Wolf Lake

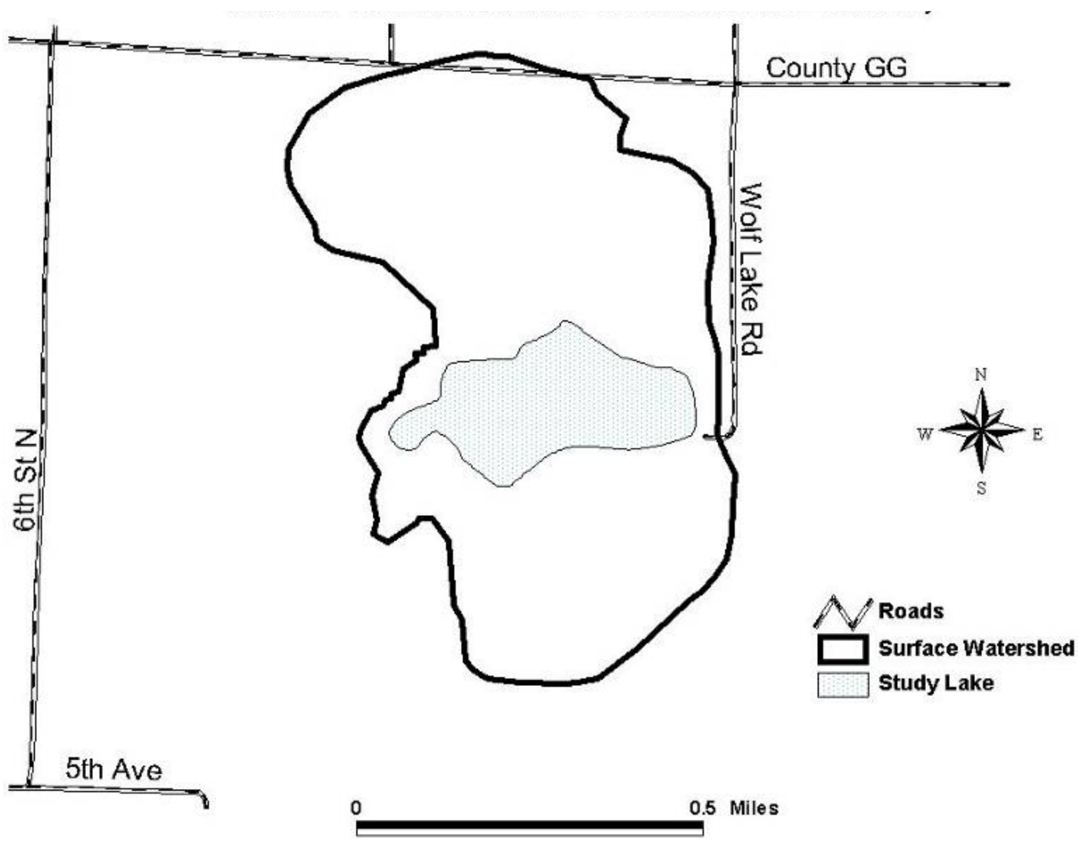
Introduction

Wolf Lake is a 36 acre moderately **hard water seepage lake** with an estimated volume of 366 acre-feet, located in the Township of Almond, five miles northeast of the Village of Almond. It has a maximum depth of 18 feet, a **marl** and sand bottom, and an estimated **retention time** of 0.8 years. The lake's 1.6 mile shoreline is completely undeveloped despite intense pressure from a developer in recent years. Community opposition defeated the development proposal. There is a County park on the east side of the lake with a sand beach, picnic area, and boat launch. Large scale fluctuations in the water level have resulted in numerous fish winterkills in the past which were followed up with fishery restocking (WDNR 1972). The sport fish population is presently dominated by bluegill, bluegill/pumpkinseed hybrids and largemouth bass.

Land Use and Watershed

The surface **watershed** for Wolf Lake is 250 acres primarily to the north and south of the lake (Figure 1). Most of the land use in the **watershed** is forest (61%), followed by non-irrigated cropland (16%). Shrub/wetland vegetation and non-irrigated agriculture have declined since 1948, while forested acres have increased. All other changes on the landscape have remained minimal and fairly constant over this period (Figure 2 and Figure 3).

Figure 1. Wolf Lake surface watershed boundary.



*Terms in bold, see glossary pp 18-23

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

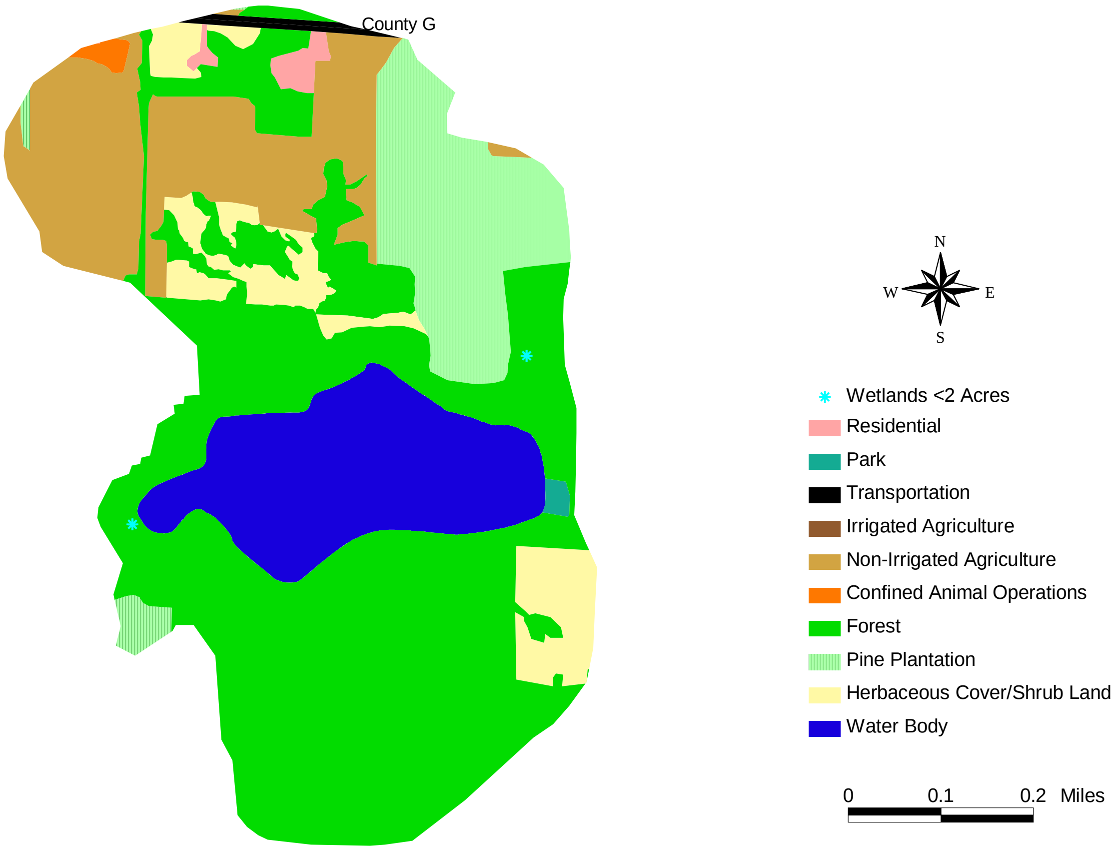
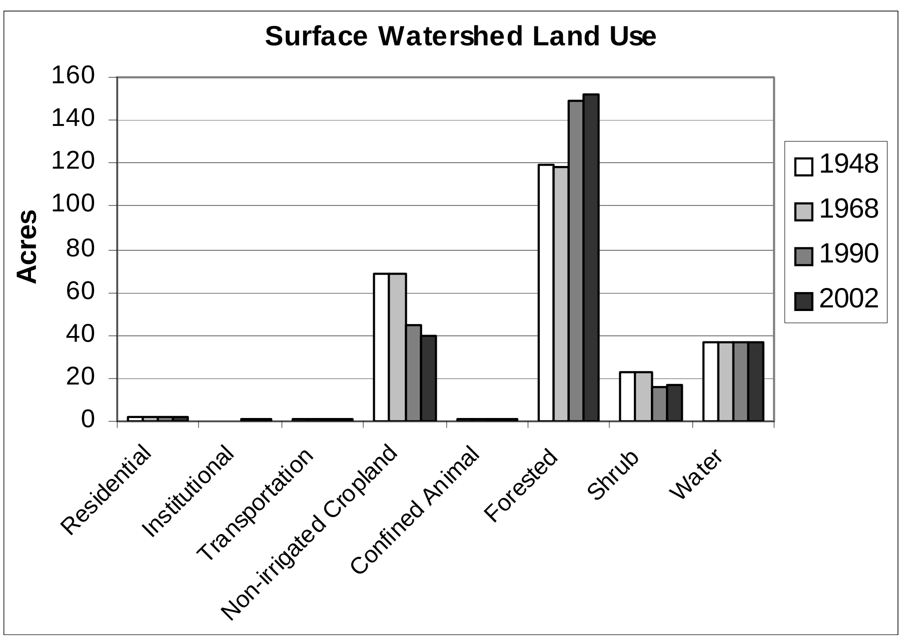


Figure 3. Land use in the Wolf Lake surface watershed between 1948 and 2002.

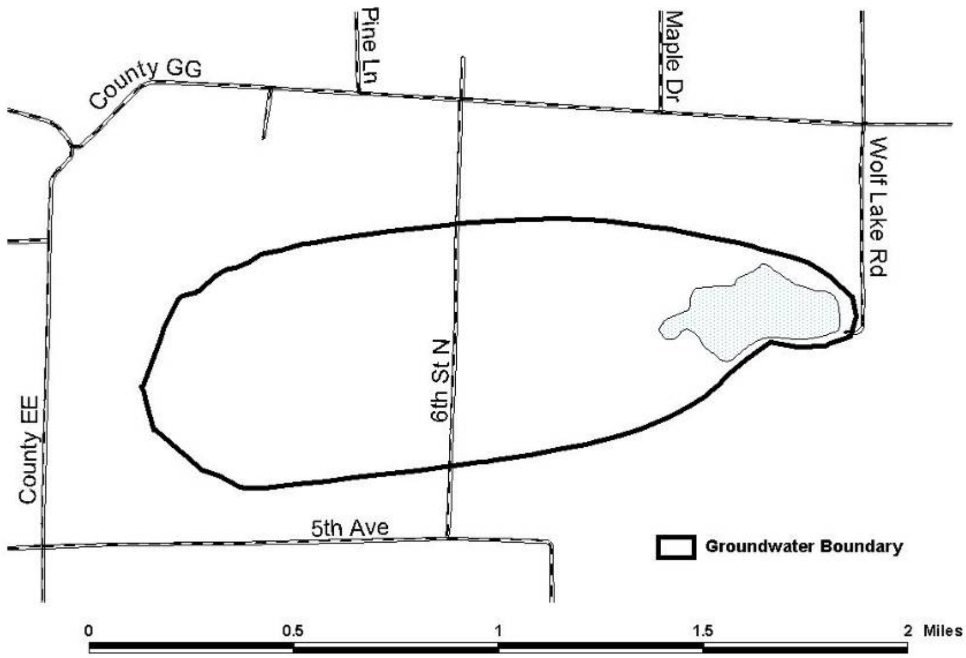


The **groundwater watershed** for Wolf Lake is 515 acres mostly located west of the lake (Figure 4). Land use is predominantly forest (60%), followed by non-irrigated cropland (11%) and

*Terms in bold, see glossary pp 18-23

shrub/wetland vegetation (12%). Sometime in the 1990s, a portion of non-irrigated cropland was converted to irrigated cropland. It is estimated that only a portion of the irrigated field is in the **groundwater watershed** (Figure 5). Forest cover has increased since 1948, while shrub/wetland cover has declined since 1968 (Figure 6). According to a records search in 2002, based on age, there are no potentially failing septic systems or former landfill sites present in either the Wolf Lake surface or **groundwater watersheds**.

Figure 4. Wolf Lake groundwater watershed boundary.



*Terms in bold, see glossary pp 18-23

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

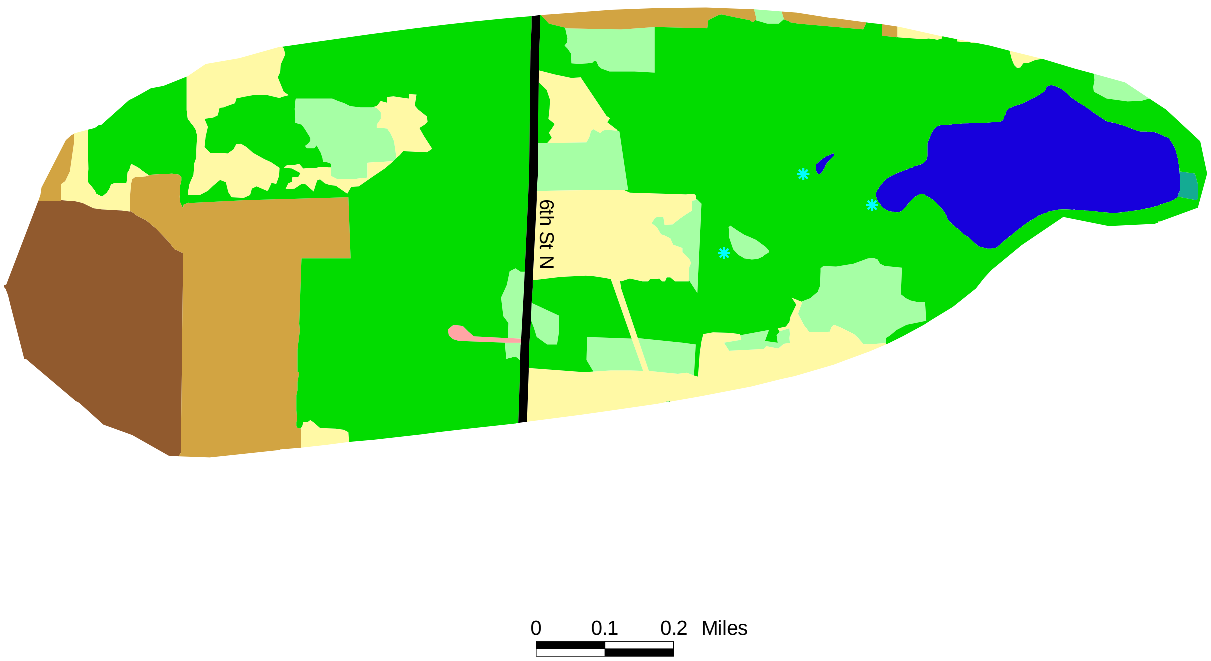
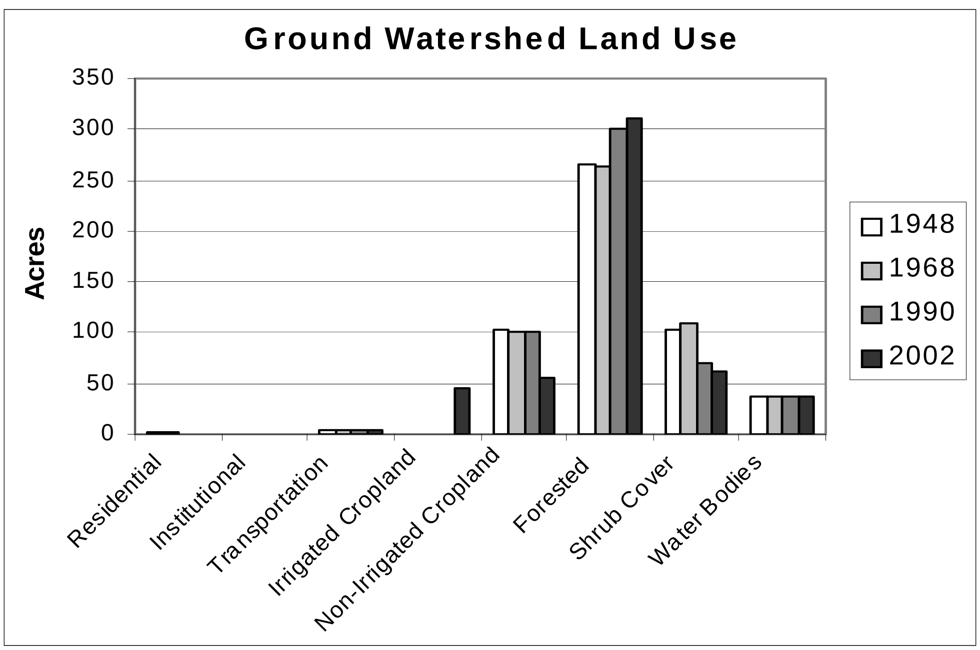


Figure 6. Land use in the Wolf Lake groundwater watershed between 1948 and 2002.



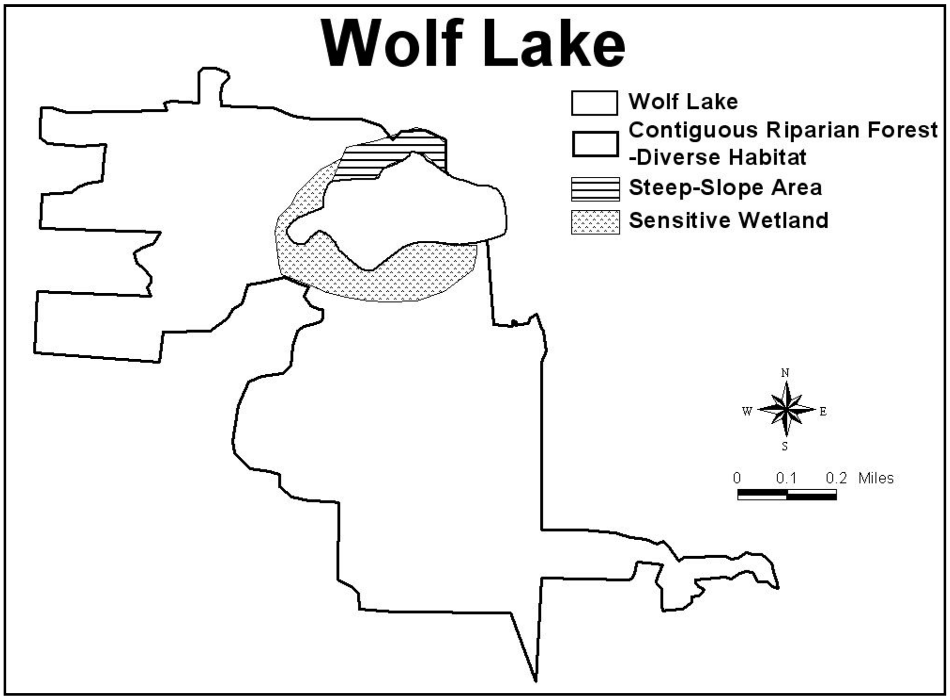
Upland Sensitive Areas

The survey of upland sensitive areas was conducted to note areas immediately around the lakeshore that are particularly ecologically valuable, or sensitive to disruption. The inventory of upland sensitive areas around Wolf Lake includes the wetlands along most of the south shore, all of the west shore, and approximately half of the north shore. The north and south shores also have steep slopes that act as a micro-habitat and are sensitive to **erosion**. In addition, there are large tracts of

*Terms in bold, see glossary pp 18-23

forested areas contiguous to the lake that should be protected as they provide diverse habitat, and large, contiguous, tracts are becoming rarer near Portage County water bodies (Figure 7).

Figure 7. Upland sensitive areas near Wolf Lake.



Birds
Lakeshore development can negatively or positively affect habitat quality for 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 around Wolf Lake. 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.

*Terms in bold, see glossary pp 18-23

Table 1. Bird species identified near Wolf Lake.

Common Name	Number Observed	Food	Foraging	Nest Type	Nest Location
American Goldfinch	4	seeds	foliage gleaner	cup	shrub
American Robin	2	insects	ground gleaner	cup	deciduous
Belted Kingfisher	1	fish	high dive	burrow	bank
Black-capped Chickadee	1	insects	foliage gleaner	cavity	deciduous
Blue Jay	3	omnivore	ground gleaner	cup	coniferous
Catbird	1	insects	ground gleaner	cup	shrub
Common Yellowthroat	2	insects	foliage gleaner	cup	shrub
Eastern Wood-Pewee	4	insects	hawker	cup	deciduous
House Wren	2	insects	ground gleaner	cavity	deciduous
Indigo Bunting	3	insects	foliage gleaner	cup	shrub
Mourning Dove	1	seeds	ground gleaner	saucer	deciduous
Ovenbird	1	insects	hawker	cup	bridge
Rose-breased Grosbeak	3	insects	foliage gleaner	cup	deciduous
Song Sparrow	2	insects	ground gleaner	cup	ground
White-breasted Nuthatch	1	insects	bark gleaner	cavity	deciduous
Yellow-throated Vireo	1	insects	foliage gleaner	cup	deciduous
Total	**32**				

Shoreline Vegetation, Reptiles, and Amphibians

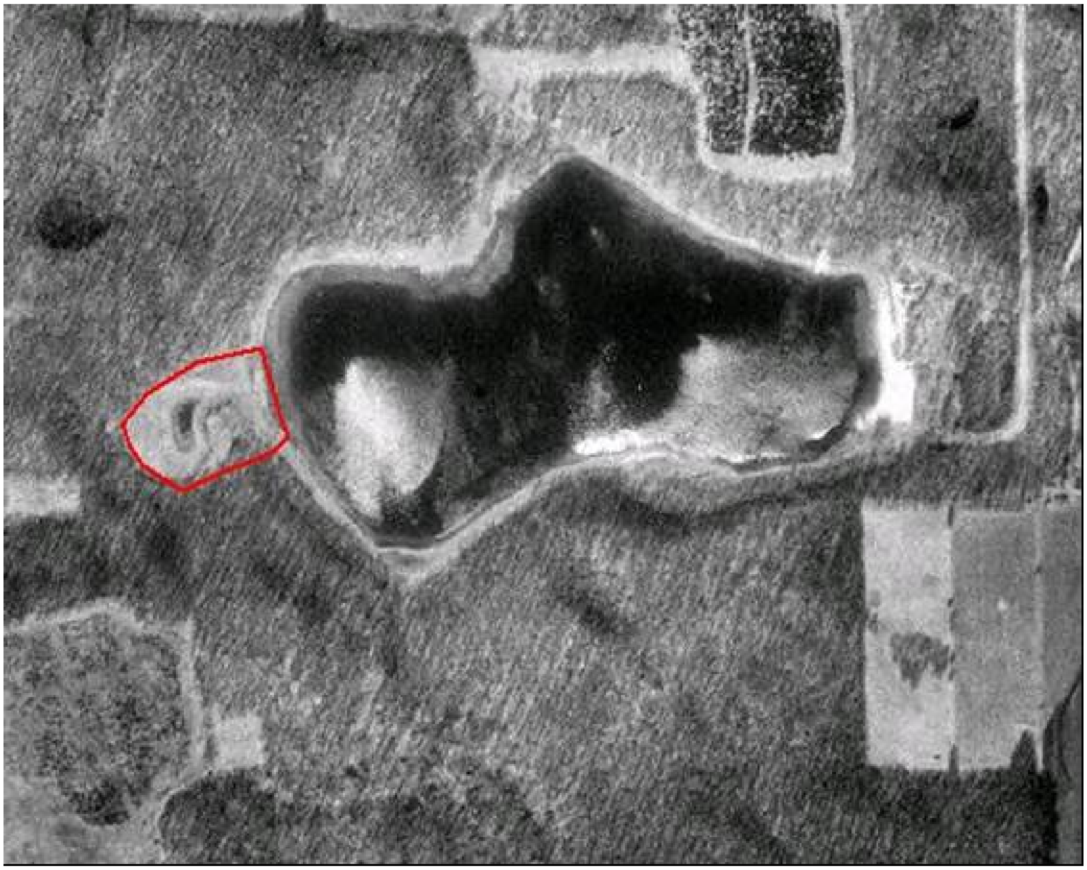
Amphibians (frogs and toads) were included in this survey because with their permeable skin and biphasic lifecycle (meaning that the young live in water while adults can survive on land) they are considered excellent indicators of overall ecosystem health. Furthermore, both turtles and amphibians utilize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

During the survey of reptiles Wolf Lake was found to contain one turtle species [painted turtle (*Chrysemys picta*)]. There is also a historical record of spiny softshell turtle (*Apalone spinifera*) being present. Two frog species [spring peeper (*Pseudacris crucifer*) and green frog (*Rana clamitans*)] were observed during the amphibian survey near Wolf Lake. The primary amphibian habitat can be found surrounding much of the lake (the most sensitive area is identified in red in 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 Wolf Lake contains large sections of undisturbed, natural shoreline. The bad news is that recreational use of the lake may affect amphibian populations.

*Terms in bold, see glossary pp 18-23

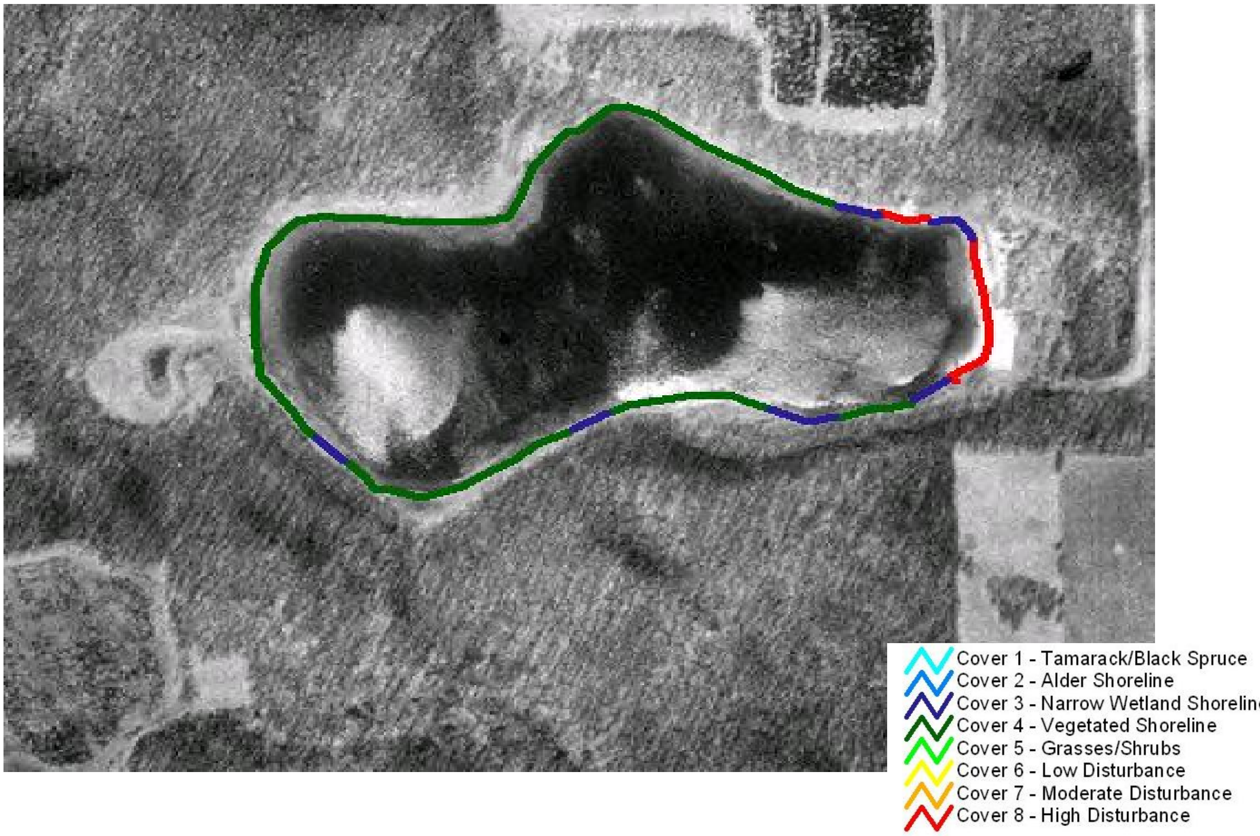
Figure 8. Regions of primary amphibian habitat around Wolf Lake.



About 60% of the shoreline of Wolf Lake is vegetated. Vegetated shoreline is characterized as being upland areas with dense vegetation comprised of tall grasses or shrubs that lack a rocky component. It is shown in dark green in Figure 9. Narrow wetlands comprise about 14.9% of the shoreline. Narrow wetlands are characterized as being wetland areas that extend less than 15 feet onto the shore and have an adjacent undeveloped upland area. Around Wolf Lake, 25.1% of the shoreline's vegetation is considered to be highly disturbed. 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.

*Terms in bold, see glossary pp 18-23

Figure 9. **Shoreline vegetation around Wolf Lake.**



Aquatic Plants

There are 49 species of aquatic **macrophytes** (48 species of **vascular plants** plus one **macrophytic alga**) that have been found in Wolf Lake or in the wet areas of the surrounding shoreline and adjacent wetland. This is above average for Portage County lakes. The average **coefficient of conservatism** (**c value)** is 4.2, which is slightly below average. The **floristic quality index** is 29.2, which is also below average for Portage County lakes.

The shoreline of Wolf Lake is undeveloped, except for a beach at the east end. With the low water levels in 2002 and 2003, the exposed sandy beach area is exceptionally wide. Silver-weed (*Argentina anserina*) is very abundant, especially on the south and west shores. The flora of this area is typical of exposed lake beaches in Wisconsin, especially those which have alternating periods of high water inundating the shore, followed by dry years with wide exposed beaches. The beach and vegetation are similar to nearby Pickerel Lake, Plainfield Lake, and Second Lake, all of which have populations of Fassett's locoweed (*Oxytropis chartacea*). There are reports of Fassett's locoweed having been present at Wolf Lake, but there are apparently no herbarium voucher specimens. Nevertheless, the shore should be searched every June for Fassett's locoweed when that species would be in flower and fairly conspicuous. At other times of the year it would be difficult to find because it has the same grayish coloration and pinnately compound leaves as the very abundant silver-weed.

A fairly large wetland occurs at the west end of the lake, cut-off during dry years, but probably more-or-less connected to Wolf Lake during years of high water. This wetland appears to be a degraded rich **fen**. Seeds of some of the rare or more characteristic **fen** species could still be present

*Terms in bold, see glossary pp 18-23

in this wetland. If so, several years of protection from disturbance may lead to the re-appearance of some of these species.

The Fishery

Wolf Lake supports a warm water fishery. A total of 13 species of fish have been reported from Wolf Lake since 1945, but the lake presently holds only seven species of fish (Table 2). The only newly documented taxa were bluegill/pumpkinseed hybrids (*Lepomis gibbosus x Lepomis macrochirus*). As in Thomas Lake, this limited community is probably in part due to extensive management activities including whole-lake poisoning in 1961. The lake has also been subject to periodic winterkills. The sport fish population is presently dominated by bluegill (*Lepomis macrochirus*), bluegill/pumpkinseed hybrids, and largemouth bass (*Micropterus salmoides*). The lake had been repeatedly stocked with northern pike (*Esox lucius*), bluegill, largemouth bass, yellow perch (*Perca flavescens*), and walleye (*Sander vitreum*) between 1961 and 1976. Although this lake provides little suitable habitat for walleye, stocked fish were reported to have produced five year classes of offspring by 1986. The entire population has apparently since disappeared. Presently, there is no spawning habitat for walleye in the lake, but higher water levels in the past may have inundated some additional sandy areas that are now well above the water level. Gravel is the preferred **substrate** for walleye spawning, but they have been reported to spawn over sand. Other species lost or undocumented in Wolf Lake include bullhead species (*Ictaluridae*), white suckers (*Catostomus commersoni*), and golden shiners (*Notemigonus crysoleucas*). It is likely other non-game species were present in this lake, but not documented prior to poisoning. The lake has no outlet and thus no capacity for natural repopulation. Other than the manipulation of the fishery for anglers, this lake has been yet largely unimpacted by development, despite several residential development schemes proposed in recent years.

Table 2. Species occurrence in Wolf Lake from the 2002/2003 study and WDNR records.
Note: "S" indicates WDNR stocking record.

Bluegill	2002, 1986, 1973, 1970, 1959
	S; 1971-1963
Bluegill/Pumpkinseed hybrid	2002
Pumpkinseed	2002, 1986, 1973
Rock Bass	2002, 1986
Largemouth Bass	2002, 1986, 1970, 1959
	S; 1969, 1965, 1961
Crappie sp.	1959, 1956
Walleye	1986, 1973
	S; 1976, 1971, 1961, 1958, 1956, 1953, 1945
Yellow Perch	2002, 1986, 1973, 1970, 1959
	S;1967, 1961
Northern Pike	2002, 1986, 1973, 1970, 1959
	S; 1971-1963
Bullhead sp.	1986
White Sucker	1959
Fathead Minnow	**S**; 1961
Golden Shiner	1959

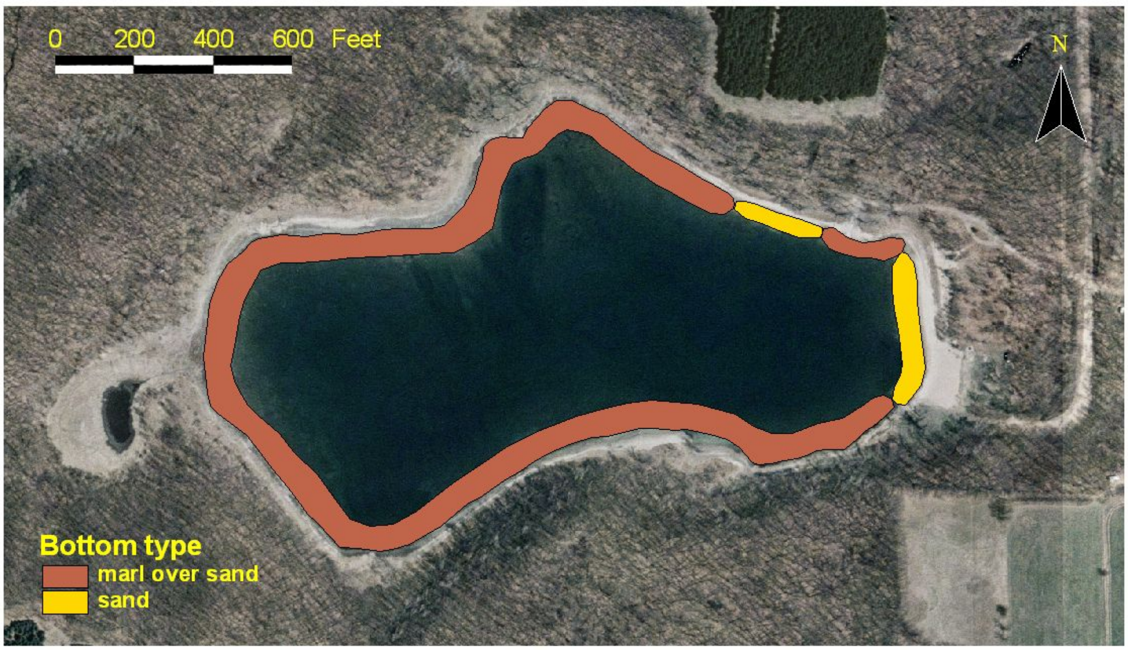
*Terms in bold, see glossary pp 18-23

Bottom Substrate, Vegetative Structure, and Critical Habitat

Bottom **substrate** in **littoral** areas is **marl** and sand (Figure 10). Suitable **substrate** exists for spawning of largemouth bass and bluegill. Largemouth bass nests were concentrated in **marl** covered areas that were excavated down to woody debris. Woody cover is scarce, and the area along the north shore of the lake was well used, as indicated by a concentration of largemouth bass nests. Spawning requirements for bluegill are less specific, and the abundance of small bluegill habitat is not limiting. No representative species of the minnow family were found in Wolf Lake, undoubtedly eliminated by the chemical treatment. The sandy areas along the eastern shore may help sustain a native minnow assemblage more typical of other glacial lakes in the area should restoration be attempted. The lake water level appeared to have receded to near record lows leaving a 20-50 foot strip of largely unvegetated beach circling the lake. This condition was typical of most area **seepage lakes** in 2002 and 2003. Although the lake is surrounded by forest, presently there are no trees close enough to the water to provide cover should they fall. Trees that have fallen into that area now should be left in place, as naturally rising water levels will eventually again submerge this area.

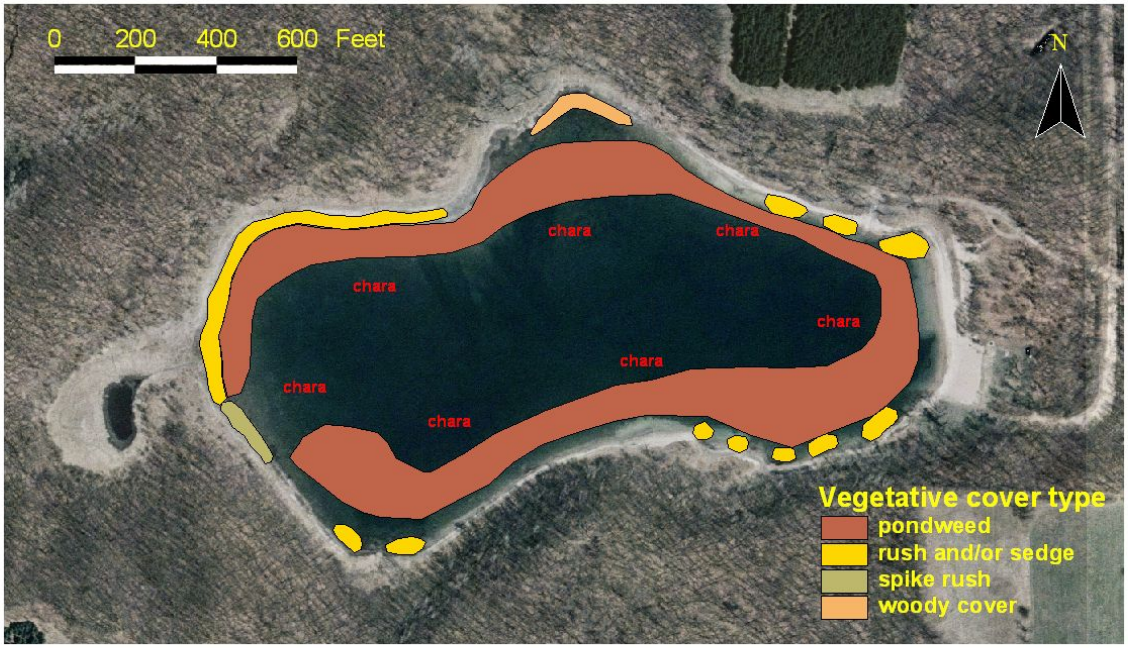
Wolf Lake provides a diversity of vegetative cover types including beds of sedge and rush along the shore with pondweeds providing open water cover (Figure 11). The bottom in deeper areas is blanketed with dense beds of muskgrass (*Chara*). Spawning habitat for northern pike is marginal given the low water levels, but with an additional 3-5 feet of water, the now isolated bay at the western end of the lake would provide excellent spawning marsh habitat for this species.

Figure 10. Littoral bottom map of Wolf Lake 6/20/03.



*Terms in bold, see glossary pp 18-23

Figure 11. Vegetative cover map of Wolf Lake 6/20/03.



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 was measured in Wolf Lake from top to bottom at the time of sample collection. Each date revealed temperatures that were uniform throughout the water column, indicating that the lake was fully mixed (Figure 12). Dissolved oxygen concentrations showed a little different picture; on many occasions the bottom water was below 5 **mg/L** which is quite normal. Measurements taken in March 2002 and 2003 showed dissolved oxygen concentrations were above 5 **mg/L** in only the upper 5 feet of the water (Figure 13). These concentrations should be monitored closely and plans should be made for years with long winter and heavy snow to preclude winterkill of the fishery.

*Terms in bold, see glossary pp 18-23

Figure 12. Profile of temperature in Wolf Lake 2002-2004.

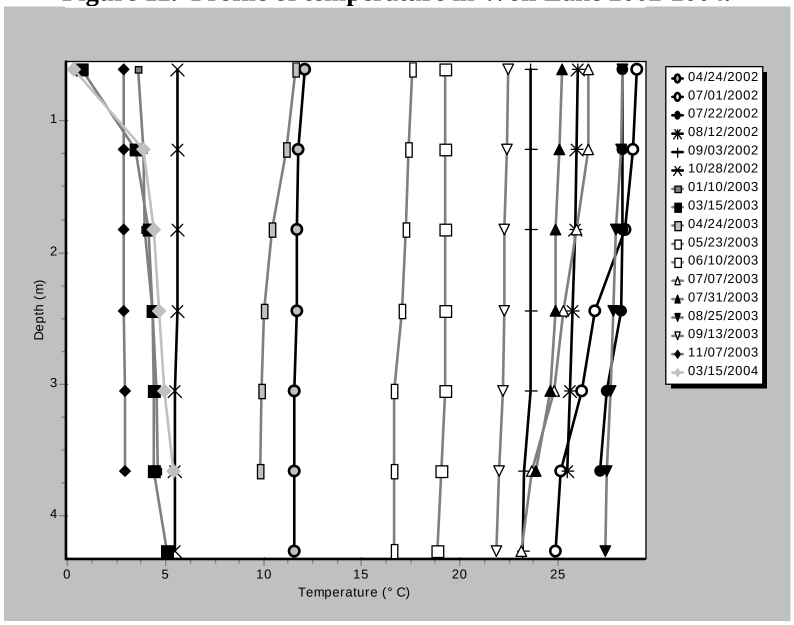
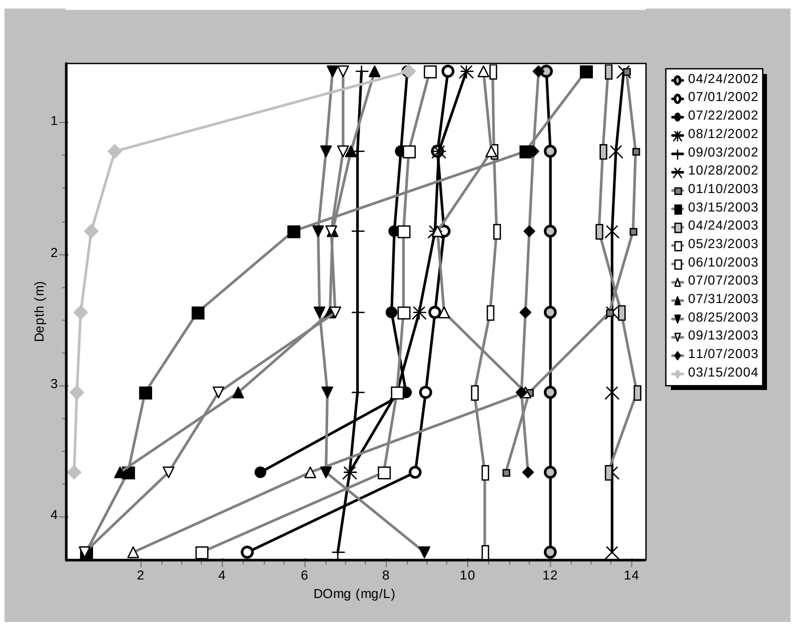


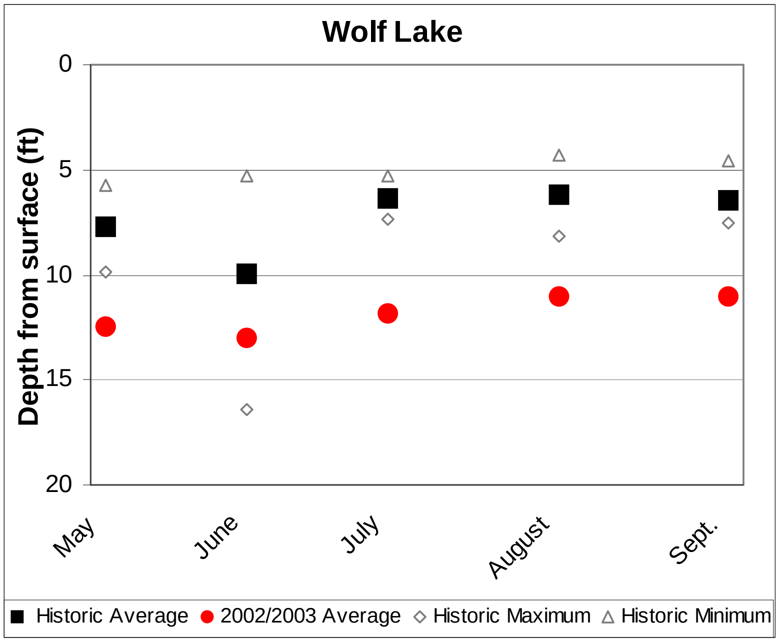
Figure 13. Profile of dissolved oxygen in Wolf Lake 2002-2004.



Water **clarity** measures how deep sunlight can penetrate water. It is both an aesthetic measure and one associated with the depth that **rooted aquatic plants** can grow. Water **clarity** is affected by water **color**, **turbidity** (suspended sediment), and **algae**. These measures were all quite low in Wolf Lake (Figure 14). The recent water **clarity** in Wolf Lake is considered good. Historically, it has been much poorer. The average **Secchi disc** depth reading for similar lakes in the county is 9 feet; Wolf Lake currently appears to have better **clarity** than this. The water **clarity** in Wolf Lake during 2002-03 growing seasons was much improved compared to the historical growing season average. The months of May and June show the best water **clarity**. Fluctuations throughout the summer are normal as **algae** populations and **sedimentation** increase and decrease.

*Terms in bold, see glossary pp 18-23

Figure 14. Monthly average water clarity measurements in Wolf Lake 2002-2003 and historic average, maximum and minimums.



Algae and aquatic plants use nutrients (**phosphorus** and **nitrogen**) for growth in much the same way as houseplants or crops do. In Wolf Lake, **phosphorus** is the most important nutrient. Currently, concentrations of **phosphorus** are fairly low throughout the year, and **nitrogen** is low through much of the year; however, in winter, **nitrate** concentrations (**NO_2+NO_3**-N) and **chloride** concentrations are elevated (Table 3). This indicates that these chemicals are being delivered to the iced-over lake by **groundwater**.

Wolf Lake is a moderately **hard water** lake with some **marl** formation occurring during the summer. Its **alkalinity** values indicate the lake has the chemistry to be a productive lake and can adequately buffer the effects of acid rain. On average, concentrations of contaminants (**sulfate**, **chloride**, **potassium**, and **sodium**) are low (Table 4). **Atrazine** was detected in low concentrations (0.11 ppb); some toxicity studies have indicated that **endocrine** disruption can occur in frogs at these levels. The presence of **atrazine** indicates that other agrichemicals may also be entering Wolf Lake.

Table 3. 2002-2003 water quality seasonal averages in Wolf Lake.

Wolf 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	24.3	6.5	0.81	0.02	0.02	122.0	126.5	64.5	14	1.4	1.5
Summer Averages	19.4	4.8	1.16	0.02	0.04	100.0	101.0	36.7	14	2.1	4.1
Fall Averages	17.5	6.5		0.01	0.06	109.5	117.5	51.5	14	1.5	
Winter Averages	11.0	4.5		1.93	0.24						
2002-2004 Averages	19.1	5.5	0.99	0.44	0.08	110.5	115.0	50.9	14	1.6	3.9

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 18-23

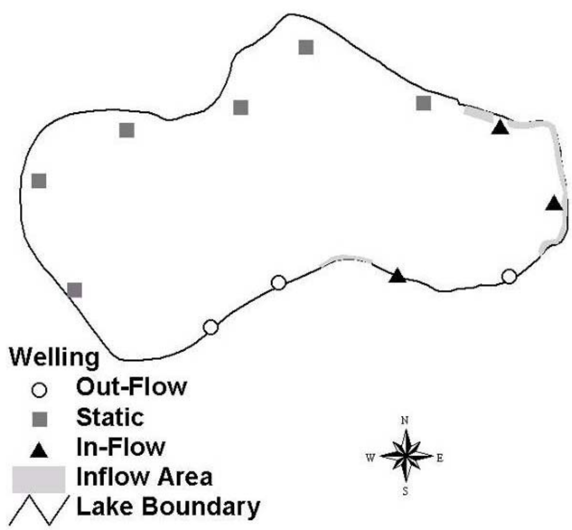
Table 4. 2002-2003 Wolf Lake average water chemistry and reference values.

Wolf Lake	Low	Medium	High	Reference Values	Low	Medium	High
Sulfate	5.73			*Sulfate*	<10	10-20	>20
Chloride	0.94			*Chloride*	<3	3-10	>10
Potassium	0.36			*Potassium**	<2.16	2.16-4.30	>4.30
Sodium	1.27			*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.*

Small wells were placed into the sediment around Wolf Lake to identify general areas of inflow, no flow, and outflow. In addition, observations were made during the late winter to identify areas of open water prior to thaw. The inflowing **groundwater** was located on the east and south side during this exercise; however, the water levels were low which may alter where the **groundwater** enters the lake when lake levels are higher (Figure 15). Only one **groundwater** sample was obtained for water quality analysis, from the inflow site on the south side of the lake. Concentrations of **nitrate**, **chloride**, and **phosphorus** were all low.

Figure 15. Locations in Wolf Lake showing groundwater inflow/no flow/outflow from mini-piezometer measurements and winter observations.



Algal Community

The algal community in Wolf Lake was not diverse. The dominant group was the green **algae** (Chlorophyta), representing 45% of all cells counted over the sampling period. The **blue-green algae** (Cyanobacteria), euglenoids (Euglenophyta), and yellow-green **algae** and **diatoms** (Ochrophyta) were subdominants (Table 5). The four dominant phyla represented 95% of all cells counted during the 2003 sampling season. In the 1659 cells counted during this period there were 5 genera of Cyanobacteria, 11 genera of Chlorophyta, 7 genera of Ochrophyta (including 7 **diatom** genera), 3 genera of Euglenophyta, 2 genera of Dinophyta, and 1 genus of Cryptophyta identified. The green **algae** (Chlorophyta) were consistently dominant, being most abundant in all five sample periods and never representing less than 38% of all cells counted during the 2003 sampling period.

*Terms in bold, see glossary pp 18-23

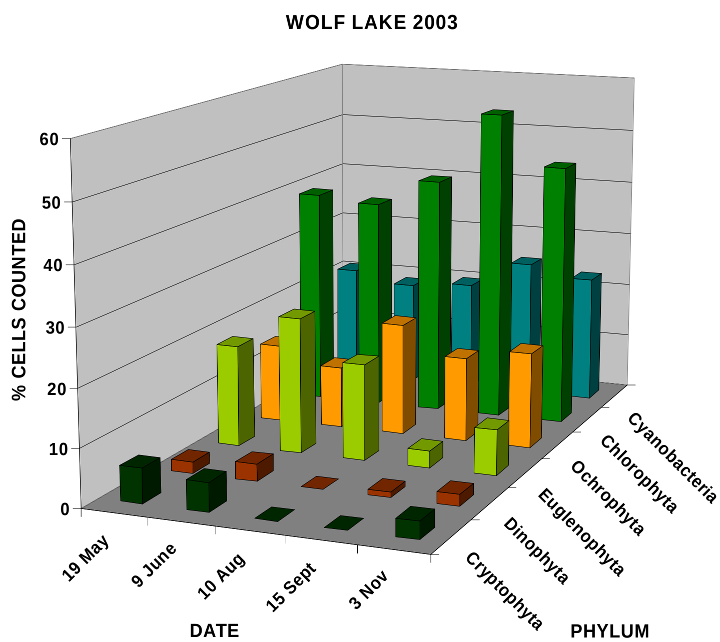
The **blue-green algae** (Cyanobacteria) abundance was very stable; it ranged from 19-25% and averaged 22% of all cells counted. Peak abundance was in the September and November sample periods. The Ochrophyta (all **diatoms**) ranged from 11-20% of cells counted and were also fairly uniform in abundance over the sampling period. The Euglenophyta, while averaging 14% for the sampling season, were only abundant during the May, June, and August periods, ranging from 17-24% over that subperiod and being insignificant in the late season samples. The other phyla (Dinophyta, Cryptophyta) totaled about 5% of all cells counted, with neither phylum ever represented by more that 6% of cells counted in a sample period (Figure 16).

Table 5. Algal phyla and mean seasonal composition in Wolf Lake from May to November 2003.

WOLF LAKE

PHYLUM	% CELLS COUNTED BY PHYLUM AND DATE					**MEAN**
	19 May	9 June	10 Aug	15 Sept	3 Nov	
Cyanobacteria	21	19	20	25	23	22
Chlorophyta	39	38	43	56	47	45
Ochrophyta	14	11	20	15	17	15
Euglenophyta	18	24	17	3	8	14
Dinophyta	2	3	0	1	2	2
Cryptophyta	6	5	0	0	3	3

Figure 16. Algal community composition by date in Wolf Lake from May to November 2003 (total phylum cells counted divided by total cells counted).



The morphologically interesting, unicellular desmid (green alga) *Cosmarium* was the most abundant genus in all samples. It was also the only green alga found in the top 15 abundance slots (Figure 17). The cyanobacterial genus *Coelosphaerium* was third most abundant early (May, June) and became the second most abundant genus during the other three sampling periods. The euglenoid type genus *Euglena* was the second most abundant genus early (May, June) and faded out of the top 15 slots after the August sample. The only **diatom** genus to crack the top 15 was large, unicellular, pinnate

*Terms in bold, see glossary pp 18-23

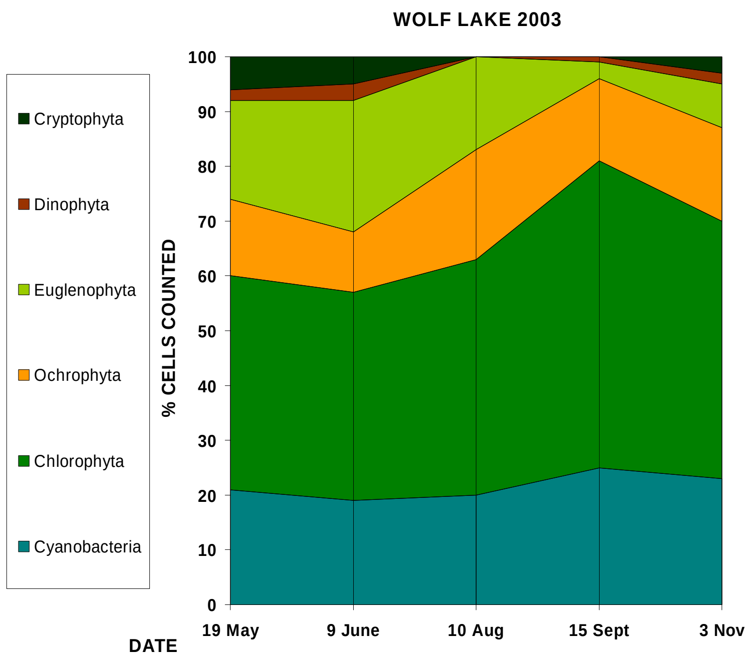
genus *Pinnularia* that was third most abundant in both the late season samples (September, November) (Table 6).

The algal community, when considered relative to the chlorophyll, **phosphorus**, and **nitrogen** values for Wolf Lake, presents a picture of a fairly **oligotrophic** lake. The 29 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. A stable, little changing algal community, especially lacking a late season **blue-green** algal bloom, such as that seen in Wolf Lake, can be taken as supporting evidence for its label as an **oligotrophic** lake. This is also supported by the generally good water **clarity** seen throughout the sampling period.

Table 6. Most common algal genera by date in Wolf Lake from May to November 2003.

DATE	TOP THREE TAXA (MOST ABUNDANT, LEFT TO RIGHT)		
19 May	*Cosmarium*	*Euglena 2*	*Coelosphaerium*
9 June	*Cosmarium*	*Euglena 2*	*Coelosphaerium*
10 August	*Cosmarium*	*Coelosphaerium*	*Euglena 2*
15 September	*Cosmarium*	*Coelosphaerium*	*Pinnularia*
3 November	*Cosmarium*	*Coelosphaerium*	*Pinnularia*

Figure 17. Algal community composition by phylum in Wolf Lake from May to November 2003.



*Terms in bold, see glossary pp 18-23

Wolf Lake Study Highlights

- The inventory of upland sensitive areas around Wolf Lake includes the wetlands along most of the south shore, all of the west shore, and approximately half of the north shore. The north and south shores also have steep slopes that act as a micro-habitat and are sensitive to **erosion**. In addition there are large tracts of forested areas contiguous to the lake that should be protected as they provide diverse habitat, and large, contiguous, tracts are becoming more rare near Portage County water bodies.
- During the survey of reptiles, Wolf Lake was found to contain one turtle species (painted turtle). There is also a historical record of spiny softshell turtle being present. Two frog species (spring peeper and green frog) were observed during the amphibian survey near Wolf Lake. Primary amphibian habitat can be found surrounding much of Wolf Lake.
- About 60% of the shoreline of Wolf Lake is vegetated, narrow wetlands comprise about 14.9% of the shoreline, and 25.1% of the shoreline's vegetation is considered to be highly disturbed.
- The number of **vascular plants** (48) plus one **macrophytic alga** that have been found in Wolf Lake or in the wet areas of the surrounding shoreline and adjacent wetland is above average for Portage County lakes. The average **coefficient of conservatism** and the **floristic quality index** are below average for Portage County lakes.
- The shoreline of Wolf Lake is undeveloped, except for a beach at the east end. With the low water levels, the flora of this area is typical of exposed lake beaches in Wisconsin, especially those which have alternating periods of high water inundating the shore, followed by dry years with wide exposed beaches. There are reports of Fassett's locoweed having been present at Wolf Lake, but there are apparently no herbarium voucher specimens. Nevertheless, the shore should be searched every June for Fassett's locoweed when that species would be in flower and fairly conspicuous.
- A fairly large wetland occurs at the west end of the lake, cut-off during dry years, but probably more-or-less connected to Wolf Lake during years of high water. This wetland appears to be a degraded rich **fen**. Seeds of some of the rare or more characteristic **fen** species could still be present in this wetland. If so, several years of protection from disturbance may lead to the re-appearance of some of these species.
- Wolf Lake supports a warm water fishery. A total of 13 species of fish have been reported from Wolf Lake since 1945, but the lake presently holds only seven species of fish. The only newly documented taxa were bluegill/pumpkinseed hybrids. This limited community is probably in part due to extensive management activities including whole-lake poisoning in 1961. The lake has also been subject to periodic winterkills. No representative species of the minnow family were found in Wolf Lake, undoubtedly eliminated by the chemical treatment. The sport fish population is presently dominated by bluegill, bluegill/pumpkinseed hybrids and largemouth bass.
- Bottom **substrate** in **littoral** areas is **marl** and sand. Suitable **substrate** exists for spawning of largemouth bass and bluegill. Largemouth bass nests were concentrated in **marl** covered areas that were excavated down to woody debris. Woody cover is scarce and the area along the north shore of the lake was well used as indicated by a concentration of largemouth bass nests. The abundance of small bluegill habitat is not limiting.
- The sandy areas along the eastern shore may help sustain a native minnow assemblage more typical of other glacial lakes in the area should restoration be attempted.
- Although the lake is surrounded by forest, presently there are no trees close enough to the water to provide cover should they fall. Trees that have fallen into that area now should be

*Terms in bold, see glossary pp 18-23

left in place for fishery habitat, as naturally rising water levels will eventually again submerge this area.

- Wolf Lake provides a diversity of vegetative cover types, including beds of sedge and rush along the shore with pondweeds providing open water cover. The bottom in deeper areas is blanketed with dense beds of muskgrass. Spawning habitat for northern pike is marginal given the low water levels, but with an additional 3-5 feet of water the now isolated bay at the western end of the lake would provide excellent spawning marsh habitat for this species.
- The fluctuating water levels in Wolf Lake respond to changes in groundwater that are due to the close proximity to the glacial moraine located to the west and variability in precipitation. This situation makes this lake particularly vulnerable to water withdrawal from high capacity wells or large numbers of wells located within its **watershed**.
- Measurements of dissolved oxygen taken in March 2002 and 2003 showed dissolved oxygen concentrations were above 5 **mg/L** in only the upper 5 feet of the water. These concentrations should be monitored closely, and plans should be made for years with long winter and heavy snow to preclude winterkill of the fishery.
- The algal community, when considered relative to the chlorophyll, **phosphorus**, and **nitrogen** values for Wolf Lake, presents a picture of a fairly **oligotrophic** lake. The 29 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. A stable, little changing algal community, especially lacking a late season **blue-green** algal bloom, such as that seen in Wolf Lake can be taken as supporting evidence for its label as an **oligotrophic** lake. This is also supported by the generally good water **clarity** seen throughout the sampling period.

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.

*Terms in bold, see glossary pp 18-23

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 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 residence 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.

*Terms in bold, see glossary pp 18-23

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.

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:

*Terms in bold, see glossary pp 18-23

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.

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 residence 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°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_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.

*Terms in bold, see glossary pp 18-23

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 18-23