Lakewatch

The Alberta Lake Management Society
Volunteer Lake Monitoring Program

Burnstick Lake

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2004 Report

Completed with support from:

Alberta Lake Management Society's Lakewatch Program

Lakewatch has several important objectives, one of which is to collect and interpret water quality 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.

Acknowledgments

The Lakewatch program is made possible through the 2004 Lakewatch Chairs, Théo Charette, Ron Zurawell, and Preston MacEachern, and the individual volunteers who dedicate their personal time. It is the local volunteers who make these sampling programs possible. The 2004 summer field technician, Heather Jones, was a valuable and hard-working addition to the program. Numerous Alberta Environment staff also contributed to successful completion of the 2005 program. Shelley Manchur was the Technical Program Coordinator, responsible for planning and organizing the field program. Technologists Mike Bilyk, Brian Jackson and John Willis were involved in the logistics and training aspects; Doreen LeClair was responsible for data management. Théo Charette (ALMS President) was responsible for program administration and planning. ALMS gratefully acknowledges Alberta Environment, the Lakeland Industry and Community Association (LICA) and Lakeland County for their financial support of the Lakewatch program.

Burnstick Lake

Located in the southern half of the province, Burnstick Lake is a moderately small water body tucked into the Boreal Foothills southwest of Caroline. Its primary inflow is West Stony Creek at the southwest end, although other streams may contribute intermittently when conditions are wet enough. Outflow is via East Stony Creek at the lake's easternmost point, which eventually flows into the James River as part of the Red Deer River Basin.

Burnstick Lake is situated in a semi-wilderness area of the lower boreal cordilleran ecoregion (Table 1). The surrounding landscape is primarily native vegetation occurring in a mix of forests and wetlands. The area is also home to the regionally uncommon round-leafed bog-orchid (*Habernaria orbiculata*). The lake supports an active sport fishery for Northern pike, Yellow perch and walleye, the perch having been introduced in the 1970s (Alberta Environment Report, 1996). Extensive marshy and ponded areas around the lake provide excellent nesting sites for a variety of waterfowl and amphibians. Bald eagles have been known to nest along the lakeshore for multiple years (Mitchell, 1994a, 1994b). Land ownership throughout the watershed is primarily crown with private near-lake properties. Most crown land is under lease as cattle grazing reserves. Private lands consist of a municipal campground at the lake's east end, the Summer Village of Burnstick Lake midway along the north shore, and the Burnstick Lake Resort on the south shore across the lake from the summer village (Alberta Environment Report, 1996).

Table 1. Summary of details describing the lower boreal-cordilleran ecoregion in which Burnstick Lake is situated (adapted from Strong and Leggat, 1992).

Lower Boreal-Cordilleran Characteristics*		
Vegetation	Aspen, Balsam Poplar, Lodgepole Pine succeeding to White and Black Spruce and Balsam Fir	
Summer	Average Temp.	12.8 ^{0}C
	Average Min. Temp.	6.9 ^{0}C
	Average Max. Temp.	18.3 ^{0}C
	Month of Max. Precip.	July
	Total Summer Precip. (mm)	295 mm
Winter	Average Temp.	-7.8 ^{0}C
	Average Min. Temp.	-14.3 ^{0}C
	Average Max. Temp.	-2.1 ^{0}C
	Total Winter Precip. (mm)	60 mm
Total Annual Precipitation (mm)		**464 mm**

*precipitation numbers are median values

Table 2. Physical characteristics of Burnstick Lake (Mitchell, 1994).

Lake surface area	2.93 km^2
Drainage basin	62.6 km^2
Mean depth	5 m
Maximum depth	approx. 18 m

The watershed of Burnstick Lake is quite large relative to lake size (Table 2). Although the lake has fairly deep areas in the middle third, most of the basin consists of shallow regions at either end (Figure 1). Despite the large drainage area and shallow lake bottom, it is a fairly unproductive lake. Burnstick has been sampled previously for water

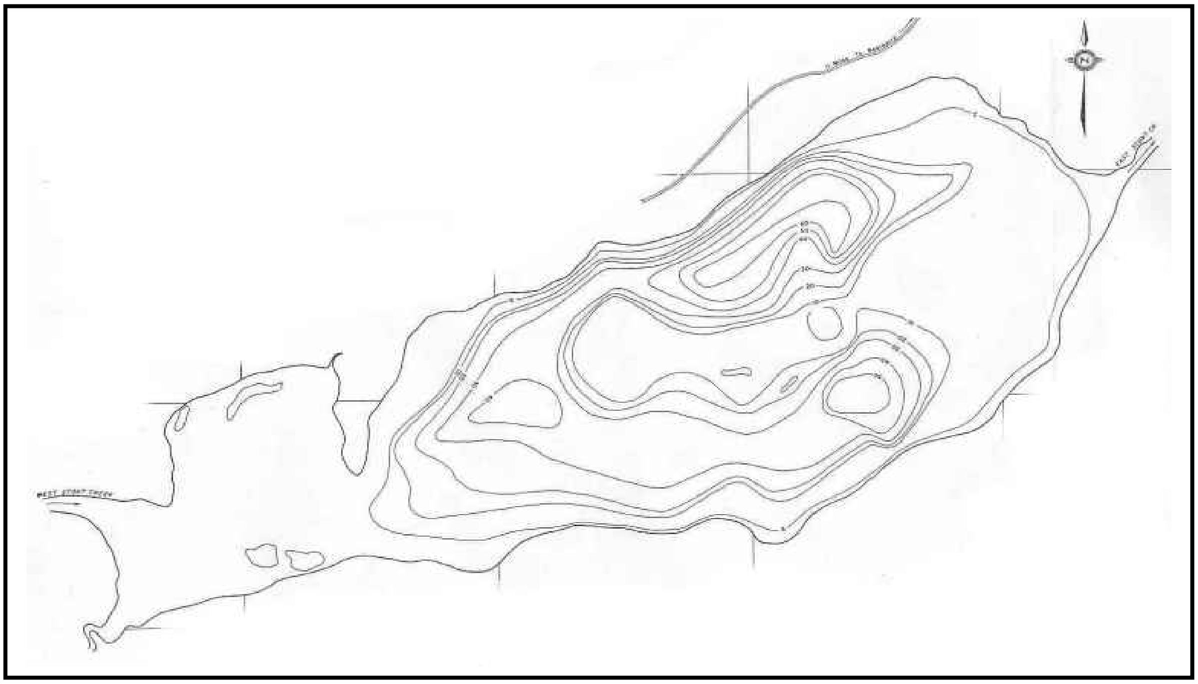

Figure 1. Bathymetric map of Burnstick Lake. Alberta Environment Historical Library.

quality as part of the Volunteer Citizens' Lake Monitoring Program, the precursor to the ALMS' Lakewatch Program. Phosphorus loading rates have also been estimated for the lake and implicated effects from cattle as having a greater potential impact on the lake's productivity level than near-shore developments (Mitchell, 1995). The results from the phosphorus calculations were included in a 1996 report from Alberta Environment detailing the Burnstick Lake Management Plan. This plan sought to '…provide guidelines for the protection, management and orderly development of lands and resources around the lake'. It was created through the efforts of Alberta Environment staff and local citizens who expressed an interest in maintaining the attributes that make Burnstick Lake attractive to all those who enjoy it.

Methods

Lakes monitored under the Alberta Lake Management Society's Lakewatch program are all monitored using standard Alberta Environment procedures: composite samples are collected from numerous sites around the lake and water is profiled at the deep water spot in each lake once per month through the warmer months. This usually results in 4 sampling trips per open-water season. On each trip, the deep-water profiles include measurements for temperature and dissolved oxygen recorded from lake surface to lake bottom, as well as maximum depth. A Secchi depth is also measured, from which the range of the euphotic zone is estimated. Once the euphotic zone depth is known, the composite samples are collected for lab analyses. After the water has been analyzed, results are examined for trends and summarized.

Water Levels

Water levels on Burnstick Lake have been monitored regularly since 1971 (Figure 2). A weir was installed on the lake in 1977. Prior to this, water levels fluctuated widely year-to-year but have remained relatively stable since. Over the monitoring period, the lake's

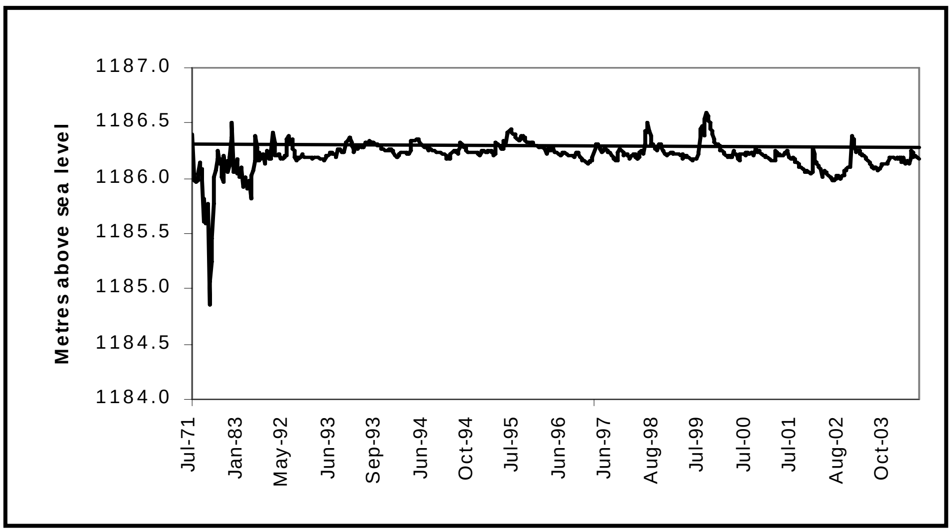

Figure 2. Historical water levels of Burnstick Lake. The horizontal line represents mean distance above sea level. Alberta Environment data.

surface has ranged from a high of 1186.589 m above sea level (asl) on July 16, 1999, to a low of 1184.849 m asl on January 22, 1976. The average water level during this time was 1186.206 m asl. At the lake's deepest point, this translates into a depth of approximately 18 m.

Temperature and Dissolved Oxygen Profiles

The temperature profiles for summer 2004 suggest that Burnstick Lake stratifies at the deep water sampling point (Figure 3). This is indicated by the thermocline, represented on the graphs by the sharp drop of the temperature line in the summer months. By September 19th, the water column has started its fall turnover and the temperature is becoming similar throughout the water column as mixing occurs. The dissolved oxygen content parallels the temperature profile closely. When the lake is stratified, water may never mix well enough to bring oxygen-rich water down below the thermocline. Without replacement, normal biological processes reduce oxygen levels at depth to a noticeably lower level. Since Burnstick has wide, shallow zones at either end, these profiles probably do not reflect what occurs across a large part of the lake.

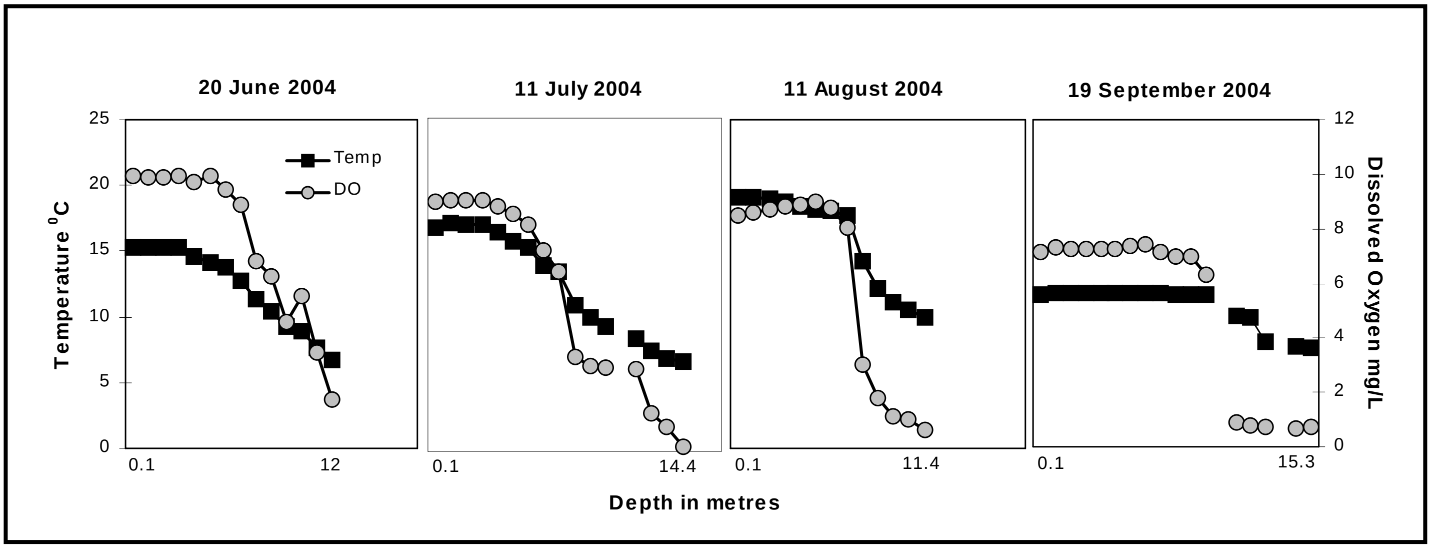

Figure 3. Temperature and dissolved oxygen profiles for Burnstick Lake, summer 2004. Alberta Environment data.

Water Clarity

Burnstick Lake is fairly unproductive – summer chlorophyll *a* levels are low enough to classify it as mesotrophic (Figure 4). As such, water clarity is quite high even in the

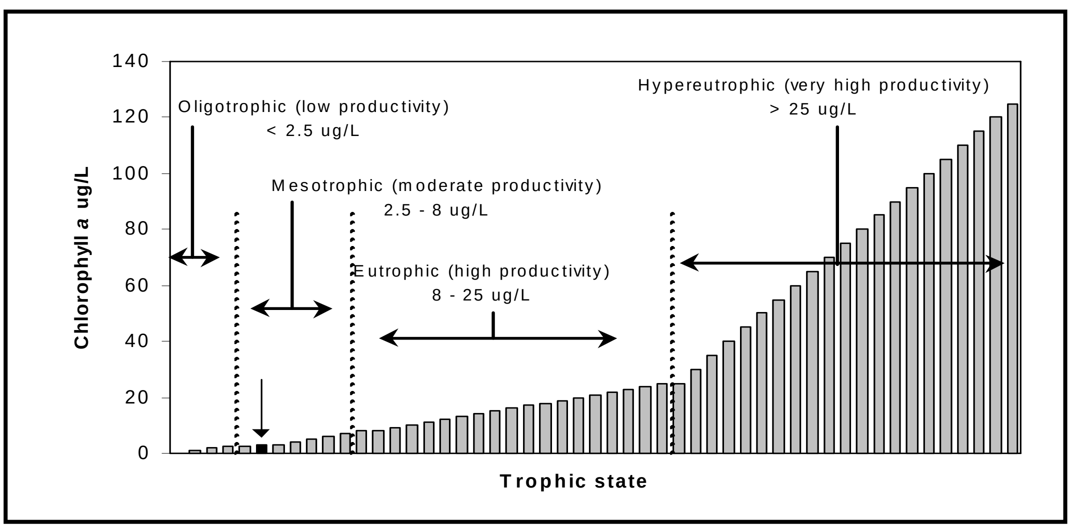

Figure 2. The black bar below the down arrow represents average chlorophyll a concentration for Burnstick Lake from summer 2004.

summer months. Figure 5 shows a classic Secchi depth response to algal growth, decreasing as chlorophyll *a* levels increase and then improving into the fall as algal cells begin to die. What is important to note is that even though the graph line shows a decrease in water clarity in mid-summer, the vertical scales indicate that Burnstick Lake remains quite clear – minimum Secchi depth is at 4 m, which is more than many other popular recreation lakes achieve for the entire open water season. This is also reflected by the nutrient inputs (Figure 6) which are also quite low relative to most Alberta lakes. Nitrogen values are very low and phosphorus appears to be the more limiting nutrient as it is closely paralleled by the chlorophyll *a* response.

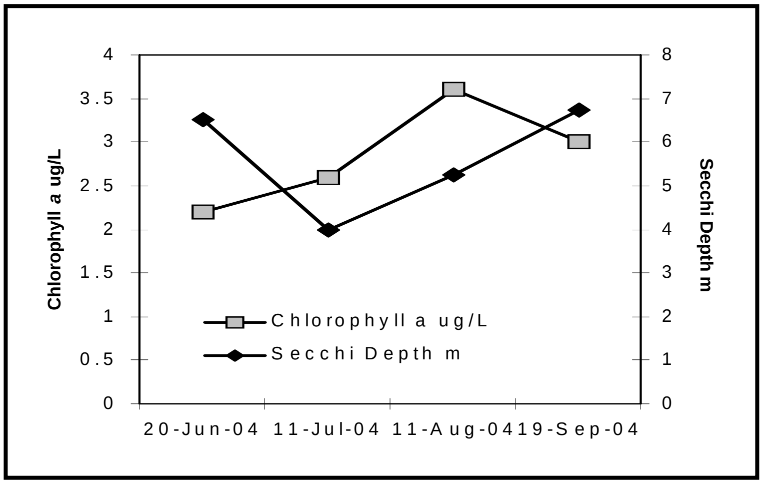

Figure 5. Secchi depth increases after the algae, as measured by chlorophyll *a,* begin to die as the summer turns to autumn.

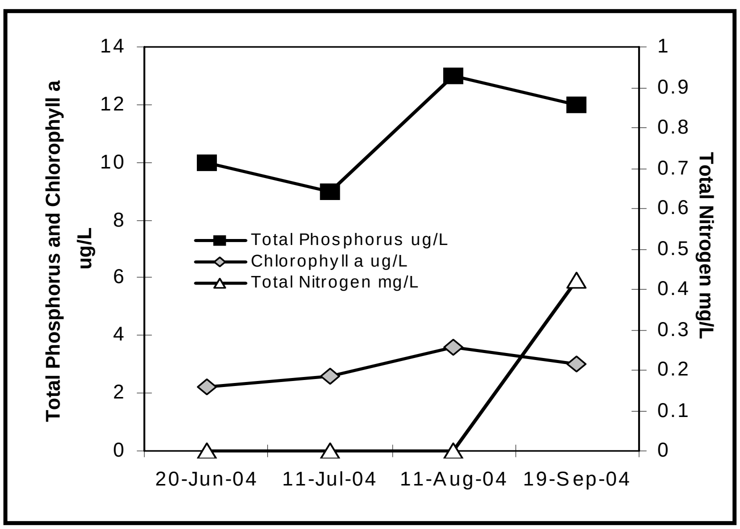

Figure 6. This graph shows the low levels for nutrients and chlorophyll *a* that seem typical of Burnstick Lake.

Water Chemistry

Since three sampling efforts were made prior to 2004, it is possible to graph some comparisons between years (Figure 7). From 1993 to 2004, phosphorus levels seem to have decreased and chlorophyll *a* levels have risen only slightly. Clarity as measured by Secchi depth appears to have had an overall downward trend. As chlorophyll *a* levels are fairly steady, sediments from run-off during wetter years could be causing this. However, it would be inappropriate to suggest any long-term trends from only four sampling years.

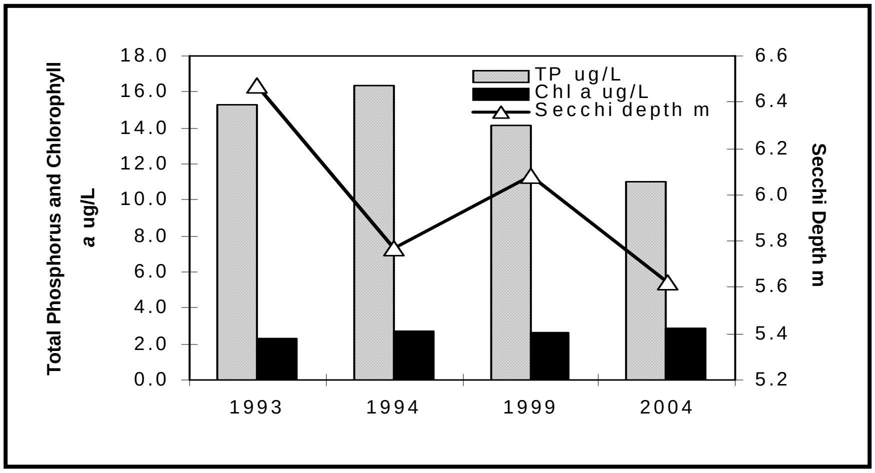

Figure 7. Summer averages for TP, chl a and Secchi depth. While chlorophyll *a* concentrations are fairly stable and phosphorus levels seem to have dropped, water clarity represented by Secchi depth shows a slight downward trend.

Lakewatch sampling efforts from summer 2004 show that Burnstick Lake has overall low salinity (Table 3). Levels for calcium and magnesium relative to those of sodium and potassium indicate that the water is hard, which is not surprising given its position in the mountain foothills. It seems probable that good watershed management is maintaining the water quality in the lake overall.

Table 3. Burnstick Lake cation concentrations place the lake in the low salinity range. Adapted from Atlas of Alberta Lakes.

Salinity Range	**Average Cation Concentrations mg/L**			
(based on Total Dissolved Solids mg/L)	Sodium	Potassium	Calcium	Magnesium
Low salinity (<500)	20	5	29	15
Slightly saline (500-1000)	113	29	31	59
Moderately saline (1000-5000)	379	34	21	46
Burnstick Lake (122.7)	**2.83**	**0.7**	**28.5**	**10.35**

Results for other water quality measurements averaged from 2004 are summarized in Appendices I and II, as well as historical values where available.

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Appendix I. Summary of historical and summer 2004 averages for various water quality parameters. The 'L' in front of some values indicates 'less than'.

Parameter	1993	1994	1999	2004
Total Phosphorus ug/L	15.3	16.3	14.1	11.0
Total Dissolved Phosphorus ug/L			5.4	4.2
Total Dissolved Solids mg/L	124.6	133.2	126.0	122.7
Chlorophyll a ug/L	2.3	2.7	2.6	2.9
Secchi depth m	6.5	5.8	6.1	5.6
Total Nitrogen mg/L			0.5	0.4
Nitrate + Nitrite mg/L	0.0084	0.0098	0.0084	0.009
Ammonium mg/L			0.015	0.017
Calcium mg/L	30.6	33.5	30.3	28.5
Magnesium mg/L	11.4	11.7	11.3	10.4
Sodium mg/L	2.8	3.2	2.5	2.8
Potassium mg/L	0.5	0.5	0.5	0.7
Sulphate mg/L	L3	L3	3.4	8.0
Chloride mg/L	0.5	L0.5	3.0	0.4
Alkalinity mg/L as $CaCO_3$	128.4	137.7	129.4	126.0
Carbonate mg/L			L5	4.0
Bicarbonate mg/L	156.4	167.3	157.6	151.7
pH	8.2	8.2	8.2	8.3
Conductivity uS/cm	239.2	253.8	244.0	217.0

Appendix II. Summary of metals, non-metals and metallic elements analyses. Guideline values are those listed for the Protection of Freshwater Aquatic Life unless otherwise noted. Concentrations represent total recoverable fractions except fluoride, which is for the dissolved fraction only.

Parameter	1993	1994	1999	2004	Guideline Values
Aluminum ug/L				18.7	100
Antimony ug/L				0.0	6 [1]
Arsenic ug/l				0.3	5
Barium ug/L				126.0	1000 [1]
Beryllium ug/L				L0.003	100
Bismuth ug/L				L0.001	
Boron ug/L				4.4	5000 [1]
Cadmium ug/L				L0.002	0.085
Chromium ug/L				0.1	
Cobalt ug/L				0.0	1000 [2]
Copper ug/L				0.9	4
Fluoride ug/L	0.094	0.10	0.15	0.12	1.5
Iron ug/L	0.0	0.1		4.0	300
Lead ug/L				0.1	7
Lithium ug/L				2.0	2500 [3]
Manganese ug/L				11.4	200 [3]
Molybdenum ug/L				0.2	73
Nickel ug/L				L0.005	150
Selenium ug/L				L0.1	1
Silver ug/L				0.0347	0.1
Strontium ug/L				73.3	
Thallium ug/L				0.0008	0.8
Thorium ug/L				0.0053	
Tin ug/L				0.13	
Titanium ug/L				1	
Uranium ug/L				0.19	100 [1]
Vanadium ug/L				0.104	100 [2]
Zinc ug/L				**14.7**	1.5

[1] Canadian Drinking Water Quality guideline value
[2] Canadian Guideline for Agricultural Use (Livestock watering)
[3] Canadian Guideline for Agricultural Use (Irrigation)

A brief introduction to Limnology

Indicators of water quality

Water samples are collected in Lakewatch to determine the water quality of lakes. 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

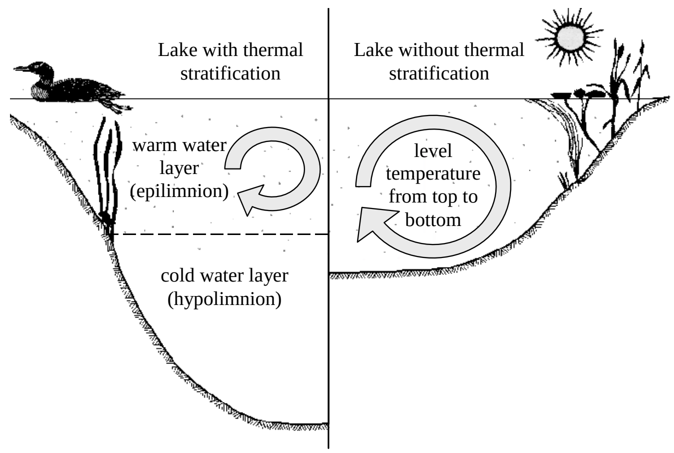

Fig. 1: Difference in the circulation of the water column depending on thermal stratification.

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 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. Some highly productive lakes are dominated by larger aquatic plants, known as macrophytes, rather than suspended algae. 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 be 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) concentrations, the trophic states are: **oligotrophic**, **mesotrophic**, **eutrophic** and **hypereutrophic**. 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. 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 Fig 2.

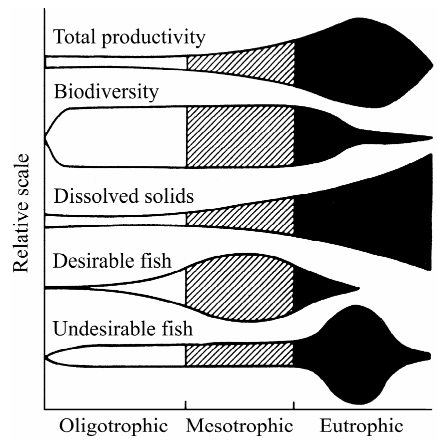

Fig. 2: Suggested changes in various lake characteristics with eutrophication. From "Ecological Effects of Wastewater", 1980

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.

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