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Lakewatch

Jackfish 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 2001 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 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. 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 Jackfish Lake, circa 1980, Development around the shore has increased substantially since this picture was taken. Photo: Mitchell and Prepas 1990.

Jackfish Lake

Jackfish Lake is an exceptional lake southwest of Edmonton. However, most of the shoreline is privately owned which has resulted in a limited ability for the county to impose management regulations that balance conflicting uses. At one time it was known for having a good yellow perch, pike and walleye fishery. The history of Jackfish Lake is poorly known. Its name likely derives from an abundance of northern pike. .

Jackfish Lake is a complex amalgamation of three main basins and a satellite pond often used as a water ski course. Two of the main basins are about 9 m deep while the most northern basin is about 7.5 m deep. The drainage basin is about 5 times the size of the lake which is small but similar to other lakes in the area. There are no permanent streams flowing into Jackfish Lake. The lake is small (2.4 km^2) but has a long shoreline (18.1 km) due the complex shape. Jackfish Lake is dimictic becoming stratified in both summer and winter and mixing in the spring and fall. The lake is mildly eutrophic which is normal for lakes in Alberta. However, dense algal blooms are known to occur during summer months due to the lake's natural fertility. Jackfish Lake has received extensive scrutiny compared to many other lakes in Alberta likely because of its recreational importance, its proximity to Edmonton and its development potential. Detailed studies have been done on the development potential for Jackfish Lake (Bird & Hale 1976), groundwater availability (Alberta Environment 1981, and the fish stock as well as fisheries potential and vegetation characteristics (R.L. & L. Env. Serv. 1987).

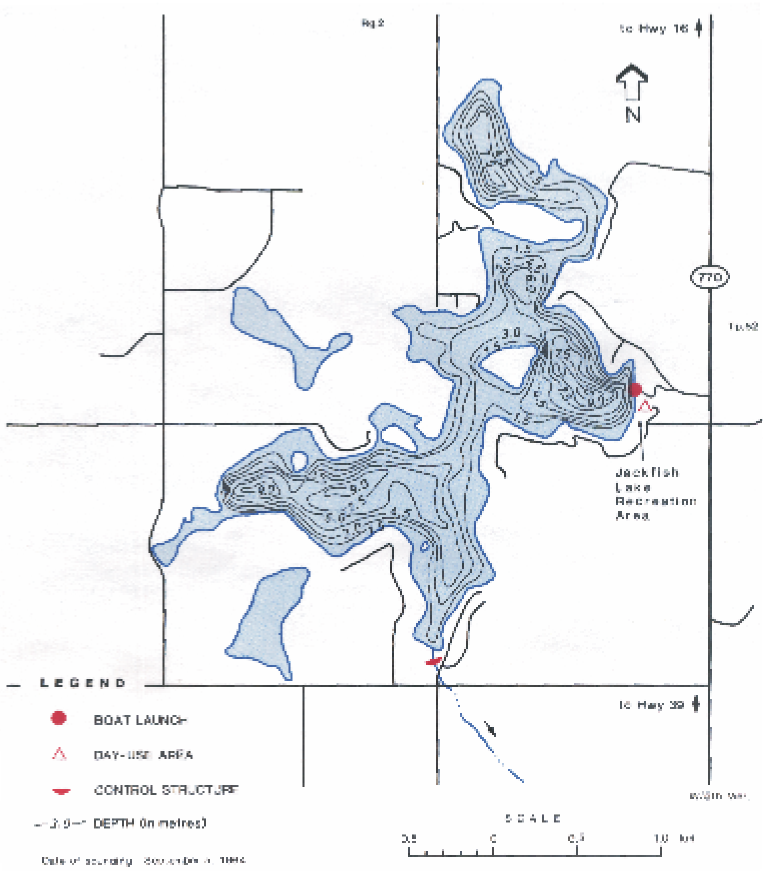


Fig. 2: Bathymetry of Jackfish Lake. From Mitchell and Prepas 1990.

Nutrient budget

Phosphorus concentrations in Jackfish Lake are about average for Alberta lakes. Theoretical phosphorus loading to Jackfish Lake was calculated in 1988. The annual phosphorus load was approximately 332 kg/y, half of which comes from agricultural and cleared land around the lake (Mitchell 1988). At the time, 26% of the annual phosphorus load derived from cottages and sewage. The impacts of cottages have likely increased in the past 14 y. The estimated phosphorus load is not excessive when compared to lakes like Sandy Lake (1100 kg/y), where water quality is significantly impaired. By far the largest contributor to phosphorus concentrations and poor water quality in Alberta lakes is derived from lake bottom sediments. The phosphorus load from sediments in Jackfish Lake has not been estimated. However, recycling from bottom sediments may contribute as much as 750 kg/y of phosphorus – more than 2 times that from all other sources combined! Internal loading is significantly reduced by aquatic weed growth. Relatively good water quality in Jackfish Lake compared to similar lakes in the region may be due in part to the weed growth that occurs in shallow areas.

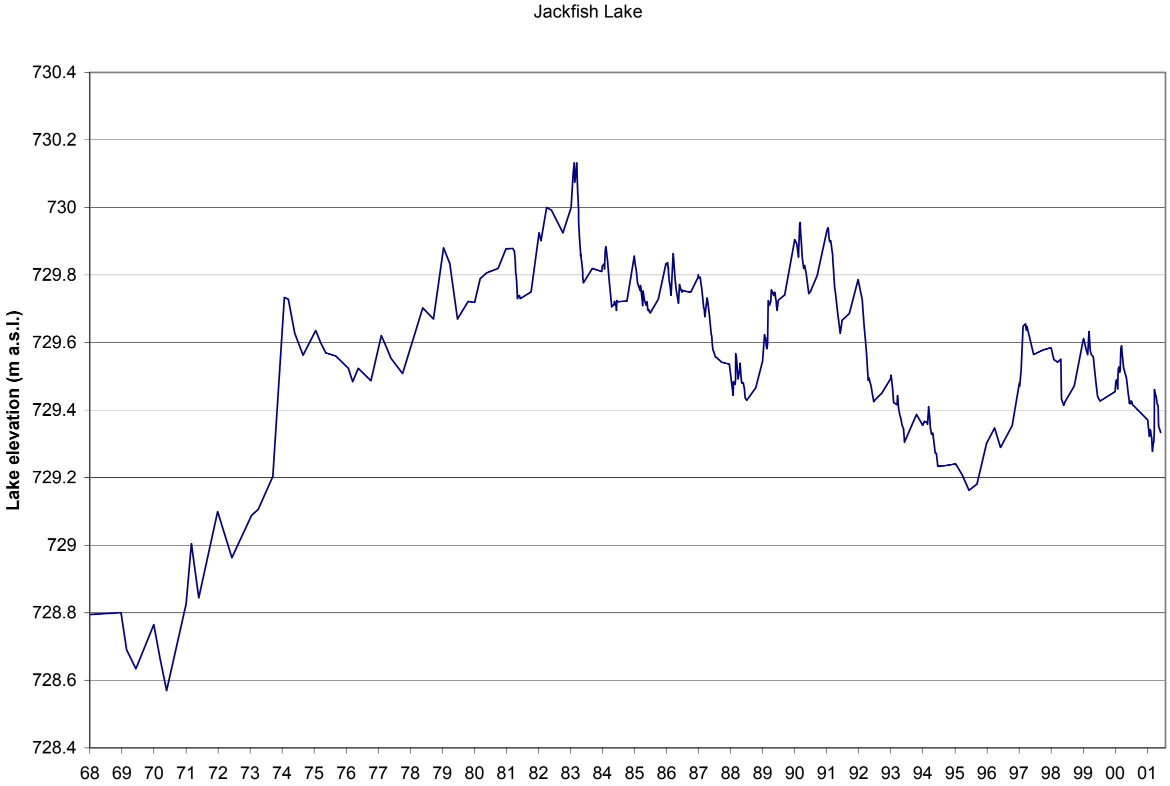


Fig. 3: Lake elevation above sea level over the period of record (1968 – 2001).

Water Levels

Water levels have been monitored at Jackfish Lake since 1968 (Fig. 3). Concern over rising lake levels during the 70s drove Parkland County to re-establish the outflow which had previously been blocked with debris. The county also constructed a low fixed-crest weir to maintain lake levels at 729.72 m. The high water levels of the 70s were likely a result of wet conditions in the area as levels in several other lakes (e.g. Sandy Lake) also rose during that period. Like other lakes, water levels in Jackfish lake have dropped through the 80s and 90s. As a result Jackfish lake rarely has an outflow. Jackfish Lake has been relatively fortunate with only a moderate decline in water levels compared to lakes like Sandy Lake.

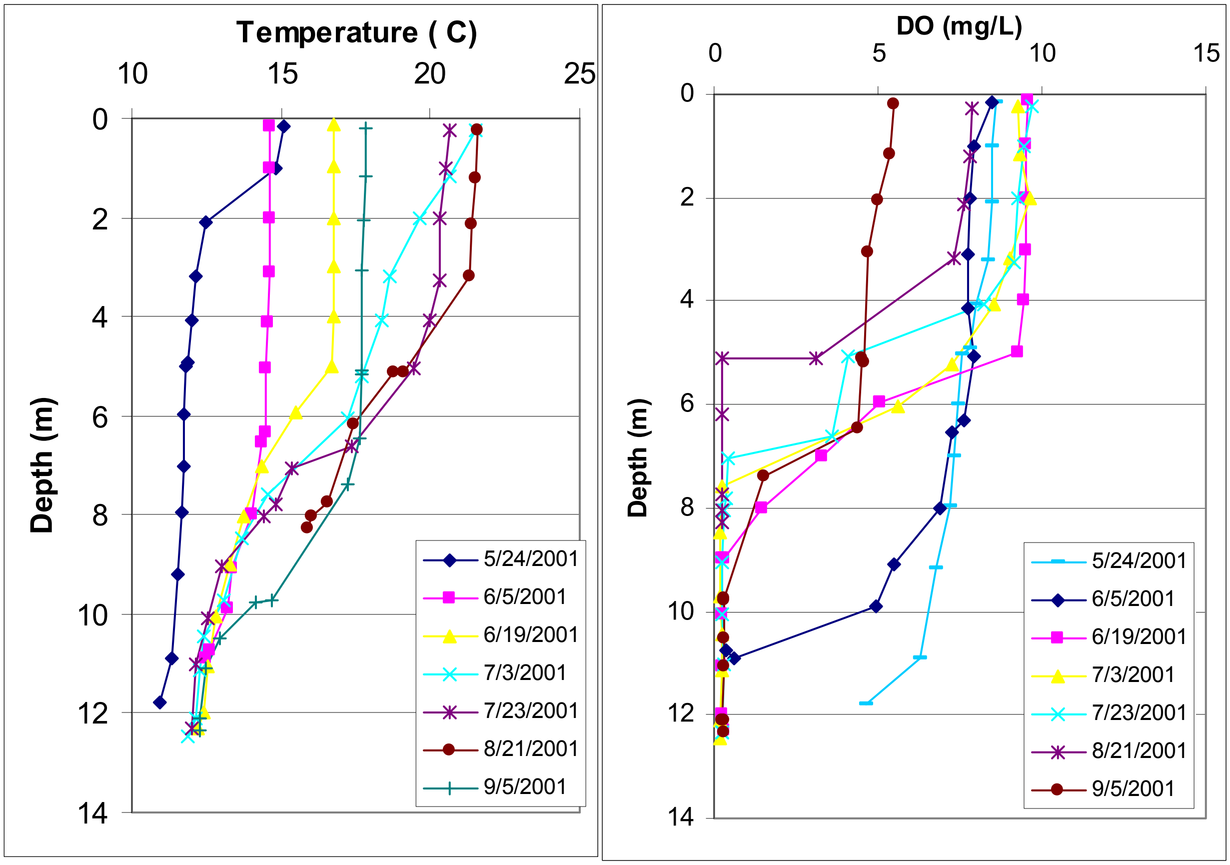


Figure 4: Temperature and dissolved oxygen profiles for Jackfish Lake in 2001.

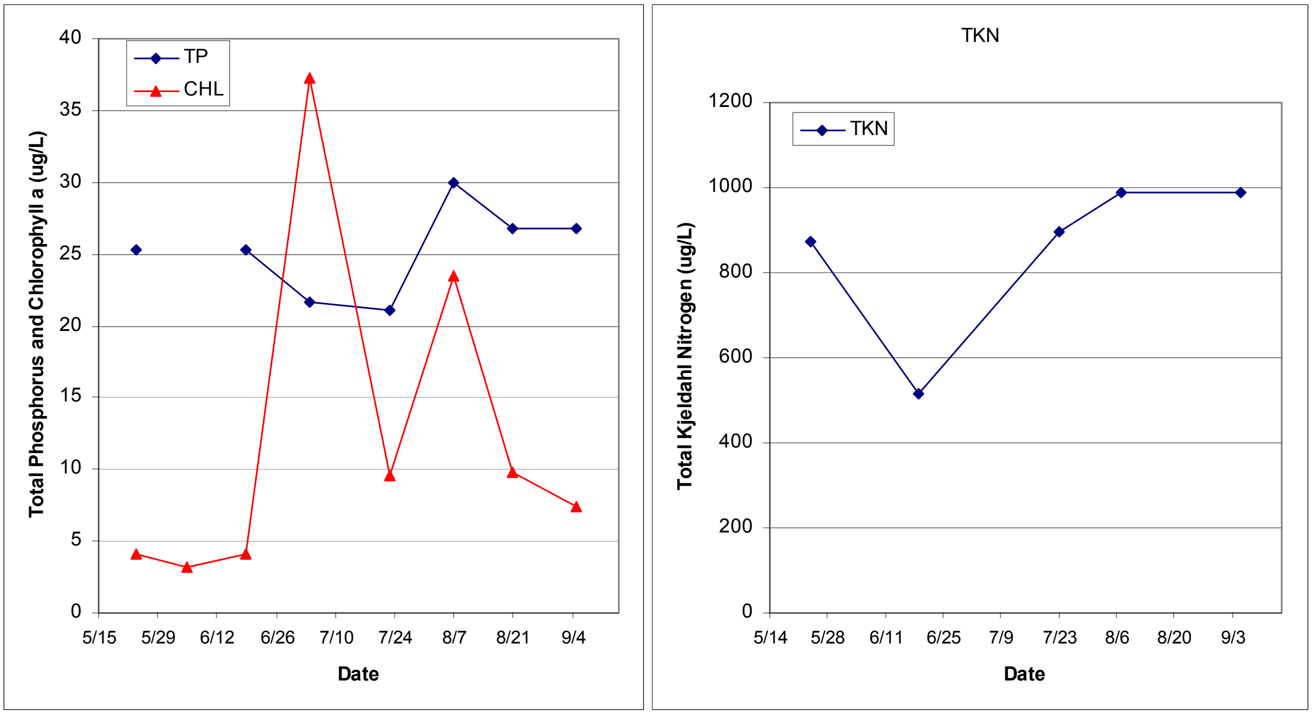
Results

Water temperature and dissolved oxygen

Thermal stratification occurred early after ice melted between 1 and 2 m depth in Jackfish Lake but seemed to be temporary and had little impact on the oxygen profile. By mid-June distinct and stable stratification was in place at 5 m depth. Below the thermocline, dissolved oxygen concentrations declined rapidly to zero 8 m depth. Stratification persisted in Jackfish Lake through to early September with the well oxygenated epilimnion ending at about 5 m depth and the oxygen depleted hypolimnion occurring below 5 m depth. Surface dissolved oxygen concentrations were low in September, however, this is uncharacteristic and likely represents a problem with the probe calibration at the time of sampling. Otherwise, the pattern of stratification and dissolved oxygen in Jackfish Lake is a classic example of healthy dimictic lakes.

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. This pattern was indeed the case for Jackfish Lake. Secchi depth was between 2.6 and 3.1 m during the early spring but increased to 4.6 m in mid-June as stratification of the water column likely assisted in the settling of suspended material. As the summer progressed and algal growth increased, Secchi depths declined slowly to 2 m by September.



Figures 3 & 4: Total phosphorus, chlorophyll *a* and Kjeldahl nitrogen for Jackfish Lake, summer 2001.

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

Parameter	1980	1981	2001
TP (μg•L^{-1})	-	39	25
Chl (μg•L^{-1})	12.6	9.2	12
Secchi (m)	3.0	2.4	2.73
TKN (μg•L^{-1})	1259	1174	853
TDN (μg•L^{-1})	-	-	687
NO_{2+3}N (μg•L^{-1})	<5	<3	5
NH_4^+ N (μg•L^{-1})	41	64	45
Ca (mg•L^{-1})	76	-	76
Mg (mg•L^{-1})	49	-	56
Na (mg•L^{-1})	20	-	22
K (mg•L^{-1})	15	-	20
SO_4^{2-} (mg•L^{-1})	346	-	392
Cl^- (mg•L^{-1})	2	-	4
Total Alkalinity (mg•L^{-1} $CaCO_3$)	98	-	77

Water chemistry

Ion concentrations have remained relatively unchanged in Jackfish Lake since data were collected in 1980. Mineral ions such as calcium and sulfate are supplied by weathering in the watershed and from groundwater inflows. The stable ion concentrations suggest Jackfish Lake has remained in equilibrium with its hydrology over the period of data records. Chloride and potassium concentrations may have increased slightly. Increases in these ions are often associated with human impacts, for example household use of bleach can supply chloride through septic systems and lawn fertilizers often contain potassium salts. Jackfish Lake has relatively high SO_4^{2-} concentrations relative to other ions indicating significant contributions from groundwater springs.

Jackfish Lake is mildly eutrophic with what is considered high productivity and algal biomass compared to lakes throughout Canada. In the Alberta context, Jackfish Lake contains about average total phosphorus and chlorophyll concentrations when compared to other lakes. Jackfish may appear to have poor water quality at times, however, it is generally a good recreational lake in the Alberta context. Phosphorus and nitrogen concentrations have declined moderately when compared to 1980 and 1981 (Table 1). Late June and early July must have been dominated by warm, stable conditions as algal growth increased markedly with peak CHL reaching 37 $\mu g \bullet L^{-1}$ (Fig. 3). The large increase in algal biomass resulted in a CHL : TP ratio of 1.7 which was indicative of an algal bloom. In recent Lakewatch studies from Hastings Lake, blooms of this magnitude were usually dominated by a group of algae that produce toxins known as *microcystin*. These toxins are usually short-lived, however, they can cause serious illness during bloom periods. Jackfish Lake residents may want to further investigate the occurrence of microcystin during blooms in their lake and ensure that they or their pets do not drink lakewater during blooms. Despite the large bloom occurring in early July, mean chlorophyll *a* (CHL) concentrations were not different from samples collected in 1980 and 1981.

Jackfish Lake is an example of a typical Alberta lake with minimal impacts. It is productive with eutrophic nutrient and chlorophyll concentrations. Deep basins and weed growth in shallow areas help protect the lake from excessive internal loading and a decline in water quality. The lake is fed by groundwater and therefore seems to be relatively protected from the impacts of the extensive development in its watershed. Continued monitoring of nutrient concentrations in Jackfish Lake are likely not required at this time. However, 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 summer bloom periods.

Eager volunteers collect water at Jackfish Lake. Photo: Susan Cassidy

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.