Lakewatch

THE ALBERTA LAKE MANAGEMENT SOCIETY
VOLUNTEER LAKE MONITORING PROGRAM

2011 Mayatan Lake Report

COMPLETED WITH SUPPORT FROM:

Alberta Government

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 Connie Schuster of the Mayatan Lake Management Association for her assistance with sampling and arranging the volunteers for each of our sampling trips. 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. Alberta Environment, the Beaver River Watershed Alliance (BRWA), and the Municipal District of Wainwright were major sponsors of the LakeWatch program.

MAYATAN LAKE:

Mayatan Lake is a small lake located 68 km west of the City of Edmonton in the North Saskatchewan River watershed. Mayatan Lake is comprised of two basins joined by a narrow water channel. The west basin is deep, measuring 26.5 m, while the eastern basin is shallow, measuring 6.1 m (Figure 1). On average, Mayatan Lake is 5.7 m deep.

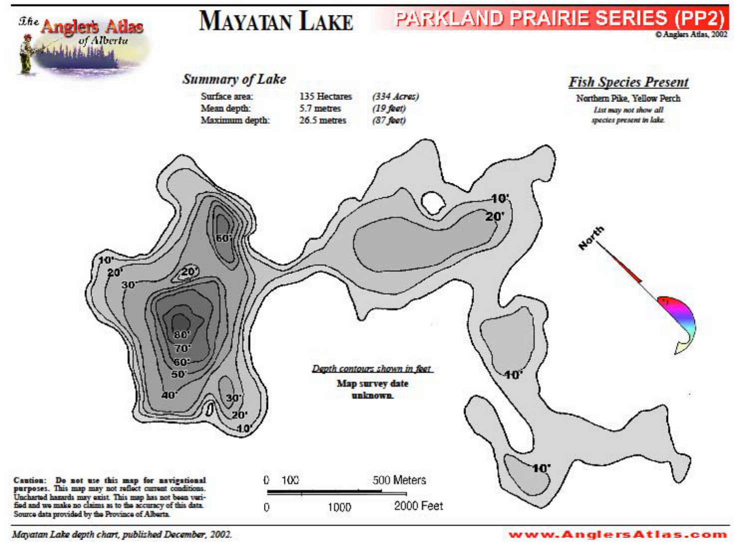


Figure 1 – Bathymetric chart of Mayatan Lake obtained from the Anglers Atlas (http://www.anglersatlas.com/lakes/8412).

According to the 2011 State of the Watershed Report released by the North Saskatchewan Watershed Alliance, Mayatan Lake has a small drainage basin (effective: 4.23 km^2; gross: 13.6 km^2) compared to the lake surface area (1.38 km^2). This results in an effective drainage basin:surface area ratio of 3.06 km^2. While a small drainage basin:surface area ratio will help to minimize the nutrients entering the lake from the watershed, there is also no outlet channel at the lake, suggesting there is nearly no flushing, and therefore nutrients entering the lake remain there for long periods of time.

The 2011 State of the Watershed Report for Mayatan Lake contains more in depth descriptions of the areas land use, climate, topography, geology, and biology. This report can be viewed at http://www.nswa.ab.ca/resources/nswa_publications.

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. Requests for water quantity monitoring should go through Environment and Sustainable Resource Developments Monitoring and Science division.

Currently no long term water quantity data exists for Mayatan Lake. The State of the Watershed Report estimates no net input or output from precipitation, runoff, and evaporation. Ground water input likely plays a large role in maintaining water levels at Mayatan Lake.

WATER CLARITY & SECCHI DEPTH:

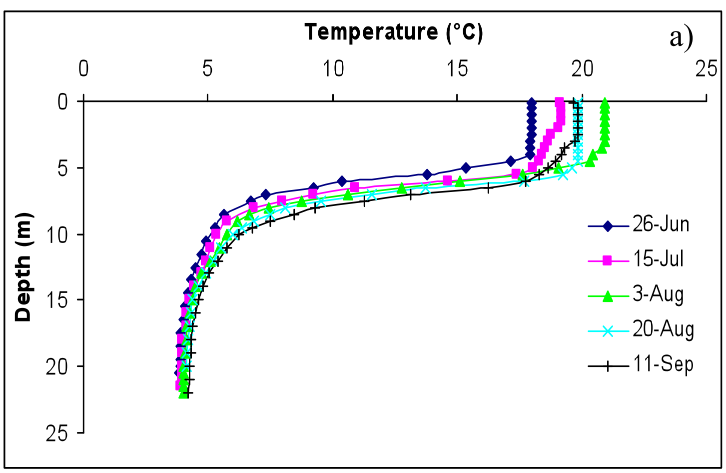
Water clarity is influenced by suspended materials, both living and dead, as well as dissolved colored compounds in the water column. During the melting of snow and ice in spring, lake water can become turbid (cloudy) from silt transported into the lake. Lake water usually clears in late spring but then 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.

Secchi disk depth at Mayatan Lake was measured from the West (deep) basin, and measured, on average, 4.3 m (Table 1). Secchi disk depth measured a minimum of 3.25 m on June 26th, and a maximum of 5.0 m on August 20th and September 11th. Because Secchi disk depth did not decrease throughout the summer, it is unlikely that algae/cyanobacteria are the primary factors affecting water clarity in the west basin of Mayatan Lake.

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.

Due to its depth, the water column in the west basin of Mayatan Lake remained stratified for the entire summer (Figure 2a). This is because in small, deep lakes it is difficult for wind energy to mix the entire water column. Thus, the zone of stratification, the thermocline, consistently measured between 4-5 meters in height. Surface water temperatures measured a seasonal-minimum of 17.99 °C on June 26th, and a seasonal-maximum of 20.91°C on August 20th. On the lakebed, temperatures were consistently between 3.0-5.0 °C.



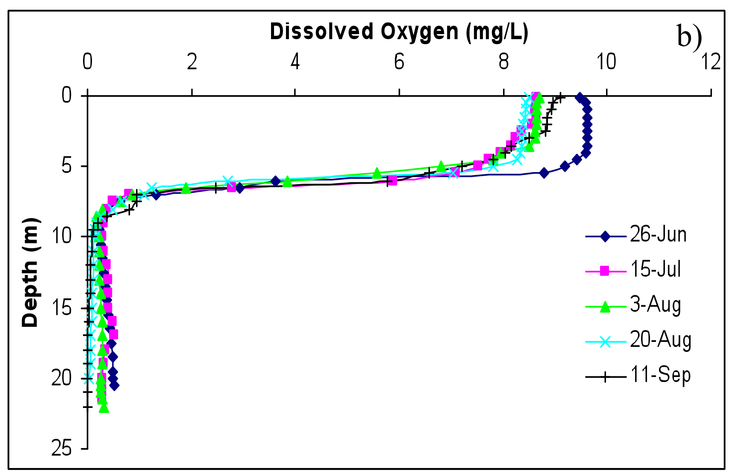


Figure 2 - a) Temperature (°C) and b) dissolved oxygen (mg/L) profiles for the west basin of Mayatan Lake in 2011.

Similar to temperature, dissolved oxygen decreased dramatically around 5.0 m due to the presence of a thermocline (Figure 2b). The thermocline prevents dissolved oxygen from the surface from mixing with deeper waters. Furthermore, oxygen-consuming decomposition at the lakebed also leads to the depletion of oxygen seen in Figure 3. This pattern of oxygen depletion is typical of small, deep, lakes in Alberta. At the surface, however, dissolved oxygen concentrations were well above the Canadian Council for Ministers of the Environment guideline of 6.5 mg/L for the Protection of Aquatic Life.

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.

In 2011, samples collected were combined from both the west and east basins of Mayatan Lake. However, for more rigour, samples in 2012 will be collected separately from each basin. Average Total Phosphorous (TP) measured during the summer of 2011 was 30.8 μg/L. This value straddles the cut-off point of 30.0 μg/L between a mesotrophic, or moderately productive, classification, and a eutrophic, or highly productive, classification.

Average Chlorophyll-*a* concentration, an indirect measure of algal/cyanobacterial biomass, measured 4.70 μg/L, which falls into the mesotrophic classification. A seasonal-minimum chlorophyll-*a* concentration of 3.19 μg/L was measured on June 26th, and a seasonal-maximum of 6.69 μg/L was measured on August 20th (Figure 3). It is typical for algae and cyanobacteria concentrations to increase throughout the summer as surface water temperatures and nutrient levels increase.

Finally, Total Kjeldahl Nitrogen (TKN) measured an average of 1488 μg/L, which falls into the hypereutrophic, or extremely productive, classification. Because chlorophyll-*a* levels do not appear to respond to this high level of nitrogen, it is likely that phosphorous acts as a limiting nutrient for algal and cyanobacterial growth.

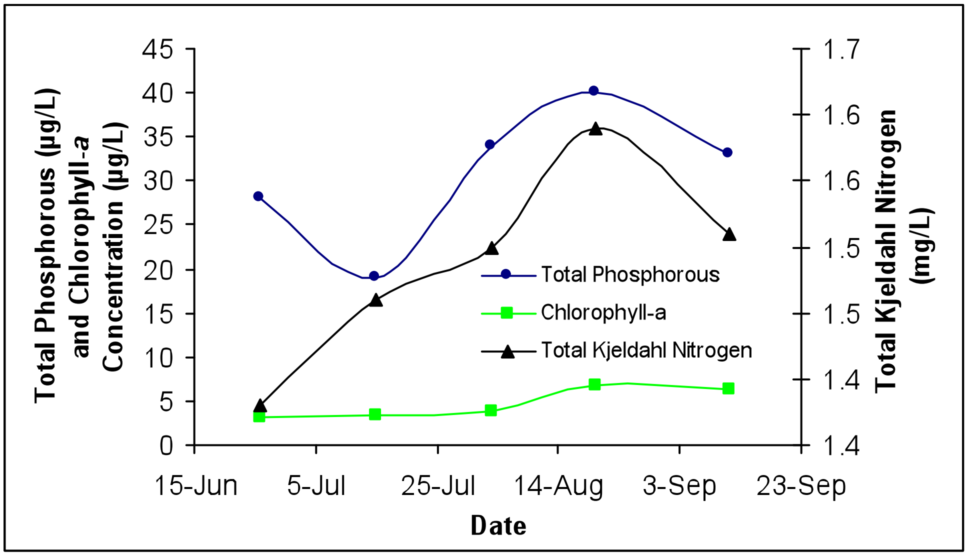


Figure 3 – Chlorophyll-*a* (µg/L), total phosphorous (µg/L), and total Kjeldahl nitrogen (mg/L) measured over the course of the summer in 2011.

Average pH measured at Mayatan Lake during the summer of 2011 was 8.57 (Table 1). Higher than neutral, this pH level is common in Alberta due to large amounts of carbonate rich soils and falls within the Canadian Council of Ministers of the Environment (CCME) guideline for the protection of aquatic life (6.5-9.0). High levels of calcium (35.4 mg/L) and bicarbonate (244.6 mg/L) contribute to a high alkalinity (215 mg/L $CaCO_3$) which helps buffer the lake against changes in pH. Other dominant ions in Mayatan Lake include magnesium (67.2 mg/L) and sulphate (185 mg/L).

Table 1 – Average Secchi disk depth and water chemistry values for 2011 at Mayatan Lake.

Parameter	2011
TP (µg/L)	30.8
TDP (µg/L)	12.5
Chlorophyll-*a* (µg/L)	4.7
Secchi depth (m)	4.3
TKN (µg/L)	1488
NO_2 and NO_3 (µg/L)	3
NH_3 (µg/L)	34
DOC (mg/L)	16.1
Ca (mg/L)	35.4
Mg (mg/L)	67.2
Na (mg/L)	21.2
K (mg/L)	23.7
SO_4^{2-} (mg/L)	185
Cl^- (mg/L)	2.2
CO_3 (mg/L)	8.8
HCO_3 (mg/L)	244.6
pH	8.57
Conductivity (µS/cm)	746.8
Hardness (mg/L)	365
TDS (mg/L)	464
Microcystin (µg/L)	0.0648
Total Alkalinity (mg/L $CaCO_3$)	215

Note: TP = total phosphorous, TDP = total dissolved phosphorous, Chl-*a* = chlorophyll-*a*, TKN = total Kjeldahl nitrogen. 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

SOME OF THE OBSERVED WILDLIFE:

Great Blue Heron – *Ardea herodias*. Photo by Jessica Davis

Common Loon – *Gavia immer* – Photo by Jessica Davis

Wood Frog – *Rana sylvatica* – Photo by Jessica Davis

Bald Eagle - *Haliaeetus leucocephalus* – Photo by Jessica Davis

Horsehair Worm – Photo by Jessica Davis

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:

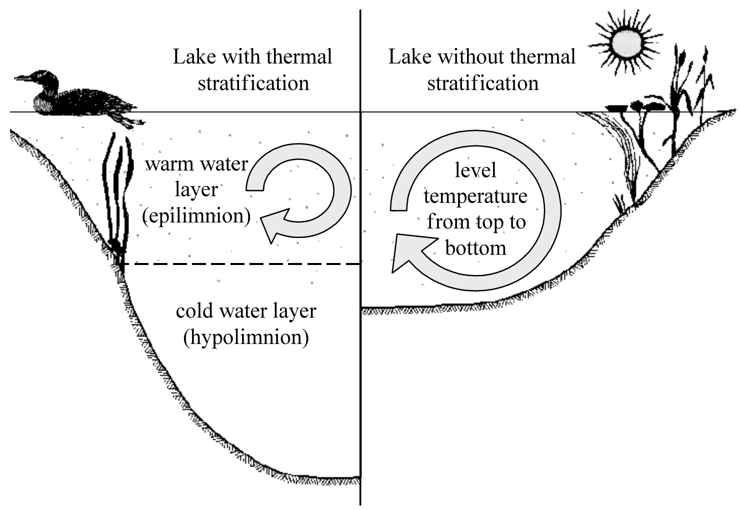


Figure A: Difference in the circulation of the water column depending on thermal stratification.

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 $mg•L^{-1}$ 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.

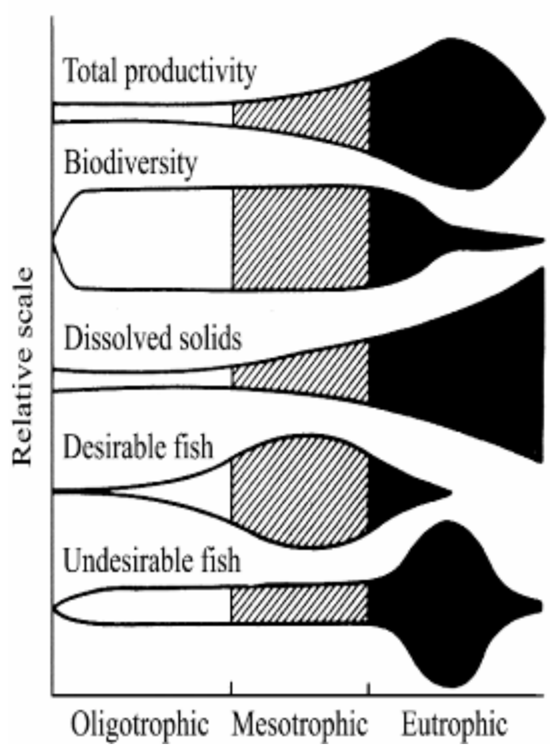


Figure B: Suggested changes in various lake characteristics with eutrophication. From "Ecological Effects of Wastewater", 1980.

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

Trophic state	Total Phosphorus ($\mu g \bullet L^{-1}$)	Total Nitrogen ($\mu g \bullet L^{-1}$)	Chlorophyll a ($\mu g \bullet L^{-1}$)	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

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.