Lakewatch

THE ALBERTA LAKE MANAGEMENT SOCIETY
VOLUNTEER LAKE MONITORING PROGRAM

2010 Snipe Lake Report

COMPLETED WITH SUPPORT FROM:

Government of Alberta

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 those 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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SNIPE LAKE:

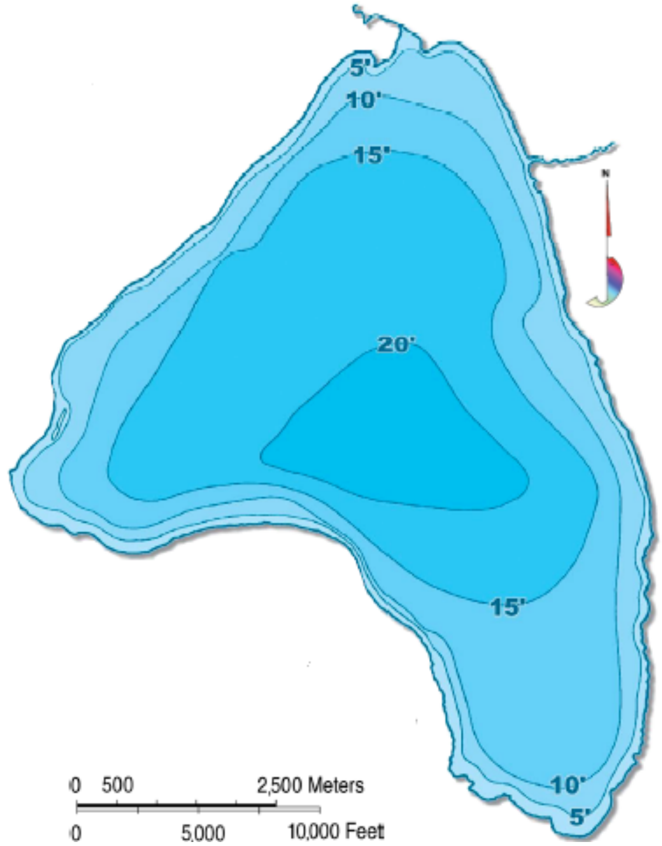

Figure 1 - Bathymetric map of Snipe Lake, AB. Image produced by the Angler's Atlas, base layer data copyright the Province of Alberta.

Snipe Lake is a large (44.5 km^2), shallow (maximum depth 6.1m) lake located 35 km northeast of the town of Valleyview and 65 km southeast of High Prairie (Figure 1). It straddles the boundary between the Municipal Districts of Greenview (west) and Big Lakes (east). It is within the Peace River watershed.

Snipe Lake is a popular year-round fishing location. It supports a variety of fish species including northern pike, walleye, yellow perch, and lake whitefish.

The south shore and west shores abut private land and consequently have more development than the north shore. In addition to agricultural fields there is one commercial resort containing a 9-hole golf course, a 200 -lot campground, seasonal camping locations, and boat launch. The north-west shore has a community campsite and boat launch with the remainder forested.

Snipe Lake is located in the central mixedwood sub-region of the boreal forest natural region. Upland aspen and spruce forests dominate the riparian areas with peatlands occurring in the north portion of the watershed along Snipe Creek. Within its watershed the main land-use activities are currently agriculture and oil and gas exploration.

WATER CLARITY AND SECCHI DEPTH

Water clarity is influenced by suspended materials, both living and dead, as well as dissolved colored compounds in the water column. During the melting of snow and ice in spring, lake water can become turbid (cloudy) from silt transported into the lake. Lake water usually clears in late spring but then becomes more turbid with increased algal growth as the summer progresses. The easiest and most widely used measure of lake water clarity is the Secchi disk depth.

Secchi disc depth at Snipe Lake was measured five times over the course of the summer and was, on average, 1.25 meters (Table 1). A maximum secchi depth of 3.00 m was recorded on June 20th. Higher-than-average secchi disc depths are typical of June, as temperatures are often too low to promote large algal blooms. On July 28th, August 10th, and August 24th, secchi disc depth measured 0.75 m. Finally, on September 30th, secchi disc depth began to increase and was 1.00 m. Algal growth throughout the summer will severely reduce water clarity. Using the average secchi disc depth as an indicator of trophic status, Snipe Lake would be considered eutrophic, or highly productive (though three of the five measurements fell within the hypereutrophic, or extremely productive, classification).

WATER TEMPERATURE AND DISSOLVED OXYGEN:

Water temperature and dissolved oxygen profiles in the water column can provide information on water quality and fish habitat. The depth of the thermocline is important in determining the depth to which dissolved oxygen from the surface can be mixed. Please refer to the end of this report for descriptions of technical terms.

Water temperature at Snipe Lake was measured five times over the course of the summer (Figure 3a). On June 20th, surface water temperature was 19.46 °C and decreased slowly to 17.01 °C at the lakebed. A small, weak thermocline was observed between 3.0 m and 4.0 m. On June 28th, surface water temperature measured 18.85 °C and showed little change throughout the water column, measuring 18.75 °C at the bottom. On August 10th, surface water temperature was 19.19 °C and reached 18.87 °C at the lakebed. On August 24th, surface water temperatures had dropped compared to prior measurements, measuring 16.02 °C at the surface and 15.96 °C at the lakebed. Finally, on September 30th, surface water temperature was at a seasonal minimum of 10.30 °C which decreased to 10.12 °C at the bottom. Because the lake is so large and shallow, wind is able to mix the entire water column thereby preventing stratification.

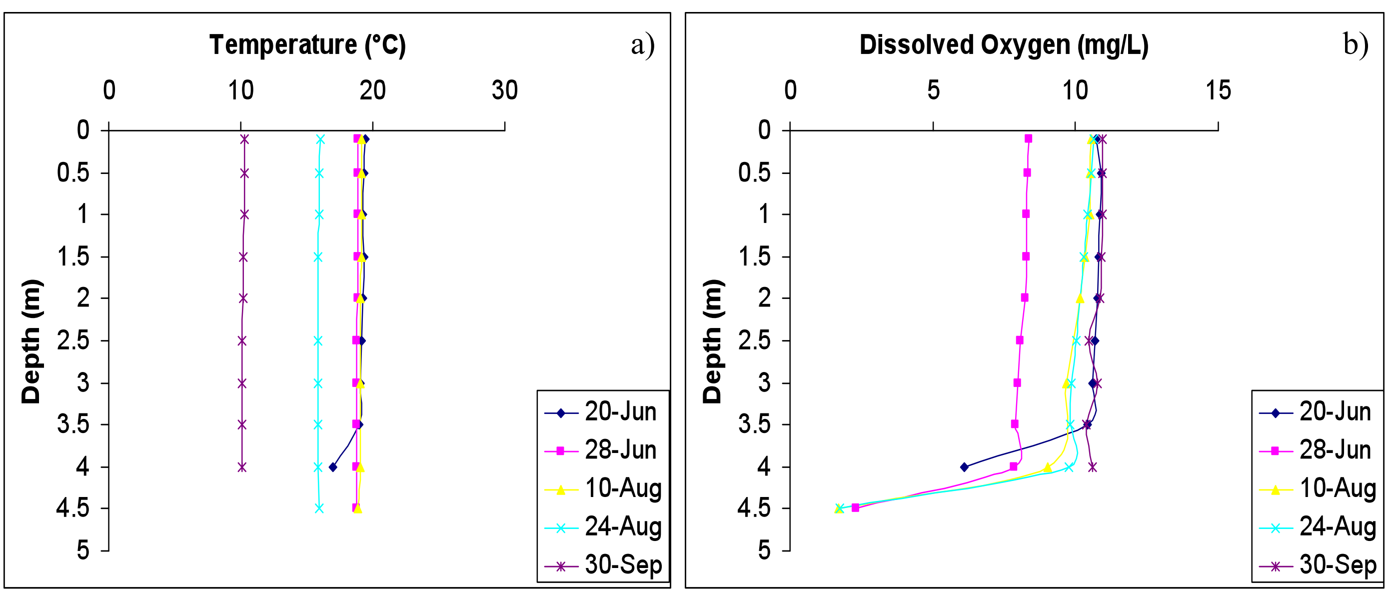

Figure 3 – a) Temperature (°C) and b) dissolved oxygen (mg/L) profiles for Snipe Lake measured during 2010.

Because the lake is constantly mixing (polymictic), dissolved oxygen in Snipe Lake, similar to temperature, remained quite uniform throughout the water column (Figure 3b). On June 20th, dissolved oxygen measured 10.74 mg/L at the surface and only showed a sharp decrease between 3.5 m and 4.0 m, where it dropped from 10.41 mg/L and 6.09 mg/L, respectively. On June 28th, surface dissolved oxygen measured 8.36 mg/L and decreased to 2.32 mg/L at the lakebed. This drop in oxygen levels at the lakebed compared to June may be related to the decomposition of algae, which is an oxygen-consuming process. On August 10th, surface dissolved oxygen measured 10.54 mg/L and decreased to the seasonal minimum of 1.72 mg/L. On August 14th, dissolved oxygen measured 10.63 mg/L at the surface and 1.76 mg/L at the lakebed. Finally, on September 30th, dissolved oxygen once again became uniform, measuring 10.93 mg/L at the surface and 10.61 mg/L at the lakebed. Snipe Lake had dissolved oxygen levels that were adequate for the protection of aquatic life for the majority of its depth (Alberta Standard is >5 mg/L).

WATER CHEMISTRY:

ALMS measures a suite of water chemistry parameters. Phosphorous, nitrogen, and chlorophyll-a are important because they are indicators of eutrophication, or excess nutrients, which can lead to harmful algal/cyanobacteria blooms. One direct measure of harmful cyanobacteria blooms are Microcystins, a common group of toxins produced by cyanobacteria. See Table 1 for a complete list of parameters.

In 2010, average total phosphorous at Snipe Lake was 109.4 μg/L (Table 1); high enough to be considered hypereutrophic. Total phosphorous measurements fluctuated greatly, with a seasonal minimum of 37 μg/L on June 20th and a seasonal maximum of 158 μg/L on August 24th (Figure 4). The Alberta water quality guideline for the Protection of Aquatic Life recommends only 50 μg/L of phosphorous.

Chlorophyll-a levels throughout the summer were strongly correlated to total phosphorous. Chlorophyll-a concentration was a seasonal minimum of 12.5 μg/L on June 20th and a seasonal maximum of 72.0 μg/L on August 24th (Figure 4). Finally, total average nitrogen measured 1.582 mg/L, which fluctuations ranging from 1.06 mg/L on June 20th and 1.88 mg/L on August 24th. Both the chlorophyll-*a* levels and nitrogen levels were high enough to classify the lake as hypereutrophic. The small nitrogen:phosphorous ratio observed at Snipe Lake may select for toxic cyanobacterial species.

Hypereutrophic lakes are the most biologically productive lakes, and can support large amounts of plants, fish and other animals. However, they also have frequent and severe nuisance algal blooms that can significantly reduce oxygen levels at lower depths or contribute to water toxicity through the release of microcystin toxins into the water. There is not enough water quality data to determine if Snipe Lake has changed trophic status through human impacts or if it is naturally hypereutrophic.

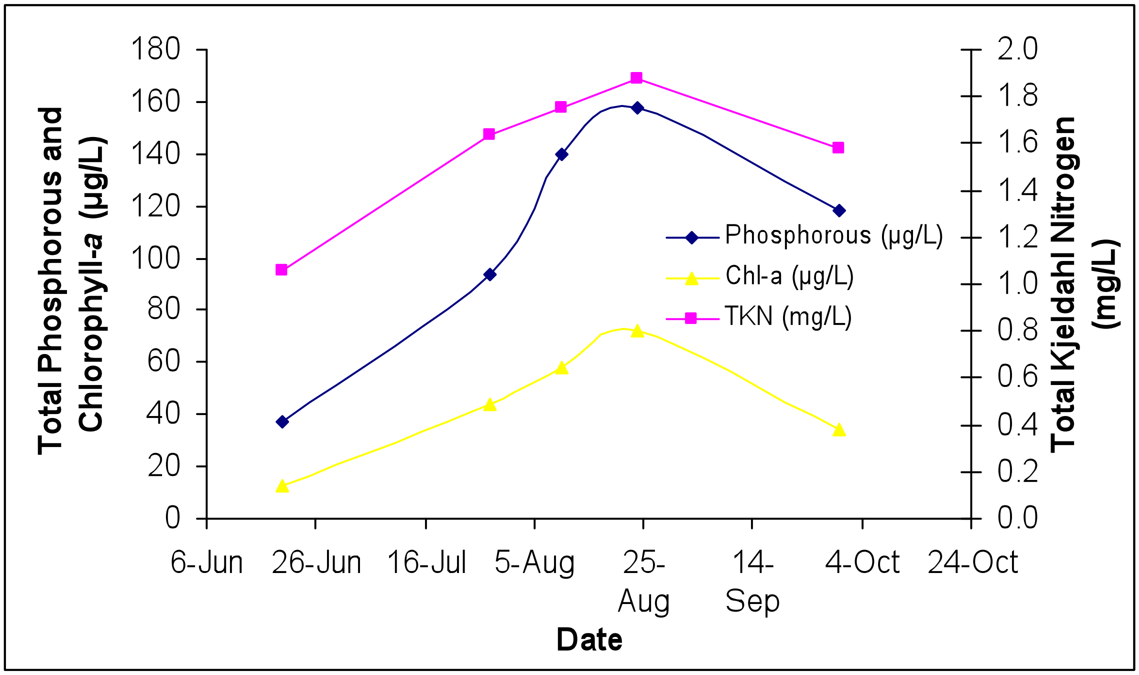

Figure 4 – Chlorophyll-*a* (µg/L), total phosphorous (µg/L), and total Kjeldahl nitrogen (mg/L) measured over the course of the summer in 2010.

In 2010, average pH at Snipe Lake was 8.56 (Table 1) which is slightly above neutral. Alkalinity, which helps to buffer lakes against changes to pH, was moderate in Snipe Lake (79 mg/L $CaCO_3$). Ion concentrations were generally low at Snipe Lake, with calcium (18.2 mg/L) and bicarbonate (88.2 mg/L) being the dominant ions.

Table 1. Average secchi depth and water chemistry values for Snipe Lake measured in 2010.

Parameter	2010
TP (µg/L)	105.4
TDP (µg/L)	24
Chlorophyll-*a* (µg/L)	44.08
Secchi depth (m)	1.25
TKN (µg/L)	1582
NO_2 and NO_3 (µg/L)	5.6
NH_3 (µg/L)	74.2
DOC (mg/L)	12.3
Ca (mg/L)	18.2
Mg (mg/L)	4.11
Na (mg/L)	9.5
K (mg/L)	4.3
SO_4^{2-} (mg/L)	9
Cl^- (mg/L)	3.5
CO_3 (mg/L)	6.5
HCO_3 (mg/L)	88.2
pH	8.56
Conductivity (µS/cm)	180.5
Hardness (mg/L)	62
TDS (mg/L)	96
Microcystin (µg/L)	0.186
Total Alkalinity (mg/L $CaCO_3$)	79

Note: TP = total phosphorous, TDP = total dissolved phosphorous, Chl-*a* = chlorophyll-*a*, TKN = total Kjeldahl nitrogen. NO_{2+3} = nitrate+nitrite, NH_3 = ammonia, Ca = calcium, Mg = magnesium, Na = sodium, K = potassium, SO_4 = sulphate, Cl = chloride, CO_3 = carbonate, HCO_3 = bicarbonate. A forward slash (/) indicates an absence of data.

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:

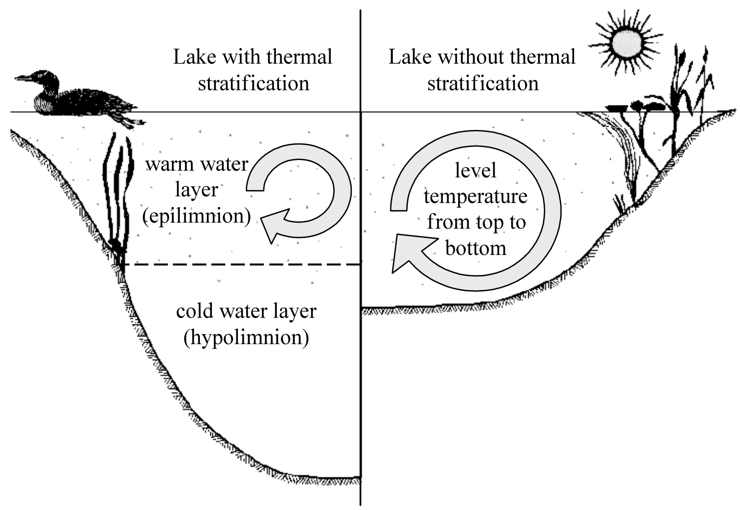

Figure A: Difference in the circulation of the water column depending on thermal stratification.

Water temperature in a lake dictates the behavior of many chemical parameters responsible for water quality. 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 (Table 2)**.

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.

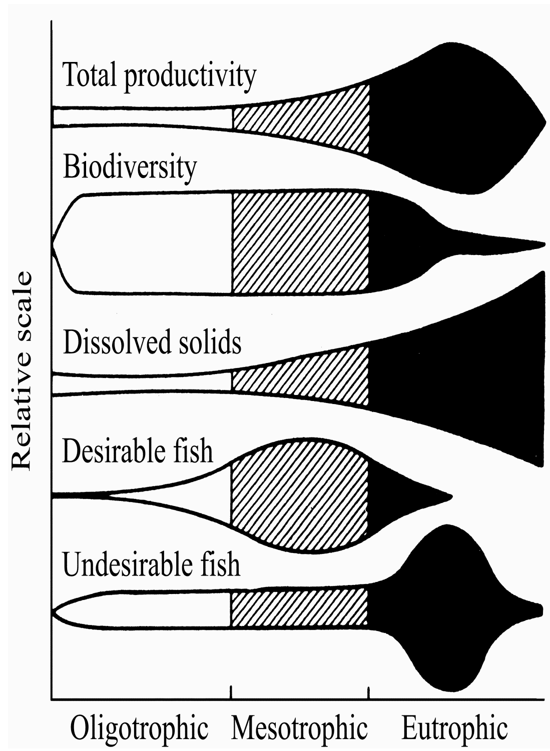

Figure B: Suggested changes in various lake characteristics with eutrophication. From "Ecological Effects of Wastewater", 1980.

Table A - Trophic status classification based on lake water characteristics.

Trophic state	Total Phosphorus ($\mu g \cdot L^{-1}$)	Total Nitrogen ($\mu g \cdot L^{-1}$)	Chlorophyll *a* ($\mu g \cdot L^{-1}$)	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.