Lakewatch

THE ALBERTA LAKE MANAGEMENT SOCIETY
VOLUNTEER LAKE MONITORING PROGRAM

2010 Fawcett 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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FAWCETT LAKE:

Figure 1. View of Fawcett Lake. Photo by Brad Peter.

Fawcett Lake is a large lake located 2.5 hours north of Edmonton, near the hamlet of Smith, within the Athabasca Watershed (Figure 1). It has a surface area of 3,415 hectares (8,438 acres) and a mean depth of 5.6 m with a maximum depth of 21.3 m (Figure 2). It has two distinct basins joined by a narrow channel. The north-east basin is consistently shallow and has dense growth of submerged aquatic vegetation. There are two inlets to the lake: Mink River in the east and Fawcett River in the north-east. On the western end of lake there is a dam on the Fawcett River outlet to stabilize lake levels.

Fawcett Lake was named for Sidney Dawson Fawcettt, a Dominion Land Surveyor who surveyed the 19th Baseline in 1912. Fawcett Lake has 54 km of shoreline that remains largely undeveloped. Land on the west end of the lake was cleared in 1939 for a millsite. German prisoners of war worked at this millsite from 1943 to 1945. This area of land is still used today as the campsite for the Provincial Recreation Area. Spread along the southern shore there is a residential subdivision (Broken Paddle Estates) and two commercial resorts. Random camping along the entire shoreline is common.

Although the lake is popular for many water sports such as wind surfing and swimming, its main use is for fishing. The lake supports a healthy sport fishery focusing on walleye, northern pike, lake whitefish, yellow perch, and burbot. Whitefish and tullibee (cisco) are commercially harvested each fall. Non-sport fish include longnose sucker, spottail shiner, and white sucker.

Fawcett Lake is in the central mixedwood subregion of the Boreal Forest natural region. Upland forests within the lake's watershed are composed of aspen, balsam poplar and birch with lowland areas containing black spruce, tamarack and bog birch. Peatlands are common in the north-western portion of the watershed. The main human activities within its watershed are forestry, oil and gas exploration and extraction, and recreation.

Fawcett Lake is known to be a green lake, with algal blooms commonly occurring from June to August each year.

Source: Alberta Forestry Lands and Wildlife. 1990. Fawcett Lake Lakeshore Management Plan. Accessed online, November 2011: http://www.srd.alberta.ca/LandsForests/LandusePlanning/documents/IntegratedResourcePlan-FawcettLake-Lakeshore-1990.pdf

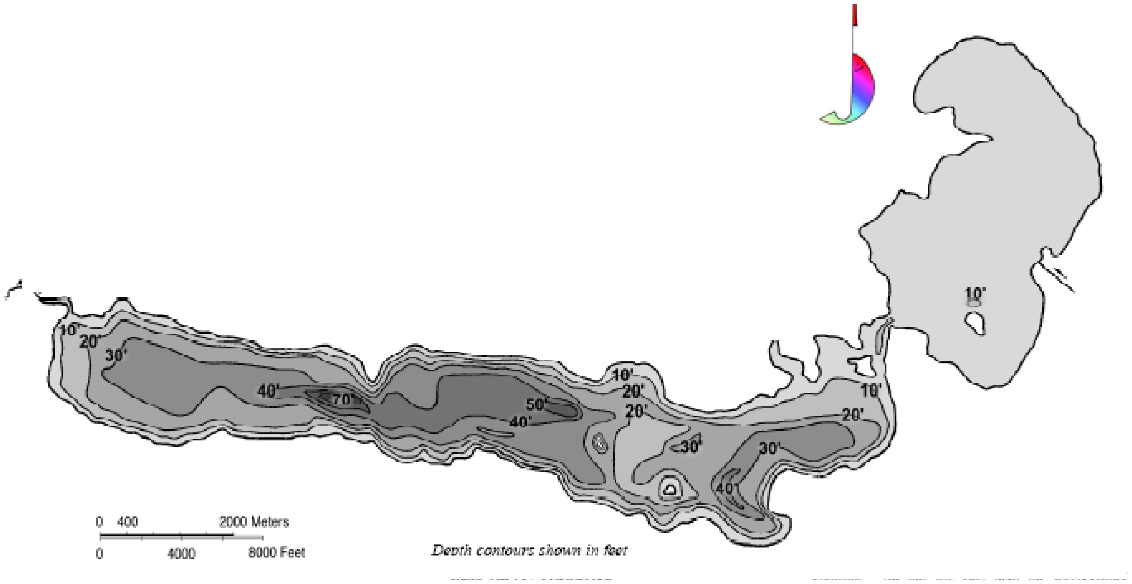


Figure 2. Bathymetric map for Fawcett Lake. Data compiled and distributed by the Anglers Atlas.

WATER LEVELS:

Water levels have shown a decreasing trend since monitoring began in 1974. In 1975, water levels reached a historical maximum of 611.9 meters above sea level (m asl), and in 1999, a historical minimum of 611.3 m asl. In 1997, one of the wettest years on record, water levels experienced a short reprieve, raising back up to 611.7 m asl. In 2010, water levels measured 611.4 m asl, only 0.3 m asl less than the original 1974 measurement.

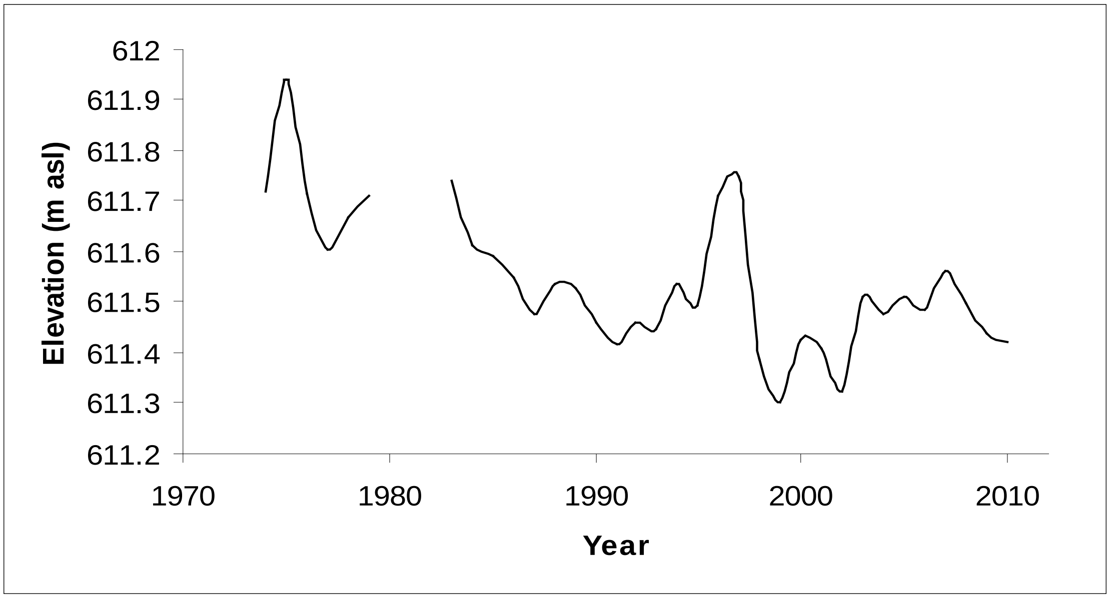


Figure 3 – Water levels at Fawcett Lake in meters above sea level (m asl) from 1974-2010. Data obtained from Environment Canada.

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.

Average secchi disc depth measured during the summer of 2010 was 1.85 m (Table 1). A seasonal maximum of 3.25 m was recorded on June 20th, and a seasonal minimum of 1.25 m was recorded on September 5th. It is typical for secchi disc depth to decrease throughout the summer as increasing temperatures and nutrient levels promote algal growth. Throughout the province, deeper-than-normal secchi disc depths were noted due to the mild summer temperatures in 2010, and it is possible this was also the case for Fawcett Lake. However, more data is required from Fawcett Lake to better interpret these results.

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.

Fawcett Lake did not show strong thermal stratification despite its depth (Figure 3a). Its orientation (east-west) and length (termed the “fetch”) allowed the wind to pick up enough speed and energy to mix the water column more thoroughly than other lakes of similar depth. On June 20th, surface water temperature measured 17.58 °C and weak thermal stratification was present between 6.0-7.0 m (Figure 4a). At the lakebed, temperature was 11.76 °C. On July 18th, surface water temperature was 17.95 °C and, with stratification broken down, decreased steadily to 12.93 °C at the lakebed. On August 1st, surface water temperatures increased to 20.85 °C and decreased to 13.63 °C at the lakebed. On August 15th, the water column was well mixed, with surface water temperature measuring 20.03 °C and temperature at the lakebed measuring 17.05 °C. Finally, on September 5th, surface water temperature had decreased to 15.93 °C, changing very little until the lakebed where temperature was 15.77 °C. It is likely that Fawcett Lake is polymictic, weakly stratifying and mixing multiple times throughout the year. It is also possible that the lake is monomictic, stratifying during the winter time under ice cover.

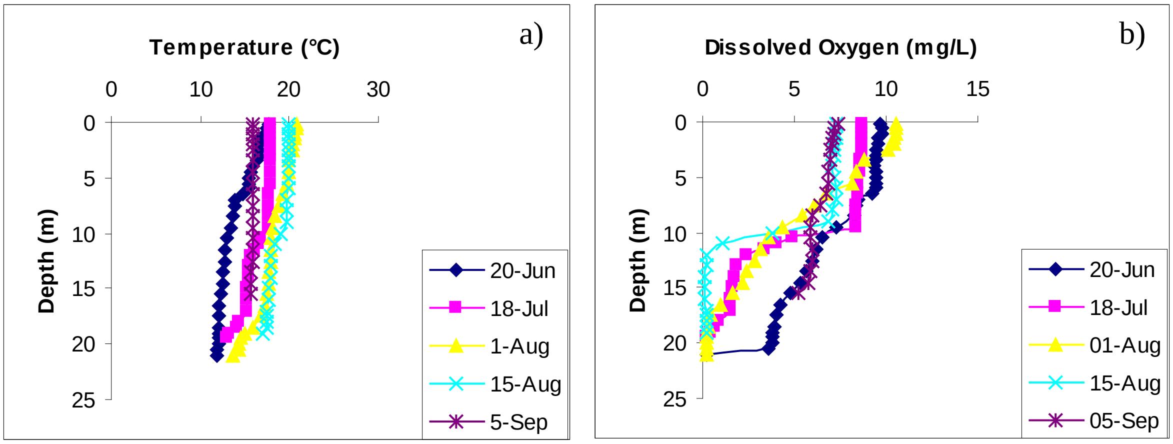


Figure 4 – a) Temperature (°C) and b) dissolved oxygen (mg/L) profiles for Fawcett Lake measured during the summer of 2010.

Despite frequent mixing of the water column at Fawcett Lake, dissolved oxygen still decreased significantly with depth (Figure 4b). On June 20th, surface dissolved oxygen was 9.68 mg/L and decreased to 0.22 mg/L at the lakebed, though much of the water column remained above the Alberta Environment recommendation of 5.0 mg/L. On July 18th, surface dissolved oxygen decreased to 8.73 mg/L, and oxygen dropped dramatically between 9.5-10.5 m from 8.37 mg/L to 4.87 mg/L, respectively. After 11.5 m, oxygen continued to decrease until anoxia at the lakebed. On August 1st, surface dissolved oxygen increased to 10.59 mg/L, and decreased until anoxia began at 16.5 m. On August 15th, surface dissolved oxygen decreased to 7.24 mg/L and anoxia was present much shallower in the water column, beginning at 11.0 m. Finally, on September 5th, dissolved oxygen again became more evenly distributed throughout the water column, measuring 7.35 mg/L at the surface and 5.27 mg/L at the lakebed. Decomposition of algae at the lakebed, an oxygen-consuming process, is one of the primary causes of anoxia near the sediments.

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 measured in 2010 (36.4 μg/L), Fawcett Lake would be considered eutrophic (Table 1). Phosphorous was at a maximum of 39 μg/L on June 20th and a minimum of 29 μg/L on August 1st (Figure 5). Total Kjeldahl nitrogen (TKN) was on average 0.97 mg/L, again a value which falls into the eutrophic classification (Table 1). Nitrogen fluctuated little throughout the summer, measuring a seasonal minimum of 0.79 on June 20th and a seasonal maximum of 1.08 mg/L on August 15th. Finally, average chlorophyll-*a* concentration at Fawcett Lake was 18.47 μg/L, again, a value which falls into the eutrophic classification. Chlorophyll-*a* concentration changed greatly throughout the summer, measuring a seasonal minimum of 5.05 µg/L on June 20th and a seasonal maximum of 26.9 µg/L on August 1st (Figure 5). More data is required to determine any changes in water quality over time.

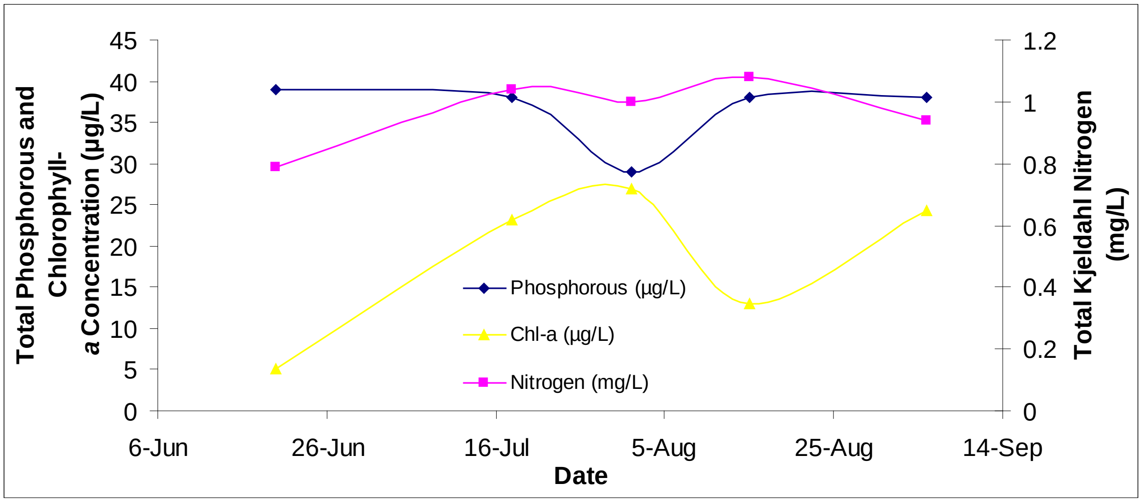


Figure 5 – Total phosphorous (µg/L), chlorophyll-*a* (µg/L), and total Kjeldahl nitrogen (mg/L) measured five times throughout the summer of 2010 at Fawcett Lake.

Average pH measured at Fawcett Lake was 7.84, slightly above neutral (7.00) (Table 1). Moderate alkalinity (70.8 mg/L $CaCO_3$) provides a buffer to changes in pH, though more monitoring is needed to determine any trends in ion concentrations. In general, ion concentration at Fawcett Lake is low, with bicarbonate being the most dominant ion.

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

Parameter	**2010**
TP (µg/L)	36.4
TDP (µg/L)	12.6
Chlorophyll-*a* (µg/L)	18.47
Secchi depth (m)	1.85
TKN (µg/L)	970
NO_2 and NO_3 (µg/L)	7.5
NH_3 (µg/L)	56.2
DOC (mg/L)	15.17
Ca (mg/L)	16
Mg (mg/L)	4.83
Na (mg/L)	4.6
K (mg/L)	1.57
SO_4^{2-} (mg/L)	4.5
Cl^- (mg/L)	0.77
CO_3 (mg/L)	0.5
HCO_3 (mg/L)	86.3
pH	7.84
Conductivity (µS/cm)	142
Hardness (mg/L)	60
TDS (mg/L)	74.5
Microcystin (µg/L)	0.12
Total Alkalinity (mg/L $CaCO_3$)	70.8

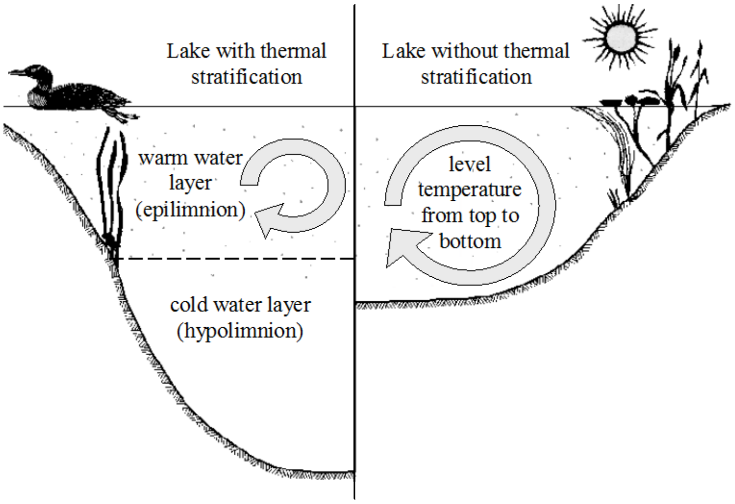
Note: TP = total phosphorous, TDP = total dissolved phosphorous, Chl-*a* = chlorophyll-*a*, TKN = total Kjeldahl nitrogen. NO_{2+3} = nitrate+nitrite, NH_3 = ammonia, Ca = calcium, Mg = magnesium, Na = sodium, K = potassium, SO_4 = sulphate, Cl = chloride, CO_3 = carbonate, HCO_3 = bicarbonate. A forward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



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.

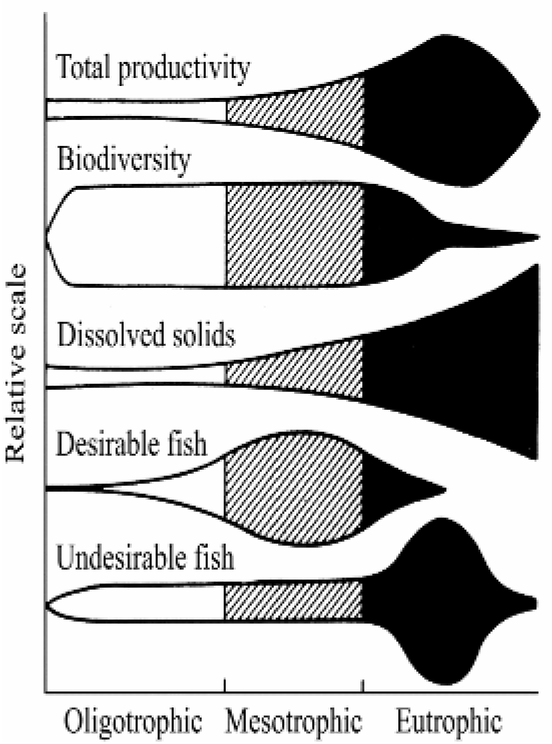


Figure B: Suggested changes in various lake characteristics with eutrophication. From “Ecological Effects of Wastewater”, 1980.

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.