

# Lake Emily

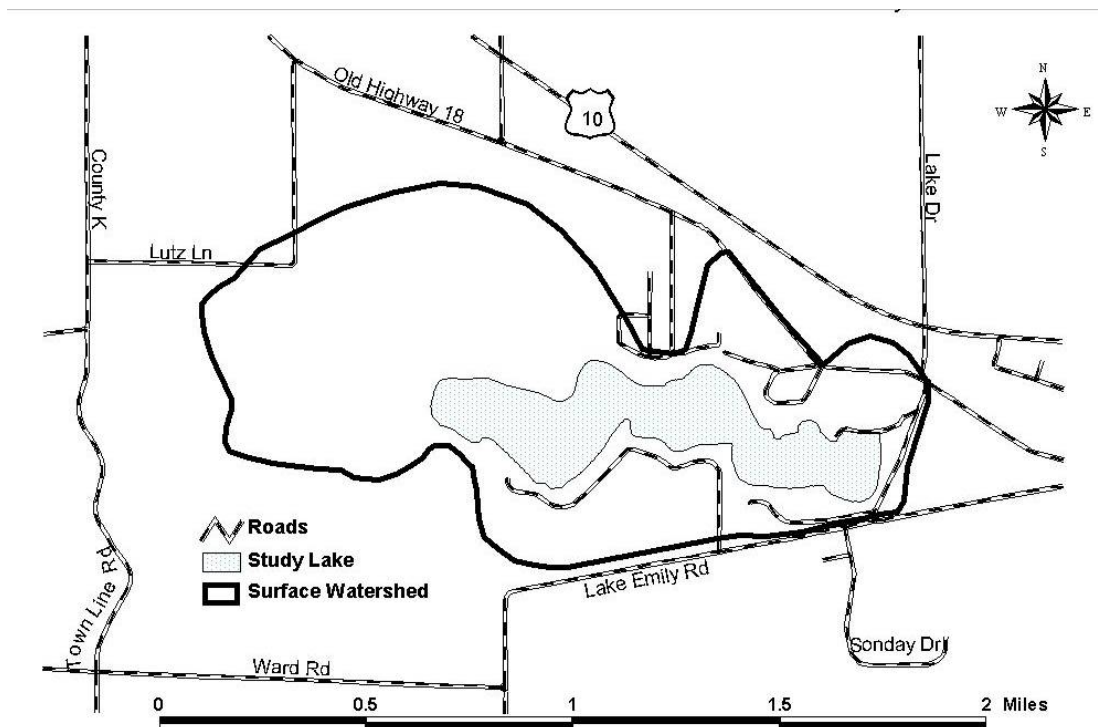
## Introduction

Lake Emily is a 95.5-acre **hard water seepage lake** located in the Town of Amherst, west of Amherst Junction. The lake is long and narrow, and the bottom drops off quickly with a maximum depth of 36 feet. Bottom materials are primarily **marl** and sand, with gravel and rubble present in the **littoral** zones. The lake has an estimated volume of 1,691 acre-feet, and an estimated **retention time** of 2.3 years. There is one intermittent inlet from Mud Lake on the west end, but no outlet. The 2.9 mile shoreline is heavily developed with homes and cottages. There is also a large County Park with a campground, beach, and public boat launches, making Lake Emily a popular area for recreation during the summer. Wildlife use is limited by the heavy development. The fishery contains northern pike, walleye, largemouth bass, panfish, and trout.

## Land Use and Watershed

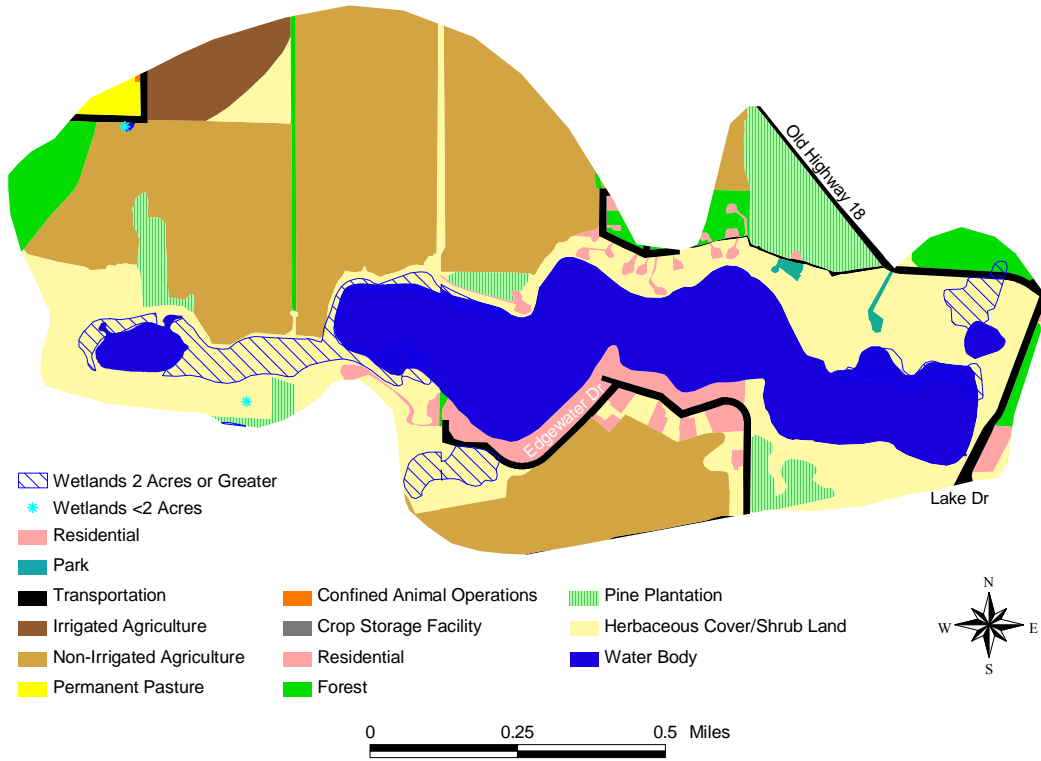
The surface watershed for Lake Emily is 646 acres and occurs all the way around the lake (Figure 1). Land use in this watershed is predominantly non-irrigated cropland (37%), followed by shrub/wetland vegetation (24%). The large area categorized as shrub/wetland vegetation appears to have been forested until sometime after 1990 when forested areas experienced a significant decrease. Non-irrigated agriculture has decreased modestly since 1948 but remains prevalent in the watershed. Residential development increased greatly between 1948 and 1968 predominantly around the lakeshore, but appears to have remained somewhat stable between 1990 and 2002 (Figure 2 and Figure 3).

Figure 1. Lake Emily surface watershed boundary.

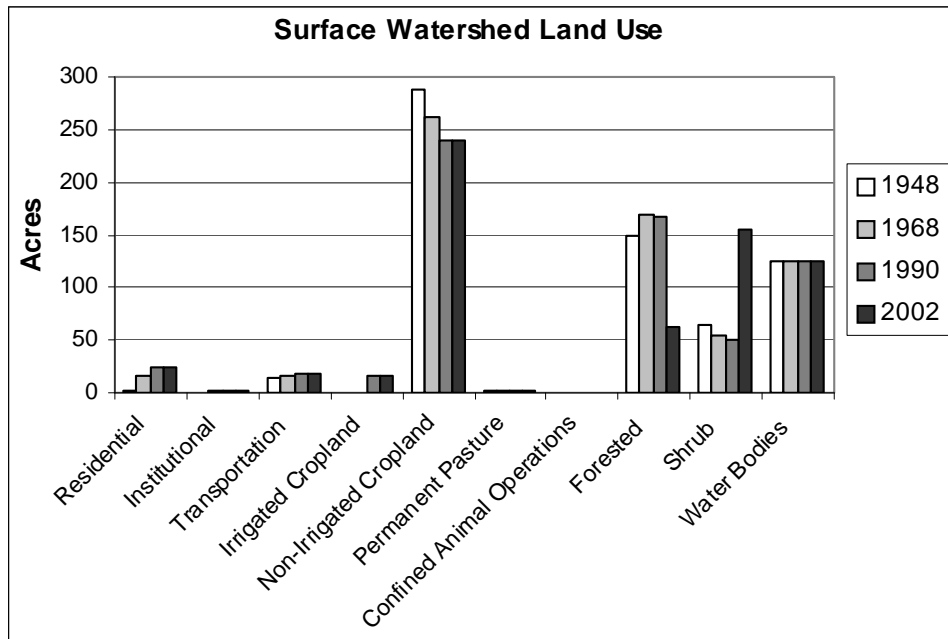


\*Terms in bold, see glossary pp 15-20

**Figure 2. Land use in the Lake Emily surface watershed (2002).**



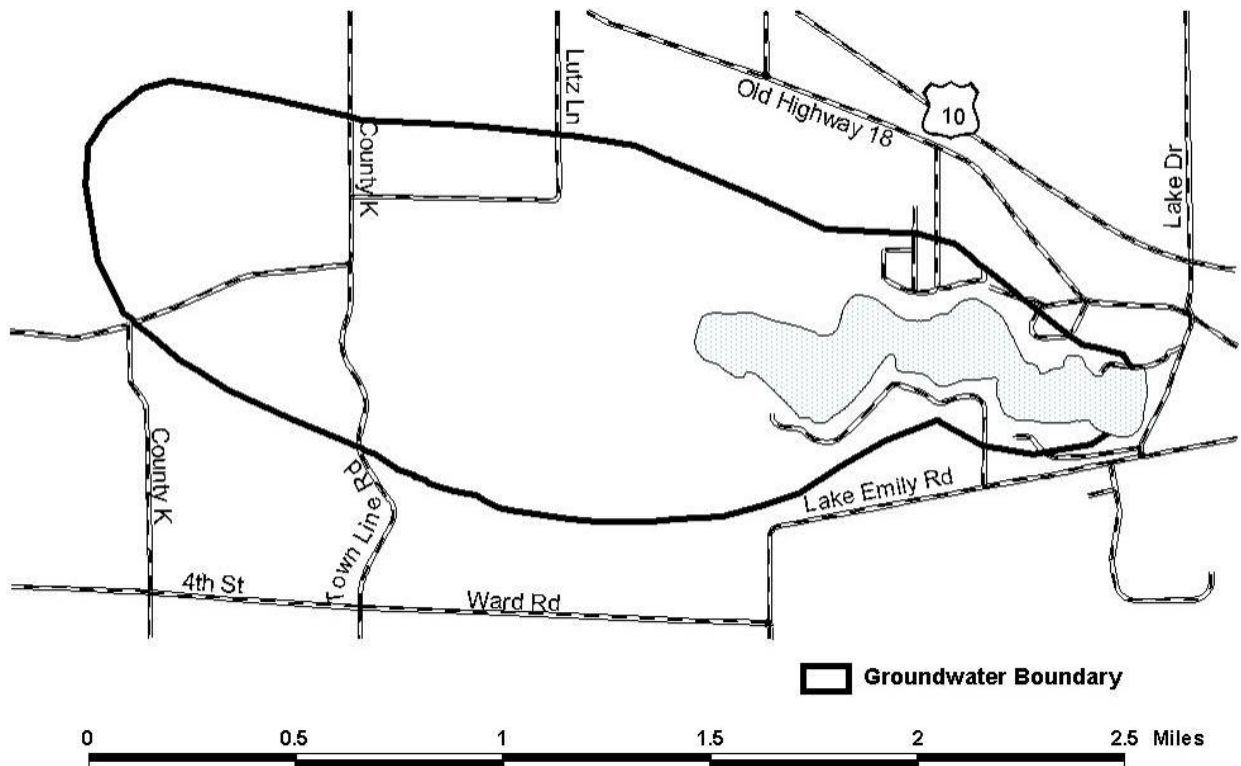
**Figure 3. Land use in the Lake Emily surface watershed 1948-2002.**



\*Terms in bold, see glossary pp 15-20

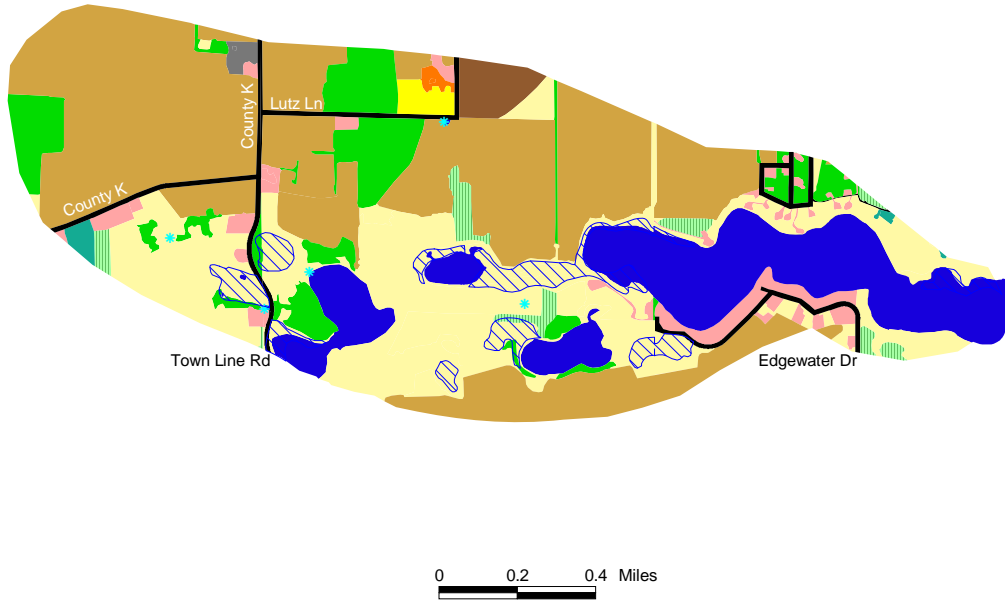
The 1,070 acre **groundwater** watershed for Lake Emily is located primarily west of the lake. Land use is largely non-irrigated agriculture (41%), followed by shrub/wetland vegetation (25%). Forested areas were fairly constant until after 1990 when they declined sharply. Non-irrigated cropland has been the leading land use since 1948 but has also shown some decline. Residential development shows a steady increase between 1948 and 1990, after which time it has remained fairly stable (Figure 5 and Figure 6). According to the 2002 County records there are no septic systems that would be failing based on system age or former landfill sites found within either the surface watershed or the **groundwater** watershed.

Figure 4. Lake Emily groundwater watershed boundary.

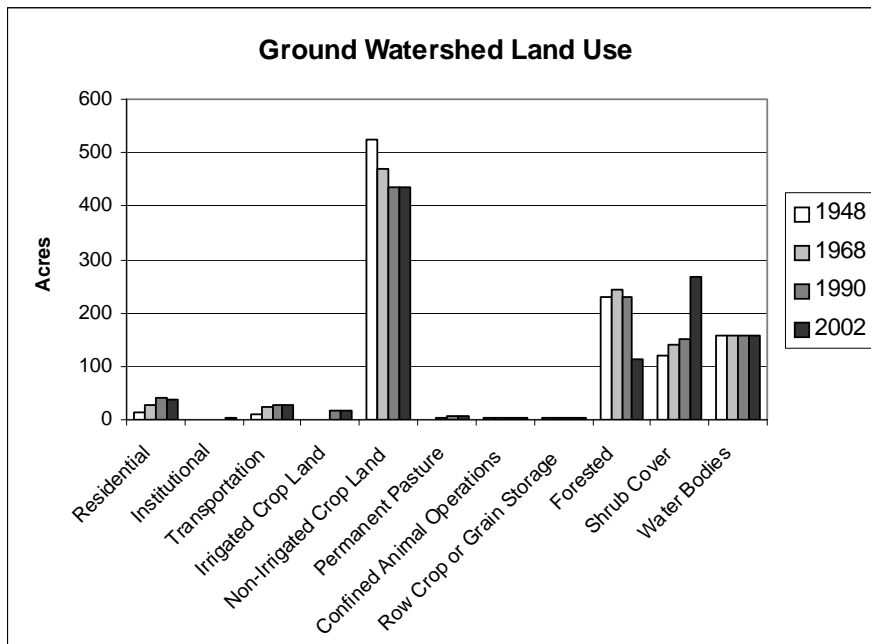


\*Terms in bold, see glossary pp 15-20

**Figure 5. Land use in the Lake Emily groundwater watershed (2002).**



**Figure 6. Land use in the Lake Emily groundwater watershed 1948-2002.**



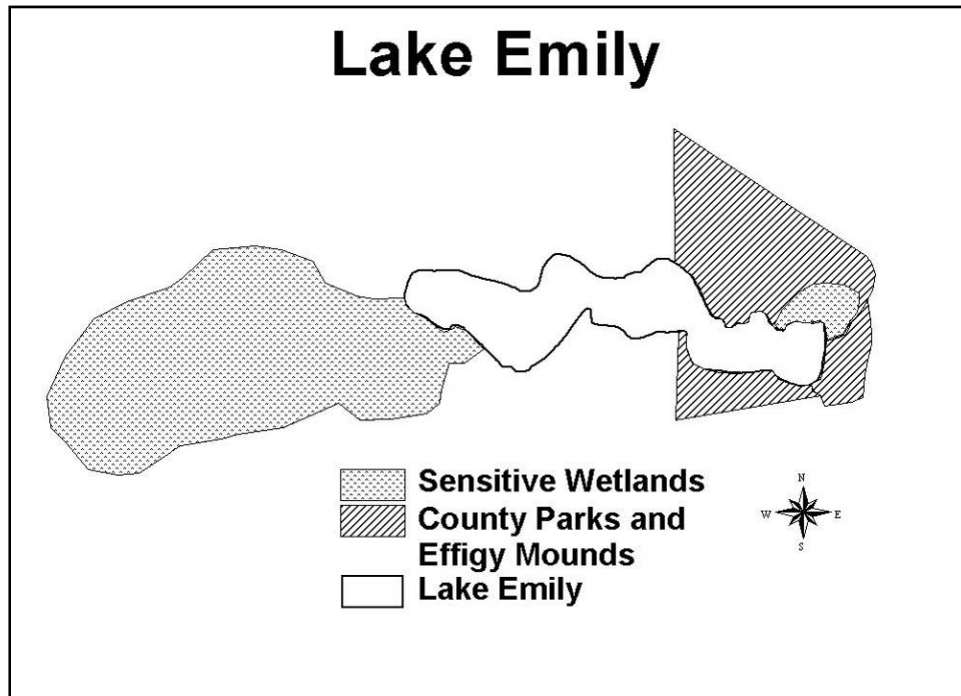
**Upland Sensitive Areas**

The survey of upland sensitive areas was conducted to identify areas near the lake that are particularly valuable, or sensitive to disruption. Lake Emily is adjacent to a large wetland located west of the lake and a smaller wetland on the eastern shore. There is a large County Park encompassing much of the eastern shoreline of the lake with Native American effigy mounds

\*Terms in bold, see glossary pp 15-20

located in the park. The park offers camping, boat access and a sand beach, and is heavily used in the summer (Figure 7).

Figure 7. Upland sensitive areas near Lake Emily.



### Reptiles and Amphibians

Amphibians (frogs and toads) were included in this survey because with their permeable skin and biphasic lifecycle (meaning that the young live in water while adults can survive on land) they are considered excellent indicators of overall ecosystem health. Furthermore, both turtles and amphibians utilize both aquatic and terrestrial habitats and especially the shoreline interface between these two habitats, and thus are of particular relevance.

Large sections of continuous natural shoreline on lakes are ideal habitats for many frog species. Natural areas with large amounts of submergent, emergent, and floating-leaf vegetation provide protection and a place for attachment of eggs during the breeding season. The upland areas surrounding these lakes also provide important habitat as many frog species migrate to lakes and other bodies of water in the spring or fall to breed and spend the summer months foraging in the uplands. Several species also use the surrounding uplands for overwintering. The turtle species found associated with lakes are predominantly aquatic, usually departing from the water only to deposit eggs in a nest. Nests are usually on south facing slopes above the shoreline where there is open vegetation and sandy soil. The newly hatched young then find their way to the water. Thus, both turtles and amphibian are intimately associated with lakes and the associated habitats of a watershed.

Two turtle species were observed during the survey of reptiles near Lake Emily (painted turtle [*Chrysemys picta*] and snapping turtle [*Chelydra serpentina*]). Six species of amphibians (all

\*Terms in bold, see glossary pp 15-20

frogs and toads) were observed during the survey (spring peeper [*Pseudacris crucifer*], chorus frog [*Pseudacris triseriata*], gray treefrog [*Hyla versicolor*], green frog [*Rana clamitans*], northern leopard frog [*Rana pipiens*], and American toad [*Bufo americanus*]). The primary amphibian habitat is located on the east and west sides of the lake (Figure 8). Some of the key features of this habitat include protected areas of marsh with large amounts of submergent, emergent, and floating-leaf vegetation.

The good news is that a number of frog species are present and several large sections of natural shoreline still exists. Unfortunately, the lake also contains a high amount of altered shoreline.

**Figure 8. Regions of primary amphibian habitat around Lake Emily.**



### **Aquatic Plants**

There are **66** species of aquatic **macrophytes** (65 species of **vascular plants** plus one species of **macrophytic algae**) that have been found in Lake Emily, on the shore, or in the small pond connected to the lake. This is above average for Portage County lakes. The average **coefficient of conservatism (c-value)** for the 65 species of **vascular plants** is **4.6** which is above average as well. The **floristic quality index** is **39.5** which is also above average for Portage County lakes.

Lake Emily supports a moderately diverse aquatic and wetland flora, although most of the species are common and widespread plants. Until recently the dominant submersed plants were common water-milfoil (*Myriophyllum sibiricum*), Illinois pondweed (*Potamogeton illinoensis*), variable pondweed (*Potamogeton gramineus*), bush-pondweed (*Najas flexilis*), wild celery (*Vallisneria americana*), stonewort (*Chara* spp.), and Canadian waterweed (*Elodea canadensis*). However, Eurasian water-milfoil (*Myriophyllum spicatum*) was present by 1995 and it is becoming more abundant. A follow-up survey of the Eurasian water-milfoil was conducted in 2003.

Water levels have dropped in recent years, converting areas, especially on the eastern and northern shores, previously under shallow water into an expanded beach. The upper portions of

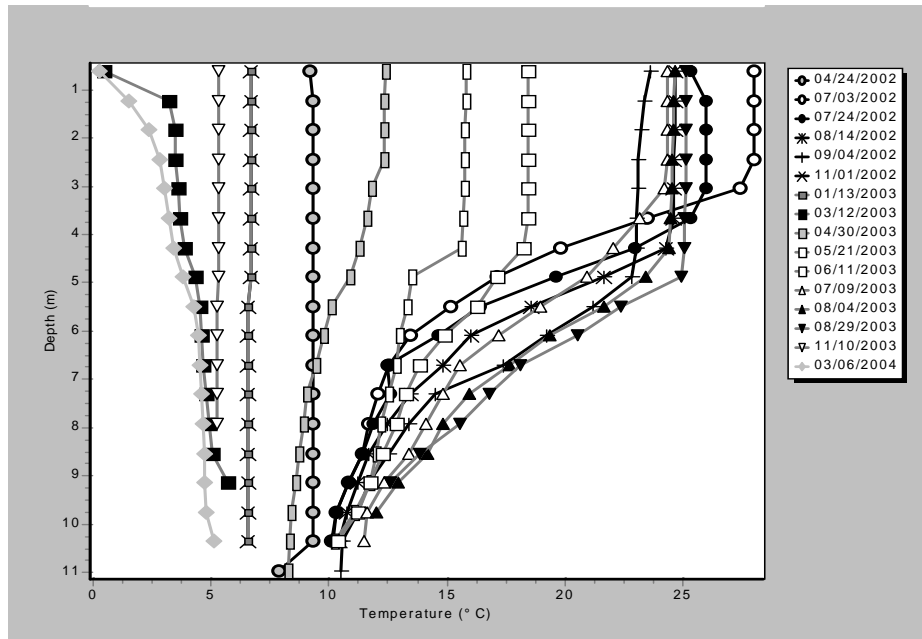
\*Terms in bold, see glossary pp 15-20

the former shore and beach were a dry upland with weedy annuals common in 2003, although with a higher water level in 2004 the wet shore is expanding toward the upper shore. However, Canada thistle (*Cirsium arvense*) is spreading aggressively on the beach and its spread will probably continue unless water levels rise enough to inundate it.

### Current Water Quality Conditions

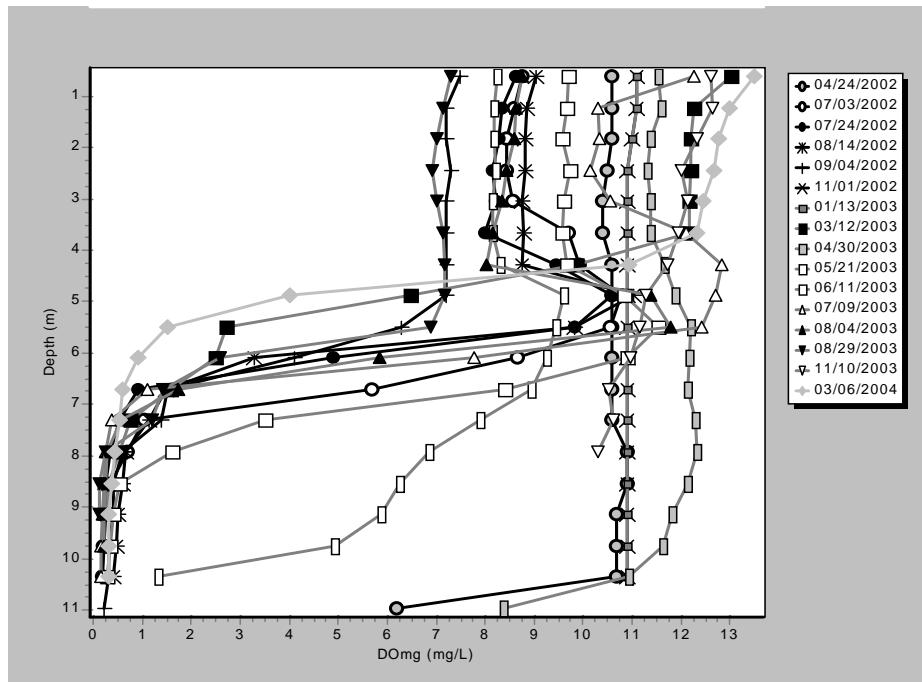
Water quality assessment of a lake involves a number of measures including temperature, dissolved oxygen, water chemistry, **chlorophyll a**, and **algae**. Each of the constituents discussed play a role in water quality. Temperature and oxygen were measured top to bottom when samples were collected. Temperature profiles show that Lake Emily generally follows typical seasonal **stratified** and mixed periods (Figure 9); however, historic data indicates that the lake does not always completely mix every season. This is likely due to the shape and depth of the lake. With the current trophic state this does not appear to present a problem. However, should the lake become more **eutrophic**, the sporadic mixing of oxygen throughout the lake may present problems for the fishery, particularly in the winter when the lake is separated by ice from the atmosphere. The dissolved oxygen in Lake Emily is shown in Figure 10. Just after mixing occurs in the spring (April and May) almost the entire water column contained good concentrations of dissolved oxygen. Once the lake stratifies, oxygen concentrations remained acceptable for most fish down to about 15 feet.

Figure 9. Profile of temperature in Lake Emily 2002-2004.



\*Terms in bold, see glossary pp 15-20

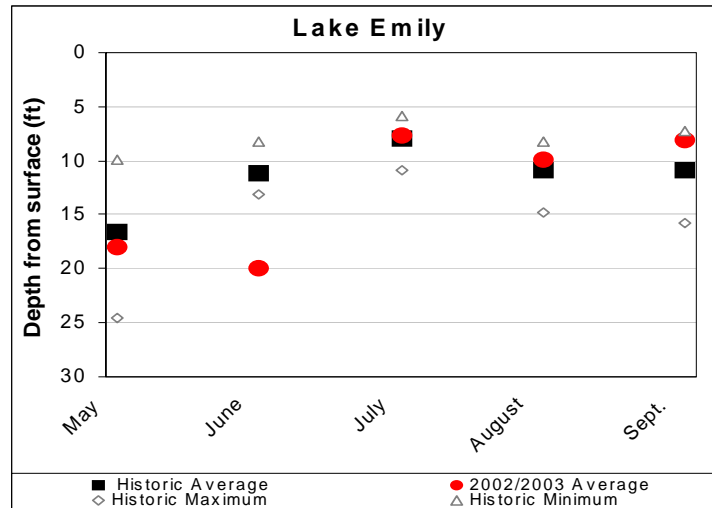
**Figure 10. Profile of dissolved oxygen in Lake Emily 2002-2004.**



Water **clarity** is a measure of how far light can penetrate the water. It is an aesthetic measure and is related to the depth that **rooted aquatic plants** can grow. Water **clarity** is affected by water **color** and suspended materials in the water (**turbidity**). **Turbidity** consists of **suspended solids**, such as suspended sediments and **algae (chlorophyll a)**. In Lake Emily these values were low, but varied a bit throughout the summer (Table 1). The water **clarity** in Lake Emily was also variable during the study. At times the **clarity** was considered very good while at others it was fair (Figure 11). Similar lakes in the area have average **Secchi disc** readings of 9 to 10 feet. The water **clarity** was the worst in July, about 7.5 feet, and the best in June, approximately 20 feet. These fluctuations can be attributed to **algae** populations and **sedimentation** increase and decrease, which are normal throughout the summer due to the seasonal formation of **marl** and sediment entering the lake during storms.

\*Terms in bold, see glossary pp 15-20

Figure 11. Monthly average water clarity measurements in Lake Emily 2002-2003 and historic average, maximum and minimums.



A variety of water chemistry measurements were used to characterize the water quality in Lake Emily (Table 2). Nutrients (**phosphorus** and **nitrogen**) are important measures of water quality in lakes because they are used for growth by **algae** and aquatic plants (similar to houseplants and crops). Lake Emily is considered a **hard water** lake due to inputs of calcium from **groundwater**. For the most part total **phosphorus** is currently being kept in check by the **marl** in the lake, but **nitrogen** concentrations are quite elevated which can enhance the growth of aquatic plants. Inorganic **nitrogen** (**nitrate** plus **ammonium**) is high enough in the spring to support **algae** blooms throughout the summer. **Alkalinity** is high enough that Lake Emily is able to support a number of aquatic biota and is not affected by acid precipitation.

**Chloride** levels, and to a lesser degree **sodium** and **potassium** levels, are commonly used as an indicator of how strongly a lake is being impacted by human activity. Both **chloride** and **sodium** are elevated. Although these constituents are not detrimental to the aquatic ecosystem, they indicate that sources of contaminants (road salt, fertilizer, animal waste and/or septic system effluent) are entering the lake from either surface runoff or via **groundwater**. **Atrazine** was found in low concentrations in the lake water (0.11 µg/L), however some toxicity studies have indicated that **endocrine** disruption can occur in frogs at these levels. The presence of **atrazine** indicates that other agri-chemicals may also be entering Lake Emily.

Table 1. 2002-2003 Seasonal water quality averages in Lake Emily.

| Lake Emily         | TP (ug/L) | RP (ug/L) | TN (mg/L) | NO2+NO3 (mg/L) | NH4 (mg/L) | Alkalinity (mg/L) | Total Hardness (mg/L) | Calcium Hardness (mg/L) | Color (CU) | Turbidity (NTU) | Chlorophyll a (ppm) |
|--------------------|-----------|-----------|-----------|----------------|------------|-------------------|-----------------------|-------------------------|------------|-----------------|---------------------|
| Spring Averages    | 15.1      | 5.5       | 6.43      | 0.39           | 0.31       | 150.5             | 159.0                 | 80.0                    | 10         | 1.0             | 0.0                 |
| Summer Averages    | 13.4      | 4.5       | 6.56      | 0.14           | 0.09       | 130.7             | 143.0                 | 47.8                    | 11         | 3.0             | 3.9                 |
| Fall Averages      | 29.5      | 8.5       |           | 0.12           | 0.35       | 140.5             | 151.5                 | 72.0                    | 14         | 1.6             |                     |
| Winter Averages    | 28.0      | 2.8       |           | 0.27           | 0.39       |                   |                       |                         |            |                 |                     |
| 2002-2004 Averages | 17.2      | 5.2       | 6.50      | 0.21           | 0.26       | 139.1             | 151.2                 | 63.9                    | 11         | 1.8             | 3.5                 |

TP=total **phosphorus**; RP=reactive or soluble **phosphorus**; TN=total **nitrogen**; NO2+NO3=**nitrite** and **nitrate nitrogen**; NH4=**ammonia nitrogen**

\*Terms in bold, see glossary pp 15-20

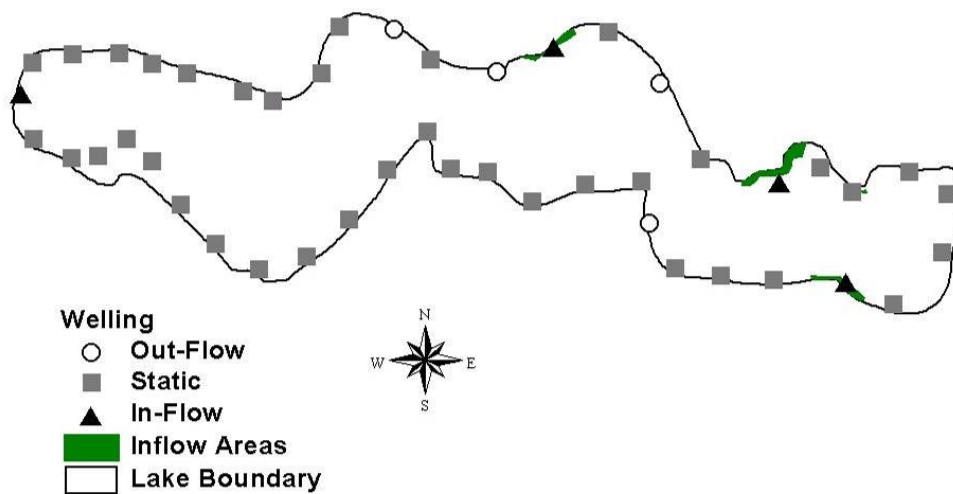
**Table 2. 2002-2003 Lake Emily average water chemistry and reference values.**

| Lake Emily | Low  | Medium | High | Reference Values | Low   | Medium    | High  |
|------------|------|--------|------|------------------|-------|-----------|-------|
| Sulfate    | 8.48 |        |      | Sulfate          | <10   | 10-20     | >20   |
| Chloride   |      | 5.11   |      | Chloride         | <3    | 3-10      | >10   |
| Potassium  | 0.87 |        |      | Potassium*       | <2.16 | 2.16-4.30 | >4.30 |
| Sodium     |      | 2.68   |      | Sodium*          | <2.28 | 2.28-5.09 | >5.09 |

\*Ranges of low, medium, high defined by taking the median values from the lake study and dividing into thirds.

**Groundwater** can enter lakes from water originating in the **groundwater** watershed, but it can also enter from local sources all around the lake, especially where there are steep slopes. Mini-wells were used to estimate where **groundwater** is entering and leaving Lake Emily. In addition, observations of open water during late winter were made by residents which enhanced the results from the mini-wells. Several areas of **groundwater** inflow exist on the north and of the lake as well as the south-east end (Figure 12). Elevated **nitrate** (8.6 mg/L) and **chloride** (15 mg/L) were measured in **groundwater** that was entering the west side of the lake. Water chemistry concentrations were low at the other **groundwater** inflow sites around Lake Emily.

**Figure 12. Locations in Lake Emily showing groundwater inflow/no flow/outflow from mini-piezometer measurements and winter observations.**



### Algal Community

The algal community in Lake Emily was very diverse and seasonally balanced (Table 3). The algal community was dominated by green **algae** (Chlorophyta), **blue-green algae** (Cyanobacteria), and Ochrophyta (yellow-green **algae** and **diatoms**). These three phyla accounted for 69% of all cells counted. Adding in the contributions of the Dinophyta (dinoflagellates, 16%), 85% of all cells counted came from these four phyla. In the 3,190+ cells counted during this period there were 9 genera of Cyanobacteria, 22 genera of Chlorophyta, 14 genera of Ochrophyta (including 12 **diatom** genera), 3 genera of Euglenophyta, 3 genera of

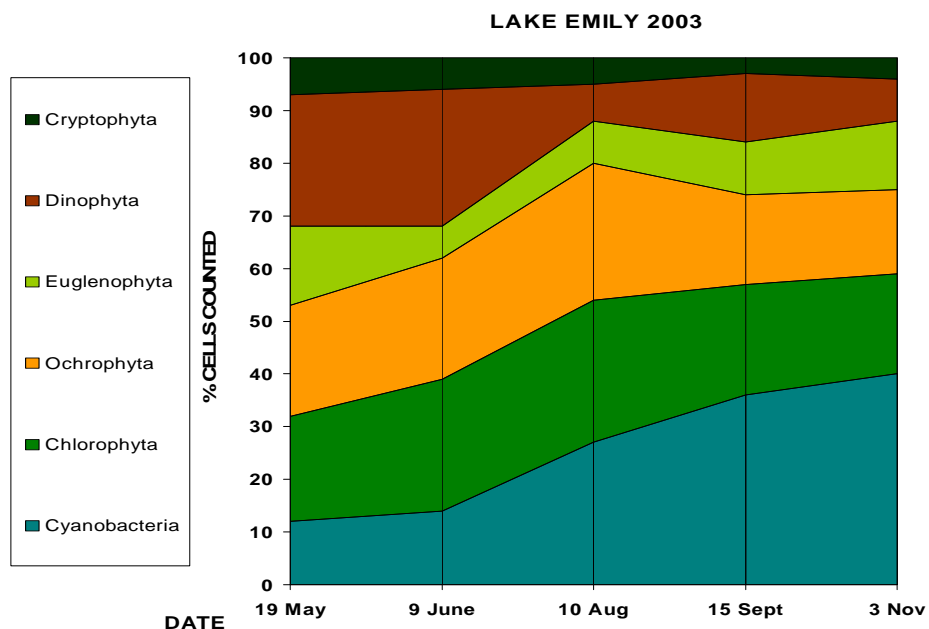
\*Terms in bold, see glossary pp 15-20

Dinophyta, and 2 genera of Cryptophyta identified. The **blue-green algae** represented between 12-40% (mean = 26%) of all cells counted, the green **algae** represented between 19-27% (mean = 22%) of all cells counted, and the ochrophytes (mostly **diatoms**) represented between 16-26% (mean = 21%) (Table 3). The dinoflagellates were the dominant group during May and June before declining in abundance for the rest of the sampling period. The “minor groups” in most lakes, the euglenoids, dinoflagellates, and cryptophytes, combined for an average of 31% of all cells counted; this was the highest seen for these groups in any lake in the study. The **blue-green algae** went from minor components of the community in May and June to the community dominants in August, September, and November. (Figure 13). The ochrophytes and chlorophytes were common and nearly equal subdominants during every sampling period but especially during May, June and August.

**Table 3. Algal phyla and mean seasonal composition in Lake Emily from May to November 2003.**  
LAKE EMILY

| PHYLUM        | % CELLS COUNTED BY PHYLUM AND DATE |        |        |         |       | MEAN |
|---------------|------------------------------------|--------|--------|---------|-------|------|
|               | 19 May                             | 9 June | 10 Aug | 15 Sept | 3 Nov |      |
| Cyanobacteria | 12                                 | 14     | 27     | 36      | 40    | 26   |
| Chlorophyta   | 20                                 | 25     | 27     | 21      | 19    | 22   |
| Ochrophyta    | 21                                 | 23     | 26     | 17      | 16    | 21   |
| Euglenophyta  | 15                                 | 6      | 8      | 10      | 13    | 10   |
| Dinophyta     | 25                                 | 26     | 7      | 13      | 8     | 16   |
| Cryptophyta   | 7                                  | 6      | 5      | 3       | 4     | 5    |

**Figure 13. Algal community composition by date in Lake Emily from May to November 2003 (total phylum cells counted divided by total cells counted).**



\*Terms in bold, see glossary pp 15-20

Dinoflagellates (*Peridinium*, *Ceratium*, *Gymnodinium*) were the dominant Lake Emily taxa in two of five sample periods and occupied the top three abundance spots in 6 of 15 samples (Table 4). The colonial blue-green *Coelosphaerium* was the dominant taxon in two of five sample periods and the colonial green alga *Scenedesmus* was the dominant taxon in one of the five samples (Figure 14). These taxa occupied 10 of 15 dominance slots in the cell counts and covered all the most and second most common slots. The third most common taxa slots were taken by the cryptophyte *Chroomonas*, the **diatom** *Asterionella*, the euglenoid *Euglena*, and the green *Ankistrodesmus*.

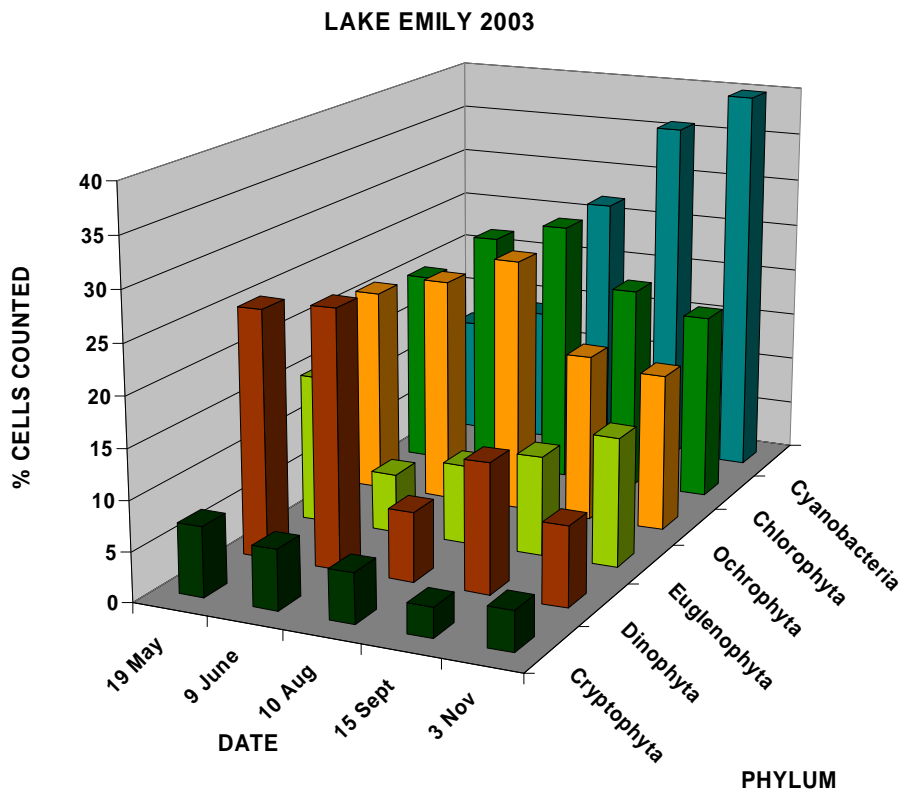
The algal community, when considered relative to the **chlorophyll**, **phosphorus**, and **nitrogen** values for Lake Emily, indicates a very **eutrophic** lake. The 55 genera identified during the sample periods were relatively common but heavy on the facultative heterotrophs from the dinoflagellates (*Peridinium*, *Ceratium*, *Gymnodinium*), euglenoids (*Euglena*, *Phacus*, *Trachelomonas*), and cryptophytes (*Cryptomonas*, *Chroomonas*). This heavy presence of motile animal-like organisms is very common in very **eutrophic** lakes. These organisms are an indication of organic matter being present at times in the lake. Motile heterotrophs like these can use organic materials for food in place of or in supplement to **photosynthesis**. In many cases, an algal community such as seen in this lake can be attributed to some source of organic enrichment such as heavy agricultural runoff, runoff sediment, or failing septic systems.

**Table 4. Most common algal genera by date in Lake Emily from May to November 2003.**

| DATE         | TOP THREE TAXA (MOST ABUNDANT, LEFT TO RIGHT) |                       |                       |
|--------------|---|-----------------------|-----------------------|
| 19 May       | <i>Peridinium</i>                             | <i>Ceratium</i> 2     | <i>Chroomonas</i>     |
| 9 June       | <i>Peridinium</i>                             | <i>Gymnodinium</i>    | <i>Chroomonas</i>     |
| 10 August    | <i>Scenedesmus</i>                            | <i>Coelosphaerium</i> | <i>Asterionella</i>   |
| 15 September | <i>Coelosphaerium</i>                         | <i>Gymnodinium</i>    | <i>Euglena</i> 2      |
| 3 November   | <i>Coelosphaerium</i>                         | <i>Gymnodinium</i>    | <i>Ankistrodesmus</i> |

\*Terms in bold, see glossary pp 15-20

**Figure 14. Algal community composition by phylum in Lake Emily from May to November 2003.**



\*Terms in bold, see glossary pp 15-20

## Lake Emily Study Highlights

- Lake Emily is adjacent to a large wetland located west of the lake and a smaller wetland on the eastern shore. There is a large County Park encompassing much of the eastern shoreline of the lake with Native American effigy mounds located in the park.
- A number of frog species are present and several large sections of natural shoreline still exists. Unfortunately, the lake also contains a high amount of altered shoreline.
- There are **66** species of aquatic **macrophytes** (65 species of **vascular plants** plus one species of **macrophytic algae**) that have been found in Lake Emily, on the shore, or in the small pond connected to the lake. This is above average for Portage County lakes. The average **coefficient of conservatism (c-value)** for the 65 species of **vascular plants** is **4.6** which is above average as well. The **floristic quality index** is **39.5** which is also above average for Portage County lakes.
- Eurasian water-milfoil was present by 1995 and it is becoming more abundant. A follow-up survey of the Eurasian water-milfoil was conducted in 2003.
- Water levels have dropped in recent years, converting areas, especially on the eastern and northern shores, previously under shallow water into an expanded beach. The upper portions of the former shore and beach was a dry upland with weedy annuals common in 2003, although with a higher water level in 2004 the wet shore is expanding toward the upper shore. However, Canada thistle is spreading aggressively on the beach and its spread will probably continue unless water levels rise enough to inundate it.
- Historic data indicates that the lake does not always completely mix every season. This is likely due to the shape and depth of the lake. With the current trophic state this does not appear to present a problem. However, should the lake become more **eutrophic**, the sporadic mixing of oxygen throughout the lake may present problems for the fishery, particularly in the winter when the lake is separated by ice from the atmosphere.
- At times the **clarity** was considered very good while at others it was fair. The water **clarity** was the worst in July, about 7.5 feet, and the best in June, approximately 20 feet.
- For the most part total **phosphorus** is currently being kept in check by the **marl** in the lake, but **nitrogen** concentrations are quite elevated which can enhance the growth of aquatic plants. Inorganic **nitrogen (nitrate plus ammonium)** is high enough in the spring to support **algae** blooms throughout the summer. **Alkalinity** is high enough that Lake Emily is able to support a number of aquatic biota and is not affected by acid precipitation.
- Both **chloride** and **sodium** are elevated. Although these constituents are not detrimental to the aquatic ecosystem, they indicate that sources of contaminants (road salt, fertilizer, animal waste and/or septic system effluent) are entering the lake from either surface runoff or via **groundwater**. **Atrazine** was found in low concentrations in the lake water. The presence of **atrazine** indicates that other agri-chemicals may also be entering Lake Emily.
- Several areas of **groundwater** inflow exist on the north and of the lake as well as the south-east end. Elevated **nitrate (8.6 mg/L)** and **chloride (15 mg/L)** were measured in **groundwater** that was entering the west side of the lake. Water chemistry concentrations were low at the other **groundwater** inflow sites around Lake Emily.

\*Terms in bold, see glossary pp 15-20

- The algal community, when considered relative to the **chlorophyll, phosphorus, and nitrogen** values for Lake Emily, indicates a very **eutrophic** lake. The heavy presence of motile animal-like organisms is very common in very **eutrophic** lakes. These organisms are an indication of organic matter being present at times in the lake. Motile heterotrophs like these can use organic materials for food in place of or in supplement to **photosynthesis**. In many cases, an algal community such as seen in this lake can be attributed to some source of organic enrichment such as heavy agricultural runoff, runoff sediment, or failing septic systems.

## Glossary

### Algae:

One-celled (phytoplankton) or multicellular plants either suspended in water (plankton) or attached to rocks and other substrates (periphyton). Their abundance, as measured by the amount of chlorophyll a (green pigment) in an open water sample, is commonly used to classify the trophic status of a lake. Numerous species occur. Algae are an essential part of the lake ecosystem and provides the food base for most lake organisms, including fish. Phytoplankton populations vary widely from day to day, as life cycles are short.

### Alkalinity:

A measure of the amount of carbonates, bicarbonates, and hydroxide present in water. Low alkalinity is the main indicator of susceptibility to acid rain. Increasing alkalinity is often related to increased algae productivity. Expressed as milligrams per liter (mg/L) of calcium carbonate (CaCO<sub>3</sub>), or as microequivalents per liter (ueq/l). 20 ueq/l = 1 mg/L of CaCO<sub>3</sub>.

### Ammonia, Ammonium:

A form of nitrogen found in organic materials and many fertilizers. It is the first form of nitrogen released when organic matter decays. It can be used by most aquatic plants and is therefore an important nutrient. It converts rapidly to nitrate (NO<sub>3</sub>) if oxygen is present. The conversion rate is related to water temperature. Ammonia is toxic to fish at relatively low concentrations in pH-neutral or alkaline water. Under acid conditions, non-toxic ammonium ions (NH<sub>4</sub><sup>+</sup>) form, but at high pH values the toxic ammonium hydroxide (NH<sub>4</sub>OH) occurs. The water quality standard for fish and aquatic life is 0.02 mg/L of NH<sub>4</sub>OH. At a pH of 7 and a temperature of 68° F (20° C), the ratio of ammonium ions to ammonium hydroxide is 250:1; at pH 8, the ratio is 26:1.

### Atrazine:

The nation's most widely used weedkiller for both grassy and broadleaf weeds.

### Blue-Green Algae:

Algae that are often associated with problem blooms in lakes. Some produce chemicals toxic to other organisms, including humans. They often form floating scum as they die. Many can fix nitrogen (N<sub>2</sub>) from the air to provide their own nutrient.

### Chloride (Cl<sup>-</sup>):

Chlorine in the chloride ion (Cl<sup>-</sup>) form has very different properties from chlorine gas (Cl<sub>2</sub>), which is used for disinfecting. The chloride ion (Cl<sup>-</sup>) in lake water is commonly considered an indicator of human activity. Agricultural chemicals, human and animal wastes, and road salt are the major sources of chloride in lake water.

### Chlorophyll a:

Green pigment present in all plant life and necessary for photosynthesis. The amount present in lake water depends on the amount of algae and is therefore used as a common indicator of water quality.

\*Terms in bold, see glossary pp 15-20

**Clarity:**

see "Secchi disc."

**Coefficient of Conservatism (c-value):**

Indicates on a scale of 0 to 10 the degree to which a species can tolerate disturbance to a native plant community; a species with a c value of 10 is found only in relatively undisturbed areas of native plant community, whereas a species with a c value of 0 never grows in undisturbed areas of native plant communities. Plants with low numbers tend to occur in a wide range of more-or-less disturbed plant communities. Alien species are also assigned a c value of 0. The c values are used in this report in calculating the Floristic Quality Index for each lake.

**Color:**

Measured in color units that relate to a standard. A yellow-brown natural color is associated with lakes or rivers receiving wetland drainage. The average color value for Wisconsin lakes is 39 units, with the color of state lakes ranging from zero to 320 units. Color also affects light penetration and therefore the depth at which plants can grow.

**Concentration Units:**

Express the amount of a chemical dissolved in water. The most common ways chemical data is expressed is in milligrams per liter (mg/L) and micrograms per liter (ug/L). One milligram per liter is equal to one part per million (ppm). To convert micrograms per liter (ug/L) to milligrams per liter (mg/L), divide by 1000 (e.g. 30 ug/l = 0.03 mg/L). To convert milligrams per liter (mg/L) to micrograms per liter (ug/L), multiply by 1000 (e.g. 0.5 mg/L = 500 ug/L). Microequivalents per liter (ueq/L) is also sometimes used, especially for alkalinity; it is calculated by dividing the weight of the compound by 1000 and then dividing that number into the mg/L.

**Diatoms:**

A major group of eukaryotic algae, which are one of the most common types of phytoplankton. Diatom communities are a popular tool for monitoring environmental conditions, past and present, and are commonly used in studies of water quality; often the brown stuff attached to rock surfaces.

**Drainage Basin:**

The total land area that drains toward the lake.

**Drainage Lakes:**

Lakes fed primarily by streams and with outlets into streams or rivers. They are more subject to surface runoff problems but generally have shorter retention times than seepage lakes. Watershed protection is usually needed to manage lake water quality.

**Endocrine:**

An integrated system of small organs that involve the release of extracellular signaling molecules known as hormones. The endocrine system is instrumental in regulating metabolism, growth, development and puberty, tissue function, and also plays a part in determining mood.

**Erosion:**

The lowering of the land surface by weathering, corrosion, and transportation, under the influence of gravity, wind, and running water.

**Eutrophic:**

Eutrophic lakes are high in nutrients and support a large biomass (all the plants and animals living in a lake). They are usually either weedy or subject to frequent algae blooms, or both. Eutrophic lakes often support large fish populations, but are also susceptible to oxygen depletion. Small, shallow, eutrophic lakes are especially vulnerable to winterkill which can reduce the number and variety of fish. Rough fish are commonly found in eutrophic lakes.

\*Terms in bold, see glossary pp 15-20

**Eutrophication:**

The process by which lakes and streams are enriched by nutrients, and the resulting increase in plants and algae. The extent to which this process has occurred is reflected in a lake's trophic classification: oligotrophic (nutrient poor), mesotrophic (moderately productive), and eutrophic (very productive and fertile).

**Fen:**

A fen is a type of wetland fed by surface and/or groundwater. Fens are characterized by their water chemistry, which is neutral or alkaline, unlike bogs, which are generally acid.

**Floristic Quality Index (FQI):**

The FQI is a standardized method for evaluating natural plant communities by multiplying the average coefficient of conservatism (c-value) for all species by the square root of the total number of species found at that lake; an additional point is added to the index for each state-listed special concern species, two points added for a threatened species, and three points added for an endangered species. A higher floristic quality index, such as FQI=60, indicates a higher floristic quality and biological integrity and a lower level of disturbance impacts. A lower floristic quality index, such as FQI=20, indicates a lower floristic quality and biological integrity and a higher level of disturbance impacts.

**Groundwater:**

Water found below the land surface in pore spaces between soil particles or in cracks in rock. It moves slowly from higher to lower areas on the landscape and may provide water to a lake.

**Groundwater Drainage Lake:**

Often referred to a spring-fed lake, has large amounts of groundwater as its source, and a surface outlet. Areas of high groundwater inflow may be visible as springs or sand boils. Groundwater drainage lakes often have intermediate retention times with water quality dependent on groundwater quality.

**Hardness, Hard Water:**

The quantity of multivalent cations (cations with more than one +), primarily calcium (Ca<sup>++</sup>) and magnesium (Mg<sup>++</sup>) in the water expressed as milligrams per liter of CaCO<sub>3</sub>. Amount of hardness relates to the presence of soluble minerals, especially limestone, in the lake watershed. Soft water has 60 mg/L CaCO<sub>3</sub> or less, moderately hard water has 61-120 mg/L CaCO<sub>3</sub>, hard water has 121-180 mg/L CaCO<sub>3</sub>, and very hard water has more than 180 mg/L CaCO<sub>3</sub>.

**Impoundment:**

Manmade lake or reservoir usually characterized by stream inflow and always by a stream outlet. Because of nutrient and soil loss from upstream land use practices, impoundments ordinarily have higher nutrient concentrations and faster sedimentation rates than natural lakes. Their retention times are relatively short.

**Littoral:**

The shallow water zone near the shoreline that is home to most aquatic plants.

**Macrophytes:**

see "Rooted aquatic plants."

**Macrophytic Algae:**

Algae that resemble true plants in that they appear to have stems and leaves, and are attached to the bottom.

\*Terms in bold, see glossary pp 15-20

**Marl:**

White to gray accumulation on lake bottoms caused by precipitation of calcium carbonate ( $\text{CaCO}_3$ ) in hard water lakes. Marl may contain many snail and clam shells, which are also calcium carbonate. While it gradually fills in lakes, marl also precipitates phosphorus, resulting in low algae populations and good water clarity. In the past, marl was recovered and used to lime agricultural fields.

**Mesotrophic:**

Mesotrophic lakes lie between the oligotrophic and eutrophic trophic stages. In late summer, they lose oxygen at depth, limiting cold water fish and causing phosphorus release from sediments.

**mg/L:**

see "Concentration units"

**Nitrate ( $\text{NO}_3^-$ ):**

An inorganic form of nitrogen important for plant growth. Nitrogen is in this stable form when oxygen is present. Nitrate often contaminates groundwater when water originates from manure pits, fertilized fields, lawns or septic systems. High levels of nitrate-nitrogen (over 10 mg/L) are dangerous to infants and expectant mothers. A concentration of nitrate-nitrogen ( $\text{NO}_3\text{-N}$ ) plus ammonium-nitrogen ( $\text{NH}_4\text{-N}$ ) of 0.3 mg/L in spring will support summer algae blooms if enough phosphorus is present.

**Nitrite ( $\text{NO}_2^-$ ):**

A form of nitrogen that rapidly converts to nitrate ( $\text{NO}_3^-$ ) and is usually included in the  $\text{NO}_3^-$  analysis.

**Nitrogen:**

A chemical element that is an essential plant nutrient and may occur in the form of nitrate, nitrite, ammonium, or organic nitrogen in lakes.

**Oligotrophic:**

A trophic state in which lakes are generally clear, deep and free of weeds or large algae blooms. Though beautiful, they are low in nutrients and do not support large fish populations. However, oligotrophic lakes often develop a food chain capable of sustaining a very desirable fishery of large game fish.

**Phosphorus:**

Key nutrient influencing plant growth in more than 80% of Wisconsin lakes. Soluble reactive phosphorus is the amount of phosphorus in solution that is available to plants. Total phosphorus includes the amount of phosphorus in solution (reactive) and in particulate form.

**Photosynthesis:**

The process by which green plants convert carbon dioxide ( $\text{CO}_2$ ) dissolved in water to sugar and oxygen using sunlight for energy. Photosynthesis is essential in producing a lake's food base, and is an important source of oxygen for many lakes.

**Potassium:**

A chemical element that is an essential plant nutrient and may enter lakes from runoff of agricultural fertilizers and animal wastes.

**Retention Time: (Turnover Rate or Flushing Rate)**

The average length of time water resides in a lake, ranging from several days in small impoundments to many years in large seepage lakes. Retention time is important in determining the impact of nutrient inputs. Long retention times result in recycling and greater nutrient retention in most lakes. Calculate retention time by dividing the volume of water passing through the lake per year by the lake volume.

\*Terms in bold, see glossary pp 15-20

**Rip Rap (Rip-Rap):**

Hard rock, commonly granite or concrete rubble recycled from construction sites, used inland on lakes, rivers, coastlines, and other waterways to prevent bank erosion. Generally rip rap is not considered good management in lakes, due to its inability to provide adequate habitat, and is no longer commonly used.

**Rooted Aquatic Plants: (Macrophytes)**

Refers to higher (multi-celled) plants growing in or near water. Macrophytes are beneficial to lakes because they produce oxygen and provide substrate for fish habitat and aquatic insects. Overabundance of such plants, especially problem species, is related to shallow water depth and high nutrient levels.

**Secchi Disc (Secchi Disk):**

An 8-inch diameter plate with alternating quadrants painted black and white that is used to measure water clarity (light penetration). The disc is lowered into water until it disappears from view. It is then raised until just visible. An average of the two depths, taken from the shaded side of the boat, is recorded as the Secchi disc reading. For best results, the readings should be taken on sunny, calm days.

**Sedimentation:**

Accumulated organic and inorganic matter on the lake bottom. Sediment includes decaying algae and weeds, marl, and soil and organic matter eroded from the lake's watershed.

**Seepage Lakes:**

Lakes without a significant inlet or outlet, fed by rainfall and groundwater. Seepage lakes lose water through evaporation and groundwater moving on a down gradient. Lakes with little groundwater inflow tend to be naturally acidic and most susceptible to the effects of acid rain. Seepage lakes often have long retention times, and lake levels fluctuate with local groundwater levels. Water quality is affected by groundwater quality and the use of land on the shoreline.

**Sodium:**

A chemical element that may enter lakes from runoff of road salt, fertilizers, and human and animal wastes.

**Stratification, Stratified:**

The layering of water due to differences in density. Water's greatest density occurs at 39°F (4°C). As water warms during the summer, it remains near the surface while colder water remains near the bottom. Wind mixing determines the thickness of the warm surface water layer (epilimnion), which usually extends to a depth of about 20 ft. The narrow transition zone between the epilimnion and cold bottom water (hypolimnion) is called the metalimnion or thermocline.

**Sulfate (SO<sub>4</sub><sup>-</sup>):**

The most common form of sulfur in natural waters. The amounts relate primarily to soil minerals in the watershed. Sulfate (SO<sub>4</sub><sup>-</sup>) can be reduced to sulfide (S<sup>-</sup>) and hydrogen sulfide (H<sub>2</sub>S) under low or zero oxygen conditions. Hydrogen sulfide smells like rotten eggs and harms fish. Sulfate input from acid rain is a major indicator of sulfur dioxide (SO<sub>2</sub>) air pollution. Sulfate concentration is used as a chemical fingerprint to distinguish acid lakes acidified by acid rain from those acidified by organic acids from bogs.

**Substrate:**

The material found at the bottom of a lake, such as silt, mud, sand, clay, marl, gravel, etc.

**Suspended Solids:**

A measure of the particulate matter in a water sample, expressed in milligrams per liter. When measured on inflowing streams, it can be used to estimate the sedimentation rate of lakes or impoundments.

**Turbidity:**

The "cloudiness" or "murkiness" of water, caused by total suspended solids.

\*Terms in bold, see glossary pp 15-20

**Vascular Plants:**

Vascular plants are those plants that have tissues for conducting water, minerals, and food through the plant. Vascular plants include the ferns, clubmosses, flowering plants, and conifers.

**Watershed:**

The total land area that drains either surface water or groundwater toward a lake.

\*Terms in bold, see glossary pp 15-20