Lakewatch

THE ALBERTA LAKE MANAGEMENT SOCIETY
VOLUNTEER LAKE MONITORING PROGRAM

2010 Calling 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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CALLING LAKE:

Calling Lake is located in the Municipal District of Opportunity No. 17, approximately 200 km north of the city of Edmonton. The hamlet of Calling Lake and the St. Jean Baptiste Gambler Indian Reserve No. 183 are located on the lake's eastern shore (Figures 1 & 2). It is within the Athabasca River watershed.

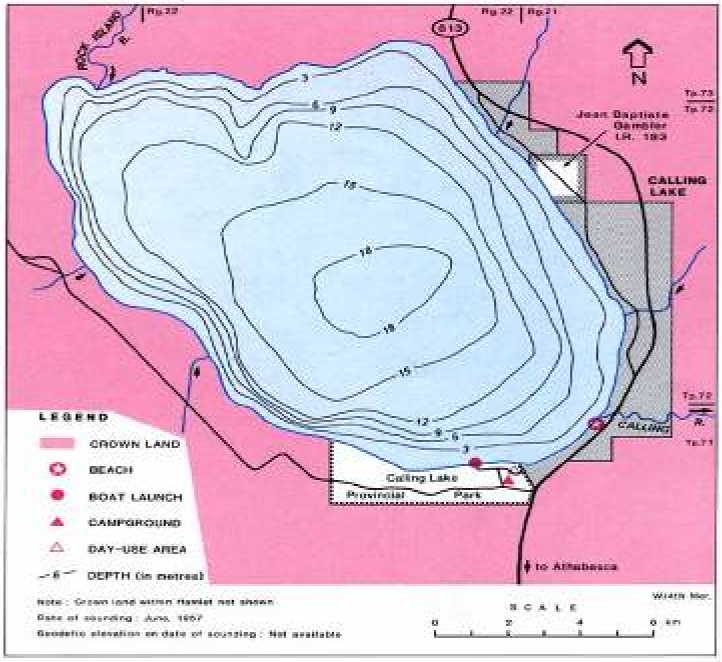

Figure 1 – Bathymetric map of Calling Lake obtained from Mitchell and Prepas 1990.

The lake's name is a translation of the Cree word which refers to the loud noises heard when the lake freezes over. The Calling Lake area has been inhabited for thousands of years; archaeological digs have discovered remnants of a hunter-gatherer band dating as far back as 6000 B.C. (Athabasca Historical Society et al. 1986). In recent history, the area was inhabited by the Woodland Cree and early fur traders who used the lake to catch their winter supply of fish (Finlay and Finlay 1987). Calling Lake Provincial Park was established in 1971 on 741 ha of land on the southern shore of the lake. Today, the park is a popular summer vacation area used for camping, fishing, motor boating, swimming, and canoeing. The main sport fish are northern pike, yellow perch, and walleye, and there is a small commercial fishery for whitefish

Calling Lake has a large drainage basin covering an area of 1,092 km^2, mostly to the north of the lake (Mitchell and Prepas 1990). The main outlet, the Calling River, flows from the southeast end of the lake to the Athabasca River, approximately 25 km downstream. Calling Lake has a surface area of 138 km^2, making it one of Alberta's larger lakes with a maximum depth of 18.3 m in the centre of the basin (Figure 1) (Mitchell and Prepas 1990).

Figure 2 – A reflective surface on Calling Lake. August 9th 2011. Photo: Pauline Pozsonyi.

Calling lake is within the central mixedwood subregion of the boreal forest natural region. A large portion of Calling Lake's drainage basin is covered by wetlands, with the remainder forested with a mixture of aspen, balsam poplar, white spruce, black spruce and jack pine. Only a few small areas southwest of the lake are being farmed. The main human activities in the watershed include forestry and oil and gas exploration and extraction.

WATER LEVELS:

The primary inflow into Calling Lake is the Rock Island River which drains Rock Island Lake to the north. Other smaller streams and run-off also contribute inflow to Calling Lake. In the past 40 years, water levels at Calling Lake have fluctuated at least 0.9 metres above sea level (m asl; Figure 3). In 1974, water levels at Calling Lake were at a historical maximum of 594.4 m asl. Since then, water levels declined until a historical minimum of 593.5 m asl in 2002. After 2002, water levels increased and have fluctuated around 594.2 m asl.

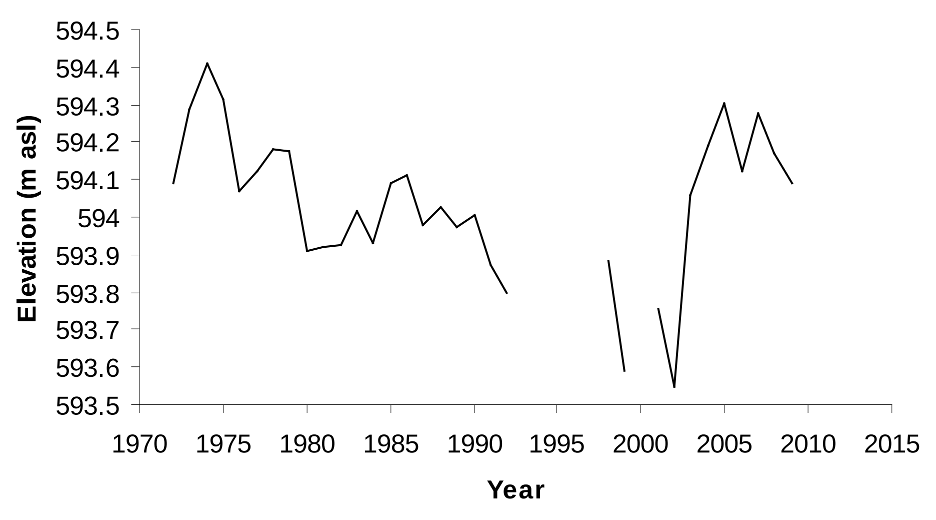

Figure 3 – Water levels at Calling Lake measured in meters above sea level (m asl). Data obtained from Environment Canada.

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 was measured twice at Calling Lake during 2010. Average secchi disc depth was 2.38 m in 2010, shallower than historical records (Table 1). However, because secchi disc depth was measured only twice, it is likely that the average is skewed in comparison to years with more samples. On June 29th, secchi disc depth was 3.00 m, and on August 6th, it had decreased to 1.75 m. It is common for secchi disc depth to be greatest in late spring, when temperature and nutrients are not yet high enough to promote large algal blooms. In August, on the other hand, temperature and nutrients are typically high enough to allow for large algal blooms which decrease water clarity. Visual observations and chlorophyll-*a* concentrations from the August 6th sample support algae as the primary cause of decreased water clarity.

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 was measured twice during the summer of 2010 (Figure 4a). On June 29th, surface water temperature measured 18.55 °C and a thermocline was present between 6.0-9.5 m. At the lakebed, water temperature was 8.37 °C. On August 6th, surface water temperatures had increased to 19.94 °C and decreased steady until a thermocline between 12.5-15.5 m. Final bottom temperature was 13.5 °C. It is likely that the thermocline was present throughout the summer, being pushed deeper throughout July and August as wind energy mixed the upper water column.

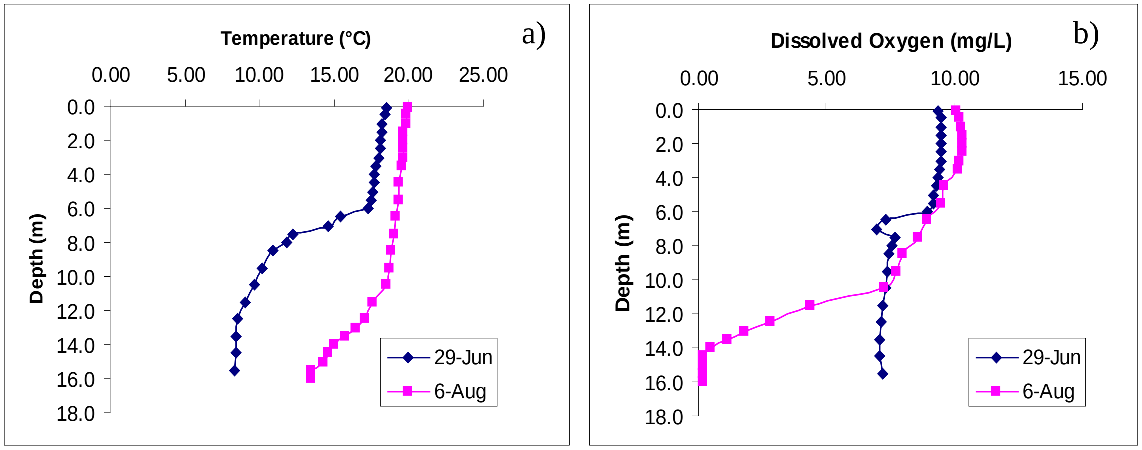

Figure 4 – a) Temperature (°C) and b) dissolved oxygen (mg/L) profiles measured twice during the summer of 2010 at Calling Lake.

Dissolved oxygen was also measured twice during the summer of 2010 (Figure 4b). On June 29th, surface dissolved oxygen was 9.33 mg/L, decreasing to 7.17 mg/L at the lakebed. During this sample trip, the entire water column was above the Canadian Council for Ministers of the Environment (CCME) guideline for the Protection of Aquatic Life of 6.5 mg/L. On August 6th, surface dissolved oxygen was 10.05 mg/L, which decreased steadily to 7.25 mg/L at 10.5 m, after which dissolved oxygen decreased dramatically to anoxia at 13.5 m. Anoxia deeper in the water column, below the thermocline, is common at many lakes throughout the province. As the decomposition of algae (an oxygen-consuming process) occurs on the lakebed, available oxygen is consumed and no new oxygen is introduced to deeper depths because temperature stratification prevents lake water mixing. Despite the anoxia present below 13.5 m, the rest of the water column remained well aerated. Because the lake is so large, the wind gains large amounts of energy moving across the lake, mixing dissolved oxygen into the water column more than smaller lakes of similar depth.

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.

Based on average total phosphorous, chlorophyll-*a*, and total Kjeldahl nitrogen (TKN) concentrations from 2010, Calling Lake is considered eutrophic, or highly productive (Table 1). Average total phosphorous in 2010 was 42.0 μg/L. This is less than in previous years, though fewer samples have likely skewed the average. On June 29th, total phosphorous measured 31 μg/L, and on August 6th, total phosphorous had increased to 53 μg/L. It is common for phosphorous levels to increase throughout the summer as anoxia at the lakebed promotes the release of sediment-bound phosphorous. Similarly, TKN increased throughout the summer from 0.74 mg/L on June 29th to 1.08 mg/L on August 6th. On average, TKN was 0.91 mg/L. This value is well within the measured historical variation, though cross-year comparisons are difficult with only two samples. Finally, chlorophyll-*a* also increased throughout the summer in response to greater nutrients and temperatures. On June 29th, chlorophyll-*a* measured 3.98 μg/L, and by August 6th it had increased 7-times to 29.1 μg/L. On average, chlorophyll-*a* was 16.54 μg/L. This is lower than in previous years, though it is unknown whether this is due to fewer samples or due to a mild-summer in 2010 which did not tend to promote algae blooms of typical size across the province.

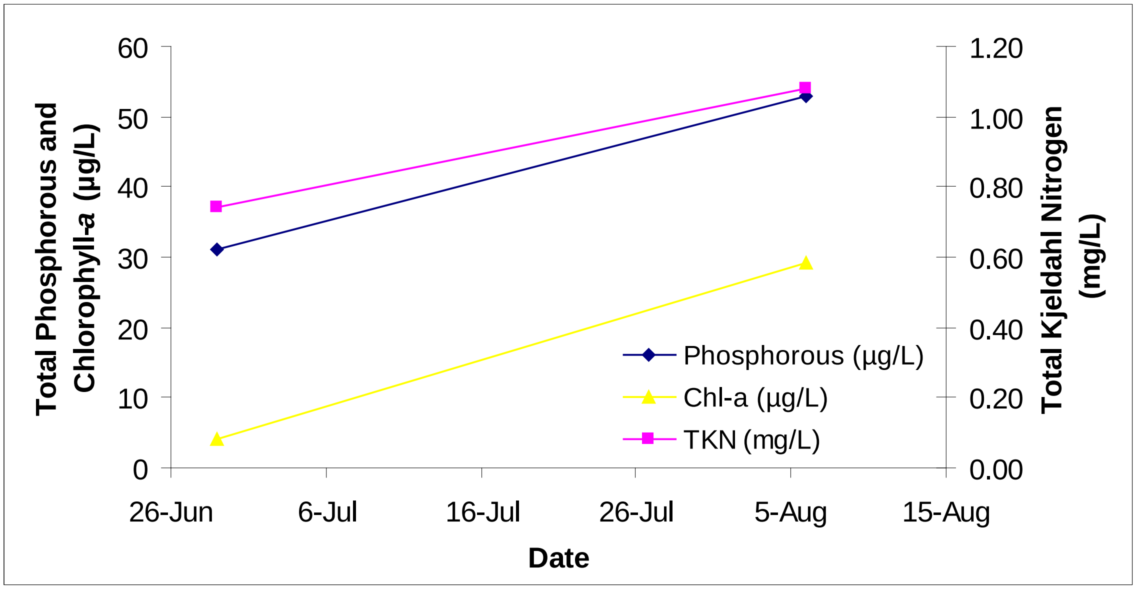

Figure 5 – Total phosphorous (µg/L), chlorophyll-*a* (µg/L), and total Kjeldahl nitrogen (mg/L) measured during the summer of 2010 at Calling Lake.

Average pH measured at Calling Lake in 2010 was 8.2 (Table 1). This is less than recorded in previous years, though more data is required to identify any trends in water chemistry. The pH at Calling Lake is moderately buffered by its alkalinity (91 mg/L $CaCO_3$). Concentrations of other ions are low, with bicarbonate (111 mg/L HCO_3) being the dominant ion present (Table 1).

Table 1 – Average secchi depth and water chemistry values for Calling Lake as measured in 2010. Water quality data from previous years is shown for comparison.

Parameter	**1988**	**2000**	**2001**	**2010**
TP (µg/L)	50.0	55.0	54.0	42.0
TDP (µg/L)	19.00	15.70	18.00	11.00
Chlorophyll-*a* (µg/L)	19.10	20.60	19.00	16.54
Secchi depth (m)	2.70	2.70	2.70	2.38
TKN (µg/L)	777.0	656.0	937.0	910.0
NO_2 and NO_3 (µg/L)	<7	2.2	6.0	4.3
NH_3 (µg/L)	33.0	14.2	31.0	14.0
DOC (mg/L)	/	/	/	10.9
Ca (mg/L)	22.0	22.0	23.0	17.1
Mg (mg/L)	6.0	6.0	6.0	5.6
Na (mg/L)	5.0	5.0	5.0	6.6
K (mg/L)	2.0	2.0	2.0	1.8
SO_4^{2-} (mg/L)	4.0	3.6	4.0	7.0
Cl^- (mg/L)	1.0	0.6	1.0	1.2
CO_3 (mg/L)	/	/	/	/
HCO_3 (mg/L)	/	/	/	111
pH	7.4-8.5	8.6	9.0	8.2
Conductivity (µS/cm)	168.0	173.3	170.0	182.0
Hardness (mg/L)	/	/	/	65.6
TDS (mg/L)	/	/	/	93.9
Microcystin (ug/L)	/	/	/	0.71
Total Alkalinity (mg/L $CaCO_3$)	82	84	85	91

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:

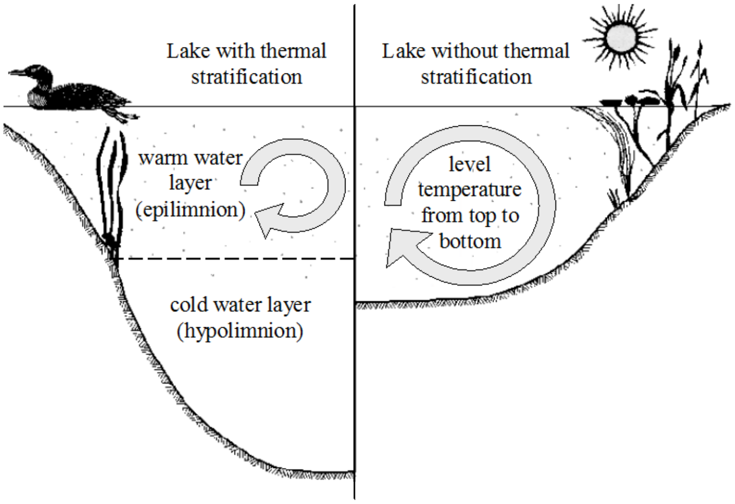

Figure A: Difference in the circulation of the water column depending on thermal stratification.

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.

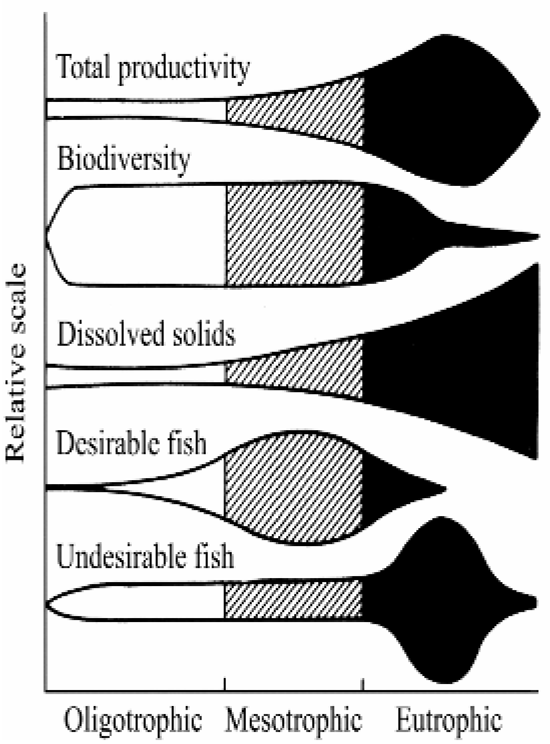

Figure B: Suggested changes in various lake characteristics with eutrophication. From "Ecological Effects of Wastewater", 1980.

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

Trophic state	Total Phosphorus ($\mu g \bullet L^{-1}$)	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.