The Alberta Lake Management Society
Volunteer Lake Monitoring Program

Hilda Lake

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2006 Report

Completed with support from:

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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 the Lakewatch Chairs, Théo Charette, and Ron Zurawell, and the volunteers. Don Harasimiuk was the main volunteer for Hilda Lake. He supplied the watercraft and made sampling possible through the dedication of his time. Our summer field technicians and volunteer coordinators, Megan Mclean and Amanda Krowski, were valuable additions and contributors to this year's program. Numerous Alberta Environment staff also contributed to successful completion of the 2006 program. Project Technical Coordinator, Shelley Manchur 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. Erika Brown, Zofia Taranu, and Jesse Vermaire prepared this report. Alberta Environment and Lakeland Industry and Community Association (LICA) financially supported the Lakewatch program.

Hilda Lake

Figure 1. Hilda Lake. Photo: Vien Lam.

Hilda Lake (**Figure 1**) is located in the Beaver River Basin in the northeast corner of Alberta. It is fed by Moore Lake upstream and drains into Ethel Lake downstream, eventually feeding the Beaver River, which then winds through Saskatchewan ultimately to Hudson Bay. The lake is accessed via Highway 897 connecting to a municipal road off the southeastern shore of the lake.

Hilda Lake is situated in rolling land characteristic of the low boreal mixedwood (**Table 1**): dominant trembling aspen, white spruce and jack pine occur on high ground, while black spruce and tamarack appear in low-lying areas. Birch and balsam poplar are also evident as well as many areas of muskeg (Trew, Yonge, and Kaminski, 1981). The lake supports some sport fish species, including Northern pike and walleye, and to a lesser extent yellow perch and burbot. Lake cisco and white suckers are also present. A 1986 census showed breeding Northern pike ranging from 2 – 12 years of age and walleye from 4 – 6 years of age (R. L. and L. Environmental Services Ltd, 1986). Good to excellent permanent wetland habitat surrounds part of the lake as well as shorelines suitable for recreation. Much of the watershed is crown land, with most development near the lake itself. This includes two campsites and two multi-lot rural subdivisions (Alberta Environment Historical Library).

Low Boreal Mixedwood Characteristics*		
Vegetation	Aspen, succeeding to White Spruce	
Summer	Average Temp (ºC)	13.8
	Average Min. Temp (ºC)	7
	Average Max. Temp (ºC)	20.4
	Month of Max. Precipitation	July
	Total Summer Precipitation (mm)	235
Winter	Average Temp (ºC)	-11
	Average Min. Temp (ºC)	-16
	Average Max. Temp (ºC)	-5.3
	Total Winter Precipitation (mm)	61
Total Annual Precipitation		380

* Precipication numbers are median values.

Table 1. Summary of details describing the low boreal mixedwood ecoregion in which Hilda Lake is situated (adapted from Strong and Leggat, 1992).

The watershed of Hilda Lake is small and surface run-off is low, with most of the total annual inflow coming from direct rainfall. Areas of muskeg probably intercept the movement of surface water to the lake. Analysis of the lake water in the early 1980's suggested that groundwater plays an important role in lake inputs, as water chemistry results revealed high sodium and potassium levels typical of groundwater in the surrounding Sand River Formation. Hilda Lake is moderately productive (mesotrophic) and tends towards algal blooms in autumn.

Lake shape and depth result in water layers stratifying in warm summer months (**Figure 2; Table 2**). It is likely that factors including landscape position and a small surface area contribute to the water column never mixing completely throughout the deepest parts of the lake (Trew, Yonge, and Kaminski, 1981).

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

Concerns over low water levels led to the creation of the Hilda Lake Water Management Study in 1990. The steering committee sought to create long-term solutions aimed at stabilizing water levels in the lake. Proposed alternatives included controlling beaver populations, installing a structure at the outlet of upstream Moore Lake, temporary pumping of water from downstream Ethel Lake and improvements made to the existing structures on Hilda Lake. The lake was also included in a study of 23 lakes in the Beaver River drainage basin throughout the 1980's, where mixing regimes and water quality were summarized from a 9-year sampling effort (Chow-Fraser, P. and D.O. Trew, 1990).

Table 2. Physical characteristics of Hilda Lake

Lake surface area	3.62 km sq.
Drainage basin	37.2 km sq.
Mean depth	6.2 m
Maximum depth	approx. 14 m

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 level in Hilda Lake has been monitored since 1980 by Environment Canada under the joint federal-provincial hydrometric agreement. Water level steadily declined from the early 1980s to 1997, when it reached a low of 446.2 m above sea level (**Figure 3**). Water level then rose quickly following 1997, which is one of the wettest years on record.

Water levels decreased due to drought experienced recently. However, since 2004, levels have been rising.

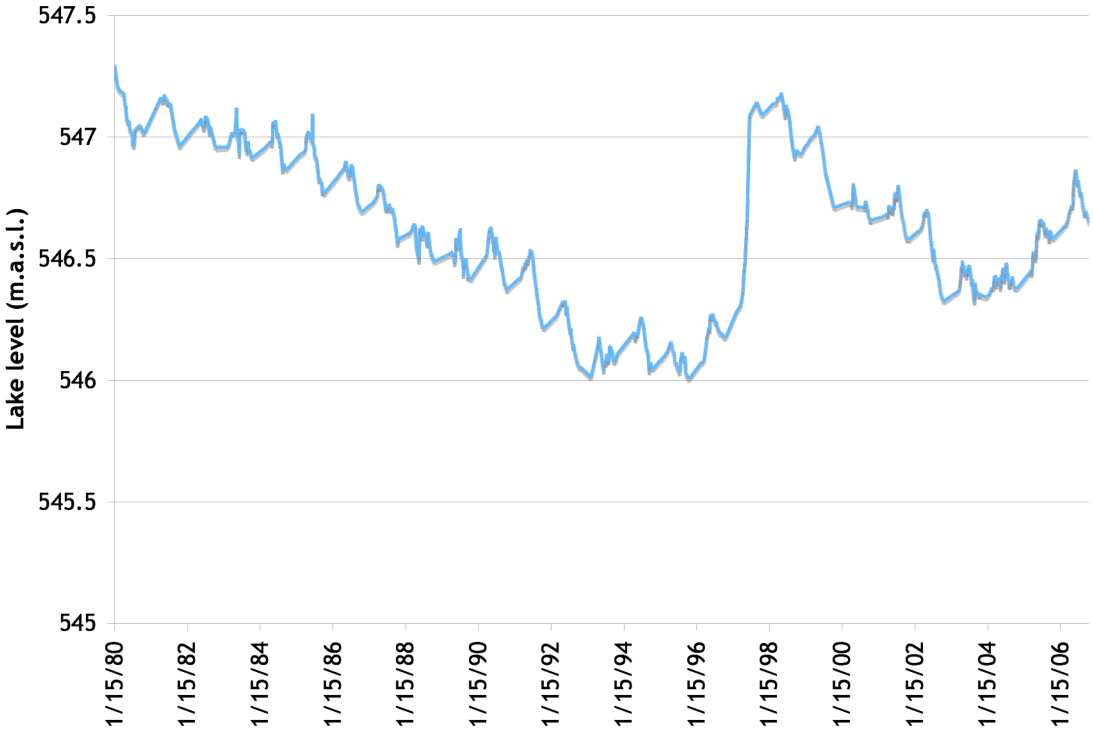


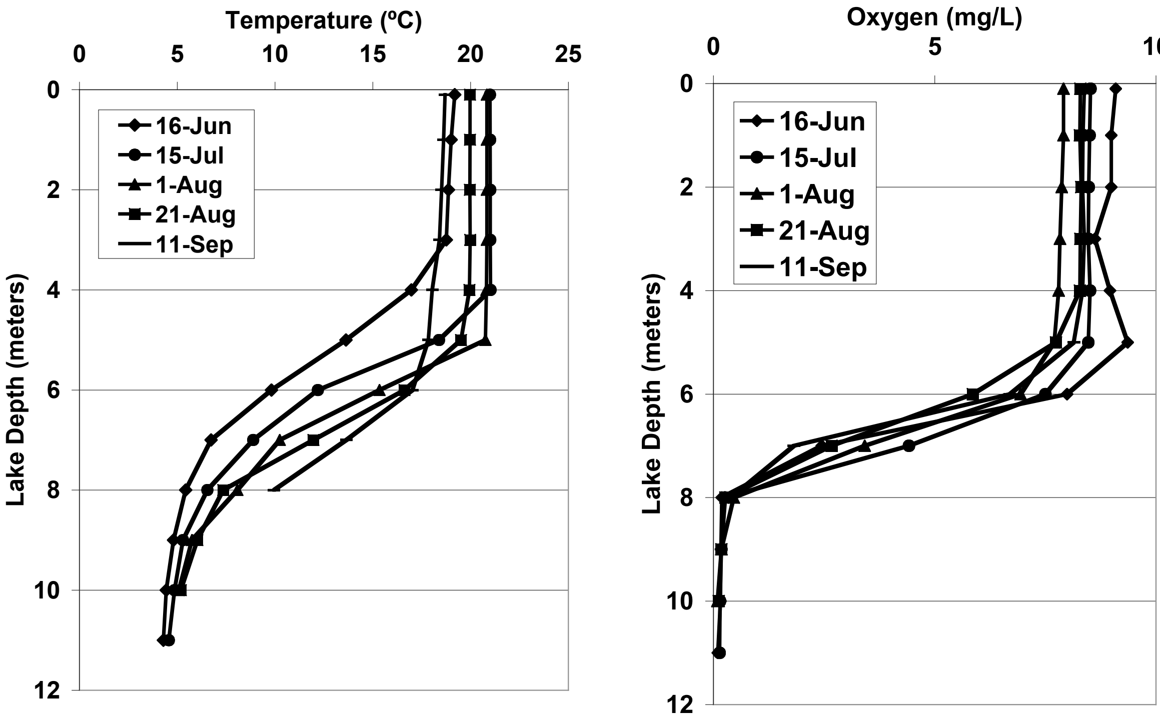
Figure 3. Historical water levels of Hilda Lake.

Results

Water Temperature and Dissolved Oxygen

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

Hilda Lake's water column showed thermal stratification throughout the summer, occurring at 3 m in June, 4 m in July, 5 m in August, and 6 m in September (**Figure 4**). The top 6 m of Hilda Lake were well-oxygenated for the duration of the summer, with oxygen levels within the provincial surface water quality guidelines of 5.0 mg/L or greater (**Figure 4**). In all profiles the oxygen content of the water column began a steady decline at a depth of 5 m, eventually reaching low oxygen conditions at 8 m. This state of poorly oxygenated lower depths is common as the lake bottom is where most of the oxygen-consuming decomposition of algae occurs.



Figures 4: Temperature and dissolved oxygen profiles for Hilda Lake, summer 2006.

Water clarity and Secchi Depth

Water clarity is influenced by suspended materials, both living and dead, as well as dissolved coloured 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 biomass as the summer progresses. The easiest and most widely used measure of lake water clarity is the Secchi disk depth.

Hilda Lake's water was clear during the summer of 2006 (average Secchi disk depth of 2.75 m; **Table 1**) and has not varied much over the past quarter-century. Maximum water clarity was observed at the beginning of the summer during the mid-June and mid-July sampling dates, when the Secchi disk depth reached 3 m. Secchi disk depth decreased to 2.5 m at the beginning of August, increased to 2.75 m by late August, and finally returned to a depth of 2.75 m by September.

Water chemistry

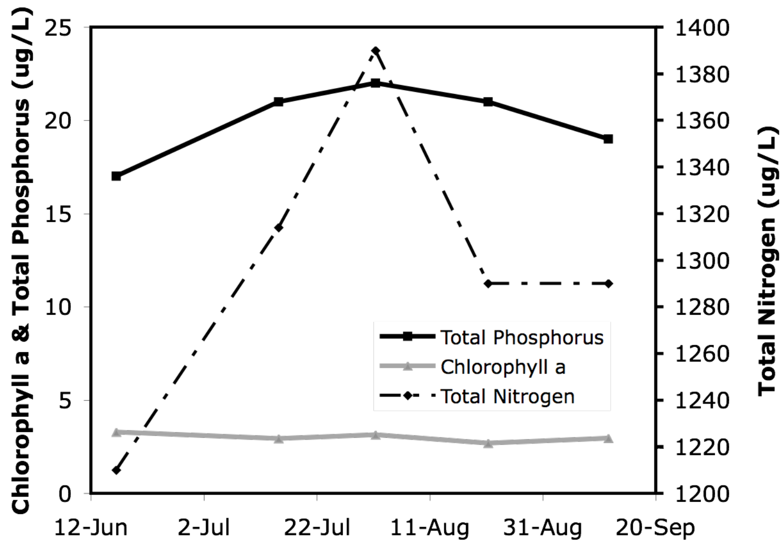


Figure 5. Total Phosphorus, Chlorophyll a (amount of algae), and Total Nitrogen concentrations for Hilda Lake, summer 2006.

Based on the trophic status of lake water characteristics, Hilda Lake is classified as mesotrophic (see *A Brief Introduction to Limnology* at the end of this report). In summer 2006 the total phosphorus concentrations (ranging between 17 and 22 µg/L) was in agreement with this classification. However, according to the Chlorophyll *a* concentrations (measure of water greenness), which ranged from 3.3 to 2.3 µg/L, the lake's trophic status should be categorized as oligotrophic. In July 2005, Chlorophyll *a* concentrations reached 4.6 µg/L (**Figure 5**). Likewise in summer 2004, Hilda Lake was classified as mesotrophic. In the context of the highly productive lakes of the province of Alberta, Hilda Lake is below average in nutrient concentrations and algae. Total phosphorus and chlorophyll *a* concentrations were stable during summer 2006. Furthermore, total nitrogen and phosphorus concentrations have not changed over the past quarter century. In general, the quality and clarity of Hilda Lake is good.

Hilda Lake is well protected from acidification; its pH of 8.9 is well above that of pure water (i.e., pH 7; Table 1). Hilda is a hardwater lake: ion concentrations (**Table 1**) are fairly high. Dominant ions include sodium, carbonate, bicarbonate, and magnesium. The concentrations of mineral ions increased over the past quarter century. These ions are supplied by weathering in the watershed and from groundwater inflows. The observed increase in magnesium and sulphate indicate the potential for increased groundwater discharge, relative to surface runoff. Reduced water level can also cause a higher concentration of ions. Due to a 20-year drought, these two scenarios are likely.

The average concentrations of various heavy metals (as total recoverable concentrations) in Hilda Lake during the summer of 2006 were below CCME guidelines for the Protection of Freshwater Aquatic Life. Results of the metal analyses, compared to guideline values, are listed in **Appendix 1**.

Table 1: Mean values from summer 2006 samples compared to values reported previously.

Parameter	1980	1981	2004	2005	2006
Total P (µg/L)	-	26	29	19	20
Total dissolved P (µg/L)	-	13	6.8	6.5	10.6
Chlorophyll-*a* (µg/L)	10	7.2	4.8	3.6	3.0
Secchi disk depth (m)	2.6	2.4	2.8	2.75	2.75
Total N (mg/L)	1.4	1.2	1.4	1.3	1.3
NO_{2+3} (µg/L)	6.4	5.8	3.1	11.7	14
NH_4 (µg/L)	52	65	14	17	18
Dissolved organic C (mg/L)	16	18	21	-	-
Ca (mg/L)	19	20	16	16	18
Mg (mg/L)	38	37	55	53	52
Na (mg/L)	77	72	116	114	116
K (mg/L)	6.9	7.0	10	9.9	10
SO_4 (mg/L)	17	20	38	35	37
Cl (mg/L)	22	21	34	32	32
CO_3 (mg/L)	-	-	47	42	41
HCO_3 (mg/L)	-	-	444	441	445
pH	8.6	8.4	9.0	8.9	8.9
Conductivity (µS/cm)	671	666	892	883	883
Total dissolved solids (mg/L)	419	433	535	518	526
Total suspended solids (mg/L)	2.0	3.2	2.5	-	-
Total Alkalinity (mg/L $CaCO_3$)	325	328	442	431	433

Note: TP = total 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.
*Atlas of Alberta Lakes (Mitchell and Prepas, 1990).

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Appendix 1

Mean concentrations of metals in Hilda Lake during the summers of 1981 and 2006, compared to CCME Guidelines for the Protection of Freshwater Aquatic Life (unless otherwise indicated).

Metals (total)	1981	2004	2005	2006	Guidelines
ALUMINUM ug/L	35	12	5.055	10.975	100[a]
ANTIMONY ug/L	-	0.049	0.045	0.041	6[e]
ARSENIC ug/L	-	2.3	2.21	1.95	5
BARIUM ug/L	-	21	20.75	21.3	1000[e]
BERYLLIUM ug/L	< 1	0.0013	<0.003	<0.003	100[d,f]
BISMUTH ug/L	-	0.0013	0.00475	0.02	-
BORON ug/L	-	265	250.5	278.5	5000[e,f]
CADMIUM ug/L	< 1	0.026	0.0028	0.005	0.085[b]
CHROMIUM ug/L	-	0.61	0.3365	0.3395	-
COBALT ug/L	< 1	0.023	0.014	0.029	1000[f]
COPPER ug/L	0.75	0.46	0.265	0.322	4[c]
IRON ug/L	33	6.2	3.4	8.93	300
LEAD ug/L	5.5	0.125	0.059	0.055	7[c]
LITHIUM ug/L	-	65	65.35	68.65	2500[g]
MANGANESE ug/L	10	3.8	6.935	6.64	200[g]
MOLYBDENUM ug/L	-	0.7	0.647	0.668	73[d]
NICKEL ug/L	< 10	0.0025	<0.005	<0.005	150[c]
SELENIUM ug/L	-	0.21	0.24	0.37	1
SILVER ug/L	< 1	0.00025	0.00245	0.0031	0.1
STRONTIUM ug/L	-	109	104	106	-
THALLIUM ug/L	-	0.0021	0.01335	0.00735	0.8
THORIUM ug/L	-	0.0103	0.1455	0.0088	-
TIN ug/L	-	0.058	0.04	<0.03	-
TITANIUM ug/L	-	0.67	0.697	0.882	-
URANIUM ug/L	-	0.168	0.176	0.176	100[e]
VANADIUM ug/L	0.5	0.363	0.272	0.270	100[f,g]
ZINC ug/L	7.5	7.3	1.55	1.04	30
FLUORIDE mg/L	-	0.26	0.22	-	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).

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

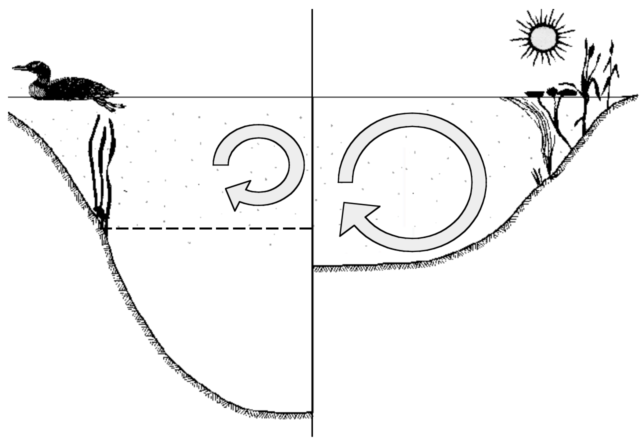

Figure 6: Difference in the circulation of the water column depending on thermal stratification.

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. A third layer, known as the metalimnion, provides an effective barrier between the epi- and hypolimnion. The metalimnion reflects a rapid transition in water temperature known as the **thermocline**. A thermocline typically occurs when water temperature changes by several degrees within one-meter of depth. The thermocline acts as an effective physico-chemical barrier to mixing between the hypolimnion and epilimnion, restricts downward movement of elements, such as oxygen, from the surface 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 state 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 terrestrial plants and plants and algae of tropical lakes, phosphorus is usually in shortest supply in temperate 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, reflect lower-nutrient trophic states than would otherwise result if macrophyte-based chlorophyll were 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 low. Secchi disk depth, however, is not only affected by algae, high concentrations of suspended sediments, particularly fine clays or glacial till common in plains or mountain reservoirs of Alberta, also impact water clarity. 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.

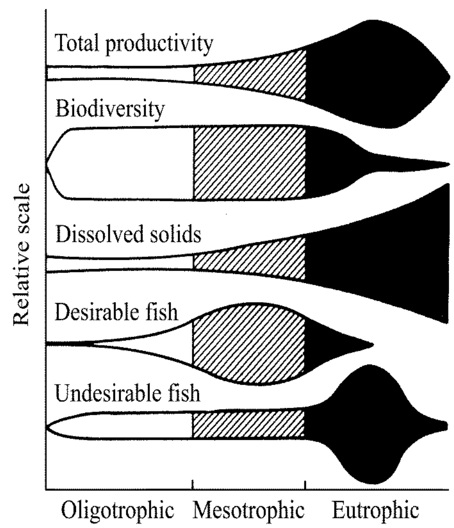

Figure 7: Suggested changes in various lake characteristics with eutrophication. From "Ecological Effects of Wastewater", 1980.

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.

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 and Kerekes (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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