## Spring Lake

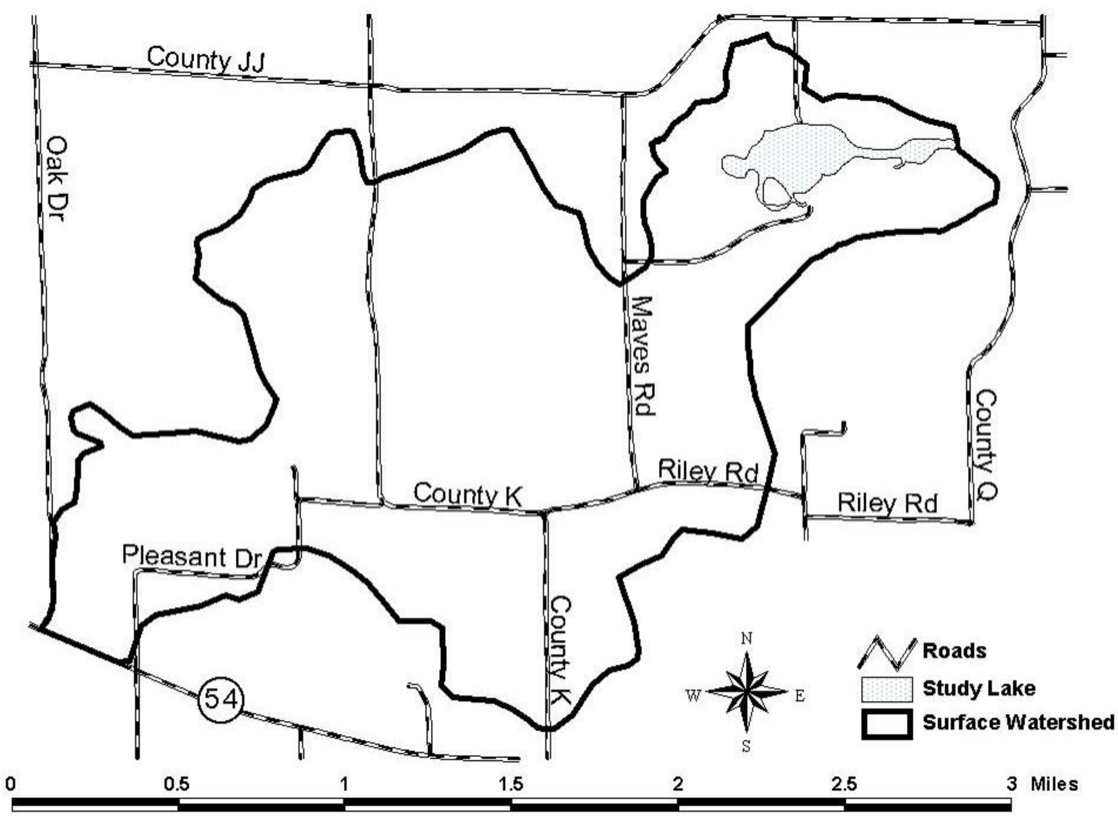
### Introduction

Spring Lake is a clear 37.5 acre **drainage** lake with an estimated volume of 311 acre-feet, located in the Town of Lanark (Figure 1). It is a relatively deep lake with a maximum depth of 42 feet and a bottom consisting primarily of marl, with sand, silt, muck, and rubble also present. The marl appears to have been mined at one time. The estimated water **retention time** is 0.1 years. The shoreline is mostly undeveloped, making Spring Lake aesthetically pleasing. Spring Lake is fed by Mack Creek and numerous springs. Spring Creek serves as an outlet. The sport fish community is dominated by bluegill, largemouth bass, and rock bass. There are two public access sites, one along the north shore and the other on the south shore.

### Land Use and Watershed

The surface **watershed** of Spring Lake is 1,753 acres (Figure 1). Land use in this area is mostly forest (42%), followed by non-irrigated agriculture (30%) and shrub vegetation (22%). Since 1948 it appears shrub cover has converted to forestland, with most of the growth occurring between 1968 and 1990. Residential development has been increasing, but most riparian landowners have set back homes and left generous buffers that provide water quality benefits and habitat. All other usage within the surface watershed has remained minimal during this period (Figure 2 and Figure 3).

**Figure 1. Spring Lake surface watershed boundary.**




*Terms in bold, see glossary pp 16-21

**Figure 2. Land use in the Spring Lake surface Watershed 2002.**

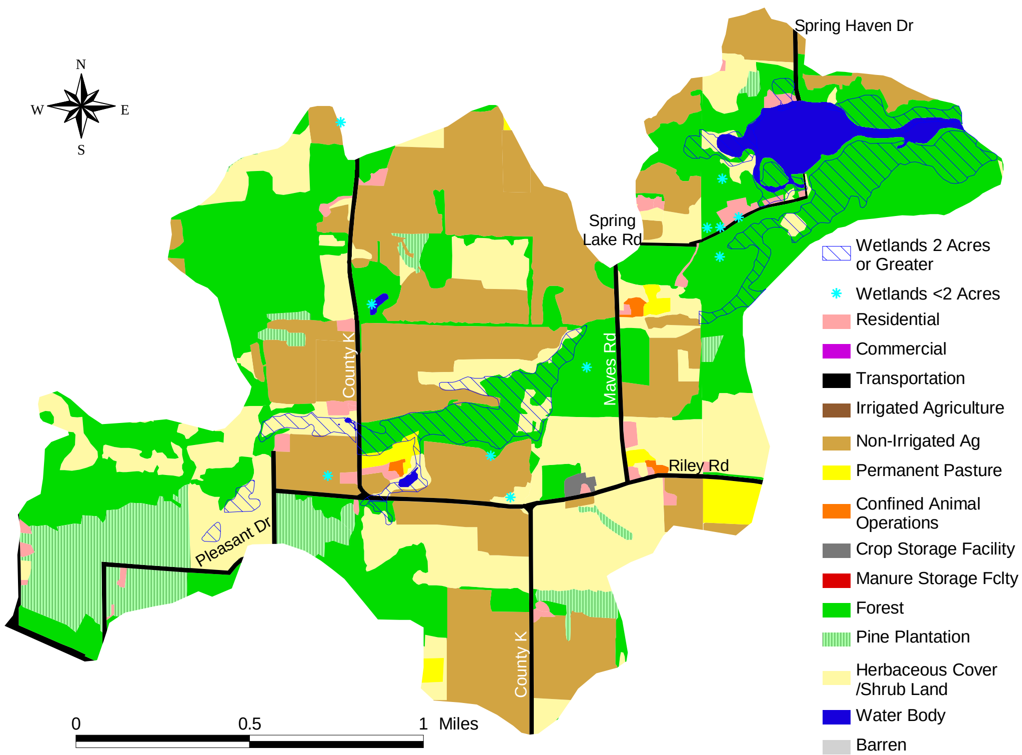
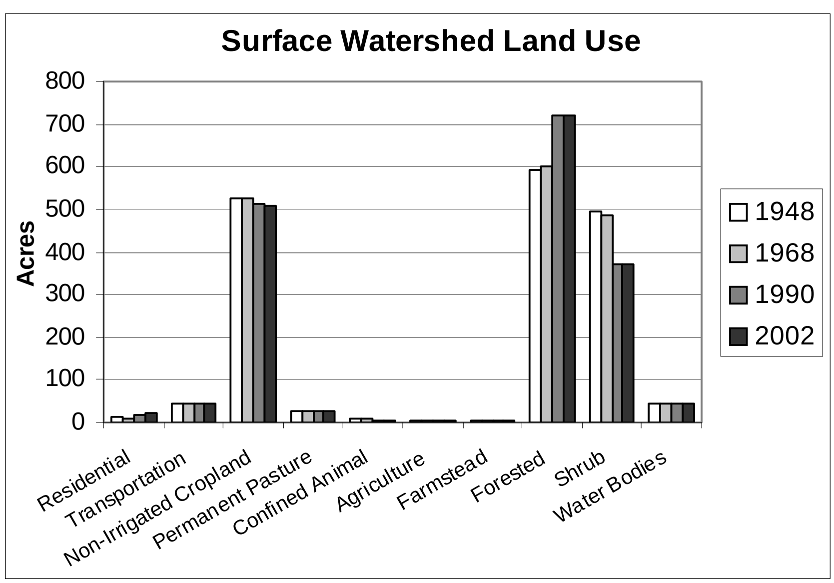



**Figure 3. Land use in the Spring Lake surface Watershed 1948-2002.**




The **groundwater watershed** of Spring Lake is 4,739 acres (Figure 4). Land use is primarily forested (42%), followed by non-irrigated cropland (32%) and shrub cover (18%). Forestland has been increasing since 1948, primarily between 1968 and 1990. Shrub vegetation has shown a

*Terms in bold, see glossary pp 16-21

corresponding decrease. Residential development has been rising modestly since 1968 (Figure 5 and Figure 6). According to the records there are three potentially failing septic systems present in both the surface and **groundwater watershed**s, all of them being at or near the shoreline. There is no indication that any former landfill sites are present in either.

**Figure 4. Spring Lake groundwater watershed boundary.**

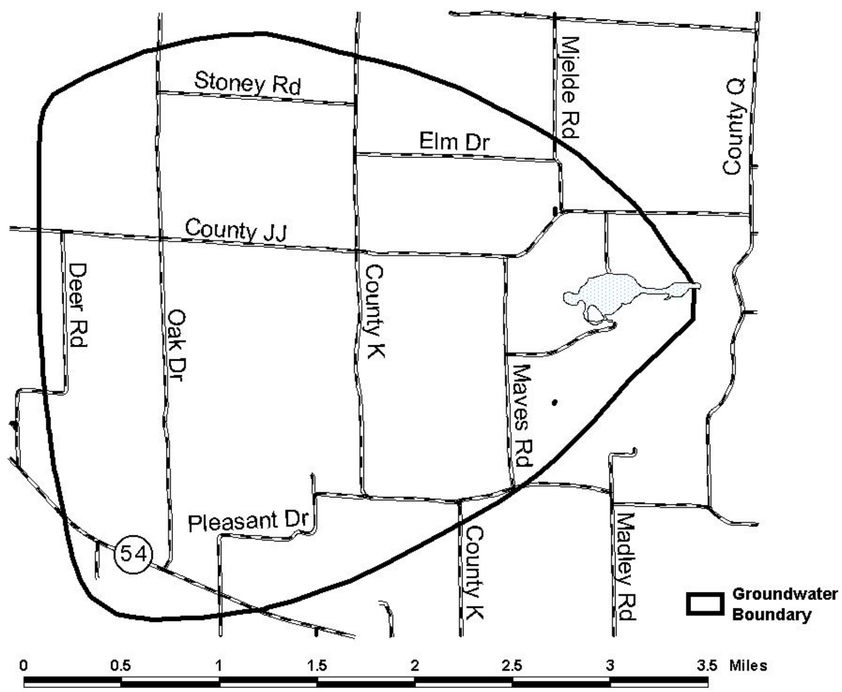
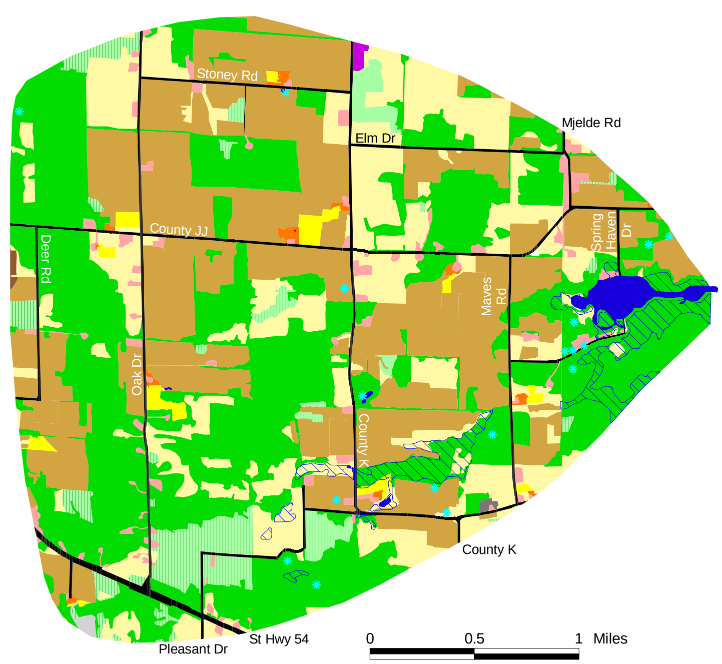
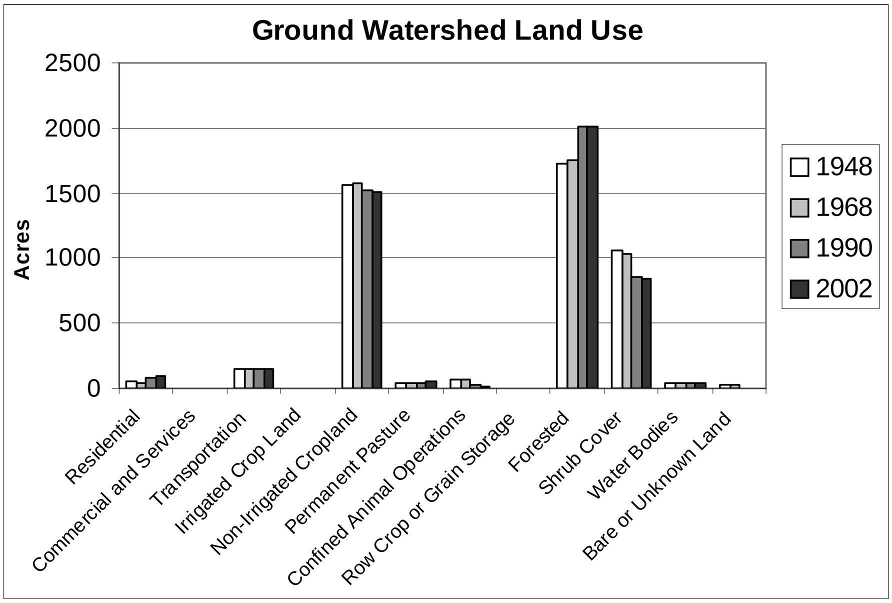



**Figure 5. Land use in the Spring Lake groundwater watershed 2002.**




*Terms in bold, see glossary pp 16-21

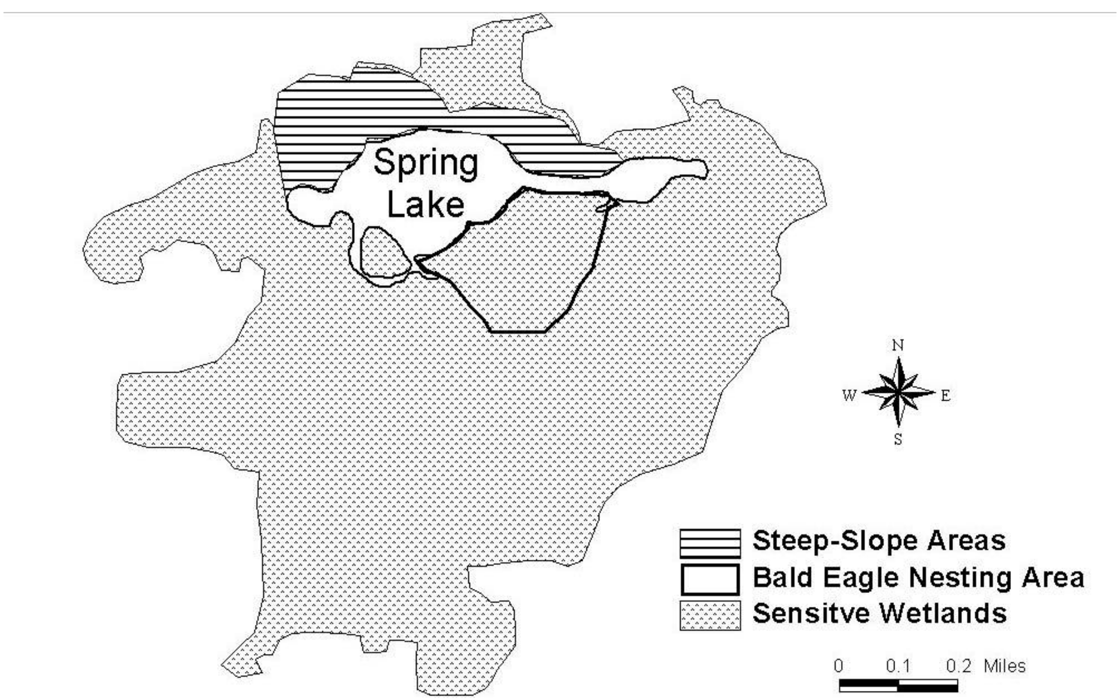
**Figure 6. Land use in the Spring Lake groundwater watershed 1948-2002.**




## Upland Sensitive Areas

The survey of upland sensitive areas was conducted to note areas immediately around the lakeshore that are particularly valuable, or sensitive to disruption. Spring Lake offers some unique areas, with bald eagles making their home on its shore. The lake is encompassed by a very large expanse of wetland, primarily south of the lake. Steep slopes line the north shore (Figure 7).

**Figure 7. Upland sensitive areas near Spring Lake.**




*Terms in bold, see glossary pp 16-21

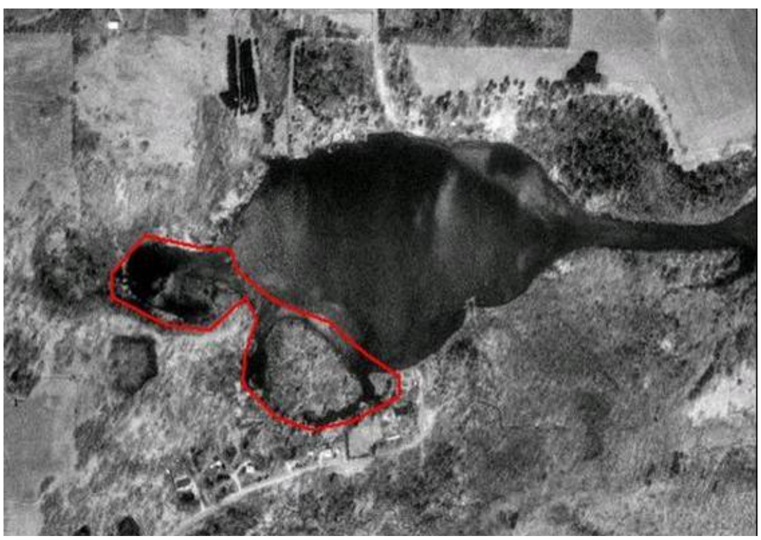
**Reptiles and Amphibians**
Amphibians (frogs and toads) were included in this survey because with their permeable skin and biphasic lifecycle (meaning that the young live in water while adults can survive on land) they are considered excellent indicators of overall ecosystem health. Furthermore, both 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 anurans are intimately associated with lakes and the associated habitats of a **watershed**.

Three frog species were identified during the survey of Spring Lake (spring peeper [*Pseudacris crucifer*], American toad [*Bufo americanus*], and green frog [*Rana clamitans*]). The primary amphibian habitat is located on several sections of shoreline (sensitive area is identified in red on 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 large sections of natural, undisturbed shoreline are present on Spring Lake. Unfortunately, there have been small sections of shoreline altered. During the survey of reptiles Spring Lake was found to be home to two turtle species (painted turtle [*Chrysemys picta*] and snapping turtle [*Chelydra serpentina*]).

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



*Terms in bold, see glossary pp 16-21

**Aquatic Plants**
There are 30 species of aquatic or wetland **vascular plants** that have been found in Spring Lake or on the wet areas of the shore. That is below average for Portage County lakes. The average **coefficient of conservatism** (**c-value**) is 3.7, which is below average. The **floristic quality index** is 20.4, which is also below average for Portage County lakes.

Spring Lake has a relatively small flora, composed mostly of common species. The alien curly leaf pondweed (*Potamogeton crispus)* is well-established. The die-off of curly leaf pondweed in late June releases nutrients when the water is warm and fuels filamentous **algae** growth for the rest of the summer. If Eurasian water-milfoil (*Myriophyllum spicatum*) becomes established in the future, it would probably become quite abundant. A large bog and conifer swamp complex on the south shore should be surveyed; a species list from this bog complex would probably raise the c value and **floristic quality index** substantially if it were included with the Spring Lake data.

**The Fishery**
Spring Lake supports a warm water fishery and stocked cold water fishery. Fifteen species were found in 2002 and 2003 compared to 19 from historical records dating back to the 1940s. A total of 22 species of fish have been reported from Spring Lake since 1948 (Table 1). Three newly documented species were found including blackchin shiner (*Notropis heterodon*), banded killifish (*Fundulus diaphanus*), and central mudminnow (*Umbra limi*). The sport fish community is dominated by bluegill (*Lepomis macrochirus*), largemouth bass, (*Micropterus salmoides*), and rock bass (*Ambloplites rupestris*).

*Terms in bold, see glossary pp 16-21

**Table 1. Species occurrence in Spring Lake from the 2002/2003 study and WDNR records.**

**Note: "S" indicates WDNR stocking record.**

| | |
|---|---|
| **Brook Trout** | 1964. **S**; 1982-1972 |
| **Brown Trout** | 1966, 1964. **S**; 1980, 1972 |
| **Rainbow Trout** | 1985, 1958, 1948. **S**; 2003-1998, 1996-1983, 1979 |
| **Bluegill** | 2003, 1985, 1960, 1959, 1948 |
| **Pumpkinseed** | 1985, 1960, 1959, 1948 |
| **Green Sunfish** | 2003, 1959 |
| **Rock Bass** | 2003, 1960, 1959, 1948 |
| **Largemouth Bass** | 2003, 1985, 1966, 1960, 1959, 1948 |
| **Black Crappie** | 2003, 1985, 1948 |
| **Walleye** | 1985 |
| **Yellow Perch** | 2003, 1985, 1959, 1948 |
| **Iowa Darter** | 2003, 1959 |
| **Banded Darter** | 1960, 1959 |
| **Northern Pike** | 2003, 1985 |
| **White Sucker** | 2003, 1959, 1948 |
| **Sucker sp**. | 1964 |
| **Bluntnose Minnow** | 2003, 1960, 1959 |
| **Golden Shiner** | 2003, 1960 |
| **Blackchin Shiner** | 2003 |
| **Brook Stickleback** | 2003, 1960, 1959 |
| **Banded Killifish** | 2003 |
| **Central Mudminnow** | 2003 |
| **Mottled Sculpin** | 1960, 1959 |

All three of these species were more numerous and larger in size than in most other area lakes. The lake has been repeatedly stocked with brown trout (*Salmo trutta*), rainbow trout (*Oncorhynchus mykiss*), and brook trout (*Salvelinus fontinalis*), but none were found in the fall 2002-2003 survey. They undoubtedly are present at times as they are periodically caught by anglers. The lake has had little detrimental development, and other than the water level being raised by a low dam downstream about one mile on the outlet stream, it retains much of its natural characteristics. Seven species previously documented over the years were not found in the present survey including the three trout species, walleye (*Sander vitreum*), banded darter (*Etheostoma zonale*), pumpkinseed (*Lepomis gibbosus*), and mottled sculpin (*Cottus bairdi*). There is no spawning habitat for walleye in this lake and the records showed just one individual reported in 1985. It does not appear walleye were ever present in any numbers here. The pumpkinseed, last reported in 1987, has declined in many area lakes because of hybridization with bluegill, although no hybrids were found in Spring Lake in 2002 and 2003. The banded darter is a stream fish and may have been more abundant when fish could more freely move into the lake before the low dam on the outlet stream was built. The mottled sculpin is also a stream fish, but restricted to colder water and would not find suitable spawning habitat in a small lake. Several of these species and others could naturally find their way back into the lake through the

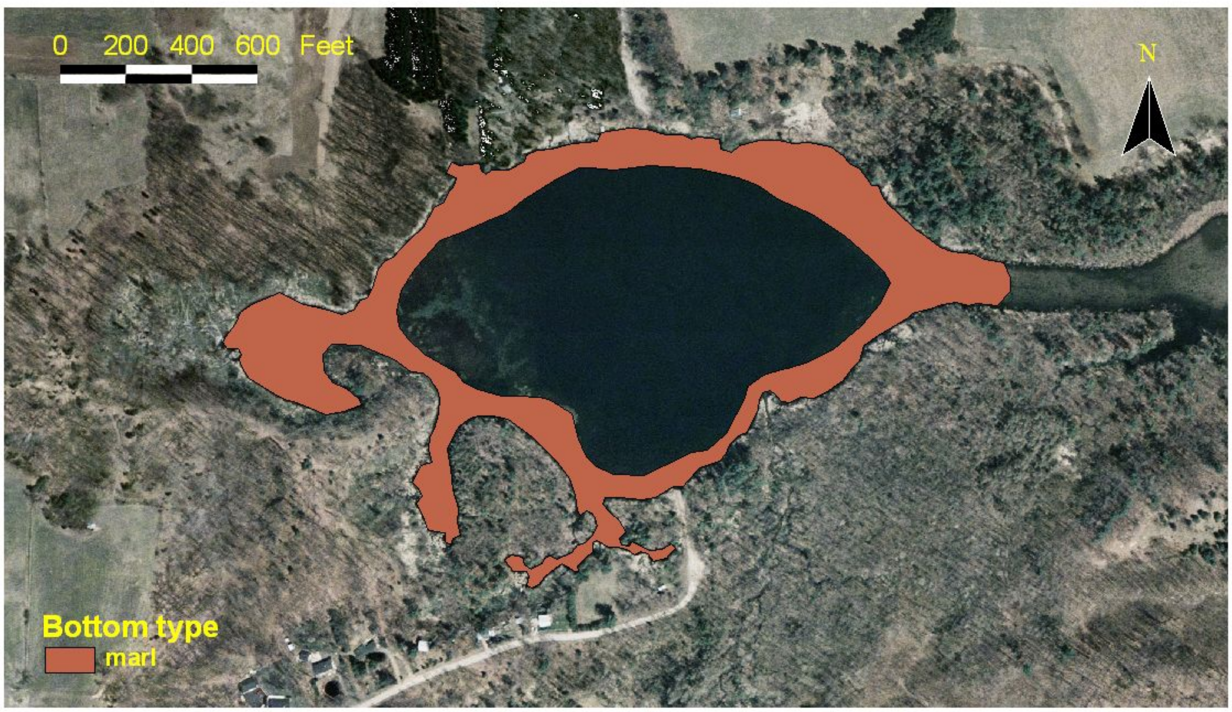
*Terms in bold, see glossary pp 16-21

outlet at high water or perhaps through the inlet, although this stream is very small and probably supports a low diversity of fish.

**Bottom Substrate, Vegetative Structure, and Critical Habitat**
Bottom **substrate** in **littoral** areas is almost entirely **marl** (Figure 9). The bottom is soft and will not support an individual wading. Although **marl** is a marginal spawning **substrate**, suitable areas exist in this lake for the largemouth bass, rock bass and bluegill to spawn as evidenced by their abundance. Woody debris and snail shells embedded in the **marl** are often successfully used as a spawning **substrate** for species that normally prefer sand and gravel. Much of the shoreline is shrub and tree-lined and down timber provides excellent permanent cover in several areas of the lake. Additional standing timber in the water that was killed by flooding from raising the stream outlet dam will provide additional habitat as it continues to fall into the water in coming years.

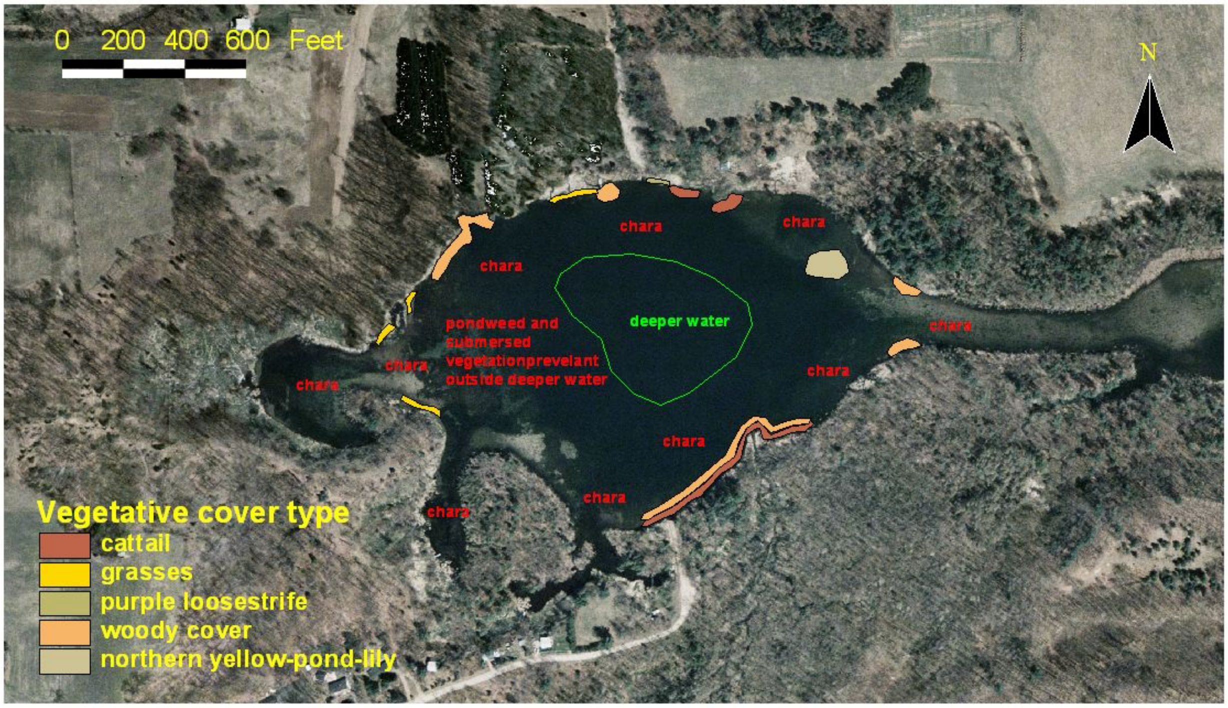
A luxuriant blanket of Chara (*Chara* spp.) covers the entire lake bottom and a few beds of water lilies (*Nymphaea* spp.) provide surface cover (Figure 10). There are a few areas of emergent vegetation represented by cattails (*Typha* spp.) and submerged grasses with rush (family *Juncaceae*) in the shallows near the outlet stream, but spawning areas with abundant emergent vegetation for northern pike (*Esox lucius*) appear limited. Based on the present survey and past records, this species appears to have never been abundant in this lake.

**Figure 9. Littoral bottom map of Spring Lake 8/3/03.**




*Terms in bold, see glossary pp 16-21

**Figure 10. Vegetative cover map of Spring Lake 8/3/03.**




## Current Water Quality Conditions

Water quality in lakes is assessed by measuring different characteristics including temperature, dissolved oxygen, water **clarity**, **chlorophyll *a***, water chemistry, and the algal community. Temperature and dissolved oxygen were measured with depth during each sampling period. The temperature in Spring Lake is quite typical of lakes it Wisconsin; it mixes from top to bottom in spring and fall and is **stratified** during the summer and winter (Figure 11). During the **stratified** time of the year dissolved oxygen concentrations are low below 12 feet of water making the lower portion of the lake undesirable for most aquatic organisms (Figure 12).

*Terms in bold, see glossary pp 16-21

**Figure 11. Profile of temperature in Spring Lake 2002-2004.**

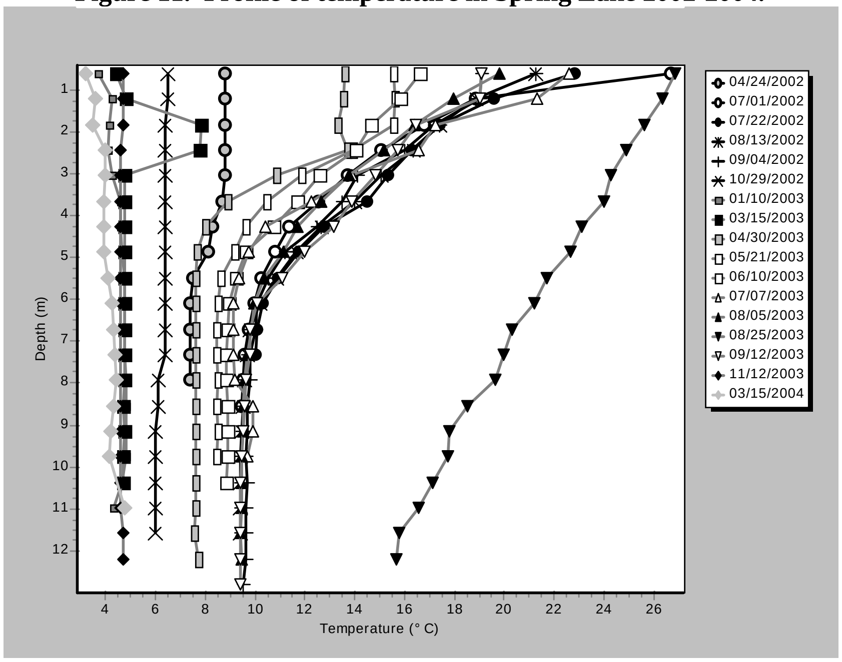
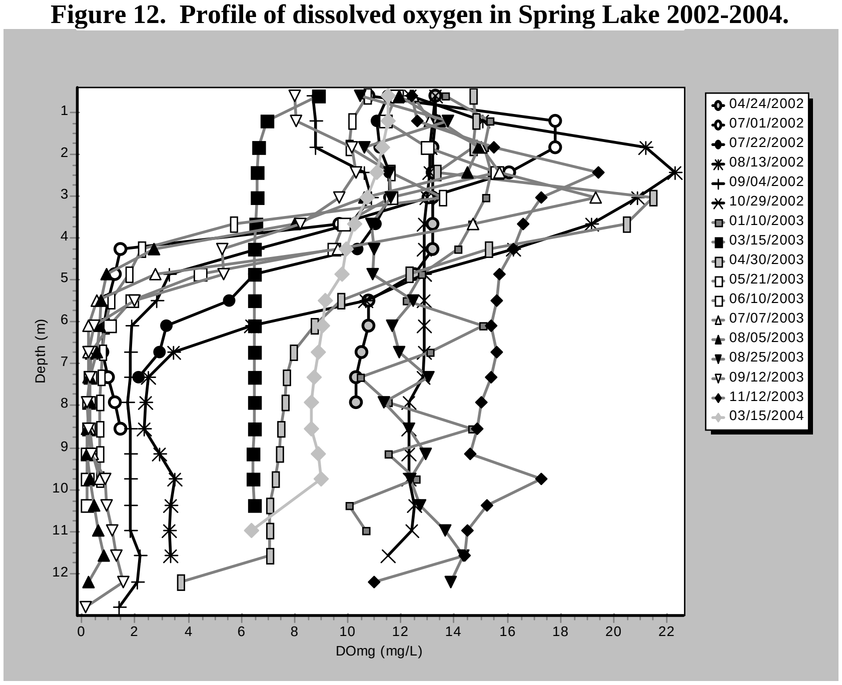



**Figure 12. Profile of dissolved oxygen in Spring Lake 2002-2004.**

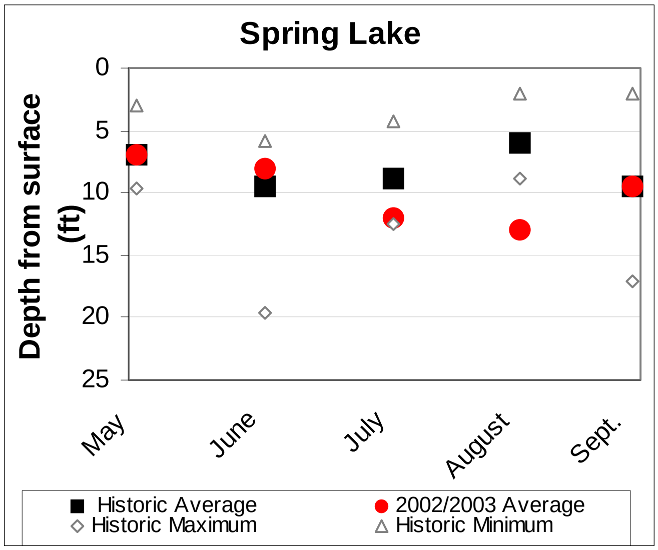



Water **clarity** is a measure of how deep light can penetrate. It is an aesthetic measure and is related to how deep **rooted aquatic plants** can grow. Water **clarity** is affected by water **color** and suspended materials in the water (**turbidity**). **Turbidity** consists of **suspended solids**, such as suspended sediments and **algae** (**chlorophyll *a***). **Color** and **turbidity** measures were low, but **chlorophyll *a*** was high throughout the summer with the exception of late July/early August 2003 (Table 2). The water **clarity** of Spring Lake during the 2002-03 growing seasons was similar to the historical growing season average, except in July and August when it was better

*Terms in bold, see glossary pp 16-21

than average. The water **clarity** in Spring Lake ranges from fair to good. Ten feet is the average water **clarity** measure for **drainage lakes** in Portage County. In Spring Lake the month of August shows the best water **clarity** and the month of May the poorest (Figure 13). Water **clarity** fluctuations are expected throughout the growing season as **algae** populations and **sedimentation** increase and decrease.

**Figure 13. Monthly average water clarity measurements in Spring Lake 2002-2003 and historic average, maximum and minimums.**




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). In Spring Lake **nitrogen** (mostly as **nitrate**) concentrations are high and so are **phosphorus** concentrations. These concentrations are high throughout the year and sufficient to produce abundant aquatic plants and **algae** blooms. **Chloride** and **sodium** concentrations are also high. 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 (0.06, 0.18, and <0.05 µg/L), however some toxicity studies have indicated that reproductive system abnormalities can occur in frogs at these levels. The presence of **atrazine** indicates that other agri-chemicals may also be entering Spring Lake. This **eutrophic** lake is a reflection of the agricultural land uses in the **watershed**.

**Table 2. 2002-2003 water quality seasonal averages in Spring Lake.**

| Spring Lake | 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 | 44.3 | 8.5 | 3.55 | 2.76 | 0.06 | 195.0 | 212.0 | 115.5 | 10 | 2.2 | 11.8 |
| Summer Averages | 41.2 | 11.8 | 2.83 | 2.19 | 0.08 | 213.0 | 215.0 | 111.7 | 6 | 1.2 | 9.9 |
| Fall Averages | 24.5 | 14.5 | | 3.09 | 0.11 | 200.0 | 224.5 | 123.0 | 7 | 1.2 | |
| Winter Averages | 49.3 | 15.7 | | 4.47 | 0.09 | | | | | | |
| 2002-2004 Averages | 41.2 | 12.9 | 3.19 | 3.17 | 0.08 | 202.7 | 217.2 | 116.7 | 8 | 1.5 | 10.1 |

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 16-21

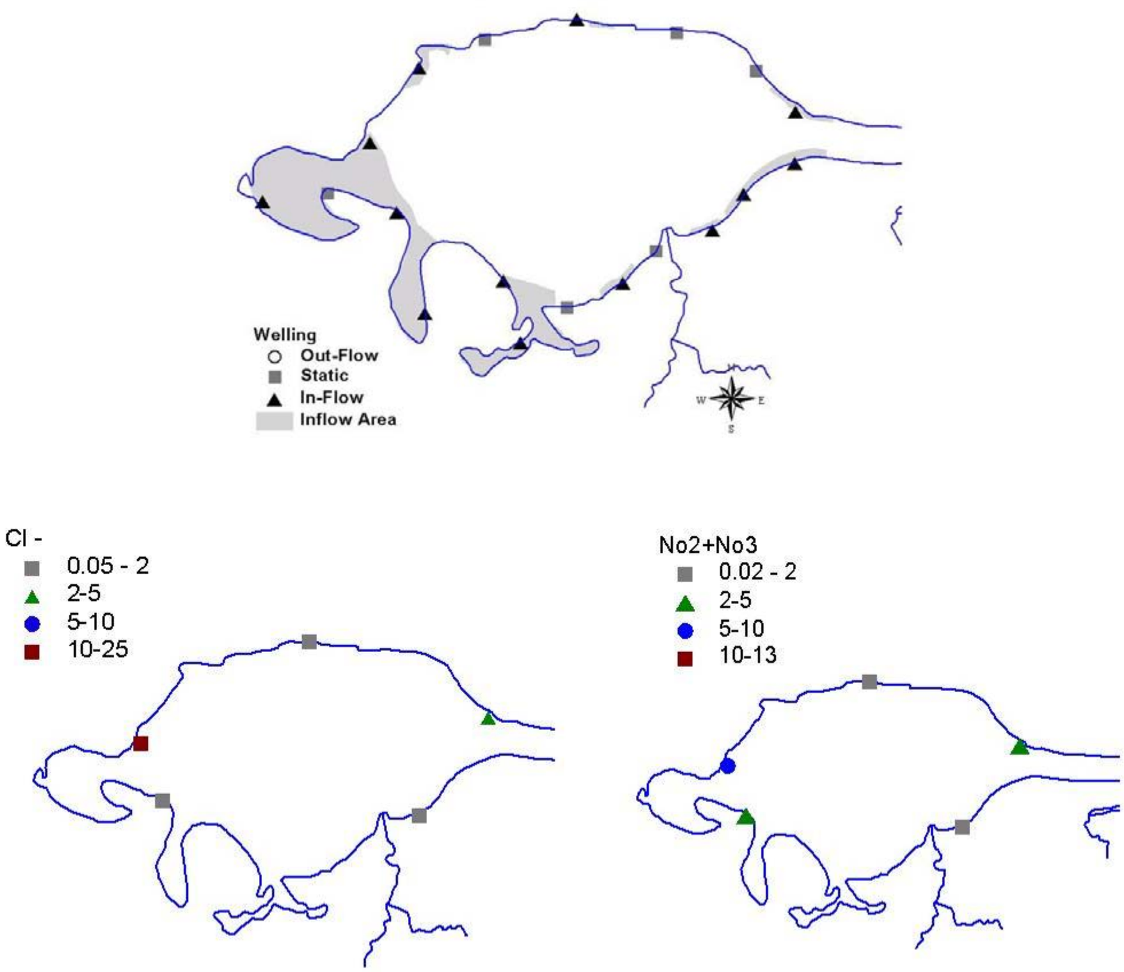
**Table 3. 2002-2003 Spring Lake average water chemistry and reference values.**

| Spring Lake | Low | Medium | High | Reference Values | Low | Medium | High |
|---|---|---|---|---|---|---|---|
| *Sulfate* | 8.95 | | | *Sulfate* | <10 | 10-20 | >20 |
| *Chloride* | | 4.70 | | *Chloride* | <3 | 3-10 | >10 |
| *Potassium* | 1.20 | | | *Potassium** | <2.16 | 2.16-4.30 | >4.30 |
| *Sodium* | | 3.00 | | *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.*

Nineteen mini wells were inserted into the lakebed around Spring Lake to determine regions of **groundwater** inflow/no flow/outflow. Sixty-eight percent of the wells showed **groundwater** inflow (Figure 14). Five samples were collected from inflow sites for water quality lab analysis. Reactive **phosphorus** and **ammonium** concentrations were low. **Nitrate** concentrations ranged from 0.2 to 7.3 **mg/l** and **chloride** ranged from 0.5 to 10.5 **mg/l**. The elevated **nitrate** and **chloride** samples were from the same sites. These were also sites with very cool **groundwater**, suggesting that it had traveled a distance before discharging into Spring Lake. **Atrazine** was analyzed and detected in two samples.

**Figure 14. Locations in Spring Lake showing groundwater inflow/no flow/outflow from mini-piezometer measurements and winter observations.**




*Terms in bold, see glossary pp 16-21

## Algal Community

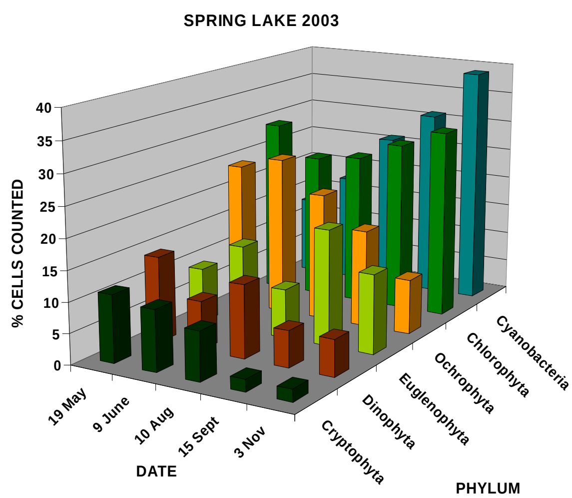
The algal community in Spring Lake was quite diverse. The dominant groups were the green **algae** (Chlorophyta, 27% of all cells counted) and the **blue-green algae** (Cyanobacteria, 25% of all cells counted). The yellow-green **algae** and **diatoms** (Ochrophyta, 19% of all cells counted) and the euglenoids (Euglenophyta, 13% of all cells counted) were subdominant phyla (Table 4). These four phyla represented 84% of all cells counted during the 2003 sampling season. In the 2399 cells counted during this period there were 8 genera of Cyanobacteria, 12 genera of Chlorophyta, 11 genera of Ochrophyta (including 10 **diatom** genera), 4 genera of Euglenophyta (5 species), 2 genera of Dinophyta (5 species), and 2 genera of Cryptophyta identified. The green **algae** (Chlorophyta) and **diatoms** (Ochrophyta) were co-dominants in May and June and were joined by the cyanophytes as nearly equal dominants during August (21-26%/phylum. In September and November the green **algae** and the cyanophytes were codominants with the **diatoms** and euglenoids as subdominants. The other two phyla (Dinophyta, Cryptophyta) represented 16% of all cells counted over the sampling season and ranged from 2-14% of all cells counted during any one sampling period (Figure 15).

**Table 4. Algal phyla and mean seasonal composition in Spring Lake from May to November 2003.**

SPRING LAKE

| PHYLUM | % CELLS COUNTED BY PHYLUM AND DATE | | | | | MEAN |
|---|---|---|---|---|---|---|
| | 19 May | 9 June | 10 Aug | 15 Sept | 3 Nov | |
| Cyanobacteria | 13 | 18 | 26 | 31 | 39 | 25 |
| Chlorophyta | 29 | 24 | 25 | 28 | 31 | 27 |
| Ochrophyta | 24 | 26 | 21 | 16 | 9 | 19 |
| Euglenophyta | 9 | 14 | 8 | 19 | 13 | 13 |
| Dinophyta | 14 | 8 | 12 | 6 | 6 | 9 |
| Cryptophyta | 11 | 10 | 8 | 2 | 2 | 7 |

**Figure 15. Algal community composition by date in Spring Lake from May to November 2003 (total phylum cells counted divided by total cells counted).**




*Terms in bold, see glossary pp 16-21

A single cyanobacterial genus *Spirulina* was present in 5 of the 15 top spots and was the most abundant genus in three of five sampling periods (Figure 16). This organism was particularly dominant in the late season samples. Chlorophytes (green **algae**) were found in 3 of the top 15 spots. The small, motile, unicellular genus *Carteria* was the dominant genus in May; and the nonmotile, colonial green alga *Coelastrum* was a subdominant in September and November. The centric, chain-forming **diatom** genus *Melosira* was the dominant taxon in June and was a subdominant in August. Euglenoids appeared 3 times in the top 15 slots. *Euglena*, a motile unicells, and *Phacus*, also a motile unicells represented this phylum as subdominants in June, September, and November. The unicellular, unarmored, motile dinoflagellate genus *Amphidinium* was a subdominant in May and August (Table 5). The algal community when considered relative to the **chlorophyll**, **phosphorus**, and **nitrogen** values for Spring Lake presents a picture of a very **mesotrophic** lake. The 40 genera identified during the sample periods were relatively common and none of those that reached numerical dominance in the sample counts are associated with toxins or health issues. The water **clarity** in Spring Lake was generally good during all algal sampling period and this seems to conflict with the high **chlorophyll** values, heavy algal densities, and water chemistry data. This is not an uncommon situation in **stratified** lakes like Spring Lake.

**Figure 16. Algal community composition by phylum in Spring Lake from May to November 2003.**

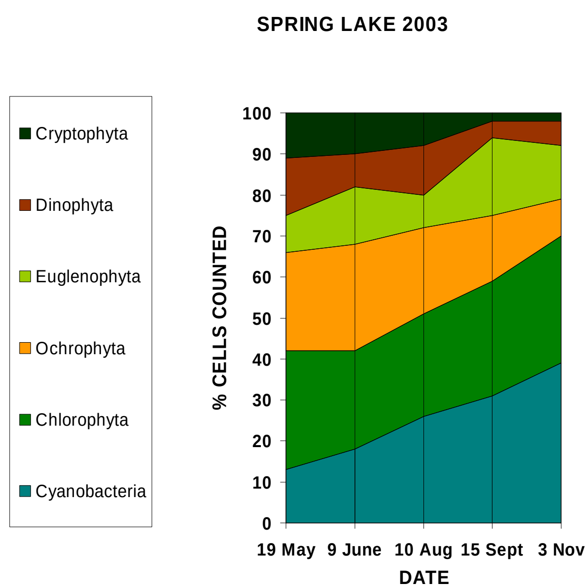



**Table 5. Most common algal genera by date in Spring Lake from May to November 2003.**

| DATE | TOP THREE TAXA (MOST ABUNDANT, LEFT TO RIGHT) | | |
|---|---|---|---|
| 19 May | *Carteria* | *Amphidinium* | *Spirulina* |
| 9 June | *Melosira* | *Spirulina* | *Euglena* 2 |
| 10 August | *Spirulina* | *Melosira* | *Amphidinium* |
| 15 September | *Spirulina* | *Coelastrum* | *Euglena* 2 |
| 3 November | *Spirulina* | *Coelastrum* | *Phacus* 1 |

*Terms in bold, see glossary pp 16-21

**Spring Lake Study Highlights**

- Spring Lake offers some unique areas, with bald eagles making their home on its shore. The lake is encompassed by a very large expanse of wetland, primarily south of the lake. Steep slopes line the north shore.
- The majority of homes on the lake have left significant amounts of natural vegetation between their home and the lake. Most of this lake makes a good example of development with minimal impact.
- Three frog species were identified (spring peeper, American toad, green frog). The primary amphibian habitat is located on several sections of shoreline. Some of the key features of this habitat include protected areas of marsh with large amounts of submergent, emergent and floating-leaf vegetation. Large sections of natural, undisturbed shoreline are present on Spring Lake. Unfortunately, there have been small sections of shoreline altered. During the survey of reptiles Spring Lake was found to be home to two turtle species (painted turtle, snapping turtle).
- The number species of aquatic or wetland **vascular plants** that have been found in Spring Lake or on the wet areas of the shore is below average for Portage County lakes. The average **coefficient of conservatism** and **floristic quality index** are below average for Portage County lakes.
- Spring Lake has a relatively small flora, composed mostly of common species. The alien curlyleaf pondweed is well-established. The die-off of curlyleaf pondweed in late June releases nutrients when the water is warm and fuels filamentous **algae** growth for the rest of the summer. If Eurasian water-milfoil becomes established in the future, it would probably become quite abundant.
- A large bog and conifer swamp complex on the south shore should be surveyed; a species list from this bog complex would probably raise the c value and **floristic quality index** substantially if it were included with the Spring Lake data.
- Spring Lake supports a warm water fishery and stocked cold water fishery. Fifteen species were found in 2002 and 2003 compared to 19 from historical records dating back to the 1940s. Three newly documented species were found including blackchin shiner, banded killifish and central mudminnow. The sport fish community is dominated by bluegill, largemouth bass, and rock bass.
- The bottom is soft and will not support an individual wading. Although **marl** is a marginal spawning **substrate**, suitable areas exist in this lake for the largemouth bass, rock bass and bluegill to spawn as evidenced by their abundance. Woody debris and snail shells embedded in the **marl** are often successfully used as a spawning **substrate** for species that normally prefer sand and gravel. Much of the shoreline is shrub and tree-lined and down timber provides excellent permanent cover in several areas of the lake. Additional standing timber in the water that was killed by flooding from raising the stream outlet dam will provide additional habitat as it continues to fall into the water in coming years.

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- A luxuriant blanket of Chara covers the entire lake bottom and a few beds of water lilies provide surface cover for fish. There are a few areas of emergent vegetation represented by cattails and submerged grasses with rush in the shallows near the outlet stream, but spawning areas with abundant emergent vegetation for northern pike appear limited but this species appears to have never been abundant in this lake.
- The water **clarity** in Spring Lake ranges from fair to good. In Spring Lake **nitrogen** (mostly as **nitrate**) concentrations are high and so are **phosphorus** concentrations. These concentrations are high throughout the year and sufficient to produce abundant aquatic plants and **algae** blooms. **Chloride** and **sodium** concentrations are also high. **Atrazine** was found in low concentrations in the lake water (0.06, 0.18, and $<0.05$ µg/L), however some toxicity studies have indicated that reproductive system abnormalities can occur in frogs at these levels. The presence of **atrazine** indicates that other agri-chemicals may also be entering Spring Lake. This **eutrophic** lake is a reflection of the agricultural land uses in the **watershed**.
- Sixty-eight percent of the shallow wells showed **groundwater** inflow. **Nitrate** concentrations ranged from 0.2 to 7.3 **mg/l** and **chloride** ranged from 0.5 to 10.5 **mg/l**. The elevated **nitrate** and **chloride** samples were from the same sites. These were also sites with very cool **groundwater**, suggesting that it had traveled a distance before discharging into Spring Lake. **Atrazine** was analyzed and detected in two samples.
- The algal community when considered relative to the **chlorophyll**, **phosphorus**, and **nitrogen** values for Spring Lake presents a picture of a very **mesotrophic** lake. The 40 genera identified during the sample periods were relatively common and none of those that reached numerical dominance in the sample counts are associated with toxins or health issues. The water **clarity** in Spring Lake was generally good during all algal sampling period and this seems to conflict with the high **chlorophyll** values, heavy algal densities, and water chemistry data. This is not an uncommon situation in **stratified** lakes like Spring Lake.

## 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 (CaCO3), or as microequivalents per liter (ueq/l). 20 ueq/l = 1 mg/L of $CaCO_3$.

*Terms in bold, see glossary pp 16-21

**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 ($NO_3$) 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 ($NH_4^+$) form, but at high pH values the toxic ammonium hydroxide ($NH_4OH$) occurs. The water quality standard for fish and aquatic life is 0.02 mg/L of $NH_4OH$. At a pH of 7 and a temperature of 68$^o$ F (20$^o$ 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 ($N_2$) from the air to provide their own nutrient.

**Chloride (Cl-):**

Chlorine in the chloride ion ($Cl^-$) form has very different properties from chlorine gas ($Cl_2$), which is used for disinfecting. The chloride ion ($Cl^-$) 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.

**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.

*Terms in bold, see glossary pp 16-21

**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.

**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.

*Terms in bold, see glossary pp 16-21

**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++) and magnesium (Mg++) in the water expressed as milligrams per liter of $CaCO_3$. Amount of hardness relates to the presence of soluble minerals, especially limestone, in the lake watershed. Moderately hard water has 61-120 mg/L $CaCO_3$, hard water has 121-180 mg/L $CaCO_3$, and very hard water has more than180 mg/L $CaCO_3$.

**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.

**Marl:**

White to gray accumulation on lake bottoms caused by precipitation of calcium carbonate ($CaCO_3$) 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 ($NO_3^-$):**

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 ($NO_3$-N) plus ammonium-nitrogen ($NH_4$-N) of 0.3 mg/L in spring will support summer algae blooms if enough phosphorus is present.

**Nitrite ($NO_2^-$):**

A form of nitrogen that rapidly converts to nitrate ($NO_3^-$) and is usually included in the $NO_3^-$ analysis.

*Terms in bold, see glossary pp 16-21

**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 ($CO_2$) 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.

**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.

**Soft Water:**

Water with less than 60 mg/L CaCO3 (see Hard water).

**Stratification, Stratified:**

The layering of water due to differences in density. Water's greatest density occurs at 39$^{o}$F (4$^{o}$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 ($SO_4^{--}$):**

The most common form of sulfur in natural waters. The amounts relate primarily to soil minerals in the watershed. Sulfate ($SO_4^{--}$) can be reduced to sulfide ($S^{--}$) and hydrogen sulfide ($H_2S$) 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 ($SO_2$) 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.

**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 16-21