Lakewatch

THE ALBERTA LAKE MANAGEMENT SOCIETY
VOLUNTEER LAKE MONITORING PROGRAM

2010 Stoney Lake Report

COMPLETED WITH SUPPORT FROM:

Beaver River Watershed Alliance
Government of Alberta
LICA
Lakeland Industry & Community Association

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

The Lakewatch program is made possible through the dedication of its volunteers and Lakewatch Chairs, Al Sosiak and Ron Zurawell. We would like to thank George Roberts for his efforts in collecting data in 2010. We would also like to thank Bradley Peter and Emily Port who were summer interns with ALMS in 2010. 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 training aspects of the program. Doreen LeClair and Chris Rickard were responsible for data management. Jill Anderson (Program Manager) was responsible for program administration and planning. Théo Charette, Ron Zurawell, Lori Neufeld, and Sarah Lord prepared the original report, which was updated for 2010 by Bradley Peter and Arin Dyer. Alberta Environment, the Beaver River Watershed Alliance (BRWA), and the Municipal District of Wainwright were major sponsors of the Lakewatch program.

STONEY LAKE:

Figure 1 – Satellite photo of Stoney Lake retrieved from Google Maps, 2011.

Stoney (Siler) Lake is located 13 km west of Elk Point on Highway 646 (Township Road 565; Figure 1). Stoney Lake has a surface area of 2.34 km^2 and drains an area of 138.76 km^2. It is in the Lakeland region of Alberta, within the North Saskatchewan River watershed.

The lake is popular spot for recreation. A county operated campground and recreational area is situated on the eastern shore and has various facilities. Sport fish include pike and yellow perch.

Stoney Lake is within the central mixedwood sub-region of the boreal forest natural region. The land-base surrounding the lake is zoned as agricultural by the County of St. Paul and multi-lot residential areas are excluded (CSP Municipal Development Plan 2007).

WATER LEVELS:

Water levels in Stoney Lake have not been monitored; however, water levels in nearby Lac Bellevue were monitored from 1969-2002. Peak water level in Lac Bellevue occurred in 1964 and since then has steadily declined. If water level change is due to either changes in precipitation or to human water usage, it is possible that Stoney Lake experiences similar pressures.

Figure 2 – Stoney Lake and some of its surrounding land.

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 Stoney Lake was measured twice during the summer of 2010 and was an average of 3.63 m (Table 1). This average is much greater than the average of 2.32 m recorded from 2007-2009. Because only two samples were collected from early in the summer, the results for 2010 may be not be as accurate as years when five samples were taken. Secchi disc depth on June 19th measured 5.00 m and 2.25 m on July 16th. The sharp decrease in secchi disc depth from June to July is typical of many lakes in Alberta, as algal growth throughout the summer greatly decreases 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 3a). On June 19th, surface water temperature measured 16.51 °C, and then decreased steadily to 12.59 °C at the lakebed. No thermal stratification was present on June 19th. On July 16th, however, surface water temperature had increased to 19.56 °C and weak thermal stratification was present between 6.5-7.5 m. At the lakebed, water temperature measured 15.34 °C. Previous reports have found Stoney Lake to be polymictic, mixing and stratifying multiple times throughout the summer.

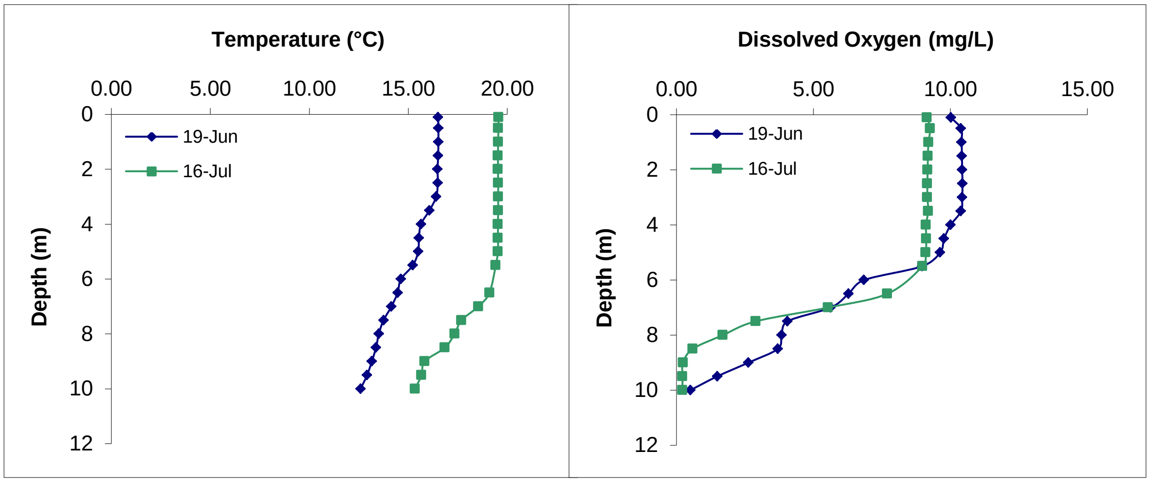

Figure 3 – a) Water temperature (°C) and b) dissolved oxygen (mg/L) profiles measured twice during the summer of 2010.

Dissolved oxygen at Stoney Lake changed little between June and July. On June 19th, surface dissolved oxygen measured 10.02 mg/L, decreasing sharply around 6.0 m until anoxia at the lakebed. On July 16th, surface dissolved oxygen measured 9.15 mg/L and also showed a sharp decrease around 6.0 m until anoxia at the lakebed. The Canadian Council for Ministers of the Environment Protection of Aquatic Life guidelines for dissolved oxygen are 6.5 mg/L, suggesting that only about half of the water column at

Stoney Lake was well aerated. One primary cause of oxygen depletion in lower depths is the decomposition of algae at the lakebed, which is an oxygen-consuming process.

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, Stoney Lake would be considered eutrophic, or highly productive (Table 1). On June 19th, total phosphorous measured 49 µg/L, and on July 16th total phosphorous measured 74 µg/L (Figure 4). Total Kjeldahl nitrogen (TKN) behaved similarly throughout the summer, measuring 1.65 mg/L on June 19th and 1.96 mg/L on July 16th. On average, TKN was 1.81 mg/L which falls into the hypereutrophic classification. Finally, chlorophyll-*a* concentration also increased throughout the summer, measuring 2.45 µg/L on June 19th and 9.61 µg/L on July 16th. On average, chlorophyll-*a* concentration was 6.03 µg/L. All of the above parameters were less than their historical averages, likely due to a lack of samples from 2010.

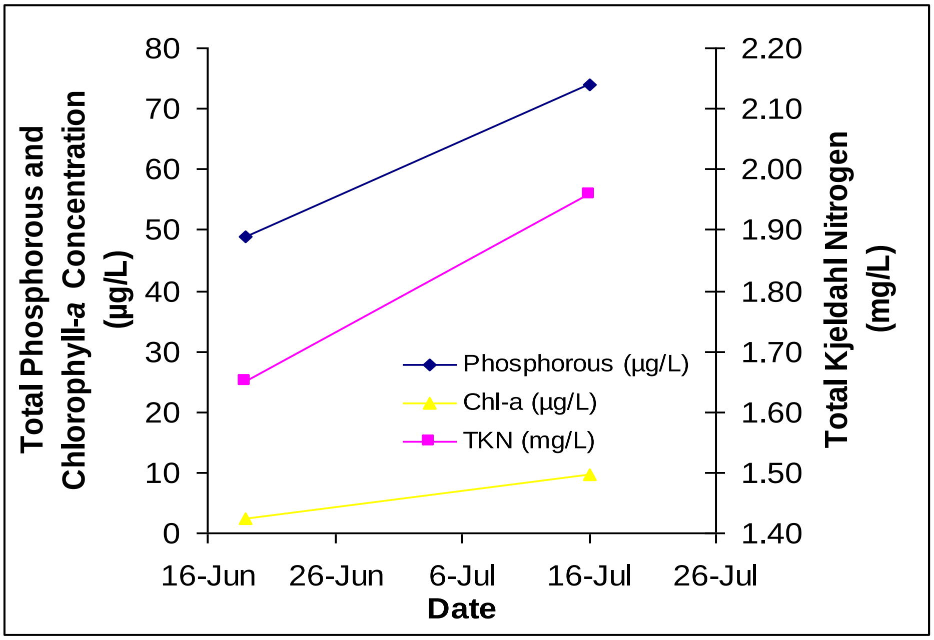

Figure 4 – Total phosphorous (µg/L), total Kjeldahl nitrogen (mg/L), and chlorophyll-*a* concentration measured during the summer of 2010 at Stoney Lake.

Average pH measured in 2010 was 8.55, well above neutral (7.00; Table 1). High alkalinity (328 mg/L $CaCO_3$) helps to buffer the lake against changes to pH. Dominant ions include magnesium, sodium, sulphate, and bicarbonate. More data is required from

Stoney Lake to determine if there are any trends in ion concentrations. Metals were also measured once at Stoney Lake, and all metals fell below their respective guidelines.

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

Parameter	**2007**	**2008**	**2009**	**2010**
TP (μg/L)	109.6	71	66.5	61.5
TDP (μg/L)	57.4	24.6	29.3	31.5
Chlorophyll-*a* (μg/L)	33.3	29.9	17.6	6.03
Secchi depth (m)	1.98	3.1	1.88	3.625
TKN (μg/L)	1970	2130	2060	1805
NO_2 and NO_3 (μg/L)	<5	25	12	38
NH_3 (μg/L)	149.2	104	221	70
DOC (mg/L)	20.6	21.2	19.5	16.5
Ca (mg/L)	27.3	30	28.6	20.6
Mg (mg/L)	41.2	40.7	40.2	44.6
Na (mg/L)	78.7	82.7	86.5	91
K (mg/L)	15.9	15.5	16.7	16.8
SO_4^{2-} (mg/L)	75.3	80.3	91	100
Cl^- (mg/L)	12.2	12.7	13.6	14.5
CO_3 (mg/L)	30	14.7	17.7	11
HCO_3 (mg/L)	322.7	369.7	363.7	377
pH	8.9	8.54	8.65	8.55
Conductivity (μS/cm)	718	763.7	773.3	786
Hardness (mg/L)	237.6	242.3	237	235
TDS (mg/L)	439.7	459.3	473.7	484
Microcystin (μg/L)	1.94	0.21	0.25	0.27
Total Alkalinity (mg/L $CaCO_3$)	315	328	328	328

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.

Table 2 - Concentrations of metals measured in Stoney Lake July 19th, 2010. The CCME heavy metal Guidelines for the Protection of Freshwater Aquatic Life (unless otherwise indicated) are presented for reference.

Metals (Total Recoverable)	**2007**	**2008**	**2009**	**2010**	**Guidelines**
Aluminum µg/L	17.5	9.42	14.7	26.04	100
Antimony µg/L	0.05	0.0586	0.0512	0.03635	6
Arsenic µg/L	4.5	5.09	4.96	0.8565	5
Barium µg/L	48.8	53.15	49.5	48.95	1000
Beryllium µg/L	<0.003	<0.003	<0.003	0.00585	100
Bismuth µg/L	0.06	0.0019	0.0034	0.00195	/
Boron µg/L	169.5	191	182	122.5	5000
Cadmium µg/L	0.004	0.0071	0.0033	0.0057	0.085
Chromium µg/L	0.47	0.26	0.29	0.242	/
Cobalt µg/L	0.06	0.0541	0.0377	0.01845	1000
Copper µg/L	0.46	0.544	0.382	0.1633	4
Iron µg/L	30.2	5.16	2.64	7.73	300
Lead µg/L	0.06	0.0292	0.0228	0.0151	7
Lithium µg/L	50.1	56.65	60.4	31.7	2500
Manganese µg/L	27.4	17.5	20.1	35.4	200
Molybdenum µg/L	0.69	1.012	0.945	0.0627	73
Nickel µg/L	0.23	0.117	0.0107	0.0025	150
Selenium µg/L	0.31	0.229	0.148	0.05	1
Silver µg/L	0.01	0.0023	0.0052	0.0013	0.1
Strontium µg/L	331.5	353	344	176	/
Thallium µg/L	<0.0007	0.00075	0.0009	0.000725	0.8
Thorium µg/L	<0.004	0.0035	0.0035	0.008025	/
Tin µg/L	<0.044	<0.03	<0.03	0.015	/
Titanium µg/L	1.41	0.995	1.05	0.336	/
Uranium µg/L	0.44	0.597	0.498	0.1965	100
Vanadium µg/L	0.4	0.353	0.33	0.214	100
Zinc µg/L	1.94	1.78	0.924	0.3085	30

Values represent means of total recoverable metal concentrations.

[a] Based on pH $\geq$ 6.5; calcium ion concentrations [Ca^{+2}] $\geq$ 4 mg/L; and dissolved organic carbon concentration [DOC] $\geq$ 2 mg/L.

[b] Based on water Hardness of 300 mg/L (as $CaCO_3$)

[c] Based on water hardness > 180mg/L (as $CaCO_3$)

[d] CCME interim value.

[e] Based on Canadian Drinking Water Quality guideline values.

[f] Based on CCME Guidelines for Agricultural use (Livestock Watering).

[g] Based on CCME Guidelines for Agricultural Use (Irrigation).

A forward slash (/) indicates an absence of data or guidelines.

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:

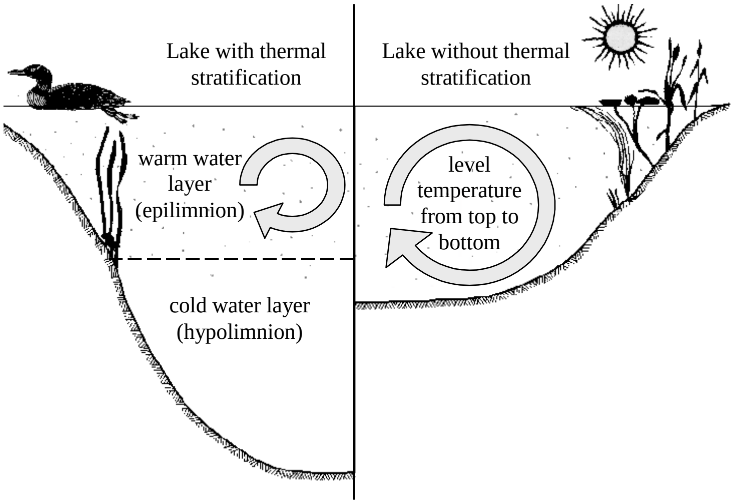

Figure A: Difference in the circulation of the water column depending on thermal stratification.

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 $\text{mg}\bullet\text{L}^{-1}$ and should not average less than 6.5 $\text{mg}\bullet\text{L}^{-1}$ over a seven-day period. However, the guidelines also require that dissolved oxygen concentrations remain above 9.5 $\text{mg}\bullet\text{L}^{-1}$ 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.

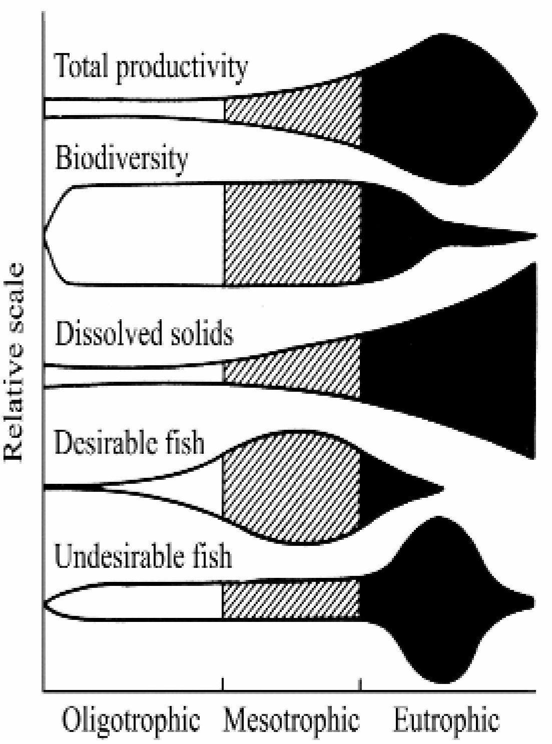

Figure B: Suggested changes in various lake characteristics with eutrophication. From "Ecological Effects of Wastewater", 1980.

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.