ALMS
Alberta Lake Management Society

Lakewatch

The Alberta Lake Management Society
Volunteer Lake Monitoring Program

Tucker Lake

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2007 Report

Completed with support from:

LICA
Lakeland Industry & Community Association

Alberta Environment

Alberta Lake Management Society

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> *Water is integral to supporting and maintaining life on this planet as it moderates the climate, creates growth and shapes the living substance of all of Earth's creatures. It is the tide of life itself, the sacred source.*
> David Suzuki (1997). The Sacred Balance.

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.

Acknowledgements

The Lakewatch program is made possible through the dedication of volunteers and the Lakewatch Chairs, Théo Charette and Ron Zurawell. We would like to thank Corey Styba for the time and effort necessary to collect field data during 2007. Numerous Alberta Environment staff also contributed to successful completion of the 2007 program. We would like to thank Jill Anderson and Wendy Markowski who were summer interns with ALMS in 2007. Project Technical Coordinator, Megan McLean was instrumental in planning and organizing the field program. Technologists, Mike Bilyk, Brian Jackson and John Willis were involved in the logistics planning and training aspects of the program. Doreen LeClair was responsible for data management. Théo Charette (ALMS Director) was responsible for program administration and planning. Théo Charette, Ron Zurawell (Limnologist, AENV), and Lori Nuefeld prepared the original report, which was updated by Heather Powell in 2007. Alberta Environment and Lakeland Industry and Community Association (LICA) financially supported the Lakewatch program.

Tucker Lake

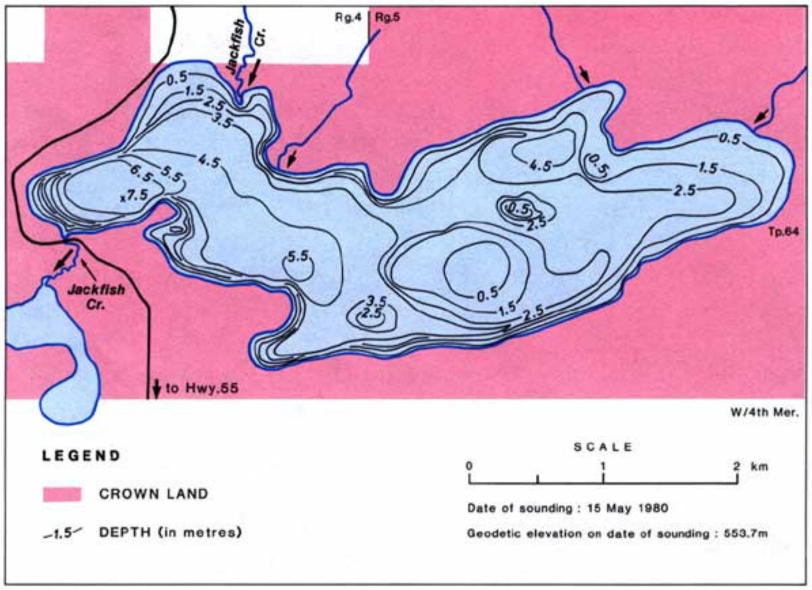

Figure 1. Bathymetry of Tucker Lake, Alberta.

Tucker Lake is located within a low-lying, rolling hill catchment. It is an isolated lake approximately 280 km northeast of the city of Edmonton. The primary urban centers are Bonnyville (south), Grande Centre and Cold Lake (southeast). To reach Tucker Lake from Edmonton, travel NE on Highway 28 and Highway 28A (toward Bonnyville), then north on Highway 41 towards La Corey. Continue east on Highway 55 for approximately 5.5 km and take the first turn (north) after Jackfish Creek. Take this gravel road for 3 km, east for 0.75 km, north for 3.25 km, and finally east for 6 km. At the end of this gravel road is the western shore of Tucker Lake. Inadequate lake access and lack of facilities limits recreational use of the lake, although boat access is available at the end of the entrance road. Sport fishing in spring and summer months (for northern pike and yellow perch) as well as swimming and camping are the preferred activities of those visiting the lake. The origin of the name “Tucker” in unknown, however, the lake is often referred to Little Jackfish Lake due to the abundance of small northern pike fish (Chipeniuk 1975).

The drainage basin of Tucker Lake is 46 times the size of the lake and is entirely located to the north of the lake (**Figure 1**). All inflowing streams are consequently located on the northern shore of Tucker Lake. Jackfish Creek, which is the largest of the four streams, drains from Bourque Lake along the lake’s northwestern shore. Tucker Lake’s catchment is located in the Boreal- mixedwood Ecoregion (Strong and Leggat 1981). The dominant tree species in the dry subregion (small area south of the lake) is trembling aspen. The moist subregion (area north of the lake) is composed of balsam poplar and trembling aspen. Jack pine, white spruce, black spruce, willows and sedges grow in both subregions. Tucker Lake is mostly on Crown Land. No cottages occupy the shoreline except for a section of privately owned land on the northwest bay.

Tucker Lake is a moderate size (surface area of 6.65 km^2) and shallow (mean depth of 2.9 m) lake (**Figure 1**). The deepest region of the lake is located in the western bay and slopes rapidly to 7.5 m in depth. For the most part, however, the depth of this western basin is 6.5 m. The eastern basin fluctuates in depth between 2.5 and 4.5 m and is characterised by numerous intermittent shallow spots of ~ 0.5 m depth.

In 1982, macrophyte vegetation of Tucker Lake (described by McGregor 1983) grew around the entire shoreline, and was of greatest density in the shallow, northeast portion of the lake. The emergent macrophytes included great bulrush (*Scirpus validus*), yellow water lily (*Nuphar variegatum*), sedges (*Carex* spp.) and reed grass (*Phragmites* spp.). Common submerged macrophytes included coontail (*Ceratophyllum demersum*), northern watermilfoil (*Myriophyllum exalbescens*), and Richardson (*Potamogeton richardsonii*), flatstemmed (*P. zosteriformis*) and Sago (*P. pectinatus*) pondweeds.

Results

Water Levels

Water levels for Tucker Lake have not been recorded. In the surrounding region, however, there have been reports of recent lowering of lake levels due to increased drought episodes. To help approximate changes in water levels in Tucker Lake and determine what trends we could expect within this lake, we opted to examined changes in water levels of a nearby lake, Crane (Moore) Lake.

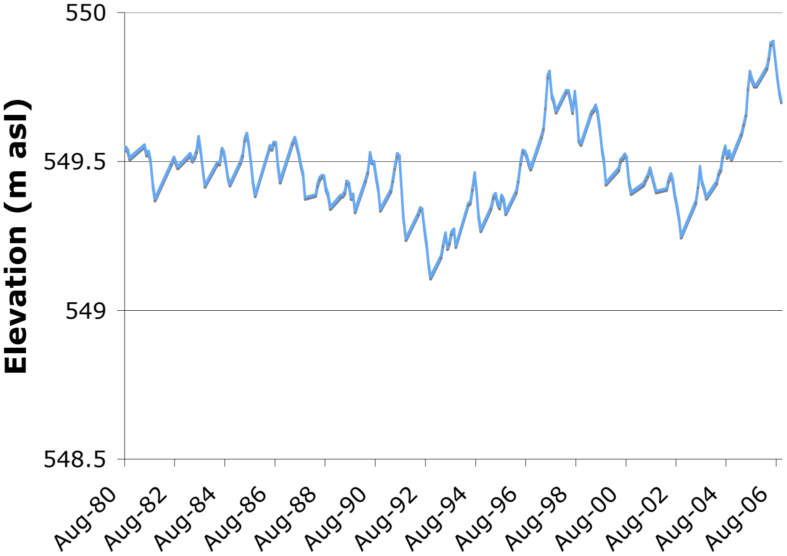

Figure. 2. Water levels for nearby Crane Lake (~ 2 km SE of Tucker Lake), Alberta for the period of 1980 to 2006.

Crane Lake is located ~ 2 km southeast of Tucker Lake, and as such, we assumed that both systems are subjected to similar microclimates. The water levels of Crane Lake were recorded regularly from 1980 to 2006. Water levels fluctuate around a mean of 549.49 m above sea level (**Figure 2**). A slight decreasing trend in water level of ~0.4m was found from 1987 to 1992. Water levels increased by 0.7 m from 1992 to 1997. A similar pattern was found in 2000-2006. Maximum water level of 549.9 m was recorded in June 2006. Minimum water level of 549.1 m was recorded in October 1992.

We assumed that Tucker Lake experienced a similar microclimate as that of Crane Lake. Thus, we might expect to see water level fluctuations in Tucker Lake in response to changes in annual precipitation. Since no steady decline in water level in Crane Lake was observed (in light of variation in annual precipitation), we suggest that if a steady decline in Tucker Lake was observed, this would be the result of changes to groundwater inputs or water use in the basin.

Water Temperature and Dissolved Oxygen

Water temperature and dissolved oxygen profiles in the water column can provide information on water quality and fish habitat. For descriptions of technical terms, please see end of report.

Tucker Lake mixes intermittently throughout the summer (e.g. polymictic), as was evidenced by the lack of stratification in summer 2007 (**Figure 3**). As surface waters warmed in mid-July, a weak thermal stratification was evident at 5 m depth. Tucker Lake mixed between the August and September sample dates, as evidenced by similar water temperatures at all depths in September. Water temperatures decreased to ~12ºC in September 2007.

Dissolved oxygen (DO) concentrations were high in surface waters in July and August and decreased in September 2007 (**Figure 3**). In July, DO concentrations approached zero (e.g. anoxic) below 7m depth, which indicates decomposition occurred near the lake bed. Between August and September, Tucker Lake mixed, as evidenced by similar DO concentrations at all depths. The oxygen levels in surface layers of Tucker Lake in July and August were within the acceptable range for surface water quality, according to Alberta Environment guidelines (DO ≥ 5.0 mg/L).

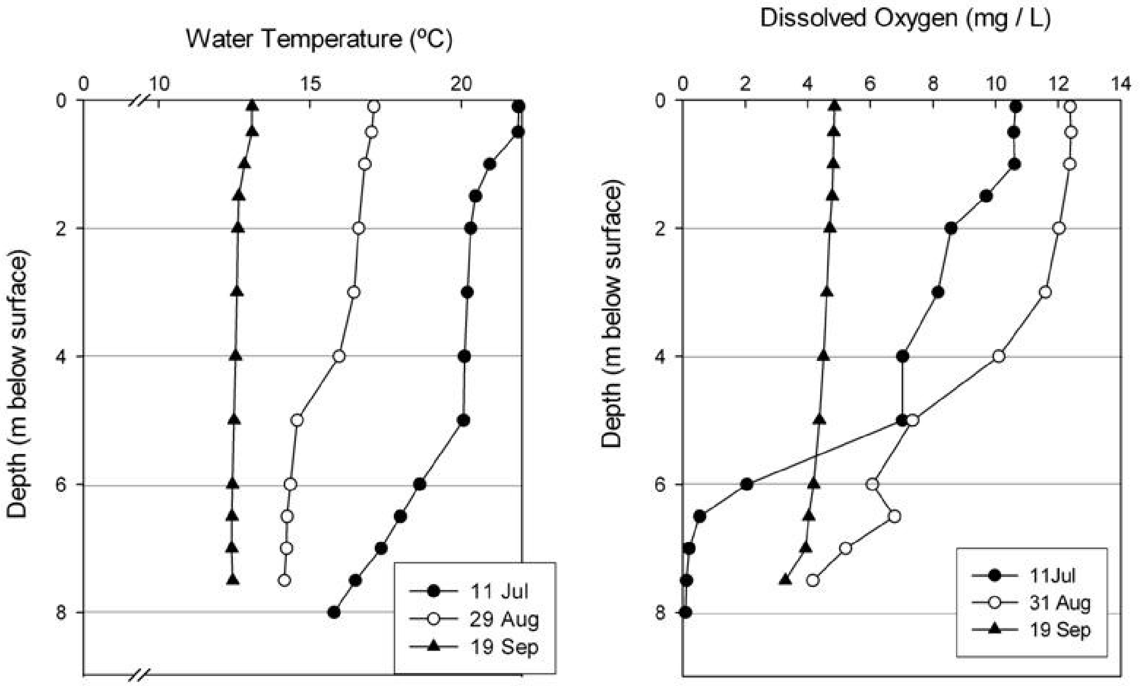

Figure 3. Water temperature (°C) and dissolved oxygen (mg /L) profiles for Tucker Lake during the summer of 2007.

Water clarity and Secchi disk depth

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

Tucker Lake is a polymictic lake (water column mixes many times per year) and as such has turbid water (e.g. murky). During the summer of 2007, light penetrated to an average 7% of the total lake depth (average Secchi disk depth of 0.5 m, **Table 1**). Thus, algal growth was limited to surface waters during the summer months. Maximum water clarity was observed in September (Secchi disk depth = 0.7 m). Secchi depth was measured just twice in 2007, which may not accurately represent water clarity during spring. Compared to other lakes in the Lakewatch program, Tucker Lake is very turbid due its polymictic nature.

Water chemistry

Based on lake water characteristics, Tucker Lake is classified as hyper-eutrophic (see *A Brief Introduction to Limnology* at end of this report). This is evidenced by high concentrations of total phosphorus (average TP = 106 µg/L) and total Kjeldahl nitrogen (average TN = 1.8 mg/L) and high algal biomass (average chl *a* = 80.7 µg/L) (**Figure 4**). Nutrient concentrations and algal biomass was measured twice in 2007, so it is difficult to determine the pattern of productivity. However, nutrient concentrations increased in Tucker Lake in summer 2006. This was thought to be the result of internal loading (e.g. nutrient release from sediments).

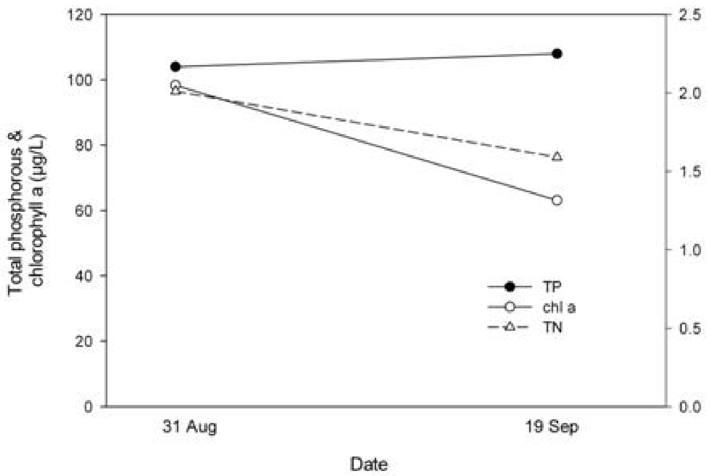

Figure 4. Total phosphorus, total nitrogen, and chlorophyll *a* (a measure of algae biomass) concentrations for Tucker Lake during the summer of 2007.

The phosphorus budget of Tucker Lake was calculated in 1982. Internal loading of phosphorus from the sediments accounted for that 75% of the mean daily TP loading. The inflow from Bourque Lake accounted for 29% of the total summer load.

Like most lakes in Alberta, Tucker Lake is well buffered from acidification. Lake pH = 8.5 is well above that of pure water (i.e., pH 7). Bicarbonate, calcium, magnesium, and sodium are the dominant ions in Tucker Lake (**Table 1**). Ion concentrations were approximately the same in 2006 and 2007.

The average concentrations of various heavy metals (as total recoverable concentrations) were below CCME guidelines for the Protection of Freshwater Aquatic Life. Results of the metal analyses, compared to guideline values, are listed in **Appendix 2**.

Table1. Mean water chemistry characteristics of Tucker Lake, Alberta summer 2007 compared to 2006.

Parameter	**2006**	**2007**
Total P (µg/L)	70	106
TDP (µg/L)	17	24
Chlorophyll *a* (µg/L)	28.5	80.7
Secchi disk depth (m)	1.55	0.53
Total N (µg/L)	1257	1800
NO_{2+3} (µg/L)	5	13
NH_4 (µg/L)	17.4	43
Dissolved organic C (mg/L)	-	15.3
Ca (mg/L)	32.7	29.8
Mg (mg/L)	22.2	23.8
Na (mg/L)	20	18.1
K (mg/L)	3.4	3.9
SO_4 (mg/L)	3.5	<3
Cl (mg/L)	1.5	1.7
CO_3 (mg/L)	9.3	9
HCO_3 (mg/L)	249	236
Conductivity (µS/cm)	-	376
Total Alkalinity (mg/L $CaCO_3$)	219	209
pH	8.55	8.5
Total dissolved solids (mg/L)	215	205

Note: TP = total phosphorus, TDP = total dissolved phosphorus, Chla = chlorophyll *a*, 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).

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Appendix 1

Concentrations of metals in Tucker Lake (total recoverable), measured once on 19 September 2007, compared to average values in summer 2006. The CCME heavy metal Guidelines for the Protection of Freshwater Aquatic Life are presented for reference.

Metals (total)	2006	2007	Guidelines
ALUMINUM µg/L	6.625	14.4	100[a]
ANTIMONY µg/L	0.0167	0.007	6[e]
ARSENIC µg/L	4.855	3.8	5
BARIUM µg/L	44.6	43.1	1000[e]
BERYLLIUM µg/L	<0.003	<0.003	100[d,f]
BISMUTH µg/L	0.007	<0.001	
BORON µg/L	78.4	62.3	5000[e,f]
CADMIUM µg/L	0.0049	0.003	0.085[b]
CHROMIUM µg/L	0.198	1.62	
COBALT µg/L	0.02295	<0.001	1000[f]
COPPER µg/L	0.1905	0.351	4[c]
IRON µg/L	79.15	146	300
LEAD µg/L	0.0435	0.04	7[c]
LITHIUM µg/L	21.5	15	2500[g]
MANGANESE µg/L	27.1	40.3	200[g]
MOLYBDENUM µg/L	1.185	1.09	73[d]
NICKEL µg/L	0.249	0.02	150[c]
SELENIUM µg/L	0.272	0.12	1
STRONTIUM µg/L	191.5	160	
SILVER µg/L	<0.0005	<0.0005	
THALLIUM µg/L	0.0032	<0.0003	0.8
THORIUM µg/L	0.0059	0.012	
TIN µg/L	<0.03	<0.03	
TITANIUM µg/L	1.765	2.11	
URANIUM µg/L	0.119	0.11	100[e]
VANADIUM µg/L	0.164	0.15	100[f,g]
ZINC µg/L	4.935	0.66	30

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).

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

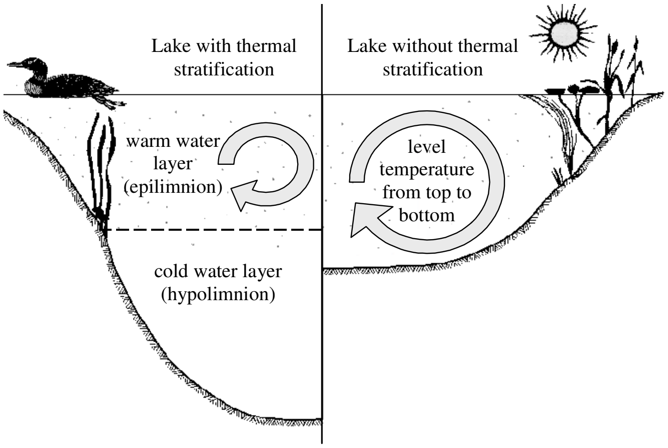

Fig. 1: Difference in the circulation of the water column depending on thermal stratification.

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.

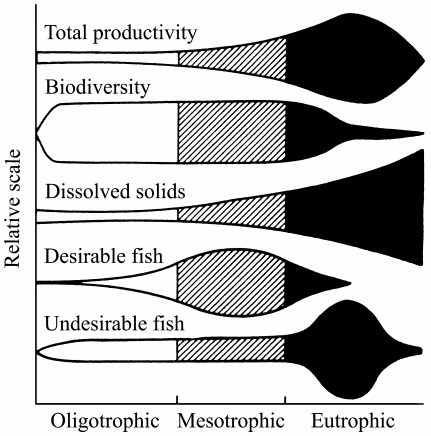

Fig. 2: Suggested changes in various lake characteristics with eutrophication. From "Ecological Effects of Wastewater", 1980

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.