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Lakewatch

Lac La Nonne



*The Alberta Lake Management Society
Volunteer Lake Monitoring Report*

"And you really live by the river? What a jolly life!"

"By it and with it and on it and in it," said the Rat. "It's brother and sister to me. What it hasn't got is not worth having, and what it doesn't know is not worth knowing." Kenneth Grahame The Wind in the Willows

"The world's supply of fresh water is running out. Already one person in five has no access to safe drinking water." BBC World Water Crisis Homepage

A note from the Lakewatch Coordinator Preston McEachern

Lakewatch has several important objectives, one of which is to document and interpret water quality in Alberta Lakes. Equally important are the objectives of educating lake users about their aquatic environment; enhancing public involvement in lake management; and facilitating a link between aquatic scientists and lake users. The 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. Substantial additional information is generally available on the lakes that have participated in Lakewatch and readers requiring more information are encouraged to seek these sources.

Since 2002, Lakewatch Reports have undergone a substantial change in format from previous years. I am no longer the author as much as an editor including text and figures from others who have done an excellent job describing lakes throughout Alberta. I have attempted to give due credit to these outstanding people and apologize for blatant plagiarism where it occurs. As editor, feel free to castrate me for errors. I have included easily accessible information that is likely to have been updated in recent years and readers are encouraged to help update these reports by sending new information to me.

Another exciting event occurred in 2003. Laboratory analyses have been switched from the University of Alberta Limnology Lab to the Alberta Research Council lab in Vegreville. The ARCV has a very broad spectrum of analyses possible and their detection levels are very good. Thus, we have added metals to our suite of analyses in 2003.

I would like to thank all people who share my love for aquatic environments and particularly those who have helped in the Lakewatch program. These people prove that ecological apathy can be overcome and give us hope that water will not be the limiting factor in the health of our planet.

Acknowledgements

The Lakewatch program is made possible through the dedication of its volunteers and Alberta Environment employees. Shelley Manchur, Mike Bilyk, Brian Jackson John Willis, and Doreen LeClair from Alberta Environment were instrumental in funding, training people and organizing with Lakewatch data. Alberta Lake Management Society members and the board of directors helped in many facets of water collection and management. Jean-Francois Bouffard was our summer field coordinator and was a valuable addition to the program. Finally, our volunteers for Lac La Nonne were Jerry Wispinski and Marcel Gauthier with whom our field coordinator spent many a pleasant mornings samplings. Without the dedication of these people and the interest of cottage owners, Lakewatch would not have occurred.

Lac La Nonne

Lac La Nonne is fairly large (11.8 km²) and deep (maximum depth 19.8 m) lake located about 90 km northwest of Edmonton in the counties of Barrhead and Lac Ste. Anne. This is a highly developed and popular recreational lake. The closest large population centre is the town of Barrhead located 20 km to the north. The name of the lake, “the nun” in French, has an uncertain origin. In 1827, Edward Ermatinger recorded the lake’s name in his journal as Lac La Nane. It has been suggested that the name comes from the White-winged Scoter, a duck with features similar to ducks in England known as “the nun”. The Hudsons’s Bay Company established a trading post at the lake in the early 1800s, by the 1830s there were many Métis and by the 1870s a catholic mission had been established. In the 1890s several families had settled around the lake, and by 1912 most of the available land had been homesteaded. Killdear Beach Resort and Elksbeach Campground are the two commercial facilities at the lake. No commercial fisheries exist on the lake although sport fishery, with the main catches being walleye and northern pike, is very popular in the summer.

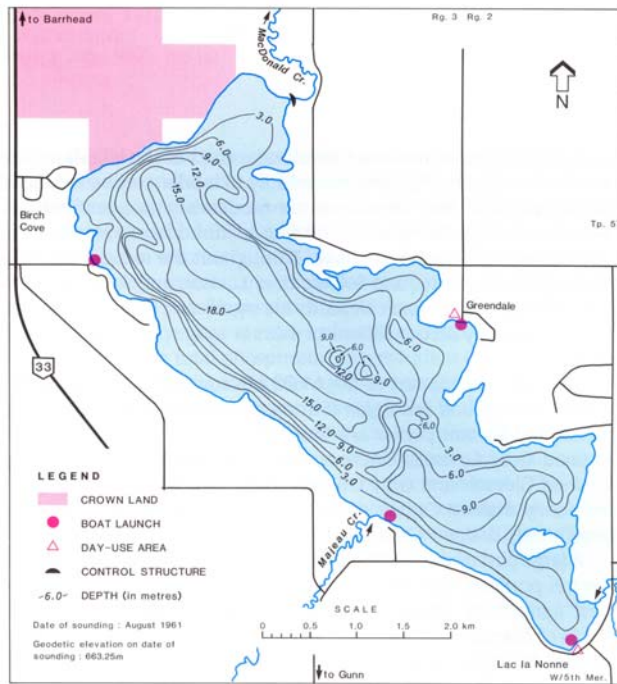


Fig. 1: Bathymetry of Lac La Nonne. From Mitchell and Prepas 1990.

Land acquisition around this lake, and cottage development on the shoreline, increased through to the 1970s until most of the shoreline became privately owned. Many cottages have been winterized and general lake use has intensified over the last half of the 1900s. Due to concerns about the quality of the lake, further development around the lake was halted through regulations enforced by Alberta Environment.

Earlier studies showed that nutrients in Lac La Nonne were highly abundant (309 µg TP/L) and that 97% of the summer algal biomass was made up of blue-greens (Mitchell and Prepas 1990). Phosphorus loading, a major determinant of blue-green algal blooms, has been determined to come from surface runoff and Majeau Creek but the internal loading rate, likely to be very significant, has not yet been determined (Mitchell and Prepas 1990).

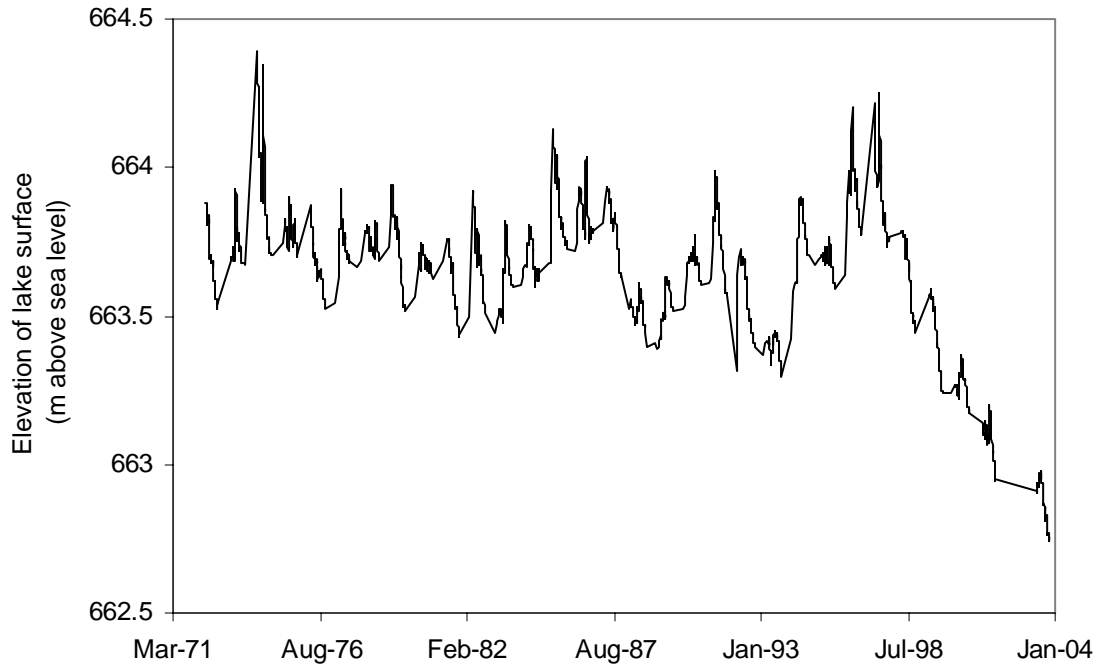


Fig. 2: Water levels in Lac LaNonne for the period of April 1972 through October 2003.

Water Levels

The water levels of Lac La Nonne have been recorded regularly since 1972. The maximum recorded lake level was 664.4 m in the Spring of 1974. The minimum lake level occurred recently on October 28, 2003 when it reached 662.741 m. Declining water levels have occurred throughout Alberta in recent years due to below-average precipitation. Lac LaNonne is no exception: water levels in 2003 were about 1 m lower than in 1998. If dry conditions persist, low water levels in Lac LaNonne may continue.

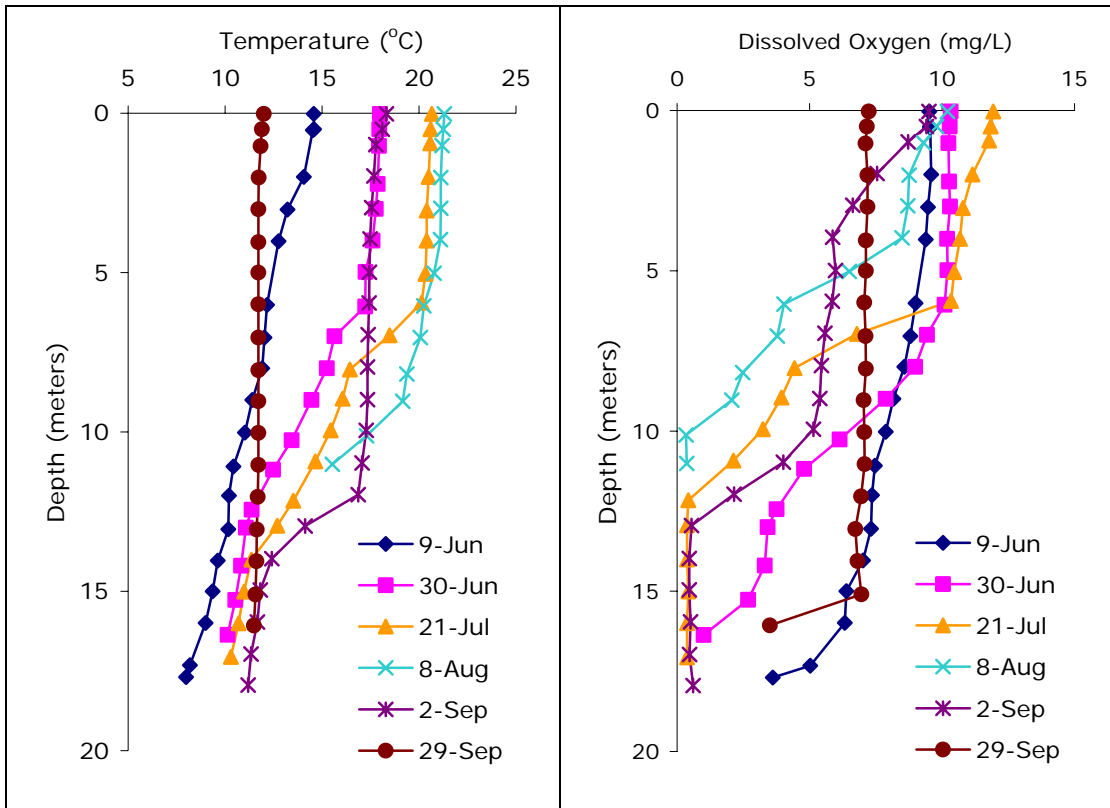


Fig. 3 & 4: Temperature and dissolved oxygen measurements at 1 m intervals of depth in Lac LaNonne, summer 2003.

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.

In early June, stratification was not apparent, but by late June and early July a thermocline developed at 6 m of depth (Fig 3). As the summer progressed stratification weakened and the thermocline dropped to deeper depths, reaching 12 m by early September. By late September when sampling concluded no stratification was apparent, as the lake had turned over.

Oxygen concentrations generally dropped with depth, with the most apparent drop happening during late summer. Late summer is typically when the oxygen-consuming decomposition of biological matter at the lake-bottom by bacteria is most active. In July, August and early September oxygen concentrations dropped to anoxic levels well above the lake bottom. Due to these low oxygen concentrations in deep water, Lac La Nonne may be too productive to support fish species that are dependent on cold water (e.g., salmonids such as trout).

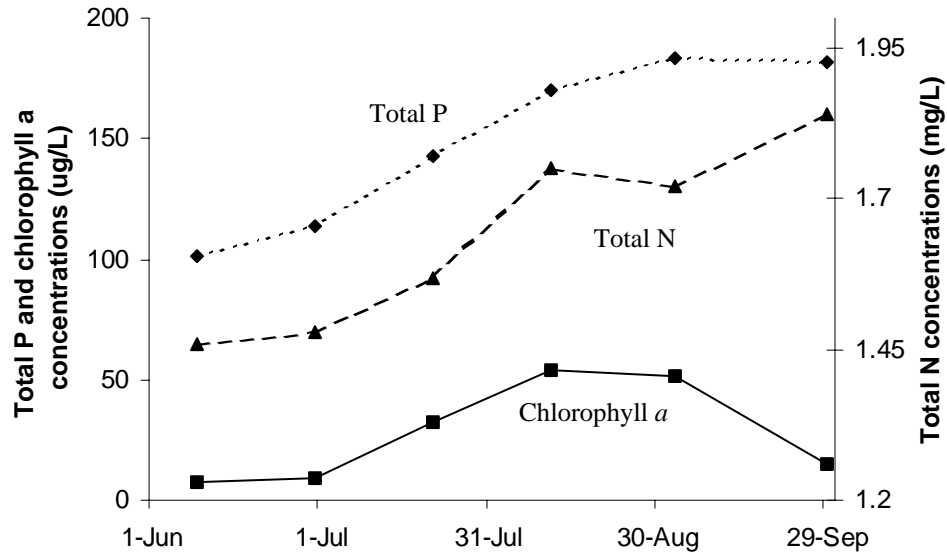


Fig. 5: Total phosphorus, chlorophyll *a* and total Kjeldahl nitrogen for Lac La Nonne, summer 2003.

Water clarity and Secchi Depth

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

Compared to other lakes in Alberta, the water clarity of Lac LaNonne was about average during the summer of 2003. Secchi disk depth was up to 3 m deep in early June and declined to 1.25 m by mid August. On some sampling occasions a thin layer of green algae was present on most of the surface of the Lake. Clarity increased again until sampling ended in late September. The decreasing clarity throughout mid-summer was consistent with a parallel increase in algal growth (Fig. 5).

Water chemistry

Because Lac LaNonne had very high nutrient concentrations and algal biomass compared to lakes throughout Canada, it is considered hyper-eutrophic (see details on trophic status classification at end of this report). In the Alberta context, Lac LaNonne is more fertile than average. In 2003, both nitrogen and phosphorus concentrations increased from June to August, explaining the parallel increase in algal biomass (measured as chlorophyll). This pattern is typical for Alberta lakes.

The concentrations of most major nutrients have not changed much throughout history (Table 1). Total Kjehdal N concentration in 2001 was about double that of other years, possibly due to an unusually high single value (about 13 mg/L) in August of that year. Also, there seems to be a decreasing trend in ammonium (NH₄) concentrations. Lac LaNonne was just as green in 2003 as in 2001 but much less green than in 1988. Hence, the clarity of Lac LaNonne has improved by 50 cm since 1988.

Lac LaNonne is well-buffered: its pH of 8.4 is well above that of pure water (=7). Its dominant ions are bicarbonate and calcium, corresponding to the alkaline nature of the groundwater in the area. Ion concentrations were very similar to historic values from the Atlas of Alberta Lakes. However, there appears to be a slight increasing trend in alkalinity and bicarbonate over time. Drier conditions in recent years suggest that the contribution of bicarbonate-rich groundwater to the water budget of Lac LaNonne may have increased. Other ion concentrations did not change much over the last 15 years. Metal concentrations were low and none surpassed provincial and federal Water Quality Guidelines for the Protection of Aquatic Life.

Table 1: Average chemical characteristics of Lac LaNonne, summer 1988 (Atlas of Alberta Lakes), 2001 and 2003.

| Parameter | 1988 | 2001 | 2003 |
|--------------------------------------|---------|------|------|
| Total phosphorus (µg/L) | 168 | 183 | 148 |
| TDP (µg/L) | 104 | 147 | 101 |
| Chlorophyll <i>a</i> (µg/L) | 55.5 | 22 | 28 |
| Secchi disk depth (m) | 1.9 | 2.4 | 2.1 |
| Total Kjehdal N (mg/L) | 2.23 | 5.55 | 1.64 |
| NO ₂₊₃ (µg/L) | <8 | 3 | 2.3 |
| NH ₄ (µg/L) | 43 | 32 | 9 |
| Ca (mg/L) | 33 | 31 | 32 |
| Mg (mg/L) | 10 | 10 | 11 |
| Na (mg/L) | 17 | 18 | 21 |
| K (mg/L) | 10 | 11 | 11 |
| SO ₄ (mg/L) | 14 | 12 | 13 |
| Cl (mg/L) | 3 | 5 | 4 |
| HCO ₃ (mg/L) | 164 | 175 | 180 |
| CO ₃ (mg/L) | <9 | 6 | 10 |
| Alkalinity (mg/L CaCO ₃) | 149 | 154 | 161 |
| Conductivity (µS/cm) | 314 | 337 | 333 |
| pH | 8.1-9.0 | 9 | 8.4 |
| Colour (mg/L Pt) | - | 19 | - |
| TSS (mg/L) | - | 4 | - |

Note. TDP = total dissolved phosphorus, NO₂₊₃ = nitrate+nitrite, NH₄ = ammonium, Ca = calcium, Mg = magnesium, Na = sodium, K = potassium, SO₄ = sulfate, Cl = chloride, HCO₃ = bicarbonate, CO₃ = carbonate, TSS = total suspended solids.

A brief introduction to Limnology

Indicators of water quality

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

Temperature and mixing

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

Limnologists call these layers of water the **epilimnion** at the surface and the **hypolimnion** at the bottom. The layers are separated by a transition layer known as the **metalimnion** which contains the effective wall separating top and bottom waters called a **thermocline**. A thermocline typically occurs when water temperature changes by more than one degree within one meter depth. The hypolimnion and epilimnion do not mix, nor do elements such as oxygen supplied at the surface move downward into the hypolimnion. In the fall, surface waters begin to cool and eventually reach the same temperature as hypolimnetic water. At this point the water mixes from top to bottom in what is called a **turnover** event. Surface water cools further as ice forms and again a thermocline develops this time with 4° C water at the bottom and 0° C water on the top.

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

Dissolved Oxygen

Oxygen enters a lake at the lake surface and throughout the water column when produced by photosynthesizing plants, including algae, in the lake. Oxygen is consumed within the lake by respiration of living organisms and decomposition of organic material in the lake sediments. In lakes

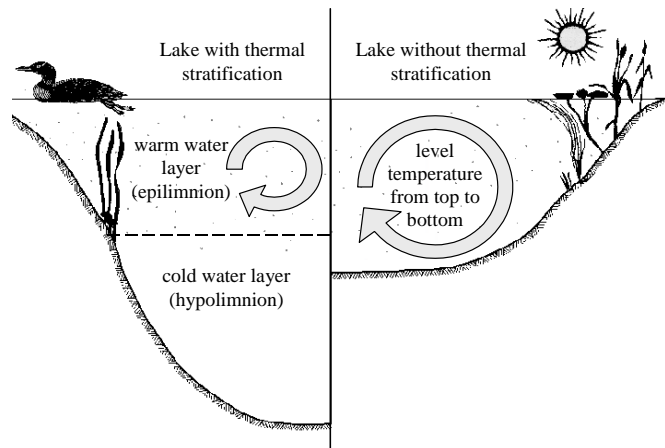


Fig. 6: Difference in the circulation of the water column depending on thermal stratification.

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

General Water Chemistry

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

Phosphorus and Nitrogen

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

Chlorophyll a

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

Secchi Disk Depth

Lakes that are clear are more attractive for recreation, whereas those that are turbid or murky are considered by lake users to have poor water quality. Secchi disk depth is the oldest, simplest, and quickest quantitative measure of water clarity. A Secchi disk is a black and white disk that is lowered

down through the water column until it can no longer be seen. Secchi disk depth is the midpoint between the depth at which it disappears when lowered and reappears when it is pulled up again. The Secchi disk depth in lakes with high algal biomass will generally be shallow. However, Secchi disk depth is not only affected by algae. High concentrations of suspended sediments, particularly fine clays or glacial till, are common in plains or mountain reservoirs of Alberta. Mountain reservoirs may have exceedingly shallow Secchi disk depths despite low algal growth and nutrient concentrations.

The euphotic zone, calculated as twice the Secchi disk depth, is the portion of the water column that has sufficient light for aquatic plants to grow. Murky waters, with shallow Secchi depths, can prevent aquatic plants from growing on the lake bottom. Aquatic plants are important because they ensure clear lake water by reducing shoreline erosion and stabilizing lake bottom sediments. Many lakes in Alberta are shallow and have bottom sediments with high concentrations of nutrients. Without aquatic plants, water quality may decline in these lakes due to murky, sediment-laden water and excessive algal blooms. Maintaining aquatic plants in certain areas of a lake is often essential for ensuring good water clarity and a healthy lake as many organisms, like aquatic invertebrates and fish, depend on aquatic plants for food and shelter.

Trophic state

Trophic state is a classification system for lakes that depends on fertility and is a useful index for rating and comparing lakes. From low to high nutrient and algal biomass (as chlorophyll) concentrations, the trophic states are: **oligotrophic**, **mesotrophic**, **eutrophic** and **hypereutrophic**. The nutrient and algal biomass concentrations that define these categories are shown in the following table, a figure of Alberta lakes compared by trophic state can be found on the ALMS website. A majority of lakes in Alberta are meso- to eutrophic because they naturally contain high nutrient concentrations due to our deep fertile soils. Thus, lakes in Alberta are susceptible to human impacts because they are already nutrient-rich; any further nutrient increases can bring about undesirable conditions illustrated in Fig 8.

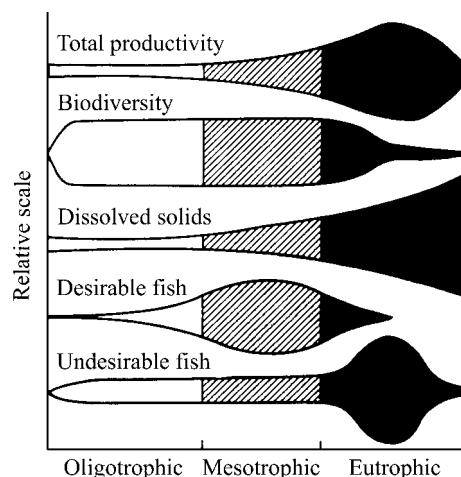


Fig. 7: Suggested changes in various lake characteristics with eutrophication. From “Ecological Effects of Wastewater”, 1980

Trophic status based on lake water characteristics.

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

Note: These values are from a detailed study of global lakes reported in Nurnberg 1996. Alberta Environment uses slightly different values for TP and CHL based on those of the OECD reported by Vollenweider (1982). The AENV and OECD cutoffs for TP are 10, 35 and 100; for CHL are 3, 8 and 25. AENV does not have TN or Secchi depth criteria. The corresponding OECD exists for Secchi depth and the cutoffs are 6, 3 and 1.5 m.