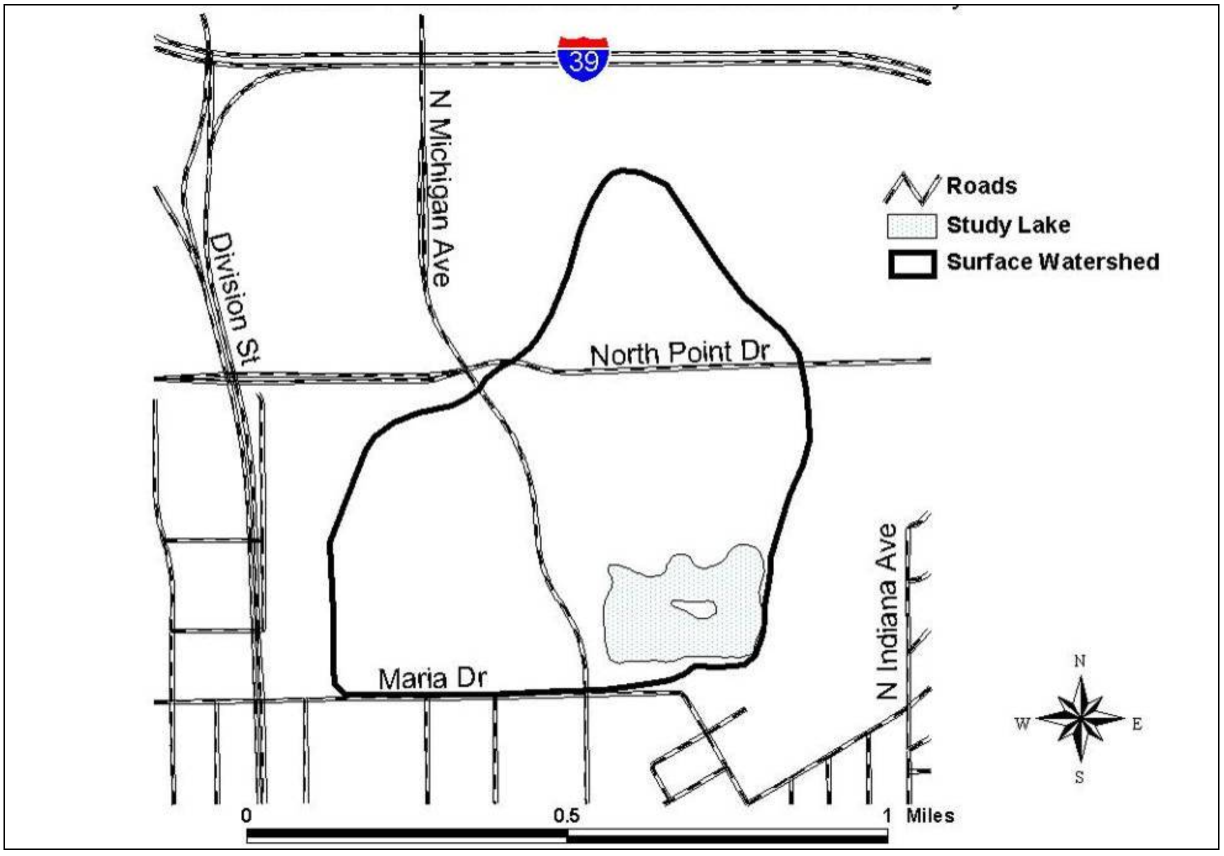
Lake Joanis

Introduction
Lake Joanis was constructed in 1976 as a joint project between the University of Wisconsin-Stevens Point and Sentry Insurance. The purpose of the project was to provide the soil needed for the construction of the Sentry Insurance complex, while creating an outdoor lab and recreation area for the University and the Stevens Point community. Lake Joanis is a **seepage lake** located north of the intersection of Maria Drive and Michigan Avenue, in the City of Stevens Point (Figure 1). It has a surface area of 23 acres and an estimated volume of 277 acre-feet. The maximum depth is 25 feet, with a bottom of sand and fine gravel. The estimated **retention time** is months.

Land Use and Watershed
The surface **watershed** for Lake Joanis is 58 acres which is defined on the west side by the commercial development that currently includes K-Mart and the University maintenance building and parking lots, and going north onto the Sentry Insurance golf course (Figure 1 and Figure 2). Land uses since its creation have remained fairly stable because this lake is within the city limits and did not exist before 1976. UWSP owns all of the property directly adjacent to the lake (Schmeekle Reserve) and manages it as a natural area (Figure 2 and Figure 3).

Figure 1. Lake Joanis surface watershed boundary.



*Terms in bold, see glossary pp 16-20

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

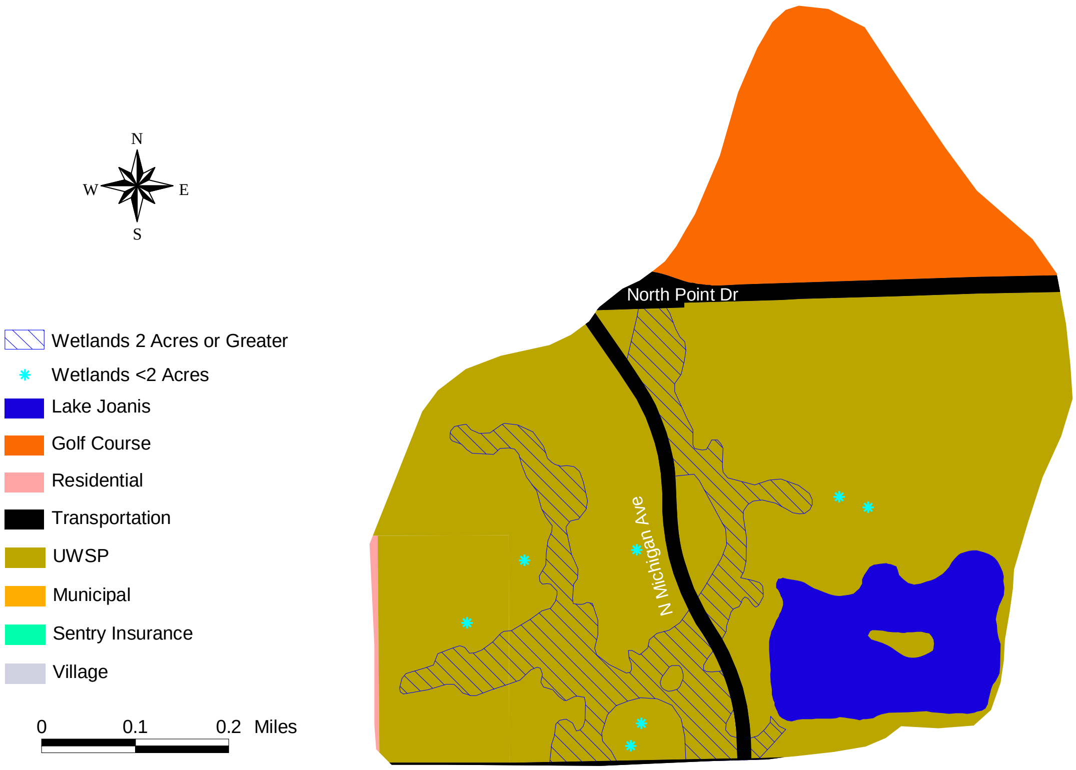
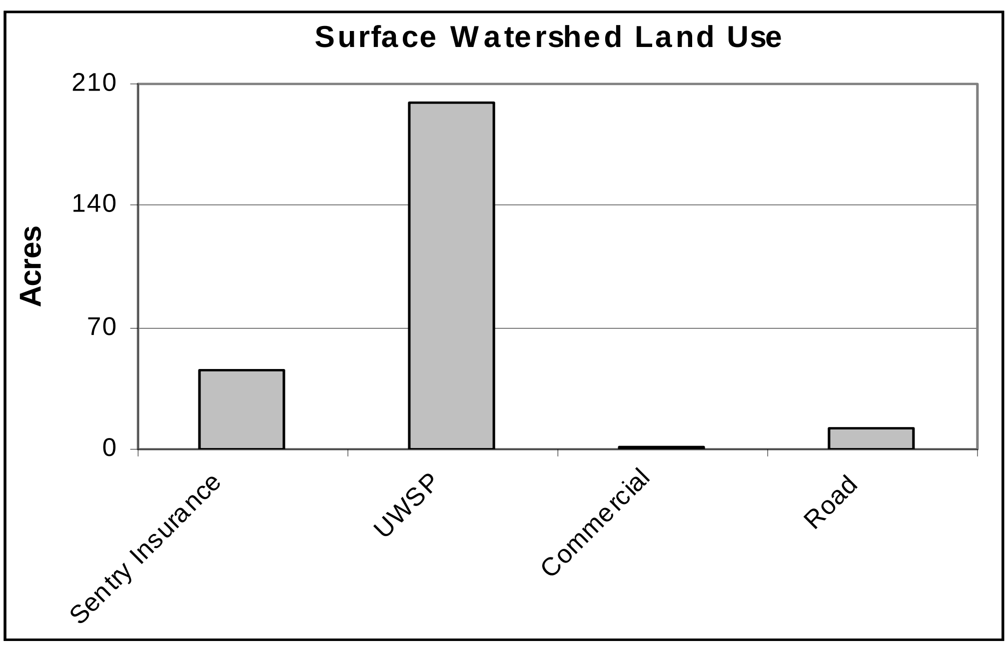


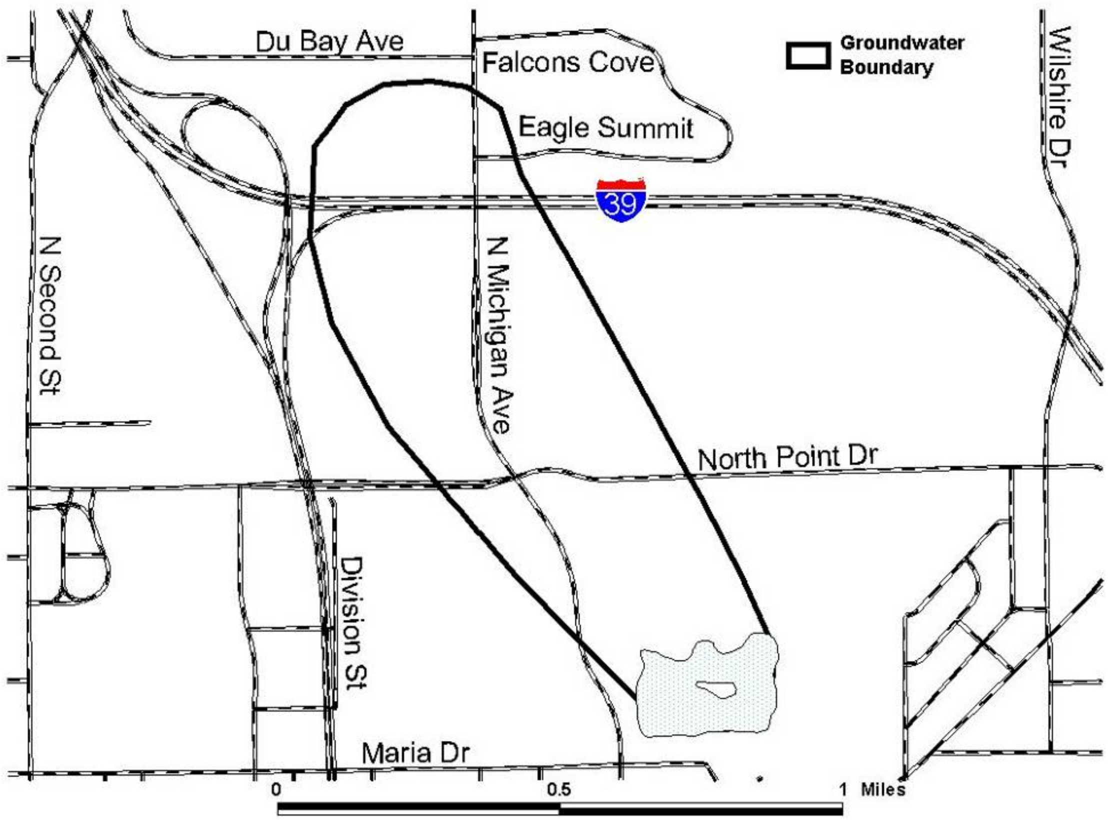
Figure 3. Land use in the Lake Joanis surface watershed.



*Terms in bold, see glossary pp 16-20

The **groundwater watershed** for Lake Joanis is 284 acres encompassing land to the northeast of the lake (Figure 4). UWSP owns 92 acres of the **groundwater watershed** adjacent to the lake as part of Schmeekle Reserve. Sentry Insurance owns 111 acres as part of their office complex and golf course. The remainder of the land use is split between residential, commercial, transportation, and vacant or undeveloped land that is not part of the Schmeekle Reserve (Figure 5 and Figure 6).

Figure 4. Lake Joanis groundwater watershed boundary.



*Terms in bold, see glossary pp 16-20

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

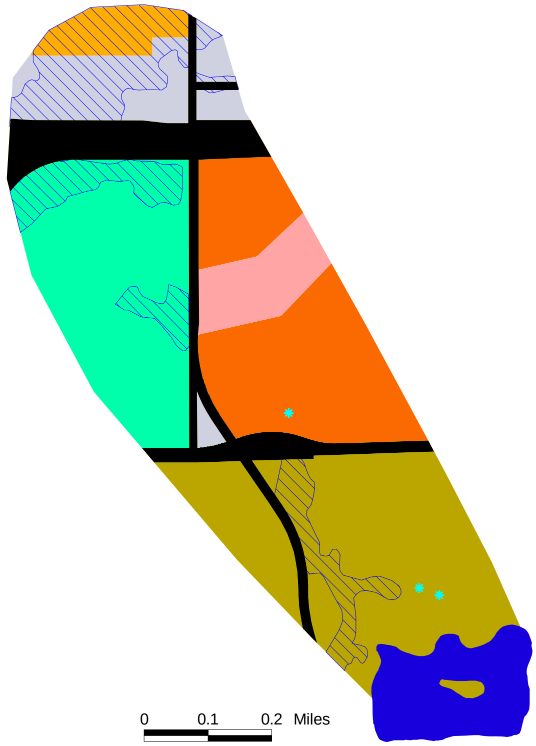
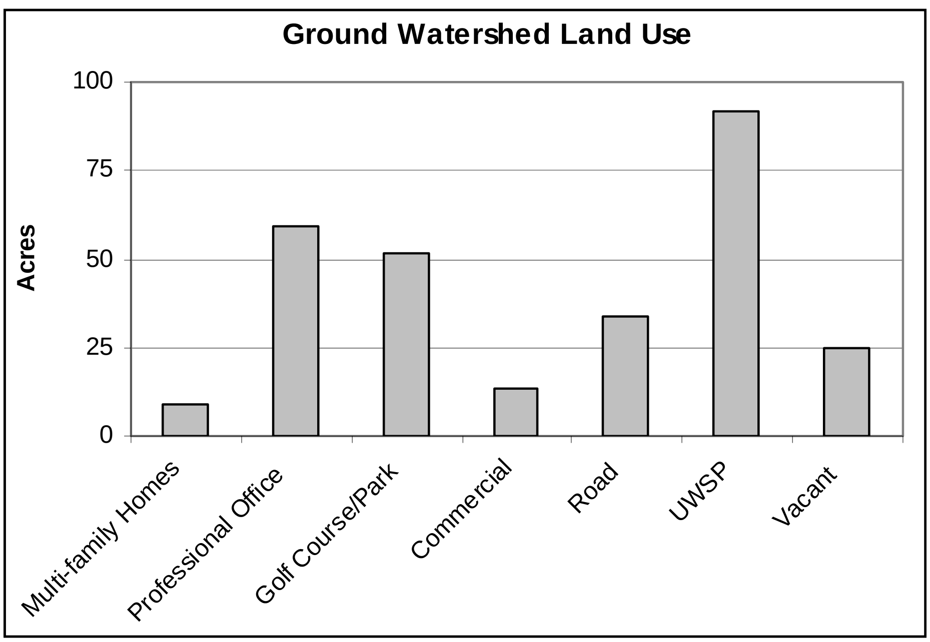


Figure 6. Land use in the Lake Joanis groundwater watershed 2002.



*Terms in bold, see glossary pp 16-20

Birds
Lakeshore development can negatively or positively affect habitat quality of birds depending on the ecological requirements of each species. Development can play a important role in providing resources unavailable to certain species in a more natural environment, yet eliminate other species' needs altogether, especially at the most extreme levels of development.

Of the 28 most common species, Eastern phoebe (*Sayornus phoebe*), American goldfinch (*Carduelis tristis*), American robin (*Turdus migratorius*), mourning dove (*Zenaida macroura*), and downy woodpecker (*Picoides pubescens*) showed the greatest tendency to be found in developed areas. These species may be taking advantage of different resources available in the urban environment, such as birdfeeders (as in the case of the American goldfinch and downy woodpecker), open foraging areas (American robin and mourning dove), or nest sites (Eastern phoebe).

At undeveloped sites, least flycatcher (*Empidonax minimus*), great crested flycatcher (*Myiarchus crinitus*), red-eyed vireo (*Vireo olivaceus*), black-capped chickadee (*Poecile atricapillus*), blue jay (*Cyaanocitta cristata*), red-bellied woodpecker (*Melanerpes carolinus*), Eastern wood-pewee (*Contopus virens*), indigo bunting (*Passerina cyanea*), and common yellowthroat (*Geothylypis trichas*) were the most common. A majority of these species are insectivores and are likely to feed in more forested environments.

Table 1. Bird species identified near Lake Joanis.

Common Name	Number Observed	Food	Foraging	Nest Type	Nest Location
American Goldfinch	5	seeds	foliage gleaner	cup	shrub
American Robin	2	insects	ground gleaner	cup	deciduous
Black-capped Chickadee	11	insects	foliage gleaner	cavity	deciduous
Blue Jay	1	omnivore	ground gleaner	cup	coniferous
Catbird	2	insects	ground gleaner	cup	shrub
Chipping Sparrow	1	insects	ground gleaner	cup	coniferous
Eastern Phoebe	1	insects	bark gleaner	cavity	snag
House Wren	3	insects	ground gleaner	cavity	deciduous
Northern Cardinal	1	insects	ground gleaner	cup	shrub
Red-eyed Vireo	2	insects	hover gleaner	cup	shrub
Red-winged Blackbird	1	insects	ground gleaner	cup	reed
Song Sparrow	4	insects	ground gleaner	cup	ground
Total	**34**				

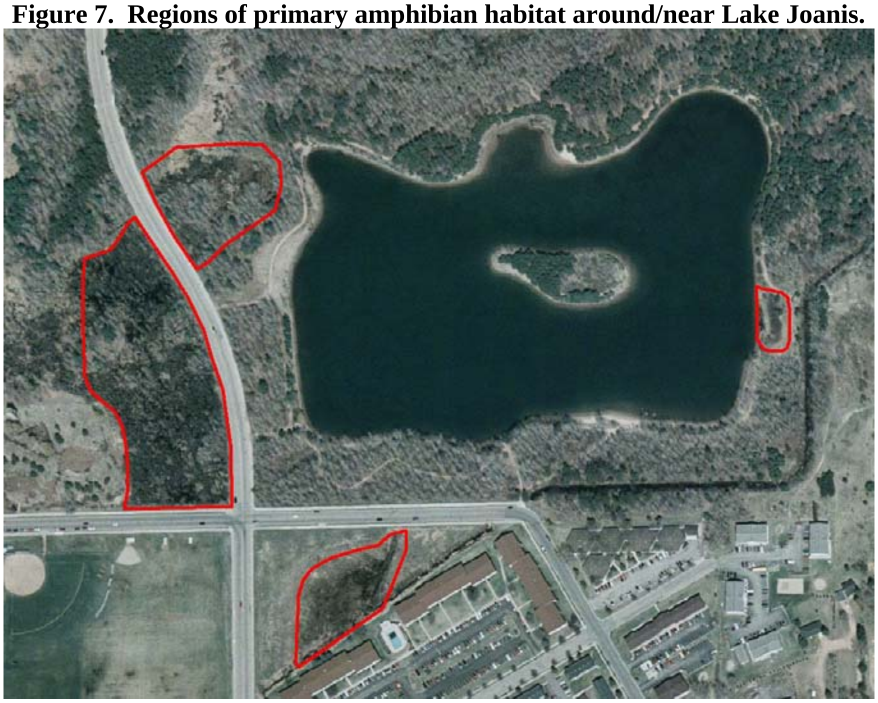
Shoreline Vegetation, Reptiles, and Amphibians
Amphibians (frogs and toads) were included in this survey because with their permeable skin and biphasic lifecycle (meaning that the young live in water while adults can survive on land) they are considered excellent indicators of overall ecosystem health. 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**.

During the survey of reptiles Lake Joanis had one species of turtle (painted turtle [*Chrysemys picta*]). Six frog species of amphibians were identified during the survey of Lake Joanis (spring peeper [*Pseudacris crucifer*], chorus frog [*Pseudacris triseriata*], American toad [*Bufo americanus*], gray treefrog [*Hyla versicolor*], Cope's gray treefrog [*Hyla chrysoscelis*], and green frog [*Rana clamitans*]). The primary amphibian habitat is located on the west side of the lake (sensitive areas are identified in red in Figure 7). Some of the key features of this habitat include protected areas of marsh with large amounts of submergent, emergent, and floating-leaf vegetation as well as downed trees, and several temporary wetlands.

The good news is that several frog species are present; there has been minimal shoreline alteration and several temporary wetlands can be found adjacent to the lake. The bad news, however, is that there is a large amount of recreational use surrounding the lake which may affect amphibian populations.

Figure 7. Regions of primary amphibian habitat around/near Lake Joanis.



*Terms in bold, see glossary pp 16-20

The shoreline around Lake Joanis is primarily comprised of vegetated shoreline (42.2%), which is represented by dark green in Figure 8. Vegetated shoreline is characterized as being upland areas that are densely vegetated by tall grass and/or shrubs with no rocky component. Another 2.1% of the upland shoreline is categorized as being grass and shrub and is represented by light green in Figure 8. The grass and shrub category is defined as an upland area without dense vegetation and may have a rocky component.

Fifty-six percent of the shoreline is considered to be in an area of disturbance. Of that, 45.2% of the lake's shoreline vegetation is considered to be in a low disturbance developed area, 5.8% is located in moderately disturbed areas, and 4.6% of the shoreline's vegetation is considered to be highly disturbed area. An area that exhibits low vegetation disturbance is defined as a location where there is an unaltered shore zone except for pier access. An area that has moderate vegetation disturbance is an area of shore that may contain a mowed lawn but has an intact overstory. An area that exhibits high vegetation disturbance is defined as a beach, **rip rap**, sea wall or where the shore is mowed to the water line.

Figure 8. Categories of shoreline vegetation around Lake Joanis.

Aquatic Plants

Fifty-five species of aquatic or wetland **vascular plants** have been found in Lake Joanis or on the wet areas of the adjacent shore. This is above the average for Portage County lakes. The average **coefficient of conservatism (c-value)** is **4.2,** which is below the average for the Portage County lakes. The **floristic quality index** is **31.1**; with 1 point added for a special concern species, the total value is **32.1**, which is slightly above average for the county lakes.

*Terms in bold, see glossary pp 16-20

Lake Joanis lies in an area excavated in the mid 1970's for landscape fill around the Sentry headquarters building. The lake filled with water shortly after the excavation, and, as far as is known, all plants within the lake arrived by natural dispersal agents, probably carried primarily by waterfowl.

The Lake has relatively sparse aquatic vegetation, but Eurasian water-milfoil (*Myriophyllum spicatum*) was found dislodged and floating or washed up on shore at several points in 2003. Additional surveys were conducted of the Eurasian water-milfoil in summer 2005. UWSP is executing a plan to address the Eurasian water-milfoil.

Because the excavation left steep banks to a berm which surrounds the lake, the lake has a very little wet shore on the west, south, and east sides, and hence relatively little biological diversity on the shoreline for the majority of the lake. Furthermore, glossy buckthorn (*Rhamnus frangula*), a very invasive alien shrub and small tree, has become abundant in recent years, further reducing diversity along the shore. Nevertheless, a small population of variegated horsetail (*Equisetum variegatum*), a special concern species, occurs at the edge of the water on the south shore. The presence of this rare plant, never found previously anywhere in central Wisconsin, is entirely unexpected.

Unlike the rest of the lake, portions of the north shore have a gradual slope and a moderately wide beach area. Bog vegetation has formed in recent years in one area, and this bog holds some relatively uncommon plants, such as sundew (*Drosera* spp.), and lance-leaved violet (*Viola lanceolata*).

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. Each of the water chemistry measures discussed play a complex role in water quality. A more detailed interpretation can be found at the beginning of this report and should be consulted for a more complete understanding of each lake.

Lake Joanis is mixed from top to bottom for much of the year; however, during the first year of the study it displayed some weak **stratification** during July and August (Figure 9). Throughout the year, oxygen was quite plentiful for most of the water’s depth (Figure 10). On several occasions in the summer oxygen increases around 15 feet; this is due to oxygen production by **algae** blooms in the metalimnion layer.

*Terms in bold, see glossary pp 16-20

Figure 9. Profile of temperature in Lake Joanis, 2002-2004.

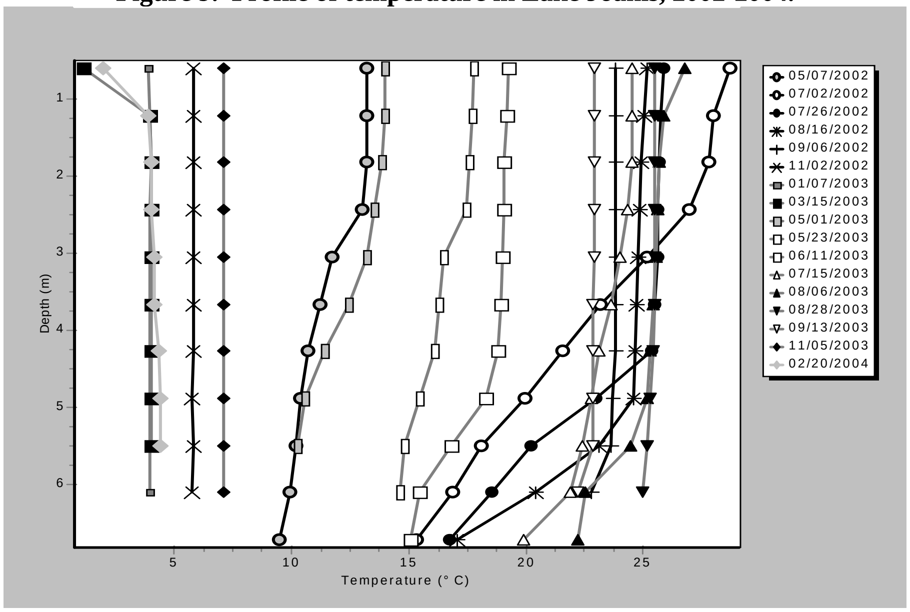
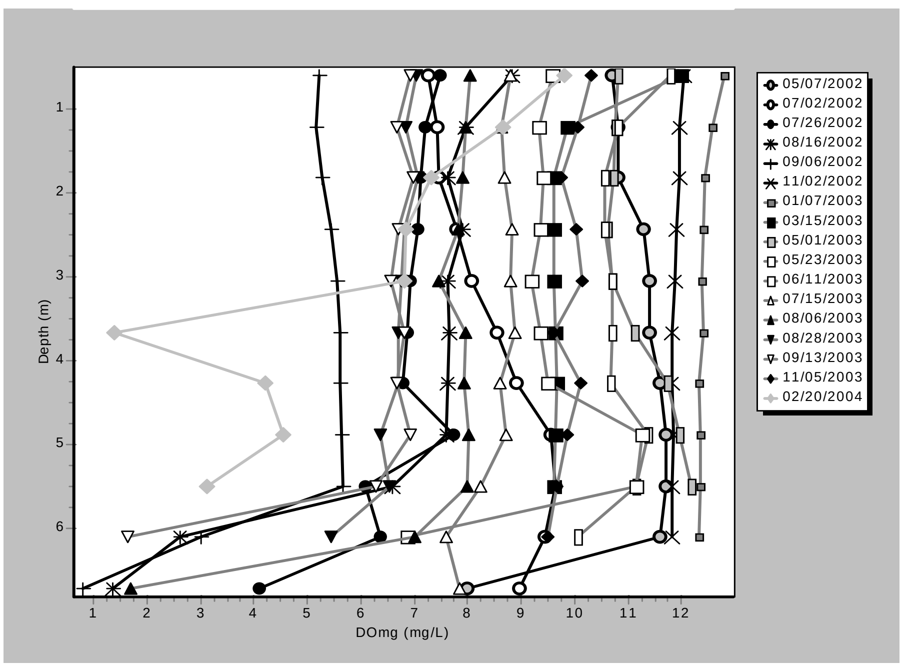


Figure 10. Profile of dissolved oxygen in Lake Joanis, 2002-2004.

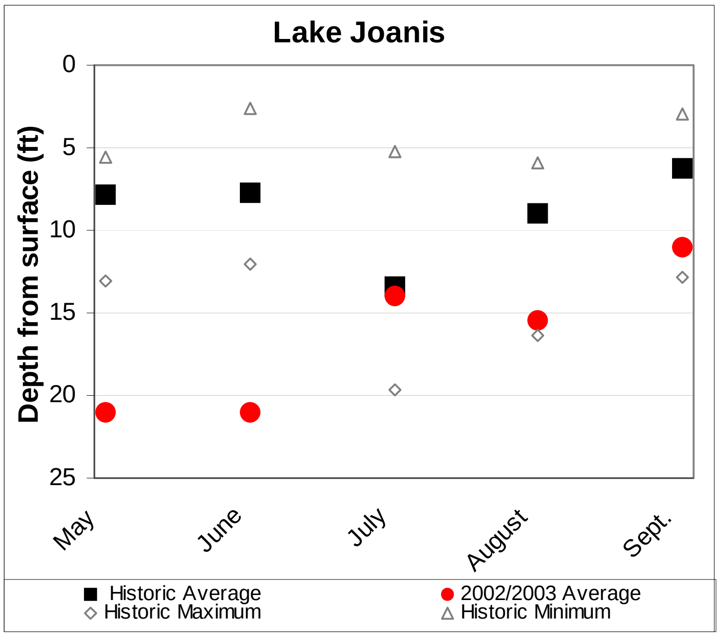


Water **clarity** is a measure of how deep light can penetrate. It is an aesthetic measure and is related to how deep **rooted aquatic plants** can grow. Water **clarity** is affected by water **color** and suspended materials in the water (**turbidity**). **Turbidity** consists of **suspended solids**, such as suspended sediments and **algae** (**chlorophyll *a***). These measures were all low throughout the study (Table 2). Water **clarity** in Lake Joanis varied greatly during our study, from good to excellent. Measurements ranged from 10.5 to 21 feet; average **Secchi disc** depth readings for

*Terms in bold, see glossary pp 16-20

similar **seepage lakes** in the region are about 9 to 10 feet (Figure 11). The water **clarity** in Lake Joanis was better than this throughout the growing season with the best average **clarity** in May and June, about 21 feet, and the poorest **clarity** in September, about 11 feet. These fluctuations can largely be attributed to **algae** blooms and **sedimentation** increase due to storms and runoff and decrease during quiet periods.

Figure 11. Monthly average water clarity measurements in Lake Joanis 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). As might be expected for a relatively young lake, the nutrients measured in Lake Joanis are all low. Total and calcium **hardness** are also quite low indicating that this is a moderately hard lake.

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. These concentrations were all low (Table 3). **Atrazine** was found in low concentrations in the lake water (0.12 and 0.07 ppb); however, some toxicity studies have indicated that disruption to the reproduction system can occur in frogs at these levels.

*Terms in bold, see glossary pp 16-20

Table 2. 2002-2004 water quality seasonal averages in Lake Joanis.

Lake Joanis	*RP (ug/L)*	*TP (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	1.5	13.0	0.64	0.08	0.03	50.0	66.0	36.0	14	0.7	1.8
Summer Averages	2.3	16.6	0.69	0.17	0.02	48.0	65.0	34.0	6	1.3	2.3
Fall Averages	4.0	12.0	0.61	0.04	0.06	52.0	70.0	39.0	6	1.9	
Winter Averages	2.8	13.5	0.54	0.09	0.06						
2002-2004 Averages	2.6	15.2	0.62	0.11	0.04	50.0	67.0	36.3	9	1.3	2.3

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

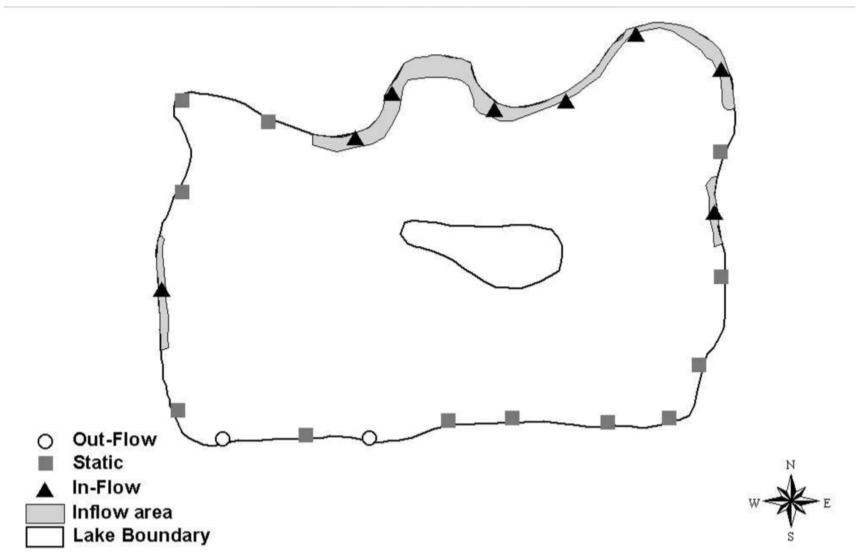
Table 3. Monthly average water clarity measurements in Lake Joanis 2002-2003 and historic average, maximum and minimums.

Lake Joanis	*Low*	*Medium*	*High*	**Reference Values**	*Low*	*Medium*	*High*
Sulfate	8.70			*Sulfate*	<10	10-20	>20
Chloride			13.67	*Chloride*	<3	3-10	>10
Potassium	0.73			*Potassium**	<2.16	2.16-4.30	>4.30
Sodium			5.70	*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.*

Mini-piezometers were installed in July 2003 to identify areas of **groundwater** inflow and outflow. These measurements were enhanced with open water observations made in late winter. Most of the **groundwater** is entering Lake Joanis from the north side of the lake, with some entering on the east and west (Figure 12). Six water samples were collected from the mini-piezometers for lab analysis. **Nitrate** concentrations were low or below detection levels, but **chloride** was elevated in most samples with concentrations in the northeast corner of the lake as high as 45 and 66 **mg/L**. At these concentrations the **chloride** should not affect the biota in the lake, but is an indicator that other contaminants may be moving to the lake from the **chloride** source. Likely the **chloride** is a result of road salt, but could also be from golf course fertilizers.

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



*Terms in bold, see glossary pp 16-20

Algal Community

The algal community in Lake Joanis was very diverse and seasonally balanced. 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 80% of all cells counted. In the 3,689 cells counted during this period there were 6 genera of Cyanobacteria, 16 genera of Chlorophyta, 13 genera of Ochrophyta (including 11 diatom genera), 3 genera of Euglenophyta, 2 genera of Dinophyta, and 1 genus of Cryptophyta identified. The **blue-green algae** represented between 17-44% of all cells counted, the ochrophytes (mostly **diatoms**) represented between 19-38% of all cells counted, and the chlorophytes represented between 12-30% (Table 4). The other three phyla (Dinophyta, Euglenophyta, and Cryptophyta) averaged 20% of all cells counted with the euglenoids representing between 3-19% of all cells counted (Figure 13). The ochrophytes dominated early (May, June) with cyanobacteria, chlorophytes, and euglenoids as nearly equal minor components. The August, September, and November sample periods were dominated by the cyanobacteria with greens and ochrophytes as nearly equal minor components.

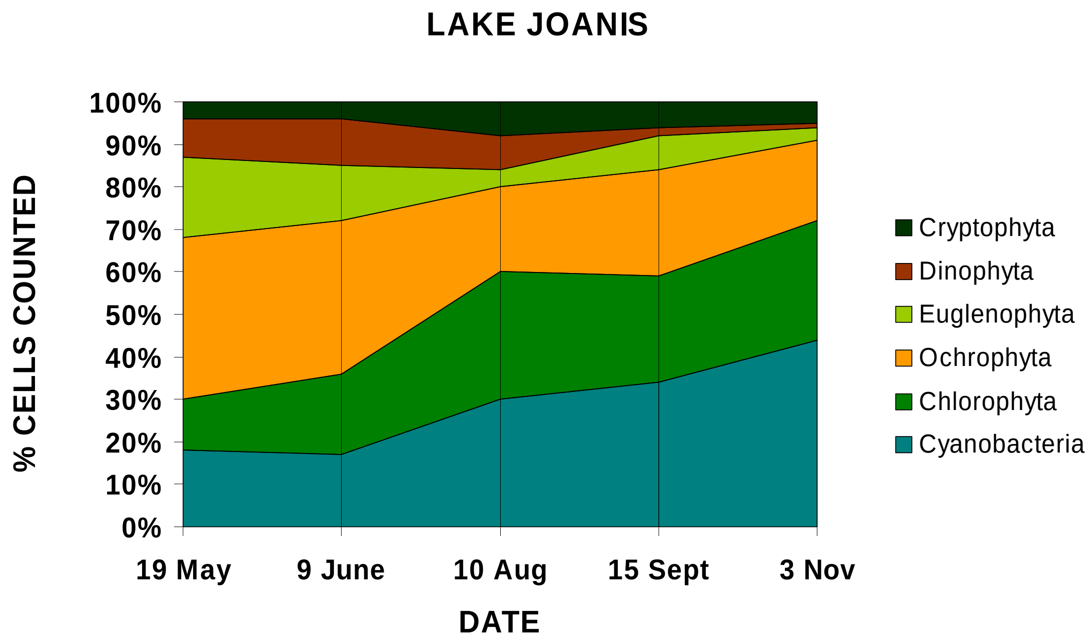
Table 4. Algal phyla and mean seasonal composition in Lake Joanis from May to November 2003.

LAKE JOANIS

PHYLUM	% CELLS COUNTED BY PHYLUM AND DATE					**MEAN**
	19 May	9 June	10 Aug	15 Sept	3 Nov	
Cyanobacteria	18	17	30	34	44	29
Chlorophyta	12	19	30	25	28	23
Ochrophyta	38	36	20	25	19	28
Euglenophyta	19	13	4	8	3	9
Dinophyta	9	11	8	2	1	6
Cryptophyta	4	4	8	6	5	5

*Terms in bold, see glossary pp 16-20

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



Diatoms (*Fragilaria*, *Asterionella*) were the dominant Lake Joanis taxa in two of five sample periods and occupied the top three abundance spots in 6 of 15 samples (Table 5). The colonial blue-green *Coelosphaerium* was the dominant taxon in three of five sample periods (Figure 14). These taxa occupied 11 of 15 dominance slots in the cell counts and covered all the most and second most common slots except one (*Phacus* – May). The third most common taxa slots were taken by the dinoflagellate *Peridinium*, the euglenoid *Euglena*, and the green alga *Micrasterias*.

The algal community presents a picture of conflict when considered relative to the **chlorophyll**, **phosphorus**, and **nitrogen** values for Lake Joanis. The chemical values indicate an **oligotrophic** lake but the algal community is more typical of **mesotrophic** and especially **eutrophic** waters. The 41 genera identified during the sample periods were relatively common but have a significant fraction of facultative heterotrophs from the dinoflagellates (*Peridinium*, *Ceratium*), euglenoids (*Euglena*, *Phacus*, *Trachelomonas*), and cryptophytes (*Chroomonas*). This noticeable presence of motile animal-like organisms is not particularly common nor typically expected of **oligotrophic** lakes like Lake Joanis. 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**. This discrepancy has no readily identifiable explanation.

*Terms in bold, see glossary pp 16-20

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

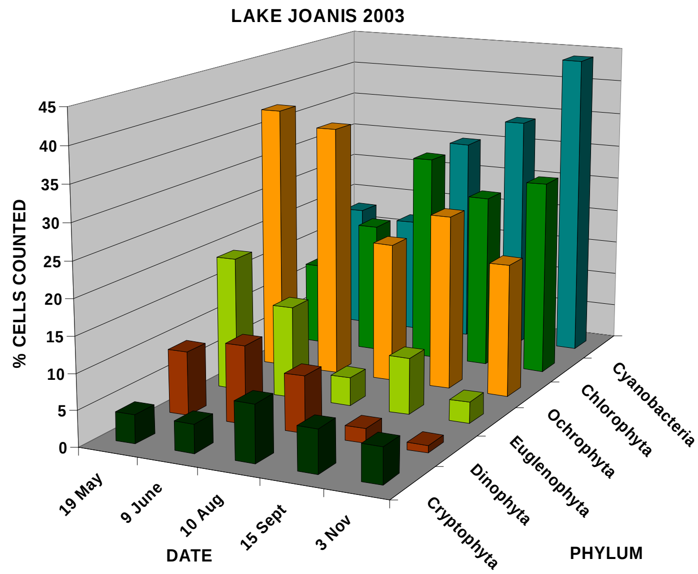


Table 5. Most common algal genera by date in Lake Joanis from May to November 2003.

DATE	TOP THREE TAXA (MOST ABUNDANT, LEFT TO RIGHT)		
19 May	*Fragilaria 1*	*Phacus 1*	*Coelosphaerium*
9 June	*Asterionella*	*Fragilaria 1*	*Coelosphaerium*
10 August	*Coelosphaerium*	*Asterionella*	*Peridinium*
15 September	*Coelosphaerium*	*Asterionella*	*Euglena 1*
3 November	*Coelosphaerium*	*Asterionella*	*Micrasterias*

*Terms in bold, see glossary pp 16-20

Joanis Lake Study Highlights

- The shoreline around Lake Joanis is primarily comprised of vegetated shoreline (42%). Fifty-six percent of the shoreline is considered to be in an area of disturbance and 2% of the shoreline is categorized as being grass and shrub.
- Because the excavation left steep banks to a berm which surrounds the lake, the lake has a very little wet shore on the west, south, and east sides, and hence relatively little biological diversity on the shoreline for the majority of the lake. Furthermore, glossy buckthorn, a very invasive alien shrub and small tree, has become abundant in recent years, further reducing diversity along the shore. A small population of variegated horsetail, a special concern species, occurs at the edge of the water on the south shore. The presence of this rare plant, never found previously anywhere in central Wisconsin, is entirely unexpected.
- Eurasian water-milfoil has been identified in Joanis Lake.
- The primary amphibian habitat is located on the west side of the lake. The good news is that several frog species are present; there has been minimal shoreline alteration and several temporary wetlands can be found adjacent to the lake. The bad news, however, is that there is a large amount of recreational use surrounding the lake which may negatively affect amphibian populations.
- Throughout the year, oxygen was quite plentiful for most of the water's depth. Water **clarity** in Lake Joanis varied greatly during our study, from good to excellent. The best average **clarity** occurred in May and June, about 21 feet, and the poorest **clarity** in September, about 11 feet.
- As might be expected for a relatively young lake the nutrients measured in Lake Joanis are all low. Total and calcium **hardness** are also quite low indicating that this is a moderately hard lake. **Chloride**, **sodium** and **potassium** concentrations were all low. **Atrazine** was found in low concentrations in the lake water.
- In **groundwater** samples **nitrate** concentrations were low or below detection levels, but **chloride** was elevated in most samples with concentrations in the northeast corner of the lake as high as 45 and 66 **mg/L**. At these concentrations the **chloride** should not affect the biota in the lake, but is an indicator that other contaminants may be moving to the lake from the **chloride** source. Likely the **chloride** is a result of road salt, but could also be from golf course fertilizers.
- The algal community presents a picture of conflict when considered relative to the **chlorophyll**, **phosphorus**, and **nitrogen** values for Lake Joanis. The chemical values indicate an **oligotrophic** lake but the algal community is more typical of **mesotrophic** and especially **eutrophic** waters. Many of the **algae** identified are an indication of organic matter being present at times in the lake. This discrepancy has no readily identifiable explanation.

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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 $CaCO_3$.

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.

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 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.

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.

*Terms in bold, see glossary pp 16-20

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++) 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. Soft water has 60 mg/L $CaCO_3$ or less, 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.

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.

*Terms in bold, see glossary pp 16-20

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^{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 16-20