JORDAN LAKE
LAKE CLASSIFICATION REPORT

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EXECUTIVE SUMMARY

Background Information about Jordan Lake

Jordan Lake is located in Adams County in south central Wisconsin and is a 215-acre mesotrophic natural seepage lake located in the Town of Jackson, Adams County, in the Central Sands Area of Wisconsin. This lake has no stream inlet or outlet and fed by precipitation, runoff and groundwater. Jordan Lake is part of the Neenah Creek Watershed, a large watershed of 182 square miles from which water flows into the Fox River and eventually into Lake Michigan. Jordan Lake has a public boat ramp owned by Adams County. There is a Native American archeological site located around Jordan Lake that cannot be further disturbed without permission of the federal government and input from the local tribes.

The soils in the ground watershed for Jordan Lake are nearly evenly split between loamy sand and sand, with slopes from very flat up to 25%. The surface watershed, on the other hand, has a much smaller proportion of sand and much larger areas of silt loam and loamy sand.

Land Use in Jordan Lake Watersheds

The surface watershed for Jordan Lake is fairly small. Overall, the two most common current land uses in the Jordan Lake surface watershed are woodlands and non-irrigated agriculture. The ground watershed is somewhat larger. In the ground watershed, woodlands occupy the greatest number of acres, with both irrigated and non-irrigated agriculture also covering larger areas of the ground watershed.

Jordan Lake has a total shoreline 2.8 miles (14,784 feet). Most of the shoreline is in residential or commercial housing. Several buildings are located less than 70 feet from the high water mark. Some of the banks are steep and sandy; some are flatter. Marsh areas are located along some of the shore. There is an undeveloped section of shore on the east end of the lake.

The Adams County Land & Water Conservation Department conducted a survey of the Jordan Lake shoreline in 2004. Shore types were categorized as "armored" and "vegetated". Only about 28% of Jordan Lake's shoreline is vegetated with native plants (grasses, forbs, shrubs, trees). Over 42% of the shore was covered with mowed lawn.

The 2004 inventory included classifying areas of the Jordan Lake shorelines as having "adequate" or "inadequate" buffers. An "adequate" buffer was defined as one having the first 35 feet landward covered by native vegetation. An "inadequate" buffer was anything that didn't meet the definition of "adequate buffer", including native vegetation strips less than 35 feet landward. Using these definitions, 25.78% (about 3811.5 feet) of Jordan Lake's shoreline had an "adequate buffer", leaving 74.22% (10972.5 feet) as "inadequate." Most of the "inadequate" buffer areas were found with mowed lawns and/or insufficient native vegetation at the shoreline to cover 35 feet landward from the water line.

Adequate buffers on Jordan Lake could be easily installed on most of the lake by either letting the first 35 feet landward from the water just grow without mowing it, except for a path to the water, or by planting native seedlings sufficient to fill in the first 35 feet.

Water Testing Results

Between 2004 and 2006, Adams County Land & Water Conservation Department gathered water chemistry and other water quality information on Jordan Lake. Part of the information was gained from periodic water sampling done by Adams County LWCD. Historic information about water testing on Jordan Lake was also obtained from the Wisconsin Self-Help Monitoring Program records and from the WDNR.

Although there are several forms of phosphorus in water, the total phosphorus (TP) concentration is considered a good indicator of a lake's nutrient status, since the TP concentration tends to be more stable than other types of phosphorus concentration. For a natural lake like Jordan Lake, a total phosphorus concentration below 20 micrograms/liter tends to prevent nuisance algal blooms. In 2004-2006, Jordan Lake's growing season (June-September) surface average total phosphorus level was low enough so that phosphorus-related nuisance algal blooms should occur only rarely.

Water clarity is a critical factor for plants. If plants don't get more than 2% of the surface illumination, they won't survive. Water clarity is measured with a Secchi disk. Average summer Secchi disk clarity in Jordan Lake in 2004-2006 was 11.19 feet. This is very good water clarity. Records since 1990 show that the water clarity in Jordan Lake has consistently remained high.

Chlorophyll-a concentrations provide a measurement of the amount of algae in a lake's water. Algae are natural and essential in lakes, but high algal populations can increase water turbidity and reduce light available for plant growth, as well as result in unpleasing odor and appearance. Studies have shown that the amount of chlorophyll a in lake water depends greatly on the amount of algae present; therefore, chlorophyll-a levels are commonly used as a water quality indicator. The 2004-2006 summer (June-September) average chlorophyll concentration in Jordan Lake was 2.23 micrograms/liter. This low algae concentration places Jordan Lake at the "oligotrophic" level for chlorophyll a results.

Low oxygen during the summer in the bottom waters of a lake occurs naturally as oxygen in the bottom layer is consumed, but not replenished. It is common that as the summer progresses, the oxygen concentration of the bottom waters decreases. In Jordan Lake, there were hypoxic periods in the depths from 30 feet to 50 feet during the summers of 1998, 2000, 2001, 2002, 2004 and 2005. By the end of summer 1998, oxygen concentration at 40 feet depth was only 3.6 mg/l and continued to decrease as depth increased down to .1 mg/l at 70 feet deep. In the summer of 2000, dissolved oxygen levels were 2.8 mg/l at 40 feet; in the summer of 2001, dissolved oxygen levels were down to 3.4 mg/l in 30 feet deep by July and again continued to decrease as the depth increased. Similar patterns were found in 2002, 2004 and 2005. This pattern was not present in other years tested when oxygen levels at all depths were over 5 mg/l (the minimum level for most fish survival).

The surface water of all of the public access lakes in Adams County have water that is moderately hard to very hard, whether they are impoundments (man-made lakes) or natural lakes. In 2005 and 2006, random samples were also taken of wells around Jordan Lake to measure the hardness of the water coming into the lake through groundwater. Hardness in the groundwater ranged from 242 (very hard) to 424 (very hard). Surface water in Jordan Lake has a much lower hardness average of 119.71 mg/l $CaCO_3$, varying from 112 to 129. The hardness in both surface and groundwater is likely due to the underlying bedrock in Adams County, which is mostly sandstone with pockets of dolomite and shale. Hard water lakes tend to produce more fish and aquatic plants than soft water lakes because they are often located in watersheds with soils that load phosphorus into the lake water. Hardness levels over 180 mg/l can cause marl to start precipitating out of the water or sediment, thus releasing phosphorus for aquatic plant and algae use. But since Jordan Lake's hardness less is far below that, the marl in the lake is likely to keep binding a significant amount of phosphorus that would otherwise be in the water column.

A lake with a neutral or slightly alkaline pH like Jordan Lake is a good lake for fish and plant survival. Natural rainfall in Wisconsin averages a pH of 5.6. This means that if the rain falls on a lake without sufficient alkalinity to buffer that acid water coming in by rainfall, the lake's fish cannot reproduce. That is not a problem at Jordan Lake.

Other water quality testing at Jordan Lake showed no particular areas of concern. The average calcium level in Jordan Lake's water during the testing period was 38.65 mg/l. The average Magnesium level was 40.58 mg/l. Both of these are relatively low-level readings. The presence of a significant amount of chloride over a period of time may indicate that there are negative human impacts on the water quality present from septic system failure, the presence of fertilizer and/or waste, deposition of road-salt, and other nutrients. However, chloride levels found in Jordan Lake during the testing period were average 2.11 mg/l, just under the estimated t natural level of chloride in this area of Wisconsin of 3 mg/l. Nitrogen levels can affect other aspects of water quality. The sum of water testing results for nitrate, nitrite and ammonium levels of over .3 mg/l in the spring can be used to project the likelihood of an algal bloom in the summer (assuming sufficient phosphorus is also present). Jordan Lake combination spring levels from 2004 to 2006 were .37, just above the .3 mg/l predictive level.

Both sodium and potassium levels in Jordan Lake are very low: the average sodium level was 2.56 mg/l; the average potassium reading was 1.56 mg/l. To prevent the formation of the gas hydrogen sulfate, levels of 10 mg/l are best. A health advisory kicks in at 30 mg/l. Jordan Lake sulfate levels average 2.56 mg/l during the testing period, far below either level. Turbidity reflects water clarity. The term refers to suspended solids in the water column—solids that may include clay, silt, sand, plankton, waste, sewage and other pollutants. Very turbid waters may not only smell and mask bacteria & other pollutants, but also tend to be aesthetically displeasing, thus curtailing recreational uses of the water. Turbidity levels for Jordan Lake's waters were all at low levels.

Phosphorus

Like most lakes in Wisconsin, Jordan Lake is a phosphorus-limited lake: of the pollutants that end up in the lake, the one that most affects the overall quality of the lake water is phosphorus. The amount of phosphorus especially affects the frequency and density of aquatic vegetation and the frequency and density of various kinds of algae, as well as water clarity and other quality aspects.

The total phosphorus (TP) concentration in a lake is considered a good indicator of a lake's nutrient status, since the TP concentration tends to be more stable than other types of phosphorus concentration. For a natural lake like Jordan Lake, a total phosphorus concentration below 25 micrograms/liter tends to prevent nuisance algal blooms. Jordan Lake's growing season (June-September) surface average total phosphorus level of 15 micrograms/liter is low enough so that nuisance algal blooms should occur only rarely and may be relatively localized.

In most lakes in Wisconsin, phosphorus concentration in the bottom sediments of the lake is considerably higher than the concentration in the water column itself. Bottom sediments can "bind up" phosphorus, making it unavailable for aquatic plants or algae to use. Some sediment types hold phosphorus at a higher rate than others. Jordan Lake does have some marl in its sediments. "Marl" is a calcium carbonate precipitate (solid) that forms in hard water lakes when both calcium and pH levels are high and has a high capacity to immobilize phosphorus and other nutrients. With such an amount of marl sediment, Jordan Lake may benefit from it removing phosphorus from water column, thus making it unavailable for algal and aquatic plant growth.

A review of historical data before the most recent aquatic plant survey suggested that nutrients in Jordan Lake have increased over the years. Testing for phosphorus in the lower depths of Jordan Lake suggests that the lower water depths may be accumulating phosphorus, added to that accumulating in the sediments. This situation should be monitored.

Land use plays a major role in phosphorus loading. A key component of the computer models used is the phosphorus budget, that is, the estimated amount of phosphorus delivered to the lake from each land use type annually. Using the current land use data, as well as phosphorus readings from 2004 through 2006 water sampling, a phosphorus loading prediction model was run for Jordan Lake. The land uses that contribute the most phosphorus are non-irrigated agriculture and residences.

Some phosphorus deposition cannot be controlled by humans. However, some phosphorus (and other nutrient) input can be decreased or increased by changes in human land use patterns. Practices such as shoreland buffer restoration; infiltrating stormwater runoff from roof tops, driveways and other impervious surfaces; using no phosphorus lawn fertilizers; and reducing phosphorus input to and properly managing septic systems will minimize phosphorus inputs into the lake.

Reducing the amount of input from the surface and ground watersheds results in less nutrient loading into the lake itself. Figure 20 graphs the changes there would be if those levels had been reduced by 10% and 25%. A 10% reduction would have meant from .7 to 1.8 fewer micrograms/liter of phosphorus in the lake. Reducing the in-lake phosphorus by 25% would result in 1.7 to 4.6 fewer micrograms/liter of phosphorus. These predictions make it clear that reducing current phosphorus inputs to the lake are essential to improve, maintain and protect Jordan Lake's health for future generations.

Aquatic Plant Community

The aquatic plant community of Jordan Lake is characterized by high quality and very good species diversity. The plant community suggests that Jordan Lake is closer to an undisturbed condition than the average lake in the state. In the North Central Hardwoods Region, Jordan Lake is in the group of lakes closest to an undisturbed condition.

Aquatic plants cover 97.8% of the littoral zone to a maximum rooting depth of 19 feet. The 0 to 1.5 foot depth zone supported the most abundant aquatic plant growth. The Jordan Lake aquatic plant community is characterized by high quality and very good species diversity. The plant community has a below average sensitivity to disturbance and is closer to an undisturbed condition than the average lake in the state.

Chara spp (muskgrass), a plant-like algae, was the most common and most dense species found during the aquatic plant survey. Second in frequency was *Najas flexilis* (bushy pondweed). *Chara* spp was also the dominant species. *Najas flexilis* was sub-dominant. Three invasive aquatic plants were found: *Myriophyllum* spicatum (Eurasian watermilfoil, a submergent), *Phalaris arundinacea* (reed canarygrass, an emergent), and *Potamogeton crispus* (curly-leaf pondweed, a submergent). Of the invasives, Eurasian watermilfoil was the most commonly occurring species and was found in all four depth zones. The lake historically has used chemical spot treatments to manage the Eurasian watermilfoil. In addition, a survey in 2007 indicated that the native weevil, *Euhrychiopsis lecontei*, was present in parts of Jordan Lake. This weevil, if present in sufficient density, can weaken Eurasian milfoil plants to the point of death.

Critical Habitat Areas

Wisconsin Rule 107.05(3)(i)(I) defines a “critical habitat areas” as: “areas of aquatic vegetation identified by the department as offering critical or unique fish & wildlife habitat or offering water quality or erosion control benefits to the body of water. Thus, these sites are essential to support the wildlife and fish communities. They also provide mechanisms for protecting water quality within the lake, often containing high-quality plant beds. Finally, critical habitat areas often can provide the peace, serenity and beauty that draw many people to lakes. Two areas on Jordan Lake were determined by a team of lake professionals to be appropriate for critical habitat designation.

JO1 extends along approximately 2600 feet of the shoreline along the north side of the lake, extending up to the ordinary high water mark. 6% of the shore is wooded; 20% is native herbaceous cover. The balance of the short is bare sand, cultivated lawn and hard structure. There is a shallow marsh area along this shoreline. Large woody cover is present for habitat. Maximum rooting depth of aquatic vegetation in JO1 was 19 feet. Seven types of emergent aquatic plants were found in this area. Emergents provide important fish habitat and spawning areas, as well as food and cover for wildlife. One free-floating and three floating-leaf rooted species were present here. Floating-leaf vegetation provides cover and dampens waves, protecting the shore. Eighteen emergent species of aquatic species were also found here. Such a diverse submergent community provides many benefits. Filamentous algae were present at this site, but not abundant.

One exotic invasive plant, *Myriophyllum spicatum*, was found in this area. Most of the aquatic vegetation in this area has multiple uses for fish and wildlife. This area of all three plant structures provides a lot of habitat diversity.

JO2 extends along approximately 1800 feet of the shoreline on the far east end of the lake, up to the ordinary high water mark. Average water depth here is about 15', with a steep dropoff. 11% of the shore is wooded; 6% has shrubs; 23% is native herbaceous cover. The remaining shore is bare sand, cultivated lawn and hard structures, which tend to be concentrated at the edges of this area. The middle area is almost entirely undeveloped and contains some shallow marsh. Large woody cover is present for habitat. With minimal human disturbance along this shoreline, the area has natural scenic beauty. Shore development present in JO2 was confined to the ends.

Maximum rooting depth in JO2 was 19 feet. No threatened or endangered species were found in this area. Two exotic invasives, *Myriophyllum spicatum* (Eurasian watermilfoil) and *Potamogeton crispus* (Curly-Leaf Pondweed), were found in this area. Filamentous algae were present, but not common. Five emergent species were present here. One free-floating plant was found at this site. Two floating-leaf rooted plants were present. Fifteen submergent aquatic plant species were also found here.

Most of these plants are used by wildlife and fish for multiple purposes. Because this site provides all three structural types of vegetation, the community has a diversity of structure and species that supports even more diversity of fish and wildlife.

Fish/Wildlife/Endangered Resources

WDNR fish stocking records for Jordan Lake extend back to 1933, when 308 black bass were stocked. Fish were stocked by that agency most years since then, through 2002. Other fish that were stocked included walleye, perch, smallmouth bass, largemouth bass, northern pike and brown & rainbow trout. The most recent shocking inventory, in October 2006, found bluegills were abundant. Prior inventories have shown the presence of bullheads, ciscos, pumpkinseeds, crappie, suckers and shiners, in addition to the fish type stocked. An endangered species, *Fundulus diaphanus (*Banded Killifish), was found in the lake previously. No other endangered resources in the Jordan Lake watersheds have been identified.

Muskrat and mink are also known to use Jordan Lake for cover, reproduction and feeding. Seen during the field surveys were various types of waterfowl, songbirds, and turkey. Frogs and salamanders are known to use this area for shelter/cover, nesting and feeding. Turtles and snakes also use this area for cover or shelter in this area, as well as nested and fed in this area. Upland wildlife feed and nest here as well.

Conclusion

Jordan Lake is currently a fairly healthy, well-managed lake with many positive aspects, as discussed in this report. The main focus of continued management should include shoreland restoration, integrated management of invasive species, reduction of human-impacts on phosphorus loading, well-managed land use and continued monitoring for water quality and invasive species. Installation of riparian buffers should be a priority. Care should be taken to maintain the overall excellent quality of the lake and its surroundings.

The recommendations on the following pages should help in these aims.

RECOMMENDATIONS

Lake Management Plan

The Jordan Lake District should continue to work on its management plan to be sure the following issues are covered fully: aquatic plant management; control/management of invasive species; wildlife and fishery management; watershed management; shoreland protection; critical habitat protection; water quality protection.

Watershed Recommendations

Results of the computer modeling and water testing suggest input of nutrients, especially phosphorus, are a factor that needs to be explored for Jordan Lake.

Therefore, it is recommended both the surface and ground watersheds be inventoried, documenting any of the following: runoff from any livestock operations that may be entering the surface water; soil erosion sites; agricultural producers not complying with nutrient management plans and/or irrigation water management plans.

If such sites are documented, steps for dealing with these issues can be incorporated into the lake management plan to be completed by the end of 2008.

Shoreland Recommendations

All lake residents should practice best management on their lake properties, including keeping septic systems cleaned and in proper condition, eliminating the use of lawn fertilizers, cleaning up pet wastes and not composting near the water.

Aquatic Plants/Invasives Recommendations

1) Residents should continue involvement in the Citizen Lake Water Monitoring Program, Invasive Species Monitoring and Clean Boats, Clean Waters. This will allow not only noting changes in the Eurasian Watermilfoil pattern, but also the other two invasive species known to occur there and any new ones that might be found. Noting the presence and density of these plants early is the best way to take preventive action to keep them from becoming a bigger problem.

2) Lake residents should protect and restore natural shoreline around Jordan Lake. Studies have shown that there is lower frequency and density of the most sensitive plant species in the disturbed shorelines. Disturbed shoreline sites support an aquatic plant community that has been less able to resist invasions of exotic species and shows impacts from nutrient enrichment. The Lake Management Plan includes installing some shoreland restoration demonstration sites—that recommendation should be followed.

3) All lake users should protect the aquatic plant community in Jordan Lake.

4) The Jordan Lake District should maintain exotic species signs at the boat landings and contact DNR if the signs are missing or damaged.

5) The Jordan Lake District should continue monitoring and control of Eurasian Watermilfoil to maintain the most effective methods and modify if necessary. Early-season treatments with a specific chemical should be continued as long as it remains effective. The Lake District may need to investigate ways to increase treatment effectiveness in the deeper water. Residents should hand-pull scattered EWM plants. Other invasives known to be present should also be monitored.

6) Consideration should be given to propagating the native weevil that attacks Eurasian Watermilfoil to assist in EWM management.

Critical Habitat Recommendations

There are also several recommendations appropriate for the critical habitat areas.

(1) Maintain current habitat for fish and wildlife.
(2) Do not remove fallen trees along the shoreline nor logs in the water.
(3) No alteration of littoral zone unless to improve spawning habitat.
(4) Seasonal protection of spawning habitat.
(5) Maintain snag/cavity trees for nesting.
(6) Maintain or increase wildlife corridor.
(7) Maintain sedge meadow and deep marsh areas.
(8) Maintain no-wake zone.
(9) Protect emergent vegetation for habitat and shoreline protection.
(10) Removal of submergent vegetation for navigation purposes only.
(11) Seasonal control of Eurasian Watermilfoil and other invasives by using control methods specific for exotics.

(12) Minimize aquatic plant and shore plant removal to maximum 30' wide access/viewing corridor. Leave as much vegetation as possible to protect water quality and habitat.
(13) Use forestry best management practices.
(14) No use of lawn products.
(15) No bank grading or grading of adjacent land.
(16) No pier construction or other activity except by permit using a case-by-case evaluation.
(17) No installation of pea gravel or sand blankets.
(18) No bank restoration unless the erosion index scores moderate or high.
(19) If the erosion index does score moderate or high, bank restoration only using biologs or similar bioengineering, with no use of riprap or retaining walls.
(20) Placement of swimming rafts or other recreational floating devices only by permit.
(21) Maintain buffer of shoreline vegetation.
(22) Maintain aquatic vegetation in undisturbed condition for wildlife habitat, fish use and water quality protection.
(23) Post landing with exotic species alert and educational signs to prevent introduction and/or spread of exotic species.
(24) Make critical habitat areas no-wake zones.

LAKE CLASSIFICATION REPORT
FOR JORDAN LAKE, ADAMS COUNTY

INTRODUCTION

In 2003, The Adams County Land & Water Conservation Department (Adams County LWCD) determined that a significant amount of natural resource data needed to be collected on the lakes with public access in order to provide it and the public with information necessary to manage the lakes in a manner that would preserve or improve water quality and keep it appropriate for public use. In some instances, there was significant historical data about a particular lake; in that instance, the study activities concentrated on combining and updating information. In other instances, there was no information on a lake, so study activities concentrating on gathering data about that lake. Further, it was discovered that information was scattered among various citizens, so often what information was actually available regarding a particular lake was unknown. To assist in updating some information and gathering baseline information, plus centralize the data collected, so the public may access it. The Adams County LWCD received a series of grants from the Wisconsin Department of Natural Resources (WDNR) from the Lake Classification Grant Program.

Objectives of the study were:

- collect physical data on the named lakes to assist in assessing the health of Adams County lake ecosystems and in classifying the water quality of the lakes.
- collect chemical and biological data on the named lakes to assist in assessing the health of Adams County lake ecosystems and in classifying the water quality of the lakes.
- develop a library of lake information that is centrally located and accessible to the public and to City, County, State and Federal agencies.
- make specific recommendations for actions and strategies for the protection, preservation and management of the lakes and their watersheds.
- create a baseline for future lake water quality monitoring.
- Provide technical information for the development of comprehensive lake management plans for each lake
- provide a basis for the water quality component of the Adams County Land and Water Resource Management Plan. Components of the plan will be incorporated into Adams County's "Smart Growth Plan".
- develop and implement educational programs and materials to inform and education lake area property owners and lake users in Adams County.

METHODS OF DATA COLLECTION

To collect the physical data, the following methods were used:

- delineation & mapping of ground & surface watersheds using topographic maps, ground truthing and computer modeling;
- identification of flow patterns for both the surface & ground watersheds using known flow maps and topographic maps;
- inventory & mapping of current land use with orthographic photos and collected county information;
- inventory & mapping of shoreline erosion and buffers using county parcel maps and visual observation;
- inventory & mapping for historical and cultural sites using information from the local historical society and the Wisconsin Historical Society;
- identification & mapping of critical habitat areas with WDNR and Adams County LWCD staff;
- identification & mapping of endangered or threatened natural resources (including natural communities, plant & animal species) using information from the Natural Heritage Inventory of Wisconsin;
- identification & mapping of wetland areas using WDNR and Natural Resource Conservation Service wetland maps;
- preparation of soil maps for each of the lake watersheds using soil survey data from the Natural Resource Conservation Service.

To collect water quality information, different methods were used:

- for three years, lakes were sampled during late winter, at spring and fall turnover, and several times during the summer for various parameters of water quality, including dissolved oxygen, relevant to fish survival and total phosphorus, related to aquatic plant and algae growth;
- random samples from wells in each lake watershed were taken in two years and tested for several factors;
- aquatic plant surveys were done on all 20 lakes and reports prepared, including identification of exotics, identifying existing aquatic plant community, evaluation of community measures, mapping of plant distribution, and recommendations;
- all lakes were evaluated for critical habitat areas, with reports and recommendations being made to the respective lakes and the WDNR;
- lake water quality modeling was done using data collected, as well as historical data where it was available.

WATER QUALITY COMPUTER MODELING

Wisconsin developed a computer modeling program called WiLMS (Wisconsin Lake Modeling Suite) to assist in determining the amount of phosphorus being loaded annually into a lake, as well as the probable source of that phosphorus. This suite has many models, including Lake Total Phosphorus Prediction, Lake Eutrophic Analysis Procedure, Expanded Trophic Response, Summary Trophic Response, Internal Load Estimator, Prediction & Uncertainty Analysis, and Water & Nutrient Outflow. The models that various types of data inputs: known water chemistry; surface area of lake; mean depth of lake; volume of lake; land use types & acreage. This information is then used in the various models to determine the hydrologic budget, estimated residence time, flushing rate, and other parameters.

Using the data collected over the course of the studies, various models were run under the WiLMS Suite. These water quality models are computer-based mathematical models that simulate lake water quality and watershed runoff conditions. They are meant to be a tool to assist in predicting changes in water quality when watershed management activities are simulated. For example, a model might estimate how much water quality improvement would occur if watershed sources of phosphorus inputs were reduced. However, it should be understood that these models predict only a relative response, not an exact response. Modeling results will be incorporated into topic discussions as appropriate.

DISSEMINATION OF PROJECT DELIVERABLES

The results of this study will be distributed various agencies, organizations and the public as previously described. Based on the classification information, the Adams County Land and Water Conservation Department will identify assistance requests and determine the appropriate future activities, based on the classification determinations. To provide the requested assistance, Adams County Land and Water Conservation Department will incorporate the lake management plans goals, priorities and action items into its Annual Plan of Operations. Goals, priorities and action items may include educational programs, formation of lake districts, further development of lake management plans and implementation of lake management plans.

ADAMS COUNTY INFORMATION

Adams County lies in south central Wisconsin, shaped roughly like the outline of Illinois. Adams County is a small rural county with a full-time population of about 20,000. Between 1980 and 2000, Adams County's population grew by more than 20%, with most of the population increase being located upon the lakes and streams. The population increase has resulted in a greater need for facilitation, technical assistance and education, including information on the lakes and streams.

Figure 1: Adams County Location in Wisconsin

JORDAN LAKE BACKGROUND INFORMATION

Jordan Lake is a 215-acre natural seepage lake located in the Town of Jackson, Adams County, in the Central Sands Area of Wisconsin. A "seepage lake" is a natural lake with no stream inlet or outlet and fed by precipitation, runoff and groundwater. It is one of many lakes in the Town of Jackson, most of which are seepage lakes similar to Jordan Lake (see arrow below pointing to location in the Town of Jackson). There is a public boat launch on the north side of the lake and several condominium and resort developments on the shores. The east end of the lake is largely undeveloped.

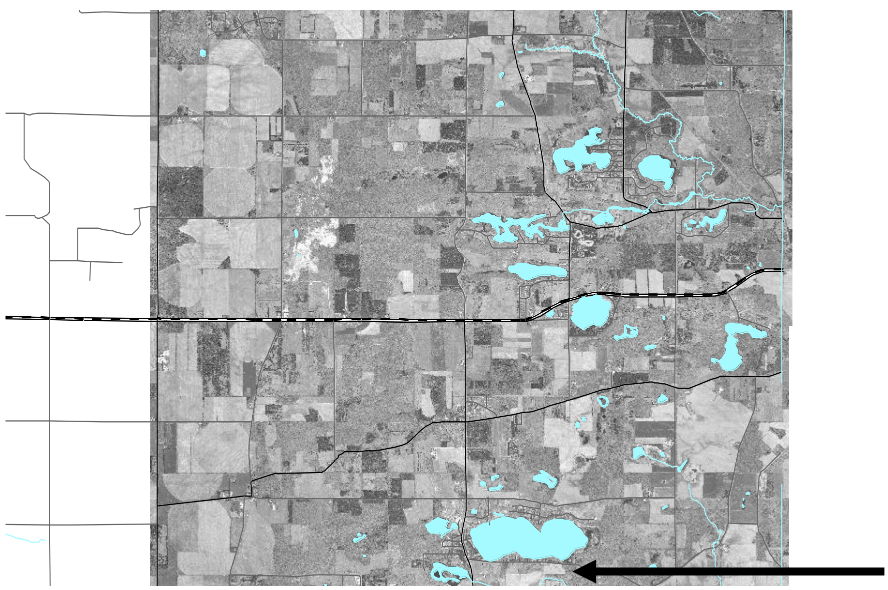

Figure 2: JORDAN LAKE location

Jordan Lake is part of the Neenah Creek Watershed, a large watershed of 182 square miles from which water flows into the Fox River and eventually into Lake Michigan. The Central Sand Hills, which contain Jordan Lake, are an ecological landscape (a recessional moraine) on the eastern edge of what was Glacial Lake Wisconsin. The area is characterized by glacial moraines and glacial outwash, as well as the kettle holes that formed natural lakes—such as Jordan Lake. Elevations average between 900 to 1000 feet above sea level. There is a lake management plan for the Jordan Lake District before the WDNR for final review and potential approval.

The landowners around Jordan Lake have expressed concern about safety on the lake. In the past few years, traffic on the lake has increased dramatically. During the summer, one may find pontoon boats, speed boats, jet skiers, water skiers and boats towing tubes full of people—mostly ignoring the boating rules such as leaving 100 feet between crafts and staying 200 feet out from the shore. Methods of dealing with these issues have been incorporated into the lake management plan.

<u>Archeological Sites</u>

There are many Native American archeological sites in Adams County, with one located on the middle north short of Jordan Lake. Under the federal act on Native American burials, this site cannot be further disturbed without permission of the federal government and input from the local tribes.

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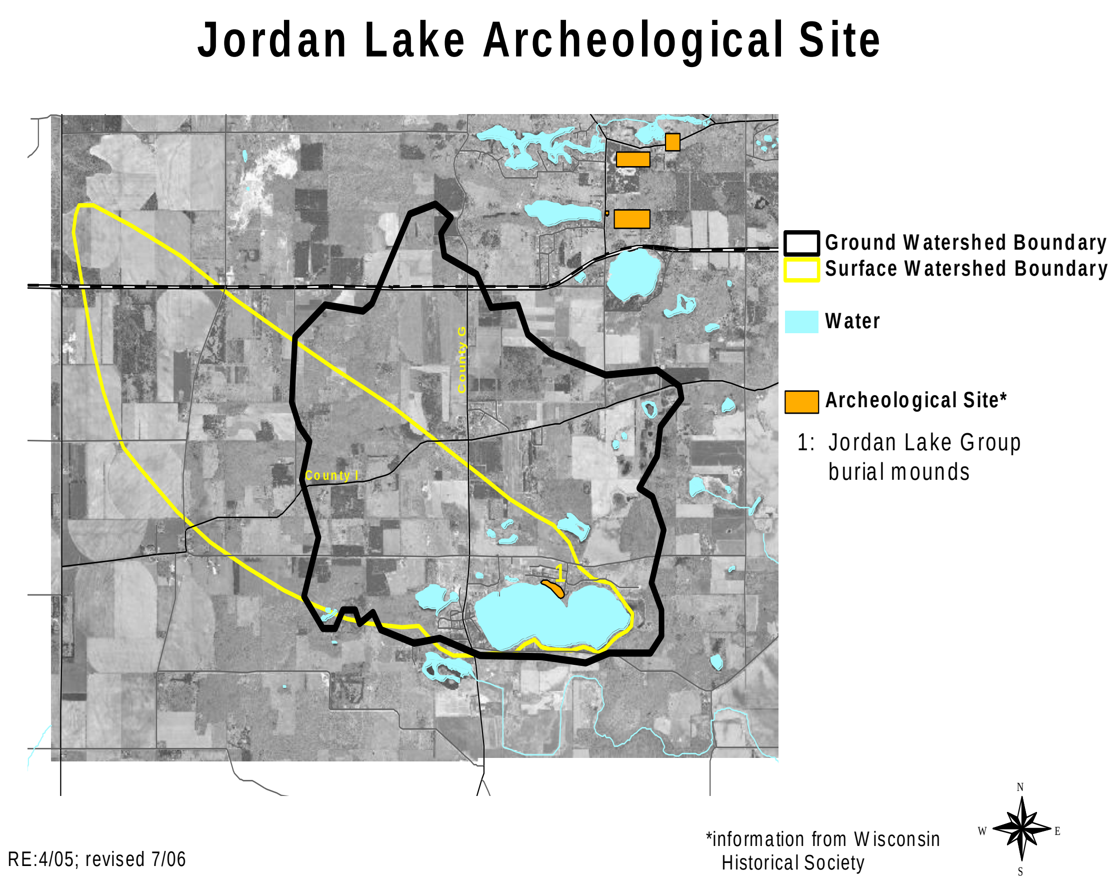
Figure 3: Jordan Lake Archeological Sites



Bedrock and Historical Vegetation

Bedrock around Jordan Lake is mostly sandstone, with pockets of dolomite and shale, formed in the Cambrian Period of Geology (542 to 488 millions years ago). Bedrock is generally 50' to 100' down from the land surface. The water table in most areas around Jordan Lake is fairly near the surface.

Original upland vegetation of the area around Jordan Lake included oak-forest, oak savanna, pine barrens and tallgrass prairie. Wetland areas were also common, including wet-mesic prairies, wet prairie, coastal plain marshes and fen. Hills and kettles created by glacial deposits make up the southeast area of Adams County, where Jordan Lake is located.

Soils in the Jordan Lake Watersheds

Except for some pockets of aquents, sandy loam and silt loam, the soils in the ground watershed for Jordan Lake are nearly evenly split between loamy sand and sand, with slopes from very flat up to 25% (see Figure 4). The surface watershed, on the other hand, has a much smaller proportion of sand and much larger areas of silt loam and loamy sand.

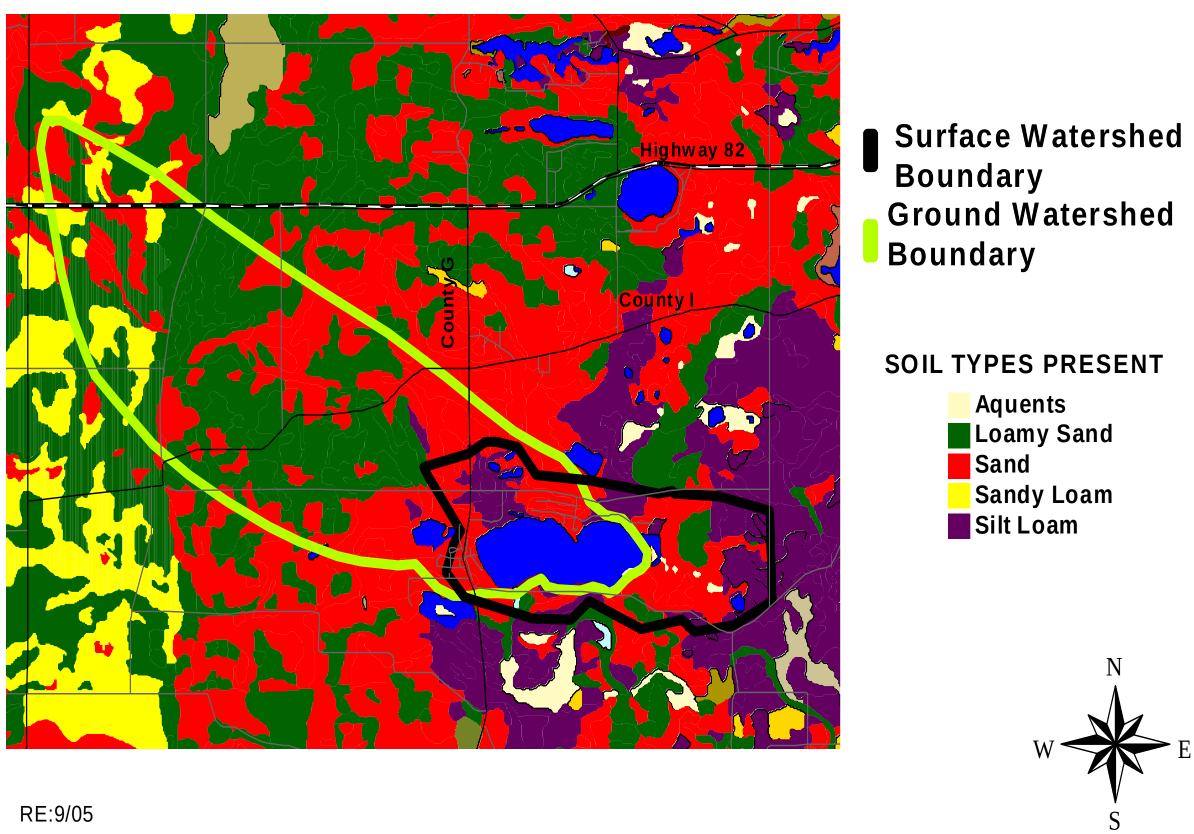
Sandy soil tends to be excessively drained, no matter what the slope. Water, air and nutrients move through sandy soils at a rapid rate, so that little runoff occurs unless the soil becomes saturated. Although water erosion can be a problem, wind erosion may be more of a hazard with sandy soils, especially since they dry out so quickly. There are also draught hazards with sandy soils. Getting vegetation started in sandy soils is often difficult due to the low available water capacity, as well as low natural fertility and organic material. Onsite waste disposal in sandy soils is also a problem because of slope and seepage; mound systems are usually required.

Loamy sands tend to be well-drained, with water, air and nutrients moving through them at a rapid rate. Runoff, when it occurs, tends to be slow. Loamy sands have little water-holding capacity and low natural fertility, although they usually have more organic matter present than do sandy soils. Both wind and water erosion are potential hazards with loamy sands, as is draught. The same difficulties with waste disposal and vegetation establishment are present with loamy sands as with sandy soils.

Silt loams are usually well-drained, although there may be pockets of poorly-drained areas. Water and air move through these soils at a slow to moderately slow rate, with runoff being slow or medium. The available water capacity is moderate. Both natural fertility and organic matter content are medium. Heavy rains or other activities that compact silt loam soils may result in restriction of roots by hardpans formed due to the compaction. These soils tend to be unsuitable for building site development and onsite waste disposal.

The soil and soil slopes around lakes and streams are very important to water quality. They affect amount of infiltration of surface precipitation into the ground and the amount of contaminants that may reach the groundwater, as well as the amount of surface stormwater runoff. In addition, these two factors affect the amount and content of pollutants and particles (including soil) that may wash into a water body, affecting its water quality, its aquatic plant community and its fishery. Further, soil types and soil slopes help determine the appropriate private sewage system and other engineering practices for a particular site, since they affect absorption, filtration and infiltration of contamination from engineering practices.

Figure 4: Jordan Lake Watersheds



Jordan Lake Levels

For the past several years, discussion has occurred about the current water level of Jordan Lake, which is considerably higher than it was thirty years ago. People have reported having to move their docks several times to keep them out of the water. Others have reported that a former outlet was blocked by road installation and development of the shore.

In 1996, several investigations were done in the area where it was reported there was once an outlet. A water elevation survey was performed in June 1996. The Natural Resource Conservation Service did a soil survey in July 1996 and reported that the soils provided no evidence of historic alluvium to support the idea that the area had regularly been a surface overflow area in the last 100 years. They indicated that there might have been occasional short-term overflow, but nothing that occurred regularly enough for evidence to be found in the soil. Other issues were investigated by the WDNR and Army Corps of Engineers.

A meeting was held in July 1996 that included the Army Corps of Engineers, the WDNR, Adams County Planning & Zoning and Adams County Land & Water Conservation Department. It was determined that the water level fluctuations in Jordan Lake were likely to be part of the lake's natural cycle, which was probably long by human years. Discussion was had at that meeting about constructing an outlet, but it was ultimately decided that doing so would disturb a currently-stable ecosystem. Specific issues of concern included: (1) an outlet would discharge into Widow Green Creek, which is a trout water fishery, creating the risk of thermal warming sufficient to harm the trout; (2) additional water through the area would increase the creek bank erosion and siltation; (3) there would be a negative impact on already declining wetlands around Jordan Lake; (4) installation of such an outlet would cause the fish and wildlife habitat at the end of the lake to be lost.

CURRENT LAND USE

The surface watershed for Jordan Lake is fairly small; the ground watershed is considerably bigger. Overall, the two most common current land uses in the Jordan Lake surface watershed are woodlands and non-irrigated agriculture. (See Figures 5, 6a, 6b & 7). In the ground watershed, woodlands occupy the greatest number of acres, with both irrigated and non-irrigated agriculture also covering larger areas of the ground watershed.

Figure 5: Jordan Lake Watersheds Land Use in Acres and Percent of Total

Jordan Lake	Surface Acres	% of Total	Ground Acres	% of Total	Total Acres	% of Total
Agriculture--Non Irrigated	1068.03	23.84%	641.9	24.65%	1709.93	24.14%
Agriculture--Irrigated	417.54	9.32%	539.71	20.73%	957.25	13.51%
Grassland/Pasture	110.66	2.47%	60.67	2.33%	171.33	2.42%
Residential	638.4	14.25%	432.27	16.60%	1070.67	15.11%
Water	384.38	8.58%	44.52	1.71%	428.90	6.05%
Woodland	1861.44	41.54%	884.98	33.98%	2746.42	38.77%
total	4480.45	100.00%	2604.05	100.00%	7084.50	100.00%

Studies have shown that land use around a lake has a great impact on the water quality of that lake, especially in the amount and content of surface runoff. (James, T., 1992, I-10; Kibler, D.F., ed. 1982. 271) For example, while natural woodland may (on the average) absorb 3.5” out of a 4” rainfall, leaving only .5” as runoff, a residential area with quarter-acre lots may absorb only 2.3” of the 4”, leaving 1.7” to run off the land into the lake—the same amount as may be expected to run off from a corn or soybean field. 1.7” of runoff translates into 46,200 gallons per acre ending up in the lake! Percentage of impervious surface, the soil type, vegetation present and slope of the site can all affect runoff volume. (Frankenberger, J, ID-230).

Figure 6a: Land Use in Jordan Lake Surface Watershed

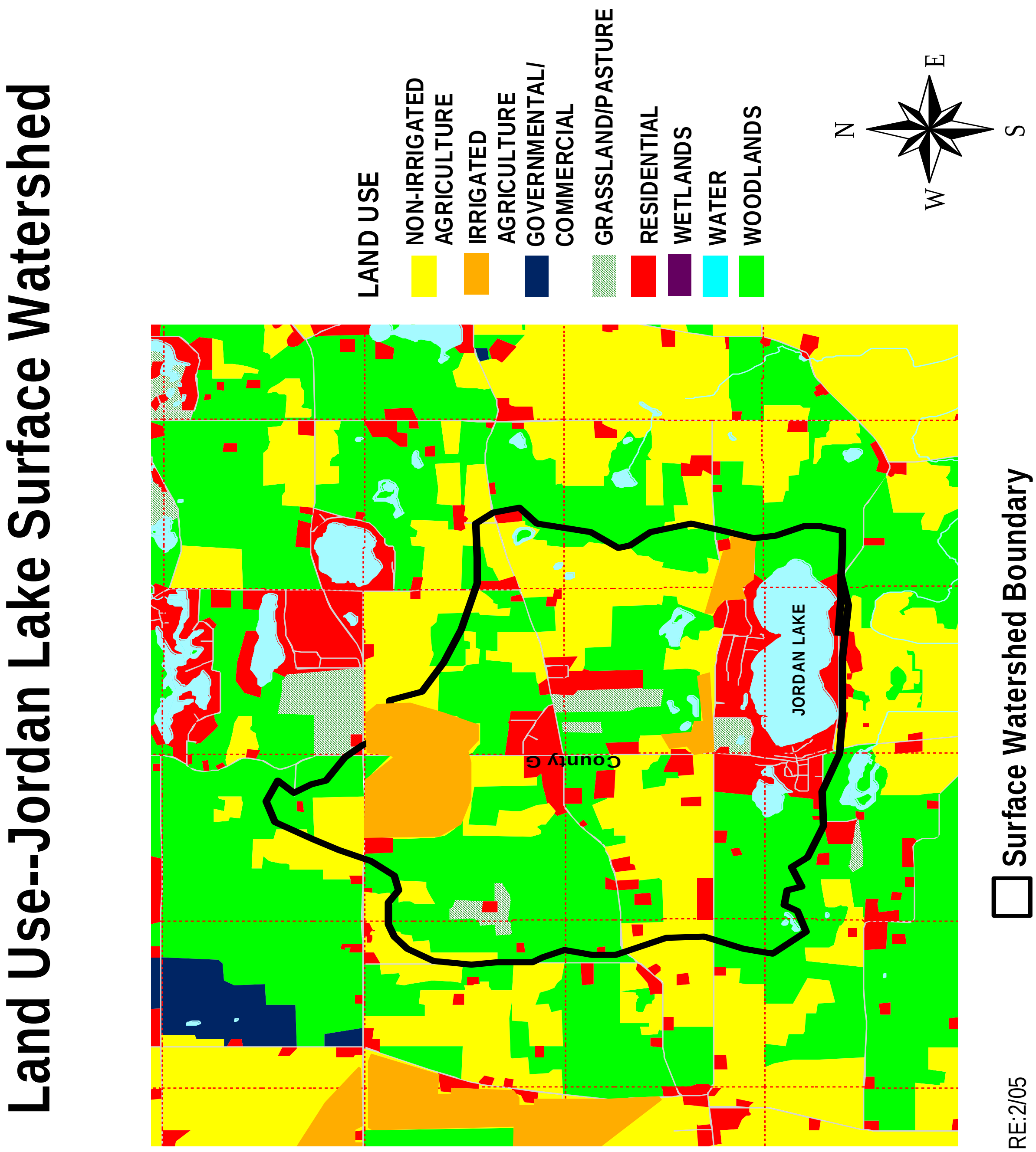
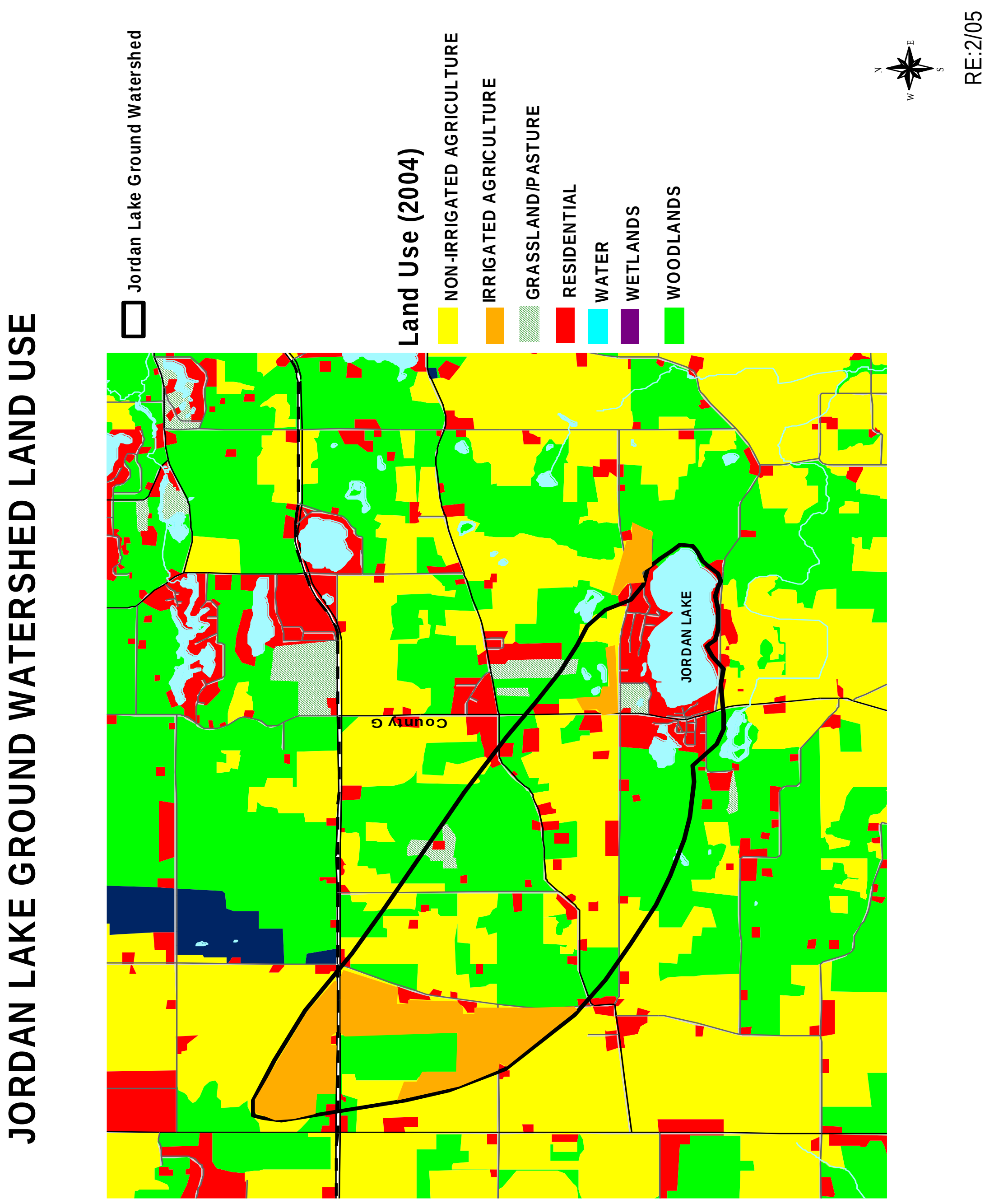
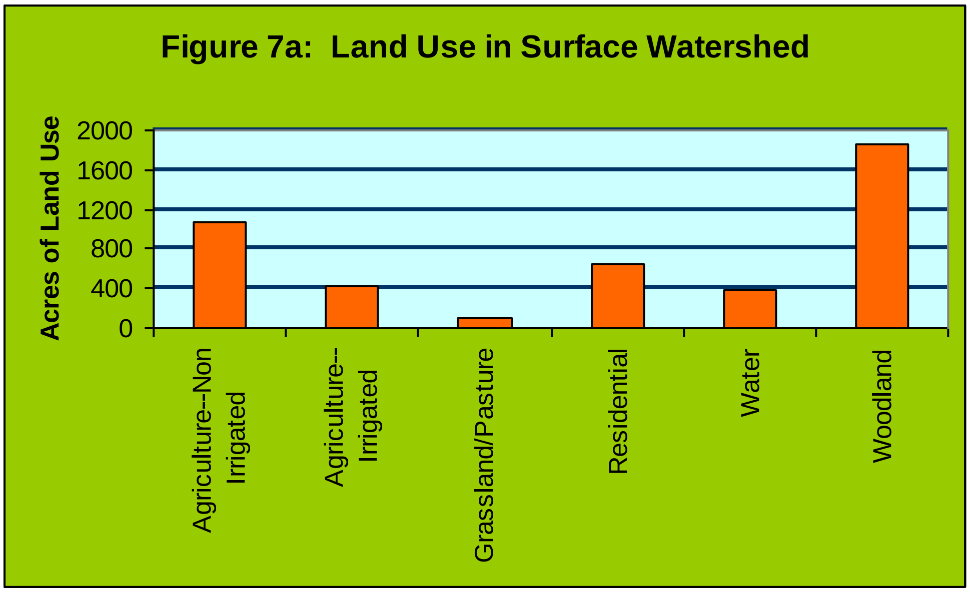
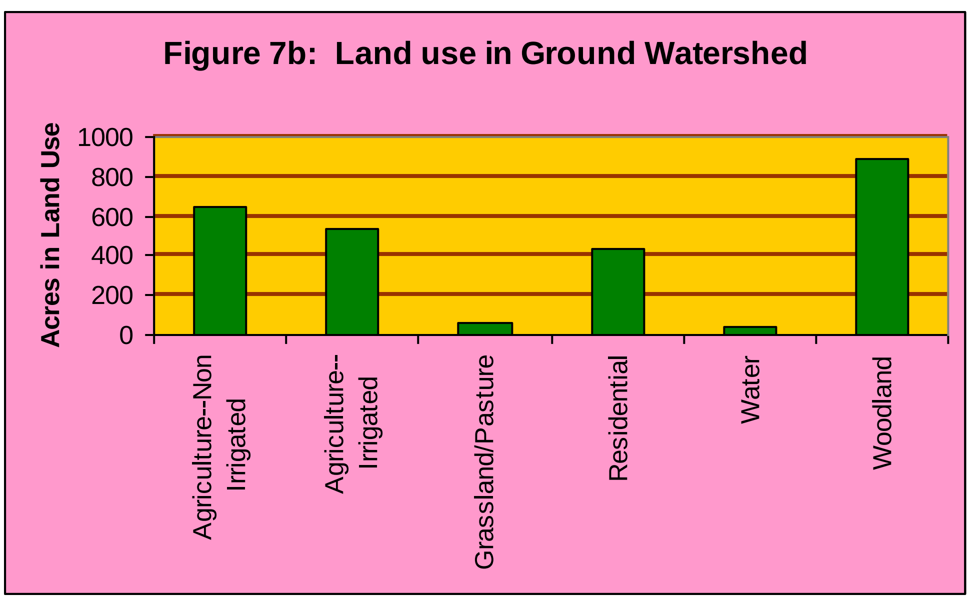


Figure 6b: Land Use in Jordan Lake Ground Watershed



When water runs over a surface, it picks up whatever loose pollutants—sediment, chemicals, metals, exhaust gas, etc—are present on that surface and takes those items with it into the lake. Increased development around a lake tends to increase the amount of pollutants being carried into the lake, thus negatively affecting water quality. Residential development areas with lots of one-quarter acre or less may deliver as much as 2.5 pounds of phosphorus per year to the lake for each acre of development.





There are two specific kinds of land use—wetlands and shorelands--that are so important to water quality that it will be separately discussed.

WETLANDS

A number of wetlands are located directly around the Jordan Lake shore, but do not show up clearly on the land use maps. Most of the shore wetlands at Jordan Lake are dominated by bulrushes. In the past, wetlands were seen as "wasted land" that only encouraged disease-transmitting insects. Many wetlands were drained and filled in for cropping, pasturing, or even residential development. In the last few decades, however, the importance of wetlands has become evident, even as wetlands continue to decline in acreage.

Wetlands play an important role in maintaining water quality by trapping many pollutants in runoff and flood waters, thus often helping keep clean the water they connect to. They serve as buffers to catch and control what would otherwise be uncontrolled water and pollutants. Wetlands also play an essential role in the aquatic food chain (thus affecting fishery and water recreation), as well as serving as spaces for wildlife habitat, wildlife reproduction and nesting, and wildlife food. It is essential to preserve these shore wetlands for the health of Jordan Lake.

Figure 8: Jordan Lake shore wetland

SHORELANDS

Jordan Lake has a total shoreline 2.8 miles (14,784 feet). Most of the shoreline is in residential or commercial housing. Several buildings are located less than 70 feet from the high water mark. Some of the banks are steep and sandy; some are flatter. Marsh areas are located along some of the shore. There is an undeveloped section of shore on the east end of the lake.

The Adams County Shoreline Ordinance defines 1000' landward from the ordinary high water mark as "shoreland". The Adams County Land & Water Conservation Department conducted a survey of the Jordan Lake shoreline in 2004. Shore types were categorized as "armored" and "vegetated". Only about 28% of Jordan Lake's shoreline is vegetated with native plants (grasses, forbs, shrubs, trees). Over 42% of the shore was covered with mowed lawn.

Figure 9: Jordan Lake Shore

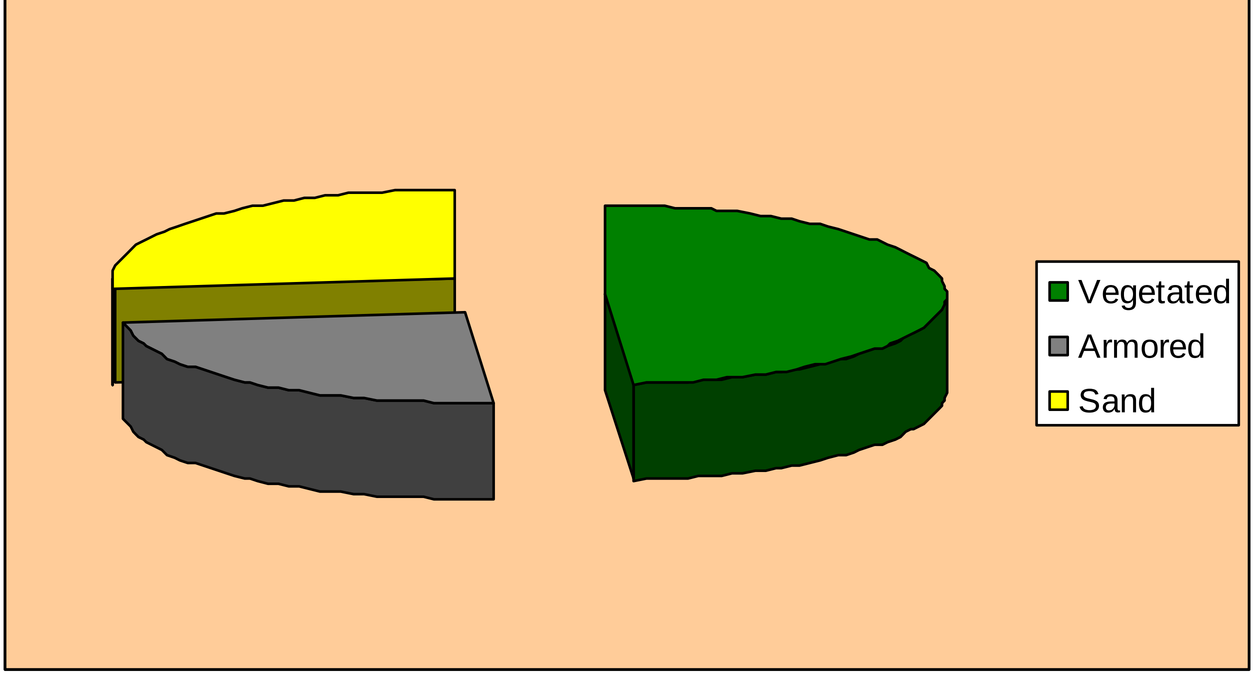
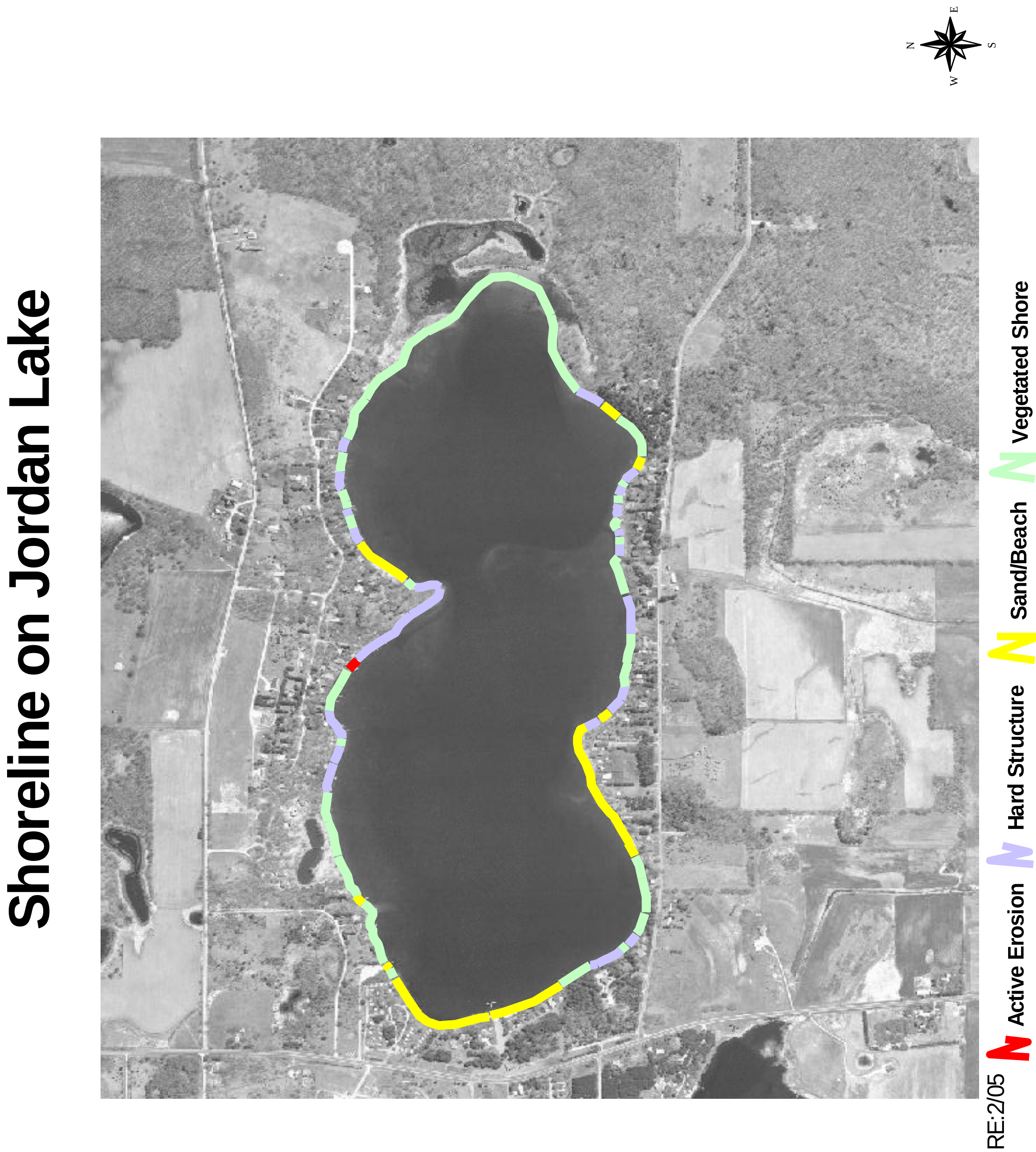
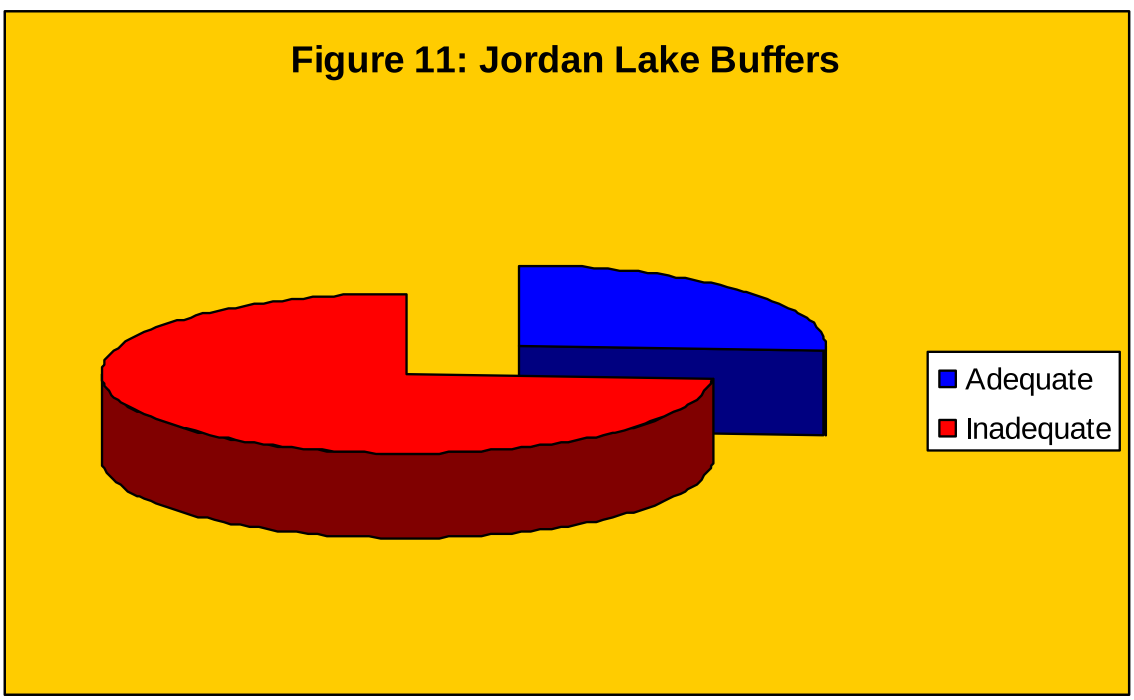


Figure 10: Shorelines on Jordan Lake



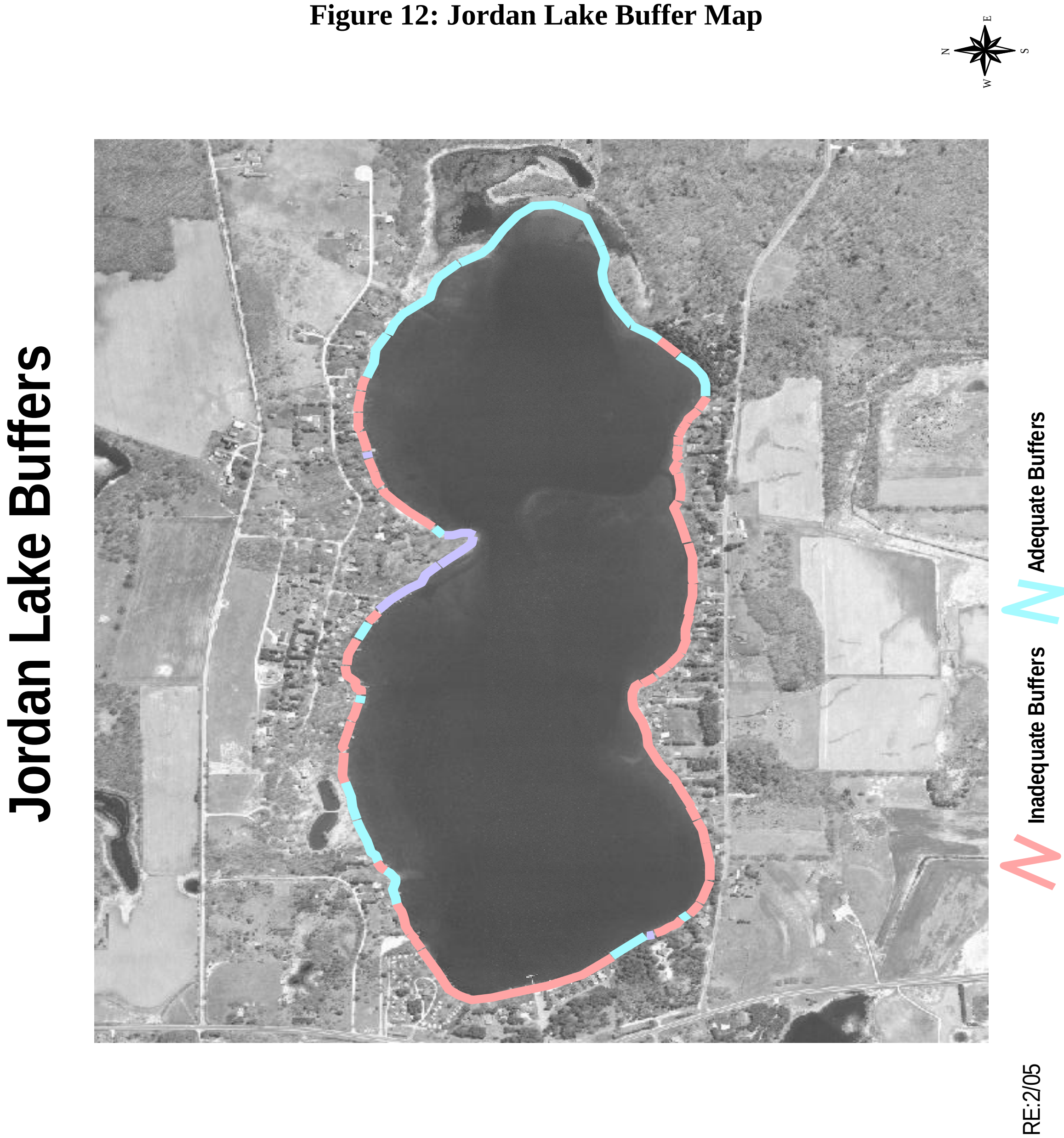
Under the shoreland ordinance, the first 35 feet landward from the water is a "buffer." Shoreland buffers are an important part of lake protection and restoration. These buffers are simply a wide border of native plants, grasses, shrubs and trees that filter and trap soil & similar sediments, fertilizer, grass clippings, stormwater runoff and other potential pollutants, keeping them out of the lake. A 1990 study of Wisconsin shorelines revealed that a buffer of native vegetation traps 5 to 18 times more volume of potential pollutants than does a developed, traditional lawn or hard-armored shore.

The 2004 inventory included classifying areas of the Jordan Lake shorelines as having "adequate" or "inadequate" buffers (see Figure 11). An "adequate" buffer was defined as one having the first 35 feet landward covered by native vegetation. An "inadequate" buffer was anything that didn't meet the definition of "adequate buffer", including native vegetation strips less than 35 feet landward. Using these definitions, 25.78% (about 3811.5 feet) of Jordan Lake's shoreline had an "adequate buffer", leaving 74.22% (10972.5 feet) as "inadequate." Most of the "inadequate" buffer areas were found with mowed lawns and/or insufficient native vegetation at the shoreline to cover 35 feet landward from the water line.



Vegetated shoreland buffers help stabilize shoreline banks, thus reducing bank erosion. The plant roots give structure to the bank and also increase water infiltration and decrease runoff. A vegetated shore is especially important when shores are steep and soft, as are many of the Jordan Lake shores. Figure 12 maps the adequate and inadequate buffers on Jordan Lake.

Figure 12: Jordan Lake Buffer Map



Lakeside buffers also serve as important habitat. Lake edges usually contain aquatic and wetland plants, grading into drier groundcover, then shrubs and trees as one moves inland towards drier land. Buffers provide habitat for many species of water-dependent wildlife, including furbearers, reptiles, birds and insects. Many wildlife species, including birds, small mammals, fish & turtles breed, nest, forage and/or perch in shore buffer areas. Further, 80% of the endangered and threatened species listed spend part of their life in this near-lake buffer area. (Wagner et al, 2006)

When the natural shoreline is replaced by traditional mowed turf-grass lawns, rock, wooden walls or similar installments, bird and animal life, land-based insects, and aquatic insects that hatch or winter on natural shore are negatively impacted. For example, on many Adams County lakes, the non-native aquatic plant, Eurasian Watermilfoil has invaded. There is a weevil native to Wisconsin that weakens Eurasian Watermilfoil by burrowing into and developing within its stems, but that weevil depends on a native-plant shore to overwinter. If the shore is instead covered by rock, seawall or traditional lawn, these weevils will be unavailable for the lake to use as Eurasian Watermilfoil control.

Figure 13: Example of Inadequate Buffer

The filtering process and bank stabilization that buffers provide help improve a lake's water quality, including water clarity. Studies in Minnesota, Maine and Michigan have shown that waterfront property value increases for every foot the water clarity of a lake increases. (Krysel et al, 2003).

Figure 14: Example of Adequate Buffer

Natural shoreland buffers serve important cultural functions. They enhance the lake's aesthetics. Studies have shown that aesthetics rank high as one of the reasons people visit or live on lakes. Shore buffers can provide visual & audio privacy screens for homeowners from other neighbors and/or lake users.

Adequate buffers on Jordan Lake could be easily installed on most of the lake by either letting the first 35 feet landward from the water just grow without mowing it, except for a path to the water, or by planting native seedlings sufficient to fill in the first 35 feet.

WATER QUALITY

Between 2004 and 2006, Adams County Land & Water Conservation Department gathered water chemistry and other water quality information on Jordan Lake. Part of the information was gained from periodic water sampling done by Adams County LWCD. Historic information about water testing on Jordan Lake was also obtained from the Wisconsin Self-Help Monitoring Program records and from the WDNR.

Phosphorus

Most lakes in Wisconsin, including Jordan Lake, are phosphorus-limited lakes: of the pollutants that end up in the lake, the one that most affects the overall quality of the lake water is phosphorus. The amount of phosphorus especially affects the frequency and density of aquatic vegetation and the frequency and density of various kinds of algae, as well as water clarity and other quality aspects. One pound of phosphorus can produce as much as 500 pounds of algae.

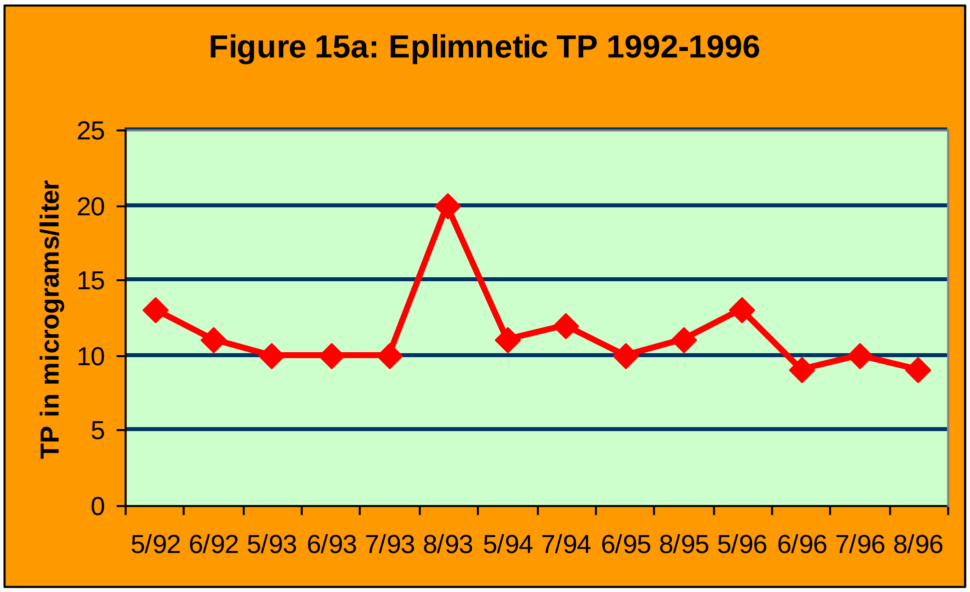
Phosphorus is not an element that occurs in high concentration naturally, so any lake that has significant phosphorus readings must have gotten that phosphorus from outside the lake or from internal loading. Some phosphorus is deposited onto the lake from atmospheric deposition, especially from soil or other particles in the air carrying phosphorus. A lake that includes a flooded wetland area may have a significant amount of phosphorus being released during the flushing of the wetland area. Phosphorus may accumulate in sediments from dying animals, dying aquatic plants and dying algae. If the bottom of the lake becomes anoxic (oxygen-depleted), chemical reactions may cause phosphorus to be released to the water column.

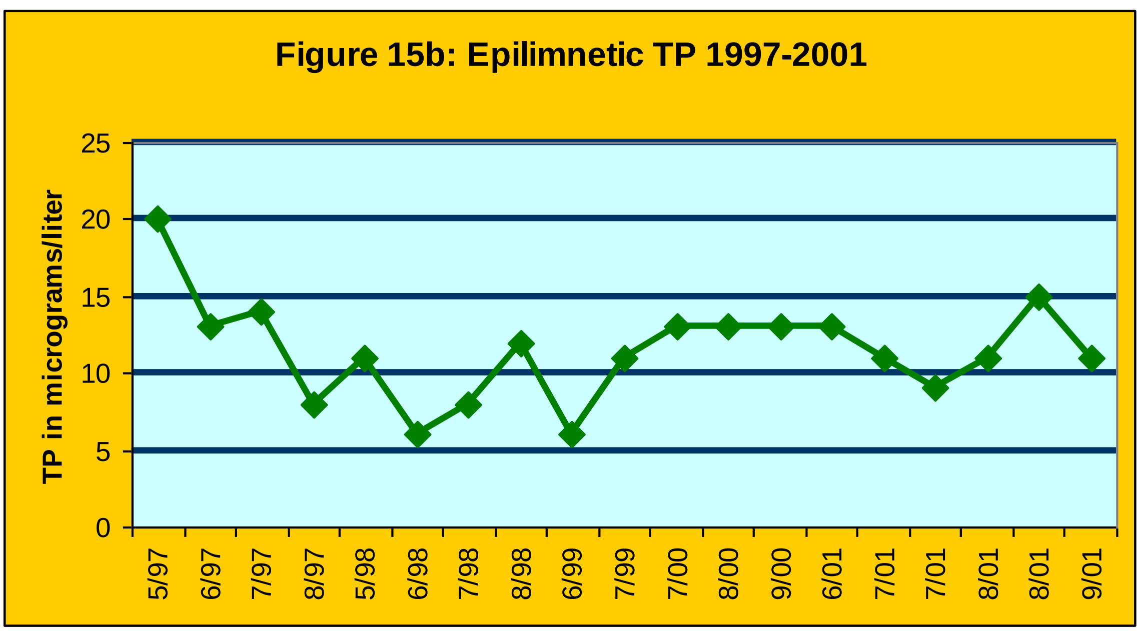
Although there are several forms of phosphorus in water, the total phosphorus (TP) concentration is considered a good indicator of a lake's nutrient status, since the TP concentration tends to be more stable than other types of phosphorus concentration. For a natural lake like Jordan Lake, a total phosphorus concentration below 20 micrograms/liter tends to prevent nuisance algal blooms. In 2004-2006, Jordan Lake's growing season (June-September) surface average total phosphorus level of 15 micrograms/liter is low enough so that nuisance algal blooms should occur only rarely.

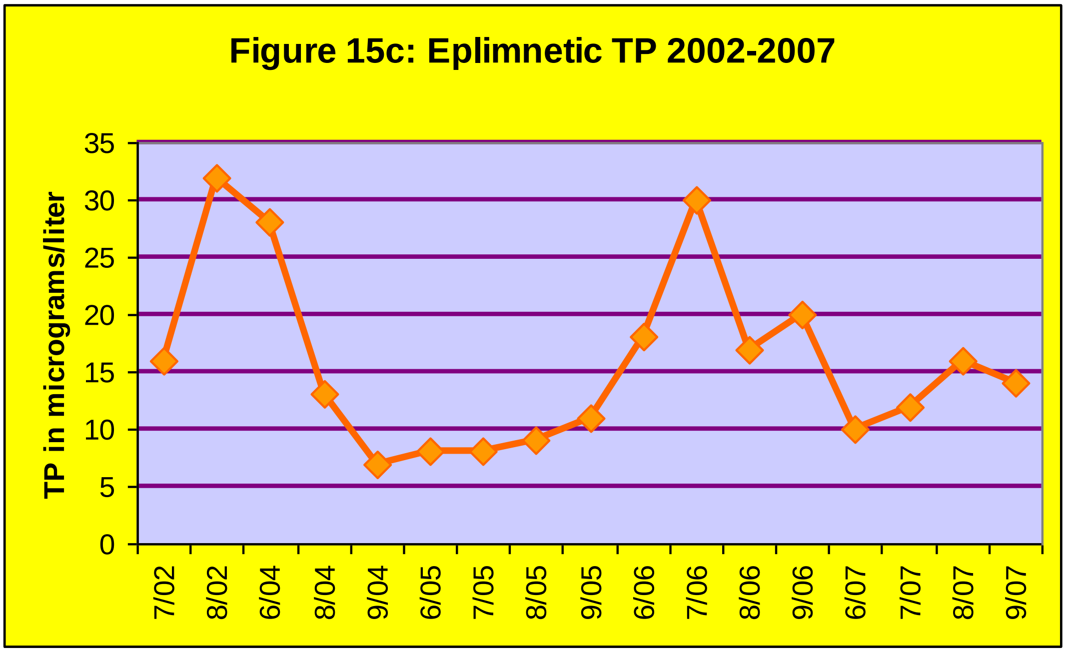
Since limiting factor is usually phosphorus, measuring the phosphorus in a lake system thus provides an indication of the nutrient level in a lake. Increased phosphorus in a lake will feed algal blooms and also may cause excess plant growth. The 2004-2006 summer average phosphorus concentration in Jordan Lake was 15 micrograms/liter. This is below the 25 micrograms/liter average for natural lakes in Wisconsin. This concentration suggests that Jordan Lake is likely to have few nuisance algal blooms.

This places Jordan Lake in the "good" water quality section for impoundments, and in the "mesotrophic" level for phosphorus.

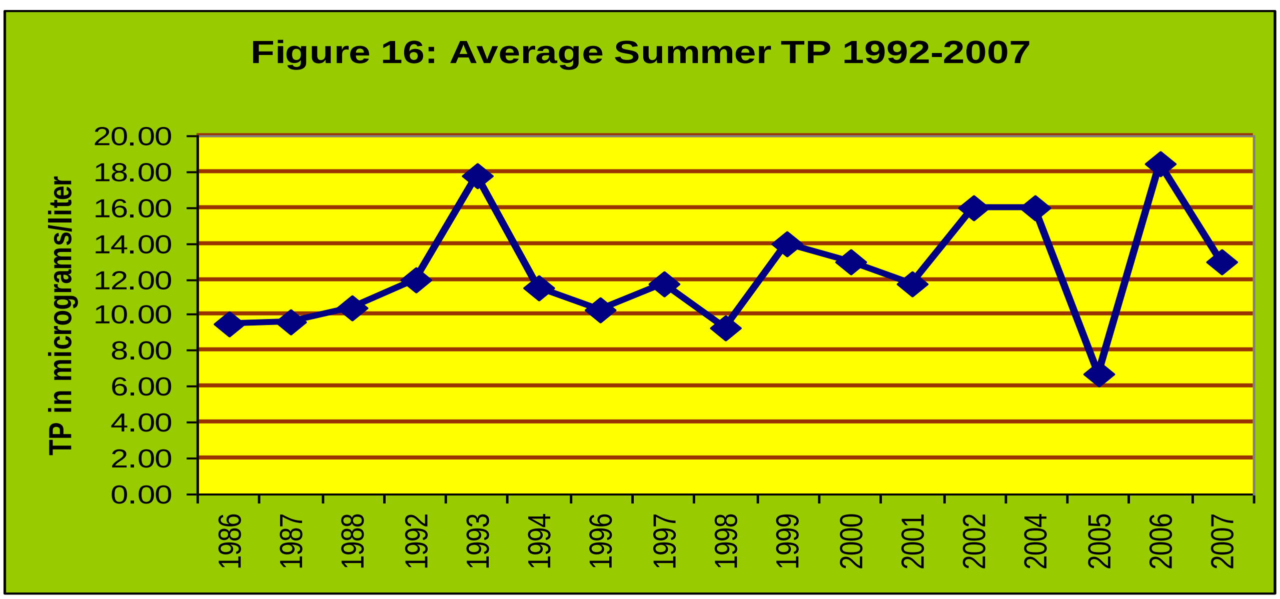
Due to the long history of citizen monitoring and occasional testing by the WDNR, total phosphorus records are available for Jordan Lake back to 1992. Out of 49 samples taken of the epilimnion for total phosphorus levels between 1992 and 2007, only three were higher than the 25 micrograms/liter recommended to avoid algal blooms.







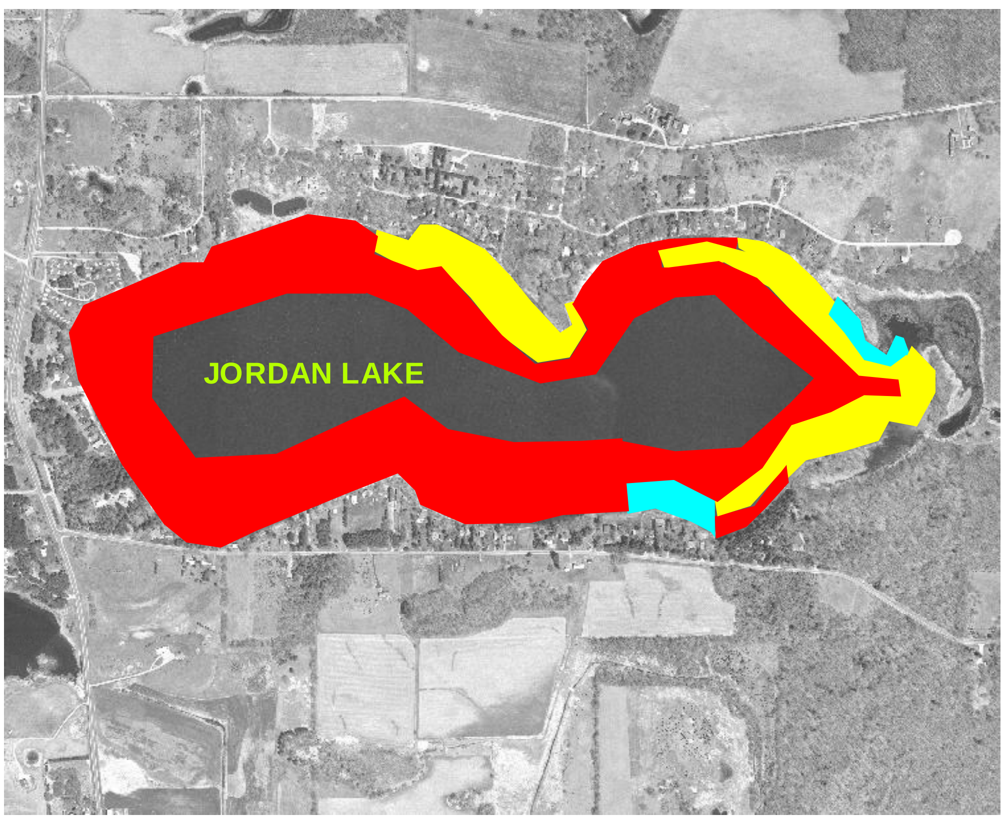
However, a comparison of the average summer phosphorus level in the lower depths of Jordan Lake (50 feet and deeper) to the upper depths (surface to 5 feet) shows that phosphorus concentrations in the lower levels of Jordan Lake are nearly three times more than those from the upper layers of water. This suggests that the lower water depths may be accumulating phosphorus, added to that accumulating in the sediments. This situation should be monitored



As the above graph (Figure 16) indicates, the growing season total phosphorus levels have varied, but stayed below the 25 micrograms/milliliter recommended to avoid nuisance algal blooms. Still, considering that the overall line since 1986 has been showing gradually increased total phosphorus levels for the growing season, phosphorus should continue to be monitored.

In most lakes in Wisconsin, phosphorus concentration in the bottom sediments of the lake is considerably higher than the concentration in the water column itself. Bottom sediments can "bind up" phosphorus, making it unavailable for aquatic plants or algae to use. Some sediment types hold phosphorus at a higher rate than others.

Figure 17: Sediments in Jordan lake



RE:11/06

Hard Sediments | Mixed Sediments | Soft Sediments

N W E S

Most of the littoral zone of Jordan Lake has sand as its sediment. However, the deeper areas were mined for marl in the past. "Marl" is a calcium carbonate precipitate (solid) that forms in hard water lakes when both calcium and pH levels are high. Marl can be good for a lake because it has a high capacity to bind phosphorus, as well as other nutrients. Jordan Lake may benefit from the marl removing phosphorus from water column, thus making it unavailable for algal and aquatic plant growth.

How much a marl sediment affects aquatic plant and algal growth will depend on where the marl sediment is located, i.e., if the aquatic plants are rooted in the marl, so that they can still draw phosphorus from it, the presence of marl may not reduce aquatic plant growth. Effect will also depend on how much phosphorus the marl has already absorbed. In 80% of Wisconsin's lakes, phosphorus is the key nutrient that determines the amount of algae and aquatic plant growth. Since nearly all of the marl in Jordan Lake is in the deeper areas of the lake, the marl sediment probably offers more protection against nuisance algal growth than aquatic plant growth.

Groundwater testing of various wells around Jordan Lake was done by Adams County LWCD and included a test one year for total phosphorus levels in the groundwater coming into the lake. The average TP level in the wells tested was 18 micrograms/ liter, just a little higher than the summer lake surface water results. This phosphorus may also seep into Jordan Lake, but would add little to the overall level.

Land use plays a major role in phosphorus loading. A key component of the computer models used is the phosphorus budget, that is, the estimated amount of phosphorus delivered to the lake from each land use type annually. The land uses that contribute the most phosphorus are non-irrigated agriculture and residences. Using the current land use data, as well as phosphorus readings from 2004 through 2006 water sampling, a phosphorus loading prediction model was run for Jordan Lake. The current results are shown in the table below:

Figure 18: Current Phosphorus Loading by Land Use

MOST LIKELY PHOSPHORUS LOADING		
BY LAND USE		lbs
	%	current
Agriculture--Non Irrigated	33.1%	365.20
Agriculture--Irrigated	24.1%	266.20
Grassland/Pasture	2.6%	28.60
Residential	15.3%	169.40
Other Water	2.1%	22.00
Woodland	4.4%	48.40
Groundshed	10.5%	116.60
Lake Surface	2.6%	28.60
Septic	5.3%	58.08
total in pounds/year	100.0%	1103.08

Phosphorus deposits such as that from flooded wetlands or from atmospheric deposition cannot be controlled by humans. However, some phosphorus (and other nutrient) input can be decreased or increased by changes in human land use patterns. Practices such as shoreland buffer restoration; infiltrating stormwater runoff from roof tops, driveways and other impervious surfaces; using no phosphorus lawn fertilizers; and reducing phosphorus input to and properly managing septic systems will minimize phosphorus inputs into the lake. Circumstances such as increased impervious surface, lawns mowed to water's edge, disturbance of shore areas, improperly-functioning septic systems and removal of native vegetation can greatly increase the volume and content of runoff—and thus increase the volume of phosphorus entering the lake. Many of these practices can also increase the concentration of phosphorus entering the lake, by runoff or other methods of entry.

The models were run using not only the current known phosphorus readings in the lake, but also representing decreases or increases of human-controlled phosphorus input by 10%, 25%, and 50%. Results are shown in Figure 20. The figures may not seem like much---until you calculate that one pound of phosphorus can result in up to 500 pounds of algae. A 10% reduction in these three areas could result in 97.75 pounds/ year of phosphorus—or up to 48,775 pounds less of algae per year!

Figure 19: Impact of Phosphorus Reduction

LAND USE	current	-10%	-25%	-50%
Agriculture--Non Irrigated	365.20	328.68	273.90	182.60
Agriculture--Irrigated	266.20	239.58	199.65	133.10
Grassland/Pasture	28.60	28.60	28.60	28.60
Residential	169.40	152.46	127.05	84.70
Other Water	22.00	22.00	22.00	22.00
Woodland	48.40	48.40	48.40	48.40
Groundshed	116.60	104.94	87.45	58.30
Lake Surface	28.60	28.60	28.60	28.60
Septic	58.08	52.27	43.56	29.04
total in pounds/year	1103.08	1005.53	859.21	615.34

Looking at this issue in terms of how much phosphorus readings in the lake might change, based on the computer modeling, looking at in-lake impact perhaps makes it clearer. Figure 16 graphed the eplimnetic summer phosphorus levels in Jordan Lake for 1986-2007. Reducing the amount of input from the surface and ground watersheds results in less nutrient loading into the lake itself. Figure 20 graphs the changes there would be if those levels had been reduced by 10% and 25%. A 10% reduction could have meant from up to 1.8 fewer micrograms/liter of phosphorus in the lake. Reducing the in-lake phosphorus by 25% could result in up to 4.6 fewer micrograms/liter of phosphorus. These predictions make it clear that reducing current phosphorus inputs to the lake are essential to improve, maintain and protect Jordan Lake's health for future generations.

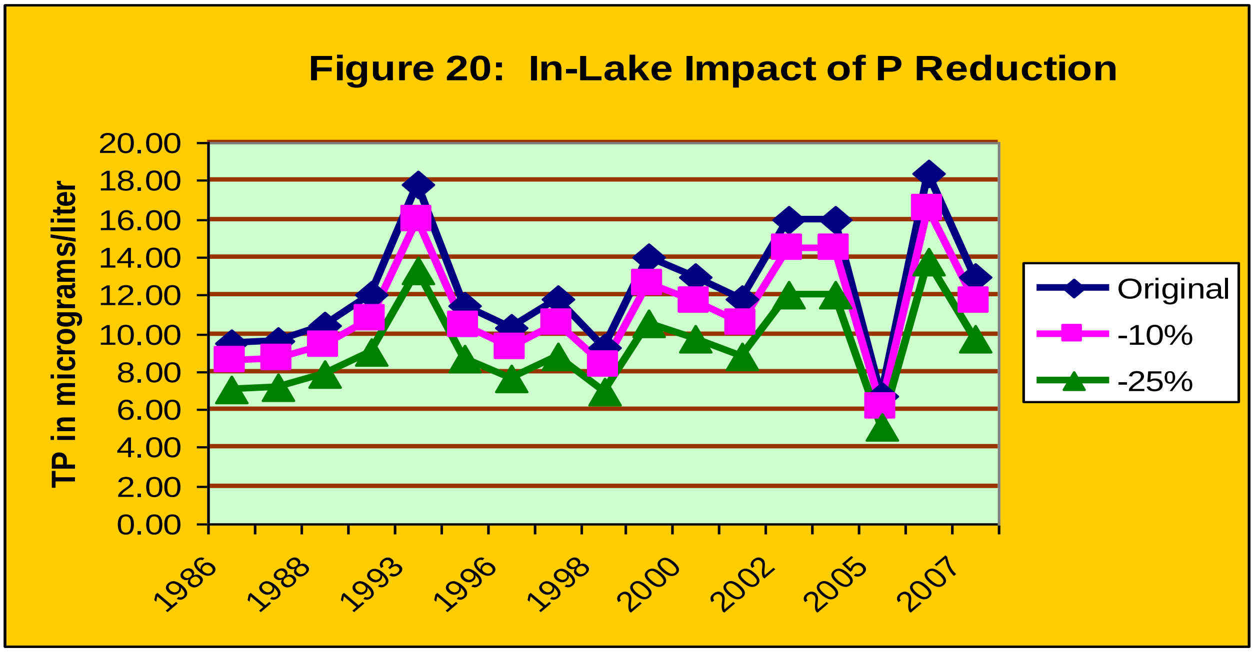
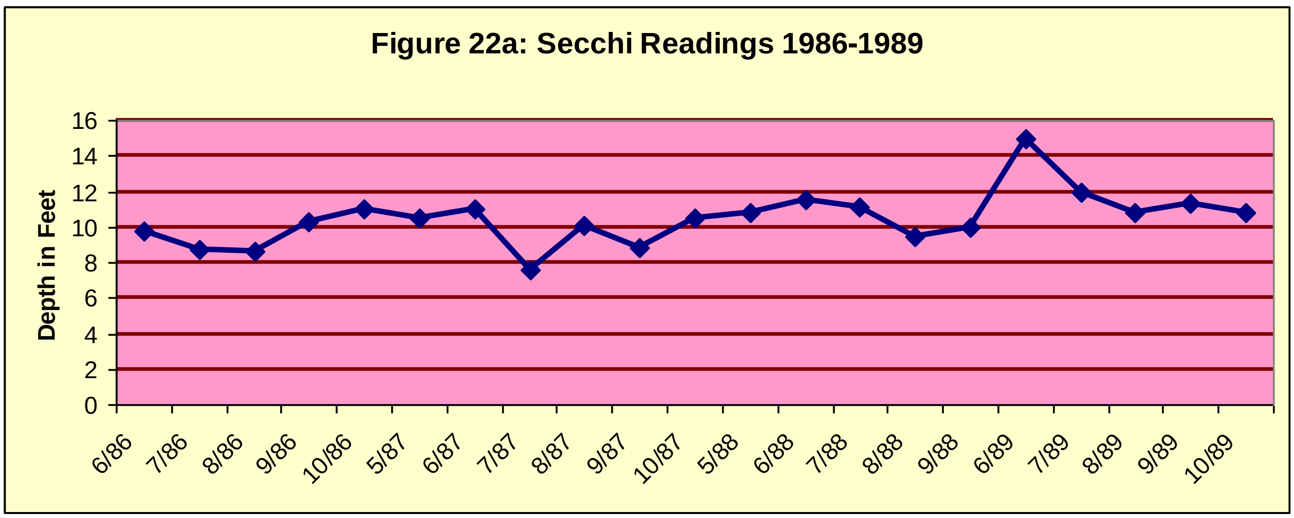
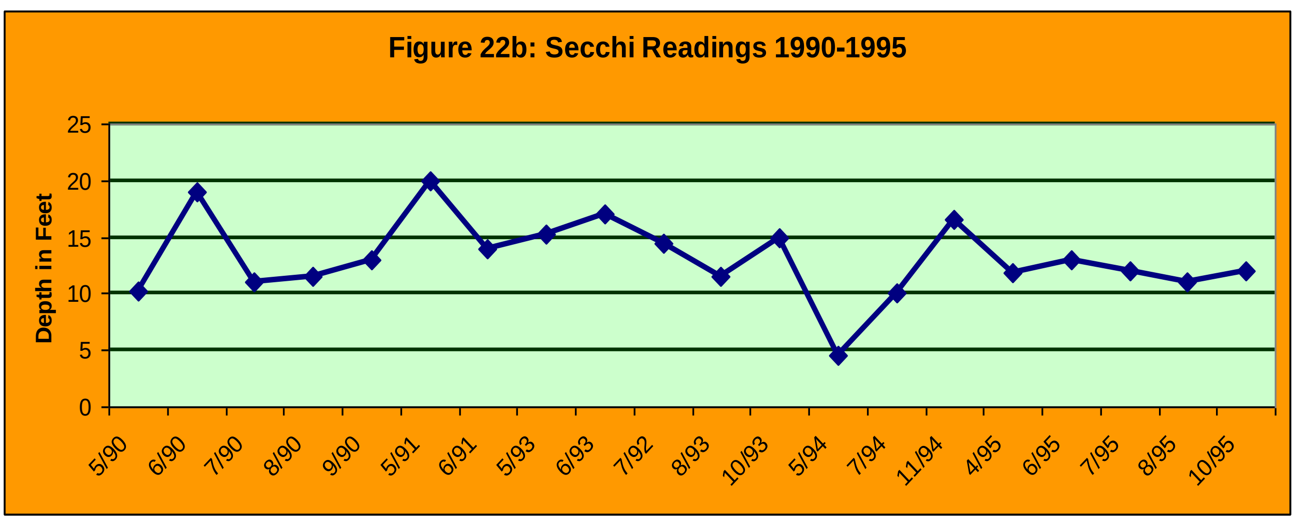


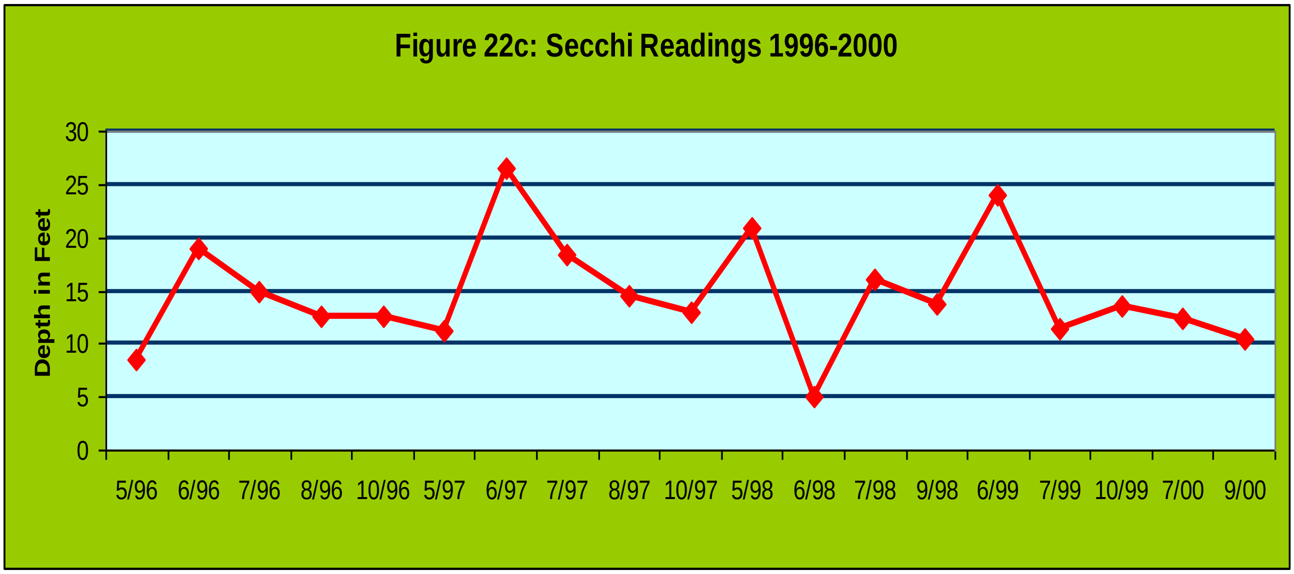
Figure 21: Photo of a Lake with Algal Bloom

Water Clarity

Water clarity is a critical factor for plants. If plants don't get more than 2% of the surface illumination, they won't survive. Water clarity can be reduced by turbidity (suspended materials such as algae and silt) and dissolved organic chemicals that color or cloud the water. Water clarity is measured with a Secchi disk. Average summer Secchi disk clarity in Jordan Lake in 2004-2006 was 11.19 feet. This is very good water clarity, putting Jordan Lake into the "oligotrophic" category for water clarity. Records since 1986 show that the water clarity in Jordan Lake has consistently remained high (see Figures 22 a,b,c,d).







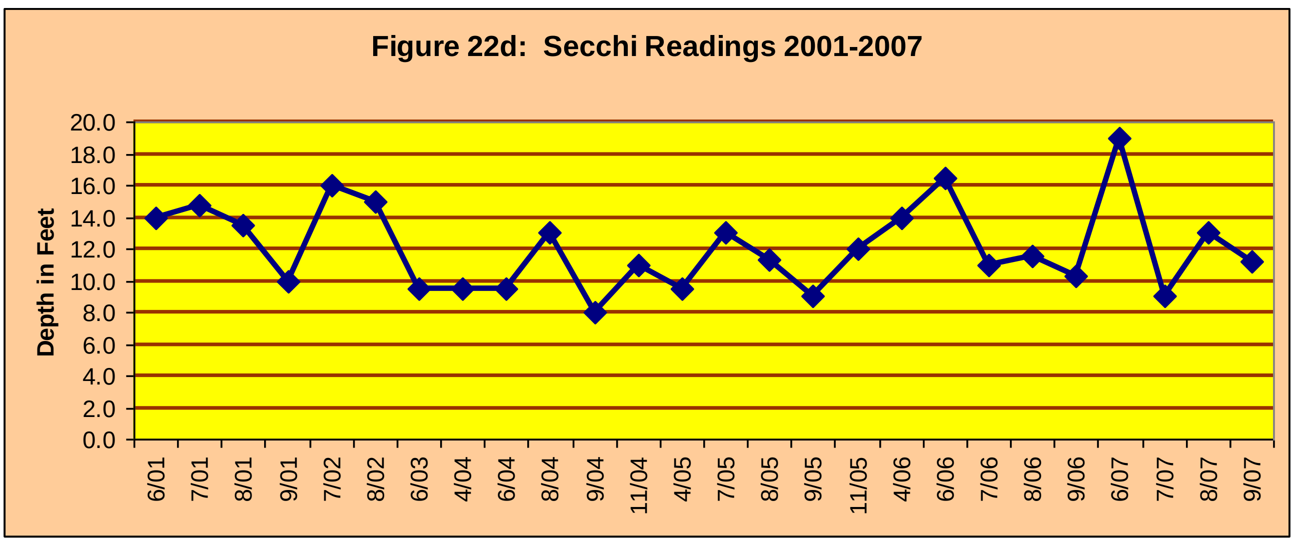


Figure 23 shows the yearly average summer Secchi readings in Jordan Lake between 1986 and 2007 and verifies that water clarity in Jordan Lake has consistently remained "very good" to "excellent". This is one indication that Jordan Lake's water quality remains high, at least in the upper levels of the lake. The overall Secchi disk average for 1986 through 2007 was 12.59 feet.

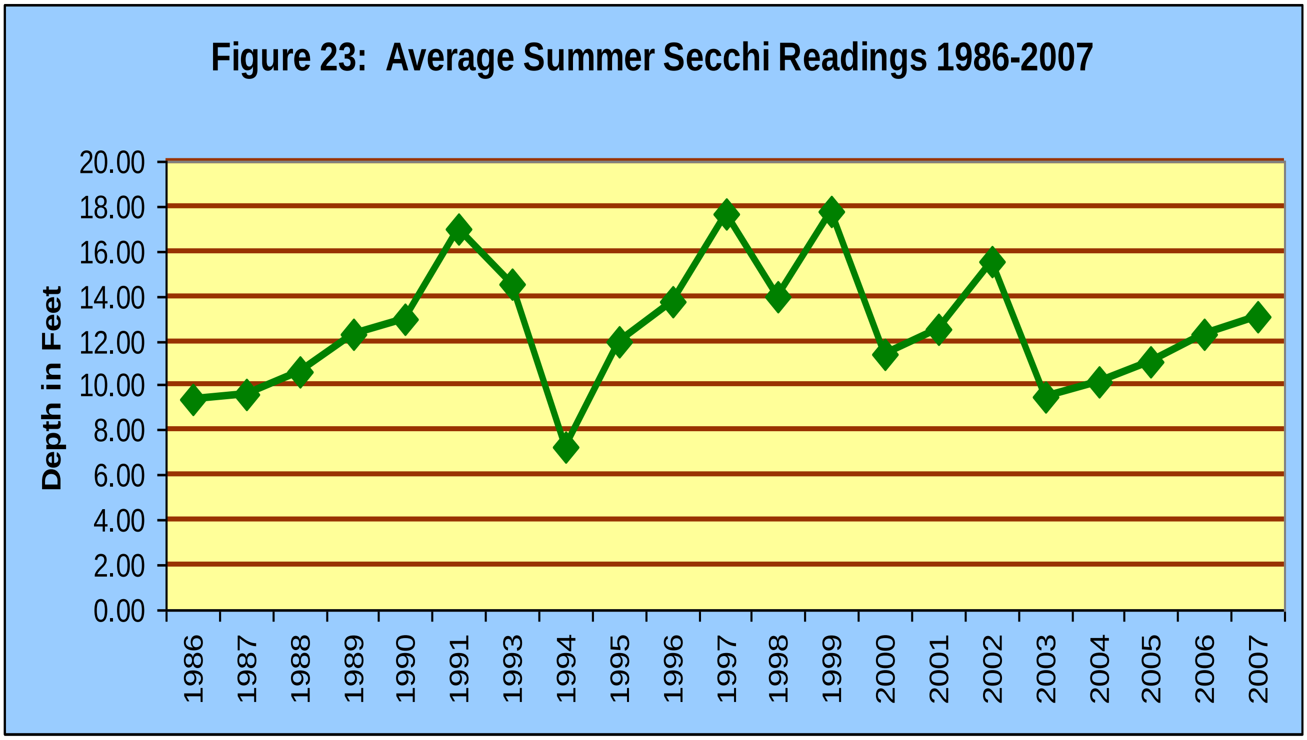


Figure 23: Average Summer Secchi Readings 1986-2007

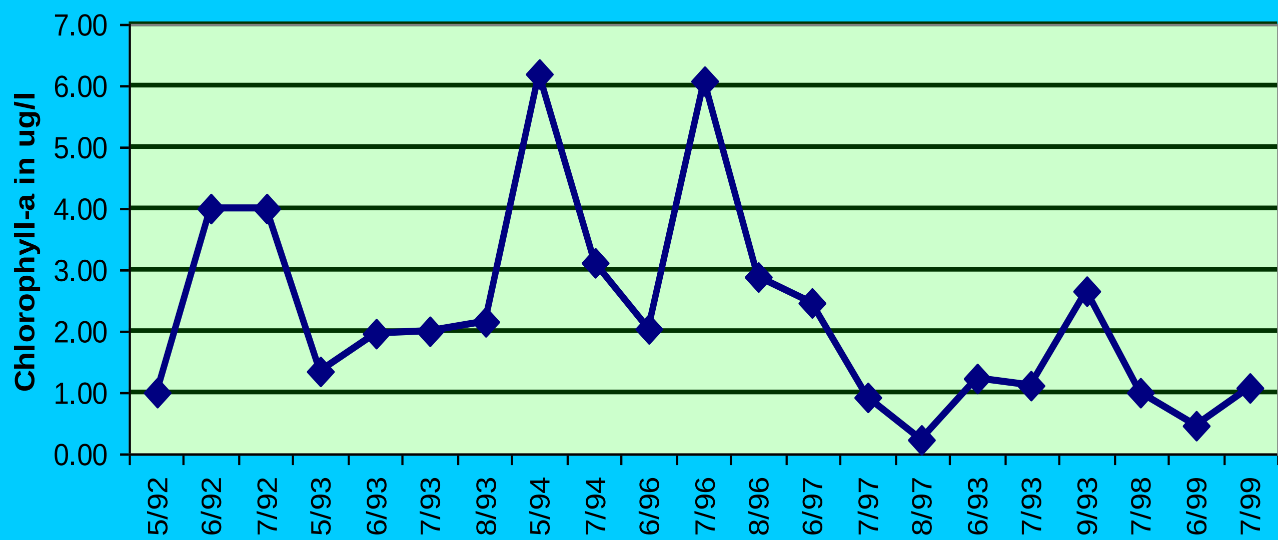
Figure 24: Photo of Testing Water Clarity with Secchi Disk

Chlorophyll a

Chlorophyll-a concentrations provide a measurement of the amount of algae in a lake's water. Algae are natural and essential in lakes, but high algal populations can increase water turbidity and reduce light available for plant growth, as well as result in unpleasing odor and appearance. Studies have shown that the amount of chlorophyll a in lake water depends greatly on the amount of algae present; therefore, chlorophyll-a levels are commonly used as a water quality indicator. The 2004-2006 summer (June-September) average chlorophyll concentration in Jordan Lake was 2.23 micrograms/liter. This low algae concentration places Jordan Lake at the "oligotrophic" level for chlorophyll a results.

Chlorophyll-a averages have stayed low since 1992, the first year for which records were found, and have remained very low through 2007, when the Adams County LWCD was monitoring the lake.

Figure 25a: Summer Chlorophyll-a Levels 1992-1999



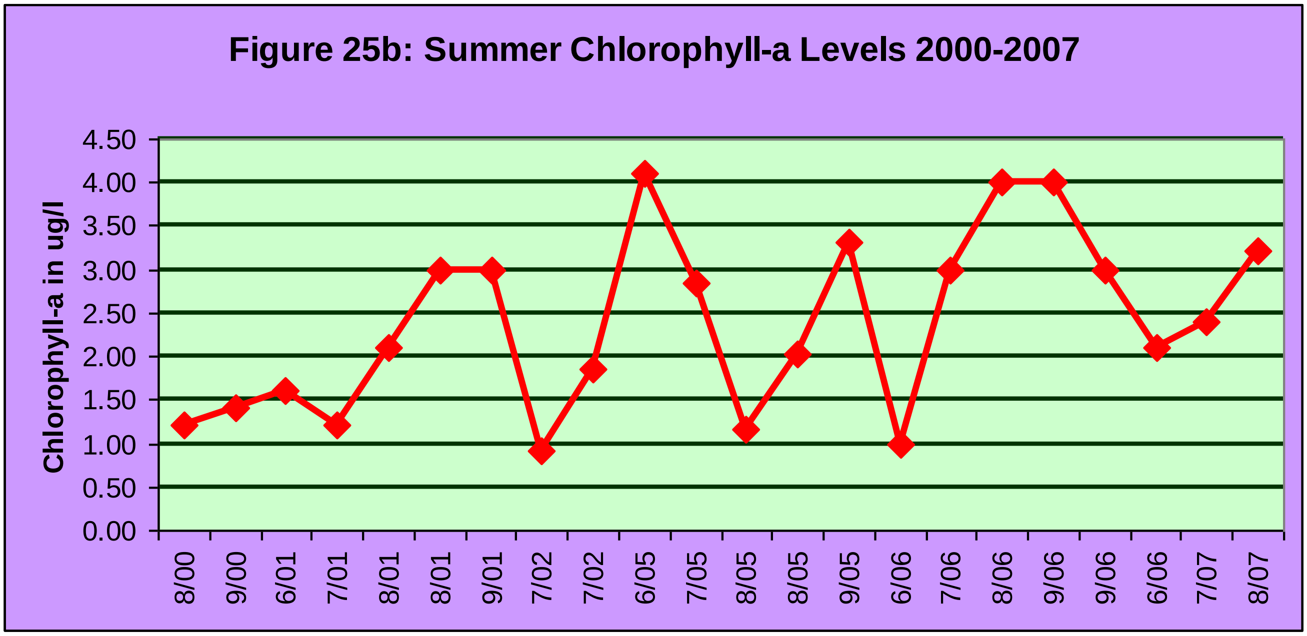
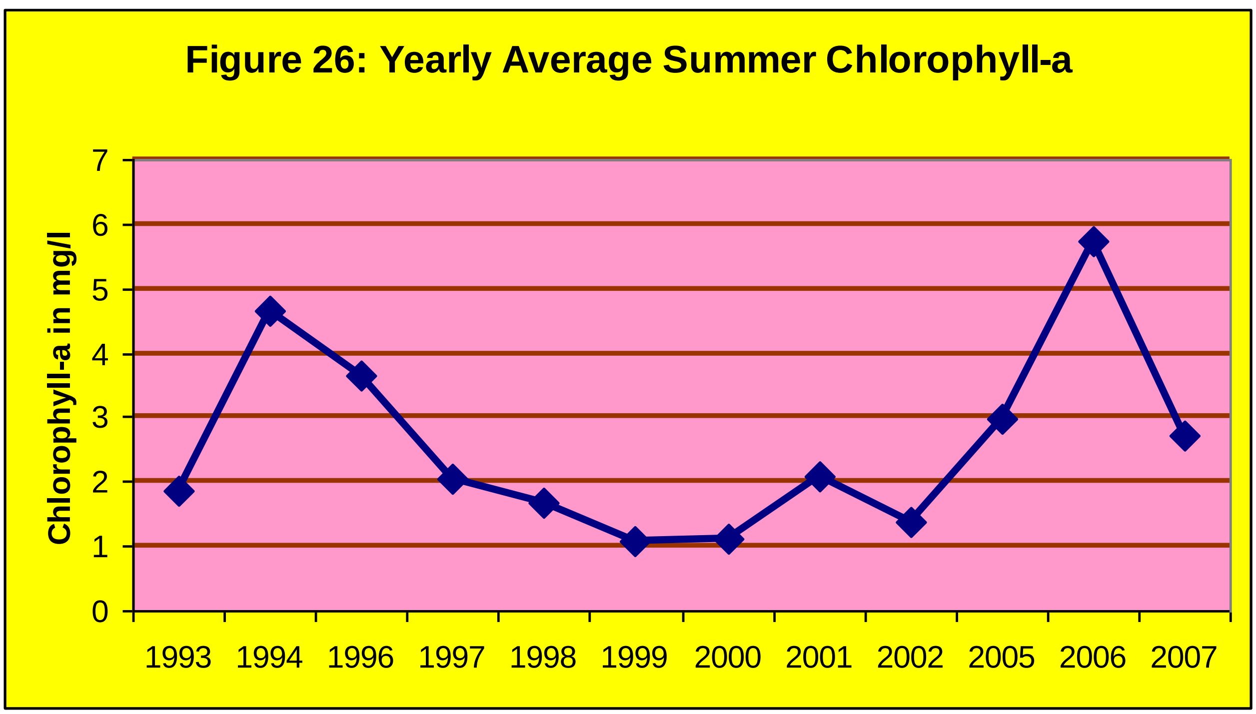


Figure 26 outlines the yearly average levels in summer chlorophyll-a in Jordan Lake from 1993 though 2007. For the entire fourteen years, the average summer chlorophyll-a level in the lake was 2.38 milligrams/liter, a very low level, unlikely to cause algal blooms.

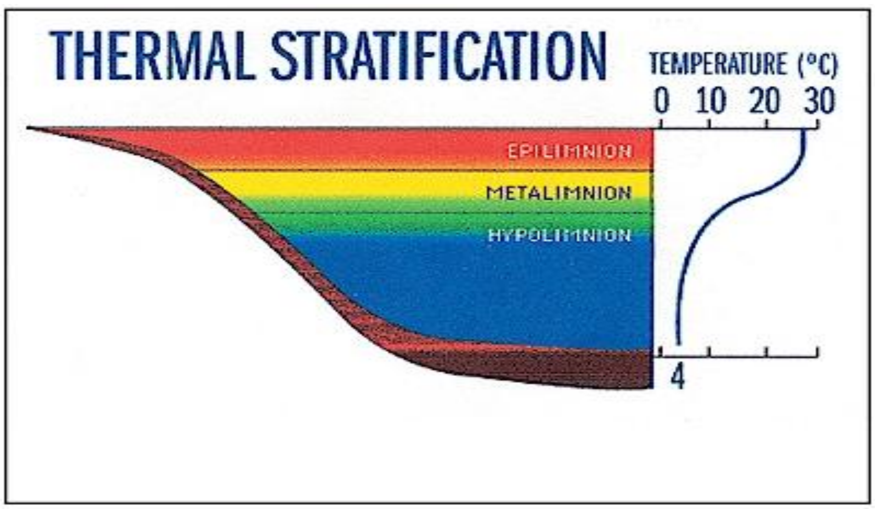


Dissolved Oxygen

Oxygen dissolved in the water is essential to all aerobic aquatic organisms. The oxygen in a lake comes from the atmosphere and from the process of photosynthesis. Aquatic plants and algae consume carbon dioxide and respirate oxygen back into the lake water. The distribution of oxygen within a lake is affected by many factors, including water circulation, water stratification, winds or storms, air temperature; water temperature, nutrient availability, and the density and location of algae and/or aquatic plants. In a deep lake like Jordan Lake, during the spring and fall, the lake turns over, redistributing the nutrients in the water column.

Oxygen consumption in the sediment and the water just above it (hypolimnion) is more sensitive that those in the two upper layers of water (metalimnion and epilimnion) because the bottom consumption is less likely to be balanced by the circulation and photosynthesis output available to the upper layers.

Figure 27: Lake Stratification Layers



Low oxygen during the summer in the bottom waters of a lake occurs naturally as oxygen in the bottom layer is consumed, but not replenished. It is common that as the summer progresses, the oxygen concentration of the bottom waters decreases. In Jordan Lake, there were hypoxic periods in the depths from 30 feet to 50 feet during the summers of 1998, 2000, 2001, 2002, 2004 and 2005. By the end of summer 1998, oxygen concentration at 40 feet depth was only 3.6 mg/l and continued to decrease as depth increased down to .1 mg/l at 70 feet deep. In the summer of 2000, dissolved oxygen levels were 2.8 mg/l at 40 feet; in the summer of 2001, dissolved oxygen levels were down to 3.4 mg/l in 30 feet deep by July and again continued to decrease as the depth increased. Similar patterns were found in 2002, 2004 and 2005. This pattern was not present in other years tested when oxygen levels at all depths were over 5 mg/l (the minimum level for most fish survival).

The charts (Figures 28 a,b,c) below show the annual (2004-2006) variations in dissolved oxygen levels in milligrams/liter, depth in feet and months of the year:

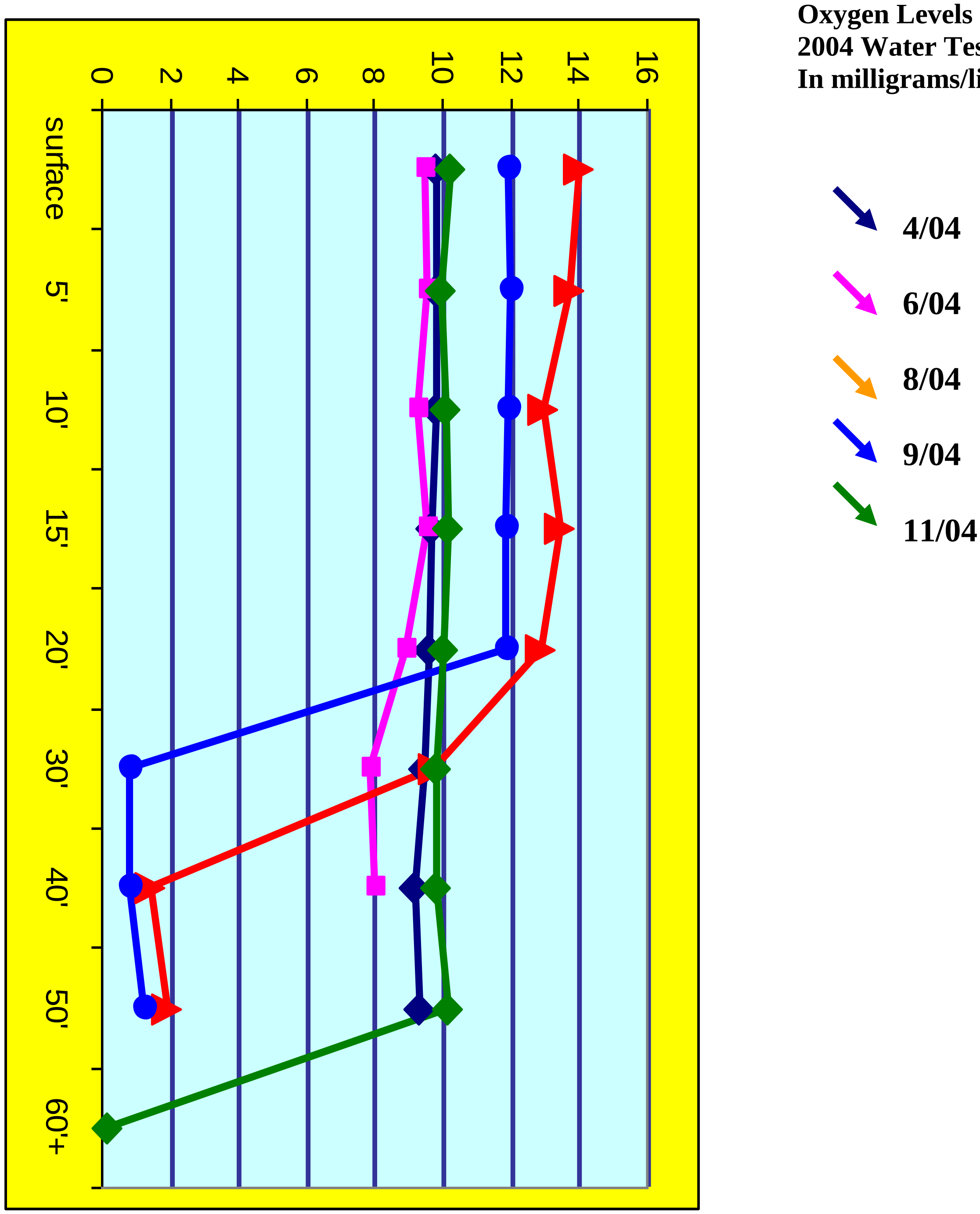


Figure 28a: Dissolved Oxygen Levels During 2004 Water Testing In milligrams/liter

Figure 28b: Dissolved Oxygen Levels During 2005 Water Testing In milligrams/liter

2/05

4/05

6/05

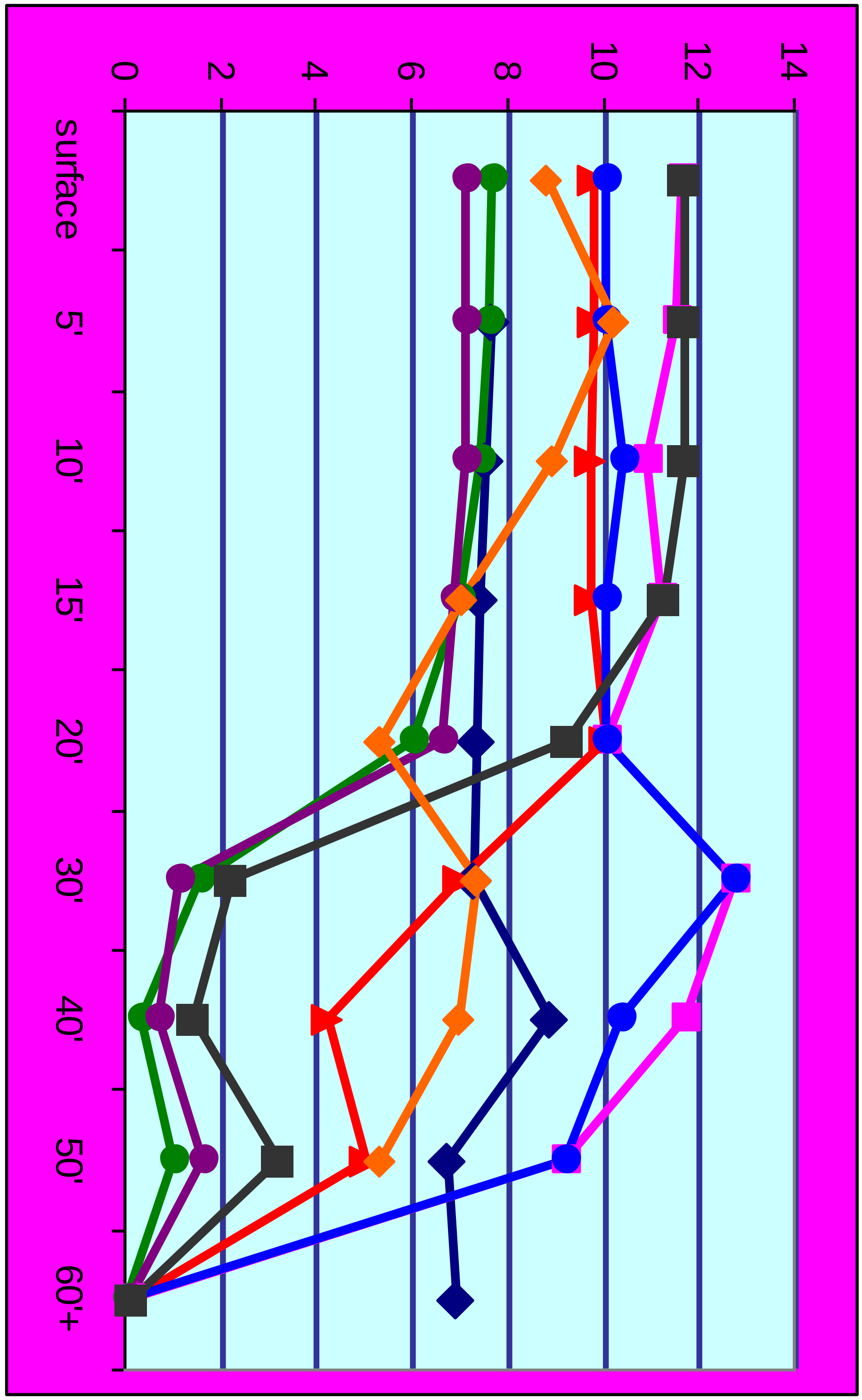
7/05

8/05

8/05

9/05

11/05



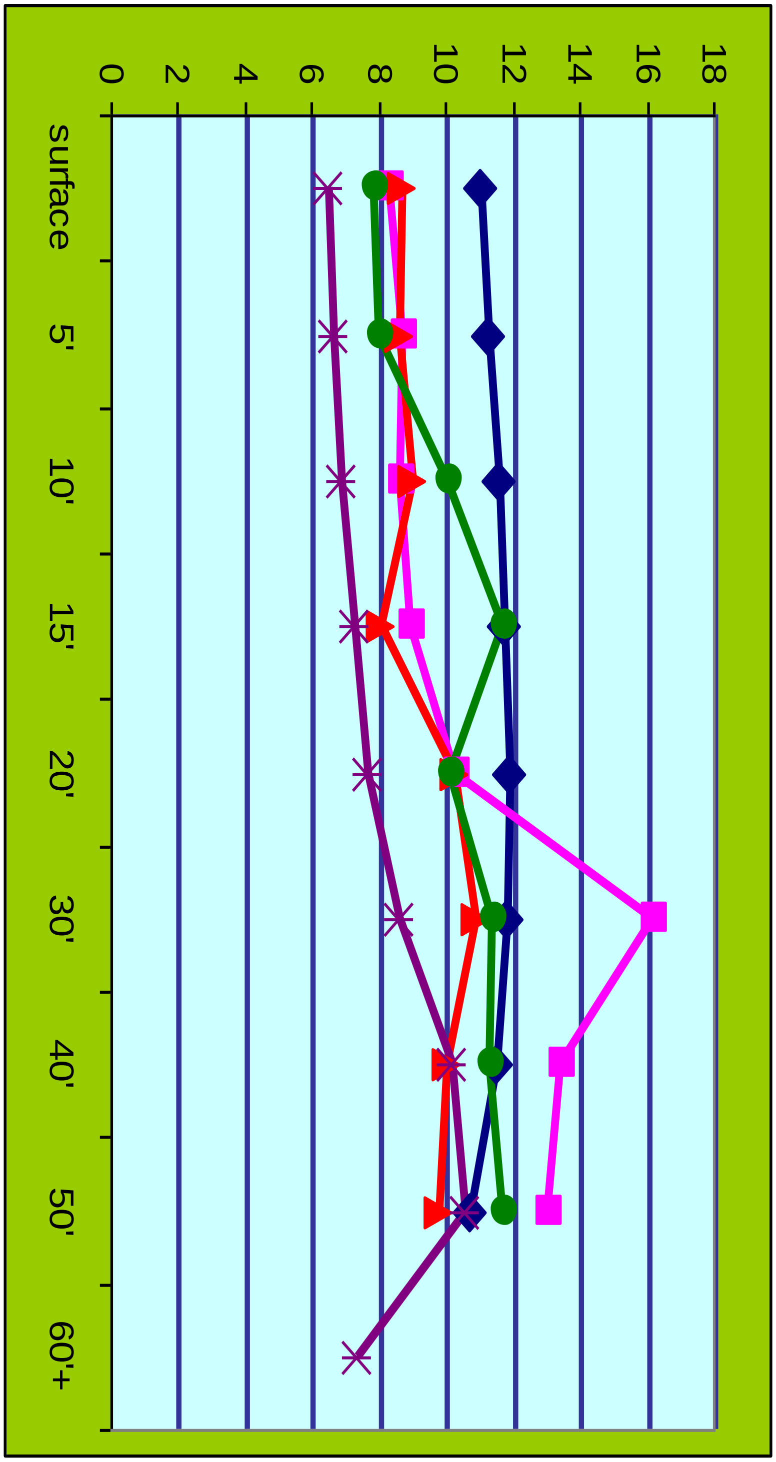


Figure28c: Dissolved Oxygen Levels During 2006 Water Testing In milligrams/liter

4/06

7/06

8/06

9/06

9/06

By autumn, when the surface waters have cooled and water density throughout the water column is the same, the water column mixes vertically, a process known as "fall turnover."

Human activity can aggravate the development of low oxygen (hypoxic) or no oxygen (anoxic) in the bottom waters. For example, the addition of phosphorus usually leads to an increase in the growth of algae and aquatic plants—both of which consume oxygen during their photosynthesis. It has also been hypothesized that hypoxia or anoxia can be affected by climate changes, such as a longer and/or warmer summer, low lake levels, and changes in water temperature due to cover (i.e., shore vegetation) being removed.

The development of hypoxia or anoxia can have negative effects. The first effect usually noticed by human is fish kills. Fish kills result when fish species that need cold oxygen-rich water to survive can't find it in the lake anymore or when some of their invertebrate food (such as mayfly nymphs) is gone due to low oxygen levels. Another noticeable effect can be an increase in the frequency and distribution of algal blooms. In some instances, anoxia can lead to blooms of toxic algae and the production of water-borne toxins that can harm humans and wildlife. Anoxia sometimes also leads to increased phosphorus cycling, undesirable water taste or odor levels, and interference with recreational uses such as swimming, boating and fishing.

As noted above, summer hypoxia or anoxia can result in phosphorus being released into the upper water column and being available for algal blooms and increased aquatic plant growth. The results from 1992 through 2007 show that summer hypoxia/anoxia in the lower depths was an issue in six of the seventeen years of records for Jordan Lake..

The data from 2004-2006 (see Figures 28a, b, c) shows there is potential for phosphorus loading from the lower depths (hypolimnion) during the summer months in Jordan Lake if the hypoxia/anoxia continues. Dissolved oxygen needs to be monitored during the late summer months in the lower depths on Jordan Lake to determine whether hypoxia/anoxia is a frequently-occurring condition that may need to be addressed by management practices.

Water Hardness, Alkalinity and pH

Testing done by Adams County LWCD on Jordan Lake included annual testing for water alkalinity and water hardness. Hardness and alkalinity levels in a lake are affected by the soil minerals, bedrock type in the watershed, and frequency of contact between lake water & these materials.

Level of Hardness	Mg/l CaCO3
SOFT	0-60
MODERATELY HARD	61-120
HARD	121-180
VERY HARD	>180

Figure 29: Levels of Hardness in Mg/l of Calcium Carbonate

One method of evaluating hardness is to test the water for the amount of calcium carbonate (CaCO3) it contains. The surface water of all of the public access lakes in Adams County have water that is moderately hard to very hard, whether they are impoundments (man-made lakes) or natural lakes. In 2005 and 2006, random samples were also taken of wells around Jordan Lake to measure the hardness of the water coming into the lake through groundwater. Hardness in the groundwater ranged from 242 (very hard) to 424 (very hard). Surface water in Jordan Lake has a much lower hardness average of 119.71 mg/l CaCO3, varying from 112 to 129. The hardness in both surface and groundwater is likely due to the underlying bedrock in Adams County, which is mostly sandstone with pockets of dolomite and shale.

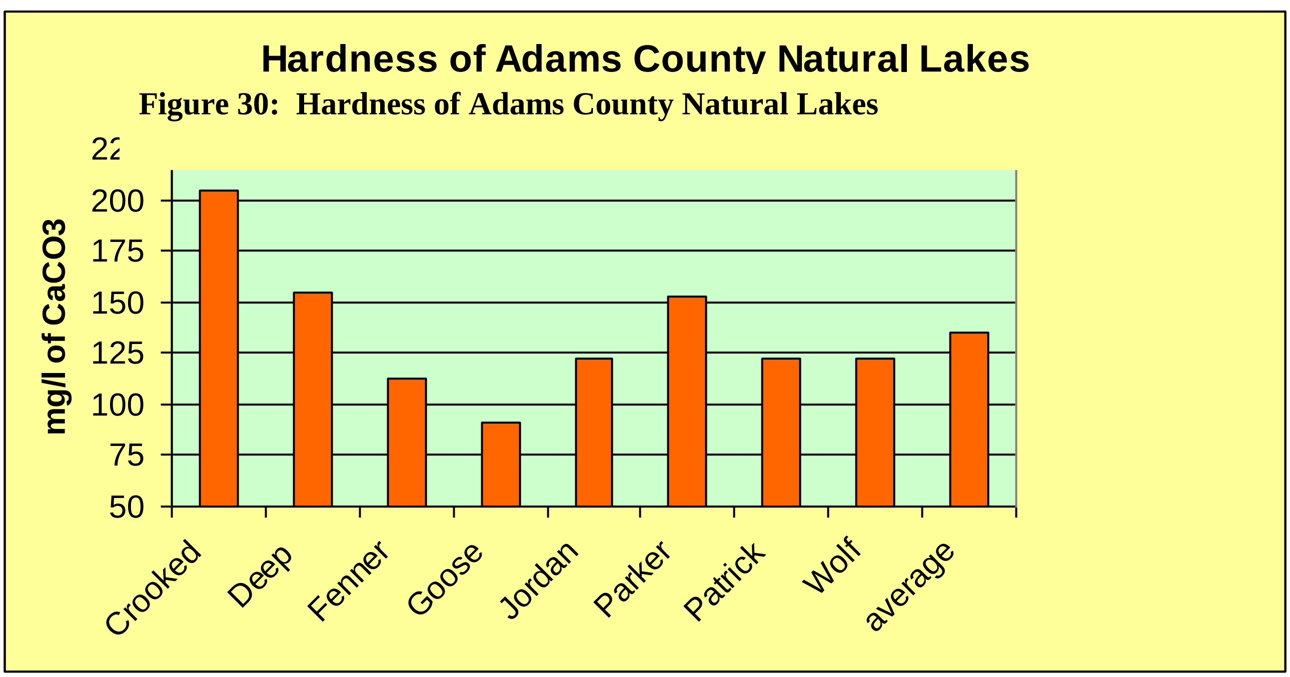


Figure 30: Hardness of Adams County Natural Lakes

As the graph (Figure 30) shows, Jordan Lake surface water testing results showed "moderately" water (119.21 mg/l CaCO3), although Jordan Lake's hardness is less than the hardness average for the natural lakes in Adams County of 135.25 mg/l of Calcium Carbonate. Hard water lakes tend to produce more fish and aquatic plants than soft water lakes because they are often located in watersheds with soils that load phosphorus into the lake water.

However, hard water lakes also often have marl sediments that precipitate the phosphorus out, serving to help balance the phosphorus loaded from the watershed. Hardness levels over 180 mg/l can cause marl to start precipitating out of the water or sediment, thus releasing phosphorus for aquatic plant and algae use. But since Jordan Lake's hardness less is far below that, the marl in the lake is likely to keep binding a significant amount of phosphorus that would otherwise be in the water column.

Alkalinity is important in a lake to buffer the effects of acidification from the atmosphere. "Acid rain" has long been a problem with lakes that had low alkalinity level and high potential sources of acid deposition. Surface water alkalinity testing of Jordan Lake ranged from 116 milliequivalents/liter to 120 milliequivalents/liter with an average of 117.29 milliequivalents/liter.

Acid Rain Sensitivity	ueq/l CaCO3
High	0-39
Moderate	49-199
Low	200-499
Not Sensitive	>500

Figure 31: Acid Rain Sensitivity

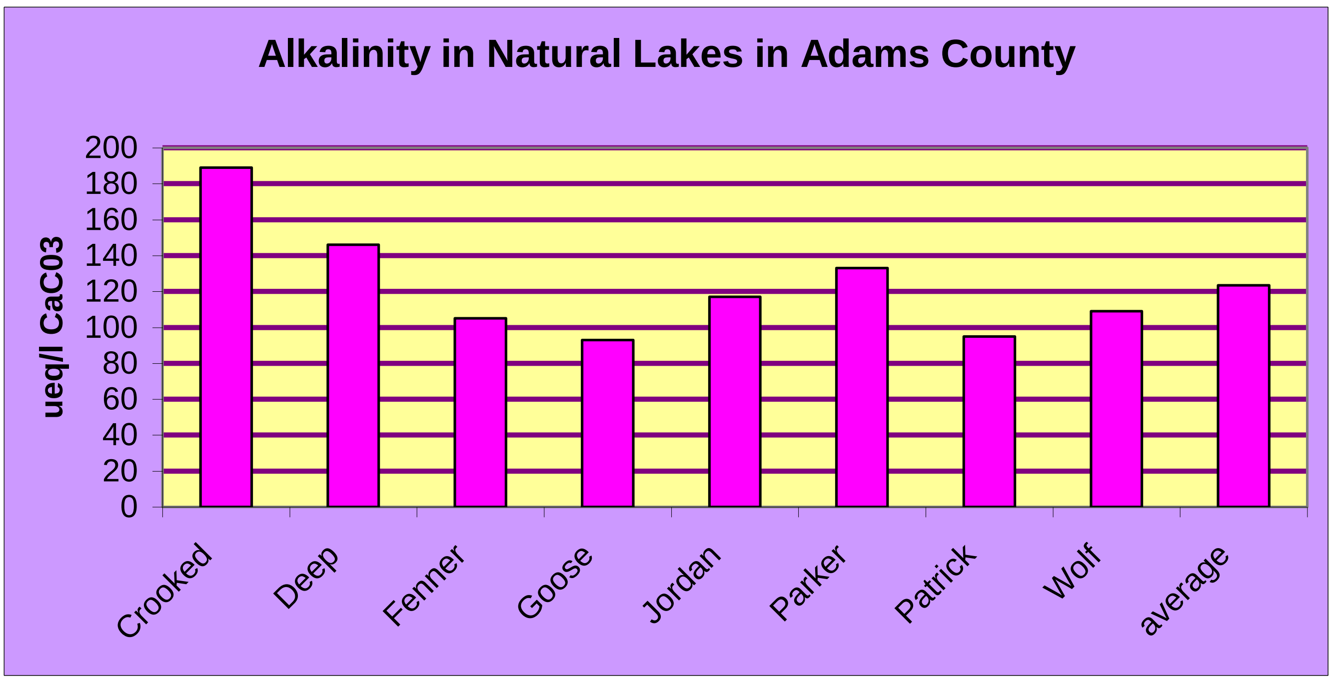
Well water testing results ranged from 120 milliequivalents/liter to 396 milliequivalents/liter in alkalinity, averaging 123.38 ueq/l, somewhat higher than the surface water results. Jordan Lake's potential sensitivity to acid rain is moderate, but luckily for Adams County, the acid deposition rate is very low, probably due to the little industrialization in the county.

Alkalinity also affects the pH level of lake water. The acidity level of a lake's water regulates the solubility of many minerals. A pH level of 7 is neutral. The pH level in Wisconsin lakes ranges from 4.5 in acid bog lakes to 8.4 in hard water, marl lakes.

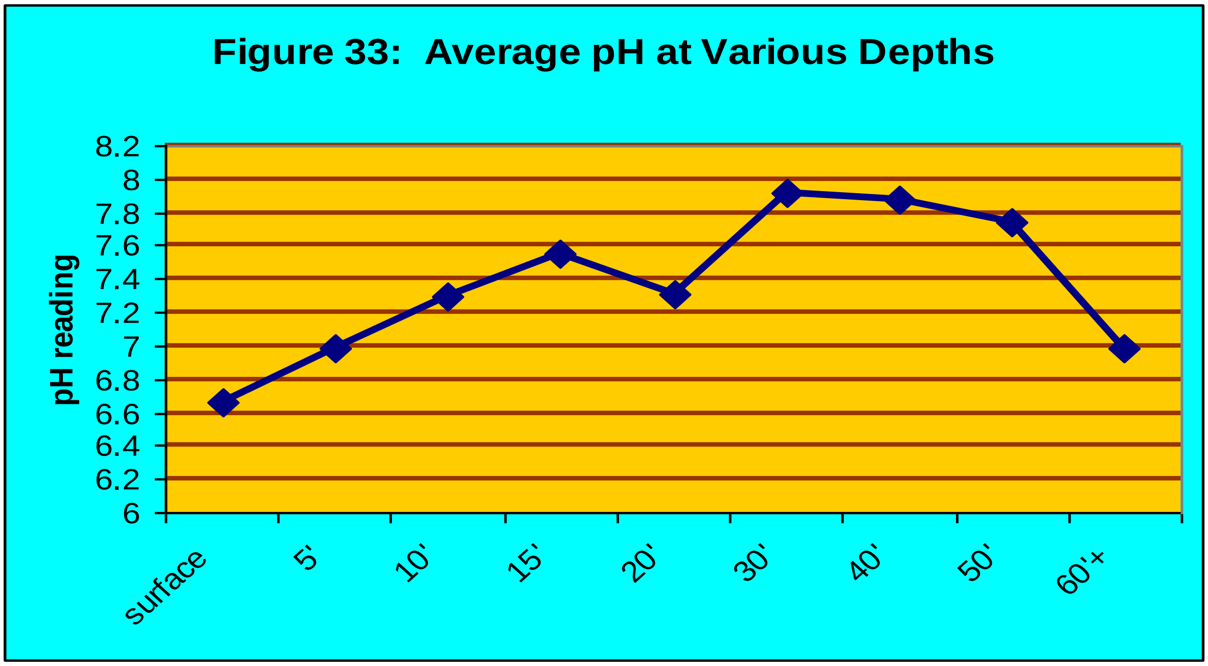
Some of the minerals that become available under low pH, especially the metals aluminum, zinc and mercury, can inhibit fish reproduction and/or survival. Even what seems like a small variance in pH can have large effects because the pH scale is set up

so that every 1.0 unit change increases acidity tenfold, i.e., water with a pH of 7 is 10 times more acid than water with pH of 8. Mercury and aluminum are not only toxic to many kinds of wildlife; they can also be toxic to humans, especially those that eat tainted fish.

Figure 32: Alkalinity in Natural Lakes in Adams County



The testing occurring from 2004-2006 also included regular monitoring of the pH at several depths in Jordan Lake. Unlike many lakes in Adams County that start at about neutral at the bottom and raise in pH to over neutral, Jordan Lake has pH levels starting at just under neutral (6.98) at 60'+ depth, then increasing in alkalinity as the depth gets less, then starting down again in pH until the surface water pH averages 6.66. A lake's pH level is important for the release of potentially harmful substances and also affects plant growth, fish reproduction and survival. Most plants grow best at pH levels between 5.5 and 8.



More importantly for many lakes, fish reproduction and survival are very sensitive to pH levels. The chart below indicates the effect of pH levels under 6.5 on fish (Figure 34):

Figure 34: Effects of pH Levels on Fish

Water pH	Effects
6.5	walleye spawning inhibited
5.8	lake trout spawning inhibited
5.5	smallmouth bass disappear
5.2	walleye & lake trout disappear
5	spawning inhibited in most fish
4.7	Northern pike, sucker, bullhead, pumpkinseed, sunfish & rock bass disappear
4.5	perch spawning inhibited
3.5	perch disappear
3	toxic to all fish

A lake with a neutral or slightly alkaline pH like Jordan Lake is a good lake for fish and plant survival. Natural rainfall in Wisconsin averages a pH of 5.6. This means that if the rain falls on a lake without sufficient alkalinity to buffer that acid water coming in by rainfall, the lake's fish cannot reproduce. That is not a problem at Jordan Lake.

Other Water Quality Testing Results

CALCIUM and MAGNESIUM: Calcium is required by all higher plants and some microscopic lifeforms. Magnesium is needed by chlorophyllic plants and by algae, fungi and bacteria. Both calcium and magnesium are important contributors to the hardness of a lake's waters. Magnesium elevated about 125 mg/l may have a laxative effect on some humans. Otherwise, no health hazards to humans and wildlife are known from calcium and magnesium. The average Calcium level in Jordan Lake's water during the testing period was 38.65 mg/l. The average Magnesium level was 40.58 mg/l. Both of these are low-level readings.

CHLORIDE: Chloride does not affect plant and algae growth and is not known to be harmful to humans. It isn't common in most Wisconsin soils and rocks, so is usually found only in very low levels in Wisconsin lakes. However, the presence of a significant amount of chloride over a period of time indicates there may be negative human impacts on the water quality present from septic system failure, the presence of fertilizer and/or waste, deposition of road-salt, and other nutrients. An increased chloride level is thus an indication that too many nutrients are entering the lake, although the level has to be evaluated compared to the natural background data for chloride. The chloride levels found in Jordan Lake during the testing period were all below 3 mg/l (average 2.11 mg/l), or just under the natural level of chloride in this area of Wisconsin.

NITROGEN: Nitrogen is necessary for plant and algae growth. A lake receives nitrogen in various forms, including nitrate, nitrite, organic, and ammonium. In Wisconsin, the amount of nitrogen in a lake's water often corresponds to the local land use. Although some nitrogen will enter a lake through rainfall from the atmosphere, that coming from land use tends to be in higher concentrations in larger amounts, coming from fertilizers, animal and human wastes, decomposing organic matter, and surface runoff. For example, the growth level of the exotic aquatic plant, Eurasian Watermilfoil (*Myriophyllum spicatum*) has been correlated with fertilization of lake sediment by nitrogen-rich spring runoff.

Nitrogen levels can affect other aspects of water quality. The sum of water testing results for nitrate, nitrite and ammonium levels of over .3 mg/l in the spring can be used to project the likelihood of an algal bloom in the summer (assuming sufficient phosphorus is also present). Jordan Lake combination spring levels from 1998 to 2006 never rose to more than .37 mg/l, just above the .3 mg/l predictive level for nitrogen-related algal blooms. If nitrogen-related algal blooms occur, they may be localized in areas of higher nitrogen levels.

SODIUM AND POTASSIUM: These elements occur naturally only in low levels in Wisconsin waters and soils. Their presence may indicate human-caused pollution. Sodium is found with chloride in many road salts and fertilizers and is also found in human and animal waste. Potassium is found in many fertilizers and also found in animal waste. The level of these two is generally not useful as a specific pollution indicator, but increasing levels or one or both of these elements can indicate possible contamination from damaging pollutants. High levels of sodium have also been found to influence the development of a large population of cyanobacteria, some of which can be toxic to animals and humans. Some health professionals have suggested that sodium levels over 20 mg/l may be harmful to heart and kidney patients if ingested.

Both sodium and potassium levels in Jordan Lake are very low: the average sodium level was 2.56 mg/l; the average potassium reading was .1.56 mg/l.

SULFATE: In low-oxygen waters (hypoxic), sulfate can combine with hydrogen and becomes the gas hydrogen sulfate, which smells like rotten eggs and is toxic to most aquatic organisms. Sulfate levels can also affect the metal ions in the lake, especially iron and mercury, by binding them up, thus removing them from the water column. To prevent the formation of hydrogen sulfate, levels of 10 mg/l are best. A health advisory kicks in at 30 mg/l. Jordan Lake sulfate levels averaged 2.65 mg/l during the testing period, far below either level.

TURBIDITY: Turbidity reflects water clarity. The term refers to suspended solids in the water column—solids that may include clay, silt, sand, plankton, waste, sewage and other pollutants. Turbid water may mask the presence of bacteria or other pollutants because the water looks murky or muddy. In general, turbidity readings of less than 5 NTU are best. Very turbid waters may not only smell, but also tend to be aesthetically displeasing, thus curtailing recreational uses of the water. Turbidity levels for Jordan Lake’s waters were 2.08 NTU in 1992; 2.03 NTU in 2004, 2.49 NTU in 2005, and 2.59 NTU in 2006—all low levels.

Figure 35: Examples of Very Turbid Water

HYDROLOGIC BUDGET

Jordan Lake has a surface area of 215 acres. The most recent bathymetric (depth) map is from 1941 and indicates a maximum depth of 85 feet. Recent testing on the lake and known increased water levels suggest that the maximum depth is closer to 100 feet, with an average depth of 25.7 feet, and a lake volume of 5525.5 acre-feet.

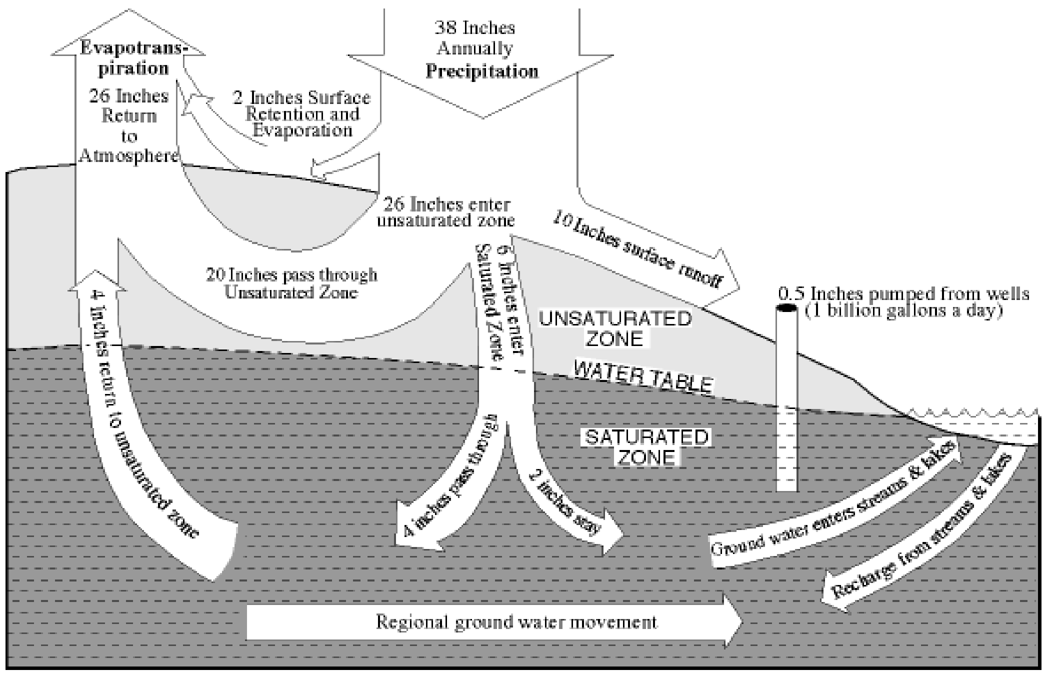
A "hydrologic budget" is an accounting of the inflow to, outflow from and storage in a hydrological unit (such as a lake). "Residence time" is the average length of time particular water stays within a lake before leaving it. This can range from several days to years, depending on the type of lake, amount of rainfall, and other factors. "Flushing rate" is the time it takes a lake's volume to be replaced. "Annual runoff volume", as used in WiLMS, is the total water yield from the drainage area reaching the lake. The "drainage area" is the amount of area (in acres) contributing surface water runoff and nutrients to the lake. The "areal water load" is the total annual flow volume reaching the lake divided by the surface area of the lake. "Hydraulic loading" is the total annual volume of all water sources (including precipitation, non-point sources & point sources) loading into the lake.

Using the data gathered from historical testing and that done by the Adams County LWCD from 2004-2006, the WiLMS model calculated the tributary drainage area for Jordan Lake as 6869.5 acres. The average unit runoff for Adams County in the Jordan Lake area is 9.4 inches. WiLMS determined the expected annual runoff volume as 5381.1 acre-feet/year. Anticipated annual hydraulic loading is 5427.7 acre-feet/year. Areal water load is 25.2 feet/year.

In a seepage lake like Jordan Lake, water and its nutrient load tend to stay longer within the lake before leaving it than in a lake with an inlet and/or outlet—in Jordan Lake's case, modeling estimates a water residence of 1.02 years. The calculated lake flushing rate is .0.98 1/year.

Figure 36: Jordan Lake Bathymetric Map

Figure 37: Example of Hydrologic Budget



TROPHIC STATE

The trophic state of a lake is one measure of water quality, basically defining the lake's biological production status. (See Figure 38). **Eutrophic lakes** are very productive, with high nutrient levels, frequent algal blooms and/or abundant aquatic plant growth. **Oligotrophic lakes** are those low in nutrients with limited plant growth and small populations of fish. **Mesotrophic lakes** are those in between, i.e., those which have increased production over oligotrophic lakes, but less than eutrophic lakes; those with more biomass than oligotrophic lakes, but less than eutrophic lakes; often with a more varied fishery than either the eutrophic or oligotrophic lakes. In comparing water quality testing results with the prediction from the computer modeling of this modeling with the actual figures outlined above, the actual Trophic State of Jordan Lake is what was predicted from the modeling. Modeling results predicted that the overall TSI for Jordan Lake would be **41**. This score places Jordan Lake's overall TSI at below the overall average of 43.88 for natural lakes in Adams County (in the case of TSI, the lower the score, the better).

Figure 38: Trophic Status Table

Jordan Lake = 41 →

Score	TSI Level Description
30-40	**Oligotrophic:** clear, deep water; possible oxygen depletion in lower depths; few aquatic plants or algal blooms; low in nutrients; large game fish usual fishery
40-50	**Mesotrophic:** moderately clear water; mixed fishery, esp. panfish; moderate aquatic plant growth and occasional algal blooms; may have low oxygen levels near bottom in summer
50-60	**Mildly Eutrophic:** decreased water clarity; anoxic near bottom; may have heavy algal bloom and plant growth; high in nutrients; shallow eutrophic lakes may have winterkill of fish; rough fish common
60-70	**Eutrophic:** dominated by blue-green algae; algae scums common; prolific aquatic plant growth; high nutrient levels; rough fish common; susceptible to oxygen depletion and winter fishkill
70-80	**Hypereutrophic:** heavy algal blooms through most of summer; dense aquatic plant growth; poor water clarity; high nutrient levels

Phosphorus concentration, chlorophyll-a concentration and water clarity data are collected and combined to determine a trophic state. As discussed earlier, the average summer epilimnetic total phosphorus for Jordan Lake was 15 micrograms/liter. The average summer chlorophyll-a concentration was 2.23 milligrams/liter. Growing season water clarity averaged a depth of 11.19 feet. Figure 40 shows where each of these measurements from Jordan Lake fall in trophic level.

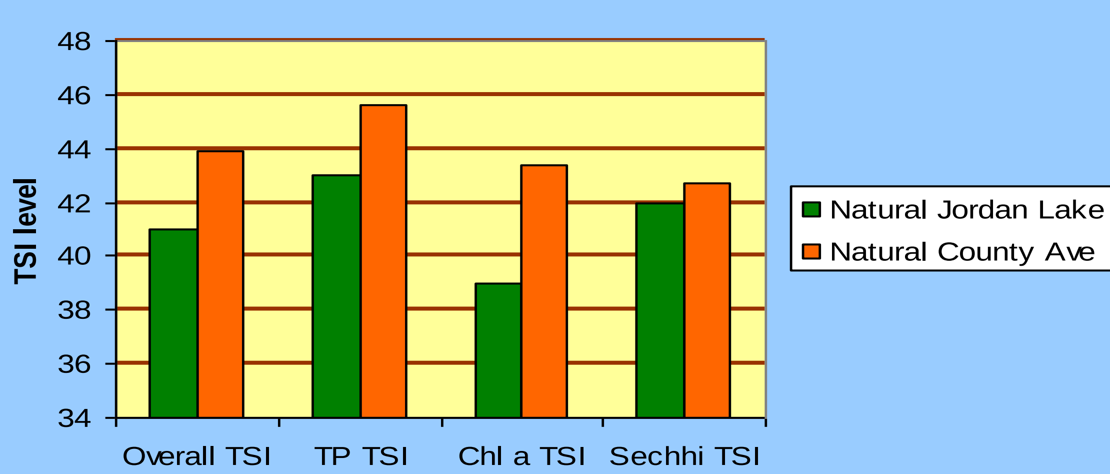
Figure 39: Jordan Lake Trophic Status Overview

Trophic State	Quality Index	Phosphorus (ug/l)	Chlorophyll a (mg/l)	Sechhi Disk (ft)
Oligotrophic	Excellent	<1	<1	>19
	Very Good	1 to 10	**1 to 5**	**8 to 19**
Mesotrophic	Good	**10 to 30**	5 to 10	6 to 8
	Fair	30 to 50	10 to 15	5 to 6
Eutrophic	Poor	50 to 150	15 to 30	3 to 4
Jordan Lake		**15**	**2.23**	**11.19**

These figures show that Jordan Lake has low levels overall for the three parameters often used to describe water quality: Secchi disk depths; average TP for the growing season; and chlorophyll a levels. It is normal for all of these values to fluctuate during a growing season. However, they can be affected by human use of the lake, by summer temperature variations, by algae growth & turbidity, and by rain or wind events.

According to these results, Jordan Lake scores as **"mesotrophic"** in its phosphorus level, and "**oligotrophic**" in chlorophyll-a readings, and Secchi disk readings. With such phosphorus readings and chlorophyll a readings, dense plant growth and frequent algal blooms would not be expected.

Figure 40: Jordan Lake TSI Index



IN-LAKE HABITAT

Aquatic Plants

A healthy aquatic plant community plays a vital role within the lake community. This is due to the role plants play in improving water quality, providing valuable habitat resources for fish and wildlife, resisting invasions of non-native species and checking excessive growth of the most tolerant species.

An aquatic plant survey was completed on Jordan Lake in the summer of 2006 by staff from the WDNR and the Adams County LWCD. The results verified that Jordan Lake is a mesotrophic lake with good water quality and very good water clarity, although nutrient level and algae frequency have increased since 1997. Filamentous algae are found in Jordan Lake, but only in the shallowest zone (0 to 1.5 feet) and with a 26.09% frequency there.

97.8% of the littoral zone covered to a maximum rooting depth of 19 feet. The 0 to 1.5 foot depth zone supported the most abundant aquatic plant growth. The Jordan Lake aquatic plant community is characterized by high quality and very good species diversity. The plant community has a below average sensitivity to disturbance and is closer to an undisturbed condition than the average lake in the state.

Chara spp (muskgrass), a plant-like algae, was the most common species found during the aquatic plant survey. Second in frequency was *Najas flexilis* (bushy pondweed). *Chara* spp. was also the densest plant found during the survey. However, a number of plants were found at higher than average density of growth where they were present: *Brasenia schreberi* (common watershield, a rooted floating-leaf plant), *Certaophyllum demersum* (coontail, a submergent species), *Chara* spp., *Phalaris arundinacea* (reed canarygrass, an emergent invasive), *Potomogeton foliosus* (leafy pondweed, a submergent), *Sagitarria latifolia* (arrowhead, an emergent species), *Scirpus validus* (softstem bulrush, an emergent), *Typha latifolia* (narrow-leaf cattail, an emergent) and *Zosterella dubia* (water stargrass, a submergent).

Chara spp was the dominant species. *Najas flexilis* was sub-dominant. Three invasive aquatic plants were found: *Myriophyllum* spicatum (Eurasian watermilfoil, a submergent), *Phalaris arundinacea* (reed canarygrass, an emergent), and *Potamogeton crispus* (curly-leaf pondweed, a submergent). Of the invasives, Eurasian watermilfoil was the most commonly occurring species and was found in all four depth zones.

Figure 41: Jordan Lake Aquatic Plant Species 2006

Scientific Name	Common Name	Type
Brasenia schreberi	Watershield	Floating-Leaf
Carex spp	Sedges	Emergent
Ceratophyllum demersum	Coontail	Submergent
Chara spp	Muskgrass	Submergent
Elodea canadensis	Waterweed	Submergent
Impatiens capensis	Jewelweed	Emergent
Lemna minor	Small Duckweed	Free-Floating
Myriophyllum sibiricum	Northern Milfoil	Submergent
Myriophyllum spicatum	Eurasian Watermilfoil	Submergent
Najas flexilis	Bushy Pondweed	Submergent
Nitella spp	Brittlewort	Submergent
Nymphaea odorata	White Water Lily	Floating-Leaf
Phalaris arundinacea	Reed Canarygrass	Emergent
Polygonum aquaticum	Water Smartweed	Floating-Leaf
Potamogeton amplifolius	Large-Leaf Pondweed	Submergent
Potamogeton crispus	Curly-Lead Pondweed	Submergent
Potamogeton foliosus	Leafy Pondweed	Submergent
Potamogeton gramineus	Variable-Leaf Pondweed	Submergent
Potamogeton illinoensis	Illinois Pondweed	Submergent
Potamogeton natans	Floating Pondweed	Submergent
Potamogeton pectinatus	Sago Pondweed	Submergent
Potamogeton pusillus	Small Pondweed	Submergent
Potamogeton praelongus	White-Stem Pondweed	Submergent
Potamogeton richardsonii	Clasping-Leaf Pondweed	Submergent
Potamogeton zosteriformis	Flat-Stem Pondweed	Submergent
Ranunculus longirostris	Longbeak Buttercup	Emergent
Sagittaria latifolia	Arrowhead	Emergent
Salix spp	Willow	Emergent
Scirpus americanus	Chairmaker's Bulrush	Emergent
Scirpus validus	Soft-Stem Bulrush	Emergent
Solanum ptycanthum	Nightshade	Emergent
Solidago spp	Goldenrod	Emergent
Typha latifolia	Narrow-Leaf Cattail	Emergent
Vallisneria americana	Water Celery	Submergent
Zosterella dubia	Water Stargrass	Submergent

The study used the results of the 2006 field survey to evaluate Jordan Lake by using several standard community measurements. For example, the Simpson's Diversity Index was 0.93, indicating excellent species diversity. A rating of 1.0 would mean that each plant in the lake was a different species (the most diversity achievable).

The Aquatic Macrophyte Community Index (AMCI) for Jordan Lake is 63. This is in the upper quartile of lakes in Wisconsin and the North Central Hardwoods Region of the state. This value places Jordan Lake in the top 25% of lakes in the state and region with the highest quality aquatic plant communities.

The Average Coefficient of Conservatism for Jordan Lake was 4.52, below average for Wisconsin lakes (6.0) and lakes in the North Central Hardwood (5.6) Region. This suggests that the aquatic plant community in Jordan Lake is less sensitive to disturbance than the average lake in the state or region. This is likely due to selection of species by past disturbance.

The Floristic Quality Index of the aquatic plant community in Jordan Lake was 25.14, in the upper quartile of Wisconsin lakes (average 22.2) and North Central Hardwood Region lakes (average 20.9). This indicates that the plant community in Jordan Lake is within the group of lakes in the state and region closest to an undisturbed condition.

Of the invasives, Eurasian watermilfoil, a non-native, invasive plant species, has been the most critical threat to habitat and native plant species of Jordan Lake. Results from the 2006 survey show it continued to be present in occurrence and density sufficient to require the lake district to treat it chemically to reduce its presence. However it did not have more than average growth density anywhere on the lake. Two other non-native, exotic species (curly-leaf pondweed and narrow-leaf cattail) occurred less frequently and less densely than the Eurasian watermilfoil. In the past few years, Jordan Lake has had much increased recreational use by water skiers, jet skiers, watertubers and speed boats, increasing the disturbance in the lake. Such disturbance creates an ideal condition for exotic species to colonize and spread.

Plant distribution, frequency and density varied considerably within Jordan Lake, depending on the plant types (see Figure 42).

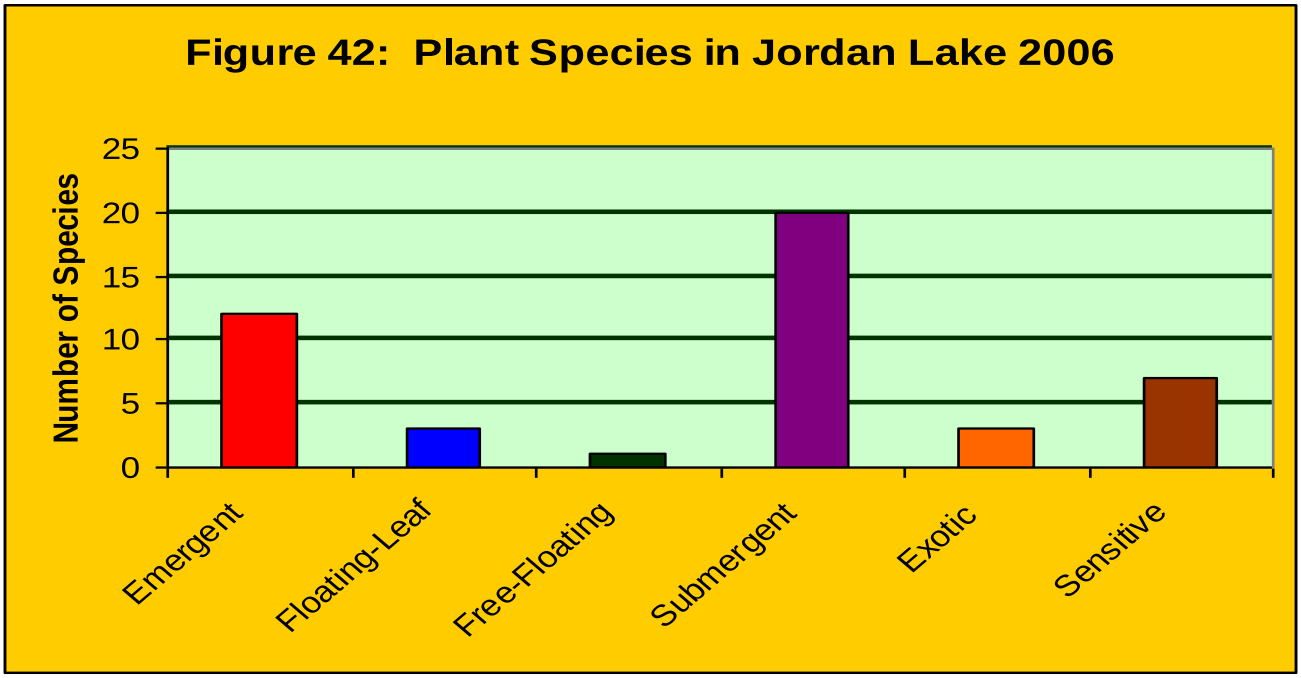


Figure 43a: Emergent Aquatic Plants in Jordan Lake 2006

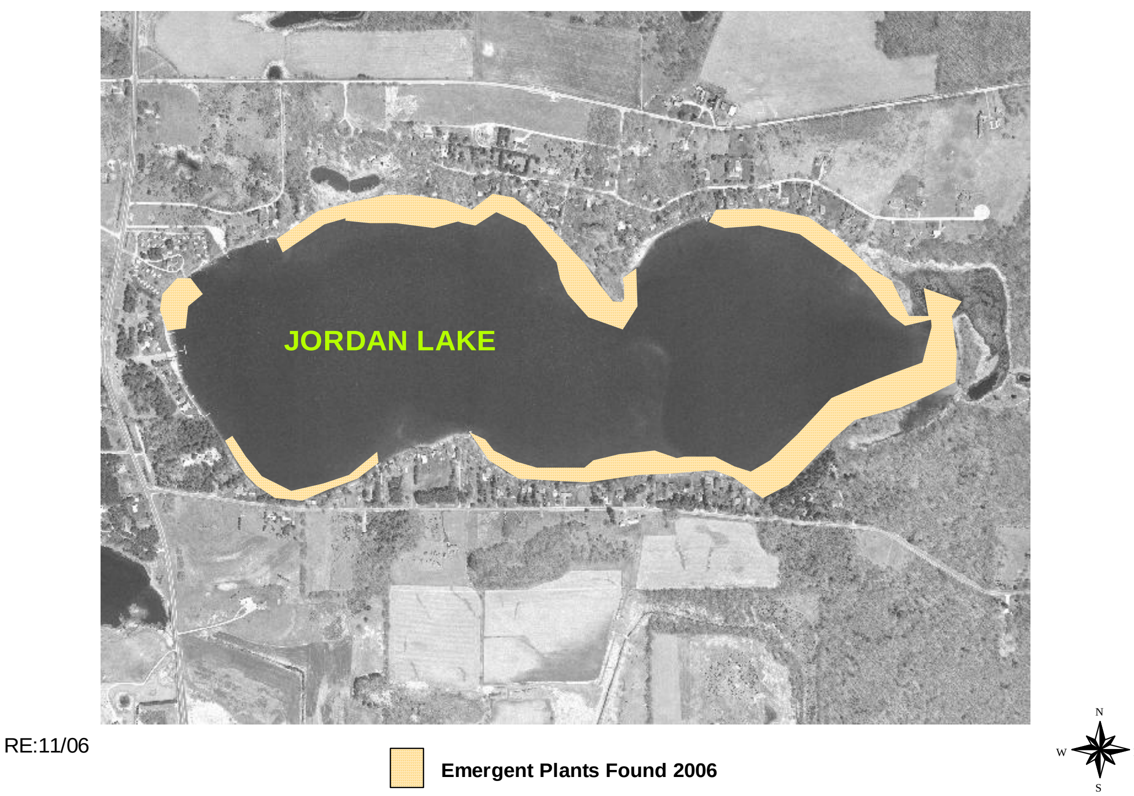


Figure 43b: Floating-Leaf Aquatic Plants in Jordan Lake 2006

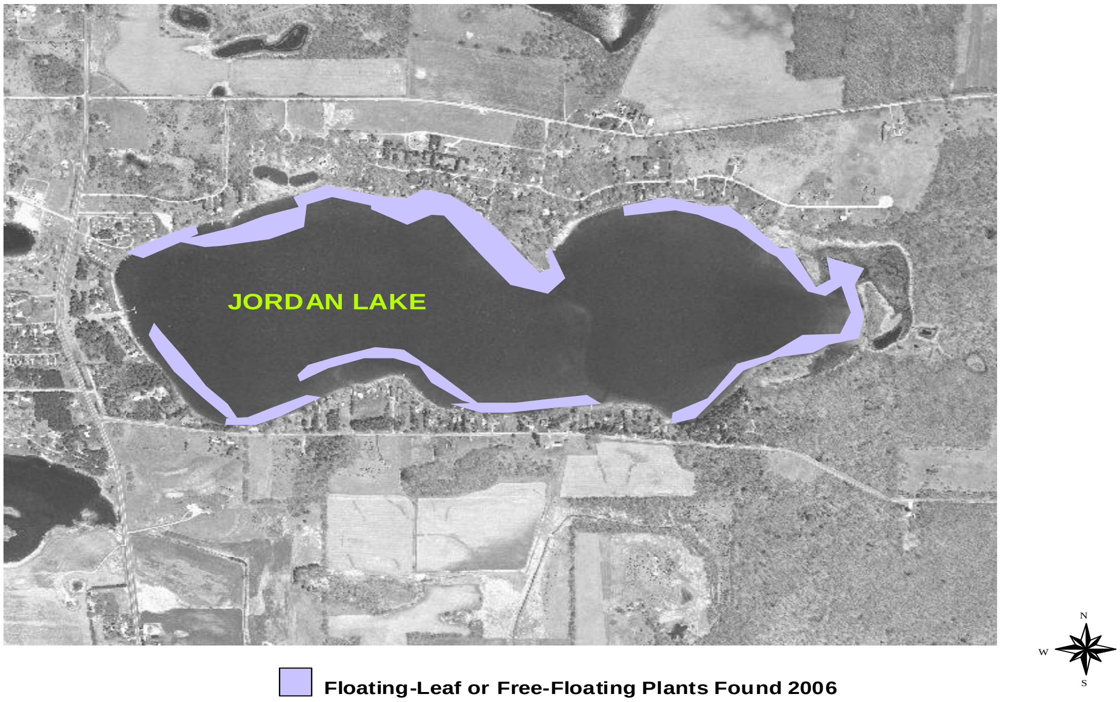
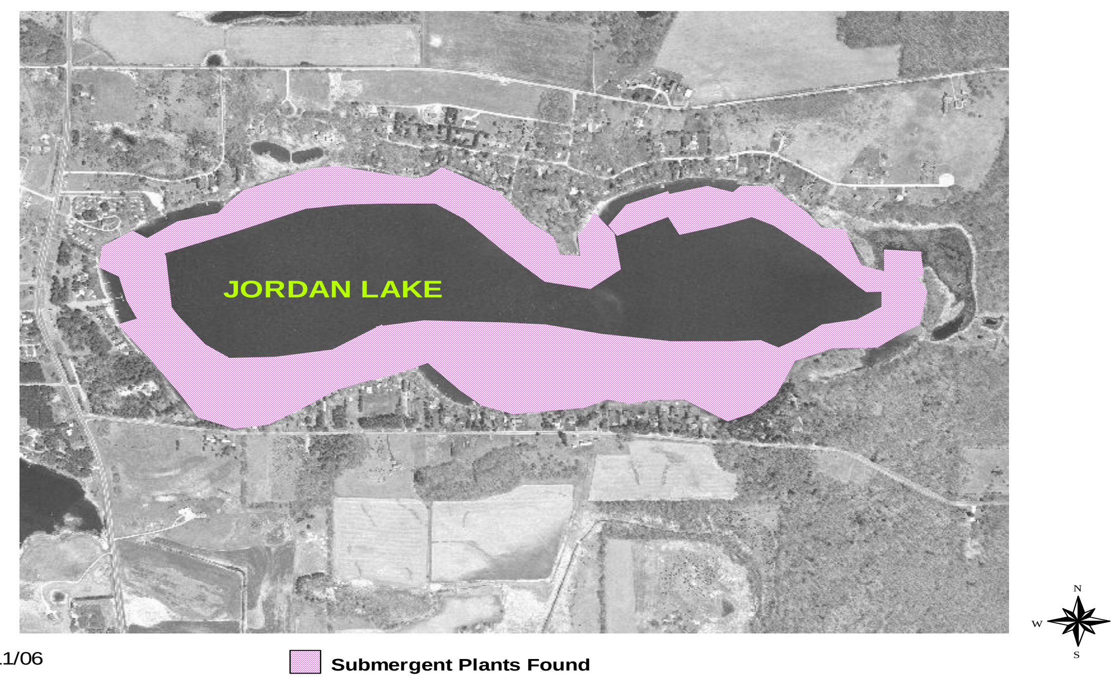
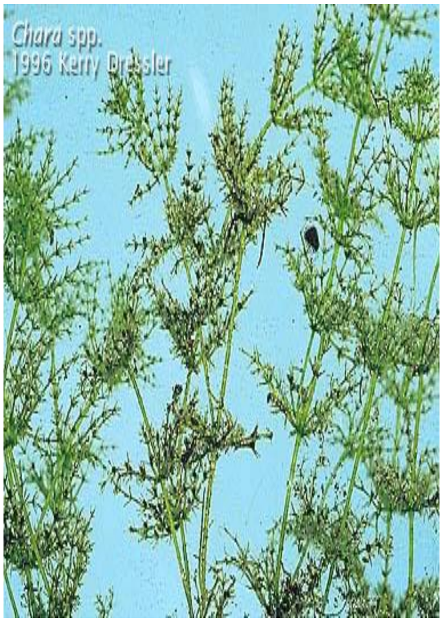


Figure 43c: Submergent Aquatic Plants in Jordan Lake 2006





Chara **spp (Muskgrass)**

Figure 44: Four Most Common Native Aquatic Species in Jordan Lake

Potamogeton amplifolius
(Large-Leaf Pondweed)

Najas flexilis
***(*Bushy Pondweed)**

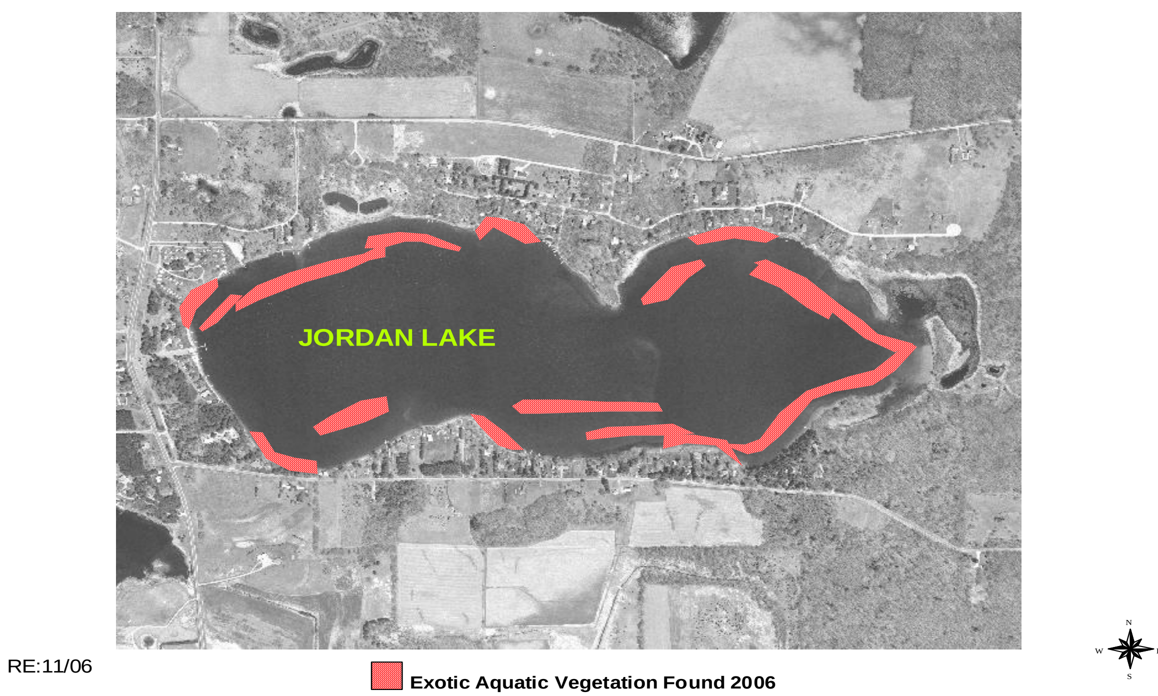
Potamogeton pectinatus
(Sago Pondweed)

Aquatic Invasives

Jordan Lake has been targeting Eurasian watermilfoil through chemical applications since 1981. Treatment was sporadic in the 1980s and 1990s, but has been steady since 1997 through 2007. In general, the number of acres to be treated has been declining, although the invasive continues to be a problem in Jordan Lake. By summer 2006, Eurasian Watermilfoil was a commonly occurring species, occurring at only average densities, in all four depth zone. It was found in 19 feet of water, along with *Cerataphyllum demersum* and *Potamogeton richardsonii* (clasping-leaf pondweed). The Jordan Lake Management Plan calls for continuing to monitor expects to continue the Eurasian Watermilfoil population and take necessary treatment steps to keep it managed.

In addition, a survey in 2007 indicated that the native weevil, *Euhrychiopsis lecontei*, was present in parts of Jordan Lake. This weevil, if present in sufficient density, can weaken Eurasian milfoil plants to the point of death.

Figure 45: Distribution of Exotic Aquatic Plants in 2006



Curly-Leaf Pondweed was also found in Jordan Lake in 2006, but only at four sites in water 1.5 feet to 5 feet deep. Although it is present, it does not appear in either high frequency or density. Reed Canarygrass was also found on the shores of Jordan Lake in 2006 in three sites, but also did not appear in either high frequency or density. However, ongoing monitoring for both of these plants should occur.

Potamogeton crispus
(Curly-Leaf Pondweed)

Phalaris arundinacea
(Reed Canarygrass)

Figure 46: Three Invasive Aquatic Plants in Jordan Lake

Myriophyllum spicatum
(Eurasian Watermilfoil)

Critical Habitat

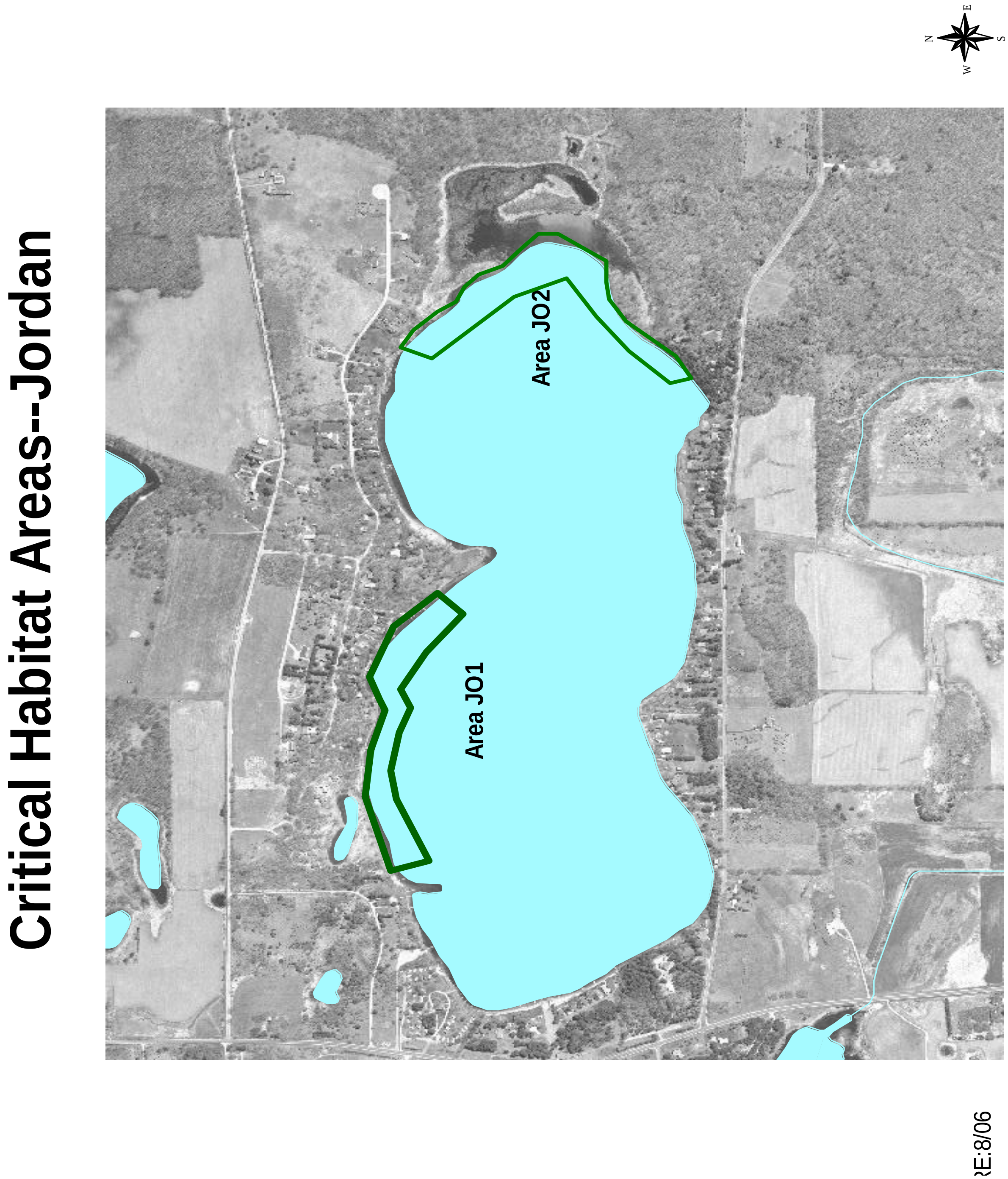
Designation of critical habitat areas within lakes provides a holistic approach for assessing the ecosystem and for protecting those areas in and near a lake that are important for preserving the qualities of the lake. Wisconsin Rule 107.05(3)(i)(I) defines a "critical habitat areas" as: "areas of aquatic vegetation identified by the department as offering critical or unique fish & wildlife habitat or offering water quality or erosion control benefits to the body of water. Thus, these sites are essential to support the wildlife and fish communities. They also provide mechanisms for protecting water quality within the lake, often containing high-quality plant beds. Finally, critical habitat areas often can provide the peace, serenity and beauty that draw many people to lakes.

Protection of critical habitat areas must include protecting the shore area plant community, often by buffers of native vegetation that absorb or filter nutrient & stormwater runoff, prevent shore erosion, maintain water temperature and provide important native habitat. Buffers can serve not only as habitats themselves, but may also provide corridors for species moving along the shores.

Besides protecting the landward shore areas, preserving the littoral (shallow) zone and its plant communities not only provides essential habitat for fish, wildlife, and the invertebrates that feed on them, but also provides further erosion protection and water quality protection.

Field work for a critical habitat area study was performed on October 4, 2006, on Jordan Lake, Adams County. The study team included: Scot Ironside, DNR Fish Biologist; Deborah Konkel, DNR Aquatic Plant Specialist; and Reesa Evans, Adams County Land & Water Conservation Department. Areas were identified visually, with GPS readings and digital photos providing additional information. Input was also obtained from Terry Kafka, DNR Water Regulation; Jim Keir, DNR Wildlife Biologist; and Buzz Sorge, DNR Lake Manager.

Figure 47: Critical Habitat Areas on Jordan Lake



Critical Habitat Area JO1

This area extends along approximately 2600 feet of the shoreline along the north side of the lake, extending up to the ordinary high water mark. Sediment includes marl, muck, peat, sand, silt and mixtures thereof. 6% of the shore is wooded; 20% is native herbaceous cover. The balance of the short is bare sand, cultivated lawn and hard structure. There is a shallow marsh area along this shoreline. Large woody cover is present for habitat.

Figure 48: Photo of Area JO1, Jordan Lake

The results of an October 2006 fish shocking survey indicated that Jordan Lake has a good panfish population of substantial size, including bluegills, black crappie and perch. More scarce were largemouth bass and northern pike, although they were present. Brown trout, cisco, bullheads, walleyes and white suckers have also been found in Jordan Lake. No exotic aquatic wildlife was noted in this area, i.e, no carp, smelt or rusty crayfish were seen.

Seen during the field survey were various types of songbirds. Frogs and salamanders are known to use this area for shelter/cover, nesting and feeding. Upland wildlife feed and nest here as well. Since human disturbance is fairly high in JO1, habitat for wildlife is somewhat limited.

Maximum rooting depth of aquatic vegetation in JO1 was 19 feet. Seven types of emergent aquatic plants were found in this area. Emergents provide important fish habitat and spawning areas, as well as food and cover for wildlife. One free-floating and three floating-leaf rooted species were present here. Floating-leaf vegetation provides cover and dampens waves, protecting the shore. Eighteen emergent species of aquatic species were also found here. Such a diverse submergent community provides many benefits. Filamentous algae were present at this site, but not abundant.

One exotic invasive plant, *Myriophyllum spicatum*, was found in this area. Most of the aquatic vegetation in this area has multiple uses for fish and wildlife. This area of all three plant structures provides a lot of habitat diversity.

Figure 49: Photo Showing Development in JO1

Critical Habitat Area JO2

This area extends along approximately 1800 feet of the shoreline on the far east end of the lake, up to the ordinary high water mark. Average water depth here is about 15', with a steep dropoff. Sediment includes peat, sand, silt and mixtures thereof. 11% of the shore is wooded; 6% has shrubs; 23% is native herbaceous cover. The remaining shore is bare sand, cultivated lawn and hard structures, which tend to be concentrated at the edges of this area. The middle area is almost entirely undeveloped and contains some shallow marsh. Large woody cover is present for habitat. With minimal human disturbance along this shoreline, the area has natural scenic beauty.

This area of some large woody cover, emergent aquatic vegetation, submergent and floating vegetation provides spawning and nursery areas for many types of fish that also feed and take cover here. No exotic aquatic wildlife was noted in this area, i.e, no carp, smelt or rusty crayfish were seen. Shore development present in JO2 was confined to the ends.

Seen during the field survey were various types of waterfowl and songbirds. It appeared that all these took cover or shelter in this area, as well as nested and fed in this area. Downed logs serving as habitat were also seen. Muskrat and mink are known to use JO2 for cover, reproduction and feeding. Frogs and salamanders are known to use this area for shelter/cover, nesting and feeding. Turtles and snakes also use this area for cover or shelter in this area, as well as nested and fed in this area. Upland wildlife feed and nest here as well. Since human disturbance is relatively minimal in JO2, it provides high-quality habitat for many types of wildlife.

Maximum rooting depth in JO2 was 19 feet. No threatened or endangered species were found in this area. Two exotic invasives, *Myriophyllum spicatum* (Eurasian watermilfoil) and *Potamogeton crispus* (Curly-Leaf Pondweed), were found in this area. Filamentous algae were present, but not common. Five emergent species were present here. One free-floating plant was found at this site. Two floating-leaf rooted plants were present. Fifteen submergent aquatic plant species were also found here.

Most of these plants are used by wildlife and fish for multiple purposes. Because this site provides all three structural types of vegetation, the community has a diversity of structure and species that supports even more diversity of fish and wildlife.

Figure 50:
Part of Area
JO2

Recommendations for preserving these areas resulted from this field survey and analysis. They included:

(1) Maintain current habitat for fish and wildlife.
(2) Do not remove fallen trees along the shoreline nor logs in the water.
(3) No alteration of littoral zone unless to improve spawning habitat.
(4) Seasonal protection of spawning habitat.
(5) Maintain snag/cavity trees for nesting.
(6) Maintain or increase wildlife corridor.
(7) Maintain sedge meadow and deep marsh areas.
(8) Maintain no-wake zone.
(9) Protect emergent vegetation for habitat and shoreline protection.
(10) Removal of submergent vegetation for navigation purposes only.
(11) Seasonal control of Eurasian Watermilfoil and other exotics, if needed, by using integrated control methods specific for exotics.
(12) Minimize aquatic plant and shore plant removal to maximum 30' wide access/viewing corridor. Leave as much vegetation as possible to protect water quality and habitat.
(13) Use forestry best management practices.
(14) No use of lawn products.
(15) No bank grading or grading of adjacent land.

(16) No pier construction or other activity except by permit using a case-by-case evaluation.
(17) No installation of pea gravel or sand blankets.
(18) No bank restoration unless the erosion index scores moderate or high.
(19) If the erosion index does score moderate or high, bank restoration only using biologs or similar bioengineering, with no use of riprap or retaining walls.
(20) Placement of swimming rafts or other recreational floating devices only by permit.
(21) Maintain buffer of shoreline vegetation.
(22) Maintain aquatic vegetation in undisturbed condition for wildlife habitat, fish use and water quality protection.
(23) Post landing with exotic species alert and educational signs to prevent introduction and/or spread of exotic species.
(24) Keep critical habitat areas as no-wake areas.

Figure 51: Jordan Shore Showing Woody Habitat

FISHERY/WILDLIFE/ENDANGERED RESOURCES

WDNR fish stocking records for Jordan Lake extend back to 1933, when 308 black bass were stocked. Fish were stocked by that agency most years since then, through 2002. Other fish that were stocked included walleye, perch, smallmouth bass, largemouth bass, northern pike and brown & rainbow trout. The most recent shocking inventory, in October 2006, found bluegills were abundant. Prior inventories have shown the presence of bullheads, ciscos, pumpkinseeds, crappie, suckers and shiners, in addition to the fish type stocked. An endangered species, *Fundulus diaphanus (*Banded Killifish), was found in the lake previously. No other endangered resources in the Jordan Lake watersheds have been identified.

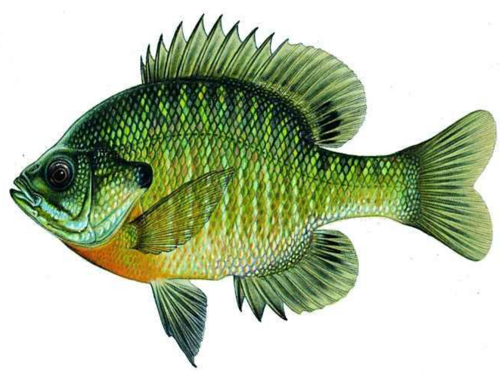


Figure 52: Abundant Fish in Jordan Lake—Bluegill

Figure 53: Banded Killifish

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