Boelter Lake/Wetland

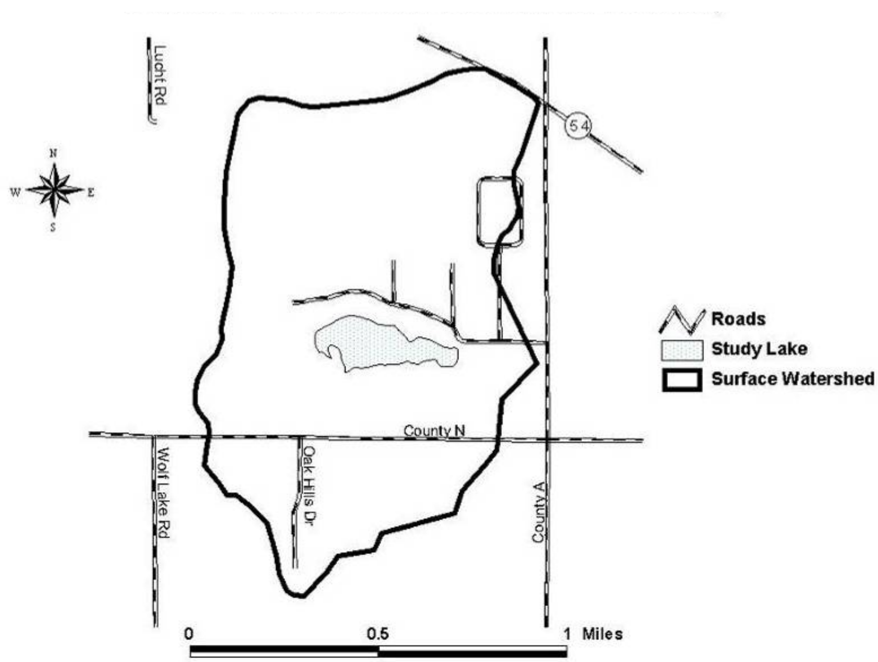
Introduction

Boelter Lake/wetland is a small, moderately **hard water groundwater drainage lake** located eight miles south of Amherst in the Town of Lanark. The lake is very shallow and choked by aquatic vegetation. In the spring of the first year of this study (2002), Boelter Lake had a maximum depth of 4 feet and roughly 14 surface acres. The estimated **retention time** was 0.3 years. By the end of the summer in 2003 the lake had become a puddle. Low **groundwater** levels combined with lack of snow and dry summers and the results of urban-like residential development land use practices have hastened the process of Boelter Lake becoming a wetland. The lake bed is comprised of muck. There is an intermittent inlet through wetlands to the west and no outlets. An attempt was made at one point to dig an inlet and drain water from nearby Peters (Lutz) Lake, but the project failed. Much of the shoreline was subdivided before 1968 in a fashion that has resulted in overcrowded conditions for such a small lake. Public access is limited to a narrow strip of land on the east end at the east end of the lake. Boelter Lake is used by migrating ducks.

Land Use and Watershed

The surface **watershed** of Boelter Lake is 572 acres primarily in forest and shrub land, 37% and 35%, respectively. The majority of land in the surface **watershed** is to the north and south of the lake (Figure 1). There are 65.7 acres (11.5% of the surface **watershed**) in residential land use. The vast majority of residential development occurred between the 1948 survey and 1968 survey, when residential land use increased from 2.8 acres up to 62.3 acres. Agricultural land, both non-irrigated and irrigated, has remained a minor component of the land use at less than 10% (Figure 2 and Figure 3).

Figure 1. Boelter Lake/Wetland surface watershed boundary.



*Terms in bold, see glossary pp 13-18

Figure 2. Land use in the Boelter Lake/Wetland surface watershed 1948-2002.

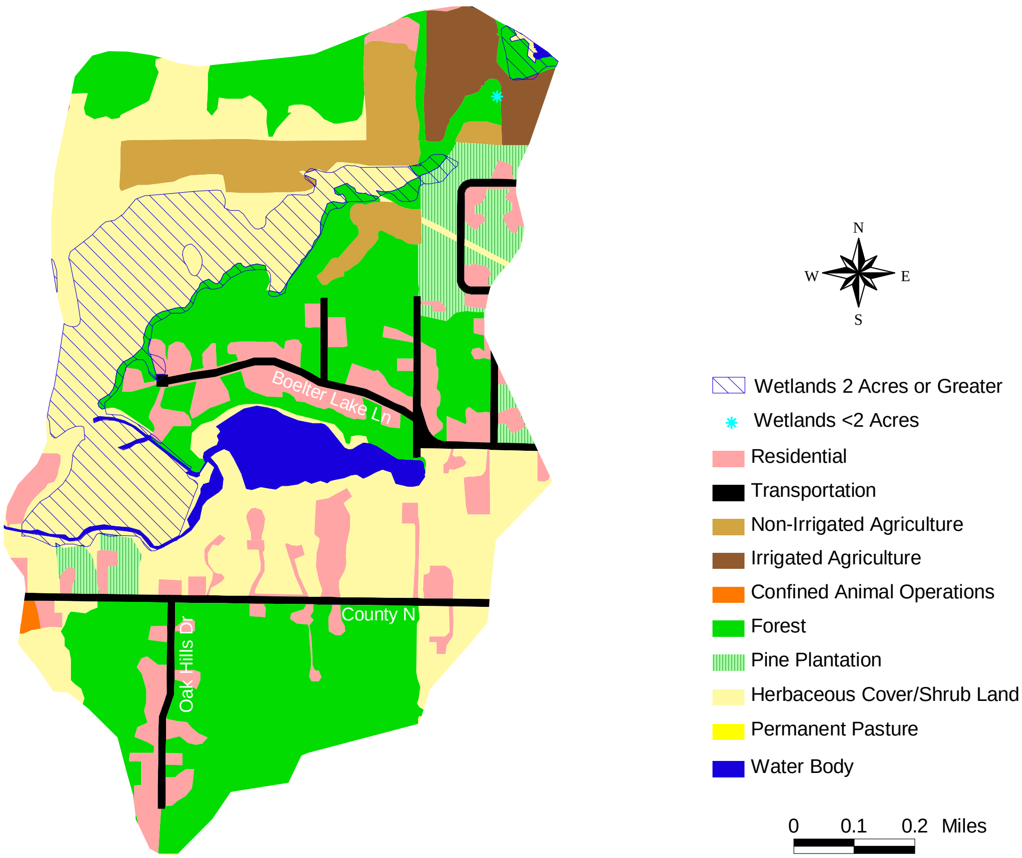
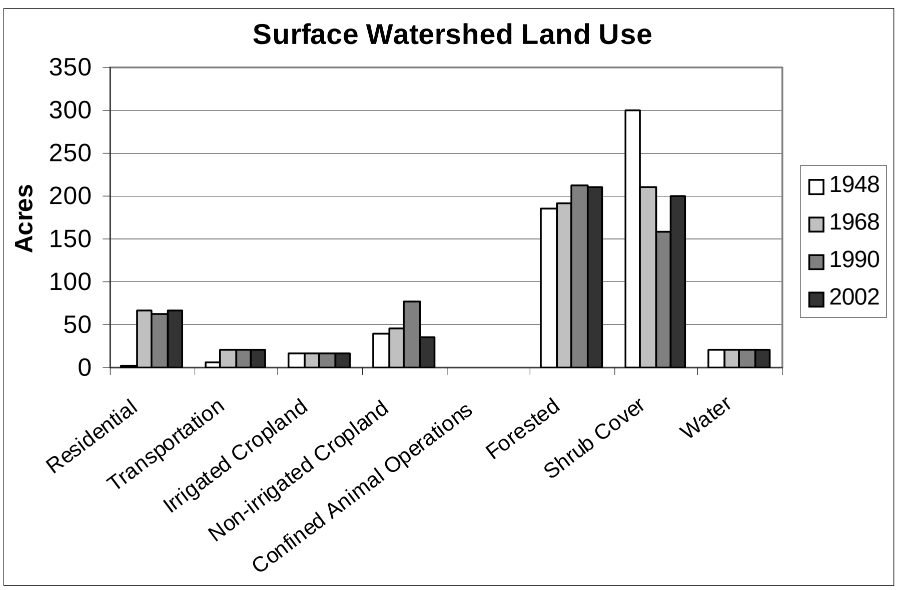


Figure 3. Land use in the Boelter Lake/Wetland surface watershed 1948-2002.



*Terms in bold, see glossary pp 13-18

The total area of the Boelter Lake/wetland **groundwater watershed** is 388 acres (Figure 4). The **groundwater watershed** for Boelter Lake is southwest of the lake and has a very different land use composition than the surface **watershed**. Currently forested land makes up 27% of the **watershed**, shrub/wetland comprises another 24%, 32% is in non-irrigated cropland and less than 5% is residential. Since 1948 there has been a decrease in land being cultivated (152 acres to 124 acres), a decrease in the shrub/wetland (133 acres to 92 acres), and an increase in the amount of land that is forested (63 acres to 104 acres) (Figure 5 and Figure 6). According to the records in 2002 based on age there is one potentially failing septic system present within the surface **watershed** of Boelter Lake. The **groundwater watershed**, however, contains none. There are no former landfill sites present in either the surface or **groundwater watershed**.

Figure 4. Boelter Lake/Wetland groundwater watershed boundary.

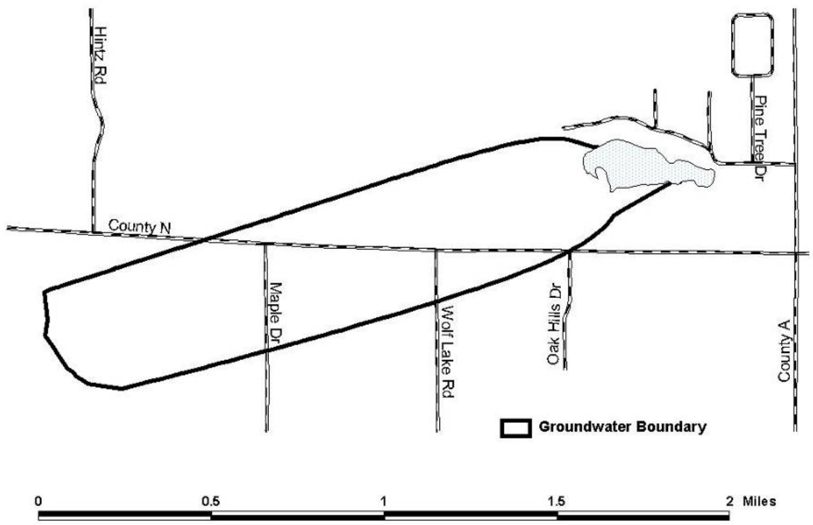
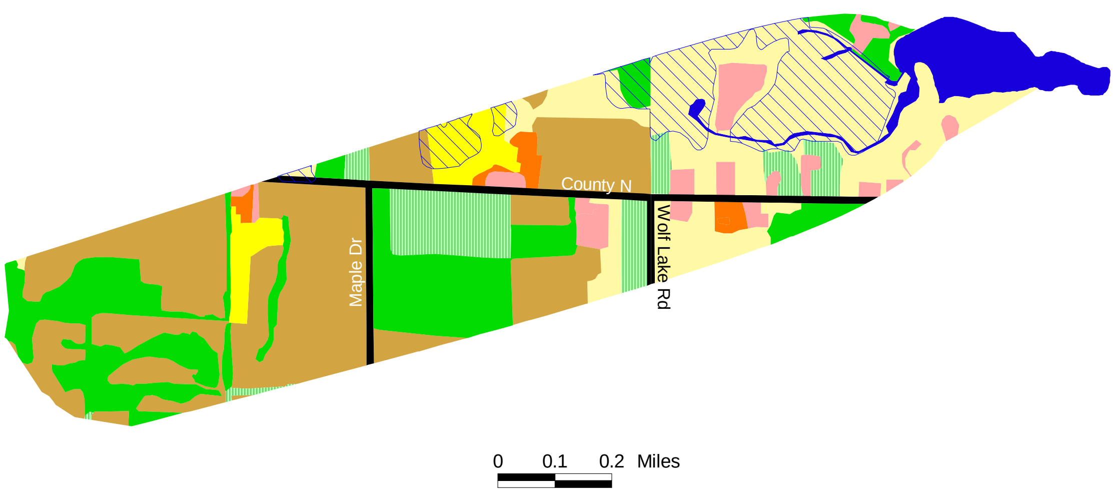
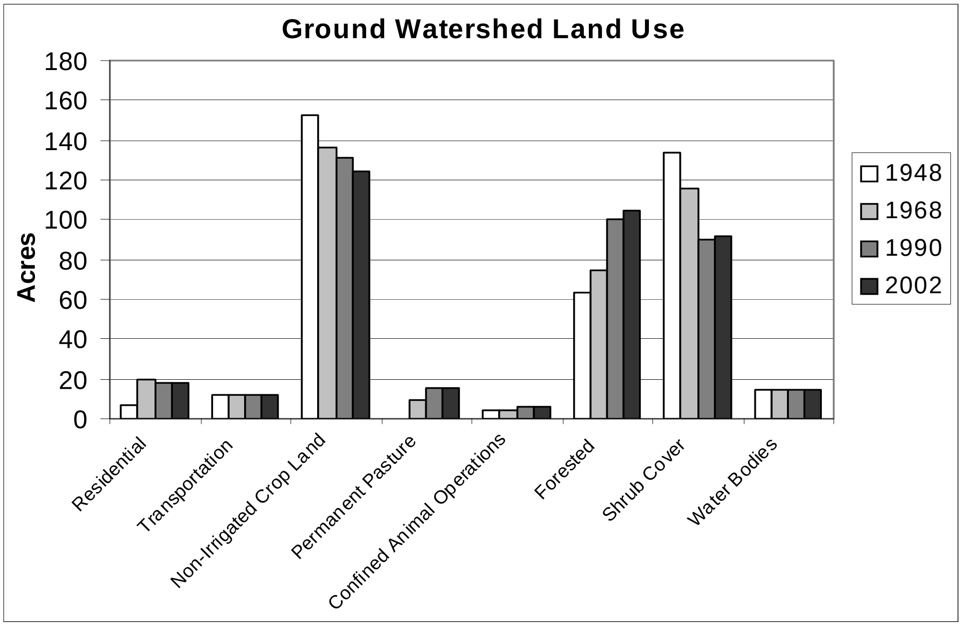


Figure 5. Land use in the Boelter Lake/Wetland groundwater watershed 2002.



*Terms in bold, see glossary pp 13-18

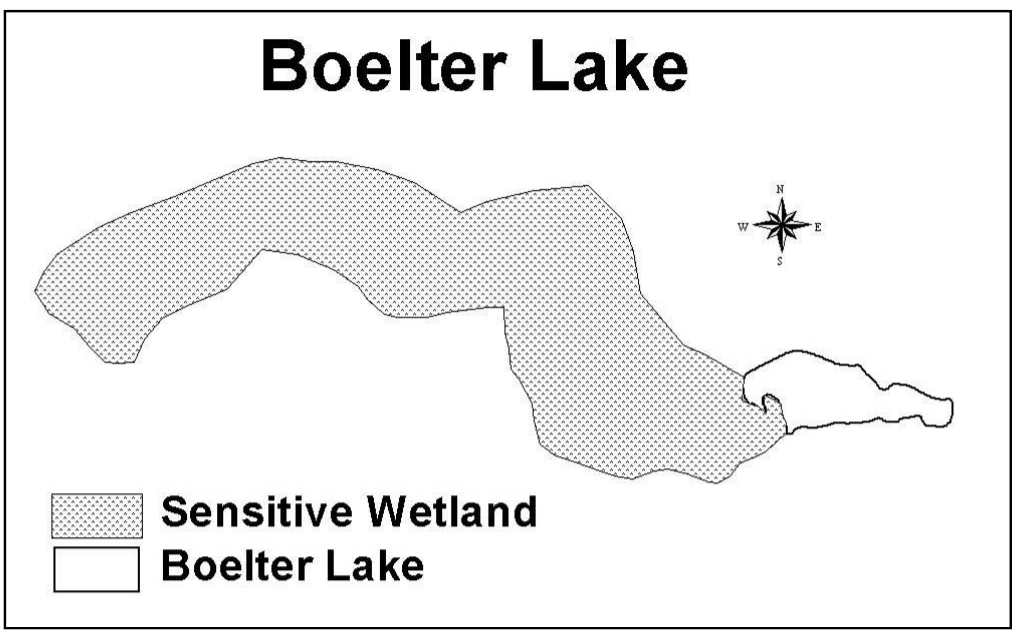
Figure 6. Land use in the Boelter Lake/Wetland groundwater watershed 1948-2002.



Upland Sensitive Areas

The survey of upland sensitive areas was conducted to note areas immediately around the lakeshore that are particularly valuable, or sensitive to disruption. Sensitive areas around Boelter Lake focus primarily on the wetland complex to the west of the lake. The wetland habitat continues west to include Peters Lake and Riley Lake (Figure 7). Because this lake is in the later stages of its life, the intense development around the lake is also noted as a factor accelerating the lake's progression toward becoming a wetland.

Figure 7. Upland sensitive areas near Boelter Lake/Wetland.



*Terms in bold, see glossary pp 13-18

Reptiles and Amphibians

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

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

The primary amphibian habitat is located on the west and southeast sides of the lake (Figure 8). Some of the key features of this habitat include undeveloped areas of shoreline with submergent and emergent vegetation. The good news is that several sections of shoreline provide ideal habitat for amphibian and reptile populations. However, some areas of altered shoreline do also exist due to development. Four frog species were identified during the amphibian study including the spring peeper (*Pseudacris crucifer*), American toad (*Bufo americanus*), gray treefrog (*Hyla versicolor*), and Cope's gray treefrog (*Hyla chrysoscelis*). Reptile surveys were not conducted on Boelter Lake.

Figure 8. Regions of primary amphibian habitat around Boelter Lake/Wetland.

*Terms in bold, see glossary pp 13-18

Aquatic Plants

There were **32** species found around Boelter Lake. Most of these were growing on the extensive wetland and exposed wet soil; a few species were submersed or rooted in the remaining small areas of water or free-floating on open water. The average **coefficient of conservatism (c-value)** of these 32 species is **4.0** which is below average when compared to the Portage County lakes. The **floristic quality index** is **22.5** which is below average as well.

The UWSP herbarium has only a few specimens and few observations made when water levels were higher. Most collection and observations were made in 2003. At this time, following dry years, little water was present in the lake and only a few submersed plants were found: coontail (*Ceratophyllum demersum*), common bladderwort (*Utricularia vulgaris*), and water star-grass (*Zosterella dubia*). A few plants of white water-lily (*Nymphaea odorata*) were growing in pockets of water one to three feet deep, but most plants were stranded on shore or on the mud-flat and were becoming desiccated.

The extensive exposed wet soil, wet sand, and mud-flat was dominated by woolly sedge (*Carex pellita*), spikerushes (*Eleocharis* spp.), broad-leaf cattail (*Typha latifolia*), reed canary-grass (*Phalaris arundinacea*), and golden dock (*Rumex maritimus*). However, except for a moderate amount of reed canary-grass, the flora of Boelter Lake is free of invasive exotic species. Given the open, early successional stage of the vegetation and its vulnerability to establishment of invasive plants, this area should be monitored to remove any exotic plants before they become established. It is also notable that Boelter Lake is the only known location in Portage County for wheelwort toothcup (*Rotala ramosior*) and golden dock, and one of only two locations for slender fringe-rush (*Fimbristylis autumnalis*).

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. Typically temperature and dissolved oxygen are measured in a lake at various depths throughout the water column. However, due to the lack of water in Boelter Lake, only single and sometimes double measurements were made. Dissolved oxygen concentrations are displayed in Figure 10. Oxygen concentrations fell below the 5 **mg/L** needed to support most aquatic biota on many occasions in 2002 and 2003. These anoxic conditions are typical of wetlands.

*Terms in bold, see glossary pp 13-18

Figure 9. Temperature in Boelter Lake/Wetland 2002-2004.

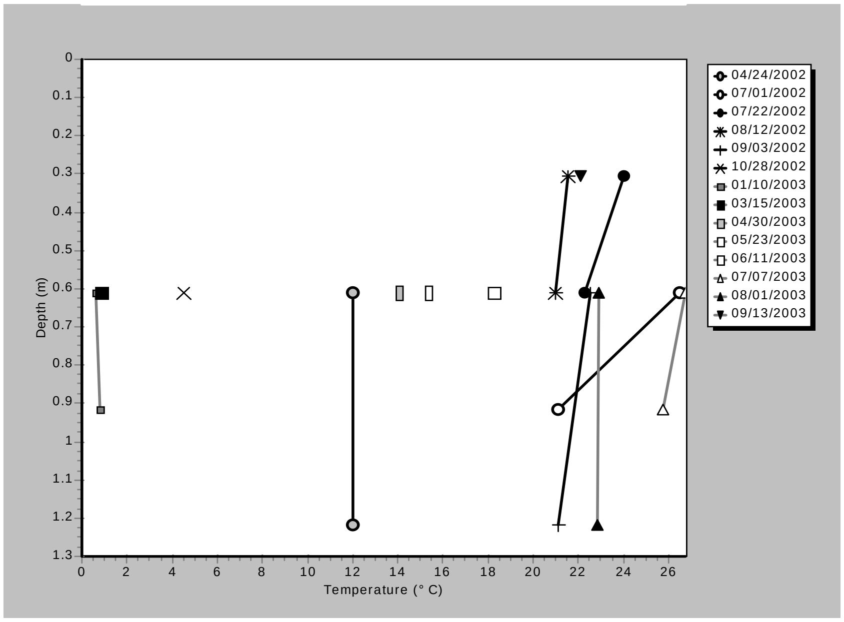
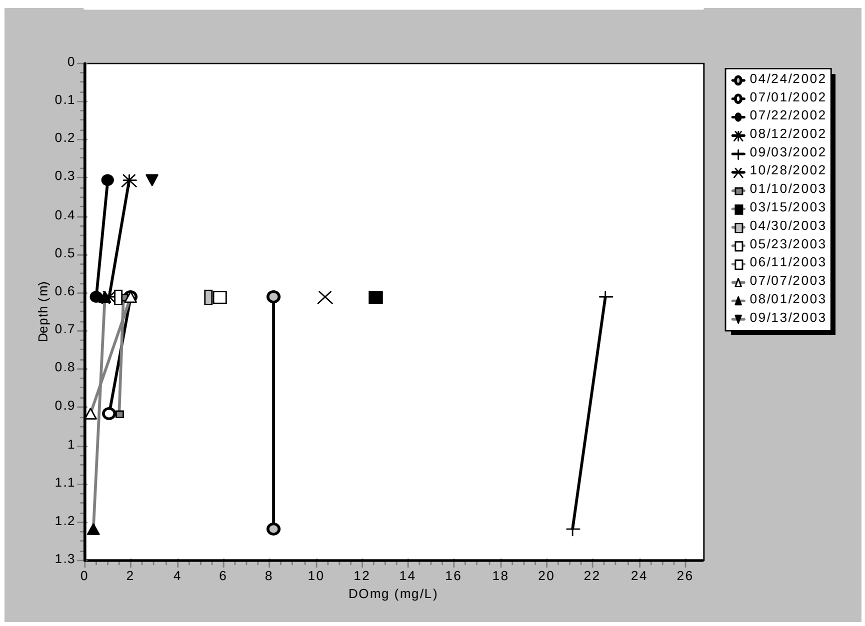


Figure 10. Dissolved oxygen in Boelter Lake/Wetland 2002-2004.

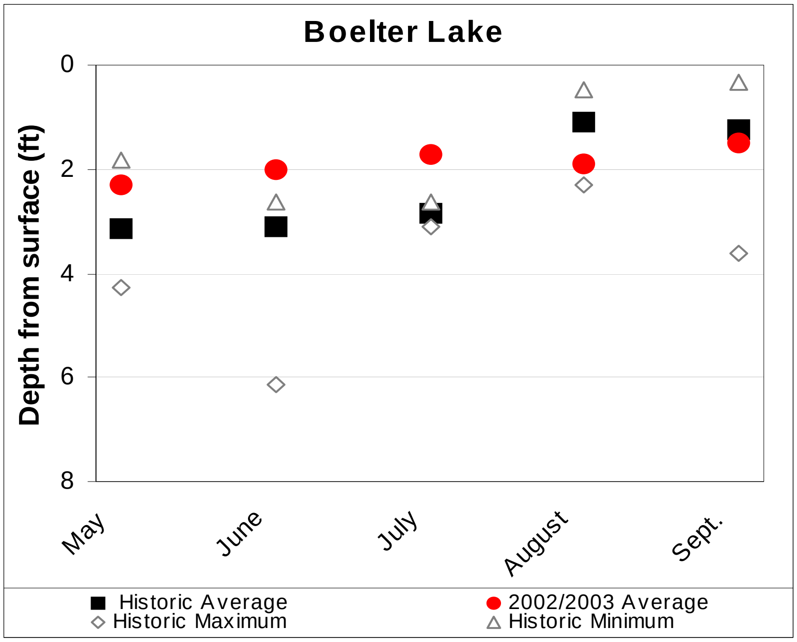


Water **clarity** is a measure of how deep light can penetrate. It is an aesthetic measure and is related to how deep **rooted aquatic plants** can grow. Water **clarity** is affected by water **color** and suspended materials in the water (**turbidity**). **Turbidity** consists of **suspended solids**, such as suspended sediments and **algae** (**chlorophyll *a***). **Color** in Boelter Lake/wetland is quite high. This brown staining is naturally occurring, resulting from tannic acids in the water which is typical of water in wetlands. **Turbidity** was low, and throughout the summer, measures of **chlorophyll *a*** were high (Table 1). The water **clarity** in Boelter Lake is considered poor. This

*Terms in bold, see glossary pp 13-18

very shallow lake/wetland is not similar to other lakes in the county. Boelter Lake is very shallow and fertile resulting in poor **clarity**. The water **clarity** of Boelter Lake during 2002-03 growing season was poorer than the historic growing season average, although on some occasions this was due to the maximum lake depth being shallower than the depth of the historic reading. Fluctuations in **clarity** throughout the summer are normal as **algae** populations and **sedimentation** increase and decrease (Figure 11).

Figure 11. Monthly average water clarity measurements in Boelter Lake/wetland 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). **Phosphorus** concentrations in Boelter are very high for a lake, but typical for a wetland. They are sufficient concentrations to grow an abundance of **algae** and aquatic plants. Common sources of **nitrogen** and **phosphorus** include fertilizers, animal waste, and septic systems. These nutrients can also move into a lake attached to soil.

Chloride levels, and to a lesser degree **sodium** and **potassium** levels, are commonly used as an indicator of how strongly a lake is being impacted by human activity. These concentrations were elevated (Table 2). Although these constituents are not detrimental to the aquatic ecosystem, they indicate that sources of contaminants (road salt, fertilizer, animal waste, and/or septic system effluent) are entering the lake from either surface runoff or via **groundwater**. **Atrazine** was found in low concentrations in the water (0.29 and 0.09 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 Boelter Lake/wetland. We were not able to conduct a **groundwater** study due to the mucky **substrate**.

*Terms in bold, see glossary pp 13-18

Table 1. 2002-2003 water quality seasonal averages in Boelter Lake/wetland.

Boelter 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	110.3	6.0		0.04	0.05	45.0	43.0	24.5	93	2.4	3.4
Summer Averages	68.0	11.3	2.00	0.02	0.05	54.0	55.5	28.7	165	1.7	24.3
Fall Averages	41.0	6.0		0.02	0.06	40.0	40.0	23.0	96	1.5	
Winter Averages	191.0	4.0		3.56	0.06						
2002-2004 Averages	82.9	8.0	2.00	0.53	0.05	47.6	47.4	25.9	122	1.9	22.0

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

Table 2. Table. 2002-2003 Boelter Lake/wetland average water chemistry and reference values.

Boelter Lake	Low	Medium	High	Reference Values	Low	Medium	High
Sulfate	3.42			Sulfate	<10	10-20	>20
Chloride		4.32		Chloride	<3	3-10	>10
Potassium			5.90	Potassium*	<2.16	2.16-4.30	>4.30
Sodium	1.18			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.*

Algal Community

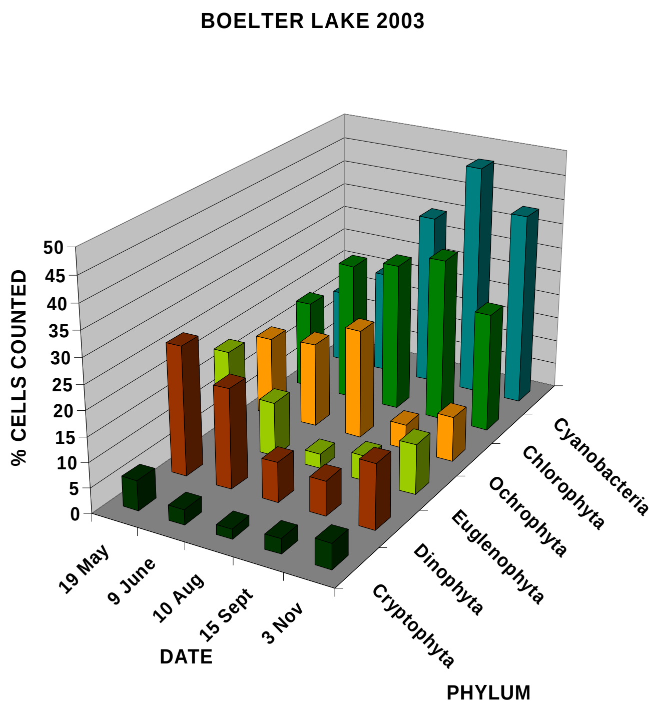
The algal community in Boelter Lake was mildly diverse. The dominant groups were the **blue-green algae** (Cyanobacteria) that represented 31% of all cells counted and the green **algae** (Chlorophyta) that represented 27% of all cells counted. Three algal phyla were subdominants; the yellow-green **algae** and **diatoms** (Ochrophyta, 14% of cells counted) the euglenoids (Euglenophyta, 10% of cells counted), and the dinoflagellates (Dinophyta, 15% of all cells counted) (Table 3). These five phyla represented 96% of all cells counted during the 2003 sampling season. In the 2,410 cells counted during this period, there were 5 genera of Cyanobacteria, 12 genera of Chlorophyta, 12 genera of Ochrophyta (including 12 **diatom** genera), 3 genera of Euglenophyta, 2 genera of Dinophyta, and 1 genus of Cryptophyta identified. In May the dinoflagellates dominated (26% of cells counted) with the other four major phyla (all except Cryptophyta) represented in nearly equal proportions (15-19% of cells counted/phylum). The green **algae** dominated the June sample (28% of cells counted) as the cyanobacteria also waxed to 21% of cells counted; the ochrophytes stayed about the same, and the other two phyla (Euglenophyta, Dinophyta) began to diminish. The Cyanobacteria dominated in August (35% of cell counted) while the chlorophytes and ochrophytes remained about the same and the euglenoids and dinoflagellates continued to wane. The late season samples were overwhelmingly dominated by the blue-green and green **algae,** as they accounted for 80% of cells counted in September and 63% of cells counted in November. No other phylum represented more than 10% of cells counted during any of these final three sampling periods. The Cryptophyta totaled about 4% of all cells counted and never represented more that 6% of cells counted in a sample period (Figure 12).

*Terms in bold, see glossary pp 13-18

Table 3. Algal phyla and mean seasonal composition in Boelter Lake/wetland from May to November 2003.

BOELTER LAKE						
PHYLUM	% CELLS COUNTED BY PHYLUM AND DATE					**MEAN**
	19 May	9 June	10 Aug	15 Sept	3 Nov	
Cyanobacteria	15	21	35	47	39	31
Chlorophyta	18	28	30	33	24	27
Ochrophyta	16	17	22	5	9	14
Euglenophyta	19	11	3	5	10	10
Dinophyta	26	20	8	7	13	15
Cryptophyta	6	3	2	3	5	4

Figure 12. Algal community composition by date in Boelter Lake/wetland from May to November 2003 (total phylum cells counted divided by total cells counted).



Blue-green algae dominated the most abundant genus categories as well as the overall community composition category (Figure 13). The cyanobacteria (**blue-green algae**) occupied 7 of 15 top abundance slots over the sampling period. The small, colonial genus *Coelosphaerium* and the heterocystous, filamentous genus *Anabaena* were dominant taxa. *Coelosphaerium* was the most abundant genus in the August, September, and November samples. The small, non-motile, unicellular green algal genus *Ankistrodesmus* was the most common organism in the June sample and then faded to subdominant in August and September, and then off the board in November. The large, heterotrophic, armored dinoflagellate genus *Peridinium* was the most abundant organism in the May samples, then slipped to subdominant in June, and then dropped

*Terms in bold, see glossary pp 13-18

significantly. The only **diatom** to appear on the top 15 most abundant list is *Gomphonema* during the midsummer period (Table 4).

The algal community when considered relative to the **chlorophyll**, **phosphorus**, and **nitrogen** values for Boelter Lake/wetland presents a picture of a very **eutrophic** body that is barely a lake. The 35 genera identified during the sample periods were relatively common and with the exception of the cyanobacterium *Anabaena*, none of those that reached numerical dominance in the sample counts are associated with toxins or health issues. The vegetation-chocked lake is becoming a wetland with poor water **clarity** and an algal flora increasingly dominated by Cyanobacteria.

Figure 13. Algal community composition by phylum in Boelter Lake from May to November 2003.

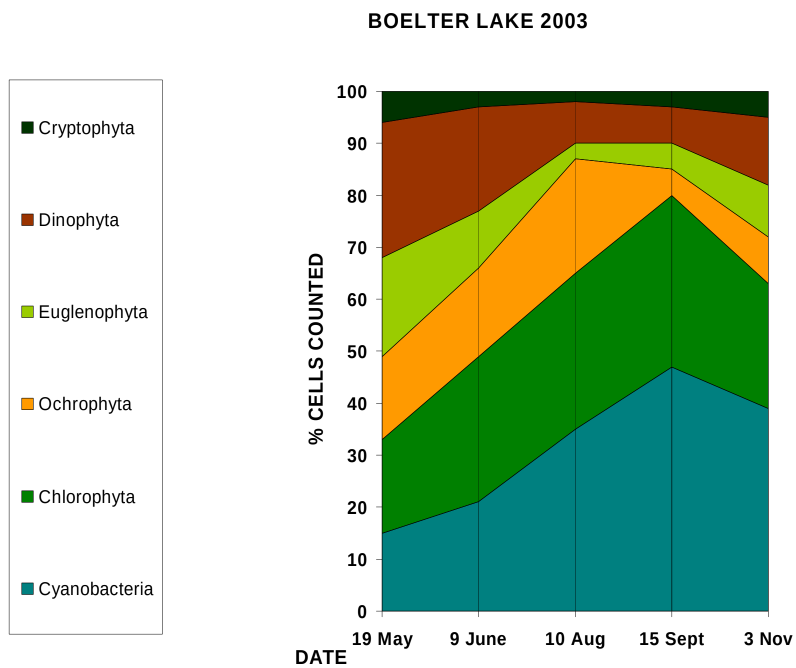


Table 4. Most common algal genera by date in Boelter Lake/wetland from May to November 2003.

DATE	TOP THREE TAXA (MOST ABUNDANT, LEFT TO RIGHT)		
19 May	*Peridinium*	*Ceratium* 2	*Coelosphaerium*
9 June	*Ankistrodesmus*	*Peridinium*	*Coelosphaerium*
10 August	*Coelosphaerium*	*Ankistrodesmus*	*Gomphonema*
15 September	*Coelosphaerium*	*Ankistrodesmus*	*Anabaena*
3 November	*Coelosphaerium*	*Anabaena*	*Planktosphaeria*

*Terms in bold, see glossary pp 13-18

Boelter Lake/Wetland Study Highlights

- Sensitive areas around Boelter Lake focus primarily on the wetland complex to the west of the lake. The wetland habitat continues west to include Peters Lake and Riley Lake.
- The primary amphibian habitat is located on the west and southeast sides of the lake. Several sections of shoreline provide ideal habitat for amphibian and reptile populations; however, some areas of altered shoreline do also exist due to development. Four frog species were identified during the amphibian study including the spring peeper, American toad, gray treefrog, and Cope's gray treefrog. Reptile surveys were not conducted on Boelter Lake.
- There were **32** species found around Boelter Lake. Most of these were growing on the extensive wetland and exposed wet soil; a few species were submersed or rooted in the remaining small areas of water or free floating on open water. The average **coefficient of conservatism (c-value)** and **floristic quality index** are below average when compared to the Portage County lakes. Observations were made in 2003 following dry years; little water was present in the lake and only a few submersed plants were found. The extensive exposed wet soil, wet sand, and mud-flat was dominated by woolly sedge, spikerushes, broad-leaf cattail, reed canary-grass, and golden dock. However, except for a moderate amount of reed canary-grass, the flora of Boelter Lake is free of invasive exotic species. Given the open, early successional stage of the vegetation and its vulnerability to establishment of invasive plants, this area should be monitored to remove any exotic plants before they become established. It is also notable that Boelter Lake is the only known location in Portage County for wheelwort toothcup, and golden dock, and one of only two locations for slender fringe-rush.
- The water **clarity** in Boelter Lake is considered poor. This very shallow lake/wetland is not similar to other lakes in the county. Boelter Lake is very shallow and fertile resulting in poor **clarity**. Oxygen concentrations fell below the 5 **mg/L** needed to support most aquatic biota on many occasions in 2002 and 2003. These anoxic conditions are typical of wetlands. **Phosphorus** concentrations in Boelter are very high for a lake, but typical for a wetland. They are sufficient concentrations to grow an abundance of **algae** and aquatic plants.
- **Chloride**, **sodium**, and **potassium** concentrations were elevated. **Atrazine** was found in low concentrations in the water (0.29 and 0.09 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 Boelter Lake/wetland.
- The algal community when considered relative to the **chlorophyll**, **phosphorus**, and **nitrogen** values for Boelter Lake/wetland presents a picture of a very **eutrophic** body that is barely a lake. The **algae** species were relatively common and with the exception of the cyanobacterium Anabaena, none of those that reached numerical dominance in the sample counts are associated with toxins or health issues. The vegetation-chocked lake is becoming a wetland with poor water **clarity** and an algal flora increasingly dominated by Cyanobacteria.

*Terms in bold, see glossary pp 13-18

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 $CaCO_3$.

Ammonia, Ammonium:

A form of nitrogen found in organic materials and many fertilizers. It is the first form of nitrogen released when organic matter decays. It can be used by most aquatic plants and is therefore an important nutrient. It converts rapidly to nitrate (NO_3) if oxygen is present. The conversion rate is related to water temperature. Ammonia is toxic to fish at relatively low concentrations in pH-neutral or alkaline water. Under acid conditions, non-toxic ammonium ions (NH_4^+) form, but at high pH values the toxic ammonium hydroxide (NH_4OH) occurs. The water quality standard for fish and aquatic life is 0.02 mg/L of NH_4OH. At a pH of 7 and a temperature of 68^o F (20^o C), the ratio of ammonium ions to ammonium hydroxide is 250:1; at pH 8, the ratio is 26:1.

Atrazine:

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

Blue-Green Algae:

Algae that are often associated with problem blooms in lakes. Some produce chemicals toxic to other organisms, including humans. They often form floating scum as they die. Many can fix nitrogen (N_2) from the air to provide their own nutrient.

Chloride (Cl-):

Chlorine in the chloride ion (Cl^-) form has very different properties from chlorine gas (Cl_2), which is used for disinfecting. The chloride ion (Cl^-) in lake water is commonly considered an indicator of human activity. Agricultural chemicals, human and animal wastes, and road salt are the major sources of chloride in lake water.

Chlorophyll *a*:

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

Clarity:

see "Secchi disc."

Coefficient of Conservatism (c-value):

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

Color:

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

Concentration Units:

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

Diatoms:

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

Drainage Basin:

The total land area that drains toward the lake.

Drainage Lakes:

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

Endocrine:

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

Erosion:

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

Eutrophic:

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

*Terms in bold, see glossary pp 13-18

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. Soft water has 60 mg/L $CaCO_3$ or less, moderately hard water has 61-120 mg/L $CaCO_3$, hard water has 121-180 mg/L $CaCO_3$, and very hard water has more than180 mg/L $CaCO_3$.

Impoundment:

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

Littoral:

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

Macrophytes:

see "Rooted aquatic plants."

Macrophytic Algae:

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

Marl:

White to gray accumulation on lake bottoms caused by precipitation of calcium carbonate ($CaCO_3$) in hard water lakes. Marl may contain many snail and clam shells, which are also calcium carbonate. While it gradually fills in lakes, marl also precipitates phosphorus, resulting in low algae populations and good water clarity. In the past, marl was recovered and used to lime agricultural fields.

Mesotrophic:

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

mg/L:

see "Concentration units"

Nitrate (NO_3^-):

An inorganic form of nitrogen important for plant growth. Nitrogen is in this stable form when oxygen is present. Nitrate often contaminates groundwater when water originates from manure pits, fertilized fields, lawns or septic systems. High levels of nitrate-nitrogen (over 10 mg/L) are dangerous to infants and expectant mothers. A concentration of nitrate-nitrogen (NO_3-N) plus ammonium-nitrogen (NH_4-N) of 0.3 mg/L in spring will support summer algae blooms if enough phosphorus is present.

Nitrite (NO_2^-):

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

Nitrogen:

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

Oligotrophic:

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

Phosphorus:

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

Photosynthesis:

The process by which green plants convert carbon dioxide (CO_2) dissolved in water to sugar and oxygen using sunlight for energy. Photosynthesis is essential in producing a lake's food base, and is an important source of oxygen for many lakes.

Potassium:

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

Retention Time: (Turnover Rate or Flushing Rate)

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

*Terms in bold, see glossary pp 13-18

Rip Rap (Rip-Rap):

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

Rooted Aquatic Plants: (Macrophytes)

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

Secchi Disc (Secchi Disk):

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

Sedimentation:

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

Seepage Lakes:

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

Sodium:

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

Stratification, Stratified:

The layering of water due to differences in density. Water's greatest density occurs at 39^{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.

*Terms in bold, see glossary pp 13-18

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 13-18