THE ALBERTA LAKE MANAGEMENT SOCIETY
VOLUNTEER LAKE MONITORING PROGRAM

2012 Cow 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 Jaye Pastuck, Amiee Delaney, and Gary Lewis for their assistance with sampling Cow Lake in 2012. We would also like to thank Randi Newton and Erin Rodger who were summer technicians with ALMS in 2012. Program Coordinator Bradley Peter was instrumental in planning and organizing the field program. Technologists Trina Ball and Brian Jackson were involved in the training aspects of the program. Lisa Reinbolt was responsible for data management. This report was prepared by Bradley Peter and Arin Dyer. Alberta Environment and the Beaver River Watershed Alliance (BRWA) were major sponsors of the program.

COW LAKE:

Figure 1 – Photograph of Cow Lake taken by Erin Rodger, 2012.

Cow Lake, which flows into the North Saskatchewan River via Cow Creek, is a moderately sized (~8.33 km^2), shallow lake (maximum depth: 2.7 m, average depth: 1.5 m) located 13 km southwest of Rocky Mountain House, Alberta. Lying in the lower-foothills, Cow Lake's drainage basin area measures only 18 km^2. Cow Lake is a popular recreation destination, with the Cow Lake Municipal Campground, owned by Clear Water County, situated on the west side of the lake – this facility hosts 110 campsites, a boat launch, a day-use area, and a beach. Access to the lake is also available on the north shore via a boat launch in the Cow Lake Natural Area and Day Use Area.

Cow Lake was a popular and successful rainbow trout fishery for many years – however, in 1993 the illegal introduction of yellow perch into the lake had a negative impact on rainbow trout populations. Because of this, stocking of large amounts of rainbow trout was discontinued, however small numbers of brood rainbow trout are still stocked in attempt to control the yellow perch population; in 2012, 693 individuals were added to Cow Lake. In addition, in 2006, northern pike were introduced as a predator species in attempt to balance fish populations. In 2010 the northern pike drew attention when pike with lymphosarcoma were discovered in the lake – this disease results in large lesions and tumours on the fish's body. Lymphosarcoma is not expected to greatly impact the overall pike population as pike generally recover from infection; however, consumption of infected fish is not recommended. Today, northern pike, rainbow trout, and yellow perch can be fished from Cow Lake.

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 Cow Lake have been monitored regularly since 1970 (Figure 1). Throughout the years, water levels have remained relatively stable, fluctuating between a maximum of 1036.243 m asl which was observed in 2011, and a minimum of 1034.894

which was observed in 1994. In 2012, water levels measured an average of 1036.036 m asl. No obvious trends are apparent in Cow Lake's water levels.

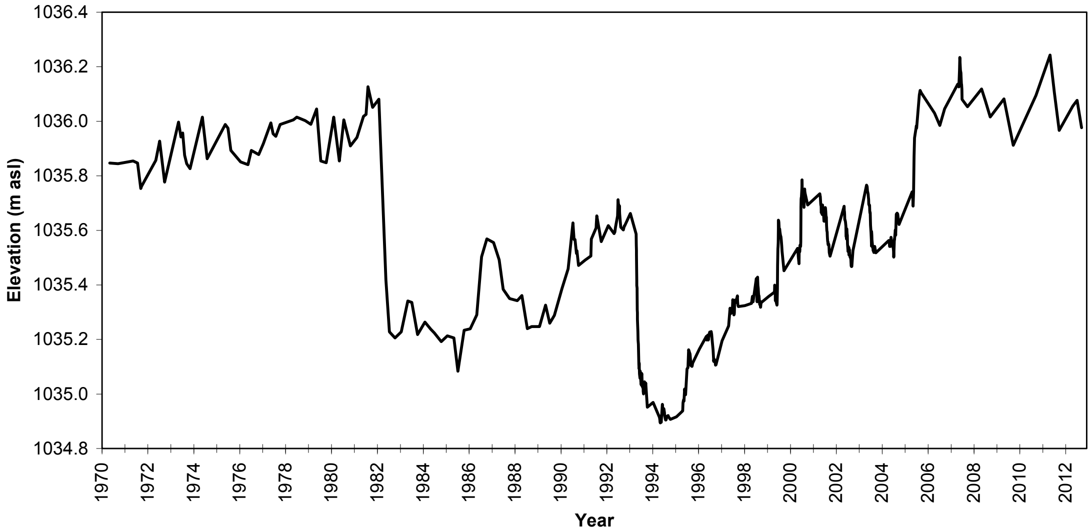

Figure 2 - Water levels measured at Cow Lake in meters above sea level (m asl) from 1970 to 2012. Data retrieved from Alberta Environment.

WATER CLARITY & 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.

Average Secchi disk depth measured 1.73 m in 2012 (Table 1); this value is lower than that measured in 2008. A maximum water clarity of 2.60 m was observed on June 4th, while a minimum water clarity of 1.25 m was observed on August 28th and September 14th. It is typical for water clarity to decrease throughout the summer as concentrations of algae/cyanobacteria increase; at Cow Lake, decreases in Secchi disk depth appeared closely correlated with increases in algae/cyanobacteria.

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 temperature varied throughout the summer from a minimum of 14.29 °C on June 4th to a maximum of 22.11 °C on July 9th. Throughout the water column, temperature changed very little – this is to be expected from a shallow lake, as wind energy is able to mix the entire water column.

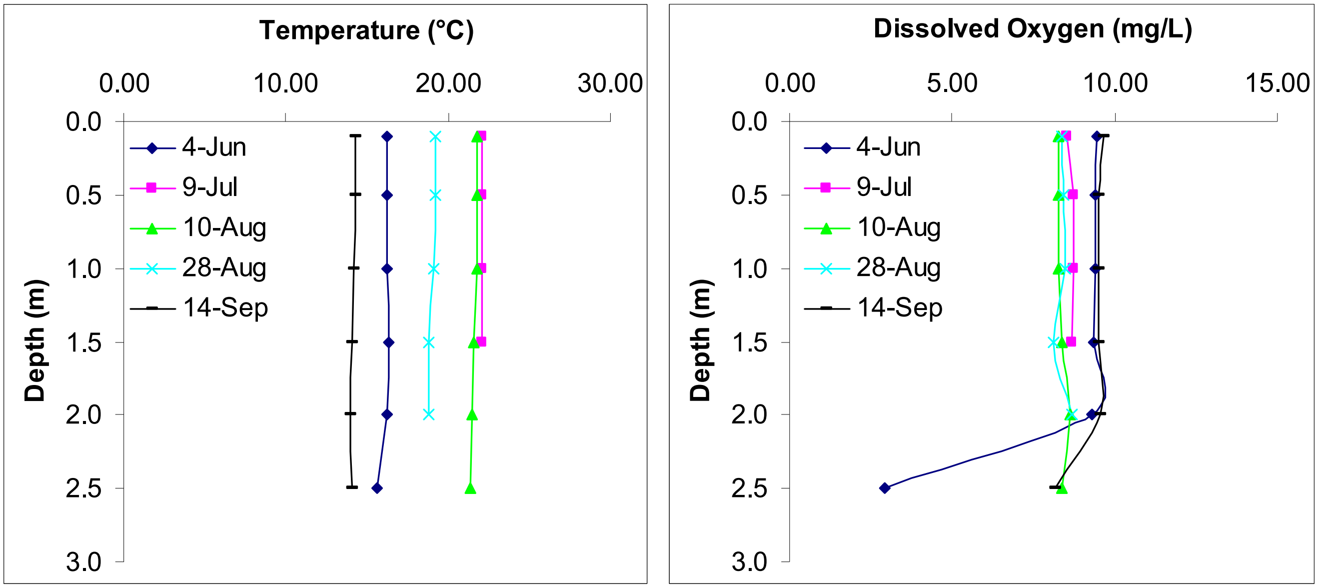

Figure 3 – a) Temperature (°C) and b) dissolved oxygen (mg/L) profiles measured five times throughout the summer at Cow Lake.

Surface dissolved oxygen concentrations remained well above the Canadian Council for Ministers of the Environment Guidelines of 6.5 mg/L for the Protection of Aquatic Life. Decreases in dissolved oxygen concentrations near the lakebed were observed on two of the five sampling trip – this is a common occurrence as oxygen-consuming decomposition occurs at the sediment-lake interface. Dissolved oxygen concentrations varied between a minimum of 8.26 mg/L on August 10th and a maximum of 9.64 mg/L on September 14th.

WATER CHEMISTRY:

ALMS measures a suite of water chemistry parameters. Phosphorus, 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 Phosphorus (TP) measured at Cow Lake in 2012 was 17.4 μg/L – this value falls into the mesotrophic, or moderately productive, classification (Table 1). This value is slightly higher than that measured in 1995 and 2008, though in all instances Cow Lake has fallen into the mesotrophic classification (Table 1). TP concentration increased throughout the summer, measuring a minimum of 11 µg/L on June 4th, and a maximum of 24 µg/L on September 14th; it is common for TP to increase throughout the summer as phosphorus is released from the sediment and mixed into the water column.

Average chlorophyll-*a* concentration measured 6.07 µg/L in 2012 – this value falls into the mesotrophic, or moderately productive classification. Compared to 1995 and 2008 this value is much higher, though is still a relatively low concentration of chlorophyll-*a*. Throughout the summer, chlorophyll-*a* concentration ranged from a minimum of 2.10 µg/L on June 4th to a maximum of 10.40 µg/L on September 14th.

In 2012, the average concentration of total Kjeldahl nitrogen (TKN) measured 1040 µg/L; in contrast, TKN measured 750.4 µg/L in 2008. TKN ranged from a minimum of 840 µg/L on June 4th to 1300 µg/L on September 14th.

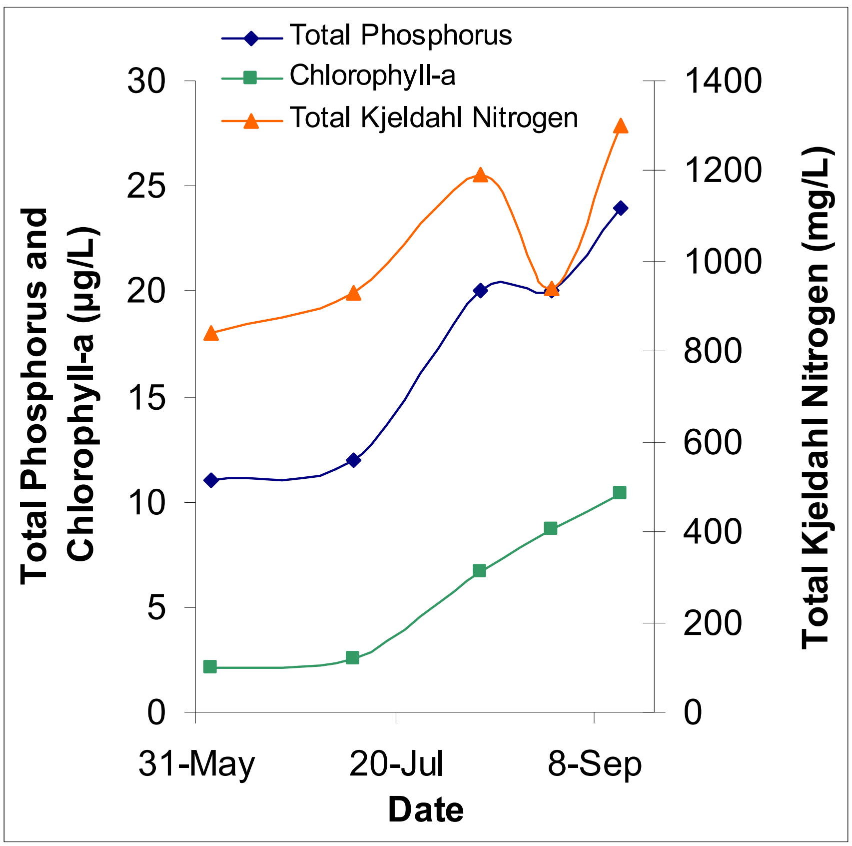

Figure 4 –Total phosphorus (µg/L), chlorophyll-*a* concentration (µg/L), and total Kjeldahl nitrogen (µg/L) measured five times over the course of the summer at Cow Lake.

Average pH of Cow Lake measured 8.34 in 2012, well above neutral (7.00; Table 1). Cow Lake has moderately high alkalinity (138.4 mg/L $CaCO_3$) and bicarbonate (166.6 mg/L HCO_3) concentration which will help to buffer the lake against changes to pH. Conductivity in Cow Lake measured 262.4 µS/cm – dominant ions contributing to conductivity include calcium (29.77 mg/L) and magnesium (12.03 mg/L). Microcystin, a toxin produced by cyanobacteria, had an average concentration of 0.081, which is well below both drinking water (1.0 µg/L) and recreational water quality (20 µg/L) guidelines.

Metal concentrations were measured twice at Cow Lake, and all concentrations fell below their recommended guidelines (Table 2).

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

Parameter	1995	2008	2012
TP (µg/L)	15.7	10.7	17.4
TDP (µg/L)	/	4.7	8.0
Chlorophyll-*a* (µg/L)	2.51	1.99	6.07
Secchi depth (m)	/	2.88	1.73
TKN (µg/L)	/	750.4	1040
NO_2 and NO_3 (µg/L)	6.33	3	4.6
NH_3 (µg/L)	/	9.3	82
DOC (mg/L)	/	/	10.3
Ca (mg/L)	20.43	23.9	29.8
Mg (mg/L)	12.42	11.8	12.0
Na (mg/L)	9.7	9	10.2
K (mg/L)	2.1	2.07	2.4
SO_4^{2-} (mg/L)	1.86	1.17	1.5
Cl^- (mg/L)	1.7	2.7	4.2
CO_3 (mg/L)	3.5	2.5	1.4
HCO_3 (mg/L)	143	145	166.6
pH	8.44	8.43	8.34
Conductivity (µS/cm)	226	237	262
Hardness (mg/L)	102.9	108.3	124
TDS (mg/L)	122.6	124	143.7
TSS	/	/	4.24
Microcystin (µg/L)	/	0.073	0.081
Total Alkalinity (mg/L $CaCO_3$)	122.4	122.7	138.4

Note: TP = total phosphorus, TDP = total dissolved phosphorus, Chl-*a* = chlorophyll-*a*, TKN = total Kjeldahl nitrogen. NO_{2+3} = nitrate+nitrite, NH_3 = ammonia, Ca = calcium, Mg = magnesium, Na = sodium, K = potassium, SO_4 = sulphate, Cl = chloride, CO_3 = carbonate, HCO_3 = bicarbonate. A forward slash (/) indicates an absence of data.

Table 2 - Concentrations of metals measured in Cow Lake on August 10th and September 14st 2012. Values shown for 2012 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)	2012	Guidelines
Aluminum µg/L	8.615	100[a]
Antimony µg/L	0.0281	6[e]
Arsenic µg/L	0.601	5
Barium µg/L	114.5	1000[e]
Beryllium µg/L	0.0015	100[d,f]
Bismuth µg/L	0.0005	/
Boron µg/L	14.6	5000[ef]
Cadmium µg/L	0.0183	0.085[b]
Chromium µg/L	0.3385	/
Cobalt µg/L	0.00395	1000[f]
Copper µg/L	0.444	4[c]
Iron µg/L	35.1	300
Lead µg/L	0.09515	7[c]
Lithium µg/L	3.12	2500[g]
Manganese µg/L	19.75	200[g]
Molybdenum µg/L	0.079	73[d]
Nickel µg/L	0.0025	150[c]
Selenium µg/L	0.05	1
Silver µg/L	0.00325	0.1
Strontium µg/L	212	/
Thallium µg/L	0.00215	0.8
Thorium µg/L	0.00015	/
Tin µg/L	0.03735	/
Titanium µg/L	0.5245	/
Uranium µg/L	0.02445	100[e]
Vanadium µg/L	0.05065	100[f,g]
Zinc µg/L	0.6665	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 $CaCO_3$)

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

[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:

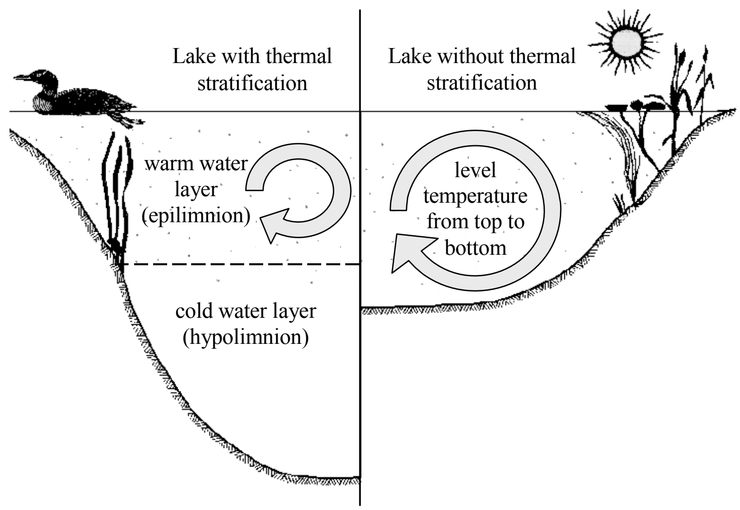

Figure A: Difference in the circulation of the water column depending on thermal stratification.

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 often 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 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 $mg \bullet L^{-1}$ and should not average less than 6.5 $mg \bullet L^{-1}$ over a seven-day period. However, the guidelines also require that dissolved oxygen concentrations remain above 9.5 $mg \bullet L^{-1}$ 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.

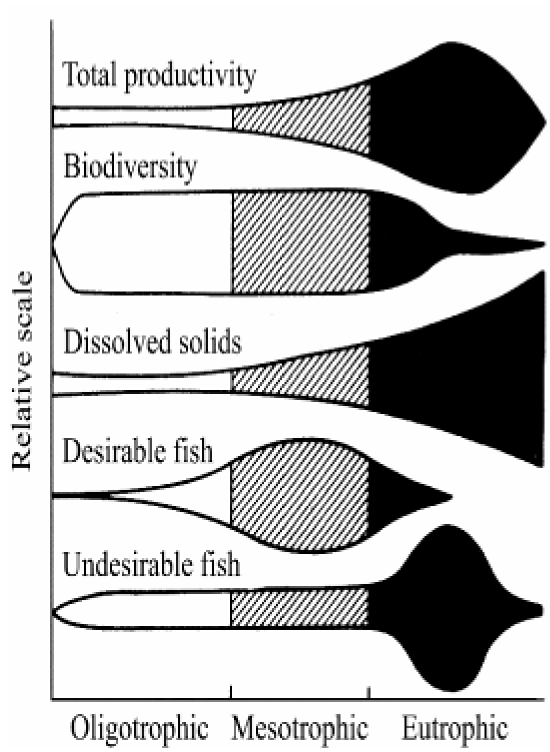

Figure B: Suggested changes in various lake characteristics with eutrophication. From “Ecological Effects of Wastewater”, 1980.

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