Adams Lake

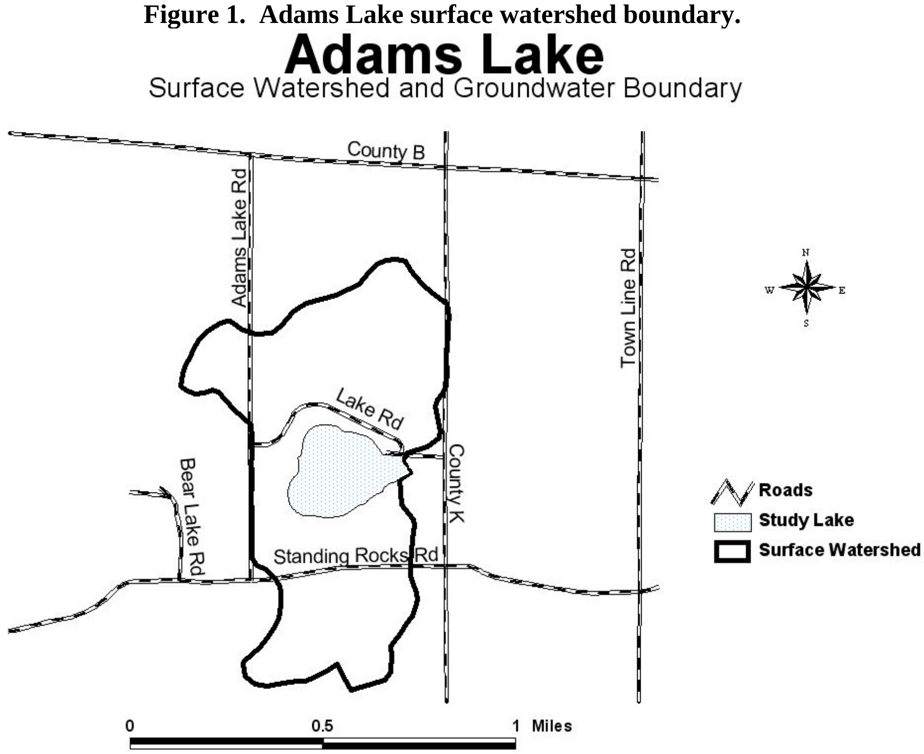
Introduction

Adams Lake is a 29 acre **hard water** spring-fed lake, located in the Town of Stockton, about five miles west of Amherst. It is one of the deeper lakes in the county with a maximum depth of 44 feet and an estimated volume of 502 acre-feet. The bottom consists primarily of **marl** with some sand. The lake has an intermittent inlet and a small outlet known as Bear Creek. The estimated **retention time** for Adams Lake is 0.6 years. The length of the shoreline is approximately 0.8 miles. Substantial residential development has been increasing over the last twenty years. Fish species present in the lake include trout, largemouth bass, and panfish. There is public access to Adams Lake on the north side with a parking area and a boat ramp.

Land Use and Watershed

The surface watershed for Adams Lake is 291 acres (Figure 1). Land use in this area is mostly non-irrigated agriculture (29%) and shrub vegetation (27%), with forests (22%) also comprising a large portion (Figure 2). The acres in non-irrigated cropland increased sharply after 1948, correlating with a decline in both forested and shrub/wetland acres. Sometime after 1968 non-irrigated cropland declined, while shrub/wetland, residential, and permanent pasture acres increased. Shrub/wetland acreage has continued to fluctuate and is currently just under 1948 levels (Figure 3). Although residential development was about six percent of the land use in the **watershed** in 2002, it has continued to increase since 1968 with much of the development being close to the lakeshore.

Figure 1. Adams Lake surface watershed boundary.



*Terms in bold, see glossary pp 20-25

Figure 2. Land use in the Adams Lake surface watershed 2002.

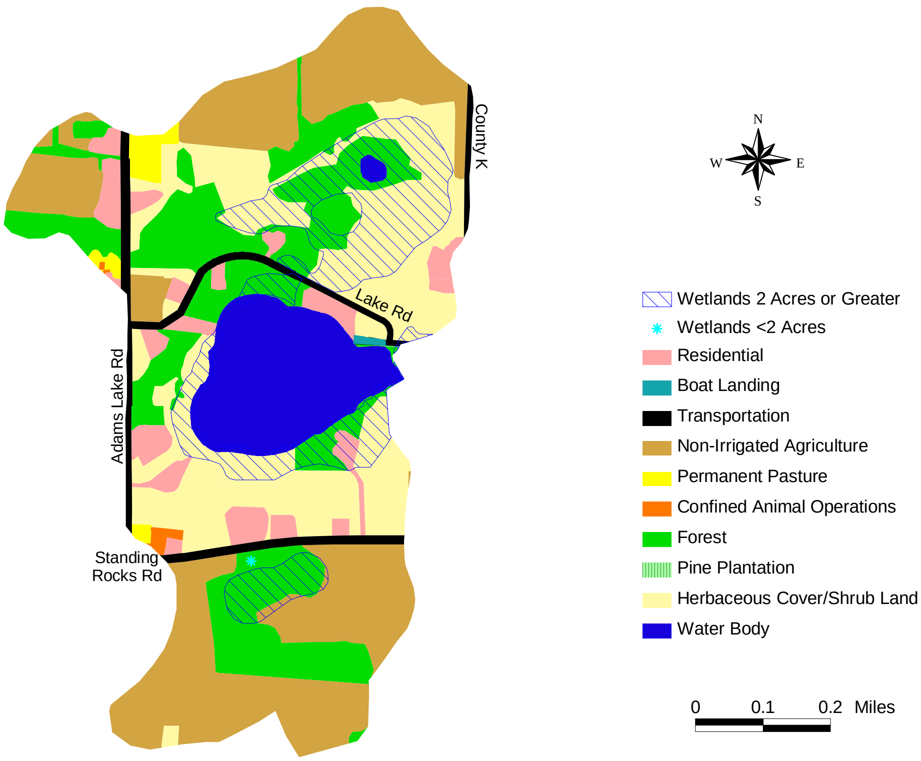
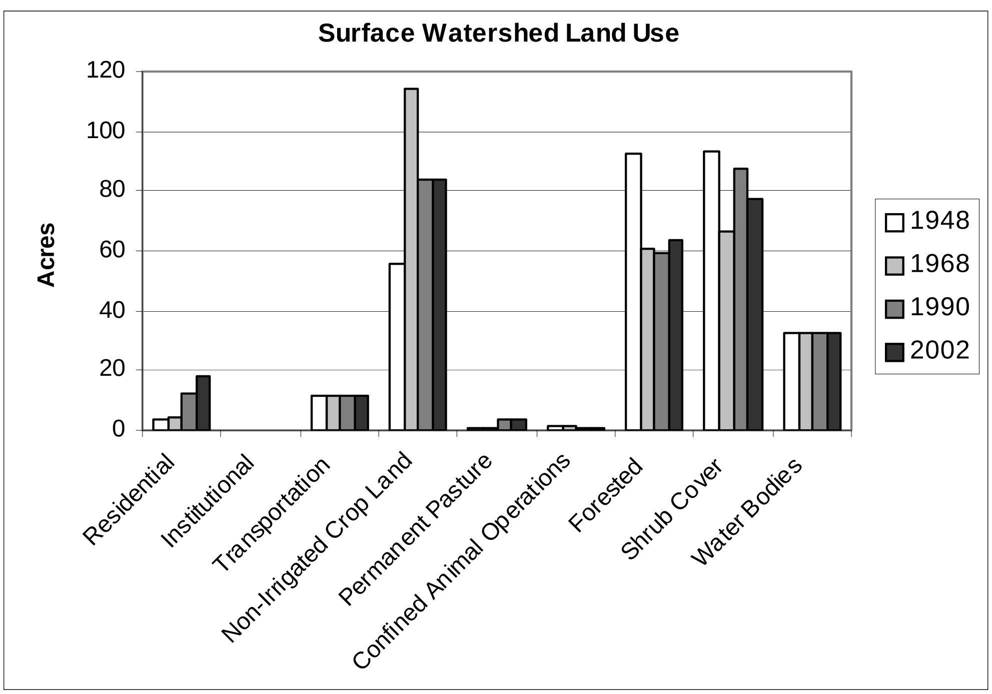


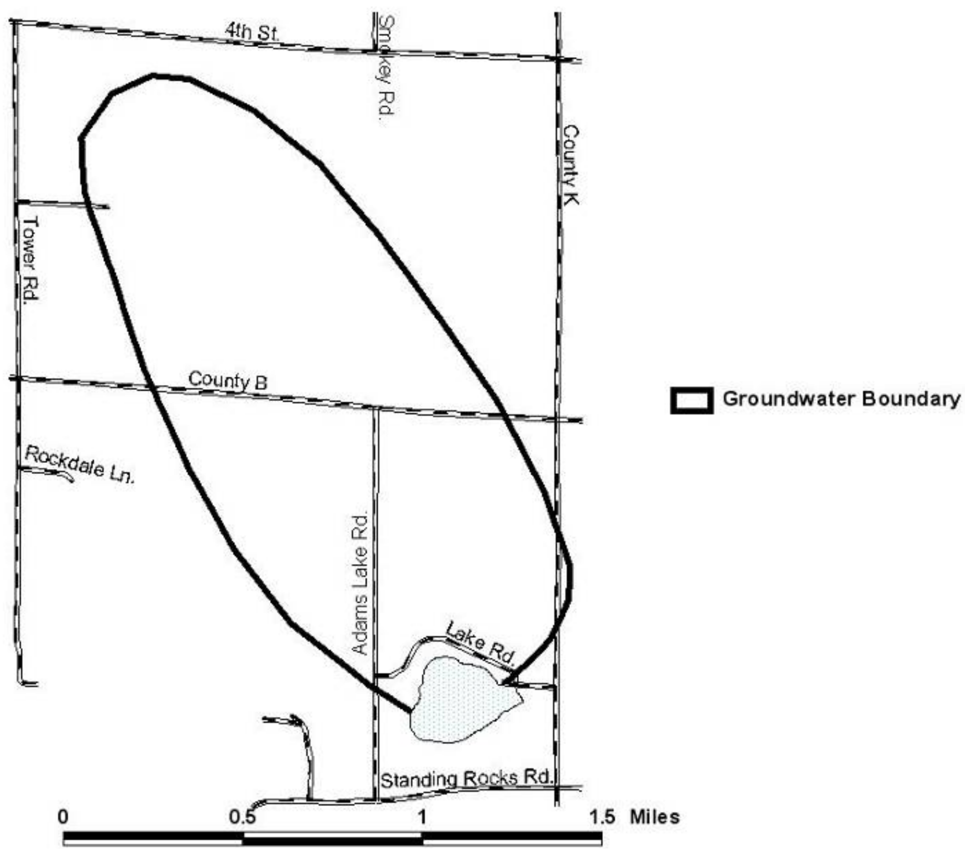
Figure 3. Land use in the Adams Lake surface watershed 1948-2002.



*Terms in bold, see glossary pp 20-25

The **groundwater watershed** for Adams Lake is 858 acres to the northwest of the lake (Figure 4). The majority of the land use is non-irrigated agriculture (48%), followed by forest (27%) (Figure 5). Between 1948 and 1968 the amount of non-irrigated cropland increased to a high of 568 acres. As of 2002 it had decreased to 414 acres. Forest land has increased slowly since 1948 to 241 acres in 2002. Shrub/wetland cover has fluctuated over the years. Residential development, along with other land uses, has remained minimal since 1948 (Figure 6). Records show that based on age there are five potentially failing septic systems present in both the surface and **groundwater watersheds** on the northeast side of the lake. There do not appear to be any former landfill sites within either **watershed** boundary.

Figure 4. Adams Lake groundwater watershed boundary.



*Terms in bold, see glossary pp 20-25

Figure 5. Land use in the Adams Lake groundwater watershed 2002.

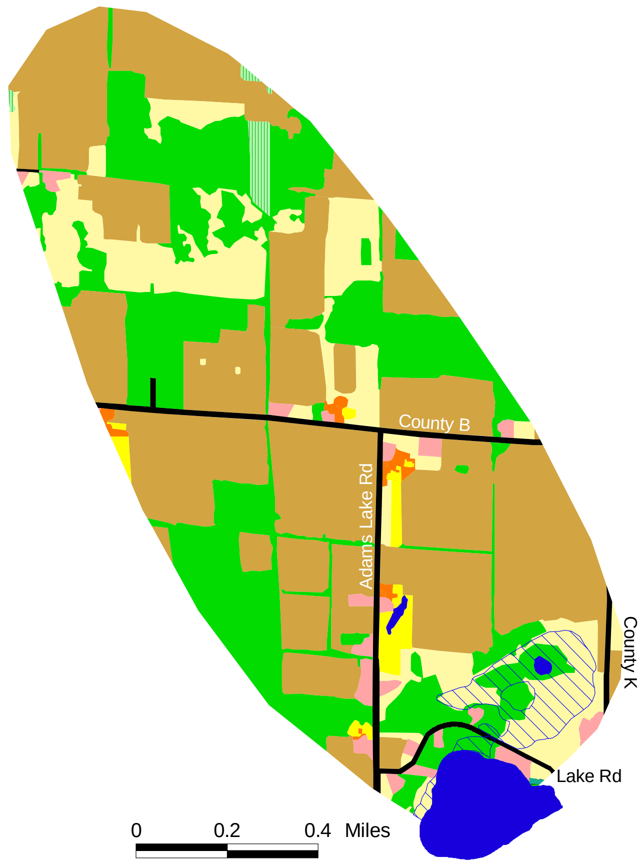
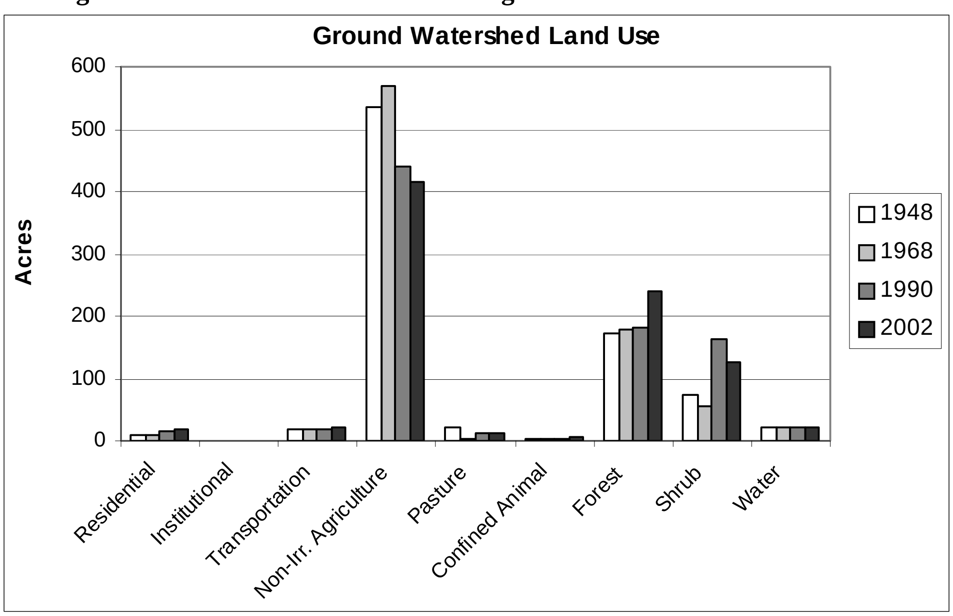


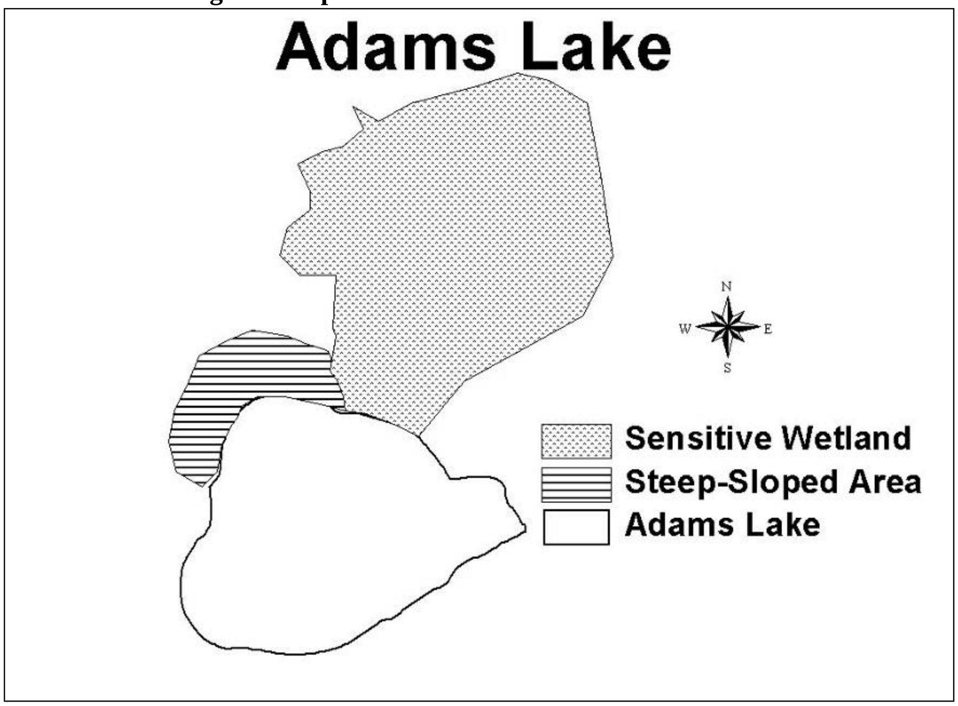
Figure 6. Land use in the Adams Lake groundwater watershed 1948-2002.



*Terms in bold, see glossary pp 20-25

Upland Sensitive Areas
Upland sensitive areas were identified for areas immediately around the lakeshore that are particularly valuable, or sensitive to disruption (Figure 7). Adams Lake is noted for the large wetland complex adjacent to the northern shore. There are also steeply sloped areas along the northwest bank. Wisconsin Department of Natural Resource records from the early 1970's document light **erosion** along the southwest bank from pastured cattle using the lake as a water source.

Figure 7. Upland sensitive areas near Adams Lake.



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

*Terms in bold, see glossary pp 20-25

(*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 Adams Lake.

Common Name	Number Observed	Food	Foraging	Nest Type	Nest Location
American Crow	5	omnivore	ground gleaner	cup	deciduous
American Goldfinch	10	seeds	foliage gleaner	cup	shrub
American Robin	9	insects	ground gleaner	cup	deciduous
Baltimore Oriole	1	insects	ground gleaner	oven	ground
Barn Swallow	1	insects	aerial foliager	cup	building
Blue-winged Warbler	1	insects	foliage gleaner	cup	ground
Brown-headed Cowbird	6	insects	ground gleaner	parasite	deciduous
Catbird	3	insects	ground gleaner	cup	shrub
Chipping Sparrow	4	insects	ground gleaner	cup	coniferous
Common Grackle	10	omnivore	ground gleaner	cavity	deciduous
Common Yellowthroat	3	insects	foliage gleaner	cup	shrub
Downy Woodpecker	1	insects	bark gleaner	cavity	snag
Eastern Kingbird	1	insects	hawker	cup	deciduous
Eastern Phoebe	1	insects	bark gleaner	cavity	snag
Field Sparrow	1	insects	ground gleaner	cup	ground
House Finch	3	seeds	ground gleaner	cup	deciduous
House Sparrow	1	seeds	ground gleaner	cavity	building
Mourning Dove	1	seeds	ground gleaner	saucer	deciduous
Northern Cardinal	1	insects	ground gleaner	cup	shrub
Red-winged Blackbird	19	insects	ground gleaner	cup	reed
Song Sparrow	7	insects	ground gleaner	cup	ground
White-breasted Nuthatch	1	insects	bark gleaner	cavity	deciduous
Yellow Warbler	3	insects	foliage gleaner	cup	shrub
Total	**93**				

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

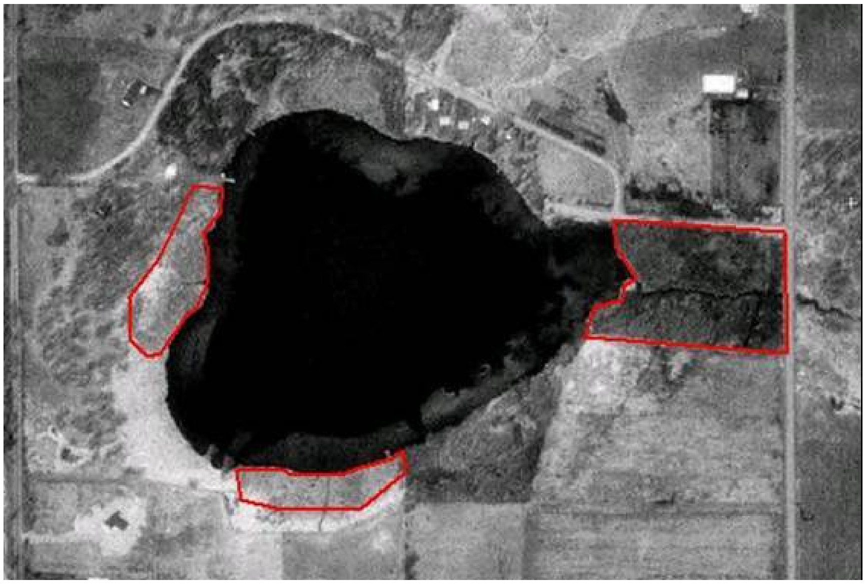
*Terms in bold, see glossary pp 20-25

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**.

Seven frog species were identified [wood frog (*Rana sylvatica*), spring peeper (*Pseudacris crucifer*), chorus frog (*Pseudacris triseriata*), northern leopard frog (*Rana pipiens*), American toad (*Bufo americanus*), gray treefrog (*Hyla versicolor*), and green frog (*Rana clamitans)*] along with one salamander species (mudpuppy [*Necturus maculosus*]) in the amphibian survey conducted for Adams Lake. The primary amphibian habitat is located on the southwest corner and east side of the lake (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 a number of frog species are present at Adams Lake; shoreline alteration due to development has been kept to a minimum by the low number of houses and protection of shoreline habitat is in place in many locations. The bad news is that small stretches of highly altered shoreline may prevent amphibian populations from establishing in some areas. During the survey of reptiles Adams Lake was found to be home to two turtle species, painted turtles (*Chrysemys picta*) and snapping turtles (*Chelydra serpentina*).

Figure 8. Regions of primary amphibian habitat near Adams Lake.



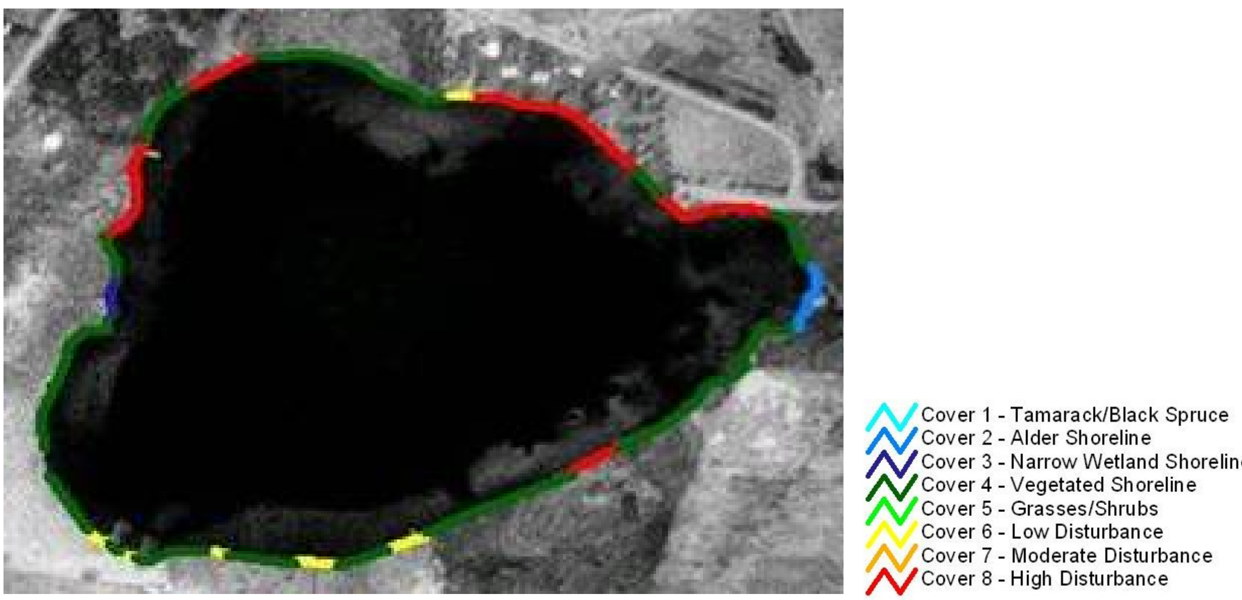
Approximately 61.2% of the Adams Lake shoreline is considered vegetated shoreline. Vegetated shoreline is characterized as being upland areas with dense vegetation comprised of tall grasses or shrubs that lack a rocky component, and are represented in dark green in Figure 9. Alder

*Terms in bold, see glossary pp 20-25

(*Alnus* spp.) comprises 3.3% of the shoreline. Alder shoreline is characterized as being areas where alder dominates the shore zone and is represented by sky blue in Figure 9. Narrow wetlands are characterized as being wetland areas that extend less than 5 meters onto the shore and have an adjacent undeveloped upland area. They make up 1.6% of the shoreline and are presented by dark blue in Figure 9.

Around Adams Lake, 34% of the shoreline is considered to be disturbed. Of that, 8.3% of the vegetation is considered to be low disturbance, moderately disturbed areas comprise 1.3% and 24.4% is considered to be highly disturbed. Low vegetation disturbance is defined as a location where there is an unaltered shore zone except for pier access, moderate vegetation disturbance is an area of shore that may contain a mowed lawn but has an intact overstory, and 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. These areas provide the least amount of habitat for birds, frogs, fish, and other forms of wildlife and may negatively impact water quality.

Figure 9. Shoreline vegetation around Adams Lake.



Aquatic Plants

Thirty-seven species of aquatic plants were found in Adams Lake or rooted in wet or water-logged soil on the shore or in the small wet shrubby thickets and associated wetlands. This is slightly less than the average found in all the Portage County lakes. The average **coefficient of conservatism** (**c-value**) of these 37 species is 4.4 which is also slightly below the average for all Portage County lakes. The **floristic quality index** is 26.4 which is below the average for the Portage County lakes.

The submersed aquatic vegetation of the lake is moderately dense, dominated by common water-milfoil (*Myriophyllum sibiricum*), 5 species of pondweed (*Potamogeton* spp.), coontail (*Ceratophyllum demersum*), and stonewort (*Chara* spp.). These species are characteristic of

*Terms in bold, see glossary pp 20-25

moderately **hard water** lakes. No alien or highly aggressive aquatic species have been found to date. The north and eastern shore and nearby wetlands consist primarily of wetland shrubs which have increased in dominance over the years. Some reed canary-grass (*Phalaris arundinacea*) is present, but not abundant. The 1977 collection of the relatively rare American grass-of-parnassus (*Parnassia glauca*) on the eastern end of the lake indicates that this part of these wetlands may have had a rich **fen** community in the past. If so, some of the **fen** species may still be present in the seed bank, and the **fen** might be restored by controlling the shrubs and reed canary-grass.

The Fishery

Adams Lake supports a two story fishery. A total of 20 species of fish have been reported from Adams Lake since 1943 (Table 2). The native fish population is warm water dominated by bluegill (*Lepomis macrochirus*), green sunfish (*Lepomis cyanellus*), and largemouth bass (*Micropterus salmoides*), but the lake is deep enough to provide a cold water environment for stocked salmonids for at least part of the year. The potential for a cold water fishery was first noted in 1948 and rainbow trout (*Oncorhynchus mykiss*) were stocked shortly thereafter. Native brook trout (*Salvelinus fontinalis*) have been stocked with the nonnative brown trout (*Salmo trutta*) stocked on an annual basis since 1978. In a 1979 study in this lake, it was reported that few stocked trout survive beyond the fishing season with 70% caught in the first month after stocking. Year-round survival may be limited by the low concentrations of dissolved oxygen in deeper cooler waters. The dissolved oxygen level below 8 meters is too low to support salmonids in the late summer and early fall and may force stocked trout into the warmer surface water that may also present lethal conditions. The lake also has a history of stocking largemouth bass and walleye (*Sander vitreum*) in the 1940s, but neither occurred after 1950.

*Terms in bold, see glossary pp 20-25

Table 2. Fish species occurrence in Adams Lake from the 2002/2003 study and WDNR records.

Note: "S" indicates WDNR stocking record.

Brook Trout.	1985, 1971, 1967. **S**; 1977
Brown Trout.	1985, 1971, 1967. **S**; 2003-1978, 1976, 1975, 1973, 1972
Rainbow Trout.	1966, 1961, 1960, 1953
Bluegill.	2003, 2002, 1987, 1985, 1971, 1967, 1966, 1961, 1960, 1953
Bluegill/Pumpkinseed hybrid.	2003
Pumpkinseed.	1985
Green Sunfish.	2003, 2002, 1987, 1985, 1967, 1966, 1961.
Rock Bass.	2003, 2002, 1987, 1985, 1971, 1967, 1960
Largemouth Bass.	2003, 2002, 1985, 1971, 1967, 1966, 1961, 1960, 1953. **S**; 1944.
Black Crappie.	1985, 1971, 1967
Crappie sp.	1966, 1961
Walleye. **S**;	1943
Yellow Perch	1985, 1971, 1967, 1966, 1961, 1960, 1953
Iowa Darter	2002, 1948
Johnny Darter	1961
Yellow Bullhead.	2002, 1985, 1967
Black Bullhead.	1980s.
White Sucker.	2002, 1985, 1966, 1961, 1960, 1953
Golden Shiner.	2002
Blackchin Shiner.	2003
Central Mudminnow	2002

Eleven species of fish were collected from Adams Lake in 2002-2003 compared to 16 from rather extensive historical records dating back to the 1940s. The most recent survey prior to this study was conducted in 1987. Taxa not previously reported from this lake include the bluegill/pumpkinseed hybrid (*Lepomis gibbosus x Lepomis macrochirus*), golden shiner (*Notemigonus crysoleucas*), and blackchin shiner (*Notropis heterodon*). As in several other area lakes the bluegill/pumpkinseed hybrid has appeared as the pure pumpkinseed (*Lepomis gibbosus*) has been lost. The golden shiner although native, is also a common bait bucket introduction. The blackchin shiner may have been previously overlooked as many of the old fishery surveys had often ignored smaller species or lumped them into unidentified categories. For example, "shiners" were reported to be present in a 1961 survey, but that could include one of several small species from the minnow family.

Species lost from the lake or not detected included walleye, yellow perch (*Perca flavescens*), johnny darter (*Etheostoma nigrum*), pumpkinseed, black crappie (*Pomoxis nigromaculatus*), black bullhead (*Ictalurus melas*), and white sucker (*Catostomus commersoni*), as well as the three salmonid species. Several "trout" were collected in late fall 2003 with mini-fyke nets set in a more extensive sampling of the lake for mudpuppy salamanders, but were not included in the fishery data tables because the species of trout was not verified. Presumably they were brown trout. The walleye was only known from Adams Lake from the early stocking records and it is likely those fish quickly disappeared. Yellow perch and black crappie were only noted in small numbers and never appeared to be important to the sport fishery here. The Johnny darter was noted only in 1961 and may no longer be present in the lake. Because Adams Lake has an intermittent outlet to the headwaters of Bear Creek, species present in the Tomorrow River **watershed** such as the black bullhead, white sucker and yellow perch, previously reported from Adams Lake, could possibly migrate back into the lake in the future.

Although the annual stocking of trout in Adams Lake has allowed the development of a cold water recreational fishery, it may have a negative impact on native warm water fish populations. Possible adverse effects would be most severe with stocking of the non-native brown or rainbow trout that would have the potential to grow much larger than the native brook trout. Adams Lake also has a notable population of mudpuppy salamanders, the only lake where they were found in the present study. They are known from the Wolf River **watershed** and have been found in other glacial lakes in central Wisconsin. They are carnivorous and would potentially eat small benthic fish, but their feeding habits in this lake are unknown. They appear to be part of the natural fauna in this lake and may have been there since the retreat of the glaciers.

Bottom Substrate, Vegetative Structure, and Critical Habitat

Bottom substrate in Adams Lake is mostly **marl** overlaid with organic detritus along the southern shore (Figure 10). In the absence of sand and gravel, largemouth bass and sunfish are known to build nests on **marl**. Depressions are deepened until small amounts of coarser **substrate**, mostly fragments of snail shells, accumulate in the bottom of the nest. In areas of soft **substrate**, largemouth bass are also reported to nest on woody debris swept clear of sediments. The presence of young bass and overabundance of sunfish indicate reproduction is successful in this lake. Adams Lake is dominated by chara throughout the **littoral** zone (Figure 11). Beds up to several feet thick blanket the bottom and extend down to the **Secchi disc** depth in much of the lake providing substantial cover for most small fish. Pondweeds along the western shore provide more sparse cover, but extend to the water surface by midsummer. Emergent beds of rush, sedge and cattail are in the northeast portion of the lake and provide more permanent cover. There are two small, but important areas with downed trees along the southeast and northwest shoreline. Because this is a **drainage lake** and water levels are more stable than in **seepage lakes**, trees that fall into the lake are likely to remain permanently submerged. These downed trees should be left in place and if possible supplemented with additional woody cover as there are few remaining large trees near enough to the water's edge to provide cover should they naturally fall.

*Terms in bold, see glossary pp 20-25

Figure 10. Littoral bottom map of Adams Lake 8/20/03.

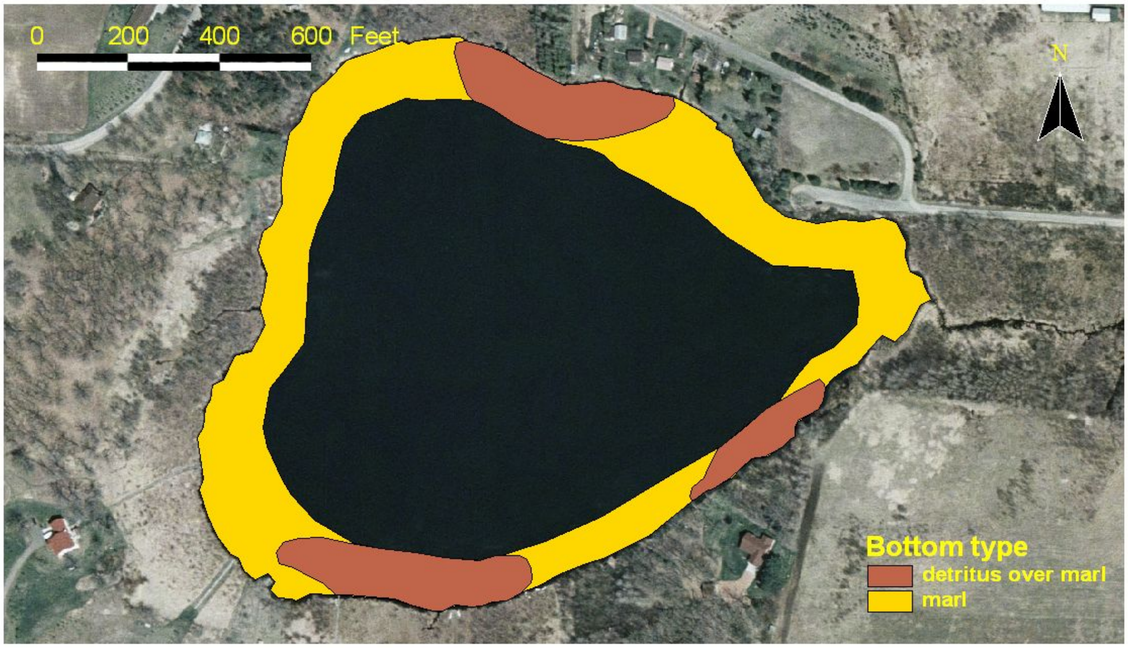
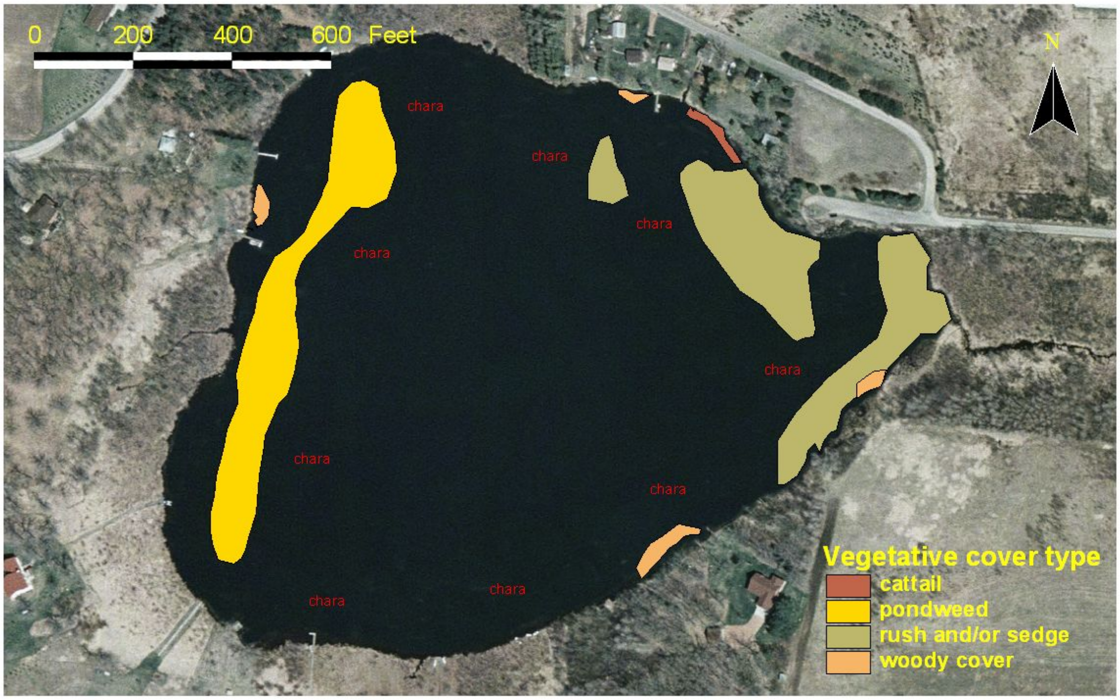


Figure 11. Vegetative cover map in Adams Lake 8/20/03.



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. Each

*Terms in bold, see glossary pp 20-25

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

The temperature profile in Adams Lake shows the typical cycle of mixing during the spring and fall and stratification in the summer and winter (Figure 12). During periods of stratification in the summer and winter the dissolved oxygen concentrations drop below 5 **mg/l** below depths of about 18 feet (Figure 13). Concentrations above 5 m/L are needed to support much of the lake's aquatic biota.

Figure 12. Temperature profiles in Adams Lake 2002-2004.

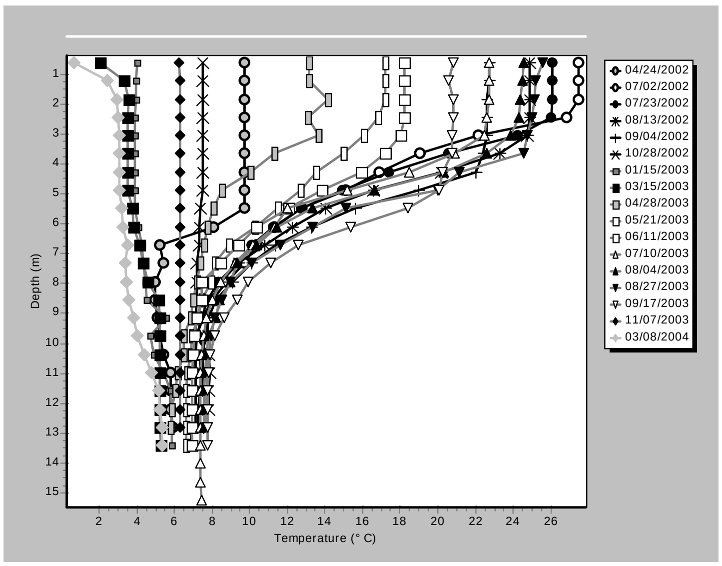
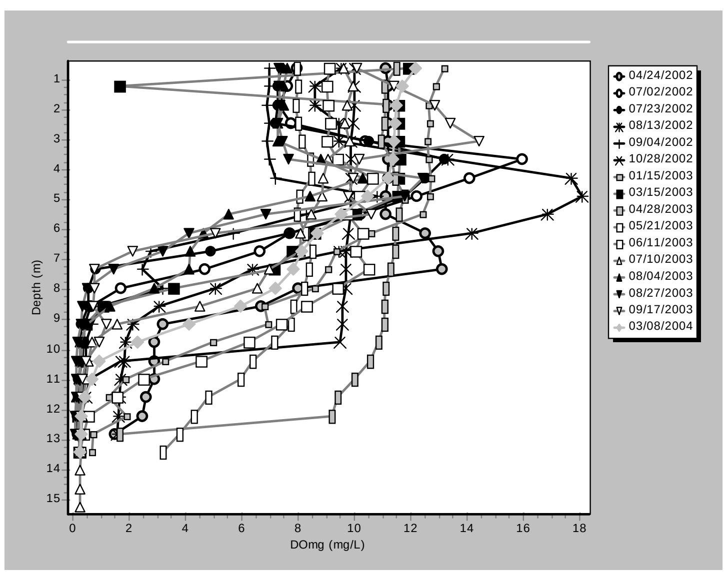


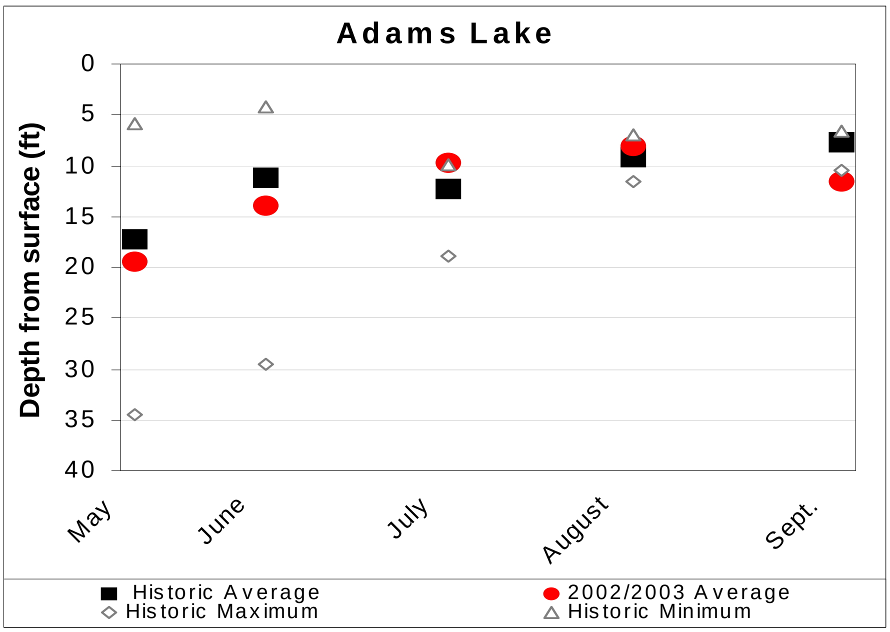
Figure 13. Dissolved oxygen profiles in Adams Lake 2002-2004.



*Terms in bold, see glossary pp 20-25

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***). The water **clarity** in Adams Lake is considered good. The average **Secchi disc** depth reading for similar **groundwater drainage lakes** in this region is around 10 feet; Adams Lake appears to have similar water **clarity** to these lakes. The water **clarity** in Adams Lake during 2002-03 growing seasons was similar to the historic growing season average, however historically in May and June water **clarity** measures have been both significantly better and poorer (Figure 14). The month of May shows the best water **clarity** in 2002-03. Fluctuations throughout the summer are normal as **algae** populations and **sedimentation** increase and decrease.

Figure 14. Monthly average water clarity measurements in Adams 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). **Nitrate** concentrations in the spring are sufficient to fuel **algae** blooms later in the summer, however **phosphorus** concentrations are low throughout the year. **Chlorophyll *a*** concentrations suggested there was little response from the **algae**, ranging from 2.3 to a high in July of 6.9 mg/L. **Turbidity** was also low.

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. 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**. These concentrations were all slightly elevated. **Atrazine** was found in low concentrations in the lake water (0.1 and 0.2 µg/L),

*Terms in bold, see glossary pp 20-25

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 Adams Lake.

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

Adams 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	15.0	4.8	1.04	0.33	0.40	212.0	221.5	110.5	12	1.2	
Summer Averages	13.6	7.0	1.25	0.14	0.12	189.0	190.5	76.4	12	2.1	3.8
Fall Averages	16.5	8.0		0.07	0.28	198.5	214.0	96.5	11	1.4	
Winter Averages	8.0	8.0		0.27	0.42						
2002-2004 Averages	13.4	6.9	1.15	0.20	0.28	199.8	208.7	94.5	11	1.6	3.8

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

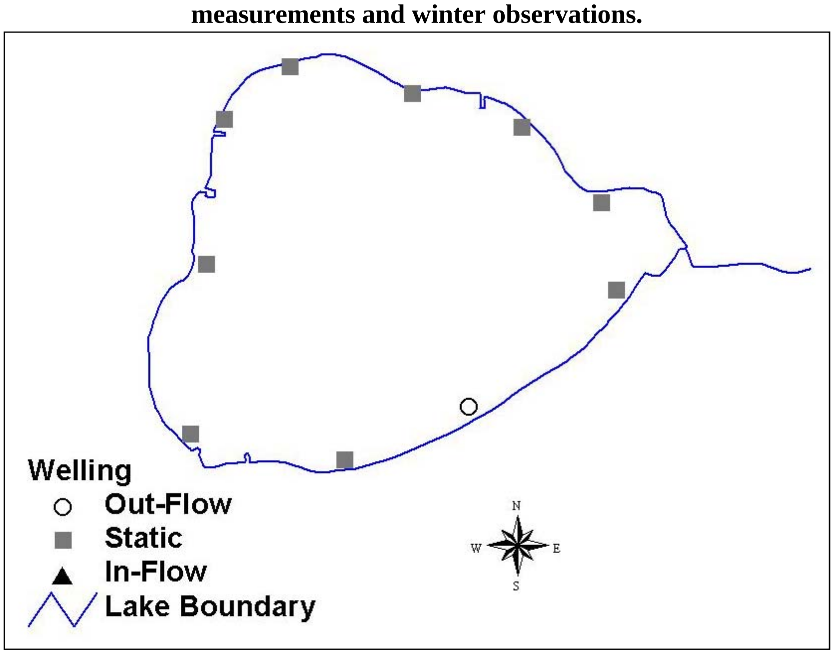
Table 4. 2002-2003 Adams Lake average water chemistry and reference values.

Adams Lake	*Low*	*Medium*	*High*	**Reference Values**	*Low*	*Medium*	*High*
Sulfate		11.12		*Sulfate*	<10	10-20	>20
Chloride		4.78		*Chloride*	<3	3-10	>10
Potassium		2.18		*Potassium**	<2.16	2.16-4.30	>4.30
Chlorophyll a				*Chlorophyll a*	<5	5-10	>10

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

Ten mini wells were installed into the Adams lakebed to evaluate **groundwater**. **Groundwater** was not entering the lake at any of the sites that were tested. One site on the south shore showed water exiting the lake to **groundwater** (Figure 15).

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



*Terms in bold, see glossary pp 20-25

Algal Community

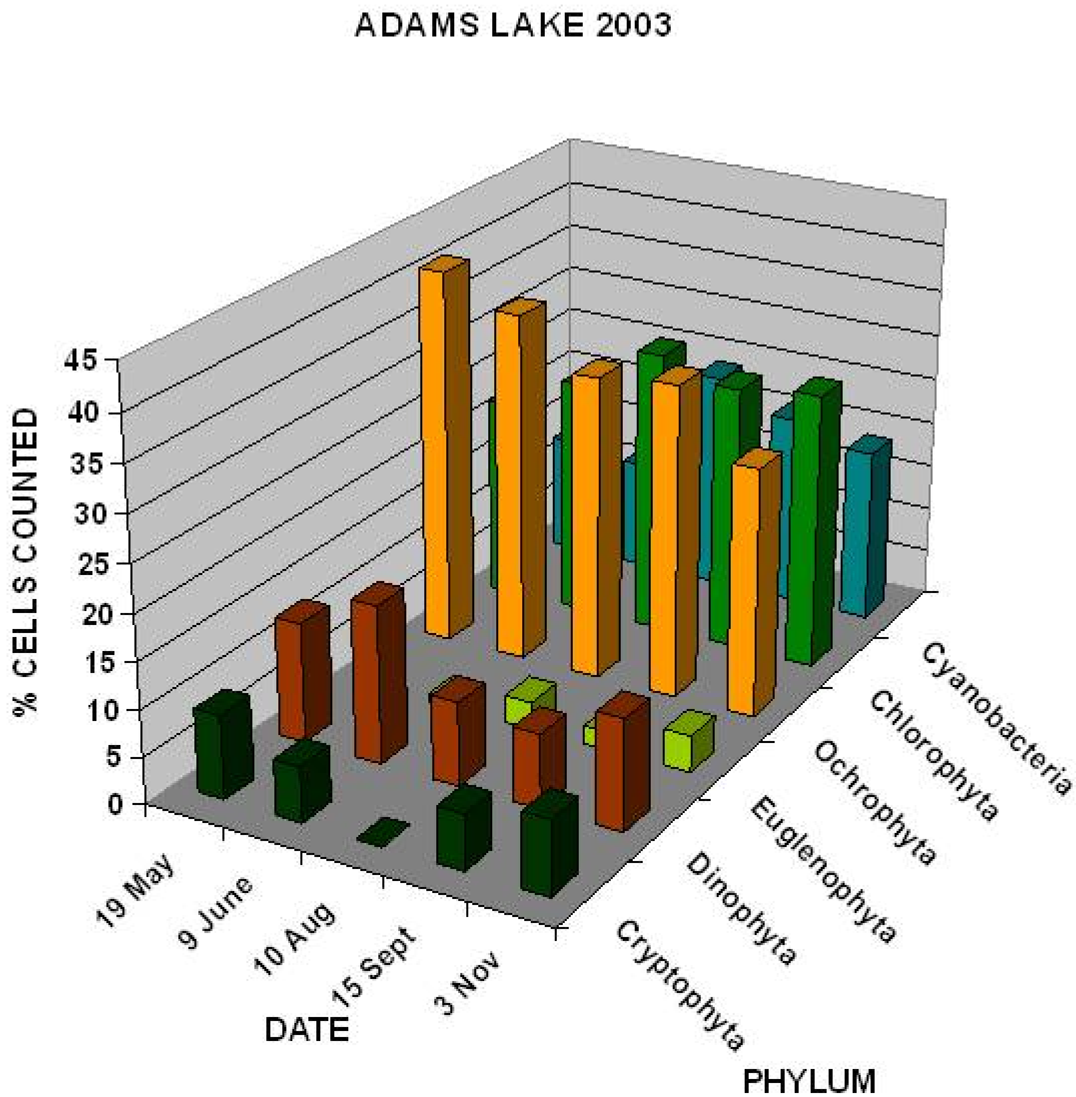
The algal community in Adams Lake was moderately diverse. The dominant group was the **diatoms** (Ochrophyta), representing 35% of all cells counted over the sampling period and this was closely followed by the green **algae** (Chlorophyta) that averaged 28% of all cells counted. The **blue-green algae** (Cyanobacteria) and dinoflagellates (Dinophyta) were subdominants comprising 18% and 12% respectively (Table 5). The four dominant phyla represented 93% of all cells counted during the 2003 sampling season. In the 2076 cells counted during this period there were 5 genera of Cyanobacteria, 11 genera of Chlorophyta, 9 genera of Ochrophyta (including 9 **diatom** genera), 4 genera of Euglenophyta, 3 genera of Dinophyta, and 2 genera of Cryptophyta were identified. The **diatoms** dominated every sample period with their seasonal maxima coming in the early season (May, June). The **diatoms** never faded during the summer and fall as typically occurs. The green **algae** were the second most abundant phylum in all samples (except November where they were slightly more abundant than the **diatoms**). Cyanobacteria started as a relatively minor component in the early samples but increased to about 20% of the cells counted from mid-season on into the November sample period. The dinoflagellates had minor peaks both early and late while dipping below 10% of cells counted during the mid-season samples. The other phyla (Euglenophyta, Cryptophyta) totaled about 7% of all cells counted with neither phylum ever represented by more than 9% of cells counted in a sample period (Figure 16).

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

ADAMS LAKE						
PHYLUM	% CELLS COUNTED BY PHYLUM AND DATE					MEAN
	19 May	9 June	10 Aug	15 Sept	3 Nov	
Cyanobacteria	13	12	24	21	19	18
Chlorophyta	22	26	31	29	30	28
Ochrophyta	41	38	33	34	27	35
Euglenophyta	2	1	3	2	4	2
Dinophyta	13	17	9	8	12	12
Cryptophyta	9	6	0	6	8	6

*Terms in bold, see glossary pp 20-25

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



Two diatoms, the colonial genus Asterionella and the unicellular genus Synedra occupied 7 of 15 most abundant slots and were the dominant taxa in four of five samples periods during the 2003 season (Figure 17). These taxa dominated through the early fall before falling into subdominant positions in November. The small, nonmotile, unicellular green alga Oocystis was present in 4 of the 15 top abundance spots and was the most abundant taxa counted in the November samples. A cyanobacterium (Coelosphaerium) was a subdominant in the early and mid season samples but faded from the top spots by September. The only other taxon to crack the top 15 was the cryptophyte genus Chroomonas present as a subdominant only in the May sample (Table 6).

The algal community when considered relative to the **chlorophyll**, **phosphorus**, and **nitrogen** values for Adams Lake presents a picture of a fairly **oligotrophic** lake. The 34 genera identified

*Terms in bold, see glossary pp 20-25

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 Adams 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.

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

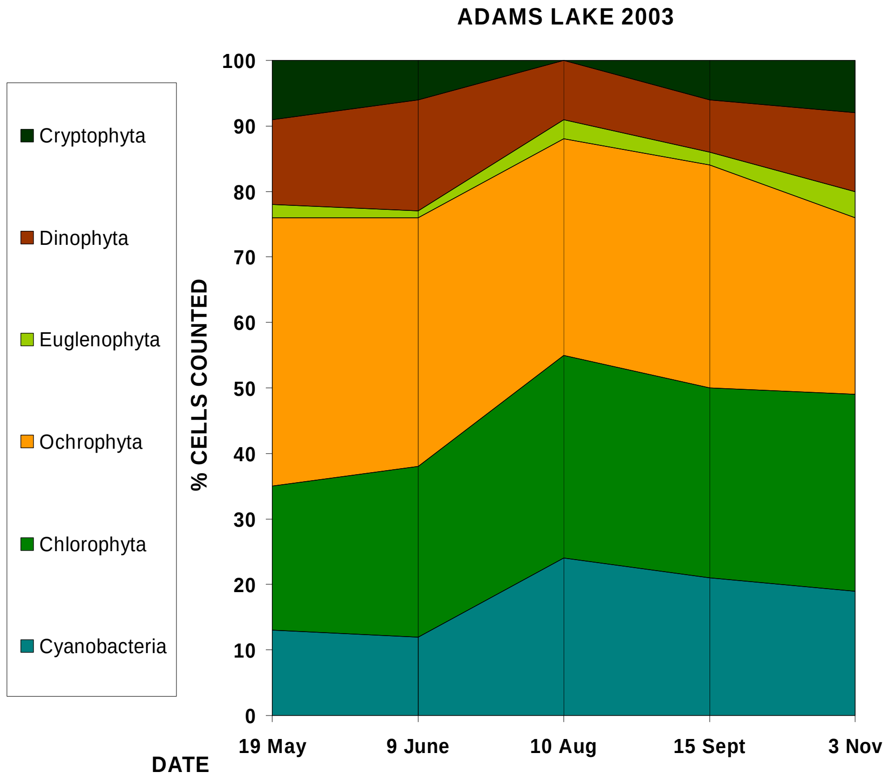


Table 6. Most common algal genera by date in Adams Lake from May to November 2003.

DATE	TOP THREE TAXA (MOST ABUNDANT, LEFT TO RIGHT)		
19 May	*Asterionella*	*Coelosphaerium*	*Chroomonas*
9 June	*Asterionella*	*Coelosphaerium*	*Oocystis*
10 August	*Synedra 2*	*Oocystis*	*Coelosphaerium*
15 September	*Synedra 2*	*Oocystis*	*Asterionella*
3 November	*Oocystis*	*Synedra 2*	*Asterionella*

*Terms in bold, see glossary pp 20-25

Adams Lake Study Highlights

- Adams Lake is noted for the large wetland complex adjacent to the northern shore. There are also steeply sloped areas along the northwest bank. Wisconsin Department of Natural Resource records from the early 1970's document light **erosion** along the southwest bank from pastured cattle using the lake as a water source.
- Seven frog species were identified (wood frog, spring peeper, chorus frog, northern leopard frog, American toad, gray treefrog, green frog) along with one salamander species (mudpuppy) in the amphibian survey conducted for Adams Lake. The primary amphibian habitat is located on the southwest corner and east side of the lake. Shoreline alteration due to development has been kept to a minimum by the low number of houses and protection of shoreline habitat is in place in many locations. The bad news is that small stretches of highly altered shoreline may prevent amphibian populations from establishing in some areas. Adams Lake was found to be home to two turtle species, painted turtles and snapping turtles.
- Adams Lake also has a notable population of mudpuppy salamanders, the only lake where they were found in the present study. They are known from the Wolf River **watershed** and have been found in other glacial lakes in central Wisconsin. They are carnivorous and would potentially eat small benthic fish, but their feeding habits in this lake are unknown. They appear to be part of the natural fauna in this lake and may have been there since the retreat of the glaciers.
- Approximately 61.2% of the Adams Lake shoreline is considered vegetated shoreline, alder comprises 3.3% of the shoreline and narrow wetlands make up 1.6% of the shoreline. Thirty-four percent of the shoreline is considered to be disturbed. Of that, 8.3% is considered to be low disturbance, 1.3% moderate disturbance, and 24.4% high disturbance.
- Adams Lake supports a two story fishery. A total of 20 species of fish have been reported from Adams Lake since 1943. The native fish population is warm water dominated by bluegill, green sunfish and largemouth bass, but the lake is deep enough to provide a cold water environment for stocked salmonids for at least part of the year but year-round survival may be limited by the low concentrations of dissolved oxygen in deeper cooler waters. Eleven species of fish were collected from Adams Lake in 2002-2003 compared to 16 from rather extensive historical records dating back to the 1940s. Taxa not previously reported from this lake include the bluegill/pumpkinseed hybrid, golden shiner and blackchin shiner.
- Bottom substrate in Adams Lake is mostly **marl** overlaid with organic detritus along the southern shore. In the absence of sand and gravel, largemouth bass and sunfish are known to build nests on **marl**. Depressions are deepened until small amounts of coarser **substrate**, mostly fragments of snail shells, accumulate in the bottom of the nest. In areas of soft **substrate**, largemouth bass are also reported to nest on woody debris swept clear of sediments. The presence of young bass and overabundance of sunfish indicate reproduction is successful in this lake.
- Adams Lake is dominated by chara throughout the **littoral** zone. Beds up to several feet thick blanket the bottom and extend down to the **Secchi disc** depth in much of the lake providing substantial cover for most small fish. Pondweeds along the western shore

*Terms in bold, see glossary pp 20-25

provide more sparse cover, but extend to the water surface by midsummer. Emergent beds of rush, sedge and cattail are in the northeast portion of the lake and provide more permanent cover. There are two small, but important areas with downed trees along the southeast and northwest shoreline. Because this is a **drainage lake** and water levels are more stable than in **seepage lakes**, trees that fall into the lake are likely to remain permanently submerged. Downed trees that are in Adams Lake should be left in place and if possible supplemented with additional woody cover as there are few remaining large trees near enough to the water's edge to provide cover should they naturally fall.

- The aquatic plant community in Adams Lake is below average in quality compared with other Portage County lakes. However the species that exist seem to be providing sufficient habitat for fish. Currently no exotic aquatic plants exist in Adams Lake. Prevention measures should be employed to ensure that exotic aquatic species do not become established in Adams Lake.
- Water **clarity** was good. **Nitrate** concentrations in the spring are sufficient to fuel **algae** blooms later in the summer, however **phosphorus** concentrations are low throughout the year. **Chlorophyll *a*** concentrations suggested there was little response from the **algae**.
- **Chloride** levels, and to a lesser degree **sodium** and **potassium** levels were all slightly elevated. **Atrazine** was found in low concentrations in the lake water (0.1 and 0.2 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 Adams Lake.
- The algal community when considered relative to the **chlorophyll**, **phosphorus**, and **nitrogen** values for Adams Lake presents a picture of a fairly **oligotrophic** lake. The **algae** species 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 Adams 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 provide 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 20-25

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 20-25

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 20-25

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 20-25

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 20-25