



*THE ALBERTA LAKE MANAGEMENT SOCIETY
VOLUNTEER LAKE MONITORING PROGRAM*

2011 Kehewin Lake 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 data on Alberta Lakes. Equally important is educating lake users about their aquatic environment, encouraging public involvement in lake management, and facilitating cooperation and partnerships between government, industry, the scientific community and lake users. LakeWatch Reports are designed to summarize basic lake data in understandable terms for a lay audience and are not meant to be a complete synopsis of information about specific lakes. Additional information is available for many lakes that have been included in LakeWatch and readers requiring more information are encouraged to seek those sources.

ALMS would like to thank all who express interest in Alberta's aquatic environments and particularly those who have participated in the LakeWatch program. These people prove that ecological apathy can be overcome and give us hope that our water resources will not be the limiting factor in the health of our environment.

Acknowledgements

The LakeWatch program is made possible through the dedication of its volunteers. We would like to thank Ken Dion for coordinating the sampling of Kehewin Lake in 2011. We would also like to thank Jessica Davis and Pauline Pozsonyi who were summer interns with ALMS in 2011. Program Coordinator Bradley Peter was instrumental in planning and organizing the field program. Technologists Shelley Manchur and Brian Jackson were involved in the training aspects of the program. Doreen LeClair, Chris Rickard, and Lisa Reinbolt were responsible for data management. The 2012 report was prepared by Bradley Peter and Arin Dyer. Alberta Environment, the Beaver River Watershed Alliance (BRWA), and the Municipal District of Wainwright were major sponsors of the LakeWatch program.

KEHEWIN LAKE:

Kehewin Lake is a long, beautiful lake located on Highway 41 north of Elk Point. The lake is surrounded by rolling pasture and hay lands. Kehewin Lake has two recreational facilities: one located on the southeast shore just off Highway 41, and the other located on the southwest shore.

Alternate spellings for Kehewin Lake are found in various literatures – spellings even differ on the two highway signs for the lake. “*Kehew*” is a Cree word meaning eagle, suggesting that “Kehewin” is the most appropriate spelling¹. Kehewin Lake is named after the Indian Chief who signed treaty No.6 for The Kehewin Indian Reserve No.123 in 1876². The Kehewin Indian Reserve is 8212.2 ha to the north of the lake, with 863 residents of 1,581 members in October 2002. The reserve is in the county of Bonnyville, but most of the lake is within the County of St. Paul.

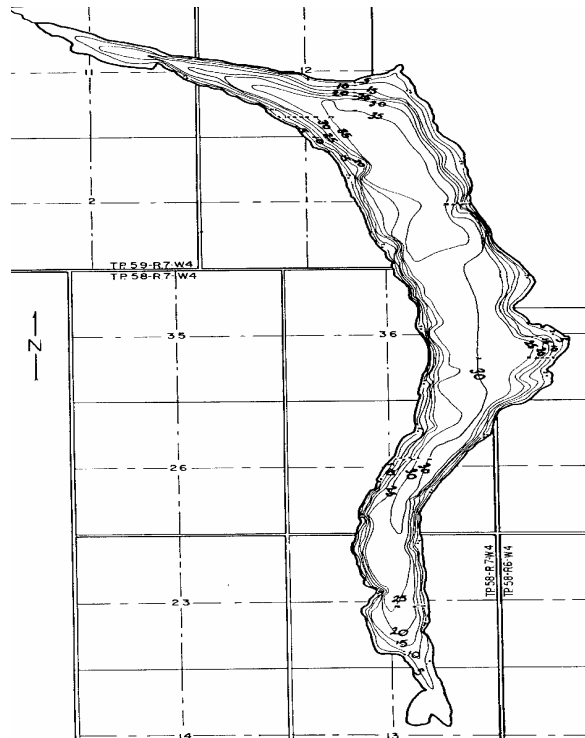


Figure 1 – Bathymetric map of Kehewin Lake. Contours in five foot intervals.



Figure 2 – Kehewin Lake sunset. Photo by Heather Jones, 2004.

Kehewin Lake is very shallow in the north and south portions. The lake is situated within the Beaver River drainage basin, which is in the Moose Lake watershed, in the westernmost part of the Churchill River system. The outflow of Kehewin Lake drains into Bangs Lake to the north via Kehewin Creek, then joins with Yelling Creek and flows into Thin Lake, finally draining into Moose Lake via Thin Lake River.

Agriculture in Kehewin’s drainage basin is limited to pasture and hay fields. The drainage basin overlies geological

¹ Ken Dion. 2002. Personal Communication.

² Mitchell, P. and E. Prepas. 1990. Atlas of Alberta Lakes, University of Alberta Press. Retrieved from <http://sunsite.ualberta.ca/projects/alberta-lakes/>

formations that are rich in heavy oils, thus oil extraction is common in the area. Kehewin Lake lies in a large melt-water channel predominated by glacial till and alluvial deposits¹. It is surrounded by rough, broken land with steep slopes dominated by aspen (*Populus* spp.). Extensive marshes on the north and south ends of the lake provide excellent habitat for waterfowl.

Marsh vegetation includes reed grass (*Calamagrostis* spp.), bulrush (*Scirpus* spp.), sedge (*Carex* spp.), cattail (*Typha latifolia*), and arrowhead (*Sagittaria cuneata*). Common submerged and floating aquatic plants include water smartweed (*Polygonum natans*), coontail (*Ceratophyllum demersum*), Richardson's pondweed (*Potamogeton richardsonii*), northern watermilfoil (*Myriophyllum exalbescens*), sago pondweed (*Potamogeton pectinatus*), large-sheath pondweed (*Potamogeton vaginatus*), and duckweed (*Lemna* spp.)². Little is known about the phytoplankton community composition, though dense blue-green algal blooms have occurred in the past.

As a popular sport fishing lake, Kehewin is noted for its large northern pike. Also present are yellow perch (*Perca flavescens*), walleye (*Sander vitreus*), cisco (*Coregonus artedii*), burbot (*Lota lota*), and white suckers (*Catostomus commersonii*). Commercial and domestic fishing has been active in the last decade, and commercial fishing has been recorded as far back as 1945².

WATER QUANTITY:

There are many factors influencing water quantity. Some of these factors include the size of the lakes drainage basin, precipitation, evaporation, water consumption, ground water influences, and the efficiency of the outlet channel structure at removing water from the lake.

Water levels at Kehewin Lake have remained relatively stable since monitoring began in 1967. Fluctuations have ranged between a maximum of 540.4 meters above sea level (m asl) in 1997 to a minimum of 538.9 m asl in 1993. Kehewin Lake receives a steady inflow of water because its drainage basin is very large (156 km²) as compared to its surface area (7.4 km²).

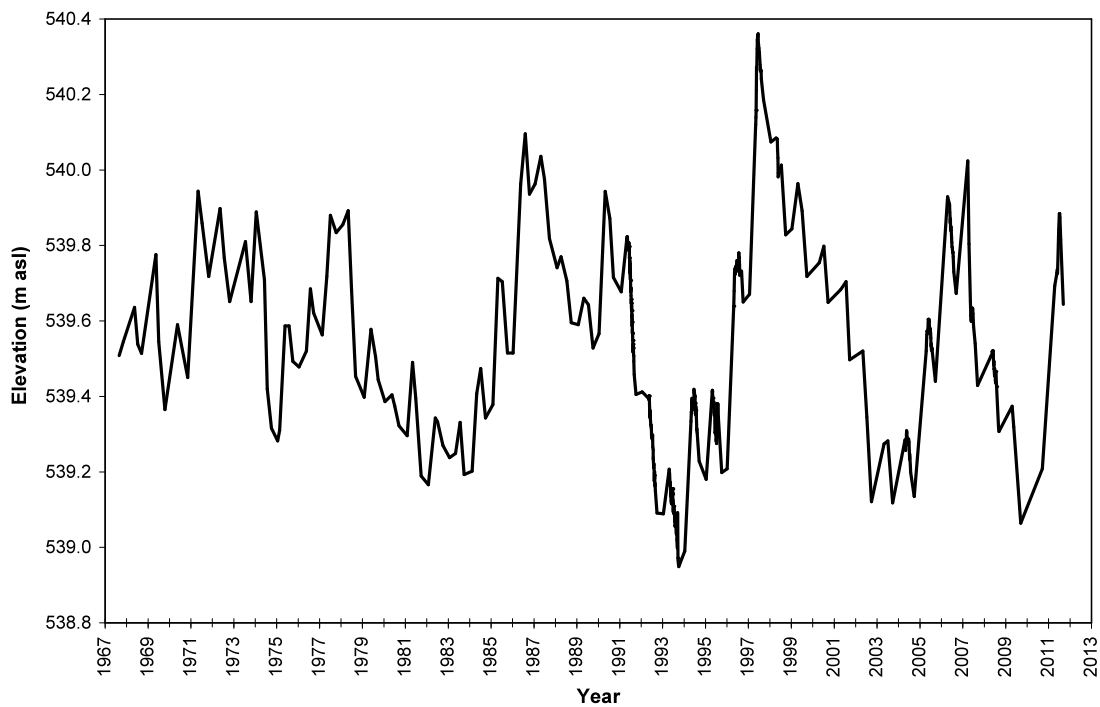


Figure 3 – Water levels measured in meters above sea level (m asl) for Kehewin Lake. Data obtained from Alberta Environment.

WATER CLARITY AND SECCHI DEPTH:

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

Secchi disk depth at Kehewin Lake was poor during the summer of 2011, though well within the natural variation previously measured. On average, Secchi disk depth was 1.5 m. Multiplying this value by two provides the euphotic depth (3.0 m): the depth to which enough light remains for photosynthesis. Thus, there is enough surface light remaining for photosynthesis for the first 1/3rd of the water column. Throughout the summer, Secchi disk depth ranged from a minimum of 0.5 m on July 19th to a maximum of 2.75 m on August 18th. It is likely that algae/cyanobacteria blooms are the primary factor affecting water transparency at Kehewin Lake (Figure 4).



Figure 4 – A photograph of the lake's surface during a large surface bloom on July 19th. Photo by Pauline Pozsonyi.

WATER TEMPERATURE AND DISSOLVED OXYGEN

Water temperature and dissolved oxygen profiles in the water column can provide information on water quality and fish habitat. The depth of the thermocline is important in determining the depth to which dissolved oxygen from the surface can be mixed. Please refer to the end of this report for descriptions of technical terms.

Surface water temperatures measured during the summer of 2011 were quite high, ranging from 19.92 °C on August 18th to 21.79 °C on July 19th (Figure 5a). With decreasing depth, temperature remained quite uniform, often changing only five degrees from the surface to the lakebed. Thermal stratification was weak and deep in Kehewin Lake. The most prominent stratification was observed on June 28th between 7.5-8.5 m.

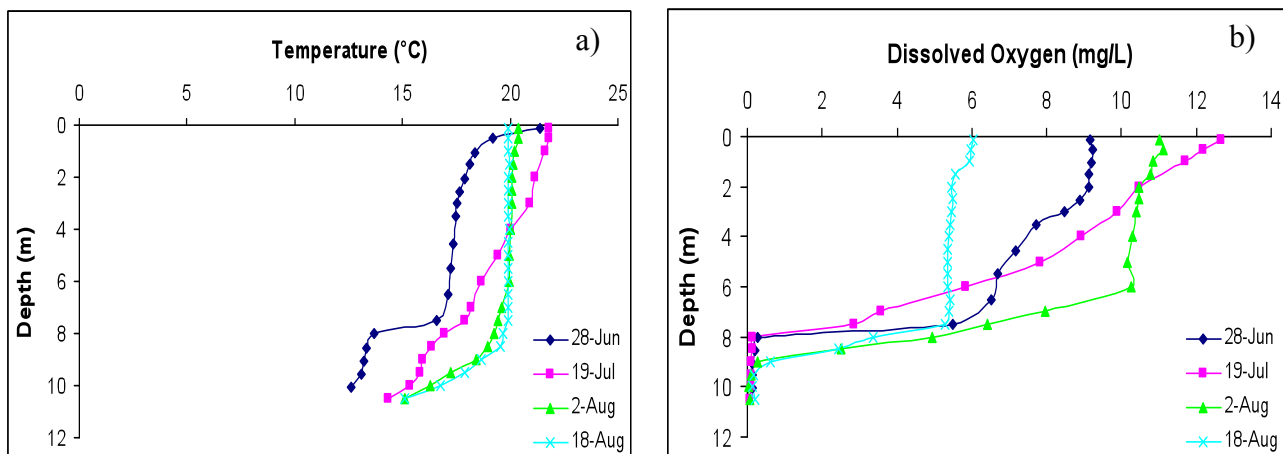


Figure 5 – a) Water temperature and b) dissolved oxygen measured four times at Kehewin Lake during the summer of 2011.

Dissolved oxygen at Kehewin Lake varied greatly throughout the summer. On July 19th, surface dissolved oxygen was at a maximum of 12.66 mg/L, which proceeded towards anoxia by 8.0 m (Figure 5b). High levels of oxygen are typical of algae/cyanobacteria blooms due to the high amounts of photosynthesis. In contrast, on August 18th, surface dissolved oxygen was at a minimum of 6.05 mg/L, which proceeded to anoxia at the lakebed. This is a dramatic decrease from the July 19th levels, and falls below the Canadian Council for Ministers of the Environment guideline of 6.5 mg/L for the Protection of Aquatic Life. Low levels of oxygen are often due to high amounts of decomposition, in particular the decomposition of algae or cyanobacteria.

WATER CHEMISTRY:

ALMS measures a suite of water chemistry parameters. Phosphorous, nitrogen, and chlorophyll-a are important because they are indicators of eutrophication, or excess nutrients, which can lead to harmful algal/cyanobacteria blooms. One direct measure of harmful cyanobacteria blooms are Microcystins, a common group of toxins produced by cyanobacteria. See Table 1 for a complete list of parameters.

Average Total Phosphorous (TP) measured 117 $\mu\text{g/L}$, which falls into the hypereutrophic, or extremely productive, classification (Figure 5). Throughout the summer, TP ranged from 92.0 $\mu\text{g/L}$ on June 28th to 136 $\mu\text{g/L}$ on August 2nd. Compared to previous years, a value of 117 $\mu\text{g/L}$ actually falls very close to the historical average (116 $\mu\text{g/L}$). Average Total Kjeldahl Nitrogen (TKN) measured 2070 $\mu\text{g/L}$ in 2011 – this is the highest TKN value recorded at Kehewin Lake. Throughout the summer, TKN ranged from 1530 $\mu\text{g/L}$ on June 28th to 2510 $\mu\text{g/L}$ on July 19th. Finally, average chlorophyll-*a* concentration measured at Kehewin Lake was 131.9 $\mu\text{g/L}$, which is also the highest in recorded history at Kehewin Lake. This value is approximately 4-times the historical average – and is the result of a large algae/cyanobacteria bloom during July, which had a chlorophyll-*a* concentration of 441 $\mu\text{g/L}$.

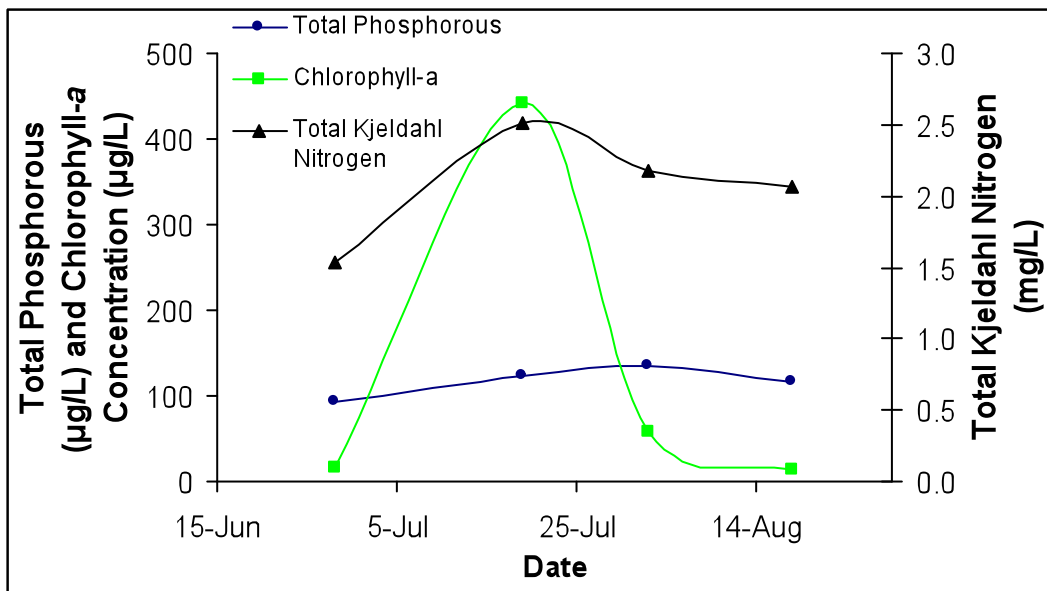


Figure 6 – Total phosphorous ($\mu\text{g/L}$), chlorophyll-*a* ($\mu\text{g/L}$), and total Kjeldahl nitrogen ($\mu\text{g/L}$) measured at Kehewin Lake during the summer of 2011.

Average pH measured at Kehewin Lake in 2011 was 8.99. This is well above neutral, which is common in many Alberta lakes. The high pH is likely maintained by high alkalinity (215 mg/L CaCO_3) and high bicarbonate concentration (221 mg/L HCO_3^-) which help to buffer the lake against changes to pH. The concentration of other ions in the lake is low, resulting in a low conductivity (480 $\mu\text{S/cm}$). Metals were also measured twice during the summer, and all values fell within their respective guidelines (Table 2).

Table 1 – Average Secchi depth and water chemistry values for Kehewin Lake. Previous years averages are provided for comparison.

Parameter	2002	2003	2004	2004	2005	2007	2008	2009	2011
TP (µg/L)	106	105	36	123	98	170.8	162.3	130	117
TDP (µg/L)	65	62	31	67	33	116.3	126.7	52.5	45.3
Chlorophyll- <i>a</i> (µg/L)	30	49	1.3	45	40	50.7	19.58	32.9	131.9
Secchi depth (m)	2.1	1.9		1.9	1.9	1.1	2.9	1.13	1.5
TKN (µg/L)	1.4	1.4	1.3	1.5	1.4	1.9	1.6	1.8	2.07
NO ₂ and NO ₃ (µg/L)	20	19	270	35	14	101	19	5	7.5
NH ₃ (µg/L)	149	69	67	65	15	89	261	23.5	90.3
DOC (mg/L)	/	/	/	/	/	13.6	13.9	13.9	14.45
Ca (mg/L)	25	26	29	24	26	24.2	25.2	25.3	22.2
Mg (mg/L)	29	29	33	25	30	28.3	26.8	29	28.1
Na (mg/L)	32	35	39	36	35	36.2	34.1	35.4	34.5
K (mg/L)	14	12	14	12	13	13.1	13.5	11.9	13.05
SO ₄ ²⁻ (mg/L)	20	27	33	28	26	22.7	26	17	14
Cl ⁻ (mg/L)	16	16	18	17	17	18.9	19.2	19.7	20.65
CO ₃ (mg/L)	6.2	14	6.7	14	17	14	20	21	19.75
HCO ₃ (mg/L)	189	245	284	238	234	226.3	228.5	228	221
pH	8.5	8.7	8.4	8.7	8.8	8.7	8.9	8.93	8.99
Conductivity (µS/cm)	/	/	/	/	/	481	499	485	480
Hardness (mg/L)		184		166	191	177	173	/	171
TDS (mg/L)	/	/	/	/	/	269.3	277.5	272	262
Microcystin (µg/L)	/	/	/	/	0.28	0.54	0.56	/	0.16
Total Alkalinity (mg/L CaCO ₃)	165	224	243	218	220	209	221	222	215

Note: TP = total phosphorous, TDP = total dissolved phosphorous, Chl-*a* = chlorophyll-*a*, TKN = total Kjeldahl nitrogen. NO₂₊₃ = nitrate+nitrite, NH₃ = ammonia, Ca = calcium, Mg = magnesium, Na = sodium, K = potassium, SO₄ = sulphate, Cl = chloride, CO₃ = carbonate, HCO₃ = bicarbonate. A forward slash (/) indicates an absence of data.

Table 2 - Concentrations of metals measured in Kehewin Lake on July 19th. Values shown for 2011 are an average of those dates. The CCME heavy metal Guidelines for the Protection of Freshwater Aquatic Life (unless otherwise indicated) are presented for reference.

Metals (Total Recoverable)	2003	2004	2005	2007	2008	2009	2011	Guidelines
Aluminum µg/L	24	13	8.8	23.4	12.3	13.2	11.8	100 ^a
Antimony µg/L	0.072	0.1	0.105	0.09	0.088	0.092	0.0812	6 ^e
Arsenic µg/L	2.1	2	1.84	2.17	2.5	2.84	2.14	5
Barium µg/L	54	56	58	50.9	51.7	52.3	55.5	1000 ^e
Beryllium µg/L	0.037	0.0015	0.0015	<0.003	<0.003		0.0015	100 ^{d,f}
Bismuth µg/L	0.0037	0.0005	0.054	0.002	<0.001	0.0273	0.0005	/
Boron µg/L	84	87	81	79	89	88	100	5000 ^{ef}
Cadmium µg/L	0.02	0.0016	0.0043	0.017	0.0071	0.0137	0.0064	0.085 ^b
Chromium µg/L	0.18	0.25	0.21	0.244	0.324	0.261	0.269	/
Cobalt µg/L	0.04	0.037	0.04	0.056	0.0379	0.0525	0.0532	1000 ^f
Copper µg/L	0.43	0.52	0.47	1.31	0.675	0.439	0.351	4 ^c
Iron µg/L	27	7.7	3.4	19.2	10.55	9.3	24.6	300
Lead µg/L	0.11	0.042	0.354	0.07	0.0467	0.0708	0.0275	7 ^c
Lithium µg/L	26	29	26	26.5	27.3	29.3	36.8	2500 ^g
Manganese µg/L	30	26	32	23.9	25.6	32.5	14.5	200 ^g
Molybdenum µg/L	0.8	0.83	0.82	0.77	0.748	0.767	0.647	73 ^d
Nickel µg/L	0.15	0.16	0.18	0.27	0.373	0.182	0.283	150 ^c
Selenium µg/L	0.42	0.05	0.2	0.35	0.183	0.214	0.327	1
Silver µg/L	/	/	/	0.005	<0.0005	0.00115	0.00025	0.1
Strontium µg/L	229	235	226	214	208	222	226	/
Thallium µg/L	0.093	0.001	0.022	0.002	0.0005	0.0131	0.0006	0.8
Thorium µg/L	0.012	0.004	0.06	0.005	0.0014	0.0033	0.0105	/
Tin µg/L	0.05	0.026	0.015	<0.03	<0.03	0.0358	0.015	/
Titanium µg/L	1.23	1.33	0.98	1.8	0.878	1.42	0.777	/
Uranium µg/L	0.57	0.6	0.64	0.56	0.617	0.678	0.6	100 ^e
Vanadium µg/L	0.66	0.56	0.4	0.45	0.426	0.458	0.369	100 ^{f,g}
Zinc µg/L	2	11.8	2.8	1.03	0.646	0.148	0.386	30

Values represent means of total recoverable metal concentrations.

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

^b Based on water Hardness of 300 mg/L (as CaCO₃)

^c Based on water hardness > 180mg/L (as CaCO₃)

^d CCME interim value.

^e Based on Canadian Drinking Water Quality guideline values.

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

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

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

A BRIEF INTRODUCTION TO LIMNOLOGY

INDICATORS OF WATER QUALITY:

Water samples are collected in LakeWatch to determine the chemical characteristics that characterize general water quality. Though not all encompassing, the variables collected in LakeWatch are sensitive to human activities in watersheds that can cause degraded water quality. For example, nutrients such as phosphorus and nitrogen are important determinants of lake productivity. The concentrations of these nutrients in a lake are impacted (typically elevated) by land use changes such as increased crop production or livestock grazing. Elevated nutrient concentrations can cause increases in undesirable algae blooms resulting in low dissolved oxygen concentrations, degraded habitat for fish and noxious smells. A large increase in nutrients over time may also indicate sewage inputs which in turn may result in other human health concerns associated with bacteria or the protozoan *Cryptosporidium*.

TEMPERATURE AND MIXING:

Water temperature in a lake dictates the behavior of many chemical parameters responsible for water quality. Heat is transferred to a lake at its surface and slowly moves downward depending on water circulation in the lake. Lakes with a large surface area or a small volume tend to have greater mixing due to wind. In deeper lakes, circulation is not strong enough to move warm water to depths typically greater than 4 or 5 m and as a result cooler denser water remains at the bottom of the lake.

As the difference in temperature between warm surface and cold deeper water increases, two distinct layers are formed. Limnologists call these layers of water the **epilimnion** at the surface and the **hypolimnion** at the bottom. The layers are separated by a transition layer known as the **metalimnion** which contains the effective wall separating top and bottom waters called a **thermocline**. A thermocline typically occurs when water temperature changes by more than one degree within one meter depth. The hypolimnion and epilimnion do not mix, nor do elements such as oxygen supplied at the surface move downward into the hypolimnion. In the fall, surface waters begin to cool and eventually reach the same temperature as hypolimnetic water. At this point the water mixes from top to bottom in what is often called a **turnover** event. Surface water cools further as ice

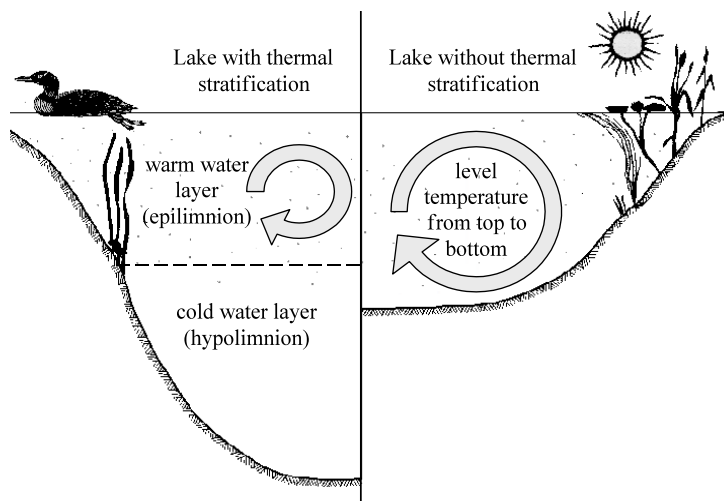


Figure A: Difference in the circulation of the water column depending on thermal stratification.

forms and again a thermocline develops this time with 4° C water at the bottom and near 0° C water on the top.

In spring another turnover event occurs when surface waters warm to 4° C. Lakes with this mixing pattern of two stratification periods and two turnover events are called **dimictic** lakes. In shallower lakes, the water column may mix from top to bottom most of the ice-free season with occasional stratification during periods of calm warm conditions. Lakes that mix frequently are termed **polymictic** lakes. In our cold climate, many shallow lakes are **cold monomictic** meaning a thermocline develops every winter, there is one turnover event in spring but the remainder of the ice free season the lake is polymictic.

DISSOLVED OXYGEN:

Oxygen enters a lake at the lake surface and throughout the water column when produced by photosynthesizing plants, including algae, in the lake. Oxygen is consumed within the lake by respiration of living organisms and decomposition of organic material in the lake sediments. In lakes that stratify (see temperature above), oxygen that dissolves into the lake at the surface cannot mix downward into the hypolimnion. At the same time oxygen is depleted in the hypolimnion by decomposition. The result is that the hypolimnion of a lake can become **anoxic**, meaning it contains little or no dissolved oxygen. When a lake is frozen, the entire water column can become anoxic because the surface is sealed off from the atmosphere. Winter anoxic conditions can result in a fish-kill which is particularly common during harsh winters with extended ice-cover. Alberta Surface Water Quality Guidelines suggest dissolved oxygen concentrations (in the epilimnion) must not decline below 5 mg•L⁻¹ and should not average less than 6.5 mg•L⁻¹ over a seven-day period. However, the guidelines also require that dissolved oxygen concentrations remain above 9.5 mg•L⁻¹ in areas where early life stages of aquatic biota, particularly fish, are present.

GENERAL WATER CHEMISTRY:

Water in lakes always contains substances that have been transported by rain and snow or have entered the lake in groundwater and inflow streams. These substances may be dissolved in the water or suspended as particles. Some of these substances are familiar minerals, such as sodium and chloride, which when combined form table salt, but when dissolved in water separate into the two electrically charged components called **ions**. Most dissolved substances in water are in ionic forms and are held in solution due to the polar nature of the water molecule. **Hydrophobic** (water-fearing) compounds such as oils contain little or no ionic character, are non-polar and for this reason do not readily dissolve in water. Although hydrophobic compounds do not readily dissolve, they can still be transported to lakes by flowing water. Within individual lakes, ion concentrations vary from year to year depending on the amount and mineral content of the water entering the lake. This mineral content can be influenced by the amount of precipitation and other climate variables as well as human activities such as fertilizer and road salt application.

PHOSPHORUS AND NITROGEN:

Phosphorus and nitrogen are important nutrients limiting the growth of algae in Alberta lakes. While nitrogen usually limits agricultural plants, phosphorus is usually in shortest supply in lakes. Even a slight increase of phosphorus in a lake can, given the right conditions, promote algal blooms causing the water to turn green in the summer and impair recreational uses. When pollution originating from livestock manure and human sewage enters lakes not only are the concentrations of phosphorus and nitrogen increased but nitrogen can become a limiting nutrient which is thought to cause blooms of toxic algae belonging to the cyanobacteria. Not all cyanobacteria are toxic, however, the blooms can form decomposing mats that smell and impair dissolved oxygen concentrations in the lake.

CHLOROPHYLL-*a*:

Chlorophyll *a* is a photosynthetic pigment that green plants, including algae, possess enabling them to convert the sun's energy to living material. Chlorophyll *a* can be easily extracted from algae in the laboratory. Consequently, chlorophyll *a* is a good estimate of the amount of algae in the water. Some highly productive lakes are dominated by larger aquatic plants rather than suspended algae. In these lakes, chlorophyll *a* and nutrient values taken from water samples do not include productivity from large aquatic plants. The result, in lakes like Chestermere which are dominated by larger plants known as macrophytes, can be a lower trophic state than if macrophyte biomass was included. Unfortunately, the productivity and nutrient cycling contributions of macrophytes are difficult to sample accurately and are therefore not typically included in trophic state indices.

SECCHI DISK TRANSPARENCY :

Lakes that are clear are more attractive for recreation, whereas those that are turbid or murky are considered by lake users to have poor water quality. A measure of the transparency or clarity of the water is performed with a Secchi disk with an alternating black and white pattern. To measure the clarity of the water, the Secchi disk is lowered down into the water column and the depth where the disk disappears is recorded. The Secchi depth in lakes with a lot of algal growth will be small while the Secchi depth in lakes with little algal growth can be very deep. However, low Secchi depths are not caused by algal growth alone. High concentrations of suspended sediments, particularly fine clays or glacial till, are common in plains or mountain reservoirs of Alberta. Mountain reservoirs may have exceedingly low Secchi depths despite low algal growth and nutrient concentrations.

The euphotic zone or the maximum depth that light can penetrate into the water column for actively growing plants is calculated as twice the Secchi depth. Murky waters, with shallow Secchi depths, can prevent aquatic plants from growing on the lake bottom. Conversely, aquatic plants can ensure lakes have clear water by reducing shoreline erosion and stabilizing lake bottom sediments. In Alberta, many lakes are shallow and

bottom sediments contain high concentrations of nutrients. Without aquatic plants, water quality may decline in these lakes due to murky, sediment laden water and excessive algal blooms. Maintaining aquatic plants in certain areas of a lake is often essential for ensuring good water clarity and a healthy lake as many organisms, like aquatic invertebrates and insects, depend on aquatic plants for food and shelter.

TROPHIC STATE:

Trophic state is classification of lakes into four categories of fertility and is a useful index for rating and comparing lakes. From low to high nutrient and algal biomass (as chlorophyll) concentrations, the trophic states are; **oligotrophic**, **mesotrophic**, **eutrophic** and **hypereutrophic** (Table 2).

A majority of lakes in Alberta contain naturally high levels of chlorophyll *a* (8 to 25 µg/L) due to our deep fertile soils. These lakes are usually considered fertile and are termed eutrophic. The nutrient and algal biomass concentrations that define these categories are shown in the following table, a figure of Alberta lakes compared by trophic state can be found on the ALMS website.

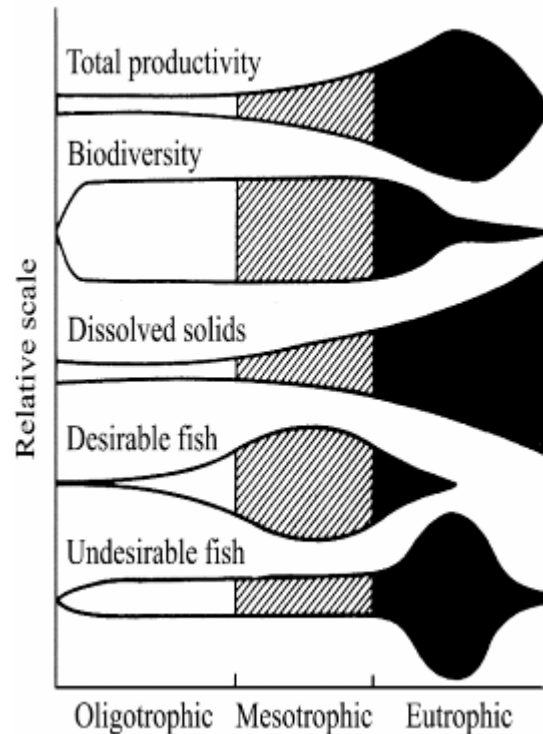


Figure B: Suggested changes in various lake characteristics with eutrophication. From “Ecological Effects of Wastewater”, 1980.

Table A - Trophic status classification based on lake water characteristics.

Trophic state	Total Phosphorus (µg•L ⁻¹)	Total Nitrogen (µg•L ⁻¹)	Chlorophyll a (µg•L ⁻¹)	Secchi Depth (m)
Oligotrophic	< 10	< 350	< 3.5	> 4
Mesotrophic	10 – 30	350 - 650	3.5 - 9	4 - 2
Eutrophic	30 – 100	650 - 1200	9 - 25	2 - 1
Hypereutrophic	> 100	> 1200	> 25	< 1