The Alberta Lake Management Society Volunteer Lake monitoring report

Stoney (Siler) Lake

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2008 Report

Completed with support from:

LICA Lakeland Industry & Community Association

Alberta Environment

Beaver River Watershed Alliance

Alberta Lake Management Society

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> *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*

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 these 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, Théo Charette and Ron Zurawell. We would like to thank George Roberts and Perry for their efforts in collecting data in 2008. We would also like to thank Lisa Brodziak and Sophie Damlencour who were summer interns with ALMS in 2008. 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 logistics planning and training aspects of the program. Doreen LeClair and Chris Rickard were responsible for data management. Théo Charette (ALMS President) and Jill Anderson (Program Manager) were responsible for program administration and planning. Théo Charette, Ron Zurawell (Limnologist, AENV), and Lori Neufeld prepared the original report, which was updated by Sarah Lord for 2008. Alberta Environment and the Beaver River Watershed Alliance (BRWA) were major sponsors of the Lakewatch program.

Stoney Lake

Figure 1. Stoney (Siler) Lake, Alberta. From Google Earth 2007.

Stoney (Siler) Lake is located 13 km west of Elk Point on Hwy 646 (Township Road 565) (**Figure 1**). Stoney Lake has a surface area of 2.34 km^2 (determined using ArcHydro, M. Raven, personal communication, 2008) and drains an area = 138.76 km^2 (M. Raven, 2008). The lake is situated in the Boreal forest region, although the lake is also within the Agricultural Use Area of the County of St. Paul Municipal Development Plan (CSP 2007).

The lake has recreational and camping facilities nearby. Sport fish include pike (*Esox lucius*) and perch (*Perca flavescens*).

Results

Water Levels

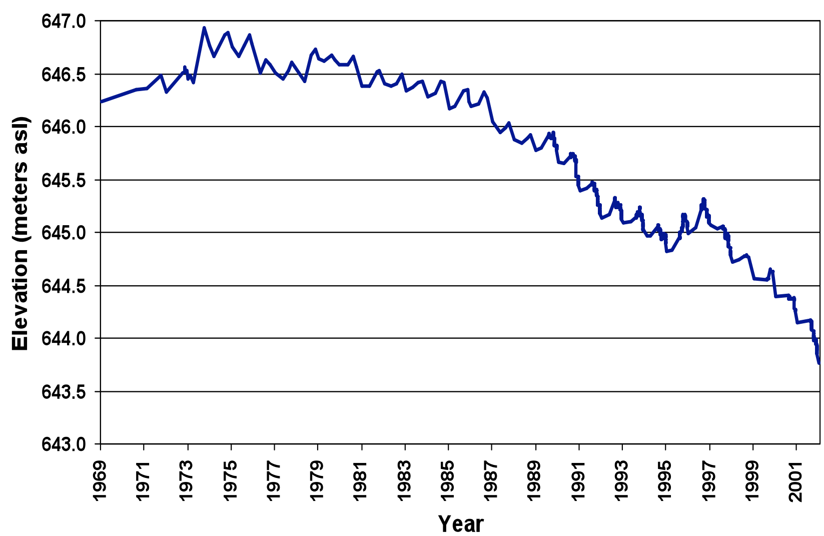

Figure 2. Lake water elevation (meters above sea level (asl)) in Lac Bellevue, Alberta, 1969-2002.

Water levels in Stoney Lake were not available. However, water levels in nearby Lac Bellevue have been monitored since 1969, although new data were not available for 2008. Peak water level occurred in July 1974 (646.9 meters above sea level (asl)). Water level elevation has steadily declined since 1974 (**Figure 3**). The lowest water level was recorded in October 2002 (elevation = 643.7 m asl). Changes in lake water levels may be an important concern for Lac Bellevue. If water level decline is due to either changes in precipitation or to agricultural activities, it is possible that Stoney Lake experiences similar pressures. Water levels should be monitored in Stoney Lake in order to determine trends in water levels as well as to identify land use activities that may potentially alter Stoney Lake water levels.

Water Temperature and Dissolved Oxygen

Water temperature and dissolved oxygen profiles in the water column can provide information on water quality and fish habitat. Please refer to the end of this report for descriptions of technical terms.

Stoney Lake mixes intermittently throughout the summer (e.g. polymictic), as is evidenced by the lack of strong thermal stratification through the open water season (**Figure 3**). In early June, surface water temperature was 15.7° C and declined gradually to 12.6° C at the lake bed. By 26 June surface waters had warmed to 19.1° C and declined to 16.2° C at the lake bed. In mid-July, surface waters were 20.8° C and a weak thermocline was evident at 2 m depth. The lake mixed prior to the 22 August sampling date, on which no thermocline was evident; water temperature was 19.6° C at the surface and less than two degrees cooler at the lake bed. In September, surface waters cooled to 15.1° C and the lake was completely isothermic.

Dissolved oxygen (DO) concentrations in upper layers of surface waters of Stoney Lake were ≥ 6 mg/L on all sampling dates through the summer, well within the acceptable range for surface water quality (DO ≥ 5.0 mg/L) (**Figure 3**). In early June, surface waters were well-oxygenated but dissolved oxygen (DO) concentration gradually declined to near zero (e.g. anoxic) with depth. By early July the chemocline had increased in intensity, but on 22 August the DO profile was similar to that in late June, with an anoxic region from 8.5 m depth down to the lake bed. By 17 September the DO concentrations were equal at all depths, suggesting the lake had mixed completely prior to sampling. Deep water anoxia is common in summer, as bacteria in lake sediments decompose organic matter (because decomposition consumes oxygen).

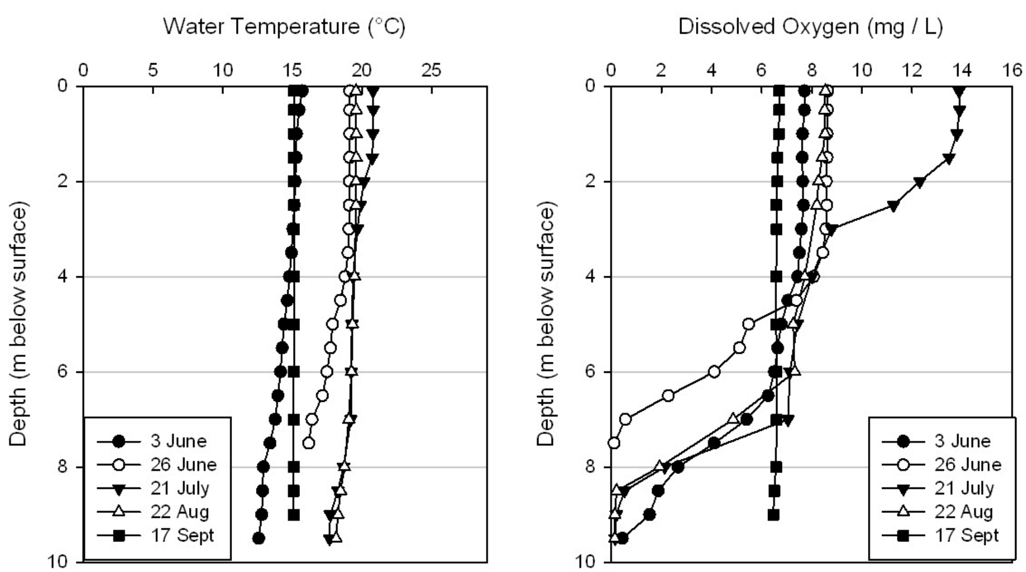

Figure 3. Water temperature (°C) and dissolved oxygen (mg/L) profiles for Stoney Lake during the summer of 2008.

Water Clarity and Secchi Depth

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

Compared to other shallow lakes, Stoney Lake appears relatively clear, with an average Secchi depth = 3.1 meters. During the summer of 2008, light penetrated to an average 31% of the total lake depth (**Table 1**), thus algae were able to grow through nearly two thirds of the water column. Water clarity was highest on 3 June, with a Secchi disk depth of 6.75 m, and then declined over the summer to a minimum of 1.0 m on 21 July and 22 August. The water clarity pattern is correlated with algal biomass (**Figure 4**). The pattern of water clarity is common for polymictic lakes, which re-suspend particles in the water column during mixing events.

Water Chemistry

Based on lake water characteristics, Stoney Lake is classified as hypereutrophic (see *A Brief Introduction to Limnology* at end of this report). Concentrations of total phosphorus (average TP = 71 μg/L) fell in the eutrophic range, while total Kjeldahl nitrogen (average TN = 2.13 mg/L) and algal biomass (average chorophyll *a* concentration = 29.9 μg/L) fell within the hypereutrophic range (**Figure 4**).

Total nitrogen concentration in early June was six times higher than the hypereutrophic threshold value (**Figure 4**). Extremely high nitrogen concentrations remained in late June, and then declined to only 15% of their initial value in July, August, and September. Total phosphorous concentrations followed a more typical pattern, reaching a maximum in late June as runoff from snowmelt delivered nutrients to the lake, and then declining over the remainder of the summer as algal growth consumed nutrients. The increase in nutrient concentrations in early summer may be influenced by surrounding land-use activities, such as agriculture and recreation.

Algae populations in Stoney Lake reached a maximum in July (chlorophyll *a* concentration = 56.6 μg/L) and remained high, but variable, for the remainder of the summer. Algal growth may have been inhibited by sediment re-suspension during mixing in June, but the 35-fold increase in chlorophyll *a* concentration between June and July corresponded with increased phosphorous loading into the lake. This suggests that algal growth in Stoney Lake is limited by phosphorous concentrations rather than nitrogen.

Stoney Lake is well-buffered from acidification. In 2008, lake pH = 8.5 is well above that of pure water (i.e., pH 7). Dominant ions are bicarbonate, sodium, sulphate, and magnesium (**Table 1**). As no historical data were available for Stoney Lake, it is difficult to detect changes in water chemistry.

The average concentrations of heavy metals (as total recoverable concentrations) in Stoney Lake were below CCME guidelines for the Protection of Freshwater Aquatic Life (**Appendix 1**).

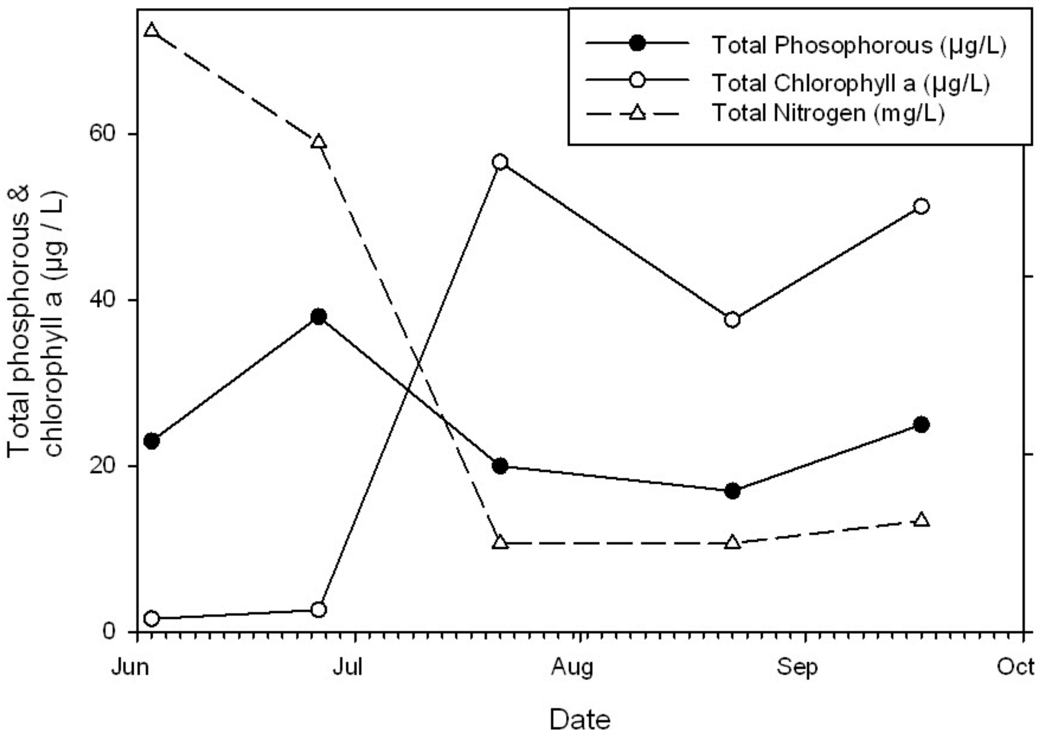

Figure 4. Total phosphorous, chlorophyll a (a measure of algal biomass), and total nitrogen concentrations for Stoney Lake during the summer of 2008.

Table 1. Mean water chemistry in Stoney (Siler) Lake, Alberta summer 2007 - 2008.

Parameter	2007	2008
TP (µg/L)	109.6	71.0
TDP (µg/L)	57.4	24.6
Chlorophyll *a* (µg/L)	33.3	29.9
Secchi disk depth (m)	1.98	3.1
TN (mg/L)	1.97	2.13
NO_{2+3} (µg/L)	<0.005	0.025
NH_4 (µg/L)	149.2	104
Dissolved organic C (mg/L)	20.6	21.2
Ca (mg/L)	27.3	30.0
Mg (mg/L)	41.2	40.7
Na (mg/L)	78.7	82.7
K (mg/L)	15.9	15.5
SO_4 (mg/L)	75.3	80.3
Cl (mg/L)	12.2	12.7
CO_3 (mg/L)	30	14.7
HCO_3 (mg/L)	322.7	369.7
Total Alkalinity (mg/L $CaCO_3$)	315	328
pH	8.9	8.54
Conductivity (µS/cm)	718	763.7
Total dissolved solids (mg/L)	439.7	459.3

Note: TP = total phosphorus, TDP = total dissolved phosphorus, Chla = chlorophyll *a*, TN= total Kjeldahl nitrogen, NO_{2+3} = nitrate+nitrite, NH_4 = ammonium, Ca = calcium, Mg = magnesium, Na = sodium, K = potassium, SO_4 = sulphate, Cl = chloride, CO_3 = carbonate, HCO_3 = bicarbonate.

*From *Atlas of Alberta Lakes* (Mitchell and Prepas, 1990).

References

CSP (County of St. Paul). 2007. http://www.county.stpaul.ab.ca/munidevplan.pdf

Mitchell, P. and E. Prepas, eds. 1990. *Atlas of Alberta Lakes*. University of Alberta Press.

Appendix 1

Mean concentrations of metals, Stoney (Siler) Lake, Alberta 2007 – 2008, compared to CCME Guidelines for the Protection of Freshwater Aquatic Life (unless otherwise indicated). Iron was also measured in 1988-1990.

Metals (total)	1988	1989	1990	2007	2008	Guidelines
ALUMINUM µg/L	-	-	-	17.5	9.42	100[a]
ANTIMONY µg/L	-	-	-	0.05	0.0586	6[e]
ARSENIC µg/L	-	-	-	4.5	5.09	5
BARIUM µg/L	-	-	-	48.8	53.15	1000[e]
BERYLLIUM µg/L	-	-	-	<0.003	<0.003	100[d,f]
BISMUTH µg/L	-	-	-	0.06	0.0019	
BORON µg/L	-	-	-	169.5	191.0	5000[e,f]
CADMIUM µg/L	-	-	-	0.004	0.0071	0.085[b]
CHROMIUM µg/L	-	-	-	0.47	0.26	
COBALT µg/L	-	-	-	0.06	0.0541	1000[f]
COPPER µg/L	-	-	-	0.46	0.544	4[c]
IRON µg/L	<20*	<10*	<10	30.2	5.16	300
LEAD µg/L	-	-	-	0.06	0.0292	7[c]
LITHIUM µg/L	-	-	-	50.1	56.65	2500[g]
MANGANESE µg/L	-	-	-	27.4	17.5	200[g]
MOLYBDENUM µg/L	-	-	-	0.69	1.012	73[d]
NICKEL µg/L	-	-	-	0.23	0.117	150[c]
SELENIUM µg/L	-	-	-	0.31	0.229	1
SILVER µg/L	-	-	-	0.01	0.0023	
STRONTIUM µg/L	-	-	-	331.5	353	
THALLIUM µg/L	-	-	-	<0.0007	0.00075	0.8
THORIUM µg/L	-	-	-	<0.004	0.0035	
TIN µg/L	-	-	-	<0.044	<0.03	
TITANIUM µg/L	-	-	-	1.41	0.995	
URANIUM µg/L	-	-	-	0.44	0.597	100[e]
VANADIUM µg/L	-	-	-	0.40	0.353	100[f,g]
ZINC µg/L	-	-	-	1.94	1.78	30
FLUORIDE mg/L	-	-	-	-	-	1.5

With the exception of fluoride (which reflects the mean concentration of dissolved fluoride only), values represent means of total recoverable metal concentrations.

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

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

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

[d] CCME interim value.

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

[f] Based of CCME Guidelines for Agricultural Use (Livestock Watering).

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

* - not a mean value. One value measured during summer.

A brief introduction to Limnology

Indicators of water quality

The goal of **Lakewatch** is to collect water samples necessary to determine the water quality of lakes. Though not all encompassing, the variables measured in **Lakewatch** are sensitive to human activities in watersheds that may cause impacts to 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 affected (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 fish habitat and production of noxious odors. Large increases in nutrients over time may also indicate sewage inputs, which in turn, may result in other human health concerns such as harmful bacteria or protozoans (e.g. *Cryptosporidium*).

Temperature and mixing

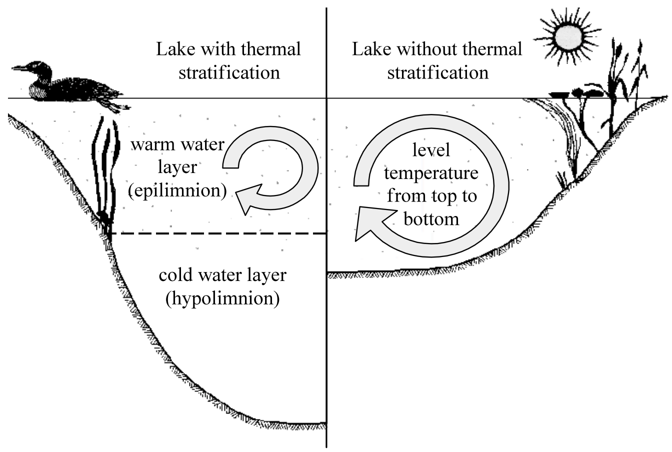

Figure 6: Difference in the circulation of the water column depending on thermal stratification.

Water temperature in a lake dictates the behavior of many chemical parameters responsible for water quality (Figure 6). 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 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 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/L and should not average less than 6.5 mg/L over a seven-day period. However, the guidelines also require that dissolved oxygen concentrations remain above 9.5 mg/L 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. Larger aquatic plants, known as macrophytes, rather than algae, dominate some highly productive lakes. In these lakes, chlorophyll-*a* and nutrient values taken from water samples do not include productivity from large aquatic plants. As a result, lakes like Chestermere, which are dominated by macrophytes, can exist at 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 Depth

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. Secchi disk depth is the oldest, simplest, and quickest quantitative measure of water clarity. A Secchi disk is a black and white disk that is lowered down through the water column until it can no longer be seen. Secchi disk depth is the midpoint between the depth at which it disappears when lowered and reappears when it is pulled up again. The Secchi disk depth in lakes with high algal biomass will generally be shallow. However, Secchi disk depth is not only affected by algae. 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 shallow Secchi disk depths despite low algal growth and nutrient concentrations.

The euphotic zone, calculated as twice the Secchi disk depth, is the portion of the water column that has sufficient light for aquatic plants to grow. Murky waters, with shallow Secchi depths, can prevent aquatic plants from growing on the lake bottom. Aquatic plants are important because they ensure clear lake water by reducing shoreline erosion and stabilizing lake bottom sediments. Many lakes in Alberta are shallow and have bottom sediments with 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 fish, depend on aquatic plants for food and shelter.

Trophic state

Trophic state is a classification system for lakes that depends on fertility and is a useful index for rating and comparing lakes. From low to high nutrient and algal biomass (as chlorophyll-*a*) concentrations, the trophic states are: **oligotrophic**, **mesotrophic**, **eutrophic** and **hypereutrophic**. The nutrient and algal biomass concentrations that define these categories are shown in table 2 and a graph of Alberta lakes compared by trophic state can be found on the ALMS website. A majority of lakes in Alberta are meso- to eutrophic because they naturally contain high nutrient concentrations due to our deep fertile soils. Thus, lakes in Alberta are susceptible to human impacts because they are already nutrient-rich; any further nutrient increases can bring about undesirable conditions illustrated in Figure. 7.

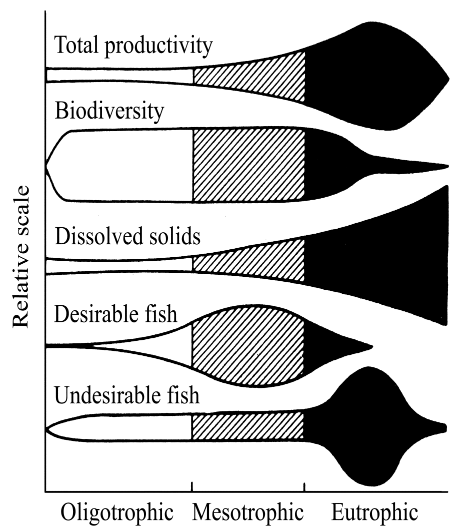

Figure 7: Suggested changes in various lake characteristics with eutrophication. From "Ecological Effects of Wastewater", 1980.

Table 2: Trophic status based on lake water characteristics

Trophic state	Total Phosphorus (µg/L)	Total Nitrogen (µg/L)	Chlorophyll a (µg/L)	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.