ranges of variation for Hastings Lake because few historical data are available.

The average concentrations of various heavy metals (as total recoverable concentrations) in Hastings Lake were not measured in the summer of 2008.

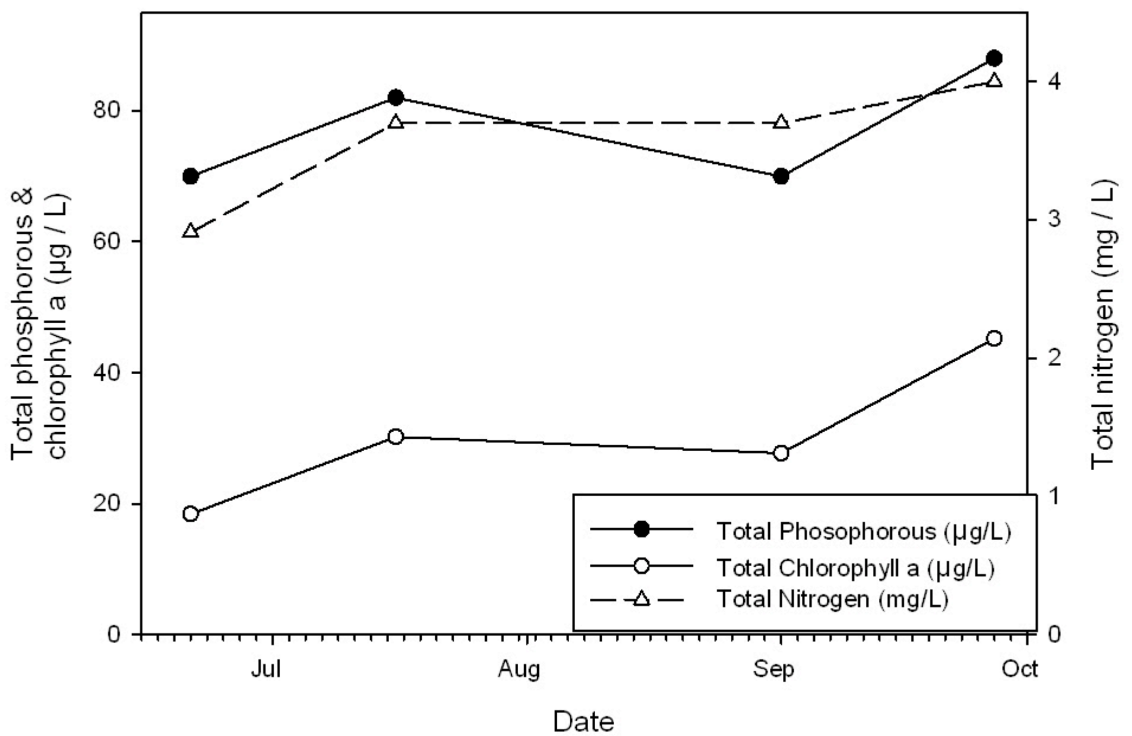

Figure 5. Total phosphorous, chlorophyll a (a measure of algal biomass), and total nitrogen concentrations for Hastings Lake during the summer of 2008.

Table 1. Water chemistry values for Hastings Lake, summer 2008 compared to 1987 values reported in Mitchell and Prepas (1990) and the 1999 Lakewatch report.

Parameter	1987	1999	2008
TP (μg/L)	116	96	77.5
TDP (μg/L)	-	-	20
Chlorophyll-*a* (μg/L)	72.5	44	30.4
Secchi disk depth (m)	0.9	2.1	0.85
TKN (μg/L)	3730	2514	3578
$NO_{2,3}$ (μg/L)	-	171	19
NH_4 (μg/L)	-	-	43.3
Dissolved organic C (mg/L)	36	-	40.75
Ca (mg/L)	29	36	28.6
Mg (mg/L)	46	-	61.3
Na (mg/L)	98	-	139
K (mg/L)	29	-	37.9
SO_4^{2-} (mg/L)	221	-	275
Cl^- (mg/L)	10	-	21.8
TDS (mg/L)	573	-	752
pH	8.8 – 9.0	-	8.9
Conductivity (μS/cm)	917	-	1165
Hardness (mg/L)	258	-	323.5
HCO_3 (mg/L)	238	-	323.5
CO_3 (mg/L)	26	-	29.5
Total Alkalinity (mg/L $CaCO_3$)	238	-	315

Note: TP = total phosphorous, TDP = total dissolved phosphorous, Chla = chlorophyll *a*, TKN = total Kjeldahl nitrogen, 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.

*Atlas of Alberta Lakes (Mitchell and Prepas, 1990).

References

Alberta Environment. n.d. Envir. Assess. Div., Envir. Qlty. Monit. Br. Unpubl. data, Edmonton.

------. n.d. Tech. Serv. Div., Surv. Br. Unpubl. data, Edmonton.

Holmgren, E.J. and P.M. Holmgren. 1976. Over 2000 place names of Alberta. 3rd ed. West. Producer Prairie Books, Saskatoon.

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

Redecop, L. and W. Gilchrist. 1981. Strathcona County-a brief history. W. Gilchrist, Univ. Alta. Printing Serv., Edmonton.

Touchings, D. 1976. Heritage resource inventory of the Cooking Lake study area [Appendix 10]. *In* Cooking Lake area study, Vol. V: Economic base and heritage resources. Alta. Envir., Plan. Div., Edmonton.

Vollenweider, R.A., and J. Kerekes, Jr. 1982. Eutrophication of Waters. Monitoring, Assessment and Control. Organization for Economic Co-Operation and Development (OECD), Paris. 156p.

Welch, E.B. 1980. Ecological Effects of Waste Water. Cambridge University 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

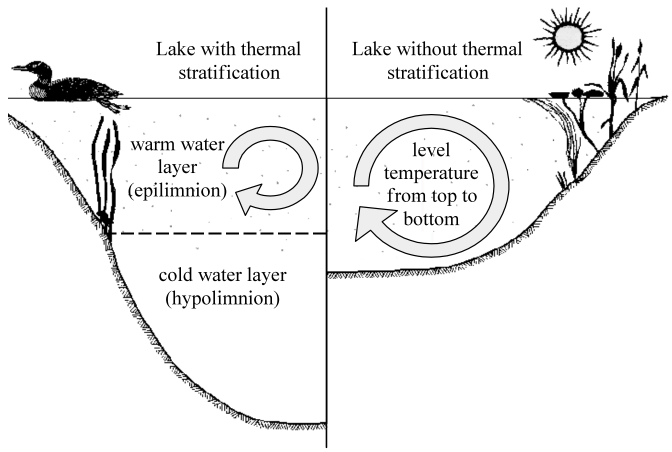

Figure 6: Difference in the circulation of the water column depending on thermal stratification.

Water temperature in a lake dictates the behavior of many chemical parameters responsible for water quality (Figure 6). 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 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 suggest 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 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. 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, can exist at 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 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 shallow. However, Secchi disk depth is not only affected by algae. 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 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.

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. 7.

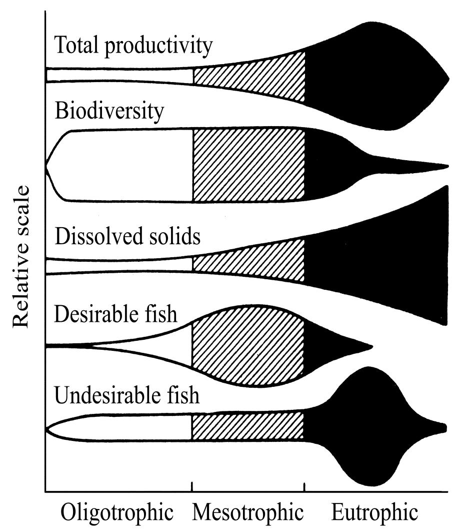

Figure 7: Suggested changes in various lake characteristics with eutrophication. From "Ecological Effects of Wastewater", 1980.

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 (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.