

# **Summer Survey of Crystal Lake**

**Montcalm County  
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**AAT Labs Job # 0308042**

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## INTRODUCTION

On August 18, 2003 AAT Labs Inc, performed the summer sampling event for Crystal Lake. At the time of sampling the weather conditions were sunny, calm, and had an air temperature of 70°F. This sampling event was conducted on a Monday morning after a heavy boating weekend on Crystal Lake.

## RESULTS

**Table 1.** Temperature and Dissolved Oxygen profile of the Central Basin at Crystal Lake.

<u>Central Basin</u>	<u>Temperature (°C [°F])</u>	<u>Dissolved Oxygen (mg/L)</u>
Surface	20.0 [68.0]	8.6
5 feet	20.0 [68.0]	9.0
10 feet	20.0 [68.0]	8.6
15 feet	20.0 [68.0]	8.1
16 feet	19.5 [67.1]	8.0
17 feet	19.5 [67.1]	8.0
18 feet	19.5 [67.1]	7.8
19 feet	19.5 [67.1]	7.6
20 feet	19.0 [66.2]	6.2
21 feet	19.0 [66.2]	5.3
22 feet	19.0 [66.2]	4.7
23 feet	18.5 [65.3]	3.8
24 feet	18.0 [64.4]	2.2
25 feet	17.5 [63.5]	1.3
26 feet	17.0 [62.6]	0.0
30 feet	15.0 [59.0]	0.0
35 feet	13.5 [56.3]	0.0
40 feet	13.0 [55.4]	0.0
45 feet	12.5 [54.5]	0.0
50 feet	11.0 [51.8]	0.4

**Table 2.** Nutrient data for the summer sample in the Central Basin at Crystal Lake.

<u>Central Basin</u>	<u>Nitrogen-Nitrate (mg/L)</u>	<u>Total Phosphorus (µg/L)</u>
Surface	0.21	20
10 feet	0.26	<10
20 feet	0.26	<10
30 feet	0.23	<10
40 feet	0.21	30
50 feet	0.27	10

**Table 3.** Transparency and Chlorophyll-*a* data for the Central Basin.

<u>Location</u>	<u>Transparency (feet)</u>	<u>Chlorophyll-<i>a</i> (µg/L)</u>
Central Basin	10.5	3.92

**Table 4.** Conductivity and pH data for Crystal Lake's Central Basin.

<u>Central Basin</u>	<u>Conductivity (µhoms/cm)</u>	<u>pH (units)</u>
Surface	310	8.0
10 feet	310	8.0
20 feet	310	7.9
30 feet	335	7.1
40 feet	340	7.5
50 feet	348	7.5

**Table 5.** Fecal Coliform count for Crystal Lake's Central Basin.

<u>Central Basin</u>	<u>Fecal Coliform (#/100ml)</u>
Surface	11

**Table 6.** Common plankton identified in Crystal Lake's summer sample.

**Phytoplankton:**

**Cyanophyta** (Blue-Green Algae)

*Anabaena*

*Merismopedia*

*Microcystis*

*Oscillatoria*

*Pandorina*

**Chlorophyta** (Green Algae)

*Coelastrum*

**Chrysophyta**

Bacillariophyceae (Diatoms)

*Fragilaria*

**Euglenophyta**

*Euglena* spp.

**Zooplankton:**

**Cladacera**

*Daphnia*

**Copepod**

*Calanoid*

*Cyclopoid*

**Rotifer spp.**

## **Lake Water Quality: Discussion of Terminology**

Lakes act as sediment traps, and it's natural for them to gradually fill with sand, silt, and organic matter. Natural lake aging or eutrophication moves from a nutrient poor (oligotrophic) condition to an intermediate (mesotrophic) stage of nutrient availability and biological productivity, and finally to a nutrient rich or highly productive (eutrophic) state. Eutrophication, the process of nutrient enrichment and basin filling, may take thousands of years, but it can be accelerated by disruptions to the watershed. Human activities that increase nutrient and sediment loadings to a lake are termed cultural eutrophication.

Trophic conditions in lakes are not absolute but rather relative, that is there is no definite line between oligotrophic and mesotrophic, or between mesotrophic and eutrophic. However, each trophic state has characteristic conditions. Oligotrophic lakes have a low level of organic productivity, clear water and low nutrient levels. These lakes often are characterized by deep water and steep basin walls. Water in mesotrophic lakes contains a moderate supply of nutrients and organic productivity. Eutrophic lakes are characterized by a very high level of nutrients which cause a significant increase in the rate of plant growth. As a result water clarity is greatly reduced, and oxygen depletion is common during the summer months. Eutrophic lakes tend to be shallow and, typically, have elevated water temperatures.

Water quality testing is the first step to obtain data on the water condition in lake. Determining the physical and chemical characteristics of the lake serves to identify trends in the lake condition, and helps isolate the cause and source of the water quality problems. Some key parameters used to evaluate the limnological condition of the lake include temperature, dissolved oxygen, nutrients (nitrogen and phosphorus), chlorophyll-*a*, and transparency. A brief discussion of these water quality measurements is as follows:

### **Temperature**

Temperature can determine the types of organisms that are favored for growth in a particular lake. It also determines how water mixes in a lake. As ice cover breaks up in the spring, water temperature becomes uniform from the surface to the bottom. This is referred to as spring turnover because water mixes throughout the entire water column. As surface waters warm, they become underlain by a colder denser stratum of water.

This process is called thermal stratification. Once thermal stratification sets in, there is little mixing of warm surface waters with colder bottom waters. The transition layer which separates these layers is referred to as the thermocline. The thermocline is defined as the zone in which the temperature decreases 1°C for every meter in depth. The water stratum above the thermocline is referred to as the epilimnion, and the hypolimnion is the water stratum below the thermocline. In the fall, warm surface waters begin to cool and become denser. Eventually, the surface temperature drops to a point that allows the lake to undergo another mixing, fall turnover. As the season progresses and ice begins to form, the lake may stratify again. However, during winter stratification, the surface waters, at or near 0°C (32°F), are underlain by slightly warmer water of about 4°C (39°F). This is referred to as inverse stratification and occurs because water is most dense at a temperature of 4°C (39°F).

### **Dissolved Oxygen**

An important factor influencing lake water quality is the quantity of dissolved oxygen in the water column. Major inputs of dissolved oxygen are the atmosphere and photosynthetic activity by aquatic plants and algae. An oxygen level of about 5 mg/L (milligrams per liter, or parts per million) is required to support warm water fish, and about 8 mg/L for cold water fish. In an idealized lake, the oxygen concentration at spring turnover is at or near 100 percent saturation, which would be between 12-13 mg/L. In lakes that exhibit thermal stratification, oxygen levels are often reduced or depleted below the thermocline once stratification has set in. This is due to oxygen consumption by bacteria which use oxygen as they decompose organic matter at the lake sediment. In the hypolimnion oxygen depletion is a common occurrence in eutrophic and some mesotrophic lakes. Thus, eutrophic and most mesotrophic lakes cannot support cold water fish because the cool, deep water does not contain sufficient oxygen.

### **Nutrients**

Nutrients, particularly nitrate and phosphorus, are the most important parameters to monitor in inland lakes. Together, these nutrients promote aquatic plant and algae growth in the lake. The bulk of the nitrates in a lake system have come from natural sources such as atmospheric deposition, blue-green algae, bacteria, and other microbiota. Due to the many natural sources of nitrates, most effort is usually put into controlling phosphorus. The concentration of phosphorus present in the water column is particularly important since phosphorus is the nutrient that most often controls aquatic plant and algae growth. In the presence of oxygen (aerobic), lake sediments act as a phosphorus trap, retaining phosphorus and thus making it unavailable for aquatic plant and algae utilization. If oxygen is depleted (anaerobic) in the hypolimnion, however, phosphorus will be released from the sediments and may be available to promote aquatic plant

growth. In some lakes, the release of phosphorus from the sediment (internal loading) is the primary source of phosphorus loading or input.

By reducing the concentration of phosphorus in a lake, it may be possible to control the amount of aquatic plant growth. In general, lakes with a total phosphorus concentration of 20  $\mu\text{g/L}$  (micrograms per liter, or parts per billion) or greater are able to support abundant plant growth and are classified as nutrient enriched or eutrophic.

### **Chlorophyll-*a***

Chlorophyll-*a* is the primary photosynthetic pigment that imparts the green color to plants and algae. An estimate of the quantity of algae present in the water column can be made by measuring the amount of chlorophyll-*a*. A chlorophyll-*a* concentration greater than 8  $\mu\text{g/L}$  is considered characteristic of an eutrophic condition.

### **Transparency**

Algal growth and turbidity (solids suspended in the water column) can both result in reduced transparency. Transparency is measured by lowering a round, black and white, 8-inch disk (Secchi disk) on a calibrated line. The disk is lowered over the deepest point of the lake until it is no longer visible, and the depth is noted. The disk is then raised until it reappears. The average of these two depths is the Secchi transparency. Generally, aquatic plants can grow at a depth of about 1.5 times the Secchi transparency measurement. In eutrophic lakes, water clarity is often reduced by algal growth in the water column, and Secchi disk readings of 6 feet or less are common.

As phosphorus loading in a lake increases, the amount of algae the lake can support increases also. Thus, the lake will exhibit increased chlorophyll-*a* levels and decreased transparency. A summary of lake classification criteria is shown in table 7.

**Table 7.** Lake classification criteria.

<b>Lake Classification</b>	<b>Total Phosphorus (mg/L)</b>	<b>Chlorophyll-<i>a</i> (mg/L)</b>	<b>Secchi Transparency (feet)</b>
Oligotrophic	< 10	< 2	> 15
Mesotrophic	10 - 20	2 - 8	6 - 15
Eutrophic	> 20	> 8	< 6

## **Conductivity**

Conductivity is a measurement of how well water conducts electricity due to the presence of dissolved inorganic salts (ions). The more dissolved salts present, the higher the conductivity will be. Sources which will increase conductivity levels in the lake include road salts, chlorinated compounds, fertilizers, and domestic sewage.

## **Fecal Coliform**

The State of Michigan Public Health standard for *E. coli* bacteria in waters used for total body contact recreation (e.g., swimming) requires that no more than 130 *E. coli* per 100 ml may be present as a 30-day geometric mean of 5 or more sampling events. For a single sampling event, the number of *E. coli* may not exceed a maximum of 300 per 100 ml.

## **pH**

Pure water consists of an equal number of hydrogen (H<sup>+</sup>) and hydroxide (H<sup>o</sup>) ions. pH is a measure of the number of hydrogen ions in solution. At a pH of 7.0, the number of hydrogen and hydroxide ions are equal (or neutral). At a number below 7.0 the number of hydrogen ions exceeds the number of hydroxide ions, and the lake is "acidic"; at a pH above 7.0, the lake is "basic". A difference in one pH unit corresponds to a ten-fold difference in the number of hydrogen (and hydroxide) ions. Most lakes fall within a pH range of 6.0 - 9.0, which is an acceptable range for most aquatic organisms. Potential problems to the lake organisms can be indicated by a pH reading that is either too high or too low.

## **Discussion of Water Quality Analyses**

Table 1 demonstrates the thermal stratification Crystal Lake experiences each summer. The upper limit of the thermocline becomes established at 22 feet. Oxygen is completely depleted, below the thermocline, from 26 feet down to the sediment layer. At 50 feet a small concentration of dissolved oxygen was detected (0.4 mg/L). This small concentration of oxygen at the sediment-water interface is common in what is called the microzone. This microzone is measured in millimeters, and is controlled by organic decomposition. The thermal stratification observed in Crystal Lake is typical for Michigan's inland lakes.

Nutrient levels (table 2) are fairly average for most Michigan lakes at this time of the year. Nitrates are 0.21 – 0.27 mg/L in the Central Basin profile, lower than the 0.3 mg/L concentrations seen in the August 2002 sample. Total phosphorus is 20µg/L at the surface of the Central Basin, right at the mesotrophic/eutrophic transition (table 7). Total phosphorus levels increase below the thermocline, due to the release of phosphorus from the sediments in the anaerobic hypolimnion.

Transparency and chlorophyll-*a* data are combined in table 3. Transparency in this summer sample was 10.5 feet, same as the August 2002 sample. Chlorophyll-*a* was 3.92 µg/L, up from last years 1.69 µg/L. Transparency and chlorophyll-*a* both fell within the mesotrophic range (table 7).

Crystal Lake's conductivity levels (table 4) look good in the Central Basin profile. The levels did slowly increase the deeper the sample was collected, indicating more dissolved ions in the deeper water. The pH values (table 4) in the samples collected throughout the water column also are in good condition. The pH values fell within the desired 6 – 9 range, and did not show a significant shift from 2002.

Fecal coliform (table 5) was detected at the surface in the Central Basin. The *E. coli* levels of 11/100 ml (read as 11 per 100 milliliters) found during the sampling event is well below the State of Michigan non-contact standard of 300/100 ml.

## CONCLUSION

Crystal Lake exhibits thermal stratification during the summer months. When stratification has set in, the hypolimnion (typically below 25 ft) becomes devoid of oxygen as decomposition of organic matter occurs. In this anaerobic condition sediments are able to release phosphorus back into the water column. The Central Basin sample had a transparency reading of 10.5 ft, which is in the mesotrophic range (table 7). The chlorophyll-*a* concentration of 3.92µg/L, also falls in the mesotrophic range (table 7). The total phosphorus concentration at the surface of the Central Basin was 20µg/L, right at the mesotrophic/eutrophic transition. This indicates there is sufficient phosphorus available in Crystal Lake to support abundant aquatic plant and algae growth. The combination of the phosphorus level with transparency and chlorophyll-*a* indicates Crystal Lake is in a mesotrophic state (table 7).

As stated before, the classification of a lake's trophic state is not absolute, but rather relative instead. A review of summer reports conducted in the past shows some fluctuations in these classification parameters. Transparency has also remained in the

mesotrophic range. Chlorophyll-*a* has also remained in the mesotrophic range, except for last summer where chlorophyll-*a* concentration dropped just into the oligotrophic range. With this year's sample, total phosphorus has been in each trophic classification. Considering all this data, it justifies Crystal Lake being considered as a mesotrophic state.

Remember, all lakes are undergoing eutrophication, or the natural aging process of lakes. Categorizing Crystal Lake as being in the mesotrophic state is just a guide to where the lake is in its aging process. This natural aging process can be sped up by human activities such as sewage and industrial contamination, fertilizer inputs, and sediment runoff. All these activities increase the rate of the lake filling in by either introducing sediment itself, or nutrients that support plant growth which leads to the lake filling in.

All analyses are in accordance with "Standard Methods for the Analysis of Water & Wastewater", 19th Edition, 1995 and EPA Approved Methodologies.

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