Church Pine, Round (Wind), and Big Lake Management Plan

Polk County, Wisconsin
November 2013

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Funded By
Wisconsin Department of Natural Resources Lake Planning Grant
Church Pine, Round, and Big Lake Protection and Rehabilitation District

We would like to thank the following persons for their contributions to this project:

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Purpose of the Study

Lakes are a product of the landscape they are situated in and of the actions that take place on the land which surrounds them. Due to this fact, lakes situated within feet of others can differ profoundly in the uses they support.

Factors such as lake size, lake depth, water sources to a lake, and geology all cause inherent differences in lake quality.

Additionally, humans, by changing the landscape, can bring about changes in a lake. This arises because rain and melting snow may eventually end up in lakes and streams through surface runoff or groundwater infiltration. Rain and melting snow entering a lake is not inherently problematic. However, water has the ability to carry nutrients, bacteria, sediments, and chemicals into a lake. These inputs can impact aquatic organisms such as insects, fish, and wildlife and—especially in the case of the nutrient phosphorus—fuel problematic algae blooms.

The landscape can be divided into watersheds and subwatersheds, which define the land area that drains into a particular lake, stream, or river. Watersheds that preserve native vegetation and minimize impervious surfaces (cement, concrete, and other materials that water can't permeate) are less likely to cause negative impacts on lakes, rivers, and streams.

Lake studies often examine the underlying factors that impact a lake's health, such as lake size, depth, water sources, and the land use in a lake's watershed. Many forms of data can be collected and analyzed to gauge a lake's health including: physical data (oxygen, temperature, etc.), chemical data (including nutrients such a phosphorus and nitrogen), biological data (algae and zooplankton), and land use within a lake's watershed.

Lakes can be classified based on their nutrient status and clarity levels. Three categories commonly used are: oligotrophic, mesotrophic, and eutrophic.

- ✓ Oligotrophic lakes are generally clear, deep, and free of weeds and large algae blooms.

- ✓ Mesotrophic lakes lie between oligotrophic and eutrophic lakes. They usually have good fisheries and occasional algae blooms.

- ✓ Eutrophic lakes are generally high in nutrients and support a large number of plant and animal populations. They are usually very productive and subject to frequent algae blooms. Lakes can also be hypereutrophic. Hypereutrophic lakes are characterized by dense algae and plant communities and can experience heavy algal blooms throughout the summer.

Lake studies often identify strengths, opportunities, challenges, and threats to a lake's health. These studies can identify practices already being implemented by watershed residents to improve water quality and areas providing benefits to a lake's ecosystem. Additionally, these studies often quantify practices or areas on the landscape that have the potential to negatively impact the health of a lake.

The end product of a lake study is a Lake Management Plan which identifies goals, objectives, and action items to either maintain or improve the health of a lake. These goals should be realistic based on inherent lake characteristics (lake size, depth, etc.) and should align with watershed residents' goals.

Included in this document are the data and conclusions drawn from a 2012 lake study completed by the Polk County Land and Water Resources Department. This study collected and analyzed the following data to aid in the creation of a Lake Management Plan for Church Pine, Round, and Big Lake:

- ✓ Lake resident opinions
- ✓ Lake level and precipitation data
- ✓ In lake physical and chemical data
- ✓ Algae and zooplankton data
- ✓ Shoreline land use results
- ✓ Tributary monitoring results
- ✓ Watershed and subwatershed land use

This study also included a number of educational opportunities for members of the Church Pine, Round, and Big Lake District including:

- ✓ Pontoon classrooms
- ✓ A shoreline restoration workshop
- ✓ A series of five meetings to review the data collected and develop a Lake Management Plan

Whenever possible, past lake studies completed on Church Pine, Round, and Big Lake are used as a baseline comparison for this study. A summary of previous lake studies can be found on page 24.

Executive Summary

1. Church Pine Lake is a 107 acre drainage lake with a mean depth of 23 feet; Round Lake is a 38 acre drainage lake with a maximum depth of 22 feet; and Big Lake is a 259 acre seepage lake with a mean depth of 24 feet.

2. Water flows from Church Pine, to Round, to Big Lake. Big Lake receives water from North Creek and a culvert on County Road K. North Creek is classified as a trout water. The outlet, Forest Creek, is located on Big Lake and is regulated by a dam.

3. The lakes respond greatly to precipitation, with levels dropping nearly a foot during 2012 drought conditions.

4. One hundred sixteen lake residents completed a survey regarding the lakes (52% response rate). The highest concerns for the lakes were property values and/or taxes, invasive species, pollution, and aquatic plants. Data collection, monitoring for new aquatic invasive species, information and education opportunities, and cost-sharing shoreline buffers and rain gardens are practices respondents feel should be continued.

5. Phosphorus levels (the primary nutrient that fuels algae blooms) were lowest on Church Pine Lake, followed by Round Lake, and Big Lake.

6. Church Pine Lake had the greatest water clarity, followed by Round Lake, and Big Lake.

7. Citizen Lake Monitoring Data has been collected since 1986 and indicate that Church Pine lake is oligotrophic/mesotrophic (low nutrient/productivity), Round Lake is mesotrophic/mildly eutrophic (moderate nutrient/productivity), and Big Lake is mildly eutrophic (high nutrient/productivity).

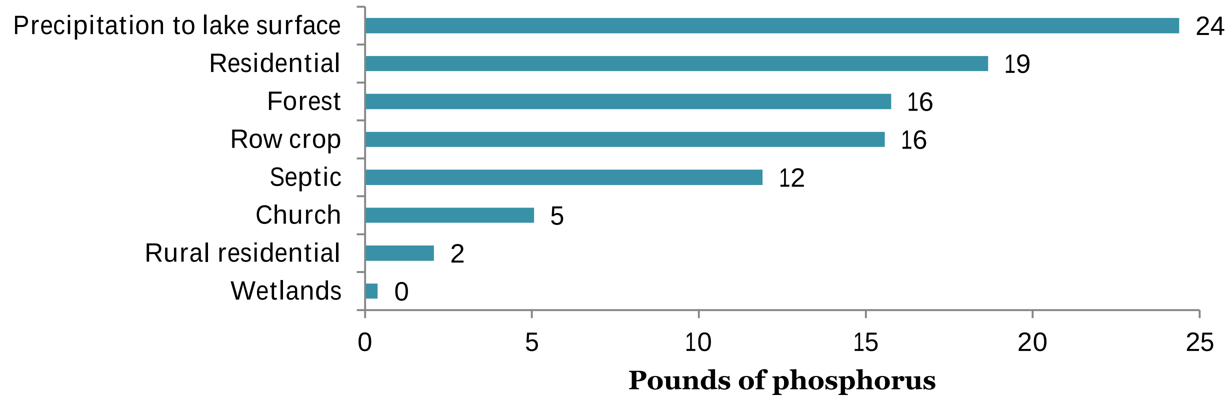
8. The most abundant type of algae on all three lakes was blue green algae. Blue green algae are of specific concern because they produce toxins when their populations are large. Populations in all three lakes in 2012 were associated with a low risk of toxin production.

9. The majority of the shoreline buffer area on all three lakes is in a natural state. However, 31% of the shoreline buffer area on Big Lake is lawn.

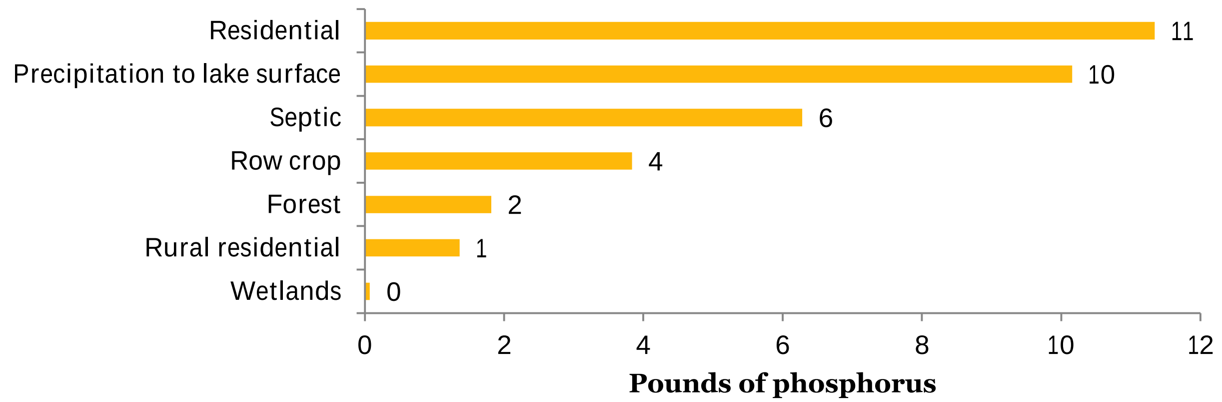
10. A watershed is the area of land that drains to a lake. The Church Pine Lake Watershed is 378 acres, the Round Lake Watershed is 107 acres, and the Big Lake Watershed is 1,766 acres.

11. Modeling was used to estimate how much phosphorus enters Church Pine, Round, and Big Lakes from watershed sources. Shoreline property owners contribute the greatest amount of phosphorus to Church Pine and Round Lakes. North Creek contributes the greatest amount of phosphorous to Big Lake, followed by shoreline property owners.

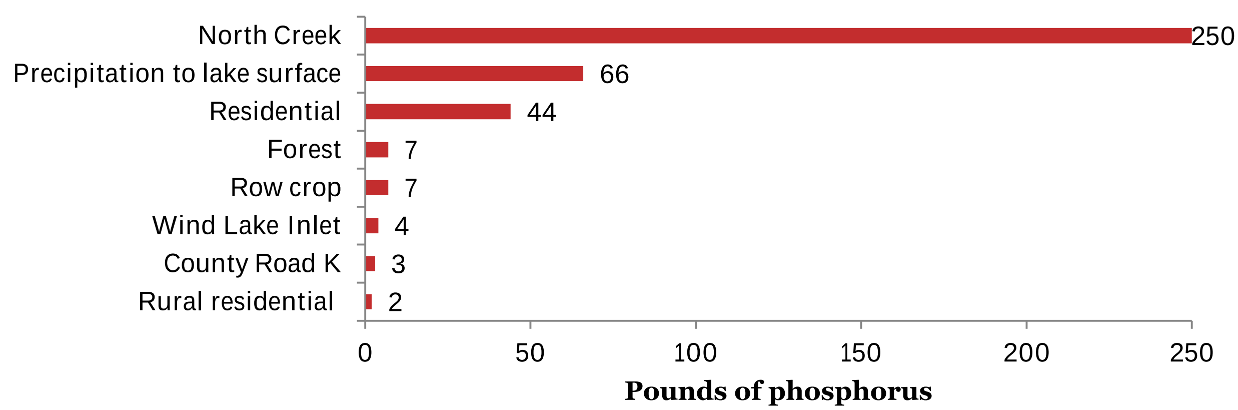
Church Pine Lake phosphorus contributions by source: 94 pounds phosphorus



Round Lake phosphorus contributions by source: 35 pounds phosphorus



Big Lake phosphorus contributions by source: 383 pounds phosphorus



The following goals for Church Pine, Round, and Big Lake were developed through a series of four meetings by the Water Quality Committee. The development of these goals take into account current and past water quality data and a 2012 sociological survey regarding the needs of the Long Lake District.

1. Reduce algae and phosphorus in the three lake system by reducing watershed runoff
2. Evaluate the progress of lake management efforts
3. Protect, maintain, and enhance fish habitat
4. Increase knowledge and participation
5. Support the goals of the Aquatic Plant Management Plan

Introduction to the Lakes

The study area is in southwest Polk County, Wisconsin and includes Church Pine Lake (WBIC 2616100), Round (Wind) Lake (WBIC 2616000), and Big Lake (WBIC 2615900). Church Pine Lake and Round Lake are located entirely in the Town of Alden; whereas, Big Lake is located in the Towns of Alden and Garfield.

Church Pine Lake is the headwaters of this three lake system, with water flowing from Church Pine, to Round, and then to Big Lake. There are two inflows to this three lake system, both of which are located on Big Lake. The main inflow, North Creek, is located on the north side of the lake. Big Lake also receives intermittent flow from a culvert located on County Road K on the east side of the lake.

The outlet for this three lake system, Forest Creek, is located on the west side of Big Lake and drains to Horse Creek. A dam on Forest Creek regulates the water level in Big Lake.

Figure 1. Aerial photo of Church Pine, Round, and Big Lake.

Ramp public access sites are located on Church Pine Lake and Big Lake. Public access on Church Pine Lake is off 45th Avenue on the south side of the lake and public access on Big Lake is off County Road K on the south side of the lake. Round Lake can be accessed from either of the other two lakes.

The soils of all three lake watersheds are loamy to sandy and well to excessively well drained with the exception of the east side of the southern shore of Big Lake which consists of loamy and silty soils ranging from well drained to poorly drained (Lim Tech, October 1987).

Lake Characteristics

Information from: (Wisconsin Department of Natural Resources).

Church Pine Lake (WBIC: 2616100)
Area: 107 Acres
Maximum depth: 45 feet
Mean depth: 23 feet
Bottom: 80% sand, 5% gravel, 0% rock, and 15% muck
Hydrologic lake type: drainage
Littoral zone depth: 25.7 feet
Total shoreline: 2.4 miles
Invasive species: Chinese mystery snail

Round Lake (WBIC: 2616000)
Area: 38 Acres
Maximum depth: 22 feet
Bottom: 90% sand, 0% gravel, 0% rock, and 10% muck
Hydrologic lake type: drainage
Littoral zone depth: 21.1 feet

Big Lake (WBIC: 2615900)
Area: 259 Acres
Maximum depth: 24 feet
Mean depth: 17 feet
Bottom: 85% sand, 5% gravel, 0% rock, and 10% muck
Hydrologic lake type: seepage
Littoral zone depth: 16 feet
Total shoreline: 3 miles
Invasive species: Chinese mystery snail, curly leaf pondweed, purple loosestrife,

With the exception of 2009, Self Help Monitoring Data has been collected on each lake almost annually since 1986. The Self Help Monitoring Data suggests that Church Pine Lake is hovering on the oligotrophic/mesotrophic line, Round Lake is hovering near the mesotrophic/eutrophic line, and Big Lake is eutrophic.

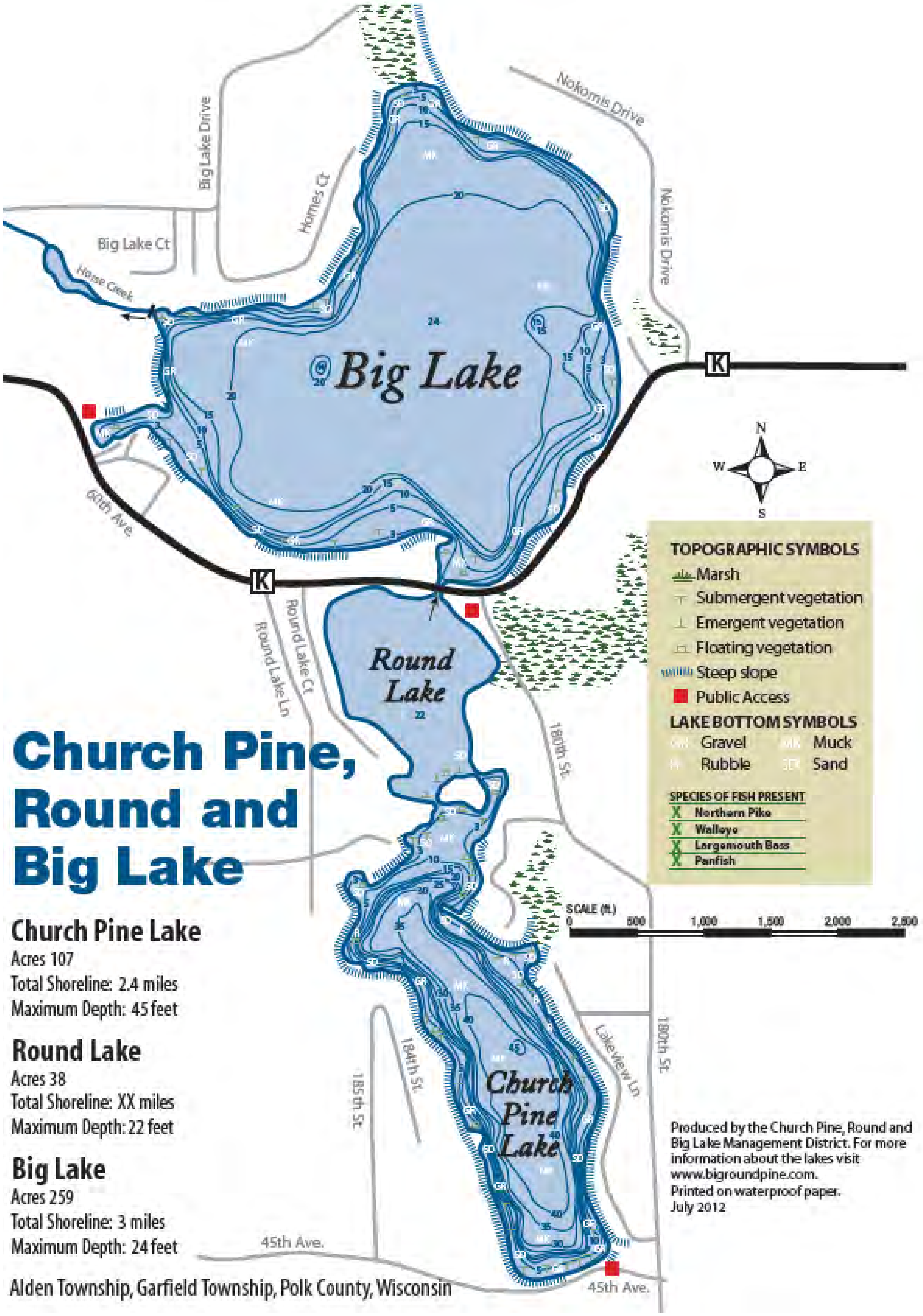


Figure 2. Bathymetric map of Church Pine, Round, and Big Lake.

Designated Waters

A designated water is a waterbody with special designations that affect permit requirements. Designations for the three lake system include:

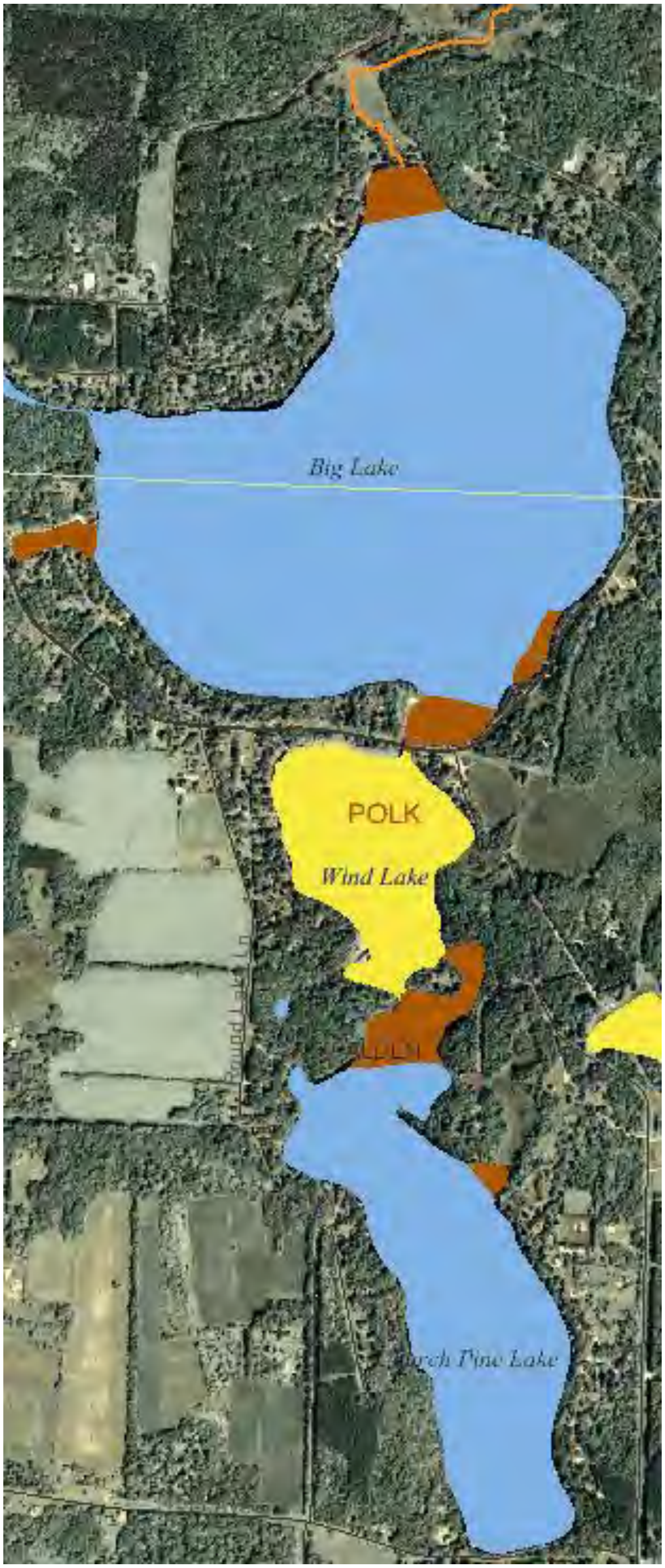
- ✓ **Areas of Special Natural Resource Interest**
  - North Creek due to its classification as a trout water under Chapter NR 1.02(7). Wis. Adm. Code [1]

- ✓ **Public Rights Feature** : identified as areas that merit special protection of aquatic habitat through lake sensitive area survey results
  - 2 locations on Church Pine Lake [2]
  - 4 locations on Big Lake [3]

- ✓ **Priority Navigable Waters**
  - Round Lake due to the size of the waterbody being less than 50 acres under Sections 30.26 and 30.27. Wis. Stats

In 1998 a Sensitive Area Survey Report and Management Guidelines was prepared for both Church Pine and Big Lake. Further information on the Public Rights Features highlighted above can be found in these reports.

[1] "State classified trout streams are considered ASNRI waters due to the narrow window of suitable habitat including substrate and temperatures required by trout species" (Wisconsin DNR).
[2] "The entire littoral zone of Church Pine Lake has a very diverse plant community and should be protected by all means. These designated sensitive areas of aquatic vegetation on Church Pine Lake offer critical or unique fish and wildlife habitat. These habitats provide the necessary seasonal or life stage requirements of the associated fisheries, and the aquatic vegetation offers water quality or erosion control benefits to the body of water" (Wisconsin DNR).
[3] "These areas of aquatic vegetation or rock substrate offer critical or unique fish and wildlife habitat. These habitats provide the necessary seasonal or life stage requirements of the associated fisheries, and the aquatic vegetation offers water quality or erosion control benefits to the body of water" (Wisconsin DNR).



A Designated Water is a waterbody that has special designations that affect permit requirements. Designated Waters include the following:

- Areas of Special Natural Resource Interest (ASNRI)
- Public Rights Features (PRF)
- Priority Navigable Waters (PNW)

PNW ASNRI PRF

Please note that Areas of Special Natural Resource Interest (ASNRI) waters and Public Rights Features (PRF) waters are also considered Priority Navigable Waters (PNW).

Figure 3. Designated waters. Map from: (Wisconsin DNR).

Habitat Areas

Information directly from: (Harmony Environmental and Ecological Integrity Services, September 2010).

Naturally occurring native plants are extremely beneficial to lakes. They provide a diversity of habitats, help maintain water quality, sustain fish populations, and support common lakeshore wildlife such as loons and frogs.

Aquatic plants can improve water quality by absorbing phosphorus, nitrogen, and other nutrients from the water that could otherwise fuel nuisance algal growth. Some plants can even filter and break down pollutants. Plant roots and underground stems help to prevent re-suspension of sediments from the lake bottom. Stands of emergent plants (whose stems protrude above the water surface) and floating plants help to blunt wave action and prevent erosion of the shoreline.

Habitat created by aquatic plants provides food and shelter for both young and adult fish. Invertebrates living on or beneath plants are a primary food source for many species of fish. Other fish such as bluegills graze directly on the plants themselves. Plant beds in shallow water provide important spawning habitat for many fish species. Plants offer food, shelter, and nesting material for waterfowl. Birds eat both the invertebrates that live on plants and the plants themselves.

The Wisconsin Department of Natural Resources (DNR) has completed sensitive area surveys to designate areas within aquatic plant communities that provide important habitat for game fish, forage fish, macroinvertebrates, and wildlife, as well as important shoreline stabilization functions. The DNR has transitioned to designations of *critical habitat areas* that include both *sensitive areas* and *public rights features*.

Sensitive areas offer critical or unique fish and wildlife habitat (including seasonal or life stage requirements) or offer water quality or erosion control benefits to the area (Administrative code 107.05(3)(1)(1)). The Wisconsin Department of Natural Resources is given the authority for the identification and protection of sensitive areas of the lakes.

Public rights features are areas that fulfill the right of the public for navigation, quality and quantity of water, fishing, swimming, or natural scenic beauty. The *critical habitat area* designation provides a holistic approach to ecosystem assessment and protection of those areas within a lake that are most important for preserving the very character and qualities of the lake. Protecting these *critical habitat areas* requires the protection of shoreline and in-lake habitat. The *critical habitat area* designation provides a framework for management decisions that impact the ecosystem of the lake.

The Department of Natural Resources completed Sensitive Areas Designations in September of 1998. Purple loosestrife was identified in Big Lake sensitive areas A, C, and D. Curly leaf pondweed was found in Big Lake sensitive area C.

The general recommendations for the sensitive/critical habitat areas are:

- Preserve/restore shoreline buffers at least 35 feet deep
- Limit aquatic vegetation removal to no more than 25 foot channels – hand pulling is the preferred method for management followed by harvesting and herbicide use
- Leave woody debris in place
- Prevent construction site erosion
- Limit rip rap for shoreline stabilization
- Strictly enforce zoning ordinances
- Control exotic species such as purple loosestrife
- Use conservation easements, deed restrictions or zoning to protect sensitive areas (Church Pine only)

Resource values of each lake sensitive area were each described in the same way: provides bass, panfish, and forage species habitat; northern spawning and nursery areas; and wildlife habitat. All major types of plants: emergent, floating, and submergent were recorded in each sensitive area.

The Natural Heritage Inventory map of Polk County indicates occurrences of aquatic listed special concern species in the sections where project lakes are located. A species list is available to the public only by Town and Range. WDNR and federal regulations regarding special concern species range from full protection to no protection. The current categories and their respective level of protection are as follows: **SC/P** = fully protected, **SC/N** = no laws regulating use, possession, or harvesting.

T32N R18W included the following aquatic species:

Cardamine pratensis	Cuckoo Flowers	Special Concern
Fundulus diaphanous	Banded Killifish	Special Concern/N
Senecio congestus	Marsh Ragwort	Special Concern

T 33N R18W also has the Banded Killifish present.

Fishery

Information directly from: (Harmony Environmental and Ecological Integrity Services, September 2010).

The three lake chain has a naturally reproducing largemouth bass and pan fishery (bluegill, black crappie, pumpkinseed, and yellow perch). In addition, a stocked northern pike and walleye fishery is present. Northern pike are stocked by the WDNR during alternate years to provide a low density top predator to improve the overall angling experience.

Continued stocking will be necessary to maintain viable populations of both northern pike and walleye. Walleye were recently stocked by the Lake District and have survived to provide a fishable population at a low level. The main limiting factor likely affecting walleye is predation by other fishes. Northern pike reproduction is limited because of the lack of spawning habitat. Northern pike prefer to spawn on shallow-flooded emergent vegetation in the spring, and this is limited in the chain. Any efforts to restore potential northern pike spawning habitat would be a valuable management effort.

The Lake District also stocked brown trout in Church Pine in 2009 on an experimental basis.

Lake Classification

Lake classification in Polk County is a relatively simple model that considers:

- ✓ lake surface area
- ✓ maximum depth
- ✓ lake type
- ✓ watershed area
- ✓ shoreline irregularity
- ✓ existing level of shoreline development

These parameters are then used to classify lakes as class one, class two, or class three lakes.

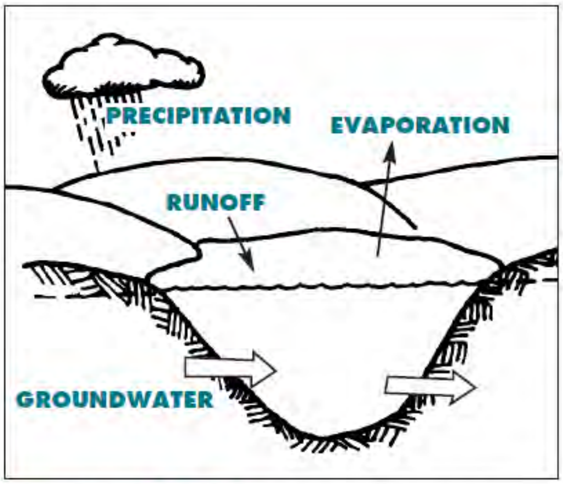
Class one lakes are large and highly developed.
Class two lakes are less developed and more sensitive to development pressure.
Class three lakes are usually small, have little or no development, and are very sensitive to development pressure.

(Polk County Shoreland Protection Zoning Ordinance, Effective April 1, 2010).

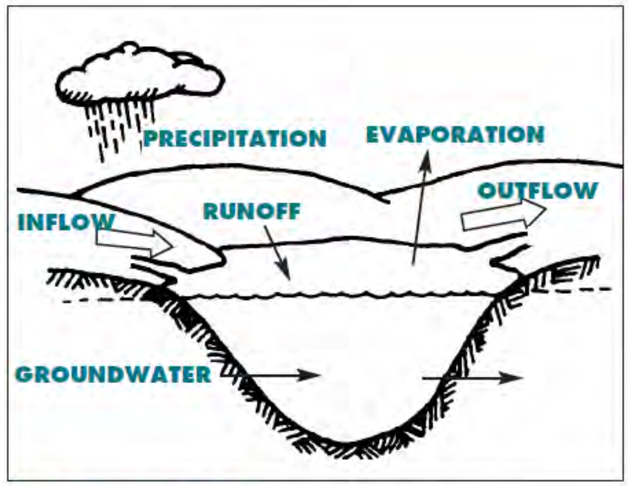
Church Pine, Round, and Big Lake are all classified as class one lakes (Polk County, Wisconsin Shoreland Property Owner Handbook A Guide to the Polk County Shoreland Protection Zoning Ordinance in Developing and Caring for Waterfront Property, October 2002).

Lake Types

Lakes are commonly classified into four main types based on water source and type of outflow: seepage lakes, groundwater drainage lakes, drainage lakes, and impoundments. The Wisconsin DNR has classified Church Pine and Round Lake as drainage lakes and Big Lake as a seepage lake. Seepage lakes do not have an outlet and are fed by precipitation, limited runoff, and groundwater; whereas, drainage lakes are drained by a stream and fed by streams, groundwater, precipitation, and runoff (Byron Shaw, Christine Mechenich, and Lowell Klessig, 2004).



1. SEEPAGE LAKE—a natural lake fed by precipitation, limited runoff and groundwater. It does not have a stream outlet.



3. DRAINAGE LAKE—a lake fed by streams, groundwater, precipitation and runoff and drained by a stream.

Figure 4. Seepage and drainage lake diagrams. Figure from: (Byron Shaw, Christine Mechenich, and Lowell Klessig, 2004).

The drainage basin: lake area ratios (DB: LA) compares the size of a lake's watershed to the size of a lake. If a lake has a relatively large DB: LA then surface water inflow (containing nutrients and sediments) occurs from a large area of land relative to the area of the lake (Byron Shaw, Christine Mechenich, and Lowell Klessig, 2004).

The DB: LA ratio [4] is largest for Big Lake (15.32), followed by Church Pine Lake (3.92) and Round Lake (3.43).

A study by Lillie and Mason (1983) found that in general seepage lakes have better water clarity and are less eutrophic as compared to drainage lakes. In this study, DB: LA for seepage lakes was smaller as compared to drainage lakes. This may explain why seepage lakes tend to have lower levels of nutrients.

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[4] DB: LA was calculated using the subwatershed areas from the Nonpoint Source Control Plan for the Horse Creek Priority Watershed Project and lake areas from the Wisconsin Department of Natural Resources website.

Impaired Waters

Every two years, the Wisconsin Department of Natural Resources publishes a list of waters considered impaired under the Federal Clean Water Act, Section 303(d). Impaired waters are not meeting water quality standards and may not support activities such as fishing, swimming, recreating, or public health and welfare.

Monitoring and assessment are used to make decisions regarding surface water quality conditions. Waterbodies are evaluated from their ability to support fish and aquatic life, recreation, and public health and welfare (fish consumption). Waterbodies are given a score based upon current condition and categorized as poor, fair, good, or excellent. Waterbodies classified as excellent or good are considered to be meeting their designated uses. Waterbodies described as fair are considered to be meeting their designated uses but may warrant additional monitoring to assure conditions are not declining. Finally, waterbodies that are listed as poor may be placed on Wisconsin's Impaired Waters List.

Waterbodies can be listed as impaired based on pollutants such as total phosphorus, total suspended solids, mercury, and PCB's.

Total phosphorus criteria for impairment vary depending on the inherent characteristics of a waterbody. For example, the total phosphorus criteria for drainage lakes that stratify (i.e. Church Pine Lake) is 0.030 mg/L; whereas the criteria for drainage lakes that do not stratify (i.e. Round Lake) and seepage lakes that do not stratify (i.e. Big Lake) is 0.040 mg/L. These values for total phosphorus represent the average as measured over the summer index period, which occurs from July 15th through September 15th.

Information summarized from: (Wisconsin Department of Natural Resources, 2013)

The total phosphorus criteria were met in 2012 on all three lakes over the summer index period (Church Pine Lake = 0.0205 mg/L; Round Lake = 0.024 mg/L; Big Lake = 0.033 mg/L).

Previous Lake Studies

Past studies that include Church Pine, Round, and Big Lake are:

- ✓ Lim Tech Consultants Study (1987)
- ✓ Nonpoint Source Control Plan for the Horse Creek Priority Watershed Project (2001)
- ✓ Barr Engineering Aquatic Plant Management (APM) Plan (1997/98)
- ✓ Harmony Environmental and Endangered Resource Services APM Plan (2010)

Lim Tech Consultants Study

The most recent water quality evaluation completed for the three lake system was conducted by Lim Tech Consultants in 1987.

This evaluation included:

- ✓ Watershed delineation
- ✓ Land-use characterization
- ✓ Water quality assessment
- ✓ Hydrological and nutrient-loading patterns
- ✓ Resident survey

Some of the notable conclusions made from the Lim Tech (1987) evaluation include:

1. Groundwater is not a significant source to any of the lakes.
2. The retention time is 7.8 years for Church Pine Lake, 2.9 years for Round Lake, and 1.9 years for Big Lake.
3. Church Pine and Round lake water quality is better than or equal to predicted water quality in the absence of development and Big Lake water quality is lower than predicted.
4. Phosphorus loading to Big Lake is excessive and due in large part to loads from North Creek (84%).
5. No evidence existed for the direct release of sewage waste along the majority of the shorelines of all three lakes with the exception of the west and northwest shores of Round Lake.
6. Algae concentrations were normal on Church Pine and Round Lake and excessive on Big Lake.
7. Aquatic macrophyte densities were normal, although residents were dissatisfied.
8. Dissolved oxygen levels were acceptable.

Nonpoint Source Control Plan for the Horse Creek Priority Watershed Project

Subwatershed descriptions are included in the 2001 Nonpoint Source Control Plan for the Horse Creek Priority Watershed Project prepared by the Polk County Land and Water Resources Department, Wisconsin Department of Natural Resources, and Wisconsin Department of Agriculture, Trade, and Consumer Protection.

	Church Pine Lake	Round Lake	Big Lake
Subwatershed (acres)	416	144	3,737
Direct drainage areas (acres)	376	111	1,775

Table 1. 2001 Church Pine, Round, and Big Lake subwatershed descriptions. Adapted from: (Polk County Land and Water Resources Department, June 2001).

Predominant land use in the direct drainage areas was also classified for this report. The predominant land uses in the direct drainage areas were: open space (173.57 acres) and rural residential (42.02 acres) for Church Pine Lake; open space (32.03 acres) and lakeshore residential (12.6 acres) for Round Lake; and open space (878.01 acres) and agriculture (394.01 acres) for Big Lake. [5]

	Church Pine Lake	Round Lake	Big Lake
Cropland (%)	5.2	8.7	20.8
Farmstead (%)	0	0	0.8
Woodland (%)	33.9	22.7	15.3
Lake (%)	24.2	39.1	18.1
Wetland (%)	0.4	6.2	26.9
Grassland (%)	11.9	0	7.2
Pasture (%)	0	0	0.5
Rural residential (%)	12.8	11.9	4.7
Lakeshore residential (%)	11.8	11.4	5.6

Table 2. 2001 Church Pine, Round, and Big Lake land use. Adapted from: (Polk County Land and Water Resources Department, June 2001).

[5] Open space includes wetland, woodland, and grassland and agriculture includes cropland, farmstead, and pasture.

Through 2009 the following projects were completed within the project lake's watershed as part of the priority watershed project:

- ✓ Nutrient/Pest Management: 316 acres
- ✓ High Residue Management: 39 acres
- ✓ Manure Storage Abandonment: 2 facilities
- ✓ Rain Gardens: 5 gardens
- ✓ Critical Area Stabilization: 2 areas
- ✓ Shoreline Habitat Restoration: 3.5 acres

Values from: (Harmony Environmental and Ecological Integrity Services, September 2010).

Barr Engineering Aquatic Plant Management Plan

Aquatic Plant Management Plans were completed by Barr Engineering for Big Lake in 1997 and Church Pine and Round Lake in 1998 (Barr Engineering, April 1997) (Barr Engineering, April 1998).

The goals for Big Lake included:

- ✓ Reduce plant density throughout the littoral region from the existing high density to a moderate plant density
- ✓ Reduce the exotic curly leaf pondweed to the greatest extent possible from Big Lake, while maintaining a healthy native aquatic plant community

The goals developed for Church Pine and Round Lake included:

- ✓ Improve navigation within the lakes through areas containing dense plant beds (two areas within in each lake)
- ✓ Remove or limit current exotic plants (i.e., curly leaf pondweed)
- ✓ Preserve native species and prevent introduction of additional exotic species
- ✓ Preserve and/or improve fish and wildlife habitat
- ✓ Protect and/or improve quality of the resources for all to enjoy (i.e., people, fish, wildlife)
- ✓ Minimize disturbance of sensitive areas (i.e., fish and wildlife)

Harmony Environmental and Endangered Resource Service Aquatic Plant Management Plan

The most recent Aquatic Plant Management Plan for the three lake system was completed in 2010 by Harmony Environmental and Ecological Integrity Services (Harmony Environmental and Ecological Integrity Services, September 2010).

The goals developed for the three lake system include:

- ✓ Prevent introduction of aquatic invasive species and pursue any new introduction aggressively
- ✓ Reduce the population and spread of curly leaf pondweed, purple loosestrife, and other invasive aquatic plants
- ✓ Maintain navigable routes for boating
- ✓ Preserve diverse native aquatic plant community
- ✓ Reduce runoff of nutrients and sediment from the lake's watershed
- ✓ Educate the public regarding aquatic plant management

Previous District Sponsored Projects

Numerous projects have already taken place to improve Church Pine, Round, and Big Lakes.

Shoreline projects implemented with Polk County cost share dollars

Shoreline habitat restoration

- ✓ Church Pine Lake: 15 restorations
- ✓ Round Lake: 4 restorations
- ✓ Big Lake: 9 restorations

Rain gardens

- ✓ Church Pine Lake: 23 rain gardens
- ✓ Round Lake: 4 rain gardens
- ✓ Big Lake: 2 rain gardens

Critical area stabilization

- ✓ Church Pine Lake: 7 projects
- ✓ Round Lake: 27 projects
- ✓ Big Lake: 5 projects

Urban practices

- ✓ Church Pine Lake: 8 practices
- ✓ Round Lake: 1 practice

Additional practices on Big Lake

- ✓ Nutrient Management
- ✓ Pest Management
- ✓ High Residue Management

Native Plant Bank Stabilization [6]

The Lake District completed dredging of the channel to maintain navigation between Round Lake and Church Pine Lakes in the fall of 2012. As part of the project, the disturbed bank was seeded with a "short dry native grass/forbs mix" containing 10 different native wild flowers from Agassis Seed Company in Minneapolis.

Curly leaf pondweed management [7]

Curly leaf pondweed (CLP) is present in Big, Round, and Church Pine Lakes – most of the dense growth of CLP is in Big Lake. CLP has been successfully treated with endothall early in the season in 2011, 2012, and 2013. Treatments have resulted in nearly complete removal

[6] Cheryl Clemens, Harmony Environmental, Email Communication, November 2013.
[7] Cheryl Clemens, Harmony Environmental, Email Communication, November 2013.

of CLP during each treatment period, and treatment acres declined from 25 in 2011 to 20 in 2012. In 2013, 20.9 acres were treated.

The entire area with CLP growth is treated in Round Lake. This amounted to .10 acres in 2011, .08 acres in 2012, and .05 acres in 2013. The littoral zone is about 59% of this 30 acre lake or 18 acres. CLP is therefore present in only 0.3 % of the littoral zone of Round Lake.

Sediment turion analysis also shows promising results with sediment turion density decreasing from 44 to 12.8 turions per square meter from 2011 to 2012 (Ecological Integrity Service, July 2013).

Purple loosestrife management [8]

The Lake District hired Dale Dressel, with Northern Aquatic Services to chemically treat purple loosestrife from 2009 through 2012. Purple loosestrife costs have declined with successful herbicide treatments. They totaled $3,126 in 2009; $820 in 2010, $763 in 2011, and $870 in 2012. Dale cut stems and treated plants with glyphosate. A homeowner has also released beetles in one large patch on Big Lake.

Knotweed management

Polk County Land and Water Resources Department located three knotweed sites on Big Lake and one near Round and Church Pine Lake. Three of these sites have been managed through herbicide and/or removal.

Clean Boats, Clean Waters [9]

The Clean Boats, Clean Waters program educates lake users regarding actions that prevent invasive species from entering lakes and records lake users' behavior. Because of the threat of introduction of invasive aquatic species, preparation for a Clean Boats, Clean Waters project began in 2006. In that year, two lake residents attended DNR training. The Lake District also acquired inspector T shirts and hats.

The Clean Boats Clean Waters inspections were launched in 2007. Residents who attended training in 2006 provided training for other volunteers. Coordinators were assigned for the Church Pine and Big Lake boat landings, and aquatic invasive species (AIS) signs were posted at these landings. Volunteers worked over 14 weekend days (57 hours) inspecting 57 boats with 2 potential AIS introductions avoided. Volunteers also looked for EWM at the boat landings in 2007. The program struggled in 2008 with fewer volunteers participating and deteriorating record keeping. Coverage at the boat landings went down to about 4 weekend days (22 hours) and 24 boat inspections.

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[8] Cheryl Clemens, Harmony Environmental, Email Communication, November 2013.
[9] Cheryl Clemens, Harmony Environmental, Email Communication, November 2013.

In 2009, the Lake District hired 4 students working every weekend from 6 to 10 a.m. with 2 assigned per landing on Big Lake and Church Pine Lake. There were also ongoing "drop by" visits by the 16 volunteer adults. The Lake District funded the program without grant assistance in 2009.

Department of Natural Resources grants supported the Clean Boats Clean Waters program in 2010, 2011, and 2012. Grant support has allowed expansion of the program. Inspectors staff the boat landings one weeknight, Saturdays, Sundays, and holidays beginning the weekend before Memorial Day and ending the weekend after Labor Day. An adult staffs the Church Pine Landing and students staff the Big Lake Landing. They are paid $10-12 per hour. Adult volunteers check in with the student inspectors periodically. Board members attend training and assist with data base entry and reporting. Heidi Hazzard coordinates the program and enters the data into the DNR database.

Landing	Boats 2009	Boats 2010	Boats 2011	Boats 2012
Big Lake	86	273	442	429
Church Pine	118	260	414	382

Lake District Resident Survey

A Wisconsin Department of Natural Resources approved sociological survey was mailed to two hundred twenty four residences of the Church Pine, Round, and Big Lake Protection and Rehabilitation District in early May 2012. Residents were reminded to return their survey at the May 19th Spring Informational Meeting and with an August educational postcard. The survey was designed to gather information from residents concerning property ownership and use, land use, lake use, concerns for the three lake system, water quality, algae, shoreline vegetation, management practices for improvement of the three lake system, and website use.

One hundred sixteen surveys were returned (52% response rate) and data was entered and analyzed. Ninety three percent of respondents own property located on the waterfront of Church Pine, Round, or Big Lake; whereas the remaining 7% do not. Respondents who did not own waterfront property were directed to skip questions to quantify shoreline habitat.

Respondents were also asked which lake their property was located on or located nearest to. If respondents owned property located on more than one lake they were directed to choose the lake they frequented most often. Respondents were directed to use the lake they had chosen to answer questions regarding current water quality, changes in water quality, negative impacts of algae, and current amount of shoreline vegetation.

Property Ownership and Use

Respondents have owed property on or near Church Pine, Round, and Big Lake for an average of 22 years. The majority of respondents use their property as a weekend, vacation, and/or holiday residence (46%) or occupy their property on a year round basis (44%). A small percentage of residents (6%) use their property as a seasonal residence (continued occupancy for months at a time). On average, respondents occupy their property for 194 days per year. At any given time, an average of three people occupy each property.

Land Use

Survey respondents were asked to classify the amount of open space (lawns or mowed areas), shrub/grass/sedge community, woods, and impervious surfaces (buildings, driveways, sidewalks, patios, gravel paths and driveways) on their property to gauge land use in the areas surrounding Church Pine, Round, and Big Lake. According to respondent classification, an average of 39% of properties are occupied by open space, 25% are occupied by woods, 20% are occupied by impervious surfaces, and 16% are occupied by the shrub/grass/sedge community.

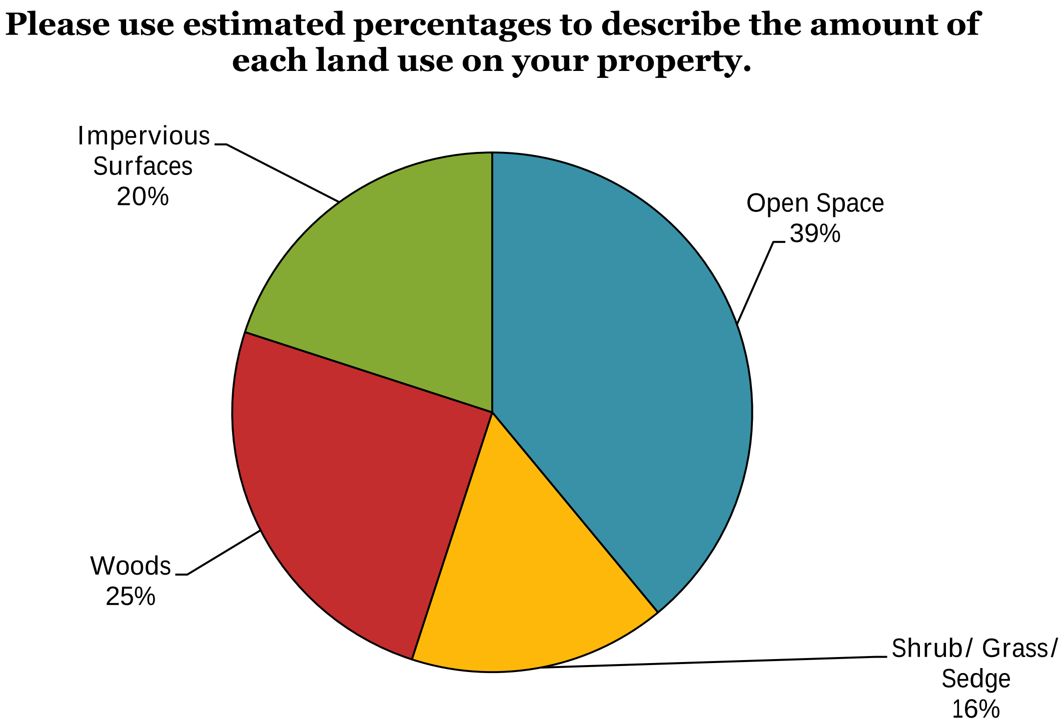


Figure 5. Survey response: Please use estimated percentages to describe the amount of each land use on your property.

Respondents owning waterfront property were also asked to describe the first 35 feet of their shoreline (the area located directly adjacent to the lake). The majority (65%) classified the first 35 feet of their shoreline as a mix of native flowers, grasses, shrubs, and trees. Twenty four percent classified the first 35 feet of their shoreline as mostly mowed grass, 9% as mostly native flowers and grasses, and 3% as a mix of native flowers, grasses, and shrubs.

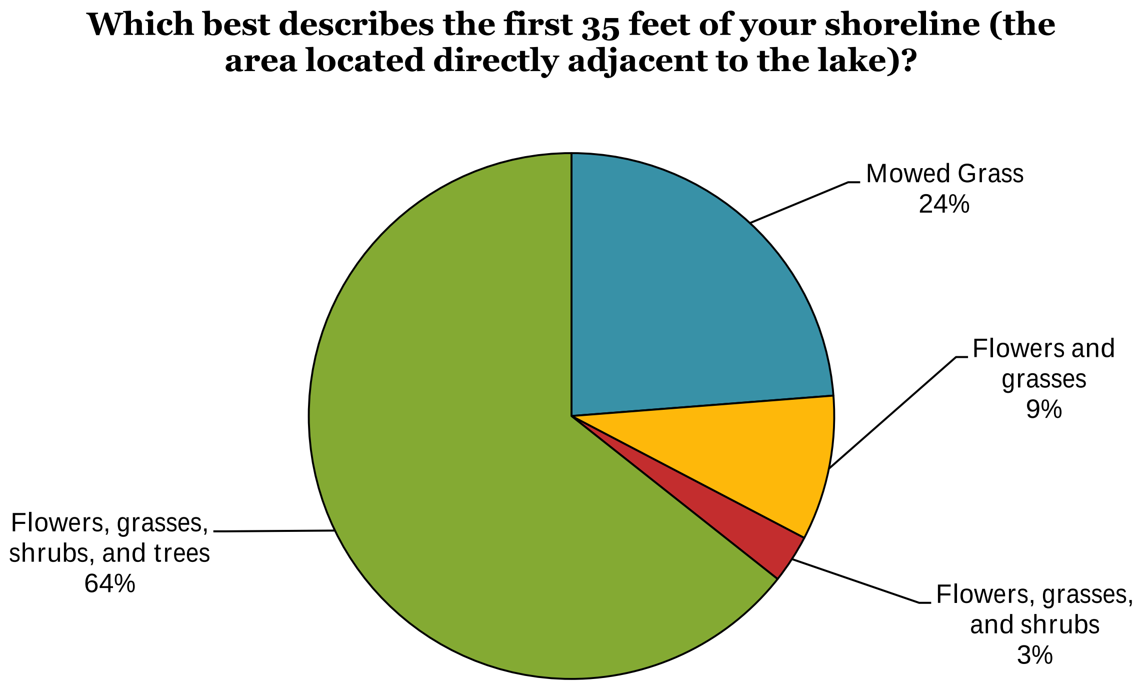


Figure 6. Survey response. Which best describes the first 35 feet of your shoreline (the area located directly adjacent to the lake)?

Lake Use

Respondents use Church Pine, Round, and Big Lake for a variety of recreational activities. Eighty eight percent of respondents partake in motorized water activities (PWC, boating, water skiing, tubing, jet skiing); 85% partake in swimming, snorkeling, or scuba diving; 81% partake in fishing (any season); and 65% partake in non-motorized activities (birding, canoeing, hiking, running). Winter specific recreational activities were less frequent on the three lake system, possibly due to the abundance respondents who do not live on the three lake system year round. Thirty nine percent of respondents partake in non-motorized winter activities (skiing, snowshoeing, ice skating) and 16% partake in motorized winter activities (ATV, snowmobile).

Respondents keep a total of 70 paddleboats/rowboats, 89 canoes/kayaks, 3 paddleboards, 8 sailboats, 24 jet skis, 24 motorboats/pontoons (1-20 HP), 64 motorboats/pontoons (21-50HP), and 58 motorboats/pontoons (50+ HP).

Concerns for Church Pine, Round, and Big Lake

Survey respondents were asked to rank their top three concerns for Church Pine, Round, and Big Lake. To analyze this data, each concern that ranked first received 3 points, each concern that ranked 2nd received 2 points, and each concern that ranked third received 1 point. Total points were then added to determine the ranking of concerns for the three lake system. Property values and/or taxes ranked as the 1st concern, followed by invasive species as the 2nd concern, and pollution and aquatic plants which tied as the 3rd concern.

Concerns for Church Pine, Round, and Big Lake	Rank	Points
Property values and/or taxes	1st	119
Invasive species *(Eurasian water milfoil, zebra mussels, curly leaf, purple loosestrife)*	2nd	117
Aquatic plants *(not including algae)*	3rd	80
Pollution *(chemical inputs, septic systems, agriculture, erosion, storm water runoff)*	3rd	80
Water clarity *(visibility)*	4th	64
Algae blooms	5th	39
Quality of life	6th	34
Water levels *(loss of lake volume)*	7th	33
Water recreation safety *(boat traffic, no wake zone)*	8th	31
Quality of fisheries	9th	30
Development *(population density, loss of wildlife habitat)*	10th	29
Other, please describe *(noise/light, preservation of recreational water sports)*	11th	3

Table 3. Survey response. Concerns for Church Pine, Round, and Big Lake.

Water Quality

The majority of respondents living on Church Pine Lake described the water quality as excellent (56%) or good (36%). In the time since these respondents have owned their property (average 24 years) the perception has been that water quality has remained unchanged (47%) or somewhat degraded (44%).

The current water quality of Round Lake was perceived as good by the majority of respondents living on Round Lake (56%), fair by a quarter of respondents (25%), and excellent by less than a quarter of respondents (19%). Since these respondents have owned their property (average 16 years) nearly half perceive that water quality has remained unchanged (47%). Twenty-nine percent of respondents perceive that water quality has somewhat degraded, twelve percent perceive that water quality has severely degraded, and twelve percent were unsure how water quality has changed.

Big Lake is perceived as having good water quality by over half of respondents living on Big Lake (59%), and fair by over a quarter of respondents (26%). Only seven percent of respondents perceived the water quality as excellent and another seven percent were unsure (n = 61). In the time since respondents have owned their property (average 22 years), over a third of respondents (34%) felt that the water quality on Big Lake has remained unchanged, less than a third (29%) felt that the water quality has somewhat degraded, and less than a quarter (19%) felt that the water quality has somewhat improved (n = 62).

Overall, the majority of respondents felt that current water quality was good to excellent on the three lake system and that water quality has remained unchanged or somewhat degraded in the time since they have owned property.

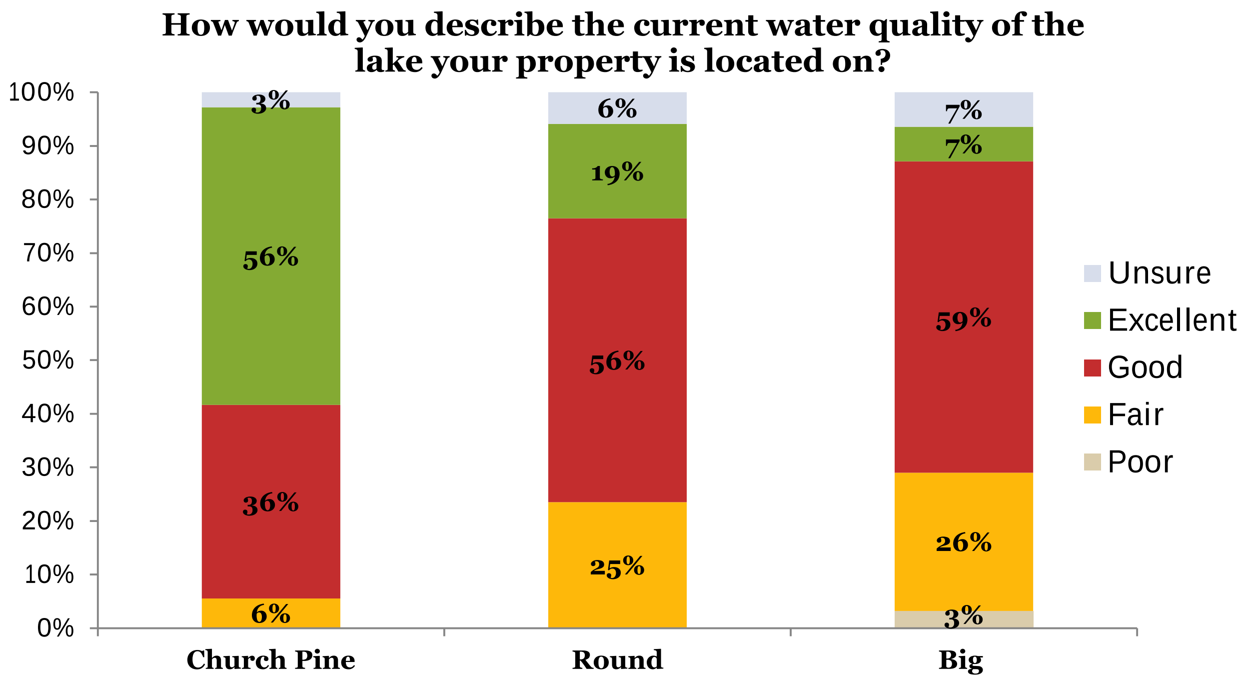


Figure 7. Survey response. How would you describe the current water quality of the lake your property is located on?

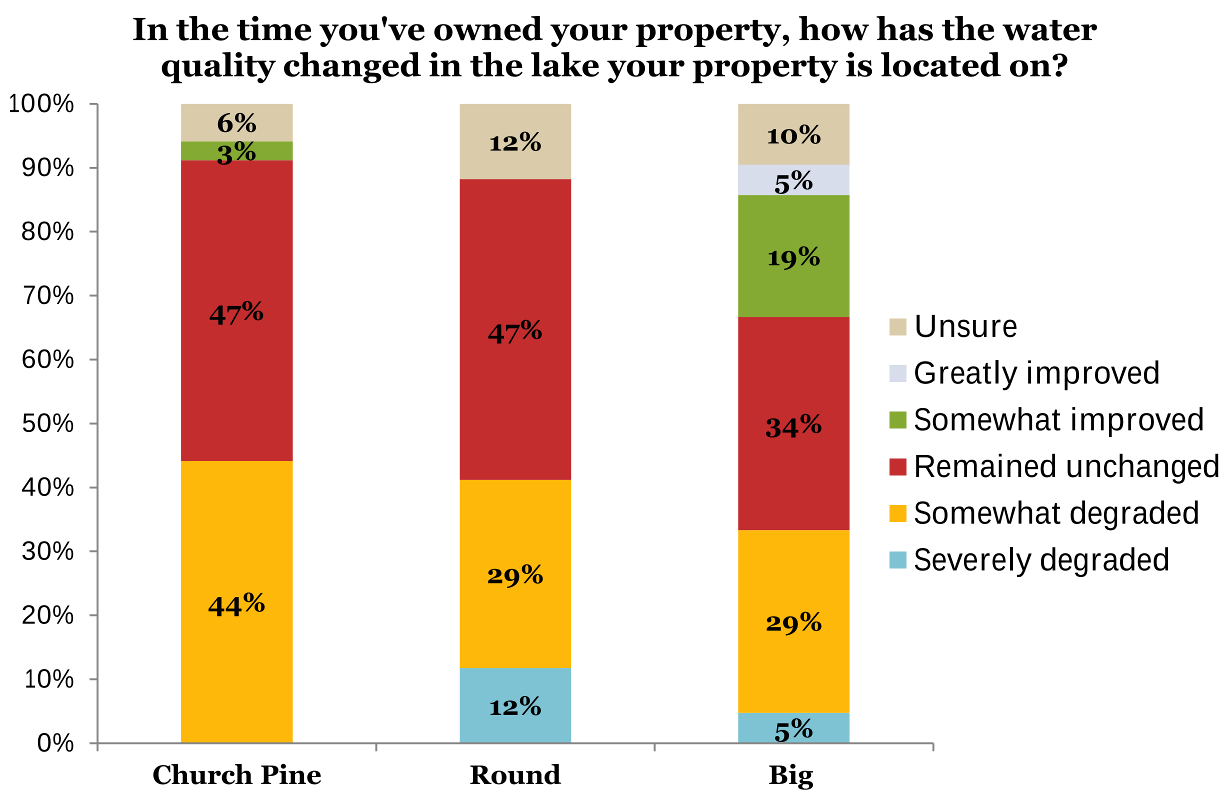


Figure 8. Survey response. In the time you've owned your property, how has the water quality changed in the lake your property is located on?

Algae

Algae appear to negatively impact the enjoyment of Big Lake more often as compared to Round Lake and Church Pine Lake. On Church Pine Lake and Round Lake, zero respondents felt that algae always negatively impacts enjoyment of the lakes as compared with 3% of respondents on Big Lake. In contrast, 31% of respondents felt that algae never negatively impacts their enjoyment of Church Pine Lake, 18% felt that algae never negatively impacts their enjoyment of Round Lake, and 6% felt that algae never negatively impacts their enjoyment of Big Lake.

Additionally, most respondents on Big Lake (50%) and Round Lake (53%) felt that algae sometimes negatively impacts their enjoyment of the lakes and most respondents on Church Pine Lake (46%) felt that algae rarely negatively impacts their enjoyment of the lake.

Across all three lakes, very few respondents feel that algae negatively impact lake enjoyment often/always.

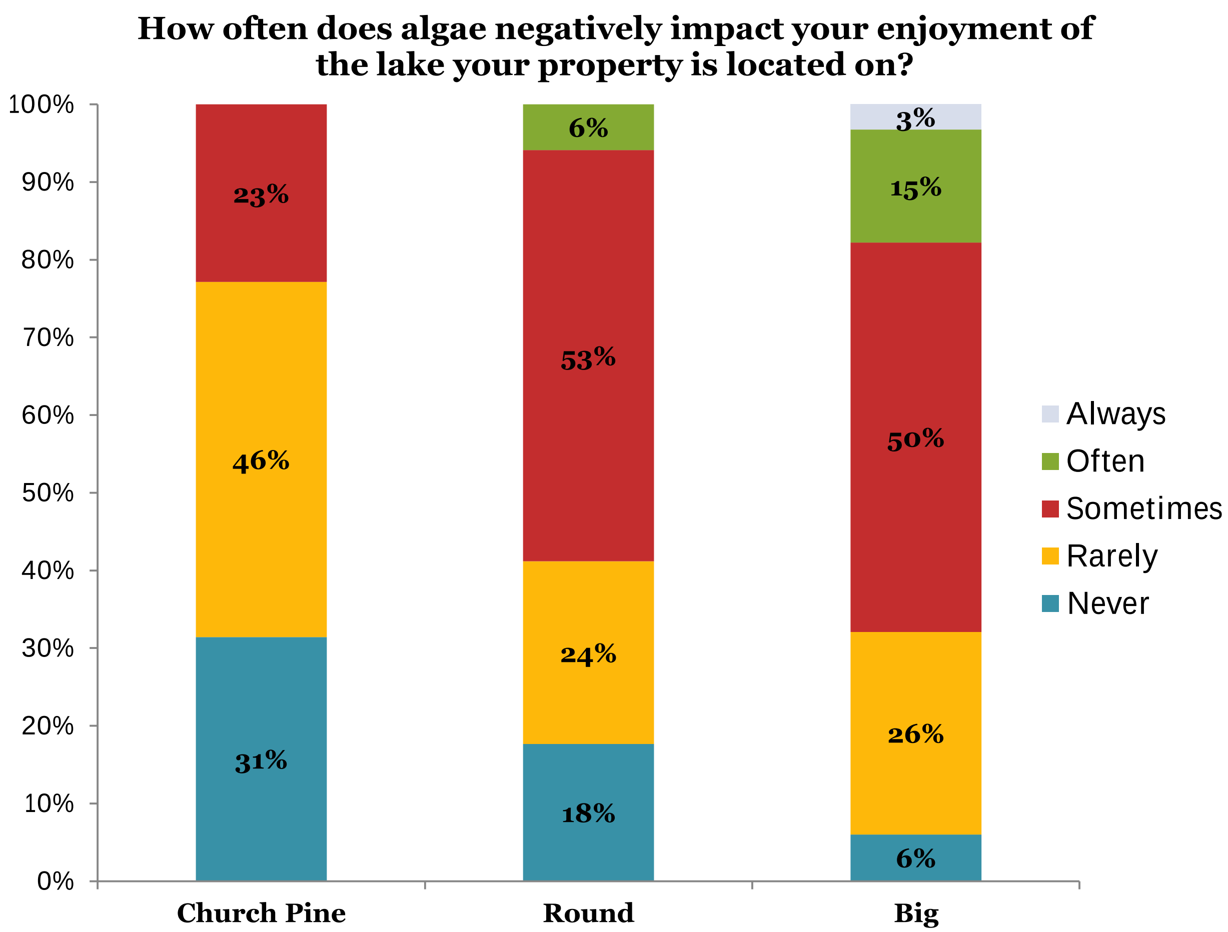


Figure 9. Survey response. How often does algae negatively impact your enjoyment of the lake your property is located on?

Shoreline Vegetation

Nearly three-fourths of the residents on Church Pine Lake (74%) felt that the amount of shoreline vegetation on the lake was just right. Slightly more respondents felt there was too much shoreline vegetation on Church Pine (9%) as compared to not enough (6%).

On Round Lake an equal amount of respondents felt that the amount of shoreline vegetation was too much or just right (41%) and very few (6%) felt that the amount of shoreline vegetation was not enough.

Most of the respondents on Big Lake felt that the amount of shoreline vegetation was just right (40%) or too much (35%). Fewer respondents (12%) felt there was not enough shoreline vegetation on Big Lake.

Across all three lakes most respondents felt that the amount of shoreline vegetation on the three lake system was just right. Additionally, more respondents felt there was too much shoreline vegetation as compared to not enough.

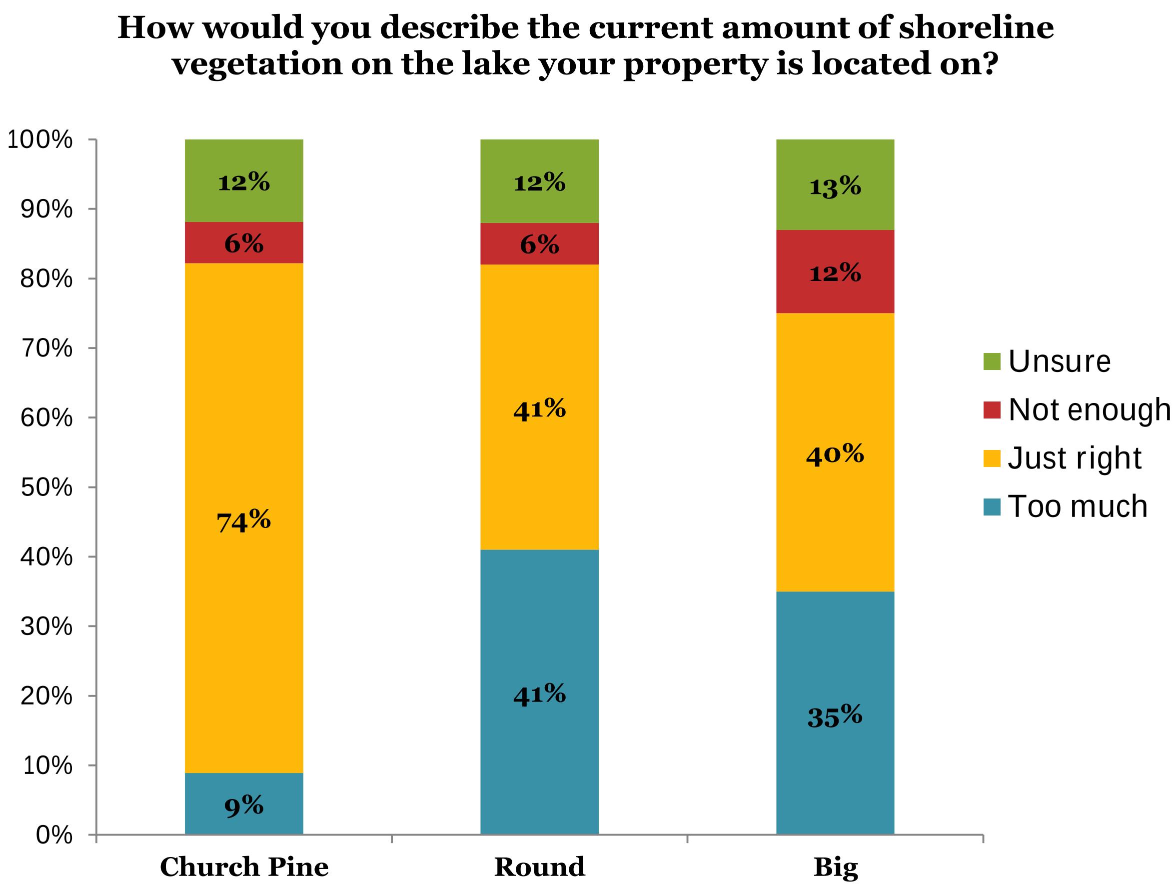


Figure 10. Survey response. How would you describe the current amount of shoreline vegetation on the lake your property is located on?

Overall respondents recognize the importance of shoreline buffers, rain gardens, and native plants to the water quality of the three lake system. Nearly half (46%) of respondents described shoreline buffers, rain gardens, and native plants as very important to water quality and just under a third (32%) described them as somewhat important. In contrast, 8% of respondents felt they were not too important and 2% felt they were not at all important. Additionally, another 12% of respondents were unsure of the importance of shoreline buffers, rain gardens, and native plants to water quality.

The results suggest a possible educational need regarding the importance of shoreline buffers, rain gardens, and native plants to water quality.

Although a combined 78% of respondents felt that shoreline buffers, rain gardens, and native plants are very important or somewhat important to water quality, half (50%) of respondents are not interested in installing a shoreline buffer or rain garden on their property. In contrast 32% of respondents have already installed a shoreline buffer or rain garden and 7% are interested in installing a shoreline buffer or rain garden. The remainder of respondents (14%) were unsure of their interest in installing a shoreline buffer or rain garden.

Overall, respondents are making educated decisions when applying fertilizer to their property. Over half of respondents (58%) do not use fertilizer on their property and over a third (35%) use zero phosphorus fertilizer. Very few respondents use fertilizer but are unsure of its phosphorus content (5%) and an extremely small percentage use fertilizer on their property that contains phosphorus (2%).

Management Practices for Improvement of the Three Lake System

Survey respondents were asked to choose all of the management practices they felt should be used to maintain or improve the water quality of Church Pine, Round, and Big Lake from a list of eight options. Three-fourths of respondents (75%) felt that the in-lake water quality data should continue to be collected and that enhanced efforts to monitor for new populations of aquatic invasive species should be implemented. Other management practices supported by many respondents were information and education opportunities (46%), cost-sharing assistance for the installation of shoreline buffers and rain gardens (44%), and establishment of slow-no-wake zones to protect aquatic plants and fisheries habitat (41%).

Management practices to improve water quality	Percent
Continued collection of in-lake water quality data	75%
Enhanced efforts to monitor for new populations of aquatic invasive species	75%
Information and education opportunities	46%
Cost-sharing assistance for the installation of shoreline buffers and rain gardens	44%
Establishment of slow-no-wake zones to protect aquatic plants and fisheries habitat	41%
Collection of sediment cores to provide information concerning historical lake conditions	33%
Practices to enhance fisheries, such as the introduction of coarse woody habitat	29%
Cost-sharing assistance for the installation of farmland conservation practices (nutrient management plans, contour strips, conservation tillage)	27%

Table 4. Survey response. Management practices to improve water quality.

Website Use

The Church Pine, Round, and Big Lake Protection and Rehabilitation District maintains a very extensive website available at www.bigroundpine.com. Less than ten percent of respondents often visit the website (9%), one third of respondents sometimes (34%) or rarely (32%) visit the website, and a quarter of respondents of respondents never visit the website (26%).

Lake Level and Precipitation Monitoring

Lake water-level fluctuations are important to lake managers, lakeshore property owners, developers, and persons using lakes for recreation. Lake level fluctuations can have significant effects on lake water quality and usability. Although lake levels naturally change from year to year, extreme high or low levels can present problems such as restricted water access, flooding, shoreline and structure damage, and changes in riparian (near shore) vegetation.

Records of lake water elevations can be very useful in understanding changes that may occur in lakes. While some lakes respond almost immediately to precipitation, other lakes do not reflect changes in precipitation until months later.

Figure 11. Installation of staff gauge.

On April 23rd, 2012 Polk County Land and Water Resources Department staff met with volunteers from Church Pine, Round, and Big Lake to provide training on lake level and precipitation data monitoring. Seven residents attended the training and staff and rain gauges were installed on all three lakes. Staff gauges were set at an arbitrary height; therefore, lake levels are not comparable at a specific point in time. However, the relative changes in lake level across all three lakes are comparable.

Lake level and precipitation data were collected daily on all three lakes beginning on April 23rd and ending on September 30th. Staff gauges were removed on October 4th. Beginning on September 1st, the lake level readings on Big Lake were negative due to low water levels. When the staff gauge on Big Lake was removed, the water level was approximately five tenths of a foot below zero.

Seasonal precipitation totaled twenty-three inches on Church Pine Lake, twenty inches on Round Lake, and twenty-four inches on Big Lake. Shortly following precipitation events, the lake levels on Church Pine, Round, and Big Lake increased.

Over the course of the sampling season, lakes levels decreased by nearly a foot on all three lakes[10].

[10] Church Pine Lake 0.97 feet; Round Lake 0.92 feet; and Big Lake 1.13 feet (estimated by adding 0.5 feet to 0.63 feet).

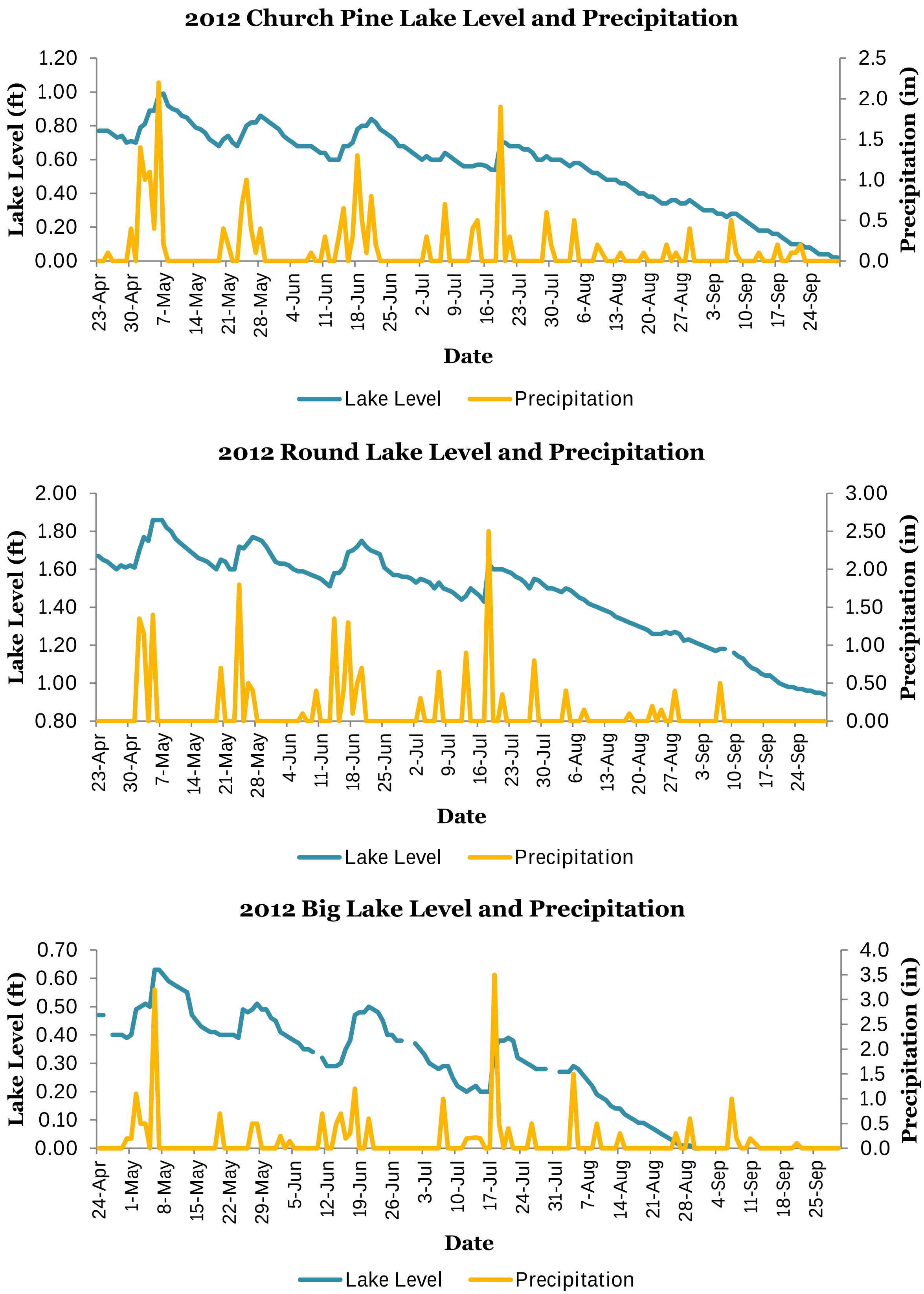


Figure 12. 2012 Church Pine, Round, and Big Lake level and precipitation.

Chemical and Physical Data Sampling Procedure

Figure 13. Lake profile monitoring.

Physical and chemical data were collected in lake at the deep hole of Church Pine, Round, and Big Lake from May 7th, 2012 through September 5th, 2012. Spring turnover samples were taken on April 3rd, 2012. However, since ice-out occurred around a month early, the lakes had already begun to stratify by this date. Fall turnover samples were taken on October 15th, 2012.

Two meter integrated samples were collected from the water column once a month during the growing season and at spring and fall turnover. Samples were analyzed at the Water and Environmental Analysis Lab (WEAL) at UW-Stevens Point for two types of phosphorus (total phosphorus and soluble reactive phosphorus), three types of nitrogen (nitrate/nitrite, ammonium, and total Kjeldahl nitrogen), chlorophyll *a*, chloride, and total suspended solids. In addition to these parameters, total hardness, calcium, sulfate, and, sodium were analyzed at both turnover events.

Figure 14. Integrated sampler.

Lake profile monitoring—which included dissolved oxygen, temperature, conductivity, pH, and secchi depth—was conducted bi-monthly during the growing season. Dissolved oxygen, temperature, and conductivity readings were recorded at every meter within the water column using a YSI 85 multi-parameter probe. pH readings were recorded at every meter within the water column using a YSI 60 pH meter. During the second sampling set in July, both YSI meters stopped working. Beginning with the August 6th sample, lake profile monitoring was collected using an HI 9828 multi-parameter probe.

Secchi depth was recorded using a secchi disk, which is an eight inch diameter round disk with alternating black and white quadrants. To record secchi depth, the secchi disk was lowered into the lake on the shady side of a boat until it just disappeared from sight. This depth was measured in feet and recorded as the secchi depth.

In most instances in this report, data is presented as an average over the **growing season**, which refers to data collected from May through September and excludes turnover data, collected in April and October. In some instances, data is averaged over the **summer index period**, which refers to data collected from July 15th through September 15th.

Lake Mixing and Stratification: Background Information

Information summarized from: (Byron Shaw, Christine Mechenich, and Lowell Klessig, 2004).

Water quality is greatly affected by the degree to which the water in a lake mixes. Within a lake, mixing is most directly impacted by the temperature-density relationship of water. When comparing why certain lakes mix differently than others, lake area, depth, shape, and position in the landscape become important factors to consider.

Water reaches its greatest density at 3.9^{o}C (39^{o}F) and becomes less dense as temperatures increase and decrease. Compared to other liquids, the temperature-density relationship of water is unusual: liquid water is denser than water in its solid form (ice). As a result, ice floats on liquid water.

When ice melts in the early spring, the temperature and density of the water will be constant from the top to the bottom of the lake. This uniformity in density allows a lake to completely mix. As a result, oxygen is brought to the bottom of a lake, and nutrients are re-suspended from the sediments. This event is termed **spring overturn**.

In spring 2012, ice out on Church Pine, Round, and Big Lake occurred approximately a month earlier than what is typical in Polk County. Since the grant start date was April 1st, spring turnover samples were not taken until April 3rd. However, due to early ice out, the spring turnover samples were likely taken after spring turnover occurred.

As the sun's rays warm the surface waters in the spring, the water becomes less dense and remains at the surface. Warmer water is mixed deeper into the water column through wind and wave action. However, these forces can only mix water to a depth of approximately twenty to thirty feet. Generally, in a shallow lake, the water may remain mixed all summer. However, a deeper lake usually experiences layering called **stratification**.

During the summer, lakes have the potential to divide into three distinct zones: the **epilimnion**, **thermocline** or **metalimnion**, and the **hypolimnion**. The epilimnion describes the warmer surface layer of a lake; whereas the hypolimnion describes the cooler bottom area of a lake. The thermocline, or metalimnion, describes the transition area between the warmer surface layer and the cooler bottom layer.

As surface waters cool in the fall, they become denser and sink until the water temperature evens out from top to bottom. This process is called **fall overturn** and allows for a second mixing event to occur. Occasionally, algae blooms can occur at fall overturn when nutrients from the hypolimnion are made available throughout the water column.

The variations in density arising from different water temperatures can prevent warmer water from mixing with cooler water. As a result, nutrients released from the sediments can become trapped in the hypolimnion of a lake that stratifies. Additionally, because mixing is one of the main ways oxygen is distributed throughout a lake, lakes that don't mix have the potential to have very low levels of oxygen in the hypolimnion.

The absence of oxygen in the hypolimnion can have adverse effects on fisheries. Species of cold water fishes, such as trout, require the cooler waters that result from stratification. Cold water holds more oxygen as compared to warm water. As a result, the cooler waters of the hypolimnion can provide a refuge for cold water fisheries in the summer as long as oxygen is present. Respiration by plants, animals, and bacteria is the primary means by which oxygen is removed from the hypolimnion. A large algae bloom can cause oxygen depletion in the hypolimnion as algae die, sink, and decay.

In the winter, stratification remains constant because ice cover prevents mixing by wind action.

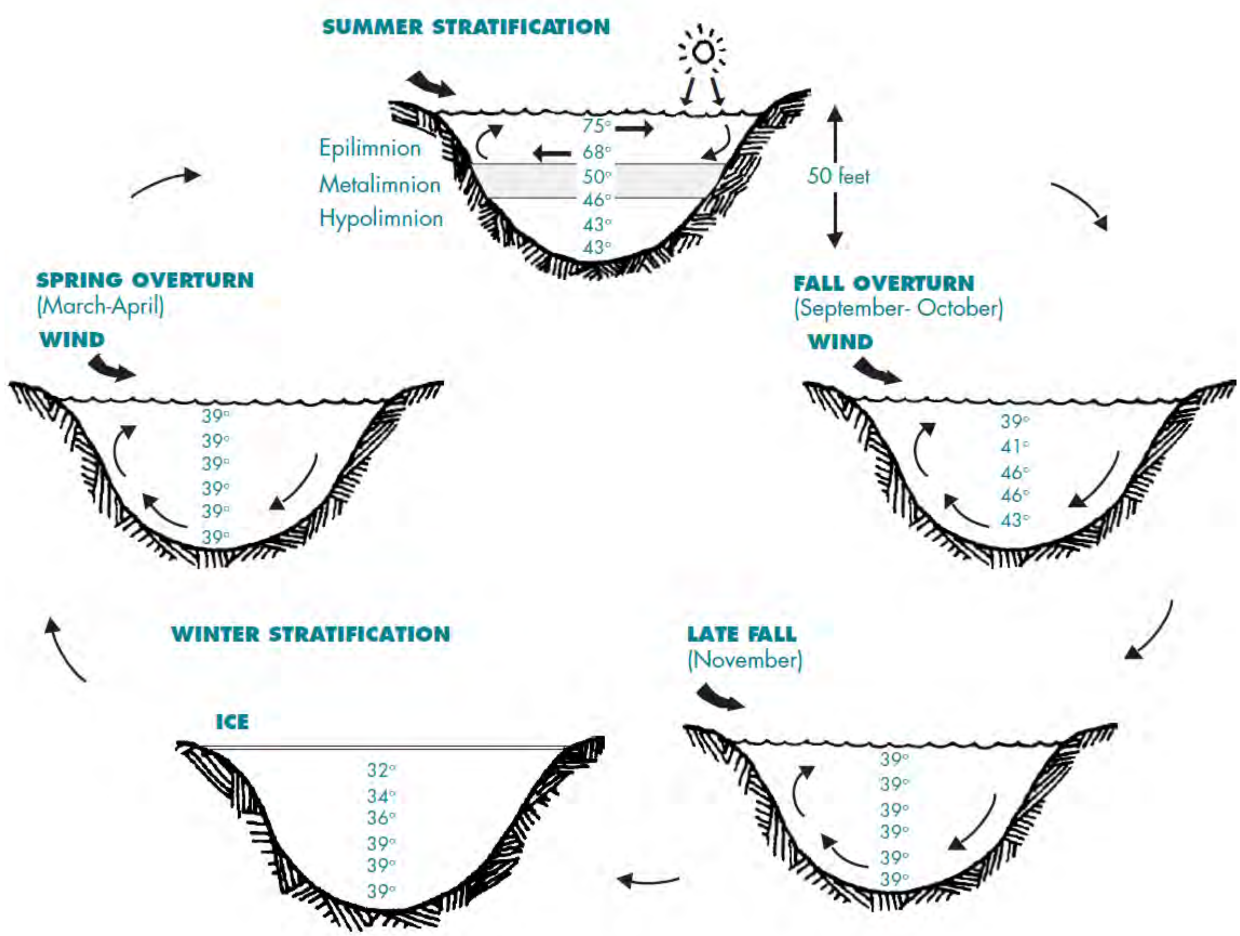


Figure 15. Temperature cycles in stratified lakes. Figure from: (Byron Shaw, Christine Mechenich, and Lowell Klessig, 2004).

Turnover Data: Calcium, Magnesium, and Sulfate

Data for a number of chemical analyses occurred only at spring and fall turnover. These include calcium, magnesium[11], and sulfate.

Calcium and magnesium concentrations in Wisconsin lakes are closely related to the bedrock geology of the landscape, with highest concentrations found in areas with limestone and dolomite deposits. In Polk County, calcium concentrations typically range from 10-20 mg/L and magnesium concentrations are typically less than 10 mg/L (Lillie, 1983).

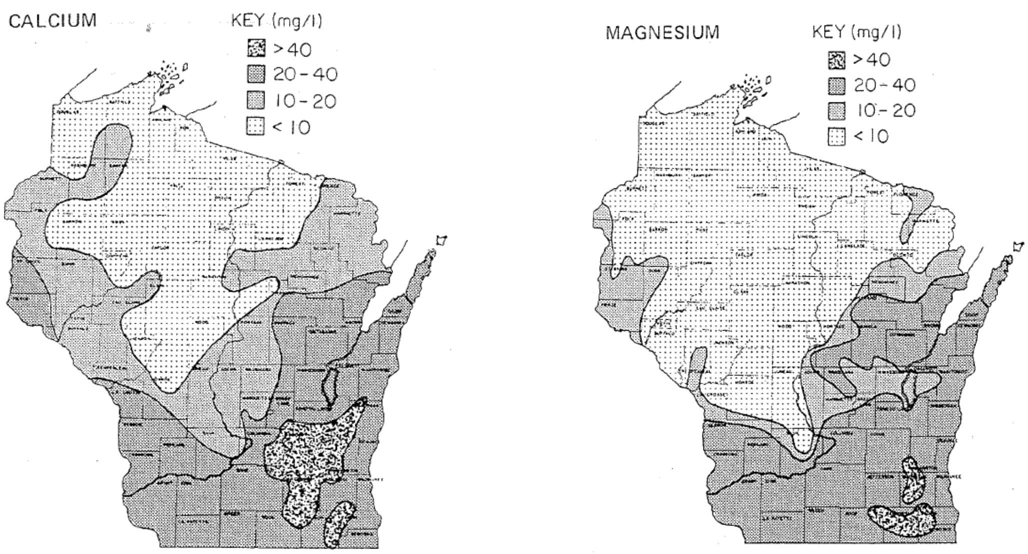


Figure 16. Calcium and magnesium concentrations in Wisconsin. Figure from: (Lillie, 1983).

Average turnover calcium concentrations were elevated as compared to what is typical in Polk County lakes on Round and Big Lake (23.6 mg/L and 26.3 mg/L respectively); whereas concentrations where within the typical range on Church Pine Lake (17.3 mg/L).

Magnesium was only analyzed at fall turnover and was within the typical range for Polk County lakes on Church Pine, Round, and Big Lake.

	Church Pine Lake	Round Lake	Big Lake
Calcium (mg/L) *fall and spring turnover average	17.3	23.6	26.3
Magnesium (mg/L) *fall turnover value	7.5	8.5	8.8

Table 5. 2012 calcium and magnesium concentrations in Church Pine, Round, and Big Lake.

[11] Magnesium was analyzed only at fall turnover.

Sulfate concentrations in lakes are most directly related to the types of minerals found in the watershed and to acid rain. Sulfur compounds released into the atmosphere by coal burning facilities can enter lakes via rainfall. In general, sulfate concentrations are higher in the southeastern portion of the state where mineral sources of sulfate and acid rain are more common.

In Polk County, sulfate concentrations are generally less than 10 mg/L (Byron Shaw, Christine Mechenich, and Lowell Klessig, 2004).

In Church Pine and Round Lake, average spring and fall turnover sulfate concentration was well below the typical concentration for Polk County (3.15 mg/L and 4.4 mg/L respectively).

At spring turnover in Big Lake, the sulfate concentration was well above what is typical in Polk County (21.3 mg/L); whereas at fall turnover the concentration was well below the typical concentration (5.2 mg/L).

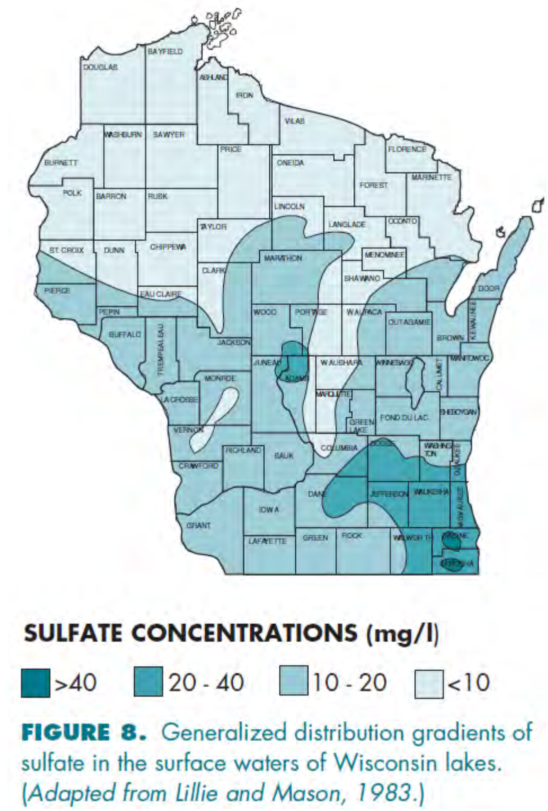


Figure 17. Sulfate concentrations in Wisconsin. Figure from: (Byron Shaw, Christine Mechenich, and Lowell Klessig, 2004).

Phosphorus

Phosphorus is an element present in lakes which is necessary for plant and algae growth. It occurs naturally in soil, rocks, and the atmosphere and can make its way into lakes through groundwater and soil erosion induced from construction site runoff or other human induced disturbances. Additional sources of phosphorus input into a lake can include fertilizer runoff from urban and agricultural settings and manure.

Phosphorus does not readily dissolve in water, instead it forms insoluble precipitates (particles) with calcium, iron, and aluminum. If oxygen is available, iron forms sediment particles that store phosphorus in the sediments. However, when lakes lose oxygen in the winter or when the hypolimnion becomes anoxic in the summer, these particles dissolve in the water. Strong wind action or turnover events can then re-distribute phosphorus throughout the water column.

While phosphorus is necessary for plant and animal growth, excessive amounts lead to an overabundance of growth which can decrease water clarity and lead to nutrient pollution in lakes. Phosphorus is present in lakes in several forms. This study measured two forms of phosphorus: total phosphorus and soluble reactive phosphorus.

Total phosphorus is a measure of all the phosphorus in a sample of water. In many cases total phosphorus is the preferred indicator of a lake's nutrient status because it remains more stable than other forms over an annual cycle. **Soluble reactive phosphorus** includes forms of phosphorus that are dissolved in the water and are readily available for uptake by algae and aquatic macrophytes (plants).

Ideally, soluble reactive phosphorus concentrations should be below 0.01 mg/L at spring turnover to prevent summer algae blooms. Soluble reactive phosphorus was below this threshold on Church Pine Lake (0.008 mg/L), but above this threshold on Round and Big Lake (0.017 mg/L and 0.028 mg/L, respectively).

A concentration of total phosphorus below 0.02 mg/L should be maintained to prevent nuisance algae blooms. Although this threshold was exceeded in all lakes on at least one date, the growing season average was below this threshold on Church Pine Lake (0.0182 mg/L), at this threshold on Round Lake (0.0212 mg/L), and slightly above this threshold on Big Lake (0.0252 mg/L).

Information summarized from: (Byron Shaw, Christine Mechenich, and Lowell Klessig, 2004).

More importantly, the total phosphorus criteria for impairment, as averaged over the summer index period, is 0.030 mg/L for Church Pine Lake and 0.040 mg/L for Round and Big Lake. In 2012, these criteria were met in all three lakes (Church Pine Lake = 0.0205 mg/L; Round Lake = 0.024 mg/L; and Big Lake = 0.024mg/L).

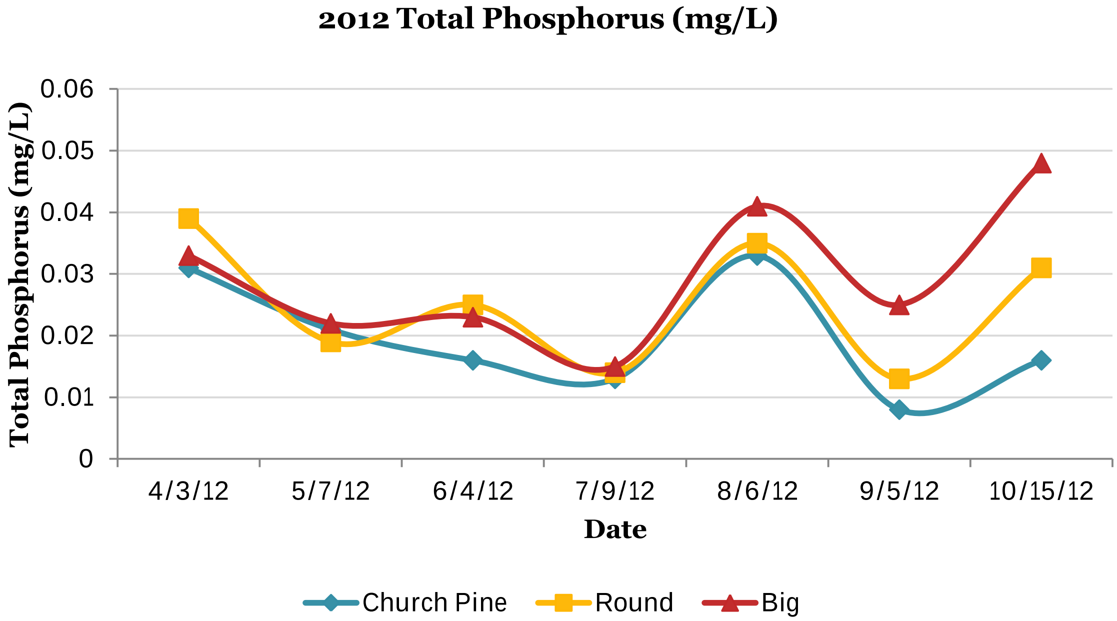


Figure 18. 2012 Church Pine, Round, and Big Lake total phosphorus (mg/L).

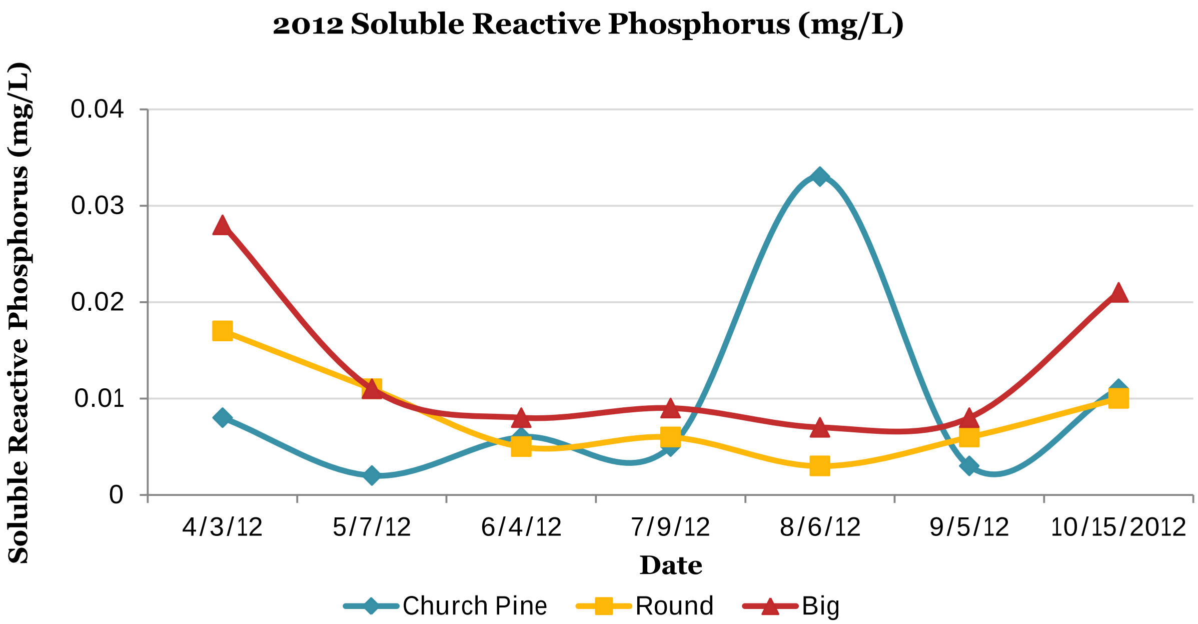


Figure 19. 2012 Church Pine, Round, and Big Lake soluble reactive phosphorus (mg/L).

Nitrogen

Nitrogen, like phosphorus, is an element necessary for plant growth. Nitrogen sources in a lake can vary widely. Although nitrogen does not occur naturally in soil minerals, it is a major component of all plant and animal matter. The decomposition of plant and animal matter releases ammonia, which is converted to nitrate in the presence of oxygen. This reaction accelerates when water temperatures increase. Nitrogen can also be introduced to a lake through rainfall, in the form of nitrate and ammonium, and through groundwater in the form of nitrate.

In most instances, the amount of nitrogen in a lake corresponds to land use. Nitrogen can enter a lake from surface runoff or groundwater sources as a result of fertilization of lawns and agricultural fields, animal waste, or human waste from septic systems or sewage treatment plants. During spring and fall turnover events, nitrogen is recycled back into the water column which can cause spikes in ammonia levels. Under low oxygen conditions, nitrogen can be lost from a lake system through a process called denitrification. Under these conditions nitrate is converted to nitrogen gas. Additionally, nitrogen can be lost through permanent sedimentation.

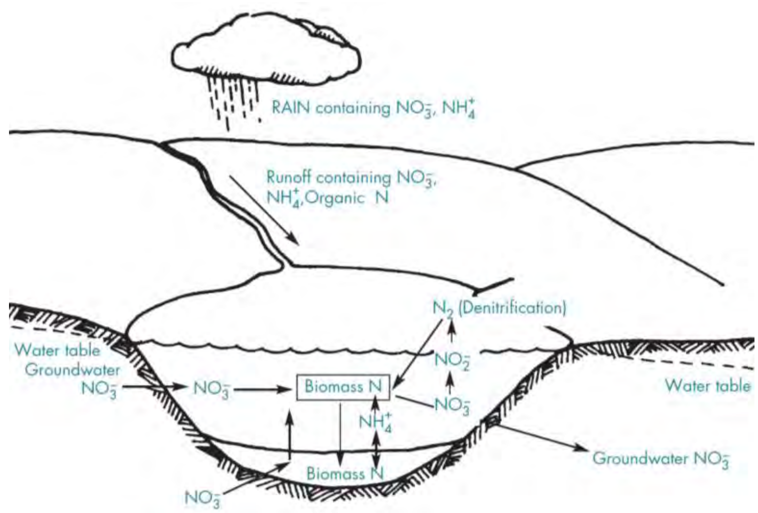


Figure 20. Sources and cycling of nitrogen in a lake. Figure from: (Byron Shaw, Christine Mechenich, and Lowell Klessig, 2004).

Nitrogen comprises the majority (78%) of the gases in the Earth's atmosphere. As with other gases nitrogen is more soluble in cooler water as compared to warmer water. Nitrogen gas is not readily available to most aquatic plants, with the exception of blue green which are the only algae able to fix nitrogen from the atmosphere.

Similar to phosphorus, nitrogen is divided into many components. In this study nitrate/nitrite, ammonium, and total Kjeldahl nitrogen were analyzed.

Nitrate/nitrite and ammonium are all **inorganic** forms of nitrogen which can be used by aquatic plants and algae. Inorganic nitrogen concentrations above 0.3 mg/L in the spring indicate sufficient nitrogen to support summer algae blooms. Inorganic nitrogen concentrations at spring turnover were below this threshold on Church Pine and Round Lake and above this threshold on Big Lake.

With the exception of Round and Big Lake at spring turnover, nitrate/nitrite levels were below the limit of detection (0.1 mg/L) in all lakes on all sample dates. Additionally, in Big Lake on July 9th, Church Pine Lake on September 5th, and Round Lake on September 5th, inorganic nitrogen levels were below the limit of detection (nitrate/nitrite <0.1 mg/L and ammonium <0.01 mg/L).

Total Kjeldahl nitrogen is a measure of organic nitrogen plus ammonium. By subtracting the ammonium concentration from TKN, the organic nitrogen concentration found in plants and algal material can be found.

Information summarized from: (Byron Shaw, Christine Mechenich, and Lowell Klessig, 2004).

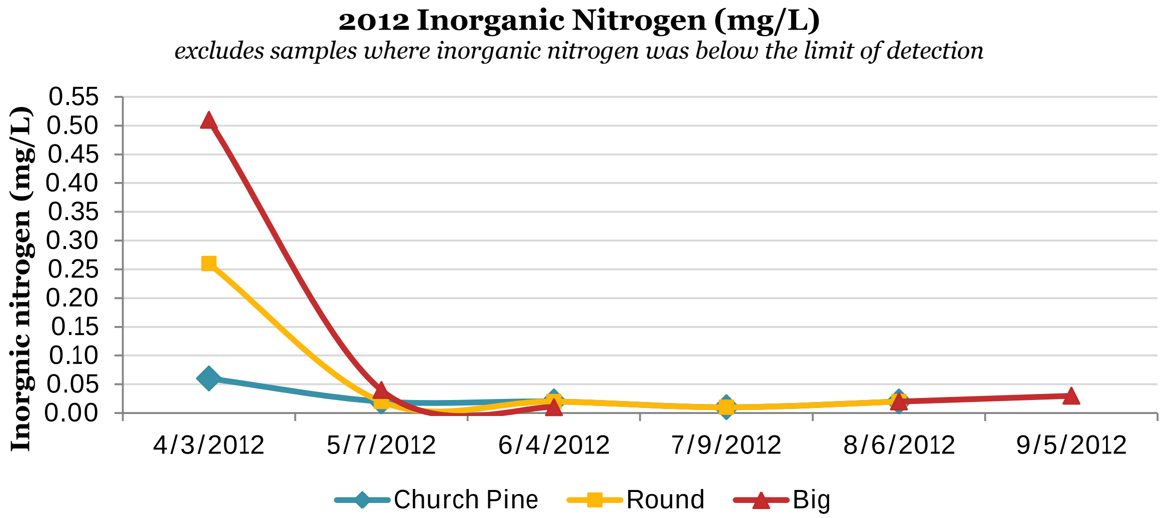


Figure 21. 2012 Church Pine, Round, and Big Lake inorganic nitrogen (mg/L).

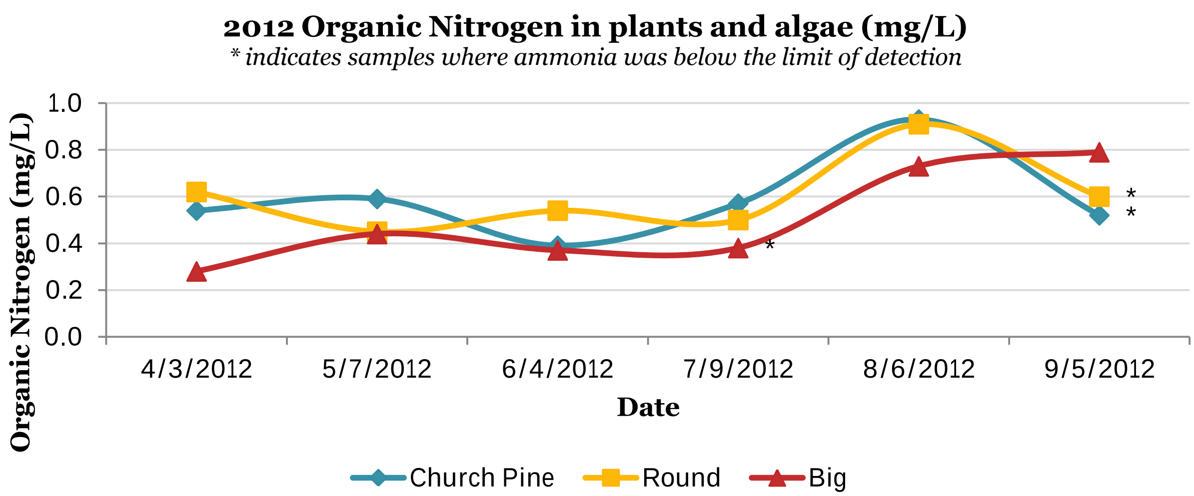


Figure 22. 2012 Church Pine, Round, and Big Lake organic nitrogen in plants and algae (mg/L).

Total Nitrogen to Total Phosphorus Ratio

The total nitrogen to total phosphorus ratio (TN: TP) is a calculation that depicts which nutrient limits algae growth in a lake.

Lakes are considered nitrogen limited, or sensitive to the amount of nitrogen inputs into a lake, when TN: TP ratios are less than 10. Only about 10% of Wisconsin lakes are limited by nitrogen. In contrast, lakes are considered phosphorus limited, or sensitive to the amount of phosphorus inputs into a lake, when the TN: TP ratio is above 15. Lakes with values between 10 and 15 are considered transitional. In transitional lakes it is impossible to determine which nutrient, either nitrogen or phosphorus, is limiting algae growth (Byron Shaw, Christine Mechenich, and Lowell Klessig, 2004).

Total nitrogen is found by adding NO2+NO3+TKN. However, with the exception of spring turnover in Round and Big Lake, NO2+NO3 was <0.1 mg/L in all lakes at all sample dates. The ratios below do not include the addition of NO2+NO3 when the value was <0.1 mg/L. However, even without these values the calculations show that all lakes are phosphorus limited. If a value of 0.1 mg/L was used in place of <0.1 mg/L the ratio would be pushed upwards indicating an even greater phosphorus limitation.

The total nitrogen to total phosphorus ratio for Church Pine, Round, and Big Lake indicates a phosphorus limited state at all sample dates. The ratio indicates that Church Pine Lake experienced the greatest phosphorus limitation, followed by Round, and Big Lake. Generally lakes with high TN: TP ratios have good water quality (Lillie, 1983).

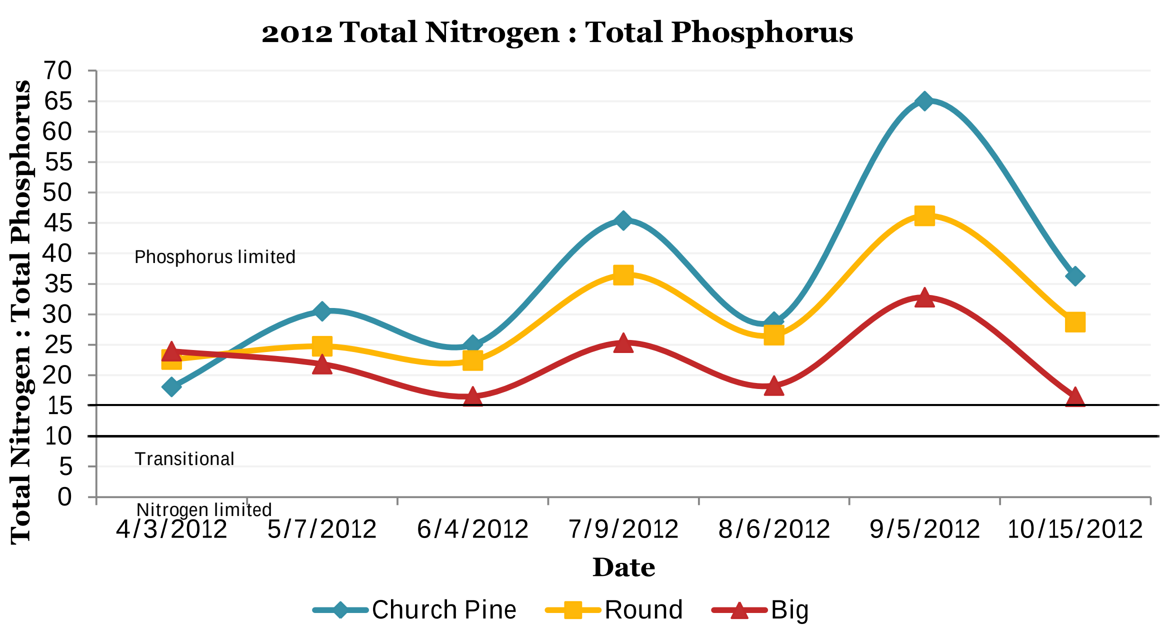


Figure 23. 2012 Church Pine, Round, and Big Lake total nitrogen : total phosphorus.

Chloride

Although chloride does not directly negatively impact plants, algae, or aquatic organisms, elevated levels of chloride in a lake can indicate possible water pollution.

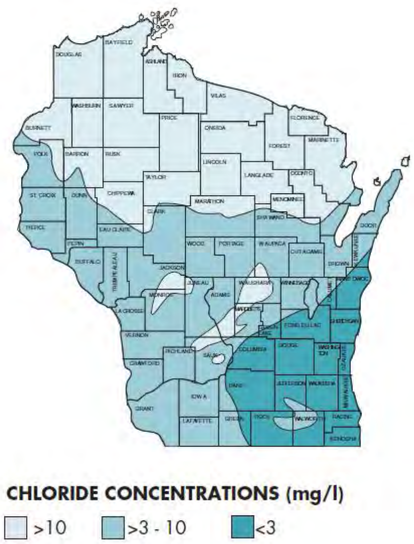


Figure 24. Chloride concentrations in Wisconsin. Figure from: (Byron Shaw, Christine Mechenich, and Lowell Klessig, 2004).

With the exception of limestone deposits, chloride is uncommon in Wisconsin soils, rocks, and minerals. Background levels of chloride are generally found in small quantities in nearly every Wisconsin lake and can be introduced to waterways through rainwater.

The watershed for Church Pine, Round, and Big Lakes is located in an area where chloride concentrations can be expected to range from greater than three up to ten mg/L.

Information summarized from: (Byron Shaw, Christine Mechenich, and Lowell Klessig, 2004).

Chloride concentrations in the three lake system range from 7.5 mg/L up to 10 mg/L with values being lowest in Church Pine Lake, followed by Round Lake and Big Lake. Average growing season chloride concentrations were 8 mg/L in Church Pine Lake, 9.1 mg/L in Round Lake, and 9.4 mg/L in Big Lake.

2012 Chloride (mg/L)

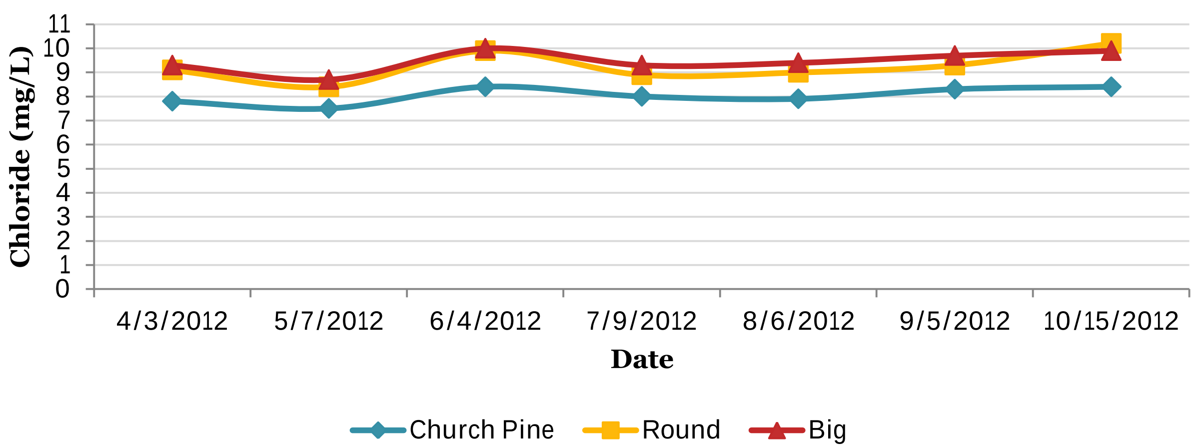


Figure 25. 2012 Church Pine, Round, and Big Lake chloride (mg/L).

Total Suspended Solids

Total suspended solids (TSS) quantify the amount of inorganic matter that is floating in the water column. Wind, waves, boats, and even some fish species can stir up sediments from the lake bottom re-suspending them in the water column. Fine sediments, especially clay, can remain suspended in the water column for weeks. These particles scatter light and decrease water transparency.

Total suspended solids were below the limit of detection (2 mg/L) in all lakes at all sampling dates with the exception of Church Pine Lake on May 7th, Round Lake on August 6th and Big Lake on September 5th.

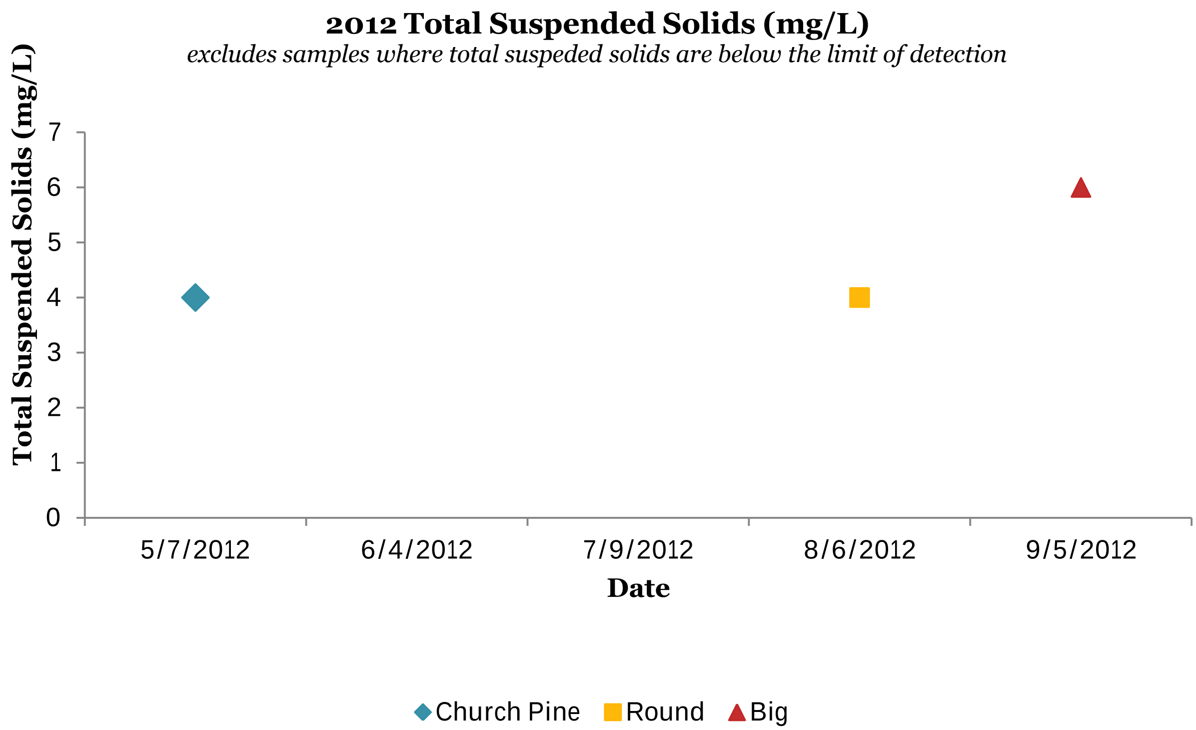


Figure 26. 2012 Church Pine, Round, and Big Lake total suspended solids (mg/L).

Dissolved Oxygen

Oxygen is required by all aquatic organisms for survival. The amount of oxygen dissolved in water depends on water temperature, the amount of wind mixing that brings water into contact with the atmosphere, the biological activity that consumes or produces oxygen within a lake, and the composition of groundwater and surface water entering a lake.

In a process called photosynthesis, plants use carbon dioxide, water, and the sun's energy to produce simple sugars and oxygen. Chlorophyll, the pigment in plants that captures the light energy necessary for photosynthesis, is the site where oxygen is produced. Since photosynthesis requires light, the oxygen producing process only occurs during the daylight hours and only at depths where sunlight can penetrate.

Plants and animals also use oxygen in a process called respiration. During respiration, sugar and oxygen are used by plants and animals to produce carbon dioxide and water.

Temperature °C	Temperature °F	Oxygen solubility (mg/L)
0	32	15
5	41	13
10	50	11
15	59	10
20	68	9
25	77	8

Table 6. Relationship between temperature and oxygen solubility.

Cold water is able to hold more oxygen as compared to warm water. However, although temperatures are coolest in the deepest part of a lake, these waters often do not contain the most oxygen. This arises because in the deepest parts of lakes, oxygen producing photosynthesis is not occurring, mixing is unable to introduce oxygen, and the only reaction occurring is oxygen consuming respiration. Therefore, it is not uncommon for oxygen depletion to occur in the hypolimnion.

During the sunlight hours, when photosynthesis is occurring, dissolved oxygen levels at a lake's surface may exceed the oxygen solubility values. Conversely, at night or early in the morning (when photosynthesis is not occurring), the dissolved oxygen values can be expected to be lower.

A water quality standard for dissolved oxygen in warm water lakes and streams is set at 5 mg/L. This standard is based on the minimum amount of oxygen required by fish for survival and growth. For cold water lakes supporting trout, the standard is set even higher at 7 mg/L.

Information summarized from: (Byron Shaw, Christine Mechenich, and Lowell Klessig, 2004).

Oxygen levels in all three lakes remained above 5 mg/L near the surface but dropped below this threshold in the bottom waters. In Church Pine and Big Lake bottom waters were anoxic (<1 mg/L) during the majority of the sampling season.

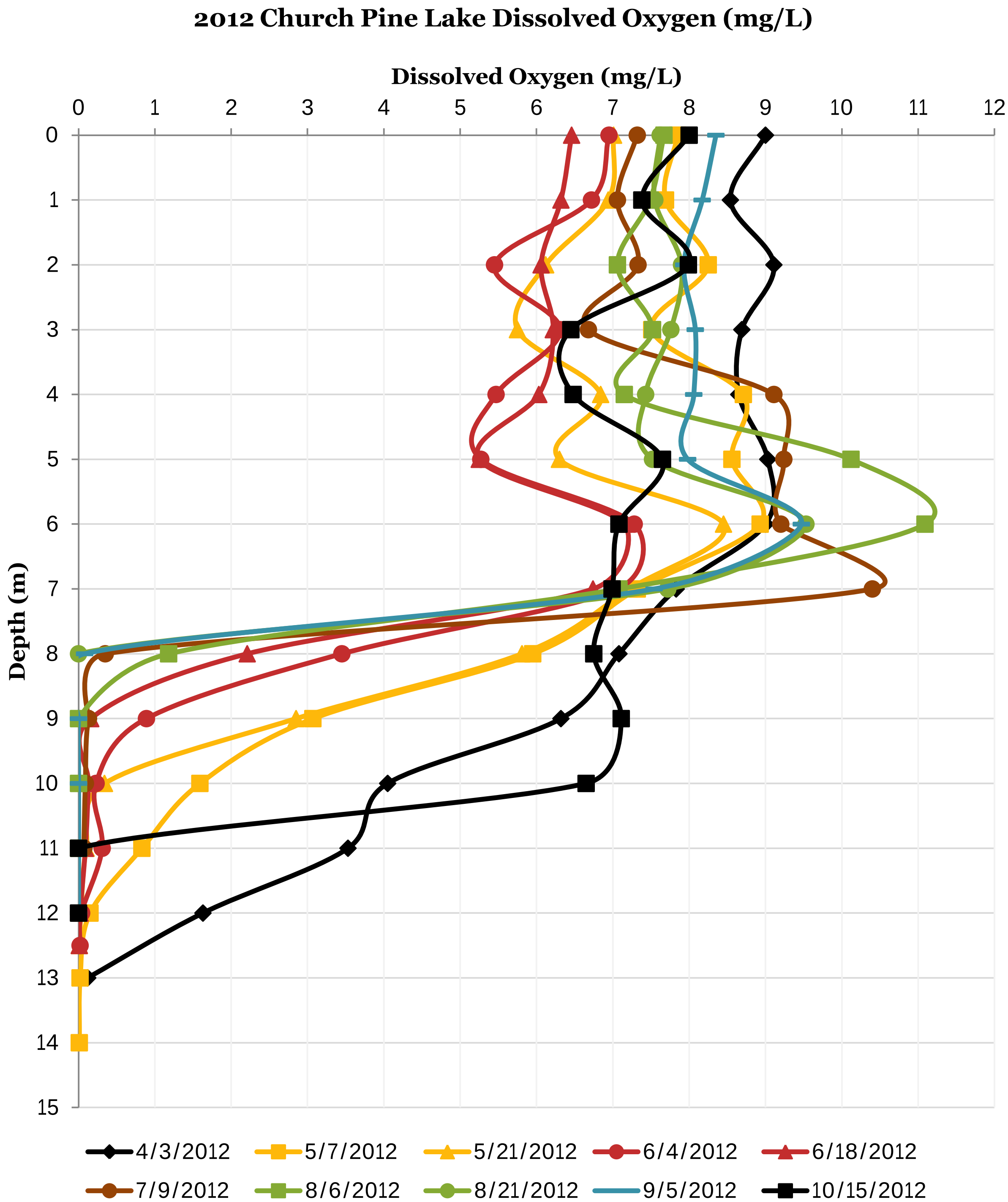


Figure 27. 2012 Church Pine Lake dissolved oxygen (mg/L).

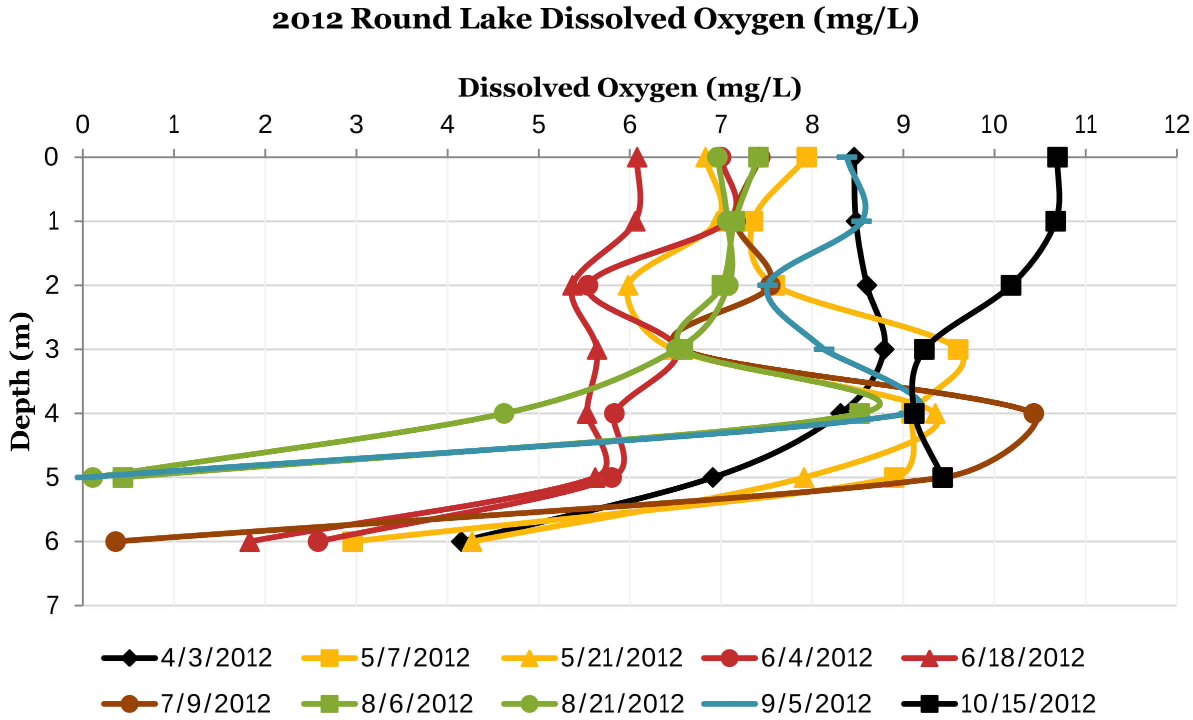


Figure 28. 2012 Round Lake dissolved oxygen (mg/L).

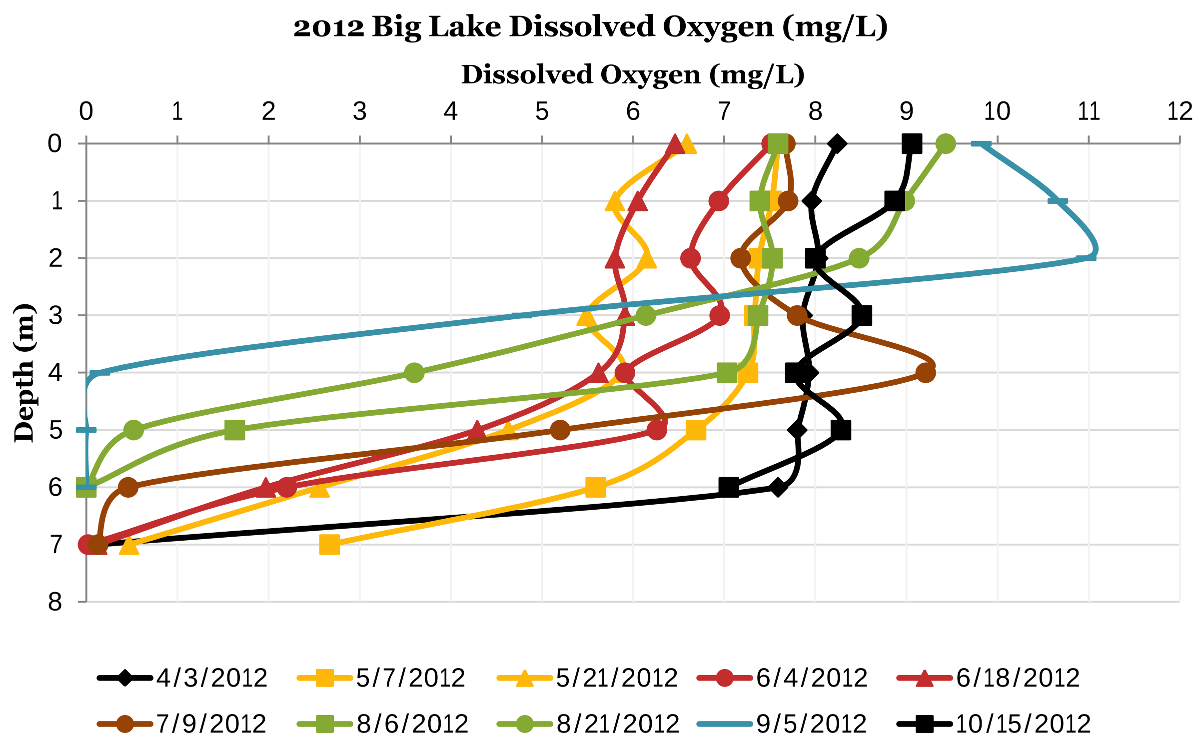


Figure 29. 2012 Big Lake dissolved oxygen (mg/L).

Temperature

Church Pine, Round, and Big Lake all reached their warmest surface temperature (~28°C) on July 9th, 2012. By examining the temperature profiles it is clear that in 2012 Church Pine Lake stratified, Round Lake weakly stratified, and Big Lake very weakly stratified. The average growing season differences between surface and bottom temperatures were 14.60°C in Church Pine Lake, 8.33°C in Round Lake, and 4.75°C in Big Lake.

In Church Pine Lake, the lake developed water temperature (thus density) differences that created distinct layers in the water column. As a result, in Church Pine Lake wind and wave action are unable to mix the benthic waters with the surface waters.

Round Lake experienced weak stratification which intensified as the summer progressed.

During the majority of the 2012 growing season, Big Lake did not stratify. When the Lake reached its maximum temperatures (July and August), slight temperature (density) differences did exist throughout the water column.

Church Pine Lake is nearly twice the depth of Round and Big Lake. Likely, the depth of Church Pine Lake is the primary explanation for why this lake stratifies. The surface area of Big Lake is over twice the size of Church Pine Lake and the surface area of Church Pine Lake is over twice the size of Round Lake. Likely the difference in surface area between Big and Round Lake is the primary explanation for why these lakes differ in stratification. Big Lake has a greater surface area exposed to wind and wave action as compared to Round Lake.

Additionally, qualitative data during the 2012 sampling season suggests a much greater degree of boat/jet ski traffic on Big Lake as compared to Round Lake. Depending on speed and horsepower, boat/jet ski traffic can have an effect similar to a large storm event in terms of mixing. Additionally, Round Lake may be more sheltered in the landscape as compared to Big Lake. When sampling on windy days, Round Lake was much calmer as compared to Big Lake.

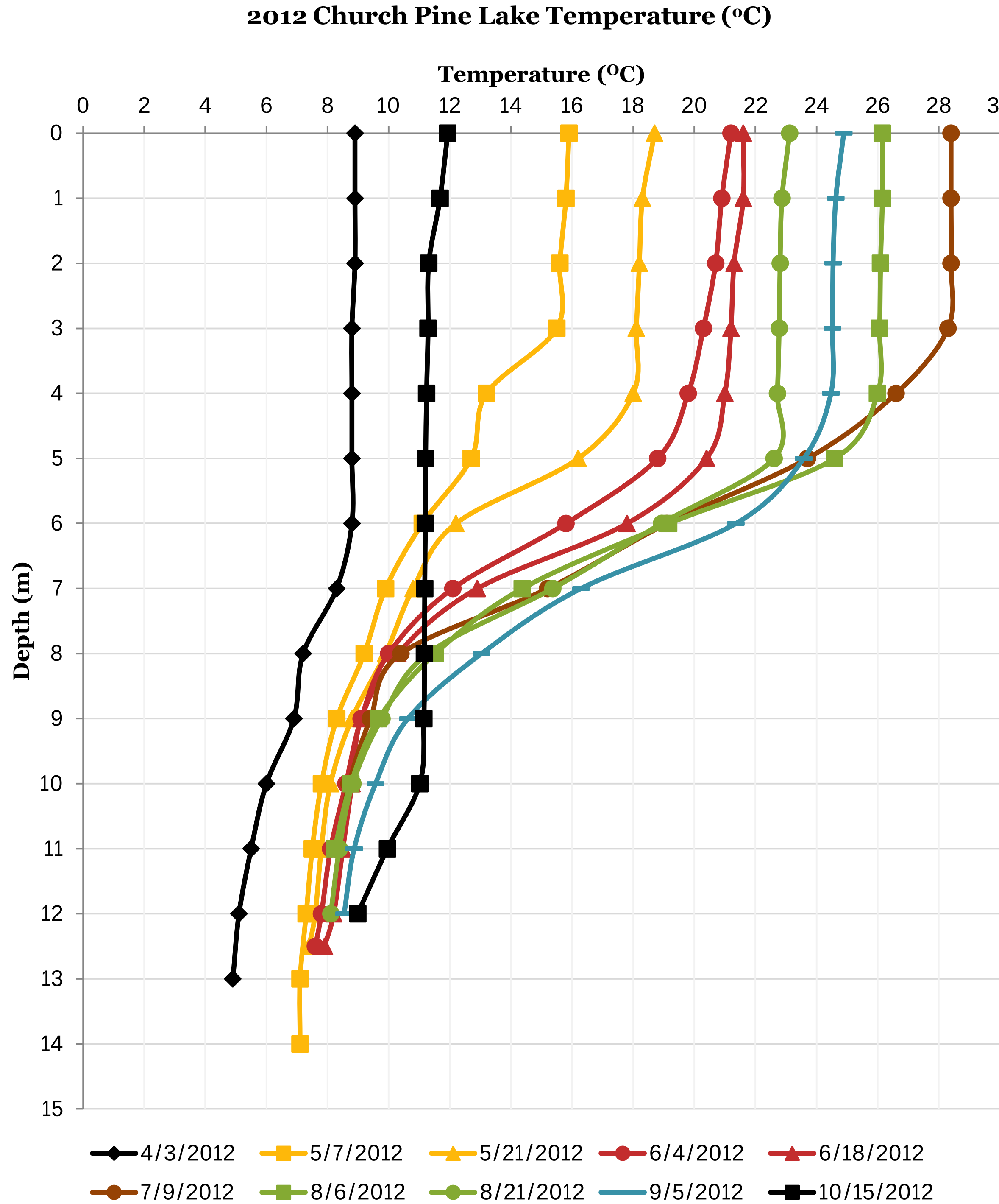


Figure 30. 2012 Church Pine Lake temperature (oC).

2012 Round Lake Temperature (°C)

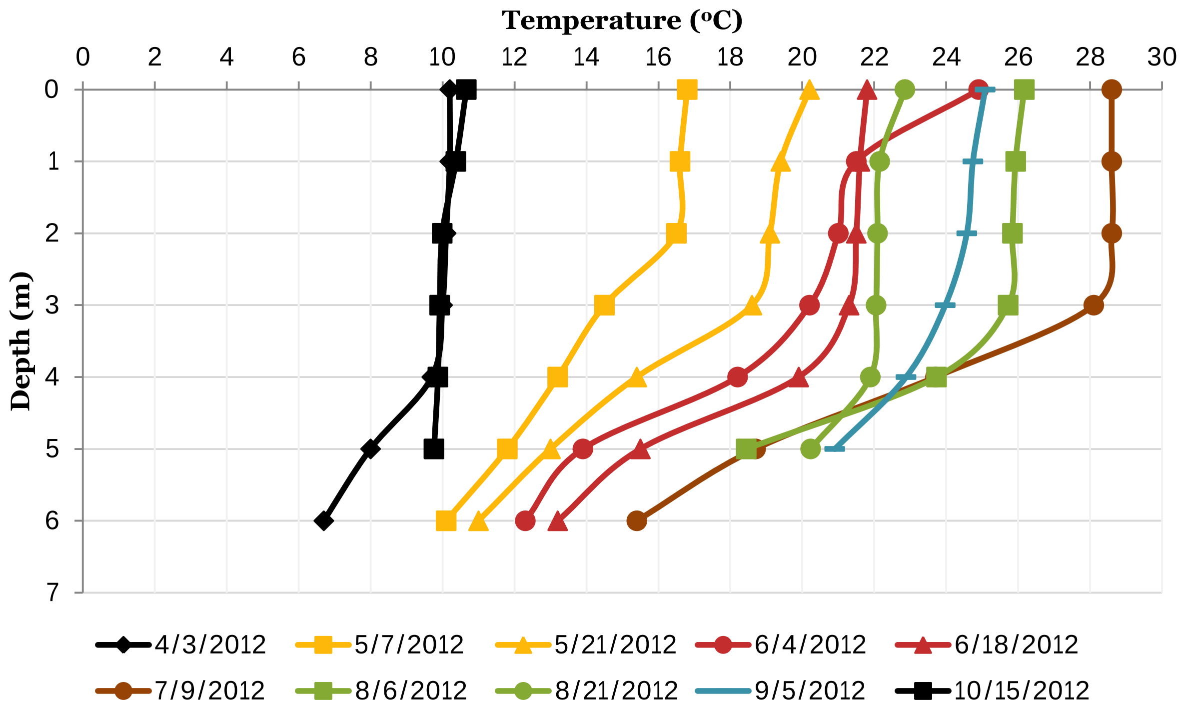


Figure 31. 2012 Round Lake temperature (°C).

2012 Big Lake Temperature (°C)

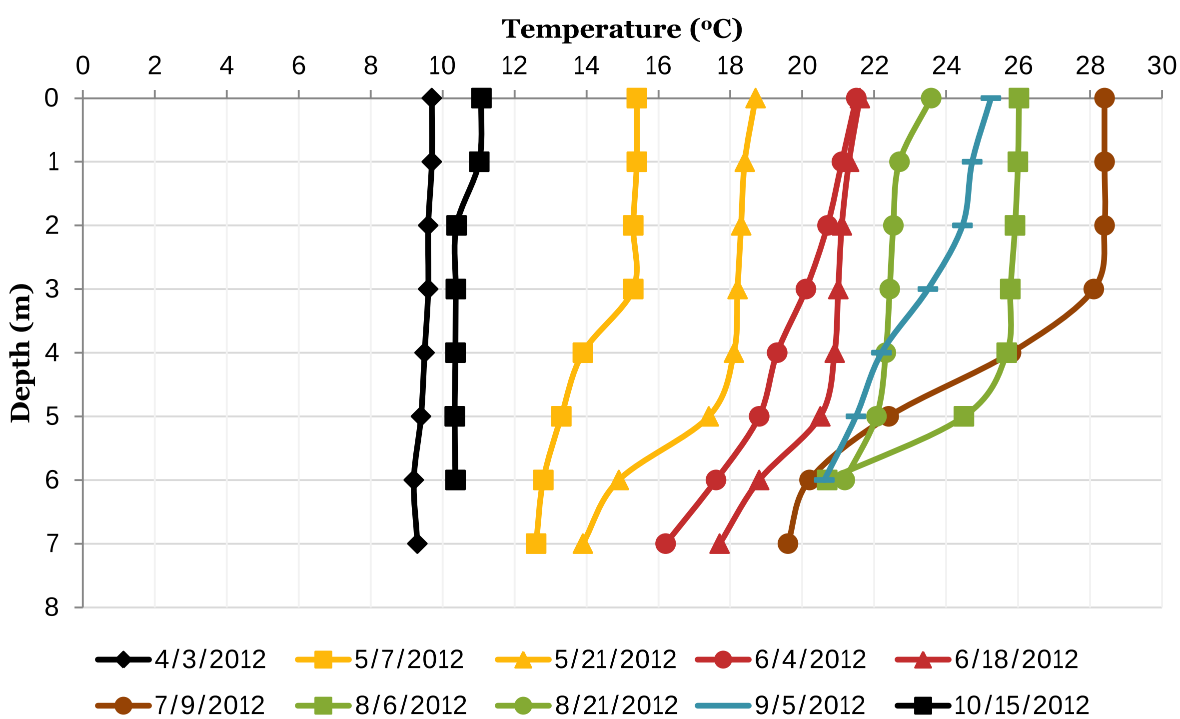


Figure 32. 2012 Big Lake temperature (°C).

Conductivity (Specific Conductance)

Conductivity is the measure of the ability of water to conduct an electrical current and serves as an indicator of the concentration of total dissolved inorganic chemicals in the water. Since conductivity is temperature related, reported values are normalized at 25°C and termed specific conductance. Specific conductance increases as the concentration of dissolved minerals in a lake increase.

Specific conductance values are typically two times the water hardness. Hardness is the quantity of cations with more than one positive charge, primarily calcium and magnesium. Soluble minerals, especially limestone, in a lakes watershed impact the value for hardness. A categorization of hardness indicates that Church Pine, Round, and Big Lake are all moderately hard (between 61-120 mg/L).

Information summarized from: (Byron Shaw, Christine Mechenich, and Lowell Klessig, 2004).

In general, conductivity was lowest on Church Pine Lake and greatest on Big Lake. Conductivity values in Church Pine fell largely between 100-200 µS/cm, values in Round Lake fell between 150-250 µS/cm, and values in Big Lake fell between 150-300 µS/cm.

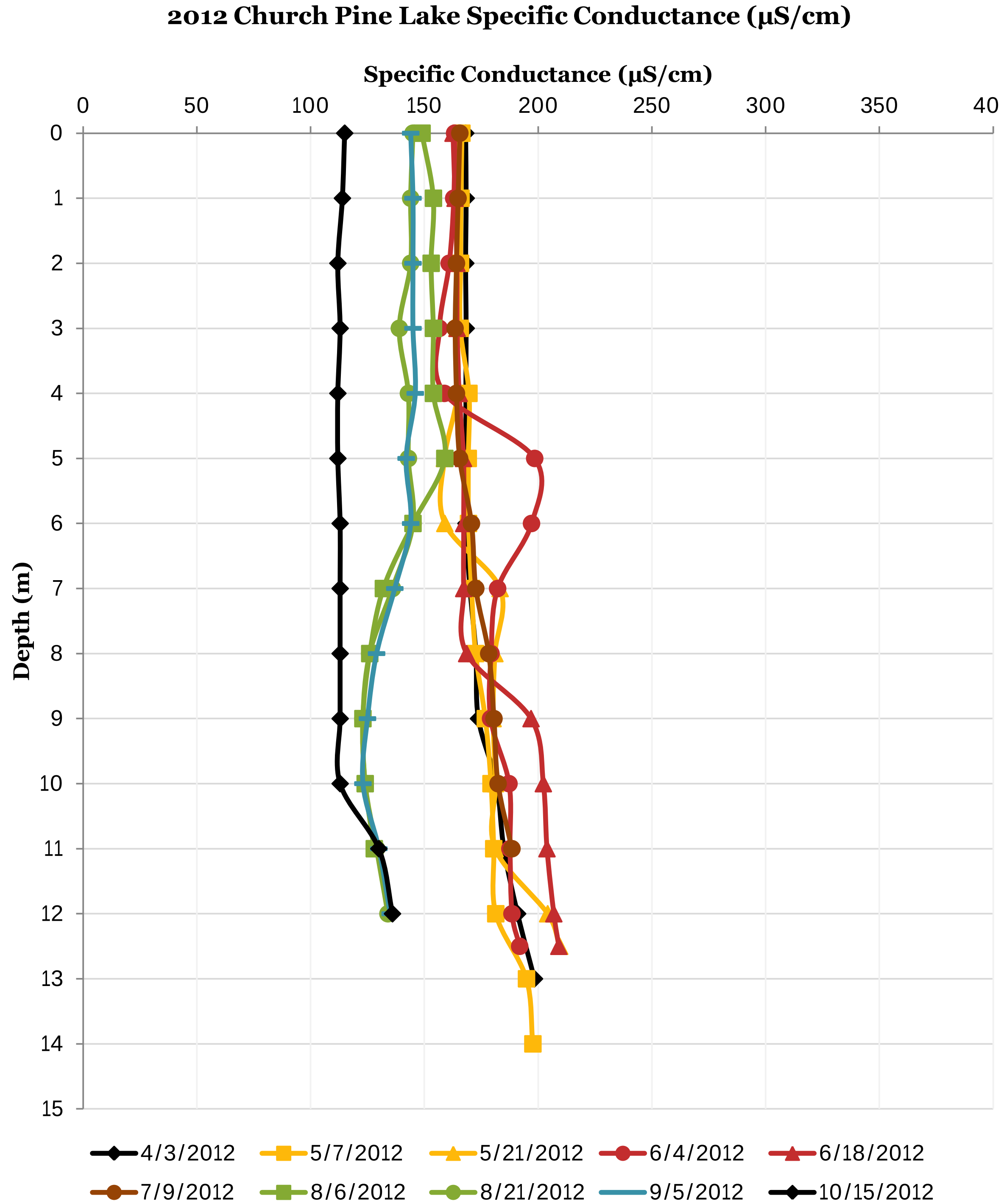


Figure 33. 2012 Church Pine Lake specific conductance (µS/cm).

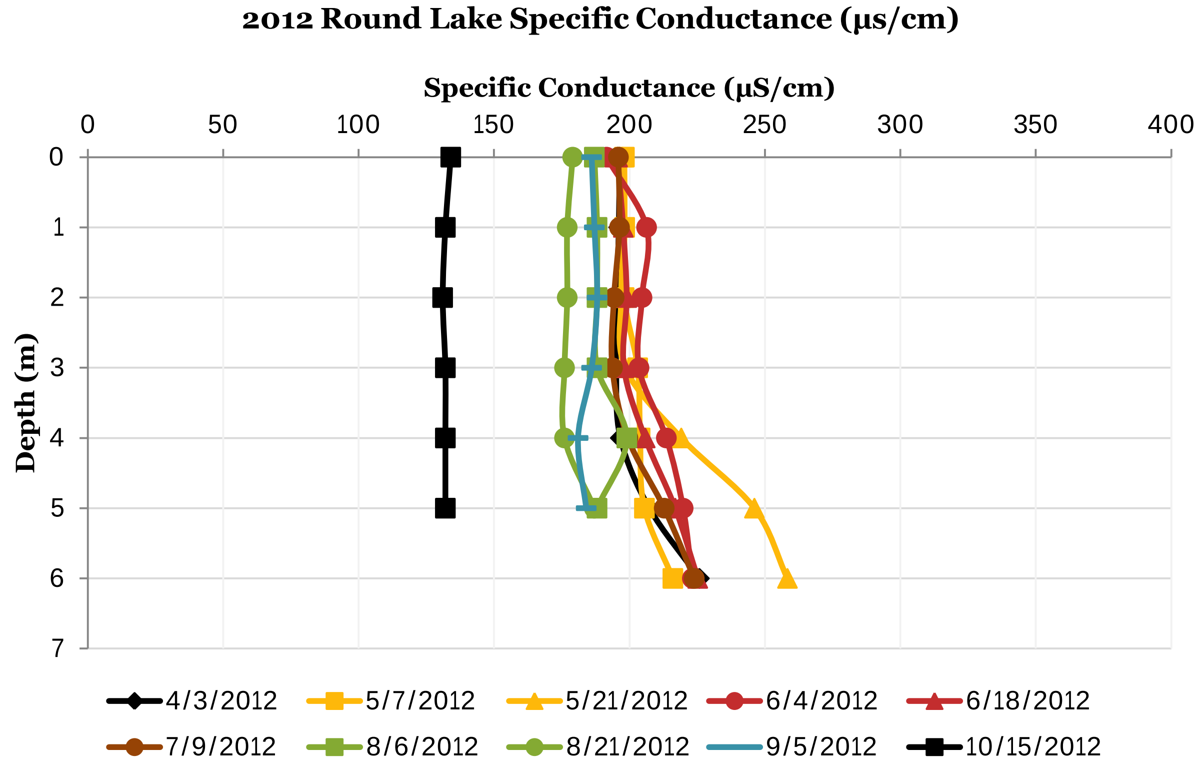


Figure 34. 2012 Round Lake specific conductance (µS/cm).

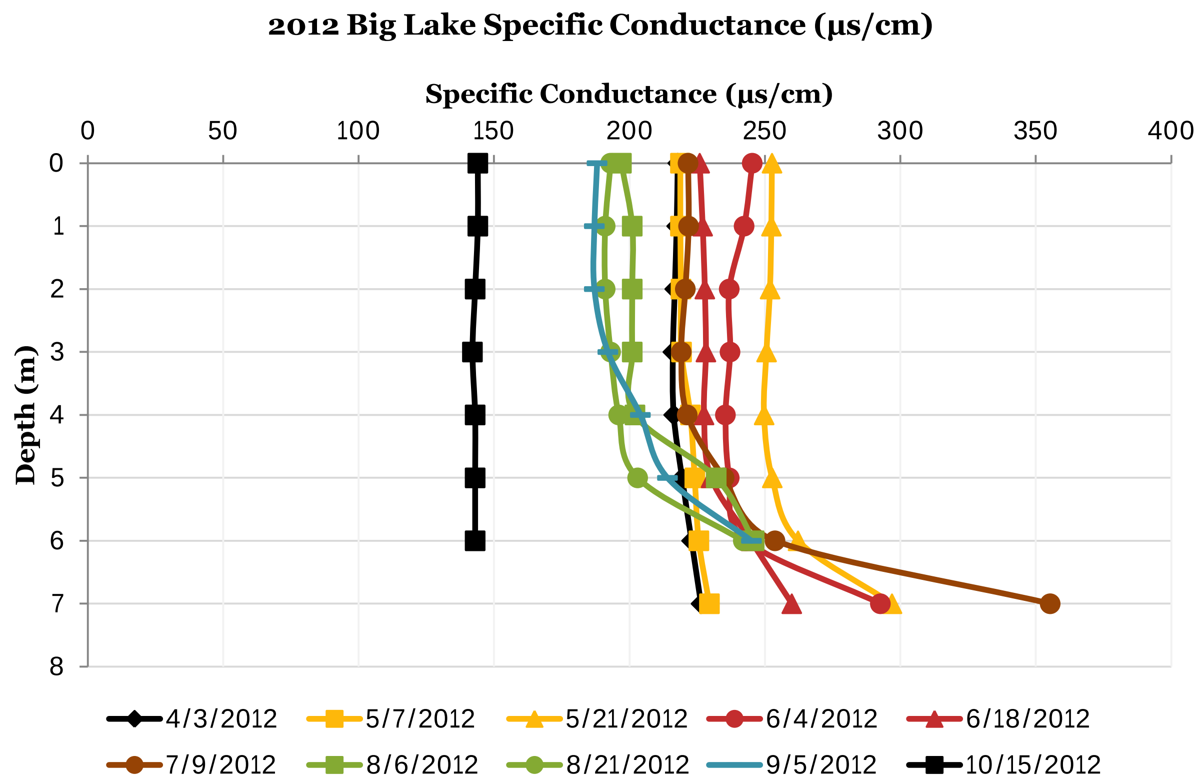


Figure 35. 2012 Big Lake specific conductance (µS/cm).

pH

An indicator of acidity, pH is the negative logarithm of the hydrogen ion (H+) concentration. Lower pH waters have more hydrogen ions and are more acidic, and high pH waters have less hydrogen ions and are less acidic.

A pH value of seven is considered neutral. Values less than seven indicate acidic conditions; whereas, values greater than seven indicate alkaline conditions. A single pH unit change represents a tenfold change in the concentration of hydrogen ions. As a result, a lake with a pH value of eight is ten times less acidic than a lake with a pH value of seven.

Across Wisconsin lakes, pH values can range from 4.5 (acid bog lakes) to 8.4 (hard water, marl lakes).

Through the removal of CO_2 from the water column, photosynthesis has the effect of increasing pH. As a result, pH generally increases during the day and decreases at night. Under conditions such as high temperature, high nutrients, and dense algae blooms, pH levels can increase.

Information summarized from: (Byron Shaw, Christine Mechenich, and Lowell Klessig, 2004).

In all three lakes, pH values were two orders of magnitude higher in August and September as compared to April, May, and June. August and September data were collected with a HI 9828 multi-parameter probe; whereas April, May, and June data were collected using a YSI 60 pH meter. Although pH values do typically increase over the course of the summer, it is impossible to tell if the order of magnitude difference in pH is a result of the meters or actual measured differences.

A general trend of decreasing pH was evident in all three lakes as the bottom waters were approached. However, in August and September in Church Pine Lake this trend was reversed, with pH increasing as bottom waters were approached.

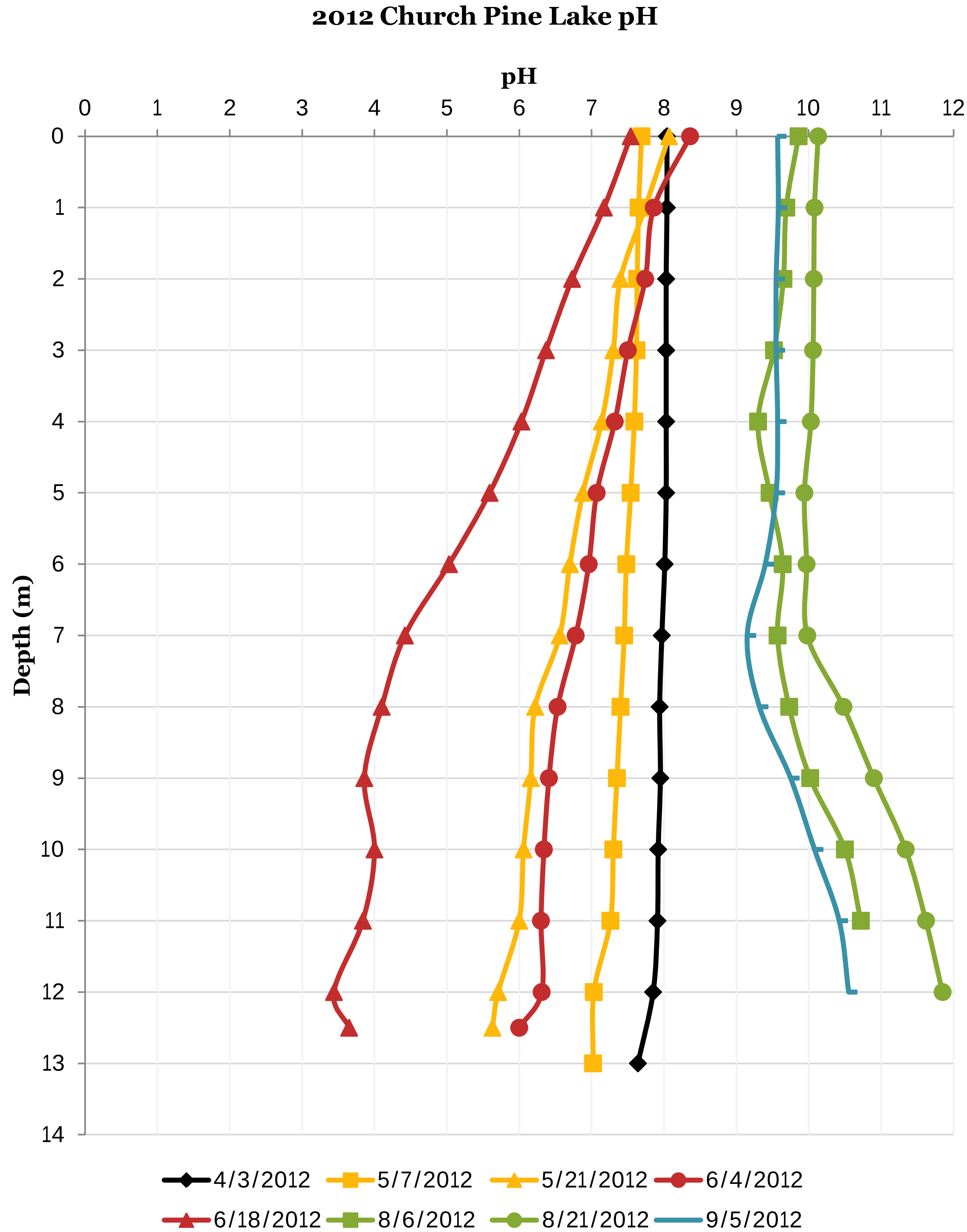


Figure 36. 2012 Church Pine Lake pH.

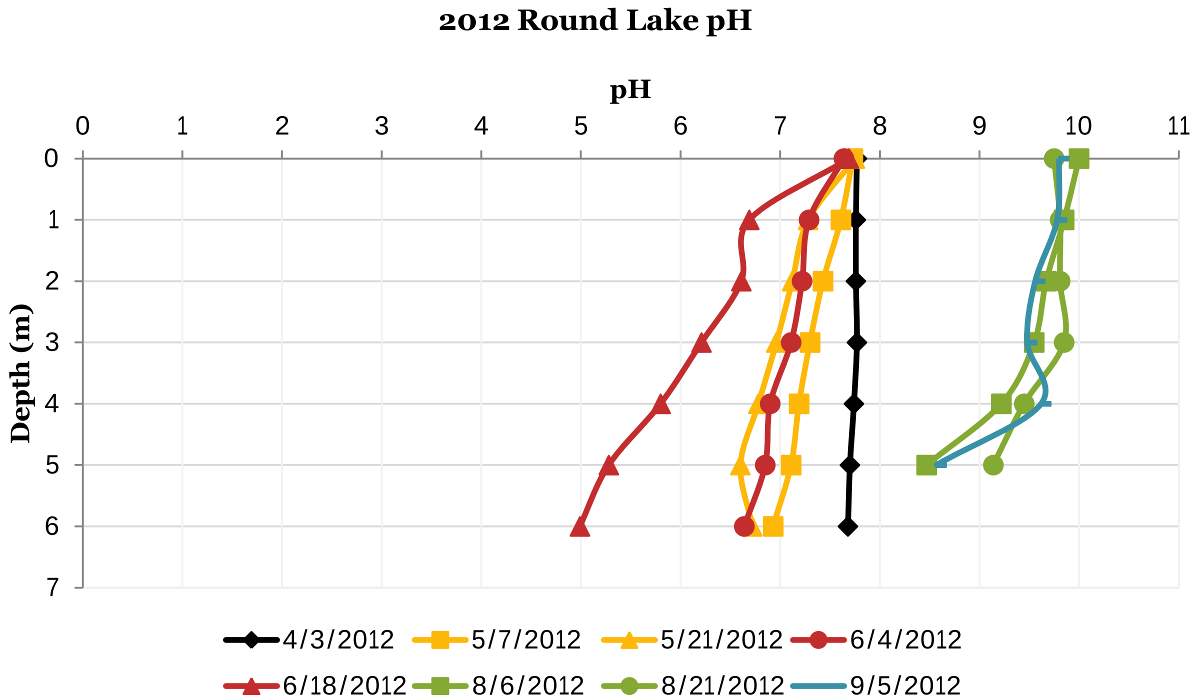


Figure 37. 2012 Round Lake pH.

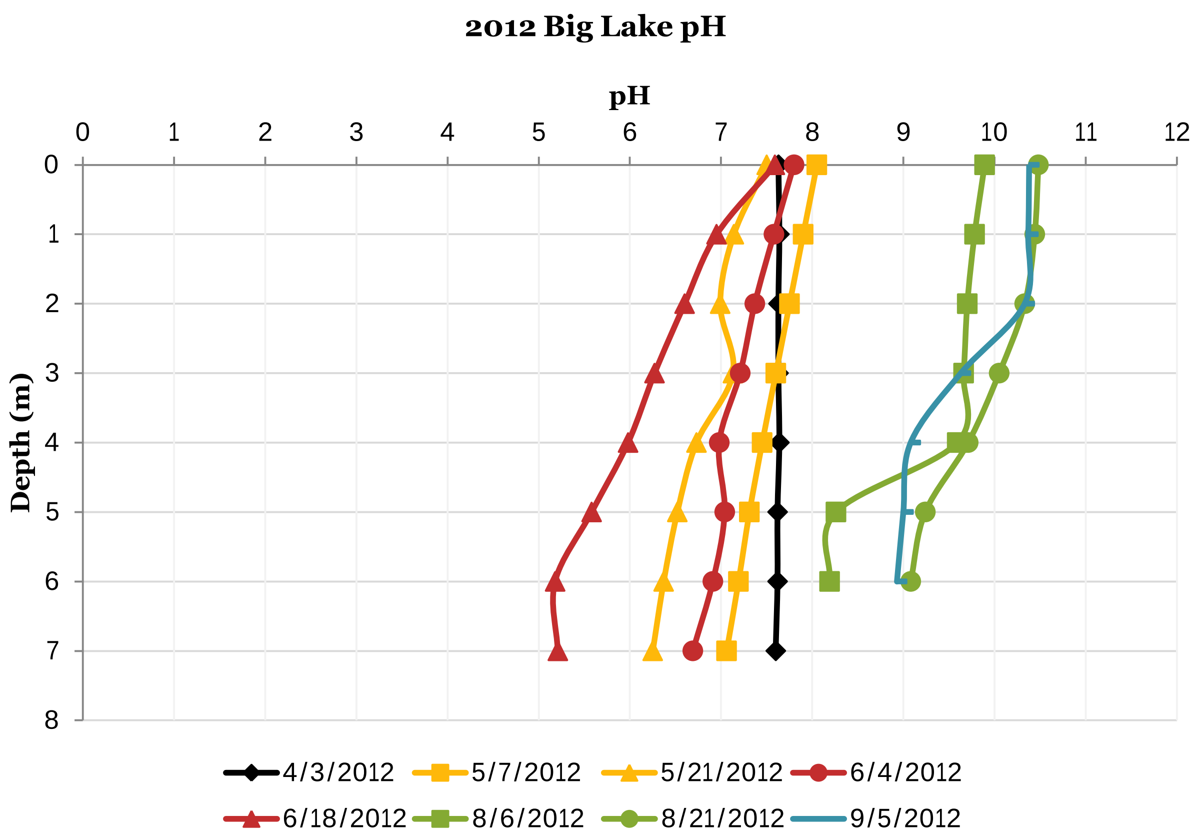


Figure 38. 2012 Big Lake pH.

Secchi Depth

The depth to which light can penetrate into lakes is affected by suspended particles, dissolved pigments, and absorbance by water. Often, the ability of light to penetrate the water column is determined by the abundance of algae or other photosynthetic organisms in a lake.

One method of measuring light penetration is with a secchi disk. A secchi disk is an eight inch diameter round disk with alternating black and white quadrants that is used to provide a rough estimate of water clarity. The depth at which the secchi disk is just visible is defined as the secchi depth. A greater secchi depth indicates greater water clarity.

Information summarized from: (Byron Shaw, Christine Mechenich, and Lowell Klessig, 2004).

Figure 39. Secchi disk data collection.

Water Clarity	Secchi Depth (feet)
Very poor	3
Poor	5
Fair	7
Good	10
Very good	20
Excellent	32

Table 7. Relationship between water clarity and secchi depth.

Church Pine Lake had the greatest water clarity as compared to Round and Big Lake over the entire sampling season (with the exception of spring turnover). Early in the year, Big Lake had greater water clarity as compared to Round Lake. Around July, this trend reversed with Round Lake exhibiting greater water clarity as compared to Big Lake.

As compared to Big and Church Pine Lake, the water of Round Lake is much more stained (brown in color)[12]. Likely this factor explains why Round Lake had a lower secchi depth as compared to Church Pine and Big Lake early in the year (when algae are less of a determining factor in water clarity).

The average growing season secchi depth was greatest for Church Pine Lake (17.9 feet), followed by Round Lake (11.8 ft) and Big Lake (11.2 ft). A similar trend is evident when averaging the secchi depths over the summer index period. Average summer index period secchi depth was greatest for Church Pine Lake (17.8 ft), followed by Round Lake (10.4 ft) and Big Lake (7.4 ft).

[12] Average spring and fall turnover color values are as follows: Church Pine Lake 11.5 units, Round Lake 14.7, and Big Lake 10.6.

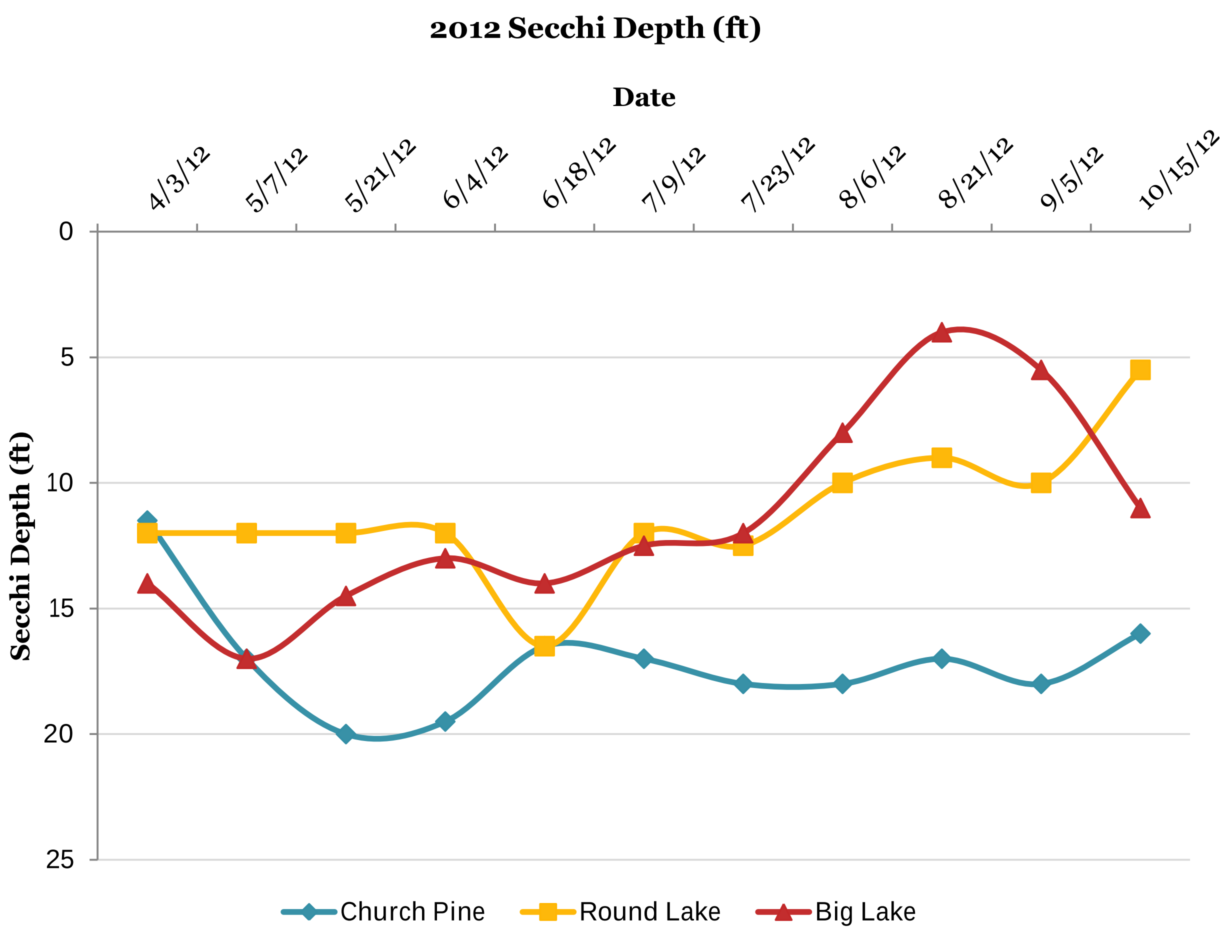
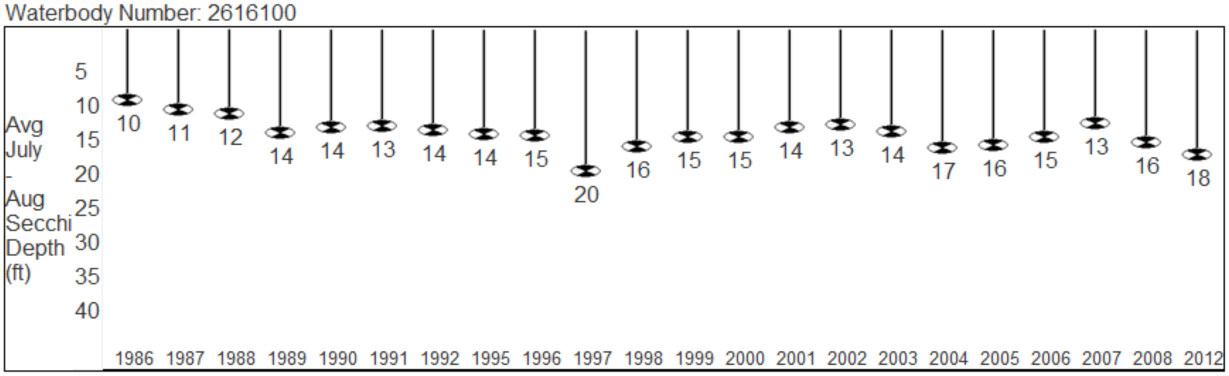


Figure 40. 2012 Church Pine, Round, and Big Lake secchi depth (ft).

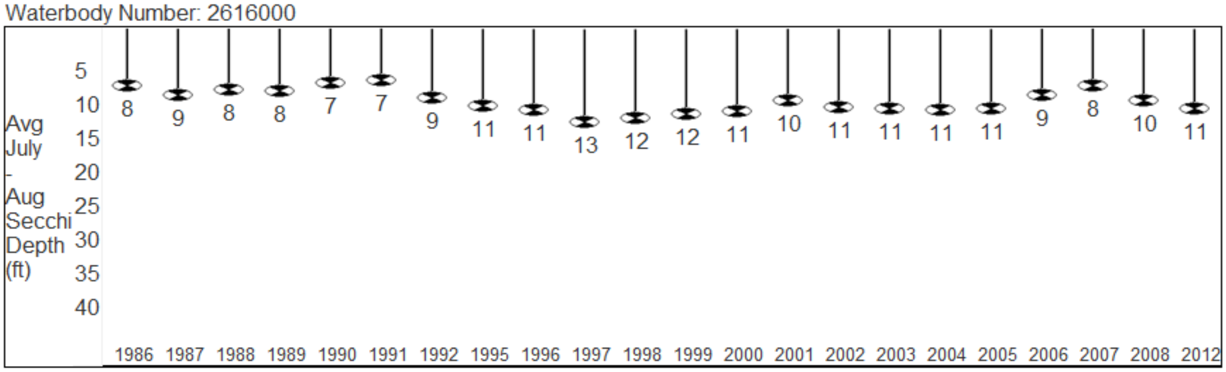
The Wisconsin Department of Natural Resources provides historic secchi depth averages for the months of July and August only. This data exists for Church Pine, Round, and Big Lake from 1986-92, 1995-08, and for 2012.

Church Pine Lake
Polk County
Waterbody Number: 2616100



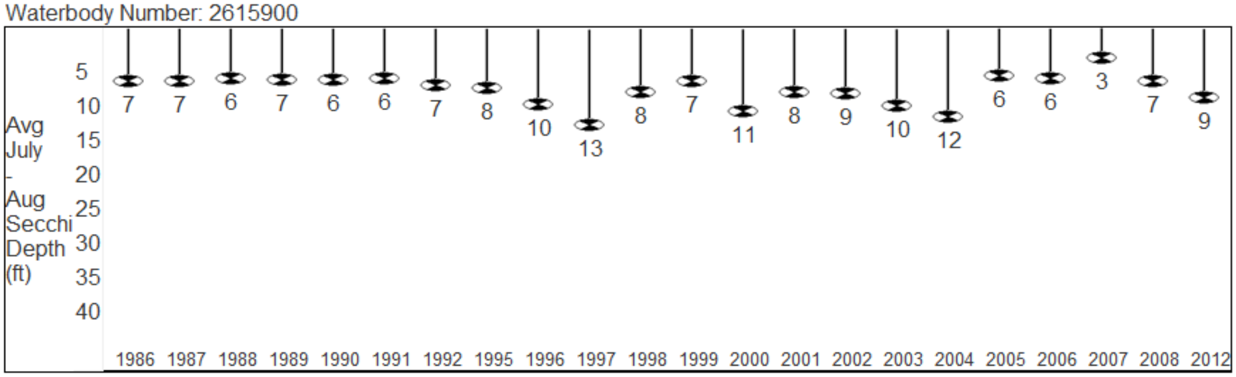
Past secchi averages in feet (July and August only).

Wind Lake
Polk County
Waterbody Number: 2616000



Past secchi averages in feet (July and August only).

Big Lake
Polk County
Waterbody Number: 2615900



Past secchi averages in feet (July and August only).

Figure 41. Historic Church Pine, Round, and Big Lake secchi depth averages (July and August only). From: Wisconsin DNR.

Chlorophyll *a*

Chlorophyll *a* is a pigment in plants and algae that is necessary for photosynthesis and is an indicator of water quality in a lake. Chlorophyll *a* gives a general indication of the amount of algae growth in a lake, with greater values for chlorophyll *a* indicating greater amounts of algae. However, since chlorophyll *a* is present in sources other than algae— such as decaying plants— it does not serve as a direct indicator of algae biomass.

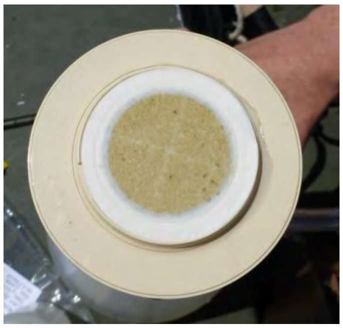


Figure 42. Chlorophyll *a* filter.

While chlorophyll *a* gives a general indication of the amount of algae growth in the water column, it is not directly correlated with algae biomass. Greater values for chlorophyll *a* do tend to indicate greater amounts of algae.

Chlorophyll *a* seems to have the greatest impact on water clarity when levels exceed 0.03 mg/L. Lakes which appear clear generally have chlorophyll *a* levels less than 0.015 mg/L.

Information summarized from: (Byron Shaw, Christine Mechenich, and Lowell Klessig, 2004).

In Church Pine, Round, and Big Lake chlorophyll *a* levels at all sampling dates were well below 0.03 mg/L and 0.015 mg/L. In Round Lake on July 9th the chlorophyll *a* was below the limit of detection (<0.001 mg/L).

The average growing season chlorophyll *a* concentration was 0.0018 mg/L in Church Pine Lake, 0.0022 mg/L in Round Lake, and 0.0042 mg/L in Big Lake. The average summer index period chlorophyll *a* concentration was 0.0015 mg/L in Church Pine Lake, 0.003 mg/L in Round Lake, and 0.0075 mg/L in Big Lake.

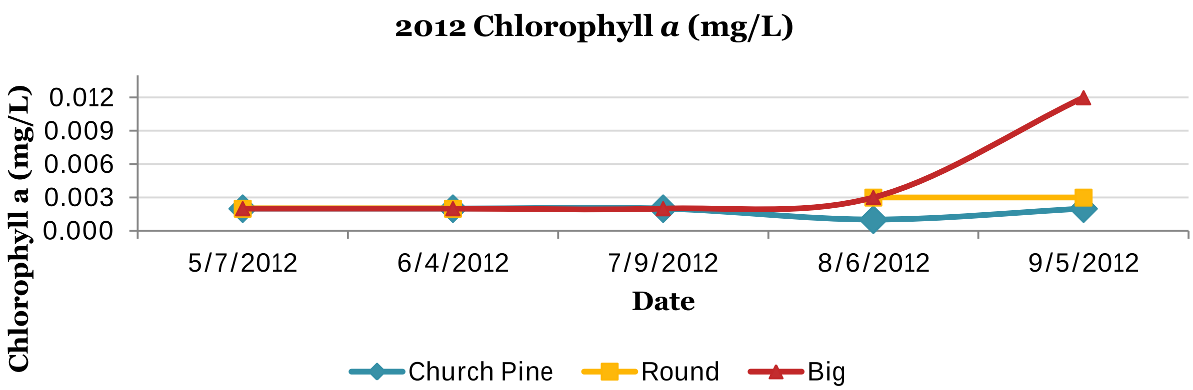


Figure 43. 2012 Church Pine, Round, and Big Lake chlorophyll a (mg/L).

Trophic State Index (TSI)

Lakes are divided into three categories based on their trophic states: oligotrophic, eutrophic, and mesotrophic. These categories reflect a lake's nutrient and clarity level and serve as an indicator of water quality. Each category is designed to serve as an overall interpretation of a lake's primary productivity.

Oligotrophic lakes are generally clear, deep, and free of weeds and large algae blooms. These types of lakes are often poor in nutrients and are therefore unable to support large populations of fish. However, oligotrophic lakes can develop a food chain capable of supporting a desirable population of large game fish.

Eutrophic lakes are generally high in nutrients and support a large number of plant and animal populations. They are usually very productive and subject to frequent algae blooms. Eutrophic lakes often support large fish populations, but are susceptible to oxygen depletion. Mesotrophic lakes lie between oligotrophic and eutrophic lakes. They usually have good fisheries and occasional algae blooms.

All lakes experience a natural aging process which causes a change from an oligotrophic to a eutrophic state. Human influences which introduce nutrients into a lake (agriculture, lawn fertilizers, and septic systems) can accelerate the process by which lakes age and become eutrophic.

Figure 44. Lake aging process. Figure from: (Byron Shaw, Christine Mechenich, and Lowell Klessig, 2004).

A common method of determining a lake's trophic state is to compare total phosphorus concentration (important for algae growth), chlorophyll *a* concentration (an indicator of the amount of algae present), and secchi disk readings (an indicator of water clarity). Although many factors influence these relationships, the link between phosphorus concentration, chlorophyll *a* concentration, and secchi disk readings is the basis of comparison for the Trophic State Index (TSI).

TSI is determined using a mathematic formula and ranges from 0 to 100. Lakes with the lowest numbers are oligotrophic and lakes with the highest values are eutrophic.

Three equations for summer index period TSI were examined for Church Pine, Round, and Big Lake. Phosphorus and chlorophyll *a* data were averaged from August 6th and September 5th. Secchi depth data were averaged from July 23rd, August 6th, August 21st, and September 5th.

TSI (P) = 14.42 * Ln [TP] + 4.15 (where TP is in µg/L)
TSI (C) = 30.6 + 9.81 Ln [Chlor-a] (where the chlorophyll *a* is in µg/L)
TSI (S) = 60-14.41 * Ln [Secchi] (where the secchi depth is in meters)
Equations from: (Carlson, 1977).

<u>Church Pine Lake</u>
Average summer index period TSI (total phosphorus) = 47.70
Average summer index period TSI (chlorophyll *a*) = 34.58
Average summer index period TSI (secchi depth) = 35.67
Average summer index period TSI = 39.32 = oligotrophic

<u>Round Lake</u>
Average summer index period TSI (total phosphorus) = 49.98
Average summer index period TSI (chlorophyll *a*) = 41.38
Average summer index period TSI (secchi depth) = 43.41
Average summer index period TSI = 44.92 = mesotrophic

<u>Big Lake</u>
Average summer index period TSI (total phosphorus) = 54.57
Average summer index period TSI (chlorophyll *a*) = 50.37
Average summer index period TSI (secchi depth) = 48.33
Average summer index period TSI = 51.09 = mildly eutrophic

TSI	General Description
<30	Oligotrophic; clear water, high dissolved oxygen throughout the year/lake
30-40	Oligotrophic; clear water, possible periods of oxygen depletion in the lower depths of the lake
40-50	Mesotrophic; moderately clear water, increasing chance of anoxia near the bottom of the lake in summer, fully acceptable for all recreation/aesthetic uses
50-60	Mildly eutrophic; decreased water clarity, anoxic near the bottom, may have macrophyte problem; warm-water fisheries only
60-70	Eutrophic; blue-green algae dominance, scums possible, prolific aquatic plant growth. Full body recreation may be decreased
70-80	Hypereutrophic; heavy algal blooms possible throughout the summer, dense algae and macrophytes
>80	Algal scums, summer fish kills, few aquatic plants due to algal shading, rough fish dominate

Figure 45. TSI general descriptions.

Monitoring the TSI of a lake gives stakeholders a method by which to gauge lake productivity over time. Fortunately, complete TSI data exists for all three lakes from 1996-2008 and 2012 (and 1995 for Church Pine). TSI secchi data exists for all three lakes from 1986-1992 and 1996-2008. Additionally, TSI phosphorus and chlorophyll *a* data exists for all three lakes for 2010.

In Church Pine Lake the majority of the historic TSI data falls between 30 and 50, in Round Lake between 40 and 60, and in Big Lake between 40 and 60.

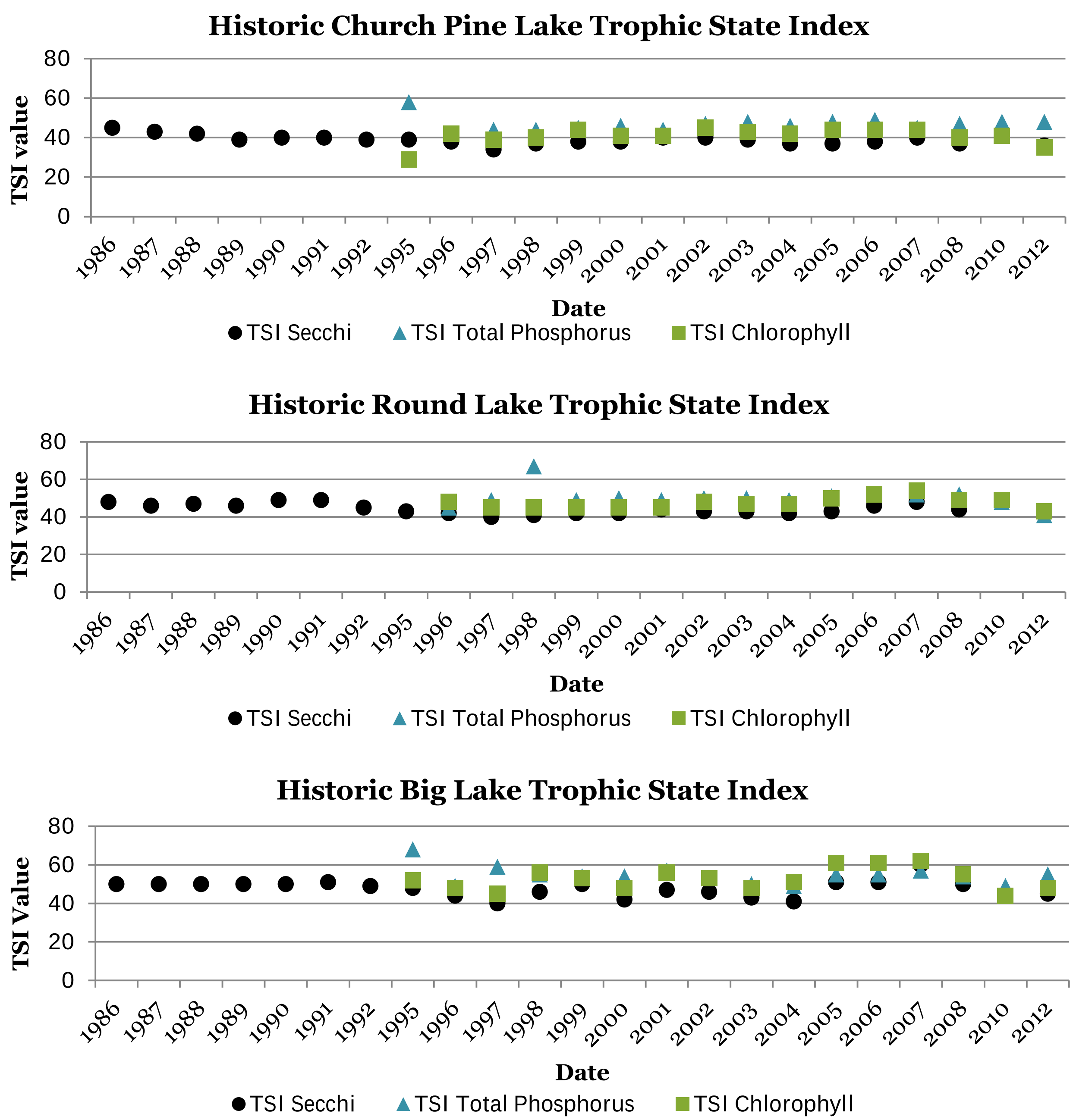


Figure 46. Historic Church Pine, Round, and Big Lake Trophic State Index.

Phytoplankton

Algae, also called phytoplankton, are microscopic plants that convert sunlight and nutrients into biomass. They can live on bottom sediments and substrate, in the water column, and on plants and leaves. Algae are the primary producers in an aquatic ecosystem and can vary in form (filamentous, colonial, unicellular, etc). Zooplankton, are small aquatic organisms that feed on algae. The size and shape of algae determine which types of zooplankton—if any—can consume them.

Algae have short life cycles. As a result, changes in water quality are often reflected by changes in the algal community within a few days or weeks. The number and types of algae in a waterbody can provide useful information for environmental monitoring programs, impairment assessments, and the identification of best management strategies.

The types of algae in a lake will change over the course of a year. Typically, there is less algae in winter and spring because of ice cover and cold temperatures. As a lake warms up and sunlight increases, algae communities begin to increase. Their short life span quickly cycles the nutrients in a lake and affects nutrient dynamics.

The types of algae present in a lake are influenced by environmental factors like climate, phosphorus, nitrogen, silica and other nutrient content, carbon dioxide, grazing, substrate, and other factors in the lake. When high levels of nutrients are available, blue green algae often become predominant.

Chlorophyll *a* is a pigment in plants and algae that is necessary for photosynthesis. Chlorophyll *a* gives a general indication of the amount of algae growth in the water column; however, it is not directly correlated with algae biomass. To obtain accurate algae data, composite samples from a two meter water column were collected monthly, preserved with glutaraldehyde, placed on ice, and sent to the State Lab of Hygiene for identification and enumeration of algae species.

Algae were identified to genus, and a relative concentration and natural unit count was made to describe the algae community throughout the growing season. This method of sampling also allows the identification of any species of concern which might be present.

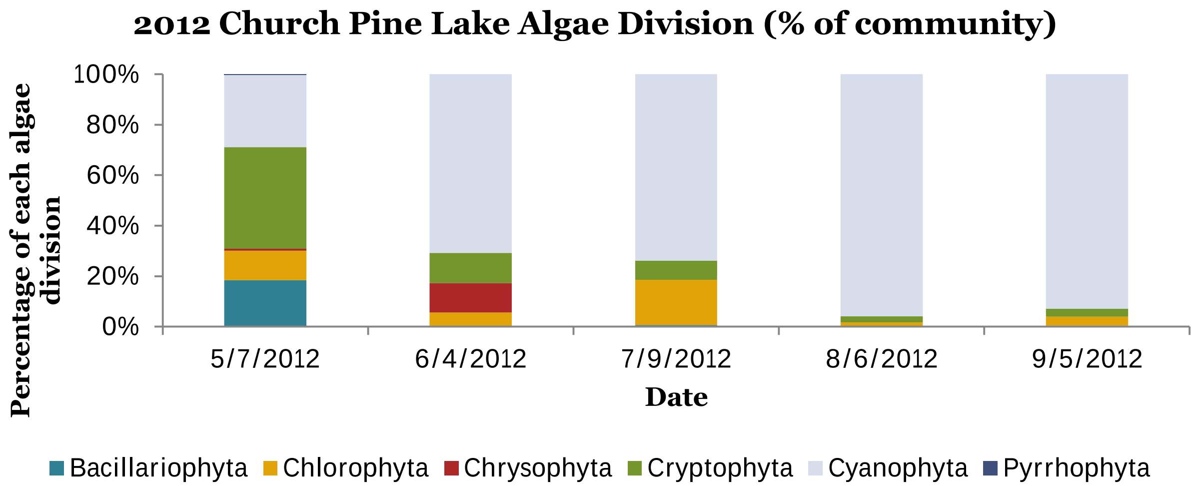
There are 12 divisions of algae typically found in Wisconsin lakes. Seven divisions were found in the three lake system. The class Euglenophyta was present in Big and Round Lakes, but was absent from Church Pine Lake.

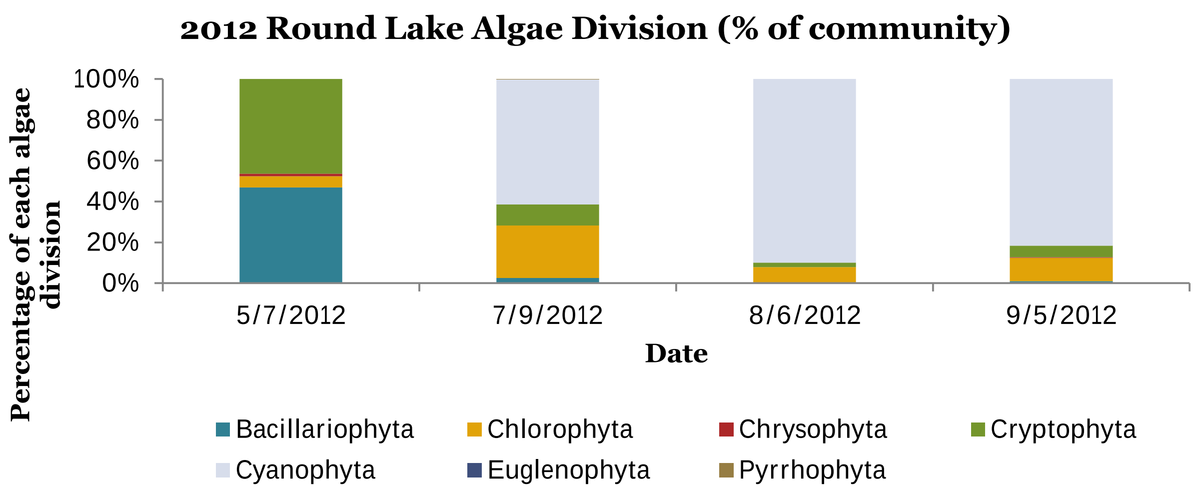
Algal Division	Common Name	Season of Peak Population	Characteristics
Bacillariophyta	Diatoms	Spring	Have a siliceous frustule that makes up the external covering. Sensitive to chloride, pH, color, and total phosphorus (TP) in water. As TP increases, see a decrease in diatoms. Generally larger in size. Tend to be highly present in spring and late spring. Can be benthic or planktonic.
Chlorophyta	Green algae	Summer	Have a true starch and provide high nutritional value to consumers. Can be filamentous and intermingle with macrophytes.
Chrysophyta	Golden brown algae	Spring	Organisms which bear two unequal flagella. A genus of single-celled algae in which the cells are ovoid. Contain chlorophyll a, c_1 and c_2, generally masked by abundant accessory pigment, fucoxanthin, imparting distinctive golden color to cells.
Cryptophyta	Cryptomonads	Spring	Have a true starch. Planktonic. Bloom forming, are not known to produce any toxins and are used to feed small zooplankton. Cryptomonads frequently dominate the phytoplankton assemblages of the Great Lakes.
Cyanophyta	Blue green algae	Summer	Prevail in nutrient-rich standing waters. Blooms can be toxic to zooplankton, fish, livestock, and humans. Can be unicellular, colonial, planktonic, or filamentous. Can live on almost any substrate. More prevalent in late to mid-summer.
Euglenophyta	Euglenoids		One of the best-know groups of flagellates, commonly found in freshwater that is rich in organic materials. Most are unicellular.
Pyrrhophyta	Dinoflagellates	Spring	Have starch food reserves and serve as food for grazers.

Table 8. Characteristics of algal divisions found in Church Pine, Round, and Big Lake.

Across all three lakes the dominant algae division in May was Cryptophyta, or cryptomonads. As the summer progressed, the dominant algae division shifted to Cyanophyta, or blue green algae, in all three lakes. By September, blue green algae made up 93% of the algae community in Church Pine Lake, 81% in Round Lake, and 92% in Big Lake.

Across the entire sampling season Euglenophyta and Pyrrhophyta made up less than 1% of the algae community in all three lakes (Euglenophyta was not present in Church Pine Lake).





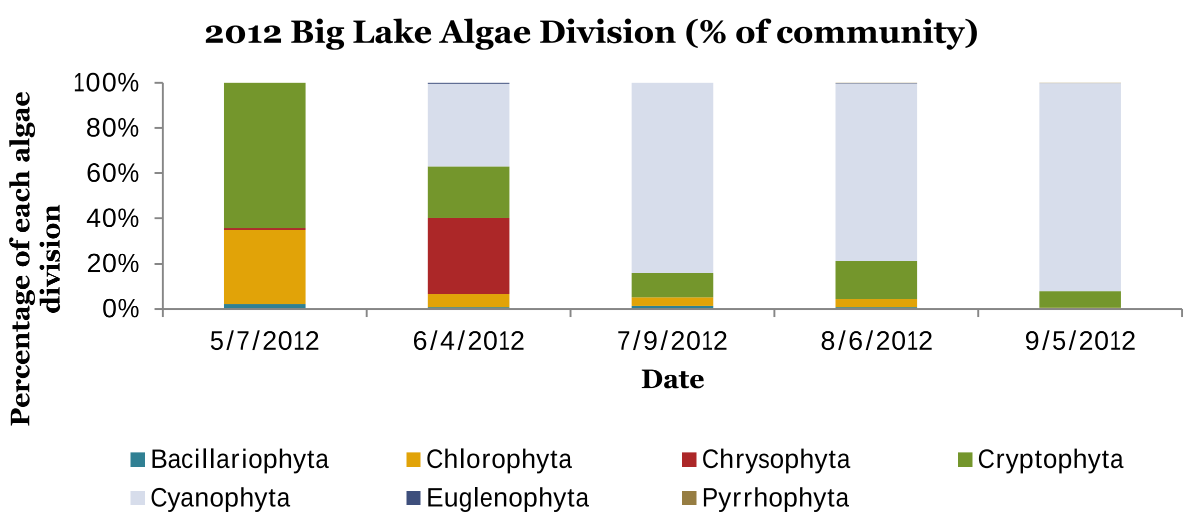


Figure 47. 2012 Church Pine, Round, and Big Lake algae division (% of community).

Blue green algae have been around for billions of years and typically bloom during the summer months. However, blue-green algae blooms become more frequent as a result of increased nutrients in the water column.

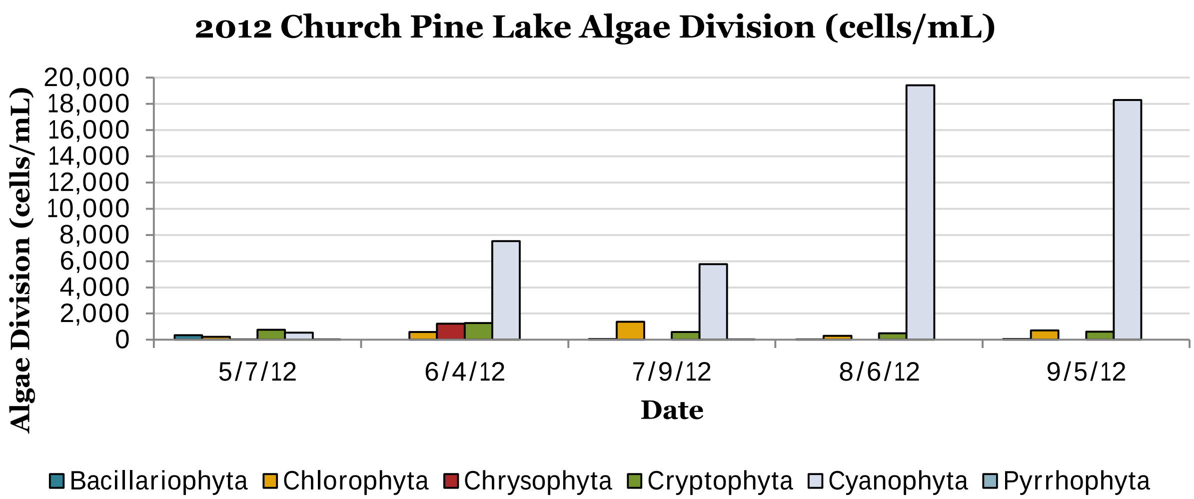
In addition to the negative aesthetics posed by algae, blue green algae are of specific concern because of their ability to produce toxins that can cause short and long term health effects if ingested or inhaled. Effects range from tingling, burning, numbness, drowsiness, and dermatitis to liver or respiratory failure possibly leading to death.

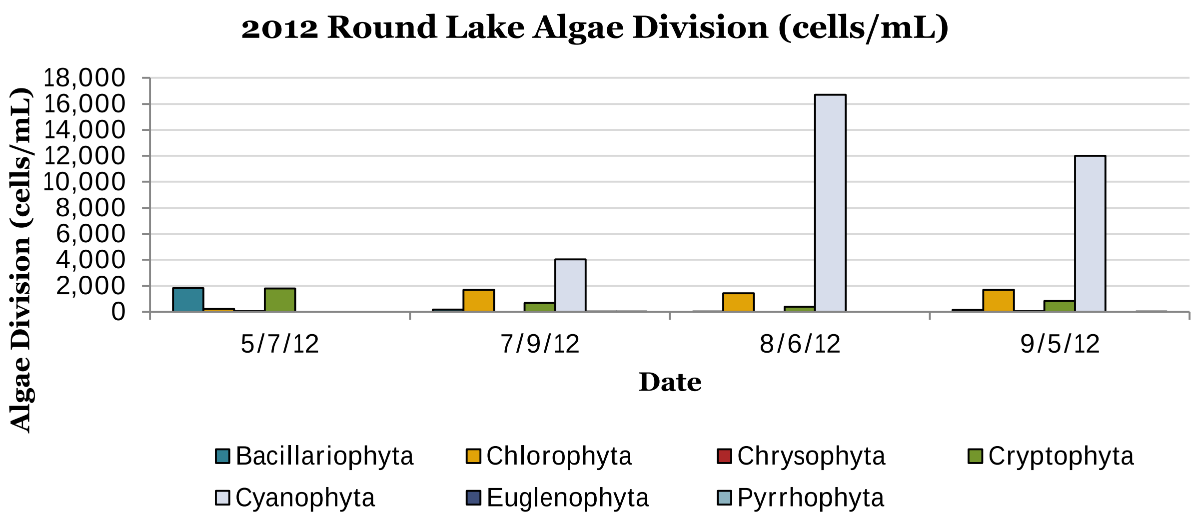
Federal guidelines for cyanobacterial cell densities and chlorophyll *a* concentrations do not exist. The Wisconsin Harmful Algal Bloom (HAB) Surveillance Program uses guidelines of the World Health Organization to determine the risk from cyanobacteria.

Cyanobacterial cell density (cells/mL)	Chlorophyll *a* (mg/L)	Risk from cyanobacteria
Less than 20,000	Less than 0.01	Low
20,000 to 100,000	0.01 to 0.05	Moderate
Greater than 100,000	Greater than 0.05	High

Table 9. Relationship between cyanobacterial cell density, chlorophyll *a*, and risk from cyanobacteria.

Although blue green algae dominated the algal community in Church Pine, Round, and Big Lakes, their cell densities were relatively low and associated with a low risk. Additionally, chlorophyll a concentrations in Church Pine, Round, and Big Lakes indicate a low risk from cyanobacteria.





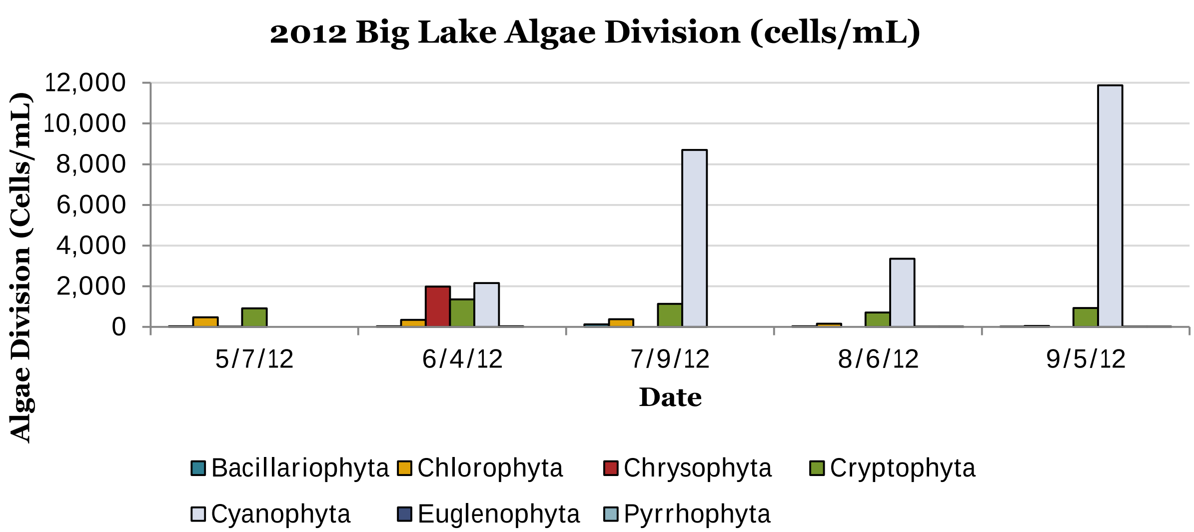


Figure 48. 2012 Church Pine, Round, and Big Lake algae division (cells/mL).

Zooplankton

Zooplankton are small aquatic animals that feed on algae and are eaten by fish. They are divided into three main components: rotifers, copepods, and cladocerans.

Rotifers eat algae, other zooplankton, and sometimes each other. Due to their small size, rotifers are not capable of significantly reducing algal biomass although they are able to shift the algae community to favor larger species.

Copepods feed on algae and other plankton. They are eaten by larger plankton and are preyed heavily upon by pan fish, minnows, and the fry of larger fish.

Cladocerans are filter feeders that play an important part in the food web. Species of cladocerans (particularly Daphnia) are well known for their ability to reduce algal biomass and help maintain clear water in lake ecosystems.

Figure 49. Zooplankton sample.

Zooplankton are often overlooked as a component of aquatic systems, but their role in a lake is extremely important. Lake systems are valued primarily for water clarity, fishing, or other recreation, all of which are strongly linked to water quality and ecosystem health. Zooplankton are the primary link between the "bottom up" processes and "top down" processes of the lake ecosystem.

"Bottom up" processes include factors such as increased nutrients, which can cause noxious algal blooms. Zooplankton have the ability to mediate algae blooms by heavy grazing. Conversely, shifts in algal composition, which can be caused by increased nutrients, can change the composition of the zooplankton community. If the composition shifts to favor smaller species of zooplankton, for example, algal blooms can be intensified, planktivorous fish can become stressed, and the development of fry can be negatively impacted.

"Top down" processes include factors such as increased fish predation. Increases in planktivorous fishes (pan fish) can dramatically reduce zooplankton populations and lead to algal blooms. In some lakes, biomanipulation is utilized to manage this effect and improve water clarity. Piscivorous fish (fish that eat other fish) are used to reduce planktivorous fish. This in turn increases zooplankton populations and ultimately reduces algae populations.

Changes in the aquatic plant community and shoreland habitat can impact zooplankton populations. This occurs especially in shallow lakes where zooplankton are more likely to have the ability to migrate horizontally to avoid predation from fish and other invertebrates. In general, a diverse shoreland habitat (substrate, plant species, and woody debris) will support a diverse zooplankton community.

Composite samples from a two meter water column were collected monthly, preserved with denatured ethanol, placed on ice, and sent to the Northland College for identification and enumeration of zooplankton species. This analysis shows the abundance of the major zooplankton groups: cladocera, copepoda, and rotifer in Church Pine, Round, and Big Lake. Replicate samples were conducted on Big Lake on July 19th and Round lake on August 6th at no extra cost.

The Big Lake zooplankton community is dominated by rotifers, with an explosion in later summer. Very low numbers of cladocera strongly suggest large populations of planktivorous fishes. The inverse relationship between cladoceran and rotifer populations appearing in the graphical representation are indicative of release from competition and predation on rotifers by elimination of larger crustaceans. Low numbers of crustacean plankton are an index of low algal grazing capacity.

Wind Lake is much like Big Lake in rotifer dominance and fewer crustaceans. In particular, cladoceran numbers are very low relative to similar systems. All groups increase in population in late summer, indicating increased productivity without any competitive interference. Overall patterns show a lake with high planktivorous fish populations and low grazing capacity. The patterns in Church Pine Lake are very similar with a much more dramatic population crash in mid-summer. It is unclear from the zooplankton data alone what may have caused this change (Lafroncois, 2013).

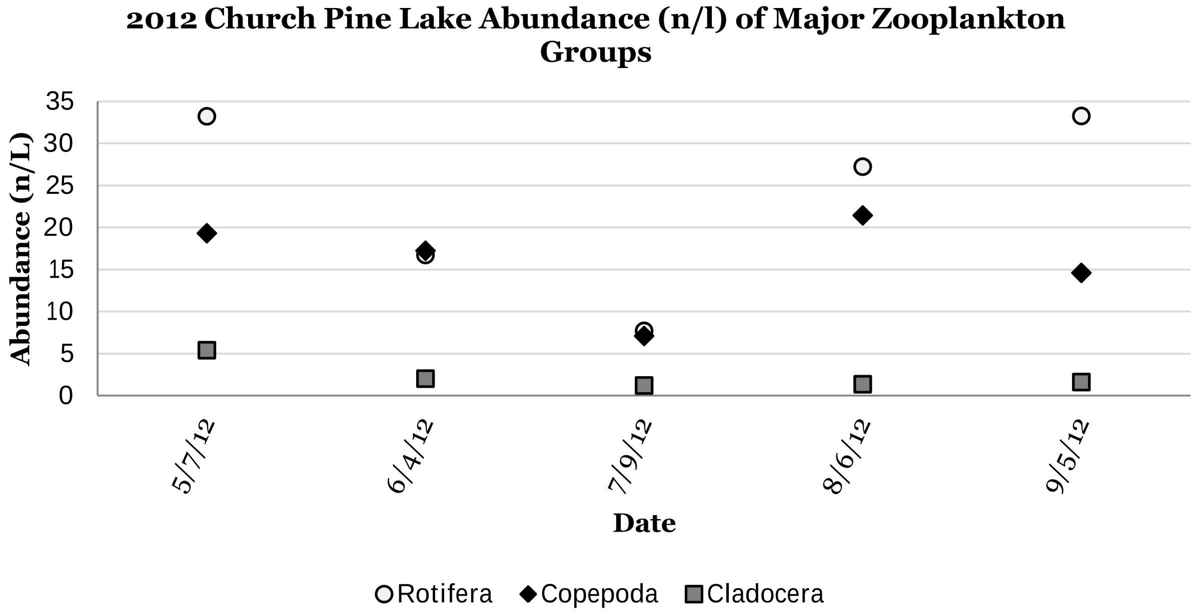


Figure 50. 2012 Church Pine Lake abundance (n/l) of major zooplankton groups.

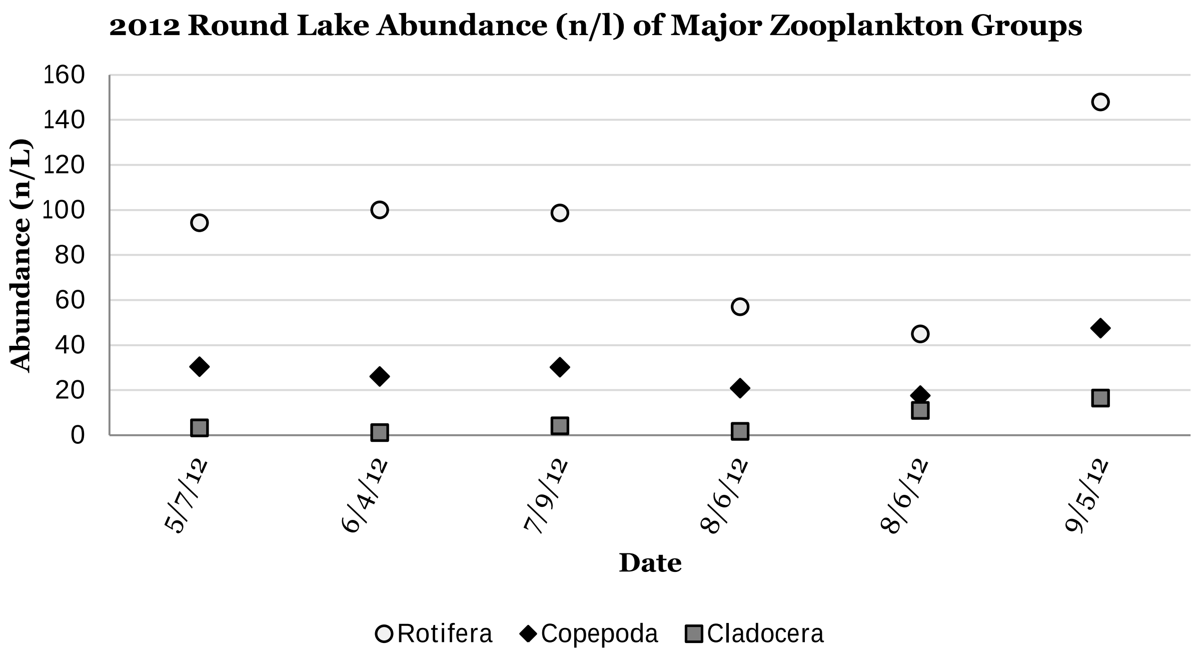


Figure 51. 2012 Round Lake abundance (n/l) of major zooplankton groups.

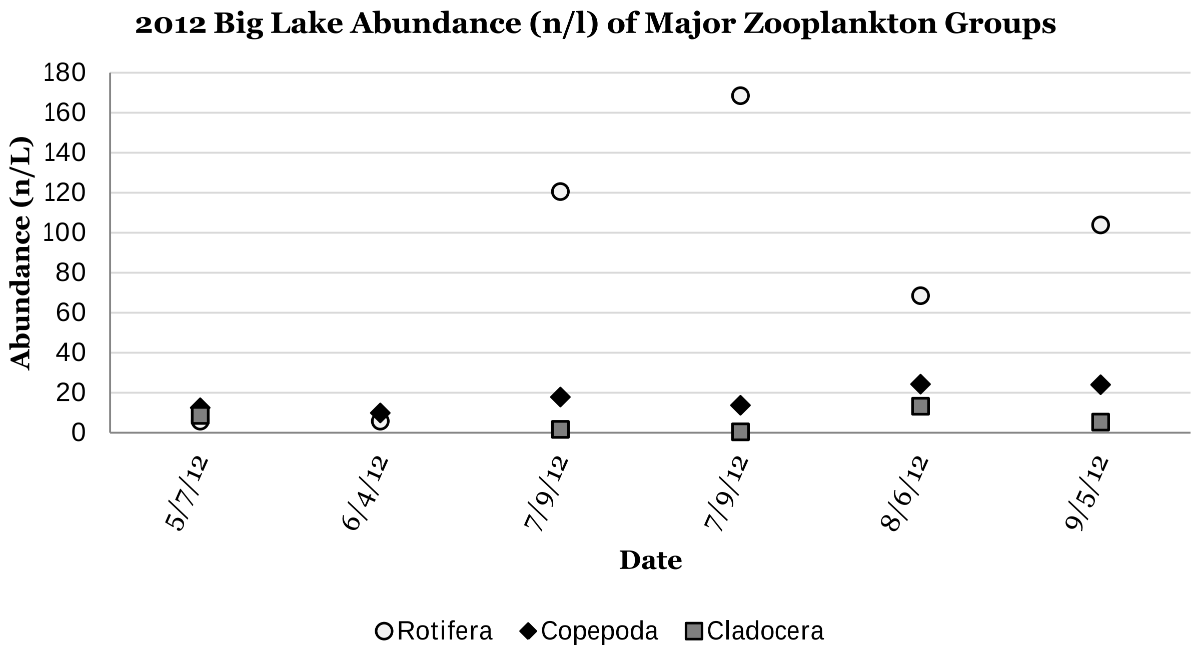


Figure 52. 2012 Big Lake abundance (n/l) of major zooplankton groups.

Land Use and Water Quality

Information summarized from: (Carrol L. Henderson, Carolyn J. Dindorf, and Fred J. Rozumalski) and (Lynn Markham and Ross Dudzik, 2012).

The health of our water resources depends largely on the decisions that landowners make on their properties. When waterfront lots are developed, a shift from native plants and trees to impervious surfaces and lawn often occurs. Impervious surfaces are defined as hard, man-made surfaces that make it impossible for rain to infiltrate into the ground. Examples of impervious surfaces include rooftops, paved driveways, and concrete patios.

Figure 53. Erosion on shoreline.

By making it impossible for rainwater to infiltrate into the soil, impervious surfaces increase the amount of rainwater that washes over the soil surface and feeds directly into lakes and streams. This rainwater runoff can carry pollutants such as sediment, lawn fertilizers, and car oils directly into a lake. Native vegetation can slow the speed of rainwater, giving it time to soak into the soil where it is filtered by soil microbes. Median surface runoff estimates from wooded areas are an order of magnitude less than those from lawn areas.

In extreme precipitation events erosion and gullies can result, causing loss of property as soil is carried to the lake. The signs of erosion are unattractive and can cause decreases in property values. Additionally, sediment can have negative impacts on aquatic life. For example, fish eggs will die when covered with sediment, and sediment influxes to a lake can cause decreases in water clarity making it difficult for predator fish species to locate food.

Increases in impervious surfaces can also cause other negative impacts to fisheries. A study of 164 Wisconsin lakes conducted in 2008 found that the amount of impervious surfaces surrounding lakes can cause shifts in fisheries species assemblages. Certain species such as smallmouth and rock bass, blackchin and blacknose shiners, and mottled sculpin become less common with increasing amounts of impervious surfaces. Many of the smaller species affected are an essential food source for common game fish species such as walleye, northern pike, and smallmouth bass.

Increases in impervious surfaces and lawns also cause a loss of habitat for birds and other wildlife. Over ninety percent of all lake life is born, raised, and fed in the area where land and water meet. Overdeveloped shorelines remove critical habitat which species such as loons, frogs, songbirds, ducks, otters, and mink depend on. Impervious surfaces and lawns can be thought of as biological desserts which lack food and shelter for birds and wildlife.

Additionally, nuisance species such as Canada geese favor lawns over taller native grasses and flowers. Lawns provide geese with a ready food source (grass) and a sense of security from predators (open views).

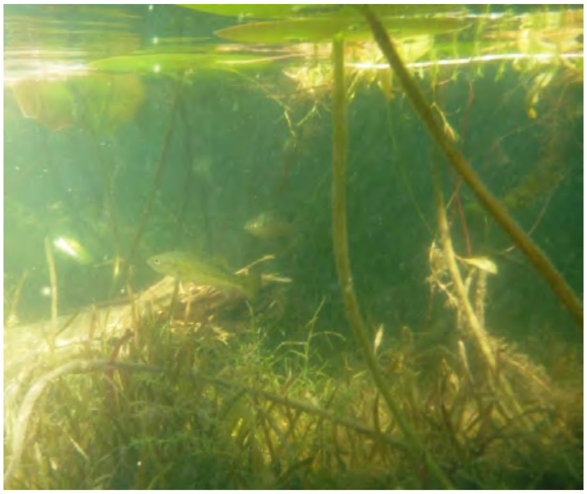


Figure 54. Fish habitat.

Additionally, fish species depend on the area where land and water meet for spawning. The removal of coarse woody habitat, or trees and braches that fall into a lake, causes decreases in fisheries habitat.

Lawns in and of themselves are not particularly harmful and can provide an area for families to recreate. However, problems arise when lawns are not properly maintained, over-fertilized, located in areas important to wildlife habitat, or located on steep slopes.

Common lawn species, such as Kentucky bluegrass, are often dependent on chemical fertilizers and require mowing. Excess chemical fertilizers are washed directly into the adjacent water during precipitation events. The phosphorus and other nutrients in fertilizers, which produce lush vegetative growth on land, are the same nutrients which fuel algae blooms and decrease water clarity in a lake. Additionally, since common lawn species have very shallow root systems, when lawns are located on steep slopes, the impacts of erosion can be intensified.

Figure 55. Algae bloom.

Avoiding establishing lawns on steep slopes and at the water land-interface can provide direct positive impacts on lake water quality. The creation of a buffer zone of native grasses, wildflowers, shrubs, and trees where the land meets the water can provide numerous benefits for water quality and restore valuable bird and wildlife habitat.

In Polk County, all new constructions on lakeshore properties require that a shoreland protection area be in place. A shoreland protection area is required to be 35 feet in depth as measured from the ordinary high water mark, which is defined as the point on the bank or shore up to which the water leaves a distinct mark (erosion, change in vegetation, etc.).

These rules are in place largely to protect water quality and also provide benefits in terms of natural beauty, and bird and wildlife viewing opportunities. Additionally, shoreline protection areas allow for a 30 foot maximum viewing corridor (or 30% of the width of the lot, whichever is less), which can be established as lawn (Polk County, Wisconsin Shoreland Property Owner Handbook A Guide to the Polk County Shoreland Protection Zoning Ordinance in Developing and Caring for Waterfront Property, October 2002) and (Polk County Shoreland Protection Zoning Ordinance, Effective April 1, 2010).

Shoreline Inventory

On Friday, September 7th seven resident volunteers were trained by Polk County Land and Water Resources Department staff to conduct a shoreline inventory for Church Pine, Round, and Big Lake. The shoreline inventory followed the protocol first developed for Bone Lake by Harmony Environmental (Harmony Environmental, Polk County Land and Water Resources Department, and Ecological Integrity Services, 2009).

Prior to the inventory, the linear feet of shoreline and the area of the shoreline buffer at each parcel were estimated using the Polk County Interactive GIS Map available online at: http://polkcowi.wgxtreme.com/.

Land use for each parcel was categorized for the shoreline (linear feet at the ordinary high water mark) and for the shoreline buffer area (area upland thirty-five feet from the ordinary high water mark). Additionally, the presence or absence of coarse woody habitat was determined at each parcel.

The shoreline (linear feet) was categorized as:

- ✓ Rip rap
- ✓ Structure
- ✓ Lawn
- ✓ Sand
- ✓ Natural

The shoreline buffer area (square feet) was categorized as:

- ✓ Hard surface
- ✓ Landscaping
- ✓ Lawn
- ✓ Bare soil
- ✓ Natural

At the training, volunteers conducted the survey on practice parcels to ensure that data collection was consistent across all three lakes.

At the time of the shoreline inventory, lake levels on Church Pine, Round, and Big Lake were close to a foot below the average ordinary high water mark. With decreased water levels, parcel owners may refrain from mowing areas that would otherwise be categorized as lawn because newly exposed soil may be too saturated to support people and/or equipment.

A total of 6.8 linear miles of shoreline and 0.04 square miles of buffer area were categorized by volunteers beginning on September 7th through September 16th.

In total, 2.52 miles of shoreline were inventoried on Church Pine Lake, 1.17 miles of shoreline were inventoried on Round Lake, and 3.08 miles of shoreline were inventoried on Big Lake.

A characterization of the entire three lake system shoreline inventory shows that the greatest land use at the ordinary high water mark is natural (60%), followed by rip rap (30%), lawn (7%), sand (2%), and structure (1%).

Coarse woody habitat was present at twenty-two sites between the three lake system: eleven on Church Pine Lake, six on Round Lake, and five on Big Lake.

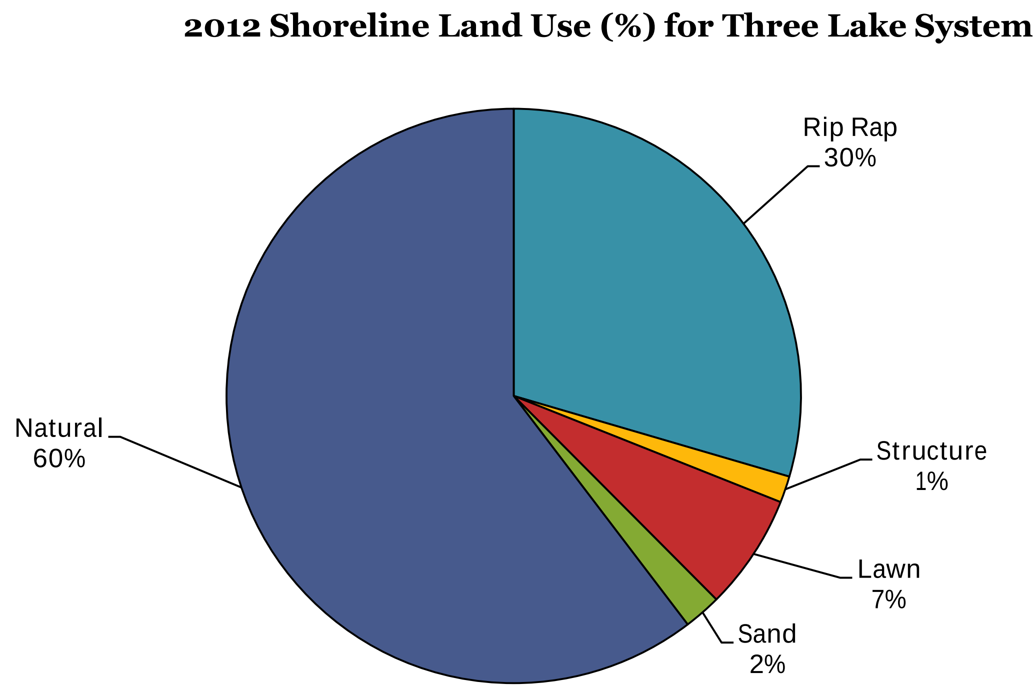


Figure 56. 2012 shoreline land use (%) for the three lake system.

The **Church Pine Lake** shoreline inventory shows that the greatest land use at the ordinary high water mark is natural (71%), followed by rip rap (24%), sand (3%), lawn (1%), and structure (1%).

The **Round Lake** shoreline inventory shows that the greatest land use at the ordinary high water mark is natural (77%), followed by rip rap (14%), structure (4%), lawn (3%), and sand (2%).

The **Big Lake** shoreline inventory shows that the greatest land use at the ordinary high water mark is natural (46%), followed by rip rap (40%), lawn (12%), sand (1%), and structure (1%).

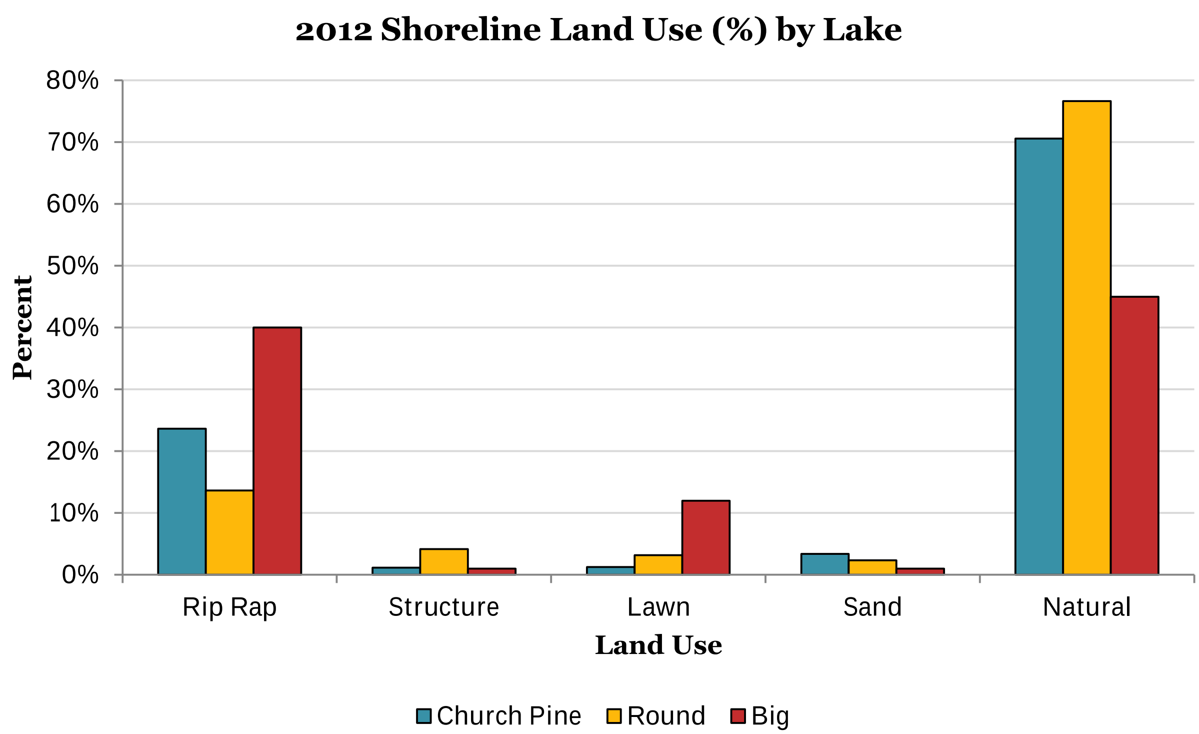


Figure 57. 2012 shoreline land use (%) by lake.

Round Lake has the greatest percentage of shoreline in its natural state (77%), followed by Church Pine Lake (71%), and finally Big Lake (46%).

Big Lake has the greatest percentage of shoreline in riprap (40%), followed by Church Pine Lake (24%), and finally Round Lake (14%).

Lawn made up 12% of the shoreline composition of Big Lake. Round Lake and Church Pine Lake both had a lesser degree of lawn (3% and 1% respectively).

A characterization of the entire three lake system shoreline buffer composition inventory shows that the greatest land use is natural (64%), followed by lawn (23%), hard surface (6%), landscaping (5%), and bare soil (2%).

In comparison to the shoreline at the ordinary high water mark, the shoreline buffer area showed a much greater percentage of lawn (23% as compared to 7%, respectively).

2012 Shoreline Buffer Land Use for Three Lake System

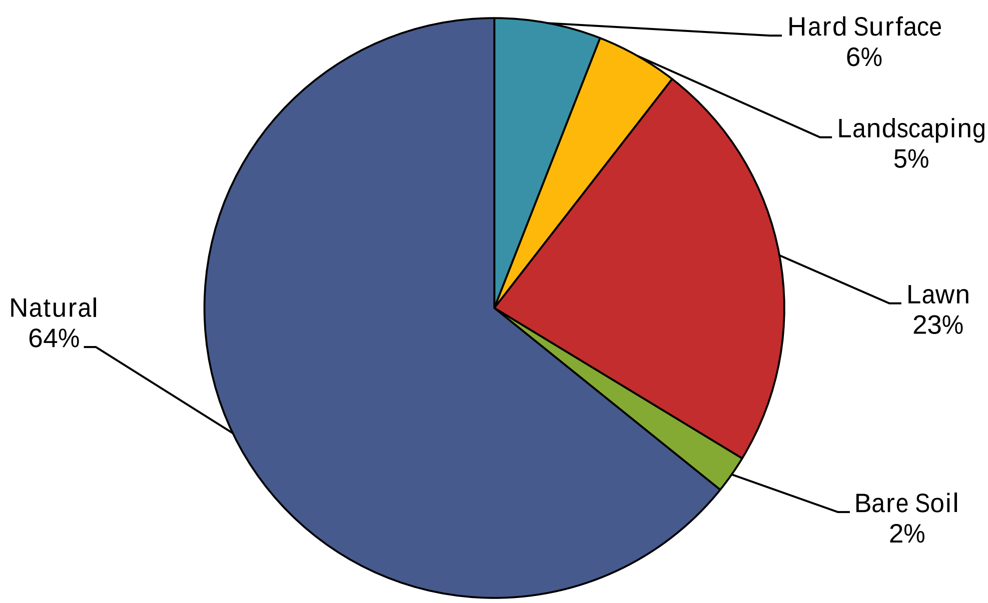


Figure 58. 2012 shoreline buffer land use for three lake system.

The **Church Pine Lake** shoreline buffer composition inventory shows that the greatest land use is natural (71%), followed by lawn (16%), landscaping (5%), hard surface (5%), and bare soil (3%).

The **Round Lake** shoreline buffer composition inventory shows that the greatest land use is natural (68%), followed by lawn (20%), hard surface (6%), landscaping (4%), and bare soil (2%).

The **Big Lake** shoreline buffer composition inventory shows that the greatest land use is natural (57%), followed by lawn (31%), hard surface (7%), landscaping (4%), and bare soil (1%).

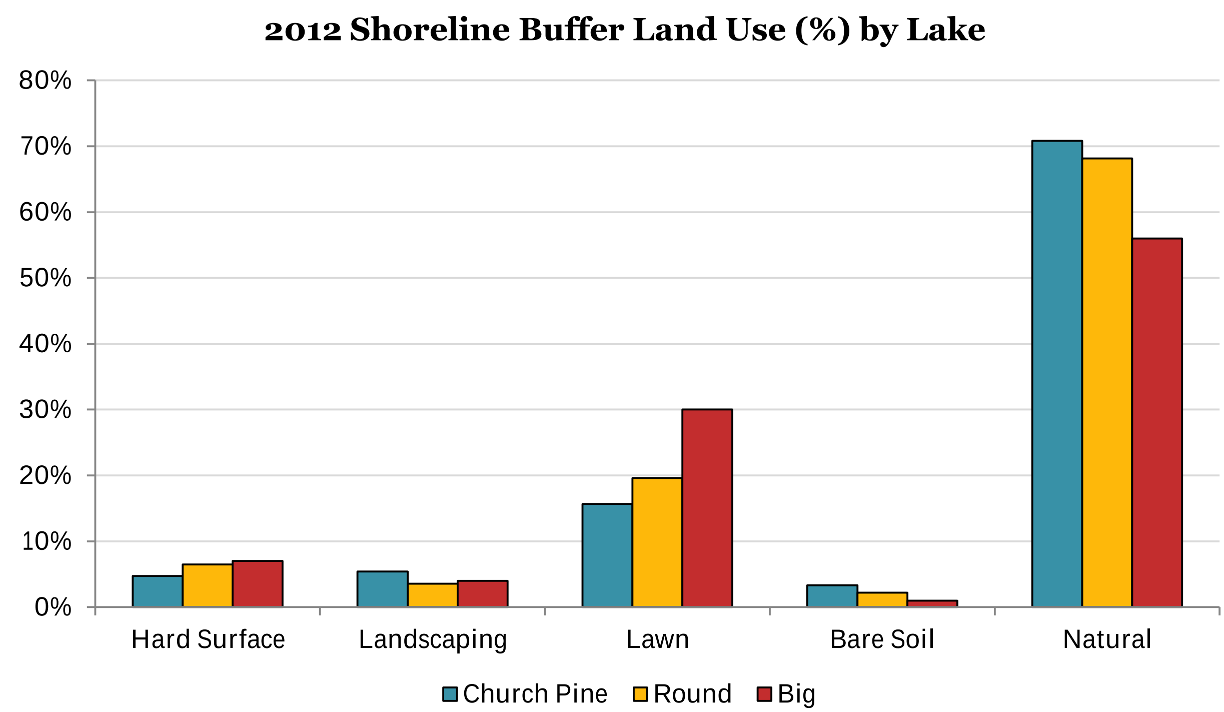


Figure 59. 2012 shoreline buffer land use (%) by lake.

Big Lake had the greatest percentage of lawn in the shoreline buffer area (31%), followed by Round (20%), and Church Pine (16%).

Tributary Monitoring

Data was collected on the tributaries of the three lake system: North Creek (top right), the County Road K culvert (bottom left), and the Big Lake outlet (bottom right).

Flow data was collected bi-weekly at each tributary with a March McBirney Flo-Mate ™ velocity flowmeter. At each foot interval across each of the tributaries, depth (ft) and velocity (m/s) were measured. Grab samples were collected once monthly on each tributary. Samples were analyzed at WEAL for total suspended solids, nitrate/nitrite, ammonium, total Kjeldahl nitrogen, total phosphorus, soluble reactive phosphorus, and chloride.

Figure 60. Tributary monitoring sites: North Creek (top right), the County Road K culvert (bottom left), and the Big Lake outlet (bottom right).

Samples were not collected when sites were dry or without flow. North Creek exhibited flow at all sample dates. The County Road K culvert had no flow beginning on July 9th through the end of the season and the Big Lake outlet had no flow beginning on August 6th through the end of the season.

The phosphorus data collected is specific to date and location and can be used to theoretically determine how much phosphorus is entering the lake. Values for phosphorus influxes are established by multiplying the phosphorus concentration at a specific location by the volume of water that moves through a specific location, or the discharge in cubic feet per second. To determine the average instantaneous load of phosphorus (in mg/s), the average phosphorus concentration is multiplied by the average seasonal discharge. Units are then converted and expressed as lb/yr. Since the flow on County Road K and Big Lake Outlet were intermittent, the annual load of phosphorus for these tributaries was calculated over a 2 month and 4 month time period, respectively.

The analysis of this data allows for areas of highest phosphorus loading to be identified. Once areas of highest phosphorus loading are identified, the land use and geology of these areas can be investigated for their total phosphorus contribution and best management recommendations can be made.

The tributary contributing the most phosphorus to Church Pine, Round, and Big Lake is North Creek. The total phosphorus concentration in North Creek is approximately two times greater when compared with County Road K. However, the annual pounds of phosphorus entering Big Lake from North Creek is approximately ninety times greater when compared with County Road K because North Creek is a larger tributary with a consistent flow.

Site	Total Phosphorus (mg/L)	Discharge (L/s)	Instantaneous Load Phosphorus (mg/s)	Annual Load Phosphorus (lb/yr)
County Road K	0.043	5.601	0.241	2.75 (2 mo. flow)
North Creek	0.087	41.409	3.603	250.63 (12 mo. flow)
Big Lake Outlet	0.024	44.884	1.077	24.62 (4 mo. flow)

Table 10. 2012 tributary monitoring data.

Land Use and Nutrient Loading in the Three Lake Watershed

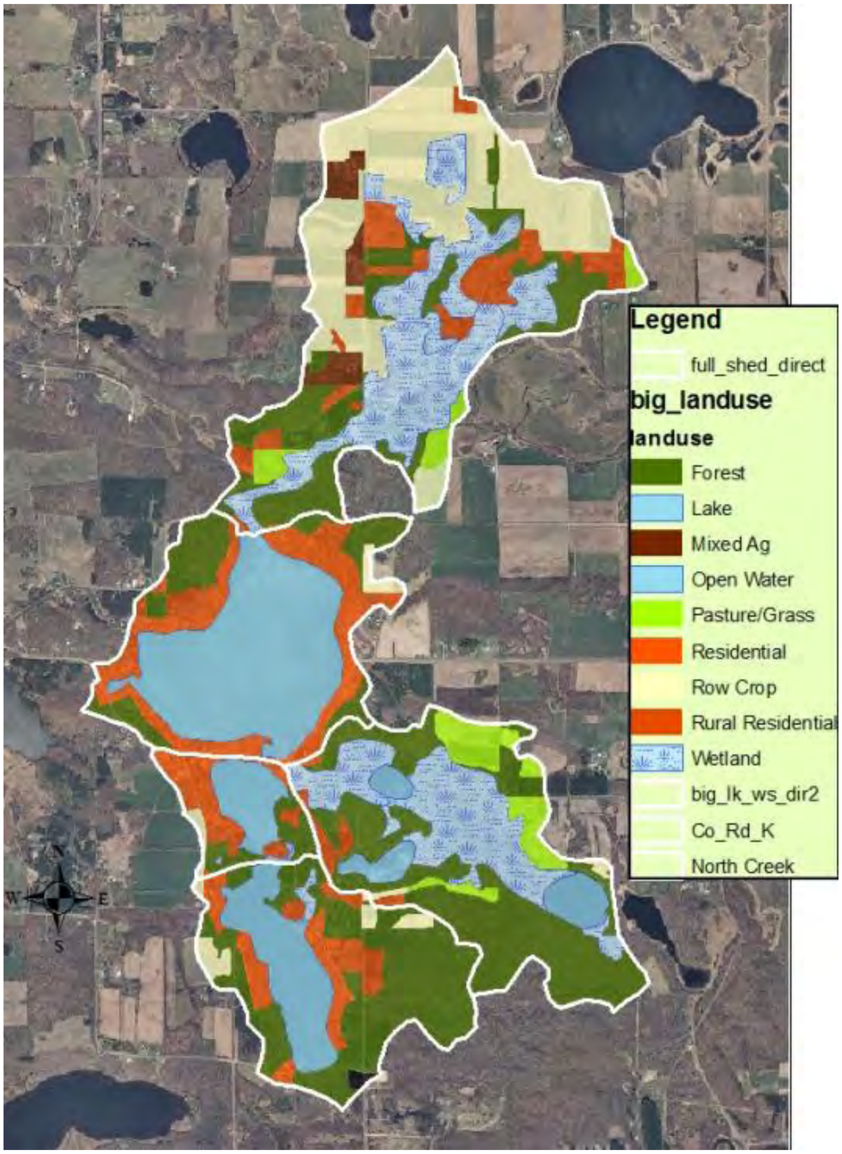


Figure 61. Watershed area land use.

The area of land that drains towards a lake is called a watershed.

The watershed area of Church Pine Lake, including the lake, is 337.5 acres in size. The lake itself is 91 acres and represents 24% of the total land use in the Church Pine Lake watershed.

The watershed area of Round Lake, including the lake, is 106.6 acres in size. The lake itself is 38 acres and represents 36% of the total land use in the Round Lake watershed.

The watershed area of Big Lake, including the lake, is 1,765.8 acres in size. The lake itself is 243 acres and represents 14% of the total land use in the Big Lake watershed.

The Wisconsin Lakes Modeling Suite (WiLMS) was used to model current conditions for Church Pine, Round, and Big Lakes, verify monitoring, and estimate land use nutrient loading for the watershed. Phosphorus is the key parameter in the modeling scenarios used in WiLMS because it is the limiting nutrient for algal growth in most lakes.

Church Pine Lake Land Use and Nutrient Loading

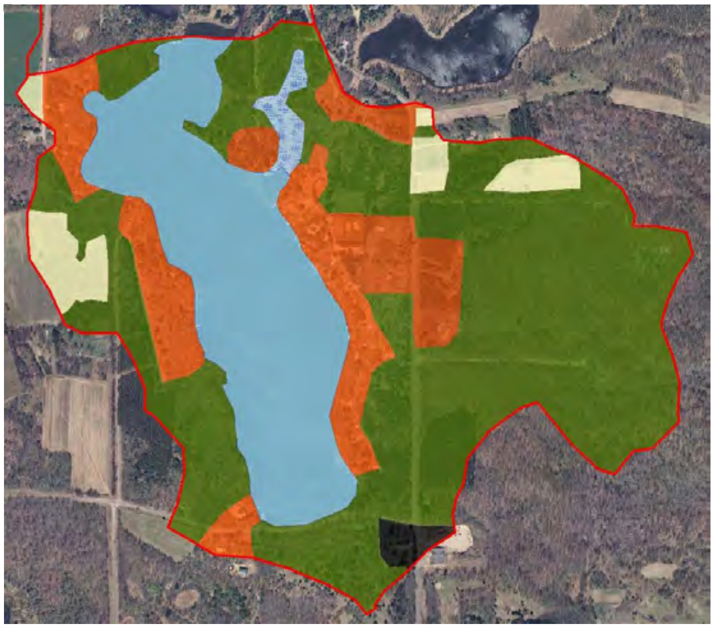


Figure 62. Church Pine Lake land use.

Forest makes up over half (52%) of the land use in the Church Pine Lake watershed. Other land uses include the lake surface (24%), medium density urban (11%), rural residential (6%), row crop (5%), high density urban (1%), and wetlands (1%).

The largest contributor of phosphorus to Church Pine Lake is the lake surface (26%), followed by medium density urban (20%), forest and row crop (each 17%), high density urban (5%), rural residential (2%), and wetlands (less than 1%).

Additionally, the model predicts that septic systems are contributing 13% of the phosphorus load to Church Pine Lake.

Church Pine Lake

	Total acres	Percent acres	Total Loading (lb P /year)	Percent loading
Row crop	17.5	5%	15.6	16.6%
Parking lot	3.8	1%	5.1	5.4%
Residential	41.9	11%	18.7	19.9%
Rural residential	23.1	6%	2.1	2.2%
Wetlands	4.4	1%	0.4	0.4%
Forest	195.8	52%	15.8	16.8%
Lake surface	91	24%	24.4	26.0%
Septic			11.9	12.70%

Table 11. Church Pine Lake land use and nutrient loading.

Round Lake Land Use and Nutrient Loading

Figure 63. Round Lake land use.

The largest land use in the Round Lake watershed is the lake itself (36%), followed by medium density urban (24%), forest (21%), rural residential (14%), row crop (4%), and wetlands (1%). The largest contributor of phosphorus is medium density urban (33%), the lake surface (29%), row crop (11%), forest (5%), rural residential (4%), and wetlands (less than 1%). Additionally, the model predicts that septic systems are contributing 18% to the phosphorus load to Round Lake.

Round Lake

	Total acres	Percent acres	Total Loading (lb P/year)	Percent loading
Row crop	4.3	4%	3.8	11.0%
Residential	25.4	24%	11.3	32.5%
Rural residential	15.4	14%	1.4	3.9%
Wetlands	0.8	1%	0.1	0.2%
Forest	22.7	21%	1.8	5.2%
Lake surface	38	36%	10.2	29.1%
Septic			6.3	18.0%

Table 12. Round Lake land use and nutrient loading.

Big Lake Land Use and Nutrient Loading

The largest land uses in the Big Lake watershed are forest (26%) and wetlands (24%). Other land uses include row crop (16%), the lake itself (14%), rural residential (8%), medium density urban (6%), pasture/grass (5%), and mixed agriculture (2%). The largest contributor of phosphorus is row crop (50%) followed by the lake surface (13%), medium density urban (9%), wetlands and forest (each 7%), mixed agriculture (5%), pasture/grass (4%), and rural residential (2%). Additionally, the model predicts that septic systems are contributing 3% of the phosphorus load to Big Lake.

Big Lake

	Total acres	Percent acres	Total Loading (lb P/year)	Percent loading
Row crop	288.6	16%	257.6	49.8%
Mixed agriculture	34	2%	24.3	4.7%
Pasture/grass	80.7	5%	21.7	4.2%
Residential	99.9	6%	44.5	8.6%
Rural residential	134.6	8%	11.9	2.3%
Wetlands	417.513	24%	37.2	7.2%
Forest	467.5	26%	37.8	7.3%
Lake surface	243	14%	65.2	12.6%
Septic			17.6	3.4%

Table 13. Big Lake land use and nutrient loading.

Land Use and Nutrient Loading in the Three Lake Subwatersheds

The total Church Pine watershed is only 246.5 acres in size and the total Round Lake watershed is only 68.6 acres in size. Due to their small size, these watersheds were not further subdivided.

The Big Lake watershed was divided into three subwatersheds to more accurately determine nutrient loading. One of the subwatersheds was determined based off the watershed associated with North Creek and a second was determined based off the watershed associated with the County Road K culvert. Water associated with these subwatersheds enters Big Lake through tributaries. The third subwatershed represents the area of land that drains to Big Lake from overland flow.

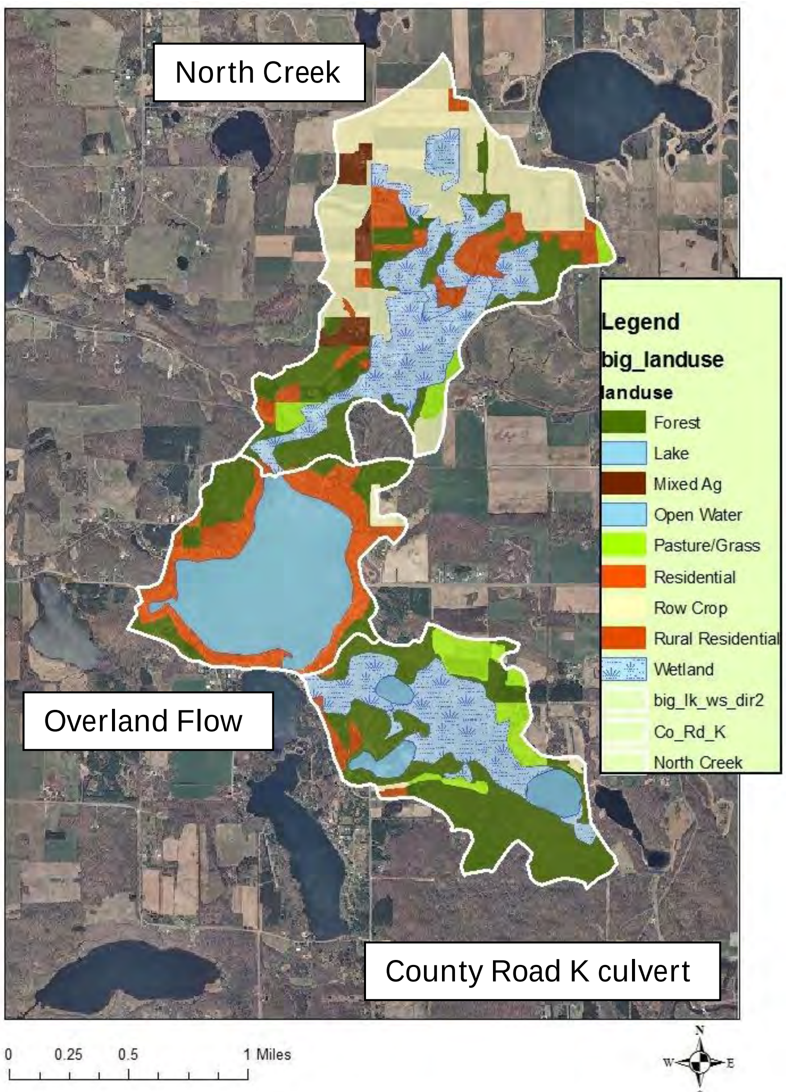


Figure 64. Big Lake subwatersheds.

Areas Providing Water Quality Benefits to the Three Lake System

Natural areas such as forests and wetlands allow for more infiltration of precipitation when compared with row cropped fields and developed residential sites containing lawns, rooftops, sidewalks, and driveways. This occurs because dense vegetation lessens the impact of raindrops on the soil surface, thereby reducing erosion and allowing for greater infiltration of water. Additionally, wetlands provide extensive benefits through their ability to filter nutrients and allow sediments to settle out before reaching lakes and rivers.

The wetlands and forests of the Church Pine, Round, and Big Lake Watersheds should be considered sensitive areas and preserved for the benefits they provide to the lakes.

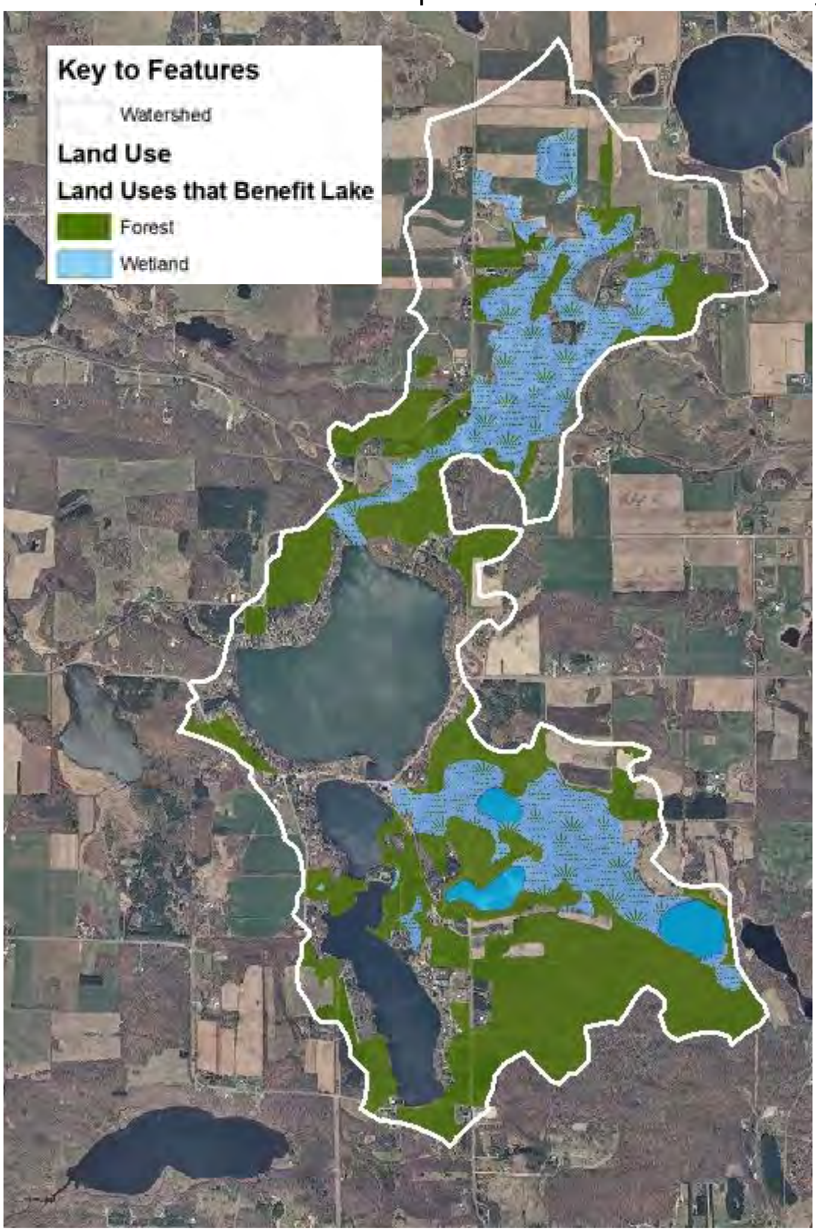


Figure 65. Areas providing water quality benefits to the three lake system.

Watershed and Lake Modeling

The Wisconsin Lake Modeling Suite (WiLMS) was used to model current conditions and nutrient reductions for Church Pine, Round and Big Lake, verify monitoring, and estimate in-lake nutrient loading. Phosphorous is the key parameter in the modeling scenarios used in WiLMS because it is the limiting nutrient for algal growth in most lakes.

Based on average evaporation, precipitation, and runoff coefficients for Polk County soils and land use, the annual non-point source load was calculated to be 93.8 pounds of phosphorous for Church Pine Lake, 34.9 pounds of phosphorous for Wind Lake and 517.8 pounds of phosphorous for Big Lake.

Sub-watersheds were also modeled to estimate the total loading per acre as was reported in the Church Pine, Round, and Big Lake Land Use and Nutrient Loading section of this report.

Since it was decided not to collect *in situ* chemistry samples near the lake bottom, internal loading needs to be estimated using the lake models selected as the best "fit" for the lakes. WiLMS uses four methods to estimate internal loading. Spring and fall turnover chemistry samples were used as a surrogate for the lack of hypolimnetic samples. This did not prove to be useful and consideration of additional studies quantifying internal loading from hypolimnetic sediment is strongly encouraged.

The first method was a complete total phosphorus mass budget; this method calculates the annual internal load to be -7 pounds of phosphorus in Church Pine Lake, -3 pounds of phosphorous in Round Lake, and -29 pounds of phosphorous in Big Lake.

In the second method the internal load was estimated from the growing season *in situ* phosphorus increases. This method calculated the annual internal load to be 4 pounds of phosphorous in Church Pine Lake, 3 pounds of phosphorous in Round Lake, and 74 pounds of phosphorous in Big Lake. The model calculated that there were 1.2 mg/m^2-day of phosphorus released in Church Pine Lake, 0.5 mg/m^2-day in Round Lake, and 1.2 mg/m^2-day in Big Lake using this method.

The third method estimated the internal load from in situ phosphorus increases in the fall. The annual load was calculated to be 70 pounds of phosphorous with a sediment release rate of 11.6 mg/m^2-day in Church Pine Lake, 19 pounds of phosphorous with a sediment release rate of 6.6 mg/m^2-day in Round Lake, and 499 pounds of phosphorous with a sediment release rate of 27.5 mg/m^2-day in Big Lake.

The fourth method uses the average of the calculated phosphorus release rates and anoxic sediment area. This method calculated the annual internal load to be 44-176 pounds of phosphorus in Church Pine Lake, 10-42 pounds of phosphorus in Round Lake, and 116-465 pounds of phosphorus in Big Lake.

The Nurnberg total phosphorus model takes internal loading into account:

$$(P = \frac{L_{Ext}}{q_s}(1-R) + \frac{L_{Int}}{q_s};\ \text{where} R = \frac{15}{18+q_s})$$ [13]

This model predicts that the mixed lake total phosphorus concentration would be 88 µg/l in Church Pine Lake, 113 µg/l in Round Lake, and, 137 µg/l in Big Lake. These estimates are quite high compared to the actual measured total phosphorus in all three lakes. There are obvious ecological and biogeochemical processes that affect measurable nutrient levels in lakes (such as sediment REDOX potential) that simply can't be modeled and need to be measured and studied before assumptions can be made about the impact of sediments and internal loading on the nutrient cycle.

The model that was used to more accurately estimate the mixed lake water column total phosphorus concentration was the Reckhow 1977 Oxic Lake Model where $zT_w < 50$ m/yr which is calculated by:

$$P = \frac{L}{(18z/10+)+1.05(z/T_w)e^{0.012z/T_w}}.$$ [14]

The model was calibrated with available data for Church Pine, Round, and Big Lakes.

The model estimated the Church Pine Lake water column total phosphorus concentration as 19.71 µg/l, which was exactly the same as the actual annual measured average. A 5% reduction in the external areal load to the lake reduces phosphorus to 19.27 µg/l, which is more than adequate to maintain the water quality of Church Pine Lake.

The model estimated the Round Lake water column total phosphorus concentration as 25.14 µg/l, which was exactly the same as the actual annual measured average. A 10% reduction in the external areal load to the lake reduces phosphorus to 24.24 µg and a 16% reduction reduces phosphorus to 19.87 µg/l which is comparable to Church Pine Lake's concentration.

The model estimated the Big Lake water column total phosphorus concentration as 29.57 µg/l, which was exactly the same as the actual annual measured average. A 10% reduction

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[13] P is the predicted mixed lake total phosphorus concentration, L_{ext} is external areal loading, L_{int} is areal internal loading, qs is areal water loading or surface overflow rate, z is the lakes mean depth, and R is the Fraction of inflow total phosphorus retained in the lake.

[14] P is the predicted mixed lake total phosphorus concentration, L is areal loading, z is the lakes mean depth, and T_w is the lake hydraulic retention time.

in the external areal load to the lake reduces phosphorus to 24.24 µg and a 16% reduction reduces phosphorus to 19.87 µg/l which is comparable to Church Pine Lake's concentration.

The Big Lake model was also calibrated to the measured 29.57 µg/l, which was exactly the same as the actual annual measured average. A 16% reduction in the external areal load to the lake reduces phosphorus to 29.02 µg and a 25% reduction reduces phosphorus to 28.71 µg/l

Using the available in situ and modeled data it is possible to predict reductions in chlorophyll a concentrations and total primary productivity within the water column by using the equation

$$\left[\overline{chl.a}\right] = 0.55\{[P]_i/(1+\sqrt{T_w}\}^{0.76}$$

for estimating the annual average chlorophyll a concentrations and

$$\sum C(gm^{-2}yr^{-1}) = \left[\frac{\{[P]_i/(1+\sqrt{T_w}\}^{0.76}}{0.3+0.011\{[P]_i/(1+\sqrt{T_w}\}^{0.76}}\right]$$ [15]

to correlate the relationship of total primary productivity with chlorophyll a. This equation is based on average chlorophyll concentrations and light extinction resulting from turbidity and dissolved organic substances (Wetzel, 2001).

Using these equations it was predicted that Church Pine Lake would have an annual chlorophyll a concentration of 8.01 µg/l under current conditions and 7.82 µg/l with a five percent external load reduction. Both numbers are much higher than the 1.8 µg/l average measured in 2012; however, the model does predict a decline in chlorophyll a even with such a small watershed reduction. Similar results were found in primary productivity with the model predicting 201.24 $\sum C(gm^{-2}yr^{-1})$ under current conditions and 198.00 $\sum C(gm^{-2}yr^{-1})$ with the reduction.

The same equations showed that under current conditions Round Lake would have an annual chlorophyll a concentration of 12.97µg/l with a 10% external load reduction, and 10.25 µg/l with a 16% external load reduction. These values are still higher than the 2.5 µg/l measured in 2012, but still show a 24% reduction in chlorophyll a. Total primary productivity went from 278.87 $\sum C(gm^{-2}yr^{-1})$ under current conditions to 272.51 $\sum C(gm^{-2}yr^{-1})$ with a 10% reduction and to 236.66 $\sum C(gm^{-2}yr^{-1})$ with a 16% reduction.

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[15] $\left[\overline{chl.a}\right]$ is the average annual concentration of chlorophyll a, $[P]_i$ is the average inflow concentration of total phosphorus, T_w is the lake hydraulic retention time, and $\sum C(gm^{-2}yr^{-1})$ is the sum of grams of carbon per meter squared of lake area per year produced during photosynthesis.

In Big Lake the model predicted the average annual chlorophyll a concentration to be 15.32 µg/l under current conditions, 15.04 µg/l with a 16% external load reduction, and 14.88 µg/l with a 25% external load reduction. Again these values are above the 4.75 µg/l measured in 2012; however, the chlorophyll a concentration on September 5th, 2012 was 12.00 µg/l, closer to what was modeled. The total primary productivity was modeled to be 298.70$\sum C(gm^{-2}yr^{-1})$ at current conditions, 295.79$\sum C(gm^{-2}yr^{-1})$ with a 16% external load reduction, and 294.13 $\sum C(gm^{-2}yr^{-1})$ with a 25% external load reduction.

Models are generally an over simplification of natural phenomenon; however, they can be useful to guide lake management because they can be used to predict many different scenarios. The models employed do show reductions in water column total phosphorus concentrations, chlorophyll a concentrations, and total primary productivity. However, to enhance current understanding of these lakes' ecosystems and guide future management decisions a clear understanding of Church Pine, Round and Big Lakes current and past ecosystem functions needs to be achieved.

Current pre and post aquatic macrophyte surveys should be coupled with continuous water column monitoring. Additionally, a detailed study of in situ sediment nutrient release and REDOX conditions should be seriously considered to adequately quantify internal loading and paleolimnological techniques should be employed to understand past water quality and ecosystem change and refine goals as needed.

Nutrient Budget Summary: Church Pine Lake

Modeling was used to estimate an annual phosphorus budget for Church Pine Lake for external (watershed) and internal (in-lake) sources of phosphorus.

Non-point source load estimated from WiLMS: 93.8 pounds phosphorus/year

Divided by land use:

- ✓ Precipitation to lake surface: 24.4 pounds
- ✓ Residential: 18.7 pounds
- ✓ Forest: 15.8 pounds
- ✓ Row crop: 15.6 pounds
- ✓ Septic: 11.9 pounds
- ✓ High density urban: 5.1 pounds
- ✓ Rural residential: 2.1 pounds
- ✓ Wetlands: 0.4 pounds

Waterfront property load estimated with Virginia Runoff Reduction Method Worksheet: 19.4 pounds phosphorus/year

Internal Load (load from sediments/dead or decaying matter): 70 pounds phosphorus/year

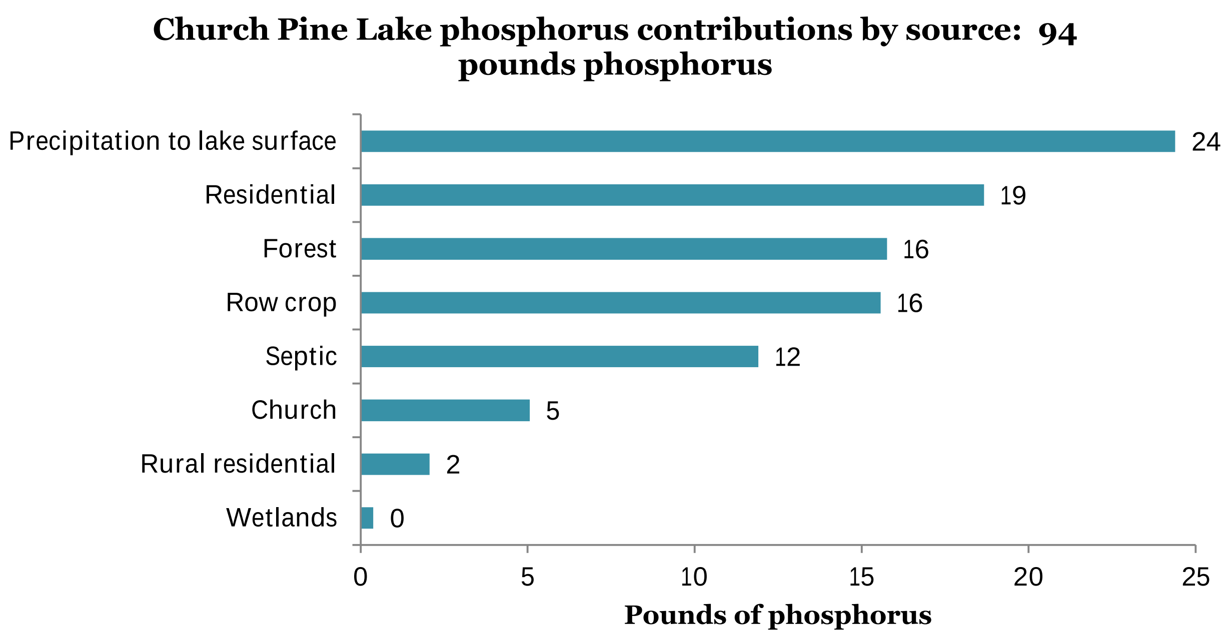

Figure 66. Church Pine Lake phosphorus contributions by source.

Modeling was used to predict changes in water quality that would result from a 5% reduction in external sources of phosphorus (4.7 pounds of phosphorus) to Church Pine Lake.

Modeling predicts that current water column phosphorus (with no reductions in internal or external loading) would be 0.0197 mg/L with a TSI(phosphorus) value of 47.1. Actual 2012 TSI(phosphorus) was 47.7.

Water column and TSI phosphorus were estimated for a 5% external reduction.

5% external reduction	
Phosphorus (mg/L)	TSI (P)
.0193	46.8

Table 14. Church Pine Lake 5% external reduction values.

Nutrient Budget Summary: Round Lake

Modeling was used to estimate an annual phosphorus budget for Round Lake for external (watershed) and internal (in-lake) sources of phosphorus.

Non-point source load estimated from WiLMS: 34.9 pounds phosphorus/year

Divided by land use:

- ✓ Residential: 11.3 pounds
- ✓ Precipitation to lake surface: 10.2 pounds
- ✓ Septic: 6.3 pounds
- ✓ Row crop: 3.8 pounds
- ✓ Forest: 1.8 pounds
- ✓ Rural residential: 1.4 pounds
- ✓ Wetlands: 0.1 pounds

Point-source load from Church Pine Lake: 11.0 pounds phosphorus/year

Waterfront property load estimated with Virginia Runoff Reduction Method Worksheet: 10.9 pounds phosphorus/year

Internal Load (load from sediments/dead or decaying matter): 10.70 pounds phosphorus/year

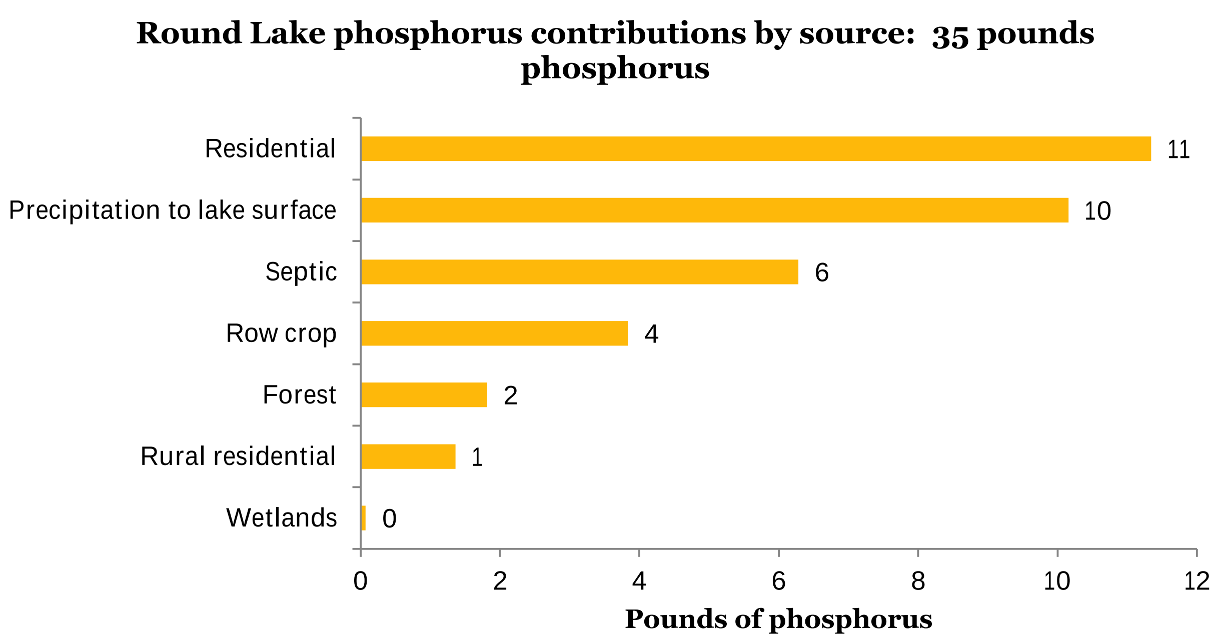

Figure 67. Round Lake phosphorus contributions by source.

Modeling was used to predict changes in water quality that would result from a 10% and 16% reduction in external sources of phosphorus (3.5 and 5.6 pounds of phosphorus, respectively) to Round Lake.

Modeling predicts that current water column phosphorus (with no reductions in internal or external loading) would be 0.0251 mg/L with a TSI (phosphorus) value of 50.6. Actual 2012 TSI(phosphorus) was 49.4.

Water column and TSI phosphorus were estimated for a 10% and 16% external reduction.

10% external reduction		16% external reduction	
Phosphorus (mg/L)	TSI (P)	Phosphorus (mg/L)	TSI (P)
.0242	50.1	.0199	47.2

Table 15. Round Lake 10% and 16% external reduction values.

Nutrient Budget Summary: Big Lake

Modeling was used to estimate an annual phosphorus budget for Big Lake for external (watershed) and internal (in-lake) sources of phosphorus.

Non-point source load estimated from WiLMS: 517.8 pounds phosphorus/year

Divided by land use:

- ✓ Row crop: 257.6 pounds
- ✓ Precipitation to lake surface: 65.2 pounds
- ✓ Residential: 44.5 pounds
- ✓ Forest: 37.8 pounds
- ✓ Wetlands: 37.2 pounds
- ✓ Mixed agriculture: 24.3 pounds
- ✓ Pasture/grass: 21.7 pounds
- ✓ Septic: 17.6 pounds
- ✓ Rural residential: 11.9 pounds

Tributary load calculated using field collected phosphorus data: 253.4 pounds phosphorus/year

- ✓ County Road K culvert: 2.8 pounds
- ✓ North Creek: 250.6 pounds

Non point and point source load estimated from WiLMS by subwatershed: 312.1 pounds phosphorus/year

- ✓ County Road K Culvert Subwatershed: 2.75 pounds
- ✓ North Creek Subwatershed: 250 pounds
- ✓ Direct Drainage Subwatershed: 59.3 pounds

Point-source load from Wind Lake: 4 pounds phosphorus/year

Tributary load leaving lake through the Big Lake Outlet calculated using field collected phosphorus data: 24.6 pounds phosphorus/year

Waterfront property load estimated with Virginia Runoff Reduction Method Worksheet: 42.4 pounds phosphorus/year

Internal Load (load from sediments/dead or decaying matter): 74 pounds phosphorus/year

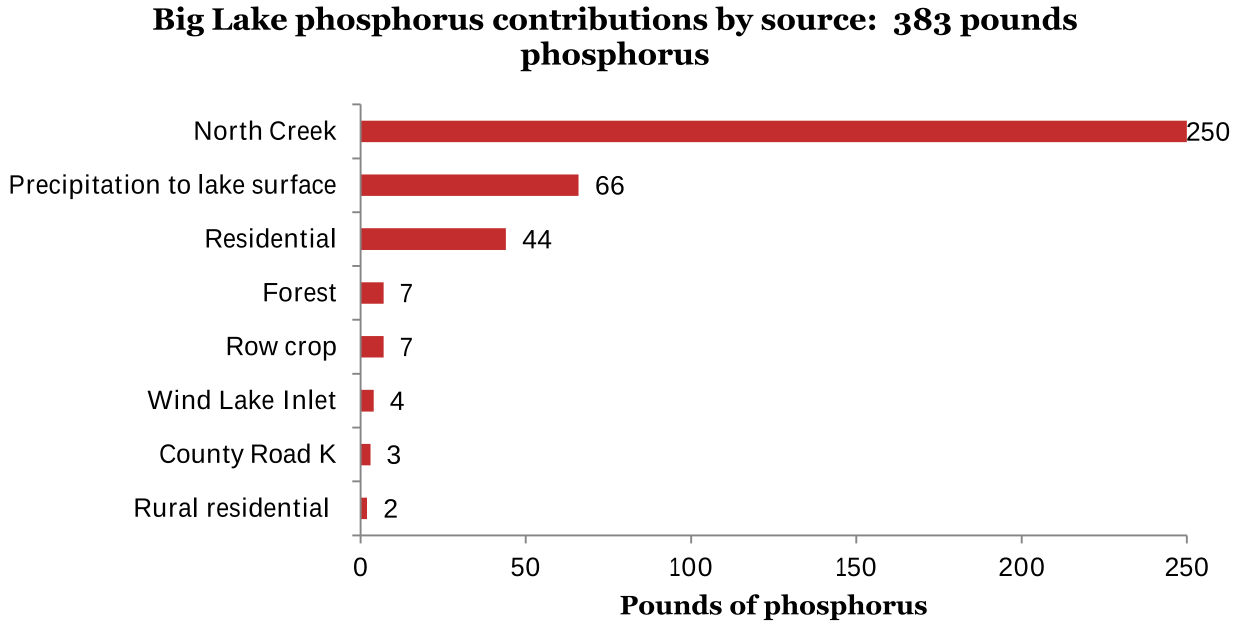

Figure 68. Big Lake phosphorus contributions by source.

Modeling was used to predict changes in water quality that would result from a 16% and 25% reduction in external sources of phosphorus (82.8 and 129.5 pounds of phosphorus, respectively) to Big Lake.

Modeling predicts that current water column phosphorus (with no reductions in internal or external loading) would be 0.0296 mg/L with a TSI (phosphorus) value of 53. Actual 2012 TSI(phosphorus) was 54.57.

Water column and TSI phosphorus were estimated for a 16% and 25% external reduction.

16% external reduction		25% external reduction	
Phosphorus (mg/L)	TSI (P)	Phosphorus (mg/L)	TSI (P)
.0290	52.7	.0287	52.5

Table 16. Big Lake 16% and 25% external reduction values.

Pontoon Classrooms

On July 20th and August 9th, 2012 pontoon classrooms were held for members of the Church Pine, Round, and Big Lake Protection and Rehabilitation District. The classroom held on July 20th was attended by five adults and the classroom held on August 9th was attended by nine children and one adult.

A third classroom was initially scheduled for August 3rd, rescheduled for August 12th, and eventually cancelled.

The pontoon classrooms were promoted through the District Spring Informational Meeting, the District Annual Meeting, a reminder postcard sent to all residents, and through the District website.

At both pontoon classrooms, participants were given the chance to collect physical and chemical data, zooplankton samples, and algae samples. Data was explained as it was collected and participants had the opportunity to see zooplankton and filter chlorophyll *a* samples. Plants were collected with a rake and shown to participants during a conversation regarding the benefits of aquatic plants and how to identify invasive species. Participants were given the chance to ask any questions they had regarding water quality. Tributary sampling was discussed with the adult group and aquatic macroinvertebrates were collected with the children group.

Figure 69. Pontoon classroom.

Shoreline Restoration Workshop

On September 13th, 2012 a shoreline restoration workshop was held for members of the Church Pine, Round, and Big Lake Protection and Rehabilitation District at the Alden Town Hall. The workshop began at 3 pm and lasted over two hours. Eight attendees gained valuable information regarding shoreline restoration and rain gardens and were offered numerous educational handouts including: native plant lists for Polk County, rain garden designs, and grids to design a project of their own.

The workshop was promoted through the District Spring Informational Meeting, the District Annual Meeting, a reminder postcard sent to all residents, and through the District website.

Polk County Ordinances

Comprehensive Land Use Planning

The Polk County Comprehensive Land Use Plan was adopted in 2009. The plan includes an analysis of population, economy, housing, transportation, recreation, and land use trends. It also reports the physical features of Polk County. The purpose of the land use plan is to provide general guidance to achieve the desired future development of the county and direction for development decisions. The lakes classification outlines restriction on development according to lake features. Plan information is available online at http://www.co.polk.wi.us/landinfo/PlanningCompPlan.asp

Town, City and Village Comprehensive Plans are available at: http://www.co.polk.wi.us/landinfo/PlanningCompPlans.asp

Smart growth is a state mandated planning requirement to guide land use decisions and facilitate communication between municipalities. Wisconsin's Comprehensive Planning Law (Statute 66.1001, Wis. Stats.) was passed as part of the 1999 Budget Act. The law requires that if a local government engages in zoning, subdivision regulations, or official mapping, those local land use regulations must be consistent with that unit of local government's comprehensive plan beginning on January 1, 2010. The law defines a comprehensive plan as having at least the following nine elements:

- ✓ Issues and opportunities
- ✓ Housing
- ✓ Transportation
- ✓ Utilities and community facilities
- ✓ Agricultural, natural, and cultural resources
- ✓ Economic development
- ✓ Intergovernmental cooperation
- ✓ Land use
- ✓ Implementation
- ✓ Polk County added "Energy and Sustainability"

Polk County Comprehensive Land Use Ordinance

The Polk County Comprehensive Land Use Ordinance, more commonly known as the Zoning Ordinance, is currently being updated due to the passage of the Comprehensive Plan. 17 of Polk County's 24 Towns have adopted county zoning, including: the Towns of Alden, Apple River, Beaver, Black Brook, Clam Falls, Clayton, Clear Lake, Eureka, Georgetown, Johnstown, Lincoln, Lorain, Luck, McKinley, Milltown, Osceola, and West Sweden. The Towns of Farmington, Garfield, and St Croix Falls have adopted Town Zoning and the Towns of Balsam Lake, Bone Lake, Laketown, and Sterling have no town or county zoning other than the state-mandated shoreland zoning. Land use regulations in the zoning ordinance include building height requirements, lot sizes, permitted uses, and setbacks among other provisions. The current Comprehensive Zoning Ordinance is available at: http://www.co.polk.wi.us/landinfo/pdfs/Ordinances/ComprehensiveLandUse.pdf

Shoreland Protection Zoning Ordinance

The State of Wisconsin's Administrative Rule NR115 dictates that counties must regulate lands within 1,000 feet of a lake, pond or flowage and 300 feet of a river or stream. The Shoreland Protection Zoning Ordinance is also currently being rewritten due to the Comprehensive Plan and the State of Wisconsin passing a new version of NR 115 in 2010. Polk County passed an update of the current Shoreland Ordinance in 2002 and again in 2008. These updates put in place standards for impervious surfaces, a phosphorus fertilizer ban for shoreland property, and lakes classification and setback standards. The current ordinance is available online at:
http://www.co.polk.wi.us/landinfo/pdfs/Ordinances/ShorelandOrdinance.pdf

Updates to the Shoreland Protection Ordinance and the Comprehensive Land Use Ordinance will be completed in 2013. The old and new version of the ordinances will be available at: http://www.co.polk.wi.us/landinfo/ordinances.asp

Subdivision Ordinance

The subdivision ordinance, adopted in 1996 and updated in 2005, requires a recorded certified survey map for any parcel less than 19 acres. The ordinance requires most new plats to incorporate storm water management practices with no net increase in runoff from development. The ordinance is available online at:
http://www.co.polk.wi.us/landinfo/PDFs/Ordinances/Subdivision%20Ordinance%202005-07-01.pdf

Animal Waste

The Polk County Manure and Water Quality Management Ordinance was revised in January 2000. A policy manual established minimum standards and specifications for animal waste storage facilities, feedlots, degraded pastures, and active livestock operations greater than 300 animal units for livestock producers regulated by the ordinances. The Land and Water Resource Department's objective was to have countywide compliance with the ordinance by 2006. The ordinance is available online at:
http://www.co.polk.wi.us/landwater/MANUR21A.htm.

Storm Water and Erosion Control

The ordinance, passed in December 2005, establishes planning and permitting requirements for erosion control on disturbed sites greater than 3,000 square feet, where more than 400 cubic yards of material is cut or filled, or where channels are used for 300 feet more of utility installation (with some exceptions). Storm water plans and implementation of best management practices are required for subdivisions, survey plats, and roads where more than ½ acre of impervious surface will result. The Polk County Land and Water Resources Department administers the ordinance. The ordinance is a local mechanism to implement the Wisconsin Non-agricultural Runoff Performance Standards found in NR 151.

WI Non-Agricultural Performance Standards (NR 151)

Construction Sites >1 acre – must control 80% of sediment load from sites

Storm water management plans (>1 acre)

- Total Suspended Solids
- Peak Discharge Rate
- Infiltration
- Buffers around water

Developed urban areas (>1000 persons/square mile)

- Public education
- Yard waste management
- Nutrient management
- Reduction of suspended solids

Amended Illegal Transport of Aquatic Plants and Invasive Animals

The purpose of this ordinance, passed in June 2011, is to prevent the spread of aquatic invasive species in Polk County and surrounding water bodies by prohibiting the transport of boats, trailer, personal watercraft, and equipment if aquatic invasive plants or invasive animals are attached.

Polk County Land and Water Resources Management Plan

The Polk County Land and Water Resources Management Plan describes the strategy the Land and Water Resources Department (LWRD) will employ from 2010-2018 to address agriculture and non-agriculture runoff management, stormwater discharge, shoreline management, soil conservation, invasive species and other environmental degradation that affects the natural resources of Polk County. The plan specifies how the LWRD will implement NR 151 (Runoff Management). It involves identifying critical sites, offering cost-share and other programs, identifying BMP's monitoring and evaluating projects for compliance, conducting enforcement activities, tracking progress, and providing information and education.

Polk County has local shoreland protection, zoning, subdivision, animal waste, and non-metallic mining ordinances. Enforcing these rules and assisting other agencies with programs are part of LWRD's ongoing activities. Other activities to implement the NR 151 Standards include information and education strategies, write nutrient management plans, provide technical assistance to landowners and lakeshore owners, perform lake studies, collaborate with other agencies, work on a rivers classification system, set up demonstration sites of proper BMP's, control invasive species, and revise ordinances to offer better protection of resources.

WI Agricultural Performance Standards (NR 151)

For farmers who grow agricultural crops

- ✓ Meet "T" on cropped fields
- ✓ Starting in 2005 for high priority areas such as impaired or exceptional waters, and 2008 for all other areas, follow a nutrient management plan designed to limit entry of nutrients into waters of the state

For farmers who raise, feed, or house livestock

- ✓ No direct runoff from feedlots or stored manure into state waters
- ✓ No unlimited livestock access to waters of the state where high concentrations of animals prevent the maintenance of adequate or self sustaining sod cover
- ✓ Starting in 2005 for high priority areas, and 2008 for all other areas, follow a nutrient management plan when applying or contracting to apply manure to limit entry of nutrients into waters of the state

For farmers who have or plan to build a manure storage structure

- ✓ Maintain a structure to prevent overflow, leakage, and structural failure
- ✓ Repair or upgrade a failing or leaking structure that poses an imminent health threat or violates groundwater standards
- ✓ Close a structure according to accepted standards
- ✓ Meet technical standards for a newly constructed or substantially-altered structure

For farmers with land in a water quality management area (defined as 300 feet from a stream, or 1,000 feet from a lake or areas susceptible to groundwater contamination)

- ✓ Do not stack manure in unconfined piles
- ✓ Divert clean water away from feedlots, manure storage areas, and barnyards located within this area

Lake Management Plan

Lake Management Plans help protect natural resource systems by encouraging partnerships between concerned citizens, lakeshore residents, watershed residents, agency staff, and diverse organizations. Lake Management Plans identify concerns of importance and set realistic goals, objectives, and action items to address each concern. Additionally, Lake Management Plans identify roles and responsibilities for meeting each goal and provide a timeline for implementation.

Lake Management Plans are living documents which are under constant review and adjustment depending on the condition of a lake, available funding, level of volunteer commitments, and the needs of lake stakeholders.

The Lake Management Plan goals presented below were created through collaborative efforts using current and past water quality data, a 2012 sociological survey regarding the needs of District members, and a series of four meetings by the Church Pine, Round, and Big Lake Water Quality Committee. Key findings of the study and draft goals were presented at the 2013 Spring Informational Meeting on Saturday, May 18th.

Vision

Church Pine, Round, and Big Lake are clear lakes with ideal nutrient levels which are free of algae blooms and provide a healthy environment that supports a diversity of fish, birds, wildlife, plants, and human uses.

Guiding Principles

- Lake management decisions are driven by what is best for the lakes according to past, present, and future data
- Communication regarding lake management is easy to understand and concise
- Financial decisions are made in cooperation with Lake District members

5-10 Year Implementation Plan Goals

- Reduce algae and phosphorus in the three lake system by reducing watershed runoff
- Evaluate the progress of lake management efforts
- Protect, maintain, and enhance fish habitat
- Increase knowledge and participation
- Support the goals of the Aquatic Plant Management Plan

Goal 1: Reduce algae and phosphorus in the three lake system by reducing watershed runoff [16]

The area of land that drains to a lake is called a watershed. The Church Pine Lake Watershed is 247 acres in size, the Round Lake Watershed is 69 acres in size, and the Big Lake Watershed is 1,523 acres in size.

Church Pine Lake: Reduce watershed runoff by 5% to ensure current water quality is maintained. Reductions on Church Pine Lake will positively impact Round and Big Lakes.

Shoreline property owners contribute the greatest amount of phosphorus to Church Pine Lake

- Identify shoreline landowners willing to install shoreline buffers, rain gardens, and water diversions on their property
- Provide technical assistance and cost sharing for implementation of projects
- Recognize landowners that have taken steps to reduce watershed runoff

Partner with landowners to install rain gardens, water diversions, and erosion control practices at or near the Church Pine Lake boat landing

Round Lake: Reduce watershed runoff by 10-16%. Reductions on Round Lake will positively impact Big Lake.

Shoreline property owners contribute the greatest amount of phosphorus to Round Lake.

- Identify shoreline landowners willing to install shoreline buffers, rain gardens, and water diversions on their property
- Provide technical assistance and cost sharing for implementation of projects
- Recognize landowners that have taken steps to reduce watershed runoff

Big Lake: Reduce watershed runoff by 16-25%.

North Creek contributes the greatest amount of phosphorus to Big Lake (63%) followed by shoreline property owners (31%).

- Support the work of the Horse Creek Watershed Farmer Led Council
- Work with Polk County LWRD/consultant to identify agricultural best management practices to reduce the phosphorus load from North Creek
- Examine the economic feasibility and effectiveness of a sediment pond on North Creek
- Identify shoreline landowners willing to install shoreline buffers, rain gardens, and water diversions on their property
- Provide technical assistance and cost sharing for implementation of projects
- Recognize landowners that have taken steps to reduce watershed runoff

Partner with landowners to install rain gardens, water diversions, and erosion control practices at or near the Big Lake boat landing

[16] Impacts of reductions can be found on pages 98 (Church Pine), 100 (Round), and 103 (Big).

Goal 2: Evaluate the progress of lake management efforts

Continue current data collection efforts

Ensure that Citizen Lake Monitoring volunteer is in place for each year

Contact WDNR in Spooner for more information and sampling materials

Expand data collection efforts depending on needs

Monitor tributaries to document reductions in watershed runoff

Goal 3: Protect, maintain, and enhance fish habitat

Balancing fish communities can impact zooplankton populations, which can impact algae populations. Zooplankton are small crustaceans that graze on algae.

Maintain desirable levels of game fish in the lakes

Work with fish biologist to determine locations for fish sticks and other habitat improvements

Communicate with WDNR to make informed decisions and encourage assessment and management

Continue monetarily supporting fish stocking based on expert recommendations

Goal 4: Increase knowledge and participation

Watershed residents and lake users are provided information to understand:

- the ever evolving nature of lake management
- the complexity of issues
- the status of projects and activities
- the costs and benefits of actions
- the opportunity and techniques to reduce or prevent any negative consequences of lake use and lakeside living

Methods for communicating information

Website

Annual Meeting

Spring Informational Meeting

Tour to view installed best management practices

Contest for best rain garden, shoreline restoration, etc

Goal 5: Support the goals of the Aquatic Plant Management Plan

- Prevent introduction of aquatic invasive species and pursue any new introduction aggressively
- Reduce the population and spread of curly leaf pondweed, purple loosestrife, and other invasive aquatic plants
- Maintain navigable routes for boating
- Preserve diverse native aquatic plant community
- Reduce runoff of nutrients and sediment from the lake's watershed
- Educate the public regarding aquatic plant management

Further considerations

1. Consider further studies to quantify internal loading, or the nutrients released back into the water column through sediment disturbance or plant die back
2. Consider a sediment core on Church Pine, Round, and Big Lake to gather historical data (i.e. 100-200 years)
3. Consider further studies to quantify groundwater phosphorus inputs within the watershed

Goal 1: **Reduce algae and phosphorus in the three lake system by reducing watershed runoff**

Action	Timeline	Cost Estimate	Volunteer Hours	Responsible Parties	Funding Sources
Identify shoreline landowners willing to install shoreline buffers, rain gardens, and water diversions on their property	2013, ongoing	$1,000	80	Board Water quality committee	District
Provide technical assistance and cost sharing for implementation of projects	2014, ongoing	$250,000		Board Consultant	District WDNR Lake Protection Grant*
Recognize landowners that have taken steps to reduce watershed runoff	Ongoing	$50 annual		Board	District
Partner with landowners to install rain gardens, water diversions, and erosion control practices at or near the Church Pine Lake boat landing	2014, ongoing	TBD		Board Consultant	District WDNR Lake Protection Grant*
Support the work of the Horse Creek Watershed Farmer Led Council	2015, ongoing	TBD		Board LWRD	District
Work with Polk County LWRD/consultant to identify agricultural best management practices to reduce the phosphorus load from North Creek	2014, ongoing	TBD		Board LWRD Consultant	District WDNR Lake Planning Grant
Examine the economic feasibility and effectiveness of a sediment pond on North Creek	2015	$2,500		Board Consultant	District WDNR Lake Planning Grant
Partner with landowners to install rain gardens, water diversions, and erosion control practices at or near the Big Lake boat landing	2014, ongoing	TBD		Board Consultant	District WDNR Lake Protection Grant*

Table 17. Goal 1: Reduce algae and phosphorus in the three lake system by reducing watershed runoff.

* Covenants and Operation and Maintenance Plans are required for activities implemented with WDNR Lake Protection Grants.

Goal 2: Evaluate the progress of lake management efforts

Action	Timeline	Cost Estimate	Volunteer Hours	Responsible Parties	Funding Sources
Ensure that Citizen Lake Monitoring volunteer is in place for each year	Ongoing	$360 annual stipend	30 annual	Board	WDNR Citizen Lake Monitoring Network
Contact WDNR in Spooner for more information and sampling materials	Ongoing	$0	1	Board	N/A
Monitor tributaries to document reductions in watershed runoff	TBD	$1,200 annual		Board Consultant	District WDNR Lake Protection Grant* WAV program

Table 18. Goal 2: Evaluate the progress of lake management efforts.

Goal 3: Protect, maintain, and enhance fish habitat

Action	Timeline	Cost Estimate	Volunteer Hours	Responsible Parties	Funding Sources
Work with fish biologist to determine locations for fish sticks and other habitat improvements	TBD	TBD		Board WDNR LWRD	District WDNR Lake Planning Grant
Communicate with WDNR to make informed decisions and encourage assessment and management	Ongoing	TBD		Board WDNR	NA
Continue monetarily supporting fish stocking based on expert recommendations	Ongoing	$4,000		Board WDNR	District

Table 19. Goal 3: Protect, maintain, and enhance fish habitat.

* Covenants and Operation and Maintenance Plans are required for activities implemented with WDNR Lake Protection Grants.

<u>Goal 4:</u> Increase knowledge and participation

Methods for communicating information	Timeline	Cost Estimate	Volunteer Hours	Responsible Parties	Funding Sources
Website	Ongoing	$100		Board	District
Annual Meeting	Ongoing	$50		Board	District
Spring Informational Meeting	Ongoing	$50		Board	District
Tour to view installed best management practices	2014	$150		Board	District
Contest for best rain garden, shoreline restoration, etc	TBD	$150		Board	District

Table 20. Goal 4: Increase knowledge and participation.

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Appendix A

Lake District Resident Survey and Results

2012 Church Pine, Round, and Big Lake Watershed Survey

The Land and Water Resources Department (LWRD) and the Church Pine, Round, and Big Lake P&R District received a WDNR lake planning grant to conduct a water quality and biological assessment on Church Pine, Round, and Big Lake in 2012. Following is a survey designed to gather information about the lakes and their intended use to direct future water quality management decisions. The survey should take approximately 5-10 minutes to complete. Please complete one survey per household. Your responses will remain confidential. Final results will be compiled and made available to the public. If you have questions, feel free to contact Katelin Holm, Information and Education Coordinator/Water Quality Specialist at LWRD, 485-8637, katelin.holm@co.polk.wi.us. Please bring your completed survey to the May 19th Spring Informational Meeting or mail in the enclosed self addressed, stamped envelope by May 19th.

---

1. How many years have you owned property on or near Church Pine, Round, and Big Lake? *Note: If you own more than one property, please answer all questions for the property you have owned the longest.*
   ________ years

2. Which of the following best describes how you use your property? Please check one.
   ____Year-round residence
   ____Seasonal residence—continued occupancy for months at a time
   ____Weekend, vacation, and/or holiday residence
   ____Rental property
   ____Other (please specify) ____________________

3. How many days in a typical year is your property used by you or others? Just provide your best estimate.
   ________ days per year

4. On the average day that your property is occupied, how many people occupy the property?
   ________ people

5. Land use generally falls into one of the following four categories: open space, shrub/grass/sedge community, woods, and impervious (hard) surfaces. Please use **estimated percentages** to describe the amount of each land use on your property. (The total should equal 100%.) We realize this may be challenging but please just provide your best estimate.
   ____% Open space (lawns or mowed areas)
   ____% Shrub/grass/sedge community
   ____% Woods
   ____% Impervious surfaces (buildings, driveways, sidewalks, patios, gravel paths and driveways)

6. Is your property located on the waterfront of Church Pine, Round, or Big Lake?
   ____No, **please skip to question 8**
   ____Yes

7. From the list below, which best describes the first 35 feet of your shoreline (the area located directly adjacent to the lake)? **If you do not own shoreline property, please skip this question.**
____Mostly mowed grass
____Mostly native flowers and grasses
____A mix of native flowers, grasses, *and shrubs*
____A mix of native flowers, grasses, shrubs, *and trees*

8. On an average year, which activities do you and/or your family partake in on Church Pine, Round, and Big Lake? Please check all that apply.
____Fishing (any season)
____Swimming, snorkeling, or scuba diving
____Non-motorized water activities (birding, canoeing, hiking, running)
____Motorized water activities (PWC, boating, water skiing, tubing, jet skiing)
____Non-motorized winter activities (skiing, snowshoeing, ice skating)
____Motorized winter activities (ATV, snowmobile)
____Other, please describe____________________________

9. How many of the following watercraft are kept on your property for use on Church Pine, Round, and Big Lake? If none, please write 0.
____ Jet skis
____ Motorboats/pontoons between 1-20 HP
____ Motorboats/pontoons between 21-50 HP
____ Motorboats/pontoons more than 50 HP
____ Canoes and kayaks
____ Paddleboats/rowboats
____ Other, please describe______________________

10. From the list below, please rank your top three concerns for Church Pine, Round, and Big Lake. (Please list your top three concerns in order of importance, with 1^{st} being most important)

1^{st} ___
2^{nd} ___
3^{rd} ___

A. **Pollution** (chemical inputs, septic systems, agriculture, erosion, storm water runoff)
B. **Development** (population density, loss of wildlife habitat)
C. **Quality of life**
D. **Property values and/or taxes**
E. **Water recreation safety** (boat traffic, no wake zone)
F. **Water clarity** (visibility)
G. **Aquatic plants** (not including algae)
H. **Algae blooms**
I. **Invasive species** (Eurasian water milfoil, zebra mussels, curly leaf pondweed, purple loosestrife)
J. **Quality of fisheries**
K. **Water levels** (loss of lake volume)
L. **Other**, please describe____________________________

11. Which lake is your property located on or located nearest to? If your property is located on more than one lake please choose the lake you frequent most often.
____Church Pine Lake
____Round (Wind) Lake
____Big Lake

Questions 12-15 are lake specific. Please answer these questions for the lake that you chose in question 11.

12. How would you describe the current water quality of **the lake your property is located on**?
____Poor
____Fair
____Unsure
____Good
____Excellent

13. In the time you've owned your property, how has the water quality changed in **the lake your property is located on**?
____Severely degraded
____Somewhat degraded
____Remained unchanged
____Somewhat improved
____Greatly improved
____Unsure

14. How often does algae negatively impact your enjoyment of **the lake your property is located on**?
____Never
____Rarely
____Sometimes
____Often
____Always

15. How would you describe the current amount of shoreline vegetation on **the lake your property is located on**?
____Too much
____Just right
____Not enough
____Unsure

16. How would you describe the importance of shoreline buffers, rain gardens, and native plants to the water quality of Church Pine, Round, and Big Lake?
____Not at all important
____Not too important
____Unsure
____Somewhat important
____Very important

17. How would you describe your current use of fertilizer on your property?
____I do not use any fertilizer on my property
____I use zero phosphorus fertilizer on my property
____I use fertilizer on my property but I'm unsure of its phosphorus content
____I use fertilizer on my property that contains phosphorus

18. From the list below, please check all of the management practices you feel should be used to maintain or improve the water quality of Church Pine, Round, and Big Lake. Note: Cost sharing assistance refers to a process where the landowner is responsible for a portion of the cost of a particular project and their contribution is matched by another source (state dollars, grant dollars, district dollars).

____ Cost-sharing assistance for the installation of shoreline buffers and rain gardens
____ Cost-sharing assistance for the installation of farmland conservation practices (for example nutrient management plans, contour strips, conservation tillage, etc)
____ Information and education opportunities
____ Establishment of slow-no-wake zones to protect aquatic plants and fisheries habitat
____ Practices to enhance fisheries, such as the introduction of coarse woody habitat
____ Continued collection of in-lake water quality data
____ Collection of sediment cores to provide information concerning historical lake conditions
____ Enhanced efforts to monitor for new populations of aquatic invasive species
____ Other, please describe_______________________________________

19. How often do you visit the Church Pine, Round, and Big Lake P&R District website: (www.bigroundpine.com)?

____Never ____Sometimes
____Rarely ____Often

20. Are you interested in installing a shoreline buffer or rain garden on your property?
____No
____Already installed
____Unsure, please contact me with additional information
____Yes

If you answered yes or unsure and would like more information about this opportunity please list your contact information below. This information will be kept separate from your responses to ensure confidentiality.

____

21. Please provide your age. I am ________ years old.

Thank you for your participation in this survey! Please feel free to use the space below for comments.

2012 Church Pine, Round, and Big Lake Watershed Survey

Surveys mailed: 224
Surveys returned: 116
Response rate: 52%

---

1. How many years have you owned property on or near Church Pine, Round, and Big Lake? *Note: If you own more than one property, please answer all questions for the property you have owned the longest.*
   113 respondents, 97%
   Average years: 22

2. Which of the following best describes how you use your property? Please check one.
   115 respondents, 99%
   ____Year-round residence **51 respondents, 44%**
   ____Seasonal residence—continued occupancy for months at a time **7 respondents, 6%**
   ____Weekend, vacation, and/or holiday residence **53 respondents, 46%**
   ____Rental property **1 respondent, 1%**
   ____Other (please specify) ____________________ **4 respondents, 3%**
   Do not use
   3-4 days/week
   Half time, year round
   Use it year round but do not live there

3. How many days in a typical year is your property used by you or others? Just provide your best estimate.
   114 respondents, 98%
   Average days per year: 194

4. On the average day that your property is occupied, how many people occupy the property?
   116 respondents, 100%
   Average people: 3

5. Land use generally falls into one of the following four categories: open space, shrub/grass/sedge community, woods, and impervious (hard) surfaces. Please use **estimated percentages** to describe the amount of each land use on your property. (The total should equal 100%.) We realize this may be challenging but please just provide your best estimate. **113 respondents, 97%**
   ____% Open space (lawns or mowed areas) **Average: 39%**
   ____% Shrub/grass/sedge community **Average: 16%**
   ____% Woods **Average: 25%**
   ____% Impervious surfaces (buildings, driveways, sidewalks, patios, gravel paths and driveways)
   Average: 20%

6. Is your property located on the waterfront of Church Pine, Round, or Big Lake? **115 respondents, 99%**
   ____No, please skip to question 8 **8 respondents, 7%**
   ____Yes **107 respondents, 93%**

7. From the list below, which best describes the first 35 feet of your shoreline (the area located directly adjacent to the lake)? If you do not own shoreline property, please skip this question.
108 respondents, 93%
____Mostly mowed grass **26 respondents, 24%**
____Mostly native flowers and grasses **10 respondents, 9%**
____A mix of native flowers, grasses, *and shrubs* **3 respondents, 3%**
____A mix of native flowers, grasses, shrubs, *and trees* **70 respondents, 65%**
Other: Rockwall: 1 respondent, 1%

8. On an average year, which activities do you and/or your family partake in on Church Pine, Round, and Big Lake? Please check all that apply. **112 respondents, 97%**
____Fishing (any season) **91 respondents, 81%**
____Swimming, snorkeling, or scuba diving **95 respondents, 85%**
____Non-motorized water activities (birding, canoeing, hiking, running) **73 respondents, 65%**
____Motorized water activities (PWC, boating, water skiing, tubing, jet skiing) **98 respondents, 88%**
____Non-motorized winter activities (skiing, snowshoeing, ice skating) **44 respondents, 39%**
____Motorized winter activities (ATV, snowmobile) **18 respondents, 16%**
____Other, please describe____________________________ **5 respondents, 4%**
Enjoy time together and the view
Gardening vegetables
Training dog on ice
Dinner parties
Clean beach of leaves, weeds, and trash that floats in

9. How many of the following watercraft are kept on your property for use on Church Pine, Round, and Big Lake? If none, please write 0. **115 respondents, 99%**
____ Jet skis **24**
____ Motorboats/pontoons between 1-20 HP **24**
____ Motorboats/pontoons between 21-50 HP **64**
____ Motorboats/pontoons more than 50 HP **58**
____ Canoes and kayaks **89**
____ Paddleboats/rowboats **70**
____ Other, please describe______________________ **11**
Paddle boards 3
Sailboat 8

10. From the list below, please rank your top three concerns for Church Pine, Round, and Big Lake. (Please list your top three concerns in order of importance, with 1st being most important).
112 respondents, 97%
1st **Property values and/or taxes**
2nd **Invasive species**
3rd **Pollution and Aquatic plants**

Property values and/or taxes **119 points**
Invasive species (Eurasian water milfoil, zebra mussels, curly leaf, purple loosestrife) **117 points**
Aquatic plants (not including algae) **80 points**
Pollution (chemical inputs, septic systems, agriculture, erosion, storm water runoff) **80 points**
Water clarity (visibility) **64 points**
Algae blooms **39 points**
Quality of life **34 points**
Water levels (loss of lake volume) **33 points**
Water recreation safety (boat traffic, no wake zone) **31 points**
Quality of fisheries **30 points**
Development (population density, loss of wildlife habitat) **29 points**
Other, please describe____________________________ **3 points**
Rank of 2: Noise and light
Rank of 1: Preservation of recreational watersports

11. Which lake is your property located on or located nearest to? If your property is located on more than one lake please choose the lake you frequent most often. **115 respondents, 99%**
____Church Pine Lake **36 respondents, 31%**
____Round (Wind) Lake **17 respondents, 15%**
____Big Lake **62 respondents, 54%**

Questions 12-15 are lake specific. Please answer these questions for the lake that you chose in question 11.

12. How would you describe the current water quality of **the lake your property is located on**?
____Poor
Big: 2 respondents, 3%
Round: 0 respondents, 0%
Church Pine: 0 respondents, 0%
____Fair
Big: 16 respondents, 26%
Round: 4 respondents, 25%
Church Pine: 2 respondents, 6%
____Unsure
Big: 4 respondents, 7%
Round: 1 respondent, 6%
Church Pine: 1 respondent, 3%
____Good
Big: 36 respondents, 59%
Round: 9 respondents, 56%
Church Pine: 13 respondents, 36%
____Excellent
Big: 4 respondents, 7%
Round: 3 respondents, 19%
Church Pine: 20 respondents, 56%

13. In the time you've owned your property, how has the water quality changed in **the lake your property is located on**?
____Severely degraded
Big: 3 respondents, 5%
Round: 2 respondents, 12%
Church Pine: 0 respondents, 0%
____Somewhat degraded
Big: 18 respondents, 29%
Round: 5 respondents, 29%
Church Pine: 15 respondents, 44%
____Remained unchanged
Big: 21 respondents, 34%
Round: 8 respondents, 47%
Church Pine: 16 respondents, 47%
____Somewhat improved
Big: 12 respondents, 19%
Round: 0 respondents, 0%
Church Pine: 1 respondent, 3%
____Greatly improved
Big: 3 respondents, 5%
Round: 0 respondents, 0%
Church Pine: 0 respondents, 0%
____Unsure
Big: 6 respondents, 10%
Round: 2 respondents, 12%
Church Pine: 2 respondents, 6%

14. How often does algae negatively impact your enjoyment of **the lake your property is located on**?
____Never
Big: 4 respondents, 6%
Round: 3 respondents, 18%
Church Pine: 11 respondents, 31%
____Rarely
Big: 16 respondents, 26%
Round: 4 respondents, 24%
Church Pine: 16 respondents, 46%
____Sometimes
Big: 31 respondents, 50%
Round: 9 respondents, 53%
Church Pine: 8 respondents, 23%
____Often
Big: 9 respondents, 15%
Round: 1 respondent, 6%
Church Pine: 0 respondents, 0%

____Always
Big: 2 respondents, 3%
Round: 0 respondents, 0%
Church Pine: 0 respondents, 0%

15. How would you describe the current amount of shoreline vegetation on **the lake your property is located on**?
____Too much
Big: 21 respondents, 35%
Round: 7 respondents, 41%
Church Pine: 3 respondents, 9%
____Just right
Big: 24 respondents, 40%
Round: 7 respondents, 41%
Church Pine: 25 respondents, 74%
____Not enough
Big: 7 respondents, 12%
Round: 1 respondent, 6%
Church Pine: 2 respondents, 6%
____Unsure
Big: 8 respondents, 13%
Round: 2 respondents, 12%
Church Pine: 4 respondents, 12%

16. How would you describe the importance of shoreline buffers, rain gardens, and native plants to the water quality of Church Pine, Round, and Big Lake? **114 respondents, 98%**
____Not at all important **2 respondents, 2%**
____Not too important **9 respondents, 8%**
____Unsure **14 respondents, 12%**
____Somewhat important **36 respondents, 32%**
____Very important **53 respondents, 46%**

17. How would you describe your current use of fertilizer on your property? **115 respondents, 99%**
____I do not use any fertilizer on my property **67 respondents, 58%**
____I use zero phosphorus fertilizer on my property **40 respondents, 35%**
____I use fertilizer on my property but I'm unsure of its phosphorus content **6 respondents, 5%**
____I use fertilizer on my property that contains phosphorus **2 respondents, 2%**

18. From the list below, please check all of the management practices you feel should be used to maintain or improve the water quality of Church Pine, Round, and Big Lake. Note: Cost sharing assistance refers to a process where the landowner is responsible for a portion of the cost of a particular project and their contribution is matched by another source (state dollars, grant dollars, district dollars).
109 respondents, 94%

____ Cost-sharing assistance for the installation of shoreline buffers and rain gardens **48 respondents, 44%**

____ Cost-sharing assistance for the installation of farmland conservation practices (for example nutrient management plans, contour strips, conservation tillage, etc) **29 respondents, 27%**

____ Information and education opportunities **50 respondents, 46%**

____ Establishment of slow-no-wake zones to protect aquatic plants and fisheries habitat **45 respondents, 41%**

____ Practices to enhance fisheries, such as the introduction of coarse woody habitat **32 respondents, 29%**

____ Continued collection of in-lake water quality data **82 respondents, 75%**

____ Collection of sediment cores to provide information concerning historical lake conditions **36 respondents, 33%**

____ Enhanced efforts to monitor for new populations of aquatic invasive species **82 respondents, 75%**

____ Other, please describe____ **14 respondents, 13%**

People need to observe proper boating practices and respect current wake areas
Have one boat launch for all three lakes to inspect all boats
Restrictions on horse power of boats
Weed control 2 respondents
Increase depth of channels between lakes 2 respondents
Control of aquatic species
Clean up of roadside waste (braches etc.); loosestrife, buckthorn, incessantly barking dogs.
More information to owners regarding use of fertilizer/use of lake water for sprinkler systems.
Lily pads are slowly but surely taking over Round Lake. Lake is filling in--very difficult to use my boats.
Harvest/cut/or reduce the amount of lily pads should be a high priority.
Boat landings open only when monitored.
Explaining effects of lawn fertilizer to water front homeowners.
Rapidly increasing weeds--harder every year to row my boat--please go back to cutting or lime slurry approved a few years ago.

19. How often do you visit the Church Pine, Round, and Big Lake P&R District website: (www.bigroundpine.com)? **115 respondents, 99%**

____Never **30 respondents, 26%**
____Rarely **37 respondents, 32%**
____Sometimes **39 respondents, 34%**
____Often **10 respondents, 9%**

20. Are you interested in installing a shoreline buffer or rain garden on your property? **116 respondents, 100%**
    ____No **58 respondents, 50%**
    ____Already installed **37 respondents, 32%**
    ____Unsure, please contact me with additional information **16 respondents, 14%**
    ____Yes **8 respondents, 7%**

    If you answered yes or unsure and would like more information about this opportunity please list your contact information below. This information will be kept separate from your responses to ensure confidentiality.

    ____

21. Please provide your age. I am ________ years old. **115 respondents, 99%**
    Average: 62 years

Thank you for your participation in this survey! Please feel free to use the space below for comments.

We truly love our place "at the lake." We wish our taxes weren't so high (!), but have a strong desire and hope to preserve the area for our grandchildren and future generations. Let's keep it clean, safe, and healthy!

As we are retired senior citizens we do not have any boat or pontoon because we are unable to run them. We just enjoy watching the fisherman. Water skiing and our children do swim when they come and do watch the wild animals and birds.

Need to remind lake homeowners to check the website out with every mailing sent. Include key information, important dates, functions, etc

Continue to use necessary measures to reduce the amount of vegetation in our lakes. Thanks for this survey. Keep up the good work.

Keep taxes down on the lake so as not to drive people out this is a nice place to live. Not all people want to voice but we all want to stay.

Make sure lake association board members representative of all of us, not their personal ideas.

The chain of three lakes is an amazing gem for outdoor people like my wife and me. Thank you for helping preserve it.

I really believe Round Lake is too small for water skiing and tubing. On a calm day 30 or 40 kayaks and pontoons can enjoy the lake quietly and safely. However, one or two boats with skiers or tubers and the lake becomes unsafe and crowded--in this day of fewer acres/users don't you think it's better for more quiet use rather than a few fast/loud boaters? Same goes for jet skis.

Lower Lake levels have done more harm than good. It has made better lake shore property for a few, and less fish habitat.

I look forward to the results of this survey!

I was fortunate to have Jeremy Williamson (in his early years) help me design an excellent buffer and shoreline restoration project for my Big Lake shoreline. Although it took me several years to afford the project, with the cost-sharing from DNR and the excellent contracting with St. Croix Landscaping, I completed my project on the west shoreline of Big Lake. It is in its 4th year and, although I have lost a few baby trees and plants, it is quite lovely.

Appendix B

Chemical Data: In-lake and Tributary

BREP CPBR

WATER & ENVIRONMENTAL ANALYSIS LAB - DATA REPORT FORM

REPORT IDENTIFICATION: POLK COUNTY LWRD
Sample Location: LAKES
Date Sampled: APRIL 3, 2012
Sample Time:
Date Received in Lab: APRIL 4, 2012
Purchase Order #:
WEAL Invoice: 372974

Sampled By: BK, JW KH
Preserved: H2SO4
Sample Type:
Field Filtered:
Circumstances that may affect results: °

FLAGS
B = Blank Contamination
D = Dilution
HT = Holding Time
J = Between LOD & LOQ (est.)
Q = QC Failure
R = Rejected

UW-STEVENS POINT
CNR, Room 200
Stevens Point, WI 54481
(715) 346-3209

DNR Cert. No. 750040280

ALL DATA mg/l UNLESS NOTED		pH (S.U.)	Conductivity	Alkalinity	Total Hardness	Calcium	Reactive Phosphorus	Total Phosphorus	Ammonium (N)	NO2+NO3(N)	Total Kjeldahl Nitrogen	Chloride	Sulfate	Sodium	Potassium	Turbidity (NTU)	Color		
Date Prepared							6-Apr	19-Apr											
Date Analyzed		9-Apr	9-Apr	11-Apr	11-Apr	13-Apr	9-Apr	20-Apr	9-Apr	6-Apr	20-Apr	6-Apr	13-Apr	13-Apr	15-Apr	15-May	14-May		
Method		4500 H B	2510 B	2320B	2340 C	EPA 200.7	4500 P F	4500 P F	4500 NH3 H	4500 NO3 F	4500-NH3 G	4500 Cl E	EPA 200.7	EPA 200.7	EPA 200.7	2130 B	20-Oct		
Lab #	Site																		
124-12-1	APPLE RIVER FLOW IN	8.15	192	108	120	26.6	0.016	0.053	0.03	0.3	0.69	5.2	3.8	3	2.3	3.7	23.4		
124-12-2	APPLE RIVER LOW 25	7.94	183	96	88	24.0	0.022	0.072	0.03	0.3	0.86	4.7	3.6	2	2.7	11.1	25.7		
124-12-3	CHURCH PINE LAKE	7.70	150	76	88	17.3	0.008	0.031	0.02	<0.1	0.56	7.8	2.9	4	1.5	1.1	12.5		
124-12-4	WIND LAKE	7.81	186	92	108	23.7	0.017	0.039	0.06	0.2	0.68	9.1	4.1	4	1.9	2.3	11.4		
124-12-5	BIG LAKE	7.06	214	88	112	26.7	0.028	0.033	0.11	0.4	0.39	9.3	21.3	4	1.8	1.9	8.7		

entered

WATER & ENVIRONMENTAL ANALYSIS LAB - DATA REPORT FORM

REPORT IDENTIFICATION: POLK COUNTY LCD
Sample Location: CPBR
Date Sampled: MAY 7, 2012
Sample Time:
Date Received in Lab: MAY 8, 2012
Purchase Order #:
WEAL Invoice: 374980

Sampled By: KH
Preserved: H2S94
Sample Type:
Field Filtered:
Circumstances that may affect results: °

UW-STEVENS POINT
CNR, Room 200
Stevens Point, WI 54481
(715) 346-3209

FLAGS
B = Blank Contamination
D = Dilution
HT = Holding Time
J = Between LOD & LOQ (est.)
Q = QC Failure
R = Rejected

DNR Cert. No. 750040280

ALL DATA mg/l UNLESS NOTED		NO2+NO3(N)	Chloride	Ammonium (N)	Total Kjeldahl Nitrogen	Total Phosphorus	Reactive Phosphorus	Total Suspended Solids	Chlorophyll-a (mg/M3 [ug/L])								
Date Prepared		10-May		10-May			10-May	21-May	6-Jun								
Date Analyzed		11-May	11-May	11-May	23-May	23-May	11-May	22-May	7-Jun								
Method		4500 NO3 F	4500 Cl E	4500 NH3 H	4500-NH3 G	4500 P F	4500 P F	2540 D	10200 H								
Lab #	Site																
202-12-1	CHURCH PINE LAKE DEEP HOLE	<0.1	7.5	0.05	0.64	0.021	0.002	4	2								
202-12-2	WIND LAKE DEEP HOLE	<0.1	8.4	0.02	0.47	0.019	0.011	<2	2								
202-12-3	BIG LAKE DEEP HOLE	<0.1	8.7	0.04	0.48	0.022	0.011	<2	2								
202-12-4	NORTH CREEK	0.7	5.9	0.05	0.86	0.102	0.088	15									
202-12-5	CITY ROAD K CULVERT	<0.1	2.9	0.04	1.77	0.027	0.025	4									
202-12-6	BIG LAKE OUTLET	<0.1	8.7	0.03	0.33	0.017	0.011	3									

entered

WATER & ENVIRONMENTAL ANALYSIS LAB - DATA REPORT FORM

REPORT IDENTIFICATION: POLK COUNTY LWRD
Sample Location: CHURCH PINE, BIG, ROUND
Date Sampled: JUNE 4, 2012
Sample Time: VARIES
Date Received in Lab: JUNE 5, 2012
Purchase Order #:
WEAL Invoice: 375128

Sampled By: KH/JW
Preserved: H2SO4
Sample Type:
Field Filtered:
Circumstances that may affect results: °

FLAGS
B = Blank Contamination
D = Dilution
HT = Holding Time
J = Between LOD & LOQ (est.)
Q = QC Failure
R = Rejected

UW-STEVENS POINT
CNR, Room 200
Stevens Point, WI 54481
(715) 346-3209

DNR Cert. No. 750040280

ALL DATA mg/l UNLESS NOTED		NO2+NO3(N)	Chloride	Ammonium (N)	Total Kjeldahl Nitrogen	Total Phosphorus	Reactive Phosphorus	Total Suspended Solids	Chlorophyll-a (mg/M3 [ug/L])										
Date Prepared					11-Jun	11-Jun		25-Jun	21-Jun										
Date Analyzed		8-Jun	8-Jun	7-Jun	13-Jun	13-Jun	7-Jun	26-Jun	22-Jun										
Method		4500 NO3 F	4500 Cl E	4500 NH3 H	4500-NH3 G	4500 P F	4500 P F	2540 D	10200 H										
Lab #	Site																		
258-12-1	CTY RD K CULVERT	<0.1	3.3	0.06	1.68	0.059	0.045	<2											
258-12-2	NORTH CREEK	1.5	8.6	0.05	0.51	0.108	0.092	13											
258-12-3	BIG LAKE OUTLET	<0.1	10.3	0.02	0.50	0.027	0.010	<2											
258-12-4	CHURCH PINE IN-LAKE	<0.1	8.4	0.01	0.40	0.016	0.006	<2	2										
258-12-5	WIND LAKE IN-LAKE	<0.1	9.9	0.02	0.56	0.025	0.005	<2	2										
258-12-6	BIG LAKE IN-LAKE	<0.1	10.0	0.01	0.38	0.023	0.008	<2	3										

entered

WATER & ENVIRONMENTAL ANALYSIS LAB - DATA REPORT FORM

REPORT IDENTIFICATION: POLK COUNTY LWRD
Sample Location: Church, Pine, Big, Round
Date Sampled: JULY 9, 2012
Sample Time:
Date Received in Lab: JULY 10, 2012
Purchase Order #:
WEAL Invoice: 376404

Sampled By: JW/KH
Preserved: H2SO4
Sample Type: SW
Field Filtered: NO
Circumstances that may affect results: °

FLAGS
B = Blank Contamination
D = Dilution
HT = Holding Time
J = Between LOD & LOQ (est.)
Q = QC Failure
R = Rejected

UW-STEVENS POINT
CNR, Room 200
Stevens Point, WI 54481
(715) 346-3209
DNR Cert. No. 750040280

ALL DATA mg/l UNLESS NOTED		NO2+NO3(N)	Chloride	Ammonium (N)	Total Kjeldahl Nitrogen	Total Phosphorus	Reactive Phosphorus	Total Suspended Solids	Chlorophyll-a (mg/M3 [ug/L])
Date Prepared		12-Jul	12-Jul	13-Jul	23-Jul	23-Jul	13-Jul	17-Jul	12-Jul
Date Analyzed		12-Jul	12-Jul	13-Jul	25-Jul	25-Jul	13-Jul	18-Jul	13-Jul
Method		4500 NO3 F	4500 Cl E	4500 NH3 H	4500-NH3 G	4500 P F	4500 P F	2540 D	10200 H
Lab #	Site								
336-12-1	North Creek	1.7	8.8	0.05	0.41	0.084	0.073	10	
336-12-2	Big Lake outlet	<0.1	9.5	0.06	0.47	0.027	0.016	<2	
336-12-3	Church Pine-in lake	<0.1	8.0	0.02	0.59	0.013	0.005	<2	2
336-12-4	Wind Lake-in lake	<0.1	8.9	0.01	0.51	0.014	0.006	<2	<1
336-12-5	Big Lake-in lake	<0.1	9.3	<0.01	0.38	0.015	0.009	<2	2

WATER & ENVIRONMENTAL ANALYSIS LAB - DATA REPORT FORM

REPORT IDENTIFICATION: POLK COUNTY LWDR
Sample Location: CPBR
Date Sampled: AUGUST 6, 2012
Sample Time: VARIES
Date Received in Lab: AUGUST 7, 2012
Purchase Order #:
WEAL Invoice: 377326

Sampled By: JW/KH
Preserved: H2SO4
Sample Type:
Field Filtered:
Circumstances that may affect results: °

FLAGS
B = Blank Contamination
D = Dilution
HT = Holding Time
J = Between LOD & LOQ (est.)
Q = QC Failure
R = Rejected

UW-STEVENS POINT
CNR, Room 200
Stevens Point, WI 54481
(715) 346-3209

DNR Cert. No. 750040280

ALL DATA mg/l UNLESS NOTED		NO2+NO3(N)	Chloride	Ammonium (N)	Total Kjeldahl Nitrogen	Total Phosphorus	Reactive Phosphorus	Total Suspended Solids	Chlorophyll-a (mg/M3 [ug/L])
Date Prepared		9-Aug	9-Aug	13-Aug	15-Aug	15-Aug	8-130	8-Aug	13-Aug
Date Analyzed		9-Aug	9-Aug	14-Aug	22-Aug	22-Aug	14-Aug	8-Aug	15-Aug
Method		4500 NO3 F	4500 Cl E	4500 NH3 H	4500-NH3 G	4500 P F	4500 P F	2540 D	10200 H
Lab #	Site								
408-12-1	North Creek	1.9	9.4	0.05	0.83	0.089	0.065	6	
408-12-2	Church Pine In-Lake	<0.1	7.9	0.02	0.95	0.033	0.003	<2	1
408-12-3	Wind Lake-In Lake	<0.1	9.0	0.02	0.93	0.035	0.003	4	3
408-12-4	Big Lake In-Lake	<0.1	9.4	0.02	0.75	0.041	0.007	<2	3

WATER & ENVIRONMENTAL ANALYSIS LAB - DATA REPORT FORM

REPORT IDENTIFICATION: POLK COUNTY LWDR
Sample Location: BRCP
Date Sampled: SEPTEMBER 5, 2012
Sample Time: VARIES
Date Received in Lab: SEPTEMBER 6, 2012
Purchase Order #:
WEAL Invoice: 137683

Sampled By: JW/KH
Preserved: H2SO4
Sample Type:
Field Filtered:
Circumstances that may affect results: °

FLAGS
B = Blank Contamination
D = Dilution
HT = Holding Time
J = Between LOD & LOQ (est.)
Q = QC Failure
R = Rejected

UW-STEVENS POINT
CNR, Room 200
Stevens Point, WI 54481
(715) 346-3209
DNR Cert. No. 750040280

ALL DATA mg/l UNLESS NOTED		NO2+NO3(N)	Chloride	Ammonium (N)	Total Kjeldahl Nitrogen	Total Phosphorus	Reactive Phosphorus	Total Suspended Solids	Chlorophyll-a (mg/M3 [ug/L])
Date Prepared		20-Sep	20-Sep	11-Sep	13-Sep	13-Sep	11-Sep	20-Sep	19-Sep
Date Analyzed		20-Sep	20-Sep	12-Sep	14-Sep	14-Sep	12-Sep	21-Sep	21-Sep
Method		4500 NO3 F	4500 Cl E	4500 NH3 H	4500-NH3 G	4500 P F	4500 P F	2540 D	10200 H
Lab #	Site								
488-12-1	North Creek	2.2	9.4	0.05	0.38	0.052	0.087	7	
488-12-2	Church Pine In-Lake	<0.1	8.3	0.01	0.52	0.008	0.012	<2	2
488-12-3	Wind Lake-In Lake	<0.1	9.3	<0.01	0.60	0.013	0.010	<2	3
488-12-4	Big Lake In-Lake	<0.1	9.7	0.03	0.82	0.025	0.015	6	12

incorrect

Katelin Holm

From: DeVita, Bill [wdevita@uwsp.edu]
Sent: Friday, October 05, 2012 8:03 AM
To: Katelin Holm
Subject: phos data

Hi Katelin,
Nancy Turyk asked me to look over your recent data set regarding the soluble reactive and total phosphorus levels. It looks like the sample ID 488-12-1 (north creek) was analyzed for SRP following an extremely contaminated sample just prior. We typically do not get carry-over from one run to the next, but I should have caught that in the final quality control review and flagged it to be reanalyzed, but this one slipped through. I have the entire set of samples prioritized for reanalysis in our next run, probably early next week.

The other sample in question, 488-12-2 (church pine in-lake) is a different issue but we will still reanalyze it. The two methods have a combined error of 8 ppb, so to have an SRP value of 4 ppb greater than total P while not ideal, is not that uncommon. The error in a method can also be defined by the method detection limit; SRP is 2 ppb, TP is 6 ppb.

I hope this helps explain what happened with your data. Sorry for not catching that error. Thanks for bringing it to our attention and please let me know if you have any questions. I will email you the revised data when it comes available.

Best regards,
Bill

Bill DeVita
Water and Environmental Analysis Laboratory
Center for Watershed Science and Education
University of Wisconsin - Stevens Point
Stevens Point, WI 54481
tel (715) 346-3753
fax (715) 346-3624
http://www.uwsp.edu/cnr-ap/watershed/

Final data after re-run by WEAL

WATER & ENVIRONMENTAL ANALYSIS LAB - DATA REPORT FORM

REPORT IDENTIFICATION: POLK COUNTY LWDR
Sample Location: BRCP
Date Sampled: SEPTEMBER 5, 2012
Sample Time: VARIES
Date Received in Lab: SEPTEMBER 6, 2012
Purchase Order #:
WEAL Invoice: 137683

Sampled By: JW/KH
Preserved: H2SO4
Sample Type:
Field Filtered:
Circumstances that may affect results: °

FLAGS
B = Blank Contamination
D = Dilution
HT = Holding Time
J = Between LOD & LOQ (est.)
Q = QC Failure
R = Rejected

UW-STEVENS POINT
CNR, Room 200
Stevens Point, WI 54481
(715) 346-3209

DNR Cert. No. 750040280

ALL DATA mg/l UNLESS NOTED		NO2+NO3(N)	Chloride	Ammonium (N)	Total Kjeldahl Nitrogen	Total Phosphorus	Reactive Phosphorus	Total Suspended Solids	Chlorophyll-a (mg/M3 [ug/L])
Date Prepared		20-Sep	20-Sep	11-Sep	13-Sep	13-Sep	11-Sep	20-Sep	19-Sep
Date Analyzed		20-Sep	20-Sep	12-Sep	14-Sep	14-Sep	12-Sep	21-Sep	21-Sep
Method		4500 NO3 F	4500 Cl E	4500 NH3 H	4500-NH3 G	4500 P F	4500 P F	2540 D	10200 H
Lab #	Site								
488-12-1	North Creek	2.2	9.4	0.05	0.38	0.052	0.048	7	
488-12-2	Church Pine In-Lake	<0.1	8.3	0.01	0.52	0.008	0.003	<2	2
488-12-3	Wind Lake-In Lake	<0.1	9.3	<0.01	0.60	0.013	0.006	<2	3
488-12-4	Big Lake In-Lake	<0.1	9.7	0.03	0.82	0.025	0.008	6	12

WATER & ENVIRONMENTAL ANALYSIS LAB - DATA REPORT FORM

REPORT IDENTIFICATION: POLK CO LWRD
Sample Location: CPBR
Date Sampled: OCTOBER 15, 2012
Sample Time:
Date Received in Lab: OCTOBER 16, 2012
Purchase Order #:
WEAL Invoice: 139867

Sampled By: KH, JW
Preserved: H2SO4
Sample Type: SW
Field Filtered:
Circumstances that may affect results: °

FLAGS
B = Blank Contamination
D = Dilution
HT = Holding Time
J = Between LOD & LOQ (est.)
Q = QC Failure
R = Rejected

UW-STEVENS POINT
CNR, Room 200
Stevens Point, WI 54481
(715) 346-3209
DNR Cert. No. 750040280

ALL DATA mg/l UNLESS NOTED		pH (S.U.)	Conductivity	Alkalinity	Calcium	Magnesium	Reactive Phosphorus	Total Phosphorus	Ammonium (N)	NO2+NO3(N)	Total Kjeldahl Nitrogen	Chloride	Sulfate	Sodium	Potassium	Turbidity (NTU)	Color		
Date Prepared		25-Oct	25-Oct	26-Oct	15-Nov	15-Nov	22-Oct	18-Oct	22-Oct	23-Oct	18-Oct	23-Oct	5-Nov	5-Nov	15-Nov	12-Nov	6-Nov		
Date Analyzed		25-Oct	25-Oct	26-Oct	15-Nov	15-Nov	23-Oct	19-Oct	23-Oct	24-Oct	19-Oct	24-Oct	5-Nov	5-Nov	15-Nov	12-Nov	6-Nov		
Method		4500 H B	2510 B	2320B	EPA 200.7	EPA 200.7	4500 P F	4500 P F	4500-NH3 G	4500 NO3 F	4500-NH3 G	4500 Cl E	EPA 200.7	EPA 200.7	EPA 200.7	2130 B	20-Oct		
Lab #	Site																		
559-12-1	Church Pine Lake	7.57	148	76	17.359	7.468	0.011	0.016	0.06	<0.1	0.58	8.4	3.40	3.97	0.89	0.9	10.4		
559-12-2	Wind Lake	7.71	188	96	23.491	8.484	0.010	0.031	0.01	<0.1	0.89	10.2	4.74	4.39	1.24	1.4	17.9		
559-12-3	Big Lake	8.06	201	104	25.870	8.782	0.021	0.048	0.03	<0.1	0.79	9.9	5.22	4.49	1.36	3.5	12.5		

Appendix C

Physical Data: In-lake and Tributary

Church Pine: 45.16.663, 92.32.098

Date	Depth (m)	DO (mg/l)	Conduct (ms/s)	SpCond (ms/s)	Temp (oC)	Salinity (ppt)	pH	ORP	Secchi (ft)
4/3/2012	0	9.00	117	168	8.90	0.10	8.04		11.5
SWIMS	1	8.54	117	168	8.90	0.10	8.04		
	2	9.11	117	168	8.90	0.10	8.03		
	3	8.69	117	168	8.80	0.10	8.03		
	4	8.65	116	168	8.80	0.10	8.03		
	5	9.03	116	168	8.80	0.10	8.03		
	6	9.00	116	168	8.80	0.10	8.01		
	7	7.83	115	170	8.30	0.10	7.97		
	8	7.08	114	173	7.20	0.10	7.94		
	9	6.32	114	174	6.90	0.10	7.95		
	10	4.05	116	182	6.00	0.10	7.92		
	11	3.53	116	185	5.50	0.10	7.91		
	12	1.63	118	191	5.10	0.10	7.85		
	13	0.12	122	198	4.90	0.10	7.64		
5/7/2012	0	7.85	138	167	15.90	0.10	7.73		17
SWIMS	1	7.69	137	166	15.80	0.10	7.69		
	2	8.25	136	166	15.60	0.10	7.65		
	3	7.51	136	166	15.50	0.10	7.63		
	4	8.71	132	170	13.20	0.10	7.62		
	5	8.56	130	169	12.70	0.10	7.59		
	6	8.93	125	169	11.10	0.10	7.54		
	7	7.32	122	171	9.90	0.10	7.48		
	8	5.95	121	173	9.20	0.10	7.45		
	9	3.07	121	177	8.30	0.10	7.40		
	10	1.59	121	179	7.80	0.10	7.35		
	11	0.83	120	181	7.50	0.10	7.30		
	12	0.15	120	181	7.30	0.10	7.26		
	13	0.02	127	195	7.10	0.10	7.03		
	14	0.01	130	198	7.10	0.10	7.02		
5/21/2012	0	7.01	145	165	18.70	0.10	8.07		20
SWIMS	1	6.94	143	164	18.30	0.10	7.74		
	2	6.12	143	164	18.20	0.10	7.40		
	3	5.75	143	164	18.10	0.10	7.30		
	4	6.84	143	165	18.00	0.10	7.14		
	5	6.30	132	159	16.20	0.10	6.88		
	6	8.45	120	159	12.20	0.10	6.70		
	7	7.22	134	183	10.80	0.10	6.56		
	8	5.81	129	181	9.90	0.10	6.22		
	9	2.85	125	180	8.80	0.10	6.16		
	10	0.34	123	181	8.10	0.10	6.06		
	11	0.10	122	181	7.80	0.10	6.00		
	12	0.03	136	204	7.60	0.10	5.71		
	12.5	0.01	139	210	7.40	0.10	5.63		
6/4/2012	0	6.95	151	163	21.20	0.10	8.36		19.5
SWIMS	1	6.72	150	163	20.90	0.10	7.86		
	2	5.45	148	161	20.70	0.10	7.74		
	3	6.31	143	157	20.30	0.10	7.50		
	4	5.47	143	159	19.80	0.10	7.32		
	5	5.27	176	199	18.80	0.10	7.07		
	6	7.28	163	197	15.80	0.10	6.96		
	7	7.06	138	182	12.10	0.10	6.78		
	8	3.45	128	179	10.00	0.10	6.53		
	9	0.89	125	179	9.10	0.10	6.41		
	10	0.23	129	187	8.60	0.10	6.34		
	11	0.31	127	188	8.10	0.10	6.30		
	12	0.04	127	189	7.80	0.10	6.31		
	12.5	0.02	128	192	7.60	0.10	6.00		
6/18/2012	0	6.46	152	163	21.60	0.10	7.54		16.5
SWIMS	1	6.32	153	164	21.60	0.10	7.17		
	2	6.06	152	164	21.30	0.10	6.73		
	3	6.22	153	164	21.20	0.10	6.37		
	4	6.03	153	165	21.00	0.10	6.03		
	5	5.25	153	167	20.40	0.10	5.59		
	6	7.15	144	167	17.80	0.10	5.03		
	7	6.74	129	167	12.90	0.10	4.42		
	8	2.21	121	169	10.30	0.10	4.10		
	9	0.16	137	197	9.10	0.10	3.86		

	10	0.13	140	202	8.80	0.10	4.00		
	11	0.09	140	204	8.50	0.10	3.84		
	12	0.02	140	207	8.20	0.10	3.44		
	12.5	0.01	142	209	7.90	0.10	3.65		
7/9/2012	0	7.32	176	166	28.40	0.10			17
SWIMS	1	7.06	175	165	28.40	0.10			
	2	7.33	175	164	28.40	0.10			
	3	6.68	174	164	28.30	0.10			
	4	9.11	169	164	26.60	0.10			
	5	9.24	161	166	23.70	0.10			
	6	9.20	151	171	19.10	0.10			
	7	10.40	140	173	15.20	0.10			
	8	0.35	129	178	10.40	0.10			
	9	0.13	127	181	9.40	0.10			
	10	0.09	126	182	8.70	0.10			
	11	0.07	128	189	8.30	0.10			
7/23/2012									18
8/6/2012	0	7.67	145	149	26.15	0.07	9.86	21.9	18
SWIMS	1	7.49	151	154	26.15	0.07	9.69	53.4	
	2	7.06	149	153	26.09	0.07	9.65	43.9	
	3	7.52	151	154	26.06	0.07	9.52	57.1	
	4	7.15	151	154	25.99	0.07	9.30	63.2	
	5	10.12	160	159	24.59	0.07	9.46	68.4	
	6	11.09	164	145	19.16	0.08	9.64	84.9	
	7	7.08	166	132	14.37	0.08	9.57	112.6	
	8	1.18	170	126	11.52	0.08	9.73	125.8	
	9	0.00	174	123	9.67	0.08	10.02	129.1	
	10	0.00	179	124	8.76	0.09	10.50	-136.8	
	11	0.00	185	128	8.23	0.09	10.72	-166.2	
8/21/2012	0	7.62	150	145	23.12	0.07	10.13	-8.4	17
SWIMS	1	7.55	150	144	22.87	0.07	10.08	-1.8	
	2	7.90	150	144	22.81	0.07	10.07	4.8	
	3	7.76	145	139	22.78	0.07	10.06	12.3	
	4	7.43	149	143	22.72	0.07	10.03	19.1	
	5	7.52	150	143	22.61	0.07	9.94	26.1	
	6	9.53	164	145	18.93	0.08	9.97	37.7	
	7	7.72	166	136	15.37	0.08	9.98	42.7	
	8	0.00	171	126	11.29	0.08	10.48	30.1	
	9	0.00	174	123	9.78	0.08	10.90	27.9	
	10	0.00	179	124	8.83	0.09	11.34	-278.7	
	11	0.00	188	129	8.39	0.09	11.62	-261.7	
	12	0.00	198	134	8.11	0.09	11.85	-247.2	
9/5/2012	0	8.35	144	144	24.89	0.07	9.57	-92.4	18
SWIMS	1	8.17	146	145	24.63	0.07	9.58	-82.4	
	2	7.93	146	145	24.54	0.07	9.55	-65.8	
	3	8.08	146	145	24.52	0.07	9.55	-58.8	
	4	8.06	147	146	24.47	0.07	9.57	-54.6	
	5	7.98	146	142	23.58	0.07	9.55	-52.1	
	6	9.47	155	144	21.36	0.07	9.40	-43.5	
	7	7.54	165	137	16.29	0.08	9.15	-47.1	
	8	0.08	167	129	13.04	0.08	9.32	-95.8	
	9	0.00	172	125	10.63	0.08	9.75	-110.7	
	10	0.00	174	123	9.57	0.08	10.08	-125.9	
	11	0.00	187	130	8.87	0.09	10.42	-489.3	
	12	0.00	197	135	8.54	0.09	10.55	-466.6	
10/15/2012	0	8.00	153	115	11.93	0.07			16
SWIMS	1	7.38	152	114	11.68	0.07			
	2	7.99	152	112	11.31	0.07			
	3	6.45	152	113	11.29	0.07			
	4	6.48	152	112	11.24	0.07			
	5	7.65	152	112	11.21	0.07			
	6	7.08	152	113	11.20	0.07			
	7	6.99	153	113	11.18	0.07			
	8	6.75	153	113	11.17	0.07			
	9	7.11	153	113	11.15	0.07			
	10	6.65	153	113	11.02	0.07			
	11	0.00	182	130	9.96	0.09			
	12	0.00	195	136	8.99	0.09			

Wind Lake: 45.17.261, 92.32.316

Date		Depth (m)	DO (mg/l)	Conduct (ms/s)	SpCond (ms/s)	Temp (oC)	Salinity (ppt)	pH	ORP	Secchi (ft)
	4/3/2012	0	8.46	141	196	10.20	0.10	7.77		12
SWIMS		1	8.48	141	196	10.20	0.10	7.76		
		2	8.60	140	195	10.10	0.10	7.76		
		3	8.79	139	195	10.00	0.10	7.77		
		4	8.31	139	197	9.70	0.10	7.74		
		5	6.91	140	207	8.00	0.10	7.70		
		6	4.15	147	226	6.70	0.10	7.68		
	5/7/2012	0	7.94	167	198	16.80	0.10	7.73		12
SWIMS		1	7.35	166	198	16.60	0.10	7.61		
		2	7.59	166	198	16.50	0.10	7.43		
		3	9.60	162	203	14.50	0.10	7.30		
		4	9.09	158	204	13.20	0.10	7.19		
		5	8.90	154	206	11.80	0.10	7.11		
		6	2.96	155	216	10.10	0.10	6.93		
	5/21/2012	0	6.83	179	198	20.20	0.10	7.75		12
SWIMS		1	6.96	177	198	19.40	0.10	7.28		
		2	5.98	175	197	19.10	0.10	7.12		
		3	6.48	175	198	18.60	0.10	6.96		
		4	9.35	179	219	15.40	0.10	6.78		
		5	7.91	190	246	13.00	0.10	6.60		
		6	4.27	190	258	11.00	0.10	6.72		
	6/4/2012	0	7.00	180	192	24.90	0.10	7.64		12
SWIMS		1	7.07	193	206	21.50	0.10	7.29		
		2	5.54	189	205	21.00	0.10	7.22		
		3	6.52	185	204	20.20	0.10	7.11		
		4	5.83	186	214	18.20	0.10	6.90		
		5	5.80	173	220	13.90	0.10	6.85		
		6	2.58	169	223	12.30	0.10	6.64		
	6/18/2012	0	6.08	184	196	21.80	0.10	7.69		16.5
SWIMS		1	6.06	185	198	21.60	0.10	6.69		
		2	5.37	186	199	21.50	0.10	6.61		
		3	5.64	184	198	21.30	0.10	6.21		
		4	5.53	186	206	19.90	0.10	5.80		
		5	5.62	178	217	15.50	0.10	5.28		
		6	1.83	174	225	13.20	0.10	4.99		
	7/9/2012	0	7.43	210	196	28.60	0.10			12
SWIMS		1	7.16	210	196	28.60	0.10			
		2	7.54	208	194	28.60	0.10			
		3	6.57	206	194	28.10	0.10			
		4	10.43	194	199	23.70	0.10			
		5	9.43	188	213	18.70	0.10			
		6	0.36	182	224	15.40	0.10			
	7/23/2012									12.5
	8/6/2012	0	7.41	183	187	26.17	0.09	10.00	11.7	10
SWIMS		1	7.15	184	188	25.93	0.09	9.85	34.7	
		2	7.01	185	188	25.84	0.09	9.67	47.3	
		3	6.58	186	188	25.72	0.09	9.55	55.8	
		4	8.52	204	199	23.73	0.10	9.22	78.6	
		5	0.44	214	188	18.44	0.10	8.47	115.4	
	8/21/2012	0	6.96	186	179	22.85	0.09	9.75	-31.9	9
SWIMS		1	7.07	187	177	22.15	0.09	9.81	-19.8	
		2	7.08	187	177	22.09	0.09	9.81	-15.1	
		3	6.51	187	176	22.05	0.09	9.85	-41.1	
		4	4.62	187	176	21.89	0.09	9.45	-81.0	
		5	0.11	206	187	20.23	0.10	9.14	-132.8	
	9/5/2012	0	8.38	186	186	25.08	0.09	9.80	-128.3	10
SWIMS		1	8.54	188	187	24.74	0.09	9.78	-113.3	
		2	7.51	189	188	24.57	0.09	9.56	-99.4	
		3	8.13	189	186	23.97	0.09	9.48	-92.1	
		4	9.06	189	181	22.88	0.09	9.62	-87.5	
		5	0.03	202	184	20.90	0.10	8.57	-155.5	
	10/15/2012	0	10.69	184	134	10.66	0.09			5.5
SWIMS		1	10.67	184	132	10.37	0.09			
		2	10.18	184	131	9.99	0.09			
		3	9.23	185	132	9.92	0.09			
		4	9.12	185	132	9.87	0.09			
		5	9.43	185	132	9.76	0.09			

Big Lake: 45.17.747, 92.32.356

Date	Depth (m)	DO (mg/l)	Conduct (ms/s)	SpCond (ms/s)	Temp (oC)	Salinity (ppt)	pH	ORP	Secchi (ft)
4/3/2012	0	8.24	154	218	9.70	0.10	7.63		14
SWIMS	1	7.96	154	217	9.70	0.10	7.64		
	2	8.03	153	217	9.60	0.10	7.63		
	3	7.86	152	216	9.60	0.10	7.63		
	4	7.93	152	216	9.50	0.10	7.64		
	5	7.80	154	219	9.40	0.10	7.62		
	6	7.59	156	223	9.20	0.10	7.62		
	7	0.12	158	226	9.30	0.10	7.60		
5/7/2012	0	7.59	179	219	15.40	0.10	8.05		17
SWIMS	1	7.52	179	219	15.40	0.10	7.90		
	2	7.38	179	219	15.30	0.10	7.75		
	3	7.33	178	219	15.30	0.10	7.60		
	4	7.26	176	223	13.90	0.10	7.45		
	5	6.69	174	224	13.30	0.10	7.31		
	6	5.59	173	226	12.80	0.10	7.19		
	7	2.67	176	230	12.60	0.10	7.06		
5/21/2012	0	6.59	223	253	18.70	0.10	7.50		14.5
SWIMS	1	5.80	221	252	18.40	0.10	7.14		
	2	6.15	220	252	18.30	0.10	6.99		
	3	5.49	218	251	18.20	0.10	7.13		
	4	5.87	217	250	18.10	0.10	6.73		
	5	4.63	216	253	17.40	0.10	6.52		
	6	2.56	211	262	14.90	0.10	6.37		
	7	0.47	234	297	13.90	0.10	6.25		
6/4/2012	0	7.52	229	245	21.50	0.10	7.80		13
SWIMS	1	6.94	224	242	21.10	0.10	7.58		
	2	6.63	217	237	20.70	0.10	7.37		
	3	6.95	212	237	20.10	0.10	7.21		
	4	5.91	210	235	19.30	0.10	6.98		
	5	6.26	209	237	18.80	0.10	7.04		
	6	2.20	209	243	17.60	0.10	6.91		
	7	0.02	244	293	16.20	0.10	6.69		
6/18/2012	0	6.46	212	226	21.60	0.10	7.59		14
SWIMS	1	6.05	211	227	21.30	0.10	6.95		
	2	5.80	211	228	21.10	0.10	6.60		
	3	5.91	211	228	21.00	0.10	6.27		
	4	5.62	210	228	20.90	0.10	5.98		
	5	4.29	211	230	20.50	0.10	5.58		
	6	1.97	216	245	18.80	0.10	5.18		
	7	0.12	223	260	17.70	0.10	5.21		
7/9/2012	0	7.67	236	222	28.40	0.10			12.5
SWIMS	1	7.70	236	222	28.40	0.10			
	2	7.18	235	221	28.40	0.10			
	3	7.80	232	219	28.10	0.10			
	4	9.21	225	221	25.80	0.10			
	5	5.20	222	235	22.40	0.10			
	6	0.46	231	254	20.20	0.10			
	7	0.13	311	355	19.60	0.20			
7/23/2012									12
8/6/2012	0	7.59	193	197	26.02	0.09	9.89	-16.2	8
SWIMS	1	7.39	197	201	25.99	0.09	9.78	10.1	
	2	7.53	198	201	25.91	0.09	9.70	27.9	
	3	7.37	198	201	25.78	0.09	9.66	38.2	
	4	7.03	200	202	25.68	0.09	9.59	47.2	
	5	1.63	235	232	24.49	0.11	8.26	88.9	
	6	0.00	267	246	20.69	0.13	8.19	111.0	
8/21/2012	0	9.43	198	193	23.58	0.09	10.48	-178.1	4
SWIMS	1	8.98	200	191	22.70	0.09	10.44	-127.5	
	2	8.48	201	191	22.53	0.09	10.33	-114.7	
	3	6.14	202	193	22.43	0.10	10.05	-111.7	
	4	3.60	207	196	22.32	0.10	9.71	-113.9	
	5	0.52	215	203	22.06	0.10	9.24	-141.3	
	6	0.00	260	242	21.18	0.12	9.08	-248.9	
9/5/2012	0	9.82	187	188	25.24	0.09	10.38	-152.4	5.5
SWIMS	1	10.66	188	187	24.72	0.09	10.37	-128.0	
	2	10.97	189	187	24.45	0.09	10.33	-116.3	
	3	4.78	197	192	23.49	0.09	9.63	-134.3	

	4	0.15	215	204	22.20	0.10	9.08	-424.1	
	5	0.00	229	214	21.49	0.11	9.00	-511.1	
	6	0.00	267	245	20.61	0.13	8.93	-501.1	
10/15/2012	0	9.06	196	144	11.08	0.09			11
SWIMS	1	8.87	197	144	11.02	0.09			
	2	8.00	198	143	10.39	0.09			
	3	8.51	197	142	10.37	0.09			
	4	7.78	198	143	10.36	0.09			
	5	8.28	198	143	10.34	0.09			
	6	7.05	198	143	10.36	0.09			

County Rd K Culvert

Date	Feet	Depth	Flow	Comments
5/7/2012	0	0.2	0.02	
	1	0.3	0.51	
	2	0.2	0.40	
	3	0.2	0.36	
	4	0.1	0.37	
5/21/2012	0	0.1	0.00	
	1	0.2	0.01	
	2	0.1	0.00	
6/4/2012	0	0.1	0.00	
	1	0.1	0.04	
	2	0.1	0.00	
6/18/2012	0	0.1	0.09	
	1	0.3	0.25	
	2	0.2	0.05	
7/9/2012				No flow
7/23/2012				No flow
8/6/2012				No flow
8/21/2012				No flow
9/5/2012				No flow

North Creek

Date	Feet	Depth	Flow
5/7/2012	0	0.3	0.03
	1	0.6	0.16
	2	0.6	0.19
	3	0.7	0.19
	4	0.7	0.30
	5	0.5	0.23
	6	0.6	0.24
	7	0.5	0.03
	8	0.4	0.00
5/21/2012	0	0.2	0.09
	1	0.5	0.17
	2	0.4	0.41
	3	0.5	0.30
	4	0.3	0.30
	5	0.3	0.13
	6	0.2	0.01
6/4/2012	0	0.3	0.07
	1	0.3	0.16
	2	0.3	0.15
	3	0.3	0.32
	4	0.3	0.23
	5	0.3	0.16
	6	0.2	0.09
6/18/2012	0	0.2	0.00
	1	0.4	0.00

	2	1.1	0.00
	3	1.1	0.22
	4	1.3	0.37
	5	1.1	0.38
	6	1.1	0.32
	7	1.2	0.42
	8	1.3	0.27
	9	1.3	0.06
	10	0.5	0.00
7/9/2012	0	0.2	0.01
	1	0.4	0.04
	2	0.3	0.10
	3	0.5	0.24
	4	0.5	0.18
	5	0.4	0.06
	6	0.2	0.01
7/23/2012	0	0.3	0.01
	1	0.5	0.08
	2	0.4	0.11
	3	0.5	0.23
	4	0.5	0.19
	5	0.5	0.09
	6	0.3	0.03
	7	0.2	0.01
8/6/2012	0	0.3	0.00
	1	0.5	0.01
	2	0.5	0.13
	3	0.5	0.17
	4	0.5	0.18
	5	0.5	0.09
	6	0.4	0.06
	7	0.3	0.03
	8	0.2	0.00
8/21/2012	0	0.3	0.03
	1	0.4	0.03
	2	0.5	0.09
	3	0.5	0.16
	4	0.5	0.17
	5	0.5	0.15
	6	0.4	0.07
	7	0.3	0.00
9/5/2012	0	0.2	0.00
	1	0.4	0.01
	2	0.5	0.05
	3	0.5	0.09
	4	0.6	0.12
	5	0.6	0.13
	6	0.5	0.12
	7	0.4	0.04
	8	0.3	0.01

Big Lake Outlet

Date	Feet	Depth	Flow	Comments
5/7/2012	0	0.3	0.01	
	1	0.5	0.01	
	2	0.7	0.02	
	3	0.7	0.01	
	4	0.9	0.03	
	5	0.8	0.04	
	6	0.9	0.04	
	7	1.0	0.17	
	8	1.0	0.31	
	9	1.1	0.43	
	10	1.1	0.43	
	11	0.9	0.08	
	12	0.9	0.16	
	13	0.8	0.03	
	14	0.5	0.07	

	15	0.5	0.04	
	16	0.1	0.02	
5/21/2012	0	0.1	0.00	
	1	0.3	0.00	
	2	0.3	0.00	
	3	0.5	0.01	
	4	0.5	0.02	
	5	0.5	0.02	
	6	0.6	0.11	
	7	0.6	0.14	
	8	0.7	0.14	
	9	0.8	0.24	
	10	0.8	0.09	
	11	0.6	0.02	
	12	0.5	0.02	
	13	0.4	0.03	
	14	0.2	0.02	
6/4/2012	0	0.2	0.00	
	1	0.2	0.02	
	2	0.3	0.03	
	3	0.4	0.03	
	4	0.4	0.02	
	5	0.5	0.02	
	6	0.5	0.03	
	7	0.5	0.15	
	8	0.7	0.24	
	9	0.7	0.31	
	10	0.6	0.17	
	11	0.5	0.03	
	12	0.4	0.01	
6/18/2012	0	0.2	0.00	
	1	0.3	0.00	
	2	0.4	0.03	
	3	0.5	0.03	
	4	0.5	0.00	
	5	0.6	0.00	
	6	0.7	0.01	
	7	0.6	0.07	
	8	0.5	0.19	
	9	0.9	0.40	
	10	0.9	0.26	
	11	0.8	0.24	
	12	0.6	0.02	
	13	0.4	0.01	
	14	0.3	0.00	
7/9/2012	0	0.1	0.00	
	1	0.2	0.11	
	2	0.2	0.11	
	3	0.2	0.05	
7/23/2012	0	0.1	0.00	
	1	0.2	0.00	
	2	0.4	0.01	
	3	0.4	0.20	
	4	0.4	0.34	
	5	0.3	0.13	
	6	0.3	0.07	
	7	0.2	0.00	
8/6/2012				No flow
8/21/2012				No flow
9/5/2012				No flow

Appendix D

Phytoplankton Data

Wisconsin State Laboratory of Hygiene
2601 Agriculture Drive, PO Box 7996
Madison, WI 53707-7996
(800)442-4618 • FAX (608)224-6213
http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division   Environmental Toxicology

WDNR LAB ID: 113133790   NELAP LAB ID: E37658   EPA LAB WI00007   WI DATCP ID: 105-415

WSLH Sample: FX000379

POLK COUNTY LAND & WATER RESOU
100 POLK COUNTY PLAZA, SUITE 1
BALSAM LAKE WI 54810

Bill To

Customer ID: 336949
POLK COUNTY LAND & WATER RESOURCES DEPARTMENT
100 POLK COUNTY PLAZA, SUITE 120
BALSAM LAKE WI 54810

ID#: 493108
Waterbody/Outfall ID: 261600
Point/Well:
Account #: PP001
Project No:
Date Received: 10/02/2012
Date Reported: 04/05/2013
Sample Reason:

Field #:
Collection Start: 05/07/2012
Collection End:
Collected By: J. WILLIAMSON
County:
Sample Source: SURFACE WATER
Sample Depth: 2 Meters
Sample Information: LPL-1473-12;
Sample Location: CHURCH PINE LAKE - DEEP HOLE
Sample Description: COMPOSITE SAMPLER
Analyses and Results:

Taxa	Division	Result	Unit	Percentage
ASTERIONELLA SP.	BACILLARIOPHYTA	177.	CELLS/ML	9.3 %
CAVINULA SP.	BACILLARIOPHYTA	9.	CELLS/ML	0.5 %
FRAGILARIA SP.	BACILLARIOPHYTA	31.	CELLS/ML	1.6 %
STEPHANODISCUS SP.	BACILLARIOPHYTA	133.	CELLS/ML	7.0 %
OOCYSTIS SP.	CHLOROPHYTA	53.	CELLS/ML	2.8 %
SCHROEDERIA SP.	CHLOROPHYTA	168.	CELLS/ML	8.9 %
DINOBRYON SP.	CHRYSOPHYTA	13.	CELLS/ML	0.7 %
CRYPTOMONAS SP.	CRYPTOPHYTA	35.	CELLS/ML	1.8 %
KOMMA CAUDATA	CRYPTOPHYTA	730.	CELLS/ML	38.5 %
DACTYLOCOCCOPSIS SP.	CYANOPHYTA	13.	CELLS/ML	0.7 %
PLANKTOTHRIX SP.	CYANOPHYTA	531.	CELLS/ML	28.0 %
PERIDINIUM SP.	PYRRHOPHYTA	4.	CELLS/ML	0.2 %

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Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division   Environmental Toxicology

WDNR LAB ID: 113133790   NELAP LAB ID: E37658   EPA LAB WI00007   WI DATCP ID: 105-415

WSLH Sample: FX000379

Test results for NELAP accredited tests are certified to meet the requirements of the NELAC standards. For a list of accredited analytes see http://www.slh.wisc.edu/nelap/

List of Abbreviations:

Natural Unit = Unicell, Colony or Filament Equals 1 Unit

LOD = Level of detection

LOQ = Level of quantification

ND = None detected. Results are less than the LOD

Responsible Party: Steve Geis Steve Geis, Chemist Supervisor

If there are questions about this report, please contact Dawn Perkins at 608-224-6230.

The results in this report apply only to the sample specifically listed above. This report is not to be reproduced except in full.

Report #: 9548129

Wisconsin State Laboratory of Hygiene
2601 Agriculture Drive, PO Box 7996
Madison, WI 53707-7996
(800)442-4618 • FAX (608)224-6213
http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division   Environmental Toxicology

WDNR LAB ID: 113133790   NELAP LAB ID: E37658   EPA LAB WI00007   WI DATCP ID: 105-415

WSLH Sample: FX000374

POLK COUNTY LAND & WATER RESOU
100 POLK COUNTY PLAZA, SUITE 1
BALSAM LAKE WI 54810

Bill To

Customer ID: 336949
POLK COUNTY LAND & WATER RESOURCES DEPARTMENT
100 POLK COUNTY PLAZA, SUITE 120
BALSAM LAKE WI 54810

ID#: 493108
Waterbody/Outfall ID: 2616100
Point/Well:
Account #: PP001
Project No:
Date Received: 10/02/2012
Date Reported: 04/05/2013
Sample Reason:

Field #:
Collection Start: 06/04/2012
Collection End:
Collected By: J. WILLIAMSON
County:
Sample Source: SURFACE WATER
Sample Depth: 2 Meters
Sample Information: LPL-1473-12;
Sample Location: CHURCH PINE LAKE - DEEP HOLE
Sample Description: COMPOSITE SAMPLER
Analyses and Results:

Taxa	Division	Result	Unit	Percentage
OOCYSTIS SP.	CHLOROPHYTA	138.	CELLS/ML	1.3 %
PANDORINA SP.	CHLOROPHYTA	249.	CELLS/ML	2.3 %
SCENEDESMUS SP.	CHLOROPHYTA	147.	CELLS/ML	1.4 %
SCHROEDERIA SP.	CHLOROPHYTA	64.	CELLS/ML	0.6 %
DINOBRYON SP.	CHRYSOPHYTA	1234.	CELLS/ML	11.6 %
KOMMA CAUDATA	CRYPTOPHYTA	1280.	CELLS/ML	12.0 %
APHANIZOMENON SP.	CYANOPHYTA	175.	CELLS/ML	1.6 %
APHANOTHECE SP.	CYANOPHYTA	7347.	CELLS/ML	69.1 %

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Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division   Environmental Toxicology

WDNR LAB ID: 113133790   NELAP LAB ID: E37658   EPA LAB   WI00007   WI DATCP ID: 105-415

WSLH Sample: FX000374

Test results for NELAP accredited tests are certified to meet the requirements of the NELAC standards. For a list of accredited analytes see http://www.slh.wisc.edu/nelap/

List of Abbreviations:

Natural Unit = Unicell, Colony or Filament Equals 1 Unit

LOD = Level of detection

LOQ = Level of quantification

ND = None detected. Results are less than the LOD

Responsible Party: ______________ Steve Geis, Chemist Supervisor

If there are questions about this report, please contact Dawn Perkins at 608-224-6230.

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Report #: 9548128

Wisconsin State Laboratory of Hygiene
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Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division — Environmental Toxicology

WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB WI00007 WI DATCP ID: 105-415

WSLH Sample: FX000373

POLK COUNTY LAND & WATER RESOU
100 POLK COUNTY PLAZA, SUITE 1
BALSAM LAKE WI 54810

Bill To

Customer ID: 336949
POLK COUNTY LAND & WATER RESOURCES DEPARTMENT
100 POLK COUNTY PLAZA, SUITE 120
BALSAM LAKE WI 54810

ID#: 493108

Field #:
Collection Start: 07/09/2012
Collection End:
Collected By: J. WILLIAMSON
County:
Sample Source: SURFACE WATER
Sample Depth: 2 Meters
Sample Information: LPL-1473-12;
Sample Location: CHURCH PINE LAKE - DEEP HOLE
Sample Description: COMPOSITE SAMPLER

Waterbody/Outfall ID: 2616100
Point/Well:
Account #: PP001
Project No:
Date Received: 10/02/2012
Date Reported: 04/05/2013
Sample Reason:

Analyses and Results:

Wisconsin State Laboratory of Hygiene
2601 Agriculture Drive, PO Box 7996
Madison, WI 53707-7996
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http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division — Environmental Toxicology

WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB WI00007 WI DATCP ID: 105-415

WSLH Sample: FX000373

Taxa	Division	Result	Unit	Percentage
CAVINULA SP.	BACILLARIOPHYTA	37.	CELLS/ML	0.5 %
FRAGILARIA SP.	BACILLARIOPHYTA	17.	CELLS/ML	0.2 %
COELASTRUM SP.	CHLOROPHYTA	51.	CELLS/ML	0.7 %
COSMARIUM SP.	CHLOROPHYTA	7.	CELLS/ML	0.1 %
DICTYOSPHAERIUM SP.	CHLOROPHYTA	1090.	CELLS/ML	14.0 %
GOLENKINIA SP.	CHLOROPHYTA	37.	CELLS/ML	0.5 %
OOCYSTIS SP.	CHLOROPHYTA	85.	CELLS/ML	1.1 %
SCENEDESMUS SP.	CHLOROPHYTA	109.	CELLS/ML	1.4 %
STAURASTRUM SP.	CHLOROPHYTA	3.	CELLS/ML	0.0 %
TETRAEDRON SP.	CHLOROPHYTA	3.	CELLS/ML	0.0 %
CRYPTOMONAS SP.	CRYPTOPHYTA	55.	CELLS/ML	0.7 %
KOMMA CAUDATA	CRYPTOPHYTA	542.	CELLS/ML	6.9 %
APHANIZOMENON ISSATSCHENKOI	CYANOPHYTA	126.	CELLS/ML	1.6 %
APHANOCAPSA SP.	CYANOPHYTA	3062.	CELLS/ML	39.2 %
APHANOTHECE SP.	CYANOPHYTA	1976.	CELLS/ML	25.3 %
CHROOCOCCUS SP.	CYANOPHYTA	504.	CELLS/ML	6.5 %
DACTYLOCOCCOPSIS SP.	CYANOPHYTA	14.	CELLS/ML	0.2 %
PLANKTOTHRIX SP.	CYANOPHYTA	89.	CELLS/ML	1.1 %
CERATIUM SP.	PYRRHOPHYTA	3.	CELLS/ML	0.0 %

Test results for NELAP accredited tests are certified to meet the requirements of the NELAC standards. For a list of accredited analytes see http://www.slh.wisc.edu/nelap/

List of Abbreviations:

Natural Unit = Unicell, Colony or Filament Equals 1 Unit
LOD = Level of detection
LOQ = Level of quantification
ND = None detected. Results are less than the LOD

Responsible Party: [signature] Steve Geis, Chemist Supervisor

If there are questions about this report, please contact Dawn Perkins at 608-224-6230.

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Report #: 9548127

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Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division — Environmental Toxicology

WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB WI00007 WI DATCP ID: 105-415

WSLH Sample: FX000372

POLK COUNTY LAND & WATER RESOU
100 POLK COUNTY PLAZA, SUITE 1
BALSAM LAKE WI 54810

Bill To

Customer ID: 336949
POLK COUNTY LAND & WATER RESOURCES DEPARTMENT
100 POLK COUNTY PLAZA, SUITE 120
BALSAM LAKE WI 54810

ID#: 493108

Field #:
Collection Start: 08/06/2012
Collection End:
Collected By: J. WILLIAMSON
County:
Sample Source: SURFACE WATER
Sample Depth: 2 Meters
Sample Information: LPL-1473-12;
Sample Location: CHURCH PINE LAKE - DEEP HOLE
Sample Description: COMPOSITE SAMPLER

Waterbody/Outfall ID: 2616100
Point/Well:
Account #: PP001
Project No:
Date Received: 10/02/2012
Date Reported: 04/05/2013
Sample Reason:

Analyses and Results:

Taxa	Division	Result	Unit	Percentage
CAVINULA SP.	BACILLARIOPHYTA	25.	CELLS/ML	0.1 %
FRAGILARIA SP.	BACILLARIOPHYTA	6.	CELLS/ML	0.0 %
DICTYOSPHAERIUM SP.	CHLOROPHYTA	68.	CELLS/ML	0.3 %
OOCYSTIS SP.	CHLOROPHYTA	124.	CELLS/ML	0.6 %
SCHROEDERIA SP.	CHLOROPHYTA	12.	CELLS/ML	0.1 %
SPHAEROCYSTIS SP.	CHLOROPHYTA	93.	CELLS/ML	0.5 %
TETRAEDRON SP.	CHLOROPHYTA	6.	CELLS/ML	0.0 %
CRYPTOMONAS SP.	CRYPTOPHYTA	25.	CELLS/ML	0.1 %
KOMMA CAUDATA	CRYPTOPHYTA	483.	CELLS/ML	2.4 %
APHANOCAPSA SP.	CYANOPHYTA	6751.	CELLS/ML	33.3 %
APHANOTHECE SP.	CYANOPHYTA	12294.	CELLS/ML	60.7 %
CHROOCOCCUS SP.	CYANOPHYTA	347.	CELLS/ML	1.7 %
DACTYLOCOCCOPSIS SP.	CYANOPHYTA	25.	CELLS/ML	0.1 %

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Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division   Environmental Toxicology

WDNR LAB ID: 113133790   NELAP LAB ID: E37658   EPA LAB WI00007   WI DATCP ID: 105-415

WSLH Sample: FX000372

Test results for NELAP accredited tests are certified to meet the requirements of the NELAC standards. For a list of accredited analytes see http://www.slh.wisc.edu/nelap/

List of Abbreviations:

Natural Unit = Unicell, Colony or Filament Equals 1 Unit
LOD = Level of detection
LOQ = Level of quantification
ND = None detected. Results are less than the LOD

Responsible Party: Steve Geis, Chemist Supervisor

If there are questions about this report, please contact Dawn Perkins at 608-224-6230.

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Report #: 9548156

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Madison, WI 53707-7996
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http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division Environmental Toxicology

WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB WI00007 WI DATCP ID: 105-415

WSLH Sample: FX000371

POLK COUNTY LAND & WATER RESOU
100 POLK COUNTY PLAZA, SUITE 1
BALSAM LAKE WI 54810

Bill To

Customer ID: 336949
POLK COUNTY LAND & WATER RESOURCES DEPARTMENT
100 POLK COUNTY PLAZA, SUITE 120
BALSAM LAKE WI 54810

ID#: 493108
Waterbody/Outfall ID: 2616100
Point/Well:
Account #: PP001
Project No:
Date Received: 10/02/2012
Date Reported: 04/05/2013
Sample Reason:

Field #:
Collection Start: 09/05/2012
Collection End:
Collected By: J. WILLIAMSON
County:
Sample Source: SURFACE WATER
Sample Depth: 2 Meters
Sample Information: LPL-1473-12;
Sample Location: CHURCH PINE LAKE - DEEP HOLE
Sample Description: COMPOSITE SAMPLER
Analyses and Results:

Wisconsin State Laboratory of Hygiene
2601 Agriculture Drive, PO Box 7996
Madison, WI 53707-7996
(800)442-4618 • FAX (608)224-6213
http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division   Environmental Toxicology

WDNR LAB ID: 113133790   NELAP LAB ID: E37658   EPA LAB WI00007   WI DATCP ID: 105-415

WSLH Sample: FX000371

Taxa	Division	Result	Unit	Percentage
ASTERIONELLA SP.	BACILLARIOPHYTA	11.	CELLS/ML	0.1 %
CAVINULA SP.	BACILLARIOPHYTA	11.	CELLS/ML	0.1 %
FRAGILARIA SP.	BACILLARIOPHYTA	32.	CELLS/ML	0.2 %
COSMARIUM SP.	CHLOROPHYTA	5.	CELLS/ML	0.0 %
DICTYOSPHAERIUM SP.	CHLOROPHYTA	524.	CELLS/ML	2.7 %
GOLENKINIA SP.	CHLOROPHYTA	11.	CELLS/ML	0.1 %
OOCYSTIS SP.	CHLOROPHYTA	27.	CELLS/ML	0.1 %
SCENEDESMUS SP.	CHLOROPHYTA	65.	CELLS/ML	0.3 %
SPHAEROCYSTIS SP.	CHLOROPHYTA	87.	CELLS/ML	0.4 %
STAURASTRUM SP.	CHLOROPHYTA	5.	CELLS/ML	0.0 %
CRYPTOMONAS SP.	CRYPTOPHYTA	5.	CELLS/ML	0.0 %
KOMMA CAUDATA	CRYPTOPHYTA	606.	CELLS/ML	3.1 %
APHANIZOMENON SP.	CYANOPHYTA	368.	CELLS/ML	1.9 %
APHANOCAPSA SP.	CYANOPHYTA	3325.	CELLS/ML	16.9 %
APHANOTHECE SP.	CYANOPHYTA	14307.	CELLS/ML	72.7 %
CHROOCOCCUS SP.	CYANOPHYTA	249.	CELLS/ML	1.3 %
DACTYLOCOCCOPSIS SP.	CYANOPHYTA	43.	CELLS/ML	0.2 %

Test results for NELAP accredited tests are certified to meet the requirements of the NELAC standards. For a list of accredited analytes see http://www.slh.wisc.edu/nelap/

List of Abbreviations:

Natural Unit = Unicell, Colony or Filament Equals 1 Unit
LOD = Level of detection
LOQ = Level of quantification
ND = None detected. Results are less than the LOD

Responsible Party: Steve Geis, Chemist Supervisor

If there are questions about this report, please contact Dawn Perkins at 608-224-6230.

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Report #: 9548155

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Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division   Environmental Toxicology

WDNR LAB ID: 113133790   NELAP LAB ID: E37658   EPA LAB WI00007   WI DATCP ID: 105-415

WSLH Sample: FX000366

POLK COUNTY LAND & WATER RESOU
100 POLK COUNTY PLAZA, SUITE 1
BALSAM LAKE WI 54810

Bill To

Customer ID: 336949
POLK COUNTY LAND & WATER RESOURCES DEPARTMENT
100 POLK COUNTY PLAZA, SUITE 120
BALSAM LAKE WI 54810

ID#: 493116
Waterbody/Outfall ID: 2616000
Point/Well:
Account #: PP001
Project No:
Date Received: 10/02/2012
Date Reported: 03/26/2013
Sample Reason:

Field #:
Collection Start: 05/07/2012
Collection End:
Collected By: J. WILLIAMSON
County:
Sample Source: SURFACE WATER
Sample Depth: 2 Meters
Sample Information: LPL-1473-12;
Sample Location: WIND LAKE - DEEP HOLE
Sample Description: COMPOSITE SAMPLER
Analyses and Results:

Taxa	Division	Result	Unit	Percentage
ASTERIONELLA SP.	BACILLARIOPHYTA	365.	CELLS/ML	9.5 %
CYCLOTELLA SP.	BACILLARIOPHYTA	73.	CELLS/ML	1.9 %
FRAGILARIA SP.	BACILLARIOPHYTA	1375.	CELLS/ML	35.6 %
PANDORINA SP.	CHLOROPHYTA	97.	CELLS/ML	2.5 %
QUADRIGULA SP.	CHLOROPHYTA	49.	CELLS/ML	1.3 %
SCHROEDERIA SP.	CHLOROPHYTA	61.	CELLS/ML	1.6 %
DINOBRYON SP.	CHRYSOPHYTA	49.	CELLS/ML	1.3 %
CRYPTOMONAS SP.	CRYPTOPHYTA	73.	CELLS/ML	1.9 %
KOMMA CAUDATA	CRYPTOPHYTA	1715.	CELLS/ML	44.5 %

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http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division Environmental Toxicology

WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB WI00007 WI DATCP ID: 105-415

WSLH Sample: FX000366

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List of Abbreviations:

Natural Unit = Unicell, Colony or Filament Equals 1 Unit

LOD = Level of detection

LOQ = Level of quantification

ND = None detected. Results are less than the LOD

Responsible Party: [signature] Steve Geis, Chemist Supervisor

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Report #: 9546869

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Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division   Environmental Toxicology

WDNR LAB ID: 113133790   NELAP LAB ID: E37658   EPA LAB WI00007   WI DATCP ID: 105-415

WSLH Sample: FX000368

POLK COUNTY LAND & WATER RESOU
100 POLK COUNTY PLAZA, SUITE 1
BALSAM LAKE WI 54810

Bill To

Customer ID: 336949
POLK COUNTY LAND & WATER RESOURCES DEPARTMENT
100 POLK COUNTY PLAZA, SUITE 120
BALSAM LAKE WI 54810

ID#: 493116
Waterbody/Outfall ID: 2616000
Point/Well:
Account #: PP001
Project No:
Date Received: 10/02/2012
Date Reported: 03/26/2013
Sample Reason:

Field #:
Collection Start: 07/09/2012
Collection End:
Collected By: J. WILLIAMSON
County:
Sample Source: SURFACE WATER
Sample Depth: 2 Meters
Sample Information: LPL-1473-12;
Sample Location: WIND LAKE - DEEP HOLE
Sample Description: COMPOSITE SAMPLER
Analyses and Results:

Wisconsin State Laboratory of Hygiene
2601 Agriculture Drive, PO Box 7996
Madison, WI 53707-7996
(800)442-4618 • FAX (608)224-6213
http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division   Environmental Toxicology

WDNR LAB ID: 113133790   NELAP LAB ID: E37658   EPA LAB WI00007   WI DATCP ID: 105-415

WSLH Sample: FX000368

Taxa	Division	Result	Unit	Percentage
CAVINULA SP.	BACILLARIOPHYTA	8.	CELLS/ML	0.1 %
CYCLOTELLA SP.	BACILLARIOPHYTA	8.	CELLS/ML	0.1 %
FRAGILARIA SP.	BACILLARIOPHYTA	145.	CELLS/ML	2.2 %
NAVICULOID DIATOMS	BACILLARIOPHYTA	12.	CELLS/ML	0.2 %
COELASTRUM SP.	CHLOROPHYTA	47.	CELLS/ML	0.7 %
DICTYOSPHAERIUM SP.	CHLOROPHYTA	1366.	CELLS/ML	20.7 %
GOLENKINIA SP.	CHLOROPHYTA	16.	CELLS/ML	0.2 %
OOCYSTIS SP.	CHLOROPHYTA	110.	CELLS/ML	1.7 %
QUADRIGULA SP.	CHLOROPHYTA	23.	CELLS/ML	0.3 %
SCENEDESMUS SP.	CHLOROPHYTA	110.	CELLS/ML	1.7 %
SCHROEDERIA SP.	CHLOROPHYTA	12.	CELLS/ML	0.2 %
TETRAEDRON SP.	CHLOROPHYTA	12.	CELLS/ML	0.2 %
CRYPTOMONAS SP.	CRYPTOPHYTA	86.	CELLS/ML	1.3 %
KOMMA CAUDATA	CRYPTOPHYTA	599.	CELLS/ML	9.1 %
ANABAENA SP.	CYANOPHYTA	305.	CELLS/ML	4.6 %
APHANOCAPSA SP.	CYANOPHYTA	1002.	CELLS/ML	15.2 %
APHANOTHECE SP.	CYANOPHYTA	2142.	CELLS/ML	32.4 %
CHROOCOCCUS SP.	CYANOPHYTA	591.	CELLS/ML	9.0 %
EUGLENA SP.	EUGLENOPHYTA	4.	CELLS/ML	0.1 %
CERATIUM SP.	PYRRHOPHYTA	4.	CELLS/ML	0.1 %

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List of Abbreviations:

Natural Unit = Unicell, Colony or Filament Equals 1 Unit
LOD = Level of detection
LOQ = Level of quantification
ND = None detected. Results are less than the LOD

Responsible Party: Steve Geis Steve Geis, Chemist Supervisor

If there are questions about this report, please contact Dawn Perkins at 608-224-6230.

Report #: 9546870

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http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division Environmental Toxicology

WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB WI00007 WI DATCP ID: 105-415

WSLH Sample: FX000369

POLK COUNTY LAND & WATER RESOU
100 POLK COUNTY PLAZA, SUITE 1
BALSAM LAKE WI 54810

Bill To

Customer ID: 336949
POLK COUNTY LAND & WATER RESOURCES DEPARTMENT
100 POLK COUNTY PLAZA, SUITE 120
BALSAM LAKE WI 54810

ID#: 493116
Waterbody/Outfall ID: 2616000
Point/Well:
Account #: PP001
Project No:
Date Received: 10/02/2012
Date Reported: 03/26/2013
Sample Reason:

Field #:
Collection Start: 08/06/2012
Collection End:
Collected By: J. WILLIAMSON
County:
Sample Source: SURFACE WATER
Sample Depth: 2 Meters
Sample Information: LPL-1473-12;
Sample Location: WIND LAKE - DEEP HOLE
Sample Description: COMPOSITE SAMPLER
Analyses and Results:

Wisconsin State Laboratory of Hygiene
2601 Agriculture Drive, PO Box 7996
Madison, WI 53707-7996
(800)442-4618 • FAX (608)224-6213
http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division   Environmental Toxicology

WDNR LAB ID: 113133790   NELAP LAB ID: E37658   EPA LAB WI00007   WI DATCP ID: 105-415

WSLH Sample: FX000369

Taxa	Division	Result	Unit	Percentage
FRAGILARIA SP.	BACILLARIOPHYTA	30.	CELLS/ML	0.2 %
CLOSTERIUM SP.	CHLOROPHYTA	30.	CELLS/ML	0.2 %
COELASTRUM SP.	CHLOROPHYTA	72.	CELLS/ML	0.4 %
DICTYOSPHAERIUM SP.	CHLOROPHYTA	723.	CELLS/ML	3.9 %
DYSMORPHOCOCCUS SP.	CHLOROPHYTA	6.	CELLS/ML	0.0 %
GOLENKINIA SP.	CHLOROPHYTA	30.	CELLS/ML	0.2 %
OOCYSTIS SP.	CHLOROPHYTA	120.	CELLS/ML	0.6 %
QUADRIGULA SP.	CHLOROPHYTA	155.	CELLS/ML	0.8 %
SCENEDESMUS SP.	CHLOROPHYTA	239.	CELLS/ML	1.3 %
SCHROEDERIA SP.	CHLOROPHYTA	36.	CELLS/ML	0.2 %
TETRAEDRON SP.	CHLOROPHYTA	18.	CELLS/ML	0.1 %
CRYPTOMONAS SP.	CRYPTOPHYTA	30.	CELLS/ML	0.2 %
KOMMA CAUDATA	CRYPTOPHYTA	365.	CELLS/ML	2.0 %
ANABAENA SP.	CYANOPHYTA	729.	CELLS/ML	3.9 %
APHANIZOMENON SP.	CYANOPHYTA	161.	CELLS/ML	0.9 %
APHANOCAPSA SP.	CYANOPHYTA	11409.	CELLS/ML	61.5 %
APHANOTHECE SP.	CYANOPHYTA	3795.	CELLS/ML	20.4 %
CHROOCOCCUS SP.	CYANOPHYTA	233.	CELLS/ML	1.3 %
PSEUDANABAENA SP.	CYANOPHYTA	382.	CELLS/ML	2.1 %

List of Abbreviations:

Natural Unit = Unicell, Colony or Filament Equals 1 Unit
LOD = Level of detection
LOQ = Level of quantification
ND = None detected. Results are less than the LOD

Responsible Party: Steve Geis, Chemist Supervisor

If there are questions about this report, please contact Dawn Perkins at 608-224-6230.

Report #: 9546871

Wisconsin State Laboratory of Hygiene
2601 Agriculture Drive, PO Box 7996
Madison, WI 53707-7996
(800)442-4618 • FAX (608)224-6213
http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division　　Environmental Toxicology

WDNR LAB ID: 113133790　NELAP LAB ID: E37658　EPA LAB　WI00007　WI DATCP ID: 105-415

WSLH Sample: FX000370

POLK COUNTY LAND & WATER RESOU
100 POLK COUNTY PLAZA, SUITE 1
BALSAM LAKE WI 54810

Bill To

Customer ID: 336949
POLK COUNTY LAND & WATER RESOURCES DEPARTMENT
100 POLK COUNTY PLAZA, SUITE 120
BALSAM LAKE WI 54810

ID#: 493116
Waterbody/Outfall ID: 2616000
Point/Well:
Account #: PP001
Project No:
Date Received: 10/02/2012
Date Reported: 03/26/2013
Sample Reason:

Field #:
Collection Start: 09/05/2012
Collection End:
Collected By: J. WILLIAMSON
County:
Sample Source: SURFACE WATER
Sample Depth: 2 Meters
Sample Information: LPL-1473-12;
Sample Location: WIND LAKE - DEEP HOLE
Sample Description: COMPOSITE SAMPLER
Analyses and Results:

Wisconsin State Laboratory of Hygiene
2601 Agriculture Drive, PO Box 7996
Madison, WI 53707-7996
(800)442-4618 • FAX (608)224-6213
http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division   Environmental Toxicology

WDNR LAB ID: 113133790   NELAP LAB ID: E37658   EPA LAB WI00007   WI DATCP ID: 105-415

WSLH Sample: FX000370

Taxa	Division	Result	Unit	Percentage
CYCLOTELLA SP.	BACILLARIOPHYTA	7.	CELLS/ML	0.0 %
FRAGILARIA SP.	BACILLARIOPHYTA	130.	CELLS/ML	0.9 %
NAVICULOID DIATOMS	BACILLARIOPHYTA	7.	CELLS/ML	0.0 %
CLOSTERIUM SP.	CHLOROPHYTA	7.	CELLS/ML	0.0 %
OOCYSTIS SP.	CHLOROPHYTA	130.	CELLS/ML	0.9 %
QUADRIGULA SP.	CHLOROPHYTA	87.	CELLS/ML	0.6 %
SCENEDESMUS SP.	CHLOROPHYTA	1247.	CELLS/ML	8.5 %
SCHROEDERIA SP.	CHLOROPHYTA	181.	CELLS/ML	1.2 %
TETRAEDRON SP.	CHLOROPHYTA	43.	CELLS/ML	0.3 %
DINOBRYON SP.	CHRYSOPHYTA	51.	CELLS/ML	0.3 %
CRYPTOMONAS SP.	CRYPTOPHYTA	116.	CELLS/ML	0.8 %
KOMMA CAUDATA	CRYPTOPHYTA	725.	CELLS/ML	4.9 %
APHANIZOMENON SP.	CYANOPHYTA	2138.	CELLS/ML	14.5 %
APHANOCAPSA SP.	CYANOPHYTA	2341.	CELLS/ML	15.9 %
APHANOTHECE SP.	CYANOPHYTA	5429.	CELLS/ML	36.8 %
CHROOCOCCUS SP.	CYANOPHYTA	72.	CELLS/ML	0.5 %
COELOSPHAERIUM SP.	CYANOPHYTA	1500.	CELLS/ML	10.2 %
MICROCYSTIS SP.	CYANOPHYTA	239.	CELLS/ML	1.6 %
PLANKTOLYNGBYA SP.	CYANOPHYTA	145.	CELLS/ML	1.0 %
PSEUDANABAENA SP.	CYANOPHYTA	138.	CELLS/ML	0.9 %
CERATIUM SP.	PYRRHOPHYTA	7.	CELLS/ML	0.0 %

Test results for NELAP accredited tests are certified to meet the requirements of the NELAC standards. For a list of accredited analytes see http://www.slh.wisc.edu/nelap/

List of Abbreviations:

Natural Unit = Unicell, Colony or Filament Equals 1 Unit
LOD = Level of detection
LOQ = Level of quantification
ND = None detected. Results are less than the LOD

Responsible Party: *Steve Geis* Steve Geis, Chemist Supervisor

If there are questions about this report, please contact Dawn Perkins at 608-224-6230.

The results in this report apply only to the sample specifically listed above. This report is not to be reproduced except in full.

Report #: 9546872

Wisconsin State Laboratory of Hygiene
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Madison, WI 53707-7996
(800)442-4618 • FAX (608)224-6213
http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division   Environmental Toxicology

WDNR LAB ID: 113133790   NELAP LAB ID: E37658   EPA LAB   WI00007   WI DATCP ID: 105-415

WSLH Sample: FX000365

POLK COUNTY LAND & WATER RESOU
100 POLK COUNTY PLAZA, SUITE 1
BALSAM LAKE WI 54810

Bill To

Customer ID: 336949
POLK COUNTY LAND & WATER RESOURCES DEPARTMENT
100 POLK COUNTY PLAZA, SUITE 120
BALSAM LAKE WI 54810

ID#: 493107

Field #:
Collection Start: 05/07/2012
Collection End:
Collected By: J. WILLIAMSON
County:
Sample Source: SURFACE WATER
Sample Depth: 2 Meters
Sample Information: LPL-1473-12;
Sample Location: BIG LAKE - DEEP HOLE
Sample Description: COMPOSITE SAMPLER
Analyses and Results:

Waterbody/Outfall ID: 2615900
Point/Well:
Account #: PP001
Project No:
Date Received: 10/02/2012
Date Reported: 03/25/2013
Sample Reason:

Taxa	Division	Result	Unit	Percentage
FRAGILARIA SP.	BACILLARIOPHYTA	28.	CELLS/ML	2.0 %
CLOSTERIUM SP.	CHLOROPHYTA	14.	CELLS/ML	1.0 %
SCHROEDERIA SP.	CHLOROPHYTA	453.	CELLS/ML	32.0 %
DINOBRYON SP.	CHRYSOPHYTA	9.	CELLS/ML	0.6 %
CRYPTOMONAS SP.	CRYPTOPHYTA	51.	CELLS/ML	3.6 %
KOMMA CAUDATA	CRYPTOPHYTA	859.	CELLS/ML	60.7 %

Wisconsin State Laboratory of Hygiene
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Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division — Environmental Toxicology

WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB WI00007 WI DATCP ID: 105-415

WSLH Sample: FX000365

Test results for NELAP accredited tests are certified to meet the requirements of the NELAC standards. For a list of accredited analytes see http://www.slh.wisc.edu/nelap/

List of Abbreviations:

Natural Unit = Unicell, Colony or Filament Equals 1 Unit
LOD = Level of detection
LOQ = Level of quantification
ND = None detected. Results are less than the LOD

Responsible Party: [signature] Steve Geis, Chemist Supervisor

If there are questions about this report, please contact Dawn Perkins at 608-224-6230.

The results in this report apply only to the sample specifically listed above. This report is not to be reproduced except in full.

Report #: 9546652

Wisconsin State Laboratory of Hygiene
2601 Agriculture Drive, PO Box 7996
Madison, WI 53707-7996
(800)442-4618 • FAX (608)224-6213
http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division   Environmental Toxicology

WDNR LAB ID: 113133790   NELAP LAB ID: E37658   EPA LAB WI00007   WI DATCP ID: 105-415

WSLH Sample: FX000364

POLK COUNTY LAND & WATER RESOU
100 POLK COUNTY PLAZA, SUITE 1
BALSAM LAKE WI 54810

Bill To

Customer ID: 336949
POLK COUNTY LAND & WATER RESOURCES DEPARTMENT
100 POLK COUNTY PLAZA, SUITE 120
BALSAM LAKE WI 54810

ID#: 493107

Field #:
Collection Start: 06/04/2012
Collection End:
Collected By: J. WILLIAMSON
County:
Sample Source: SURFACE WATER
Sample Depth: 2 Meters
Sample Information: LPL-1473-12;
Sample Location: BIG LAKE - DEEP HOLE
Sample Description: COMPOSITE SAMPLER

Waterbody/Outfall ID: 2615900
Point/Well:
Account #: PP001
Project No:
Date Received: 10/02/2012
Date Reported: 03/25/2013
Sample Reason:

Analyses and Results:

Taxa	Division	Result	Unit	Percentage
CAVINULA SP.	BACILLARIOPHYTA	13.	CELLS/ML	0.2 %
FRAGILARIA SP.	BACILLARIOPHYTA	13.	CELLS/ML	0.2 %
STEPHANODISCUS SP.	BACILLARIOPHYTA	13.	CELLS/ML	0.2 %
SCHROEDERIA SP.	CHLOROPHYTA	354.	CELLS/ML	6.0 %
DINOBRYON SP.	CHRYSOPHYTA	1991.	CELLS/ML	33.6 %
CRYPTOMONAS SP.	CRYPTOPHYTA	79.	CELLS/ML	1.3 %
KOMMA CAUDATA	CRYPTOPHYTA	1271.	CELLS/ML	21.5 %
APHANIZOMENON SP.	CYANOPHYTA	655.	CELLS/ML	11.1 %
APHANOTHECE SP.	CYANOPHYTA	799.	CELLS/ML	13.5 %
MICROCYSTIS SP.	CYANOPHYTA	354.	CELLS/ML	6.0 %
PLANKTOLYNGBYA SP.	CYANOPHYTA	354.	CELLS/ML	6.0 %
PHACUS SP.	EUGLENOPHYTA	26.	CELLS/ML	0.4 %

Wisconsin State Laboratory of Hygiene
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Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division — Environmental Toxicology

WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB WI00007 WI DATCP ID: 105-415

WSLH Sample: FX000364

Test results for NELAP accredited tests are certified to meet the requirements of the NELAC standards. For a list of accredited analytes see http://www.slh.wisc.edu/nelap/

List of Abbreviations:

Natural Unit = Unicell, Colony or Filament Equals 1 Unit

LOD = Level of detection

LOQ = Level of quantification

ND = None detected. Results are less than the LOD

Responsible Party: Steve Geis, Chemist Supervisor

If there are questions about this report, please contact Dawn Perkins at 608-224-6230.

The results in this report apply only to the sample specifically listed above. This report is not to be reproduced except in full.

Report #: 9546651

Wisconsin State Laboratory of Hygiene
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http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division   Environmental Toxicology

WDNR LAB ID: 113133790   NELAP LAB ID: E37658   EPA LAB   WI00007   WI DATCP ID: 105-415

WSLH Sample: FX000363

POLK COUNTY LAND & WATER RESOU
100 POLK COUNTY PLAZA, SUITE 1
BALSAM LAKE WI 54810

Bill To

Customer ID: 336949
POLK COUNTY LAND & WATER RESOURCES DEPARTMENT
100 POLK COUNTY PLAZA, SUITE 120
BALSAM LAKE WI 54810

ID#: 493107
Waterbody/Outfall ID: 2615900
Point/Well:
Account #: PP001
Project No:
Date Received: 10/02/2012
Date Reported: 03/25/2013
Sample Reason:

Field #:
Collection Start: 07/09/2012
Collection End:
Collected By: J. WILLIAMSON
County:
Sample Source: SURFACE WATER
Sample Depth: 2 Meters
Sample Information: LPL-1473-12;
Sample Location: BIG LAKE - DEEP HOLE
Sample Description: COMPOSITE SAMPLER
Analyses and Results:

Wisconsin State Laboratory of Hygiene
2601 Agriculture Drive, PO Box 7996
Madison, WI 53707-7996
(800)442-4618 • FAX (608)224-6213
http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division   Environmental Toxicology

WDNR LAB ID: 113133790   NELAP LAB ID: E37658   EPA LAB WI00007   WI DATCP ID: 105-415

WSLH Sample: FX000363

Taxa	Division	Result	Unit	Percentage
CAVINULA SP.	BACILLARIOPHYTA	16.	CELLS/ML	0.2 %
FRAGILARIA SP.	BACILLARIOPHYTA	115.	CELLS/ML	1.1 %
OOCYSTIS SP.	CHLOROPHYTA	94.	CELLS/ML	0.9 %
PANDORINA SP.	CHLOROPHYTA	262.	CELLS/ML	2.5 %
SCHROEDERIA SP.	CHLOROPHYTA	31.	CELLS/ML	0.3 %
CRYPTOMONAS SP.	CRYPTOPHYTA	31.	CELLS/ML	0.3 %
KOMMA CAUDATA	CRYPTOPHYTA	1101.	CELLS/ML	10.6 %
ANABAENA SP.	CYANOPHYTA	84.	CELLS/ML	0.8 %
APHANIZOMENON SP.	CYANOPHYTA	189.	CELLS/ML	1.8 %
APHANOCAPSA SP.	CYANOPHYTA	1494.	CELLS/ML	14.4 %
APHANOTHECE SP.	CYANOPHYTA	5335.	CELLS/ML	51.6 %
COELOSPHAERIUM SP.	CYANOPHYTA	975.	CELLS/ML	9.4 %
MICROCYSTIS SP.	CYANOPHYTA	199.	CELLS/ML	1.9 %
OSCILLATORIA SP.	CYANOPHYTA	356.	CELLS/ML	3.4 %
PLANKTOLYNGBYA SP.	CYANOPHYTA	63.	CELLS/ML	0.6 %

Test results for NELAP accredited tests are certified to meet the requirements of the NELAC standards. For a list of accredited analytes see http://www.slh.wisc.edu/nelap/

List of Abbreviations:

Natural Unit = Unicell, Colony or Filament Equals 1 Unit

LOD = Level of detection

LOQ = Level of quantification

ND = None detected. Results are less than the LOD

Responsible Party: Steve Geis Steve Geis, Chemist Supervisor

If there are questions about this report, please contact Dawn Perkins at 608-224-6230.

The results in this report apply only to the sample specifically listed above. This report is not to be reproduced except in full.

Report #: 9546650

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http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division   Environmental Toxicology

WDNR LAB ID: 113133790   NELAP LAB ID: E37658   EPA LAB WI00007   WI DATCP ID: 105-415

WSLH Sample: FX000362

POLK COUNTY LAND & WATER RESOU
100 POLK COUNTY PLAZA, SUITE 1
BALSAM LAKE WI 54810

Bill To

Customer ID: 336949
POLK COUNTY LAND & WATER RESOURCES DEPARTMENT
100 POLK COUNTY PLAZA, SUITE 120
BALSAM LAKE WI 54810

ID#: 493107
Waterbody/Outfall ID: 2615900
Point/Well:
Account #: PP001
Project No:
Date Received: 10/02/2012
Date Reported: 03/25/2013
Sample Reason:

Field #:
Collection Start: 08/06/2012
Collection End:
Collected By: J. WILLIAMSON
County:
Sample Source: SURFACE WATER
Sample Depth: 2 Meters
Sample Information: LPL-1473-12
Sample Location: BIG LAKE - DEEP HOLE
Sample Description: COMPOSITE SAMPLER
Analyses and Results:

Wisconsin State Laboratory of Hygiene
2601 Agriculture Drive, PO Box 7996
Madison, WI 53707-7996
(800)442-4618 • FAX (608)224-6213
http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division Environmental Toxicology

WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB WI00007 WI DATCP ID: 105-415

WSLH Sample: FX000362

Taxa	Division	Result	Unit	Percentage
CAVINULA SP.	BACILLARIOPHYTA	10.	CELLS/ML	0.2 %
CYCLOTELLA SP.	BACILLARIOPHYTA	10.	CELLS/ML	0.2 %
FRAGILARIA SP.	BACILLARIOPHYTA	7.	CELLS/ML	0.2 %
NAVICULOID DIATOMS	BACILLARIOPHYTA	3.	CELLS/ML	0.1 %
DYSMORPHOCOCCUS SP.	CHLOROPHYTA	10.	CELLS/ML	0.2 %
OOCYSTIS SP.	CHLOROPHYTA	37.	CELLS/ML	0.9 %
PANDORINA SP.	CHLOROPHYTA	17.	CELLS/ML	0.4 %
SCENEDESMUS SP.	CHLOROPHYTA	95.	CELLS/ML	2.2 %
CRYPTOMONAS SP.	CRYPTOPHYTA	37.	CELLS/ML	0.9 %
KOMMA CAUDATA	CRYPTOPHYTA	674.	CELLS/ML	15.8 %
ANABAENA SP.	CYANOPHYTA	41.	CELLS/ML	1.0 %
APHANIZOMENON SP.	CYANOPHYTA	473.	CELLS/ML	11.1 %
APHANOTHECE SP.	CYANOPHYTA	695.	CELLS/ML	16.3 %
COELOSPHAERIUM SP.	CYANOPHYTA	1877.	CELLS/ML	44.0 %
OSCILLATORIA SP.	CYANOPHYTA	191.	CELLS/ML	4.5 %
PLANKTOLYNGBYA SP.	CYANOPHYTA	82.	CELLS/ML	1.9 %
TRACHELOMONAS SP.	EUGLENOPHYTA	3.	CELLS/ML	0.1 %
CERATIUM SP.	PYRRHOPHYTA	3.	CELLS/ML	0.1 %

Test results for NELAP accredited tests are certified to meet the requirements of the NELAC standards. For a list of accredited analytes see http://www.slh.wisc.edu/nelap/

List of Abbreviations:

Natural Unit = Unicell, Colony or Filament Equals 1 Unit

LOD = Level of detection

LOQ = Level of quantification

ND = None detected. Results are less than the LOD

Responsible Party: Steve Geis Steve Geis, Chemist Supervisor

If there are questions about this report, please contact Dawn Perkins at 608-224-6230.

The results in this report apply only to the sample specifically listed above. This report is not to be reproduced except in full.

Report #: 9546649

Wisconsin State Laboratory of Hygiene
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Madison, WI 53707-7996
(800)442-4618 • FAX (608)224-6213
http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division   Environmental Toxicology

WDNR LAB ID: 113133790   NELAP LAB ID: E37658   EPA LAB WI00007   WI DATCP ID: 105-415

WSLH Sample: FX000361

POLK COUNTY LAND & WATER RESOU
100 POLK COUNTY PLAZA, SUITE 1
BALSAM LAKE WI 54810

Bill To

Customer ID: 336949
POLK COUNTY LAND & WATER RESOURCES DEPARTMENT
100 POLK COUNTY PLAZA, SUITE 120
BALSAM LAKE WI 54810

ID#: 493107
Waterbody/Outfall ID: 2615900
Point/Well:
Account #: PP001
Project No:
Date Received: 10/02/2012
Date Reported: 03/25/2013
Sample Reason:

Field #:
Collection Start: 09/05/2012
Collection End:
Collected By: J. WILLIAMSON
County:
Sample Source: SURFACE WATER
Sample Depth: 2 Meters
Sample Information: LPL-1473-12
Sample Location: BIG LAKE - DEEP HOLE
Sample Description: COMPOSITE SAMPLER
Analyses and Results:

Taxa	Division	Result	Unit	Percentage
CAVINULA SP.	BACILLARIOPHYTA	14.	CELLS/ML	0.1 %
OOCYSTIS SP.	CHLOROPHYTA	19.	CELLS/ML	0.1 %
PANDORINA SP.	CHLOROPHYTA	37.	CELLS/ML	0.3 %
CRYPTOMONAS SP.	CRYPTOPHYTA	135.	CELLS/ML	1.0 %
KOMMA CAUDATA	CRYPTOPHYTA	798.	CELLS/ML	6.2 %
ANABAENA SP.	CYANOPHYTA	854.	CELLS/ML	6.6 %
APHANIZOMENON SP.	CYANOPHYTA	2501.	CELLS/ML	19.4 %
APHANOTHECE SP.	CYANOPHYTA	7121.	CELLS/ML	55.2 %
OSCILLATORIA SP.	CYANOPHYTA	653.	CELLS/ML	5.1 %
PLANKTOLYNGBYA SP.	CYANOPHYTA	751.	CELLS/ML	5.8 %
TRACHELOMONAS SP.	EUGLENOPHYTA	5.	CELLS/ML	0.0 %
CERATIUM SP.	PYRRHOPHYTA	19.	CELLS/ML	0.1 %

Wisconsin State Laboratory of Hygiene
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Madison, WI 53707-7996
(800)442-4618 • FAX (608)224-6213
http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division   Environmental Toxicology

WDNR LAB ID: 113133790   NELAP LAB ID: E37658   EPA LAB WI00007   WI DATCP ID: 105-415

WSLH Sample: FX000361

Test results for NELAP accredited tests are certified to meet the requirements of the NELAC standards. For a list of accredited analytes see http://www.slh.wisc.edu/nelap/

List of Abbreviations:

Natural Unit = Unicell, Colony or Filament Equals 1 Unit
LOD = Level of detection
LOQ = Level of quantification
ND = None detected. Results are less than the LOD

Responsible Party: Steve Geis, Chemist Supervisor

If there are questions about this report, please contact Dawn Perkins at 608-224-6230.

The results in this report apply only to the sample specifically listed above. This report is not to be reproduced except in full.

Report #: 9546648

Appendix E

Zooplankton Data

Taxa abundance

Site	Big Lake	Big Lake	Big Lake	Big Lake	Big Lake	Big Lake	Church Pine	Church Pine	Church Pine	Church Pine	Church Pine	Wind Lake	Wind Lake	Wind Lake	Wind Lake	Wind Lake	Wind Lake
Date	7-May-12	4-Jun-12	9-Jul-12	9-Jul-12	6-Aug-12	5-Sep-12	7-May-12	4-Jun-12	9-Jul-12	6-Aug-12	5-Sep-12	7-May-12	4-Jun-12	9-Jul-12	6-Aug-12	6-Aug-12	5-Sep-12
				Replicate												Replicate	
Site Code	BigL	BigL	BigL	BigL	BigL	BigL	ChurP	ChurP	ChurP	ChurP	ChurP	Wind	Wind	Wind	Wind	Wind	Wind
Taxa richness	7	11	14	15	19	18	17	16	16	17	18	15	20	16	12	15	14
#/l -->																	
total n (#/l)	26.8482981	16.437734	139.9947	182.5958236	107.3247	134.72092	57.953548	36.003642	16.024156	50.622424	49.49233	131.04526	127.11847	142.46036	79.449046	73.421877	211.86412
Rotifera	5.75320674	5.7532067	120.54338	168.486769	68.490556	103.87734	33.226701	16.734087	7.7078219	27.23816746	33.265336	94.288666	99.996212	98.626401	56.984143	44.929805	147.9396
Copepoda	12.4652813	9.8626401	17.807545	13.6981113	24.245657	23.971695	19.317849	17.24118	7.0993096	21.44281269	14.604294	30.364147	26.026411	30.135845	20.821129	17.533582	47.486786
Cladocera	8.62981012	0	1.6437734	0.410943339	13.218677	5.2737728	5.4089978	2.0283742	1.2170245	1.361908373	1.6226993	3.196226	1.0958489	4.1094334	1.6437734	10.958489	16.437734
testate protozoa	0	0.8218867	0	0	1.3698111	1.598113	0	0	0	0.579535478	0	3.196226	0	9.5886779	0	0	0
#/l -->																	
ROTIFERA																	
Anuraeopsis fissa													2.7396223				
Ascomorpha sp.					9.5886779				0.8113497	2.318141912	1.6226993				2.1916978	3.2875467	12.784904
Asplanchna herricki	2.87660337			1.36981113		1.598113											
Aplanchna priodonta		0.8218867						0.5070935		1.159070956		4.794339	9.5886779			2.1916978	
Collotheca sp.			1.3698111	1.36981113		3.196226			3.2453987	5.215819302		3.196226	5.4792445	34.245278	21.916978	17.533582	
Colurella sp.																	
Conochilus unicornis			71.230179	104.1056459	13.698111	51.139616											
Euchlanis sp.									0.4056748								
Filinia longiseta											0.4056748						
Filinia terminalis						1.598113											
Hexarthra mira																	1.8264148
Kellicottia bostoniensis											8.9248464						5.4792445
Kellicottia longispina	0.95886779						22.408705	5.0709354	0.4056748			20.775469	2.7396223				
Keratella cochlearis cochlearis	1.91773558	0.8218867	36.984901	42.46414502	23.286789	31.96226		1.5212806	0.8113497	2.89767739	15.009969		15.067922	28.766034	30.683769	19.72528	115.06413
Keratella cochlearis hispida		0.8218867						4.0567483	0.8113497	1.159070956							
Keratella cochlearis robusta				2.73962226		6.3924519						17.579243		10.958489			7.3056594
Keratella cochlearis tecta							0.772714										

Keratella earlinae					1.3698111		1.5454279	1.5212806			0.4056748		15.067922				
Monostyla lunaris									0.4056748				1.3698111				
Monostyla quadridentata														1.3698111			
Polyarthra sp.						1.598113							17.807545				
Polyarthra dolichoptera					2.7396223		0.772714						9.5886779	1.3698111			
Polyarthra euryptera			2.7396223	4.109433389					0.4056748					1.3698111	1.0958489	1.0958489	
Polyarthra major								1.5212806									
Polyarthra remata			6.8490556	10.95848904	2.7396223			1.5212806		0.579535478	0.4056748	44.747164	2.7396223				
Polyarthra vulgaris		0.8218867			1.3698111		6.9544257		0.4056748	13.32931599	4.868098		1.3698111	16.437734			
Pompholyx sulcata		0.8218867	1.3698111		6.8490556	4.794339		1.0141871			0.4056748		1.3698111	4.1094334			
Proales sp.											0.4056748						
Trichocerca cylindrica				1.36981113	1.3698111											1.0958489	
Trichocerca pusilla													13.698111				
Trichocerca multicrinis		1.6437734				1.598113											
Trocosphaera sp.															1.0958489		
unidentified rotifer					5.4792445		0.772714			0.579535478	0.8113497	3.196226	1.3698111				5.4792445
COPEPODA																	
cyclopoid nauplius	7.67094233	2.46566	9.5886779	5.479244519	21.916978	15.98113	7.7271397	11.156058	3.2453987	15.64745791	9.3305212	12.784904	13.698111	13.698111	12.054338	5.4792445	20.090563
cyclopoid copepodid	3.83547116	0.8218867		1.36981113	0.4794339			0.5070935	2.0283742	1.159070956		4.794339	4.1094334	5.4792445	3.2875467	2.1916978	5.4792445
calanoid nauplius		4.1094334	1.3698111	1.36981113	1.3698111	3.196226	0.772714	2.5354677	0.4056748	0.579535478	1.6226993	4.794339	5.4792445	4.1094334	1.0958489	3.2875467	1.8264148
calanoid copepodid		2.46566					1.5454279	0.5070935									
Acanthocyclops sp.							0.772714				0.8113497			1.3698111			
Cyclops sp.										0.579535478							
Diacyclops spp.	0.95886779						2.3181419	1.5212806	1.2170245	2.89767739			1.3698111				20.090563
Mesocyclops sp.			1.3698111	1.36981113		1.598113										1.0958489	
(Metacyclops sp.)							0.772714										
Microcyclops sp.			1.3698111			3.196226					2.0283742	3.196226			3.2875467	1.0958489	
[Thermocyclops crassus]							2.3181419				0.8113497	3.196226					
Diaptomidae			2.7396223	2.73962226	0.4794339							1.598113	1.3698111	5.4792445	1.0958489	4.3833956	

(Arctodiaptomus arapahoensis)			1.3698111	1.36981113													
(Osphrantium sp.)							3.0908559	1.0141871	0.2028374	0.579535478							
CLADOCERA																	
Bosmina coregoni																	1.8264148
Bosmina longirostris												1.598113	1.0958489	1.3698111			
Bosmina longispina							0.772714										
Ceriodaphnia sp.			0.4109433			1.598113								2.7396223		1.0958489	
Chydorus sp.					1.3698111												
Diaphanosoma sp.					2.7396223	1.598113					0.4056748				1.0958489	6.5750934	3.6528297
Daphnia ambigua												1.598113					
Daphnia mendotae			1.23283	0.410943339		0.4794339	2.3181419	1.5212806	0.8113497	1.159070956	0.8113497				0.5479245	3.2875467	1.8264148
Daphnia parvula					6.2326406						0.4056748						
Daphnia pulex	8.62981012				2.8766034	1.598113	2.3181419	0.5070935	0.4056748								
Daphnia retrocurva																	9.1320742
Leptodora kindtii										0.202837417							
Difflugia oblonga		0.8218867			1.3698111												
Difflugia lobostoma						1.598113				0.579535478				9.5886779			
Trinema sp.												3.196226					

Genera abundance

Site	Big Lake	Big Lake	Big Lake	Big Lake	Big Lake	Big Lake	Church Pine	Church Pine	Church Pine	Church Pine	Church Pine	Wind Lake	Wind Lake	Wind Lake	Wind Lake	Wind Lake	Wind Lake
Date	7-May-12	4-Jun-12	9-Jul-12	9-Jul-12	6-Aug-12	5-Sep-12	7-May-12	4-Jun-12	9-Jul-12	6-Aug-12	5-Sep-12	7-May-12	4-Jun-12	9-Jul-12	6-Aug-12	6-Aug-12	5-Sep-12
				Replicate												Replicate	
Site Code	BigL	BigL	BigL	BigL	BigL	BigL	ChurP	ChurP	ChurP	ChurP	ChurP	Wind	Wind	Wind	Wind	Wind	Wind
Taxa richness	7	11	14	15	19	18	17	16	16	17	18	15	20	16	12	15	14
total n (#/l)	26.8483	16.4377	139.995	182.596	107.325	134.721	57.9535	36.0036	16.0242	50.6224	49.4923	131.045	127.118	142.46	79.449	73.4219	211.864
Rotifera	5.753207	5.75321	120.543	168.487	68.4906	103.877	33.2267	16.7341	7.70782	27.2382	33.2653	94.2887	99.9962	98.6264	56.9841	44.9298	147.94
Copepoda	12.46528	9.86264	17.8075	13.6981	24.2457	23.9717	19.3178	17.2412	7.09931	21.4428	14.6043	30.3641	26.0264	30.1358	20.8211	17.5336	47.4868
Cladocera	8.62981		1.64377	0.41094	13.2187	5.27377	5.409	2.02837	1.21702	1.36191	1.6227	3.19623	1.09585	4.10943	1.64377	10.9585	16.4377

testate protozoa		0.82189			1.36981	1.59811				0.57954		3.19623		9.58868			
ROTIFERA																	
Anuraeopsis													2.73962				
Ascomorpha					9.58868				0.81135	2.31814	1.6227				2.1917	3.28755	12.7849
Asplanchna	2.876603	0.82189	0	1.36981	0	1.59811	0	0.50709	0	1.15907	0	4.79434	9.58868	0	0	2.1917	0
Collotheca			1.36981	1.36981		3.19623			3.2454	5.21582		3.19623	5.47924	34.2453	21.917	17.5336	
Conochilus			71.2302	104.106	13.6981	51.1396											
Euchlanis									0.40567								
Filinia						1.59811					0.40567						
Hexarthra																	1.82641
Kellicottia	0.958868						22.4087	5.07094	0.40567		8.92485	20.7755	2.73962				5.47924
Keratella	1.917736	1.64377	36.9849	45.2038	24.6566	38.3547	2.31814	7.09931	1.6227	4.05675	15.4156	17.5792	30.1358	39.7245	30.6838	19.7253	122.37
Monostyla									0.40567				1.36981	1.36981			
Polyarthra		0.82189	9.58868	15.0679	6.84906	1.59811	7.72714	3.04256	0.81135	13.9089	5.27377	44.7472	31.5057	19.1774	1.09585	1.09585	
Pompholyx		0.82189	1.36981		6.84906	4.79434		1.01419			0.40567		1.36981	4.10943			
Proales											0.40567						
Trichocerca		1.64377		1.36981	1.36981	1.59811							13.6981			1.09585	
Trocosphaera															1.09585		
unidentified rotifer					5.47924		0.77271			0.57954	0.81135	3.19623	1.36981				5.47924
COPEPODA																	
cyclopoid nauplius	7.670942	2.46566	9.58868	5.47924	21.917	15.9811	7.72714	11.1561	3.2454	15.6475	9.33052	12.7849	13.6981	13.6981	12.0543	5.47924	20.0906
cyclopoid copepodid	3.835471	0.82189		1.36981	0.47943			0.50709	2.02837	1.15907		4.79434	4.10943	5.47924	3.28755	2.1917	5.47924
calanoid nauplius		4.10943	1.36981	1.36981	1.36981	3.19623	0.77271	2.53547	0.40567	0.57954	1.6227	4.79434	5.47924	4.10943	1.09585	3.28755	1.82641
calanoid copepodid		2.46566					1.54543	0.50709									
Acanthocyclops							0.77271				0.81135			1.36981			
Cyclops										0.57954							
Diacyclops	0.958868						2.31814	1.52128	1.21702	2.89768			1.36981				20.0906
Mesocyclops			1.36981	1.36981		1.59811										1.09585	
(Metacyclops)							0.77271										
Microcyclops			1.36981			3.19623					2.02837	3.19623			3.28755	1.09585	
[Thermocyclops]							2.31814				0.81135	3.19623					
Diaptomidae			2.73962	2.73962	0.47943							1.59811	1.36981	5.47924	1.09585	4.3834	
(Arctodiaptomus)			1.36981	1.36981													

(Osphrantium)							3.09086	1.01419	0.20284	0.57954							
Bosmina							0.77271					1.59811	1.09585	1.36981			1.82641
Ceriodaphnia			0.41094			1.59811								2.73962		1.09585	
Chydorus					1.36981												
Daphnia	8.62981		1.23283	0.41094	9.10924	2.07755	4.63628	2.02837	1.21702	1.15907	1.21702	1.59811			0.54792	3.28755	10.9585
Diaphanosoma					2.73962	1.59811					0.40567				1.09585	6.57509	3.65283
Leptodora kindtii										0.20284							
Difflugia		0.82189			1.36981	1.59811				0.57954				9.58868			
Trinema												3.19623					

Zooplankton of the Apple River Flowage, Big Lake, Church Pine Lake, Long Lake and Wind Lake of Polk County, WI, 2012.

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May 2013

Bosmina coregoni **from Long Lake, Polk Co., WI, 2012. Lateral field of view = 0.75 mm. Photo T. Lafrançois.**

Suggested citation: Lafrançois, T. 2013. Zooplankton of the Apple River Flowage, Big Lake, Church Pine Lake, Long Lake and Wind Lake of Polk County, WI, 2012. Final report to Polk County Land & Water Resources Department, Polk Co. WI.

Thirty five samples from lakes in Polk County were examined for zooplankton species abundances, including Wind Lake, Church Pine Lake, Big Lake, Long Lake, and two sites in the Apple River Flowage. Data and preliminary analyses have been sent with this report as an attachment in Microsoft Excel.

Methods

Laboratory methods used a dual counting technique for different size fractions modified from Chick et al. 2006 and Chick et al. 2010. Samples were processed and counted at the Applied Research and Environmental Laboratory (ARELab) of Northland College, Ashland WI and at the Great Lakes Inventory and Monitoring Network of the National Park Service who generously provided microscope access during construction at the Northland College lab. Zooplankton samples were condensed on a 20 µm filter, transferred to 40 mL centrifuge tubes and diluted to between 20 and 40 ml depending on sample density. This volume was rigorously agitated, sub-sampled with a 1mL Hensen-Stempel pipette, and transferred to a 1mL Sedgwick Rafter counting slide. Organisms of all size fractions were counted on a compound microscope at magnifications of 40x to 100x. Counts were tallied row by row (1/20 ml increments) on the Sedgwick Rafter cell until stable variance in taxa diversity was achieved (Colwell & Coddington 1994). The larger organisms (primarily copepods and cladocerans) were then counted for the entire cell and checked against the entire sample.

Stable variance in taxonomic diversity and total number for these samples was achieved when at least 50 individuals of smaller species were counted (with volume counted between 0.6 and 2 ml out of 20-40 ml). The abundance of larger individuals varied greatly so best professional judgment was used to count based not on number but subsample volume of 1 to 2 ml out of 20-40 ml. Standard identification keys were used from Thorp & Covich (2010) to allow cross study comparison. Zooplankton counts were converted from numbers per subsample to number per liter (n/l). Three replicate samples were counted, randomly chosen from three different lakes (after a sample was randomly chosen, that lake was eliminated from the next random draw). This was done because variance can be different between systems. Lab replicates are shown on Figures 1-8, below simply as additional points. The biggest difference between replicates was in taxonomic diversity of Wind Lake, with three species between lab replicates. None of the replicates show differences in variance greater than differences between groups. Sample counting was constrained by budget but the numbers here are statistically robust but indicate that diversity would be best captured with more intensive counting (adding 1-2 rafter cells per sample).

Results and Discussion

Ninety one taxa were identified from the six sampling sites of the five lakes (Table 1). The majority of this diversity is from phylum Rotifera, followed by the crustacean Cladocera and then Copepoda. Testate protists should be considered an index of protist presence since most of that group is destroyed in ETOH preservative or is too small to be caught in the net. Ostracods are benthic and should be considered incidental catch not definitive of that community. The categories 'unidentifiable X' were specimens individually un-identifiable and are not a single taxa across samples or even within a sample.

No male calanoid copepods were found during counting which presents a problem taxonomically. Calanoids were identifiable to family (Diaptomidae) and sometimes genus or species but without males it is impossible to confirm. Species names in parentheses were assigned only with at least some evidence and should be taken as preliminary estimates of diversity and species presence. Cyclopoid copepod genera *Microcyclops* and *Cryptocyclops* are difficult to distinguish. All of the specimens where full identification was possible keyed to *Microcyclops*, but it is possible that *Cryptocyclops* is present.

Other cyclopoid copepods represent a very difficult problem. Species in brackets indicate species identified with very high certainty according to Thorp & Covich (2010), with clearly seen 5^{th} legs and other definitive characters. However, these species- *Thermocyclops crassus* and *Metacyclops sp.*- are found primarily in southeast Asia, being introduced species in North America.

Metacyclops is known in North America, including the southern United States. Previous reports from Minnesota are likely to be in error (Reid 1991). This does not preclude its presence however. *Thermocyclops crassus* is primarily Asiatic in distribution and its presence in Wisconsin would be surprising (Chaicharoen and others, 2011). There are three possible explanations- taxonomic error by the identifier, problems with the new taxonomic keys, or the actual presence of introduced species. It was not possible to get good digital pictures of the identifying characters due to equipment limitations, but the taxonomic features in these cases were very clear and are made with confidence. Whether these species are actually present or the taxonomic keys need revision is a question requiring further research. Their actual presence is not out of the question if recent immigrants have brought fishing gear from their country of origin or even if anglers from other parts of North America have utilized these lakes (particularly from Louisiana, USA or other southern regions). It is also possible that lack of comprehensive taxonomic study of Wisconsin freshwaters simply has missed these species in the past.

Table 1. The following species were identified from this survey. Species in parenthesis are preliminary identifications based on incomplete evidence. Species in brackets represent problematic taxa (see discussion).

ROTIFERA

Anuraeopsis fissa
Ascomorpha sp.
Asplanchna brightwelli
Asplanchna herricki
Asplanchna priodonta
Brachionus quadridentatus
Collotheca sp.
Colurella sp.
Conochilus unicornis
Euchlanis sp.
Filinia longiseta
Filinia terminalis
Gastropus sp.
Hexarthra mira
Kellicottia bostoniensis
Kellicottia longispina
Keratella crassa
Keratella cochlearis cochlearis
Keratella cochlearis hispida
Keratella cochlearis robusta
Keratella cochlearis tecta
Keratella earlinae
Lecane luna
Monostyla bulla
Monostyla closterocerca
Monostyla lunaris
Monostyla quadridentata
Notholca squamula
Notholca acuminata var extensa
Notomata sp.
Polyarthra sp.
Polyarthra dolichoptera
Polyarthra euryptera
Polyarthra major
Polyarthra remata
Polyarthra vulgaris
Pompholyx sulcata
Proales sp.
Synchaeta sp.
Trichocerca cylindrica
Trichocerca pusilla
Trichocerca lata
Trichocerca multicrinis
Trichotria tetractis
Trocosphaera sp.
unidentified rotifer

COPEPODA

cyclopoid nauplius
cyclopoid copepodid
calanoid nauplius
calanoid copepodid
Acanthocyclops sp.
Cyclops sp.
Diacyclops spp.
Mesocyclops sp.
[*Metacyclops* sp.]
Microcyclops sp.
Paracyclops chiltoni
[*Thermocyclops crassus*]
Diaptomidae
(*Arctodiaptomus arapahoensis*)
Heterocope septeptrionalis
(*Limnocalanus* sp.)
(*Osphrantium* sp.)
(*Senecella calanoides*)

CLADOCERA

Bosmina coregoni
Bosmina leideri
Bosmina longirostris
Bosmina longispina
Ceriodaphnia sp.
Ceriodaphnia lacustris
Ceriodaphnia laticaudata
Ceriodaphnia pulchella
Chydorus sp.
Chydorus faviformis
Chydorus sphaericus
Diaphanosoma sp.
Daphnia ambigua
Daphnia mendotae
Daphnia parvula
Daphnia pulex
Daphnia retrocurva
Leptodora kindtii
Acroperus harpae
Camptocercus sp.
Paralona pigra
Sida sp.
Simocephalus mirabilis

OSTRACODA

Cypridopsinae
Candonidae
Juvenile ostracod

TESTATE PROTIST

Arcella gibbosa
Centropyxis aerophila
Cyclopyxis arcelloides
Difflugia oblonga
Difflugia lobostoma
Trinema sp.
unidentifiable protist

Basic patterns in taxa diversity and abundance of the primary groups show that the Apple River Flowage, both north and south sites, supports the greatest abundance of zooplankton but also the greatest variation (Fig. 1). Big Lake (early season) and Church Pine (late season) had the lowest total zooplankton abundance of all sites. Taxonomic diversity was similar across all sampling sites (Fig. 2).

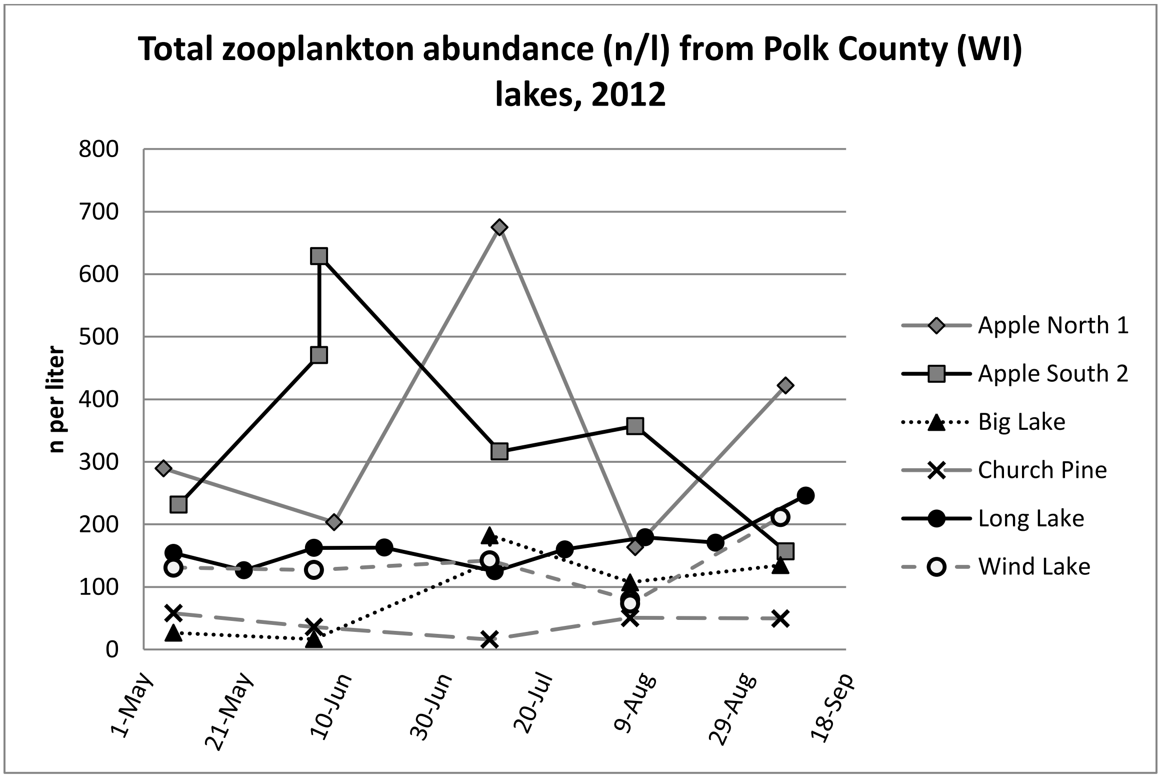

Figure 1. Total zooplankton abundance from six sampling sites in Polk Co., WI, 2012.

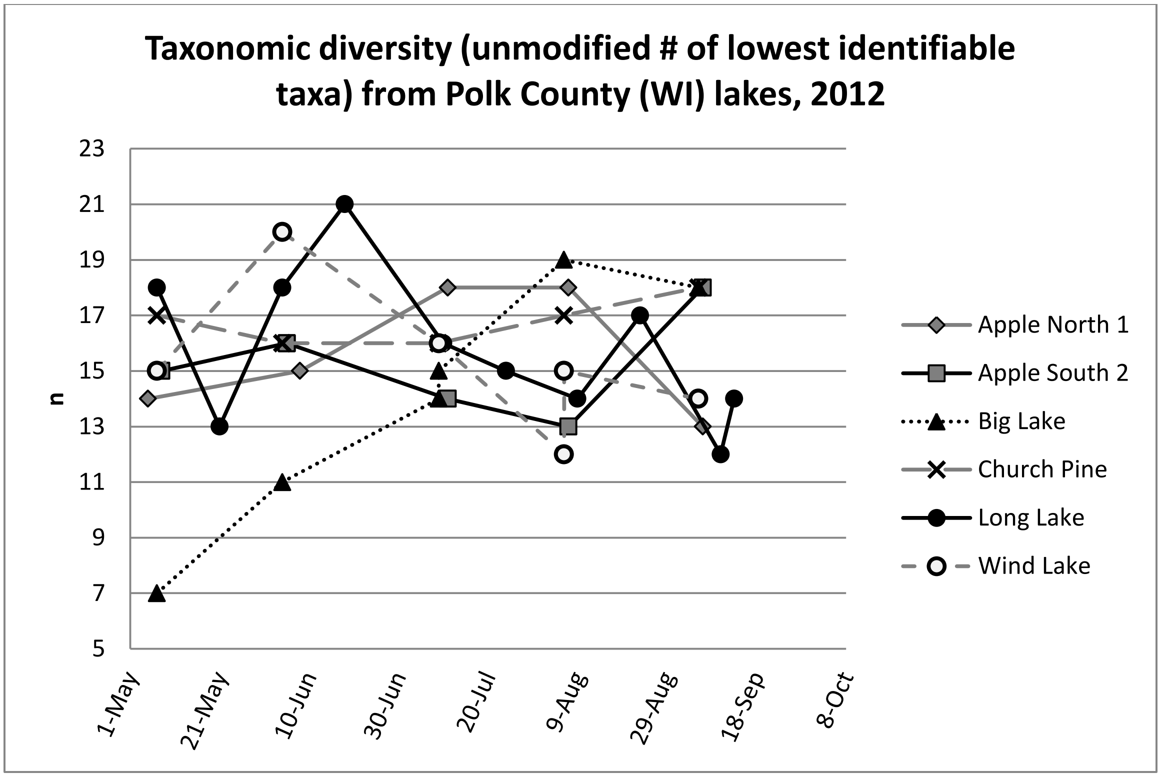

Figure 2. Total zooplankton taxonomic diversity (unmodified number of lowest identifiable taxa) from six sampling sites in Polk Co., WI, 2012.

The Apple River Flowage zooplankton were dominated by rotifers (Figs. 3 and 4), which is characteristic of flowing waters. Some cladocera are present but almost no copepods, which is somewhat unusual even for a flowing system. Abundance appears to fluctuate with the likely drivers being water retention time (higher flows reducing populations) and temperature (increasing productivity).

The Big Lake zooplankton community is dominated by rotifers, with an explosion in later summer (Fig. 5). Very low numbers of cladocera strongly suggest large populations of planktivorous fishes. The inverse relationship between cladoceran and rotifer populations appearing in the graphical representation are indicative of release from competition and predation on rotifers by elimination of larger crustaceans. Low numbers of crustacean plankton are an index of low algal grazing capacity.

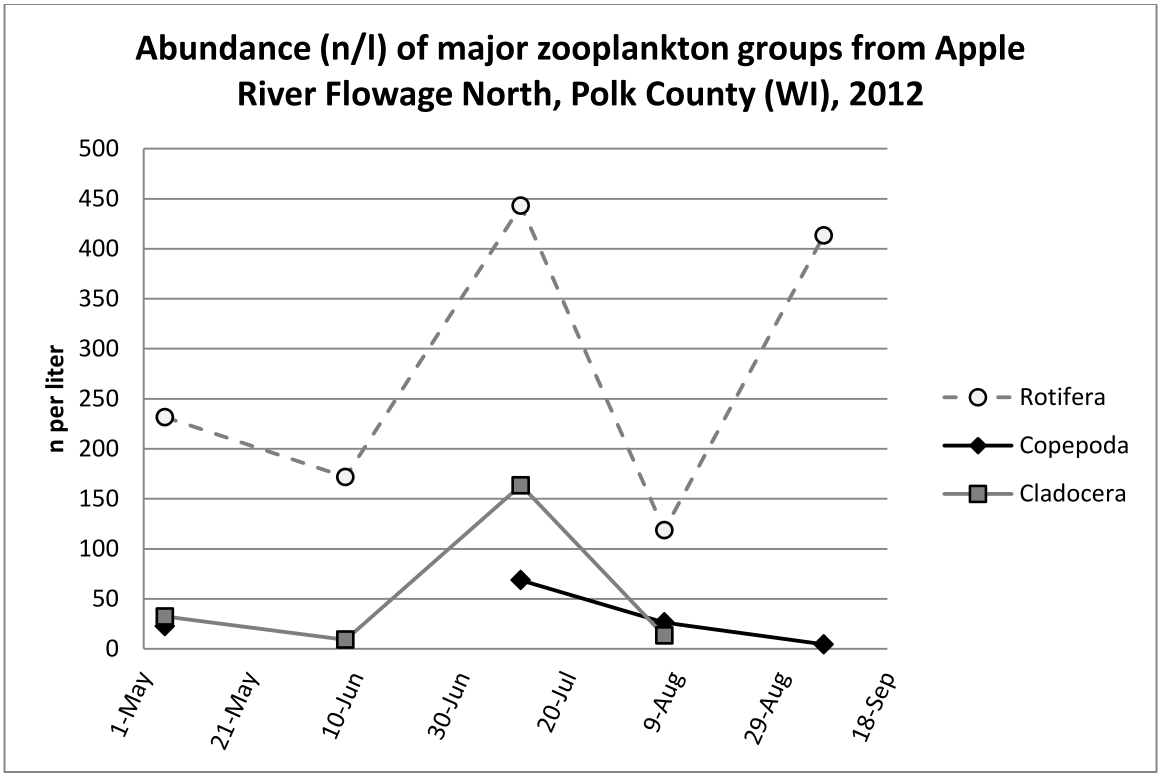

Figure 3. Zooplankton abundance (number per liter) from Apple River Flowage site 1 (north), Polk County, WI, 2012.

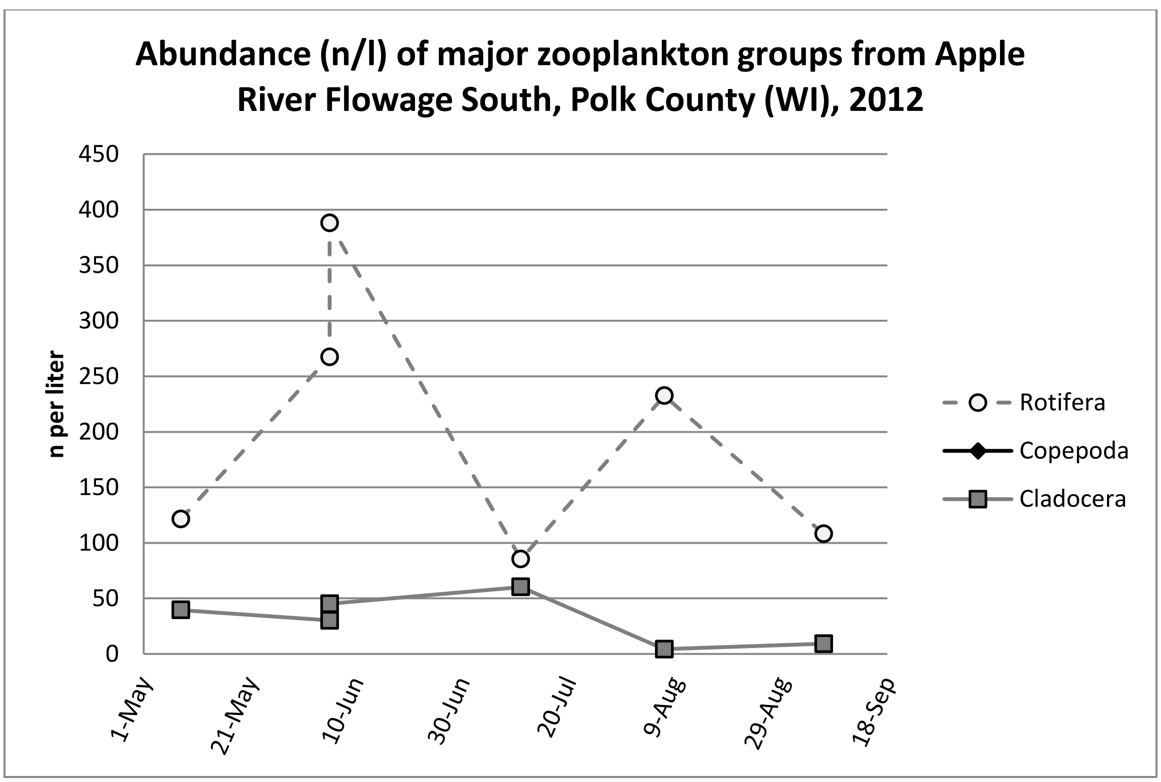

Figure 4. Zooplankton abundance (number per liter) from Apple River Flowage site 2 (south), Polk County, WI, 2012.

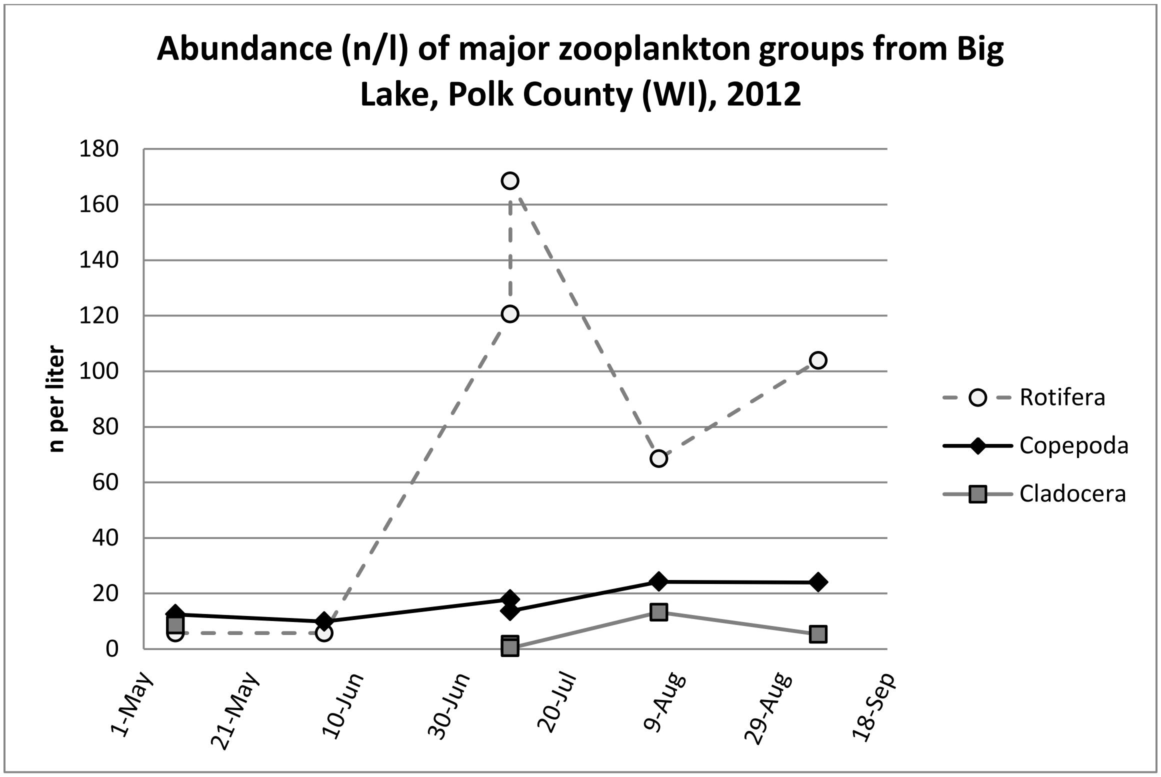

Figure 5. Zooplankton abundance (number per liter) from Big Lake, Polk County, WI, 2012.

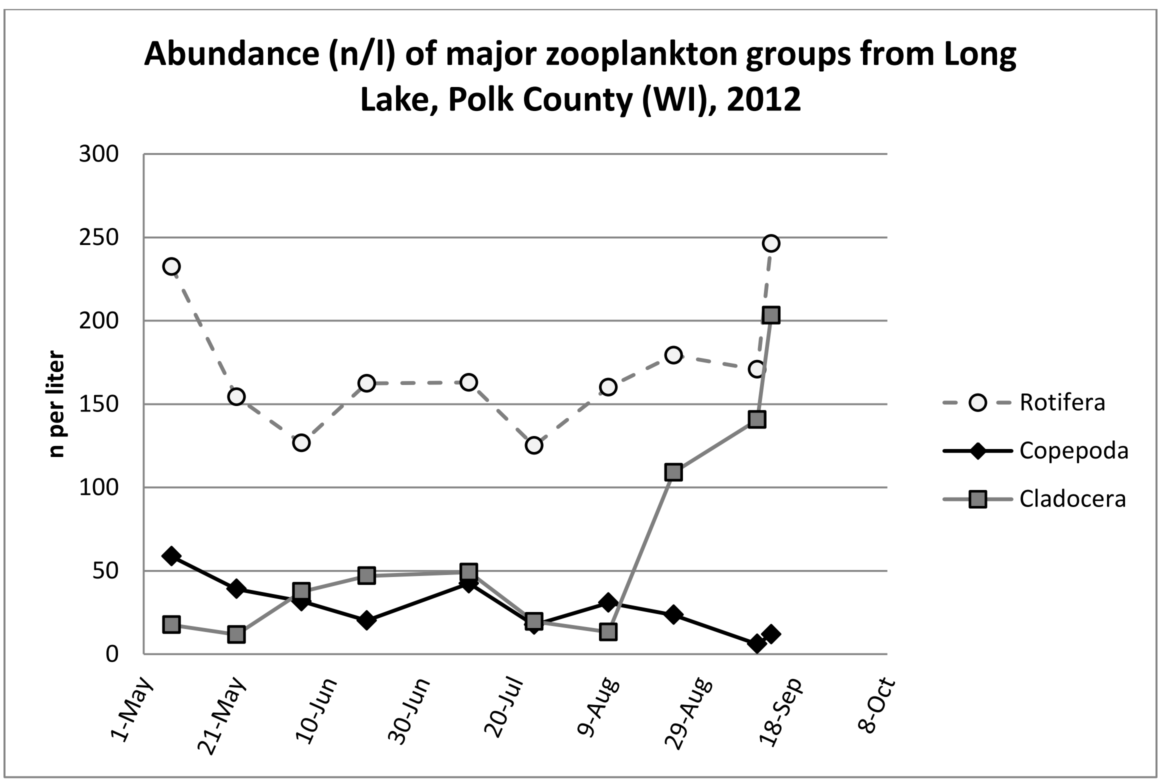

Figure 6. Zooplankton abundance (number per liter) from Long Lake, Polk County, WI, 2012.

Long lake shows a basic pattern similar to Big Lake, dominated by rotifers with (slightly) more crustacean plankton, but still lower than would be regionally expected (Lafrançois 2008, EOR 2009). The population explosion of cladocerans in late summer is primarily due to two groups (Fig. 6). One, the chydoridae and particularly *Paralona pigra*, generally indicative of the presence of macrophytes and shallower waters. Large numbers of *Bosmina coregoni* are also responsible for this trend, ironically they are often characteristic of clearer open waters, although they can be littoral as well. The concurrent drop in copepod abundance to near zero suggests that release from predation could also be a factor.

Wind Lake is again much like Big Lake and Long Lake in rotifer dominance and fewer crustaceans (Fig. 7). In particular, cladoceran numbers are very low relative to similar systems. Unlike Long lake, all groups increase in population in late summer, indicating increased productivity without any competitive interference. Overall patterns show a lake with high planktivorous fish populations and low grazing capacity. The patterns in Church Pine Lake (Fig. 8) are very similar with a much more dramatic population crash in mid-summer. It is unclear from the zooplankton data alone what may have caused this change.

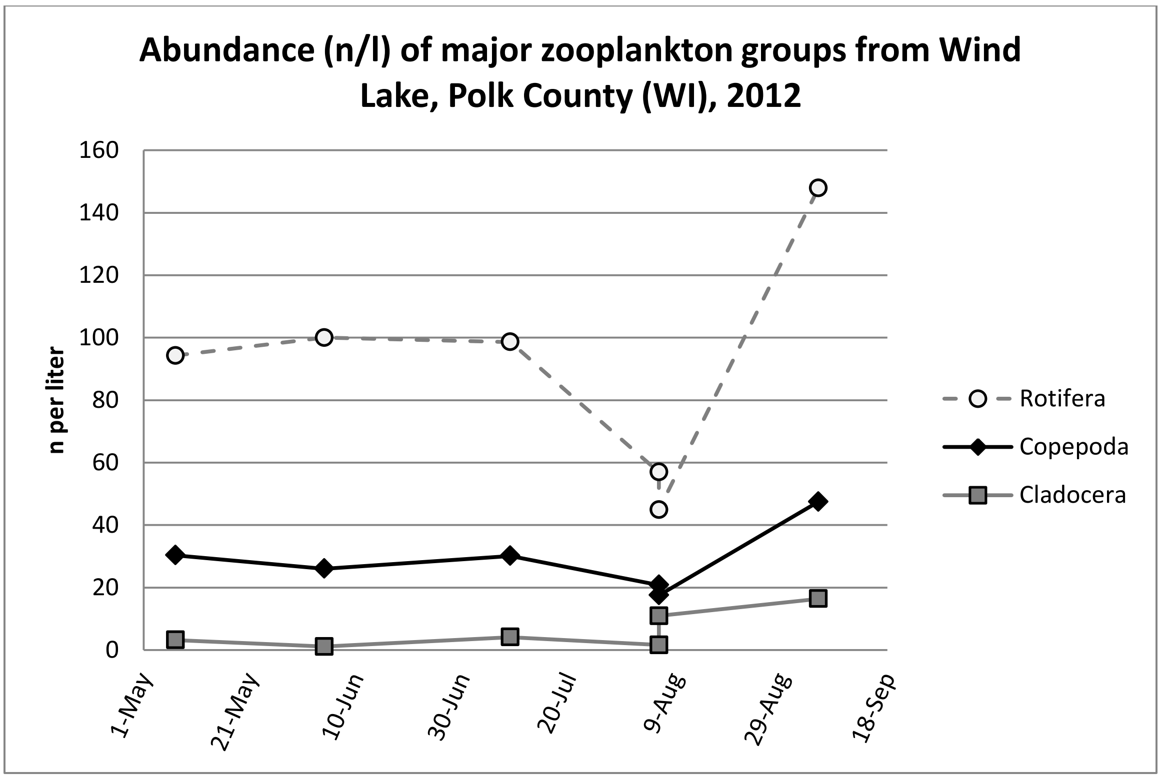

Figure 7. Zooplankton abundance (number per liter) from Wind Lake, Polk County, WI, 2012.

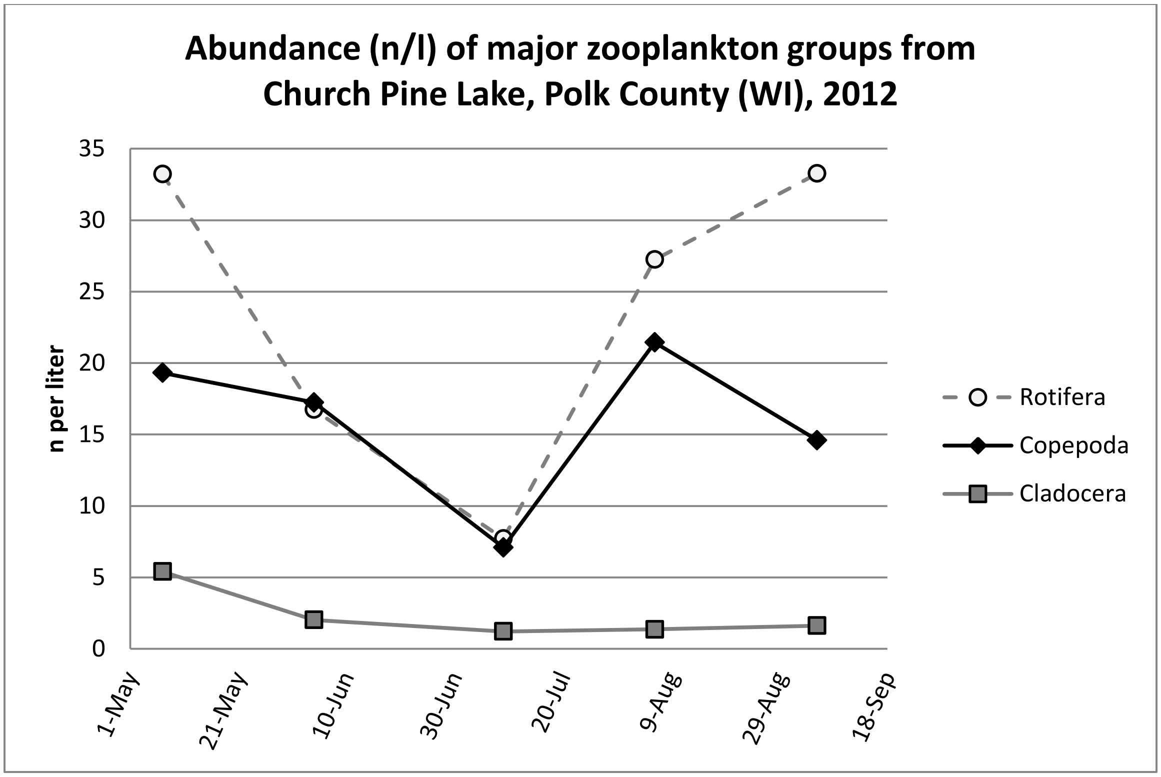

Figure 8. Zooplankton abundance (number per liter) from Church Pine Lake, Polk County, WI, 2012.

Conclusion and recommendations

In general the lakes in this study can be sorted into two groups. The Apple River Flowage sites show influence of flowing waters and other drivers typical of such systems, while Long, Big, Wind, and Church Pine Lakes show a similar pattern of very low cladoceran populations indicative of high planktivorous fish populations and low grazing capacity.

The data included as an attachment with this report can be analyzed more robustly to untangle some of the drivers of these lake ecosystems. Recommendations include:

- Statistically analyzing data against physical and water quality parameters using trend analysis and ordination techniques would help untangle the ecological significance of the zooplankton community data.
- Closely examining trends at the species level, particularly for Long Lake, where interesting dynamics are taking place in the zooplankton community that could shed light on ecosystem processes.
- More complete taxonomic investigation of the cyclopoid copepods in particular, but also the calanoid copepods, will help address the question of introduced species and/or problems with standard taxonomic keys.

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Appendix F

Modeling Data

Date: 2/4/2013 Scenario: Church Pine Lake Current Conditions

Lake Id: Church Pine

Watershed Id: 3

Hydrologic and Morphometric Data

Tributary Drainage Area: 286.4 acre
Total Unit Runoff: 8.00 in.
Annual Runoff Volume: 190.9 acre-ft
Lake Surface Area <As>: 91.0 acre
Lake Volume <V>: 2093.9 acre-ft
Lake Mean Depth <z>: 23.0 ft
Precipitation - Evaporation: 3.3 in.
Hydraulic Loading: 216.0 acre-ft/year
Areal Water Load <qs>: 2.4 ft/year
Lake Flushing Rate <p>: 0.10 1/year
Water Residence Time: 9.70 year
Observed spring overturn total phosphorus (SPO): 31.0 mg/m^3
Observed growing season mean phosphorus (GSM): 18.2 mg/m^3
% NPS Change: 0%
% PS Change: 0%

NON-POINT SOURCE DATA

Land Use	Acre **(ac)**	Low	Most Likely	High	Loading %	Low	Most Likely	High
		Loading (kg/ha-year)				**Loading (kg/year)**		
Row Crop AG	17.5	0.50	1.00	3.00	16.6	4	7	21
Mixed AG	0.0	0.30	0.80	1.40	0.0	0	0	0
Pasture/Grass	0.0	0.10	0.30	0.50	0.0	0	0	0
HD Urban (1/8 Ac)	3.8	1.00	1.50	2.00	5.4	2	2	3
MD Urban (1/4 Ac)	41.9	0.30	0.50	0.80	19.9	5	8	14
Rural Res (>1 Ac)	23.1	0.05	0.10	0.25	2.2	0	1	2
Wetlands	4.4	0.10	0.10	0.10	0.4	0	0	0
Forest	195.8	0.05	0.09	0.18	16.8	4	7	14
Lake Surface	91.0	0.10	0.30	1.00	26.0	4	11	37

POINT SOURCE DATA

Point Sources	Water Load **(m^3/year)**	Low **(kg/year)**	Most Likely **(kg/year)**	High **(kg/year)**	Loading %

SEPTIC TANK DATA

Description	**Low**	**Most Likely**	**High**	**Loading %**
Septic Tank Output (kg/capita-year)	0.30	0.50	0.80	

# capita-years	108				
% Phosphorus Retained by Soil		98.0	90.0	80.0	
Septic Tank Loading (kg/year)		0.65	5.40	17.28	12.7

TOTALS DATA

Description	**Low**	**Most Likely**	**High**	**Loading %**
Total Loading (lb)	42.1	93.8	239.8	100.0
Total Loading (kg)	19.1	42.6	108.8	100.0
Areal Loading (lb/ac-year)	0.46	1.03	2.63	
Areal Loading (mg/m^2-year)	51.86	115.55	295.34	
Total PS Loading (lb)	0.0	0.0	0.0	0.0
Total PS Loading (kg)	0.0	0.0	0.0	0.0
Total NPS Loading (lb)	32.6	57.6	120.5	87.3
Total NPS Loading (kg)	14.8	26.1	54.7	87.3

Wisconsin Internal Load Estimator
Date: 2/4/2013   Scenario: 12

Method 1 - A Complete Total Phosphorus Mass Budget

Method 1 - A Complete Total Phosphorus Mass Budget 19.71 mg/m^3
Phosphorus Inflow Concentration: 159.7 mg/m^3
Areal External Loading: 115.5 mg/m^2-year
Predicted Phosphorus Retention Coefficient: 0.80
Observed Phosphorus Retention Coefficient: 0.88
Internal Load: -7 Lb   -3 kg

Method 2 - From Growing Season In Situ Phosphorus Increases

Start of Anoxia
Average Hypolimnetic Phosphorus Concentration: 23.5 mg/m^3
Hypolimnetic Volume: 336.35 acre-ft
Anoxia Sediment Area: 48.05 acres
Just Prior To The End of Stratification
Average Hypolimnetic Phosphorus Concentration: 16 mg/m^3
Hypolimnetic Volume: 408.425 acre-ft
Anoxia Sediment Area: 48.05 acres
Time Period of Stratification: 56 days
Sediment Phosphorus Release Rate: -0.2 mg/m^2-day   -4.22E-004 lb/acre-day
Internal Load: -4 Lb   -2 kg

Method 3 - From In Situ Phosphorus Increases In The Fall

Start of Anoxia
Average Hypolimnetic Phosphorus Concentration: 23.5 mg/m^3

Hypolimnetic Volume: 336.35 acre-ft
Anoxia Sediment Area: 48.05 acres
Just Prior To The End of Stratification
Average Water Column Phosphorus Concentration: 16 mg/m^3
Lake Volume: 2093.9 acre-ft
Anoxia Sediment Area Just Before Turnover: 48.05 acres
Time Period Between Observations: 14 days
Sediment Phosphorus Release Rate: 11.6 mg/m^2-day   3.15E-002 lb/acre-day
Internal Load: 70 Lb   32 kg

Method 4 - From Phosphorus Release Rate and Anoxic Area
Start of Anoxia Anoxic Sediment Area: 48.05 acre
End of Anoxia Anoxic Sediment Area: 48.05 acre
Phosphorus Release Rate As Calculated In Method 2: -0.2 mg/m^2-day
Phosphorus Release Rate As Calculated In Method 3: -0.2 mg/m^2-day
Average of Methods 2 and 3 Release Rates: 5.7 mg/m^2-day
Period of Anoxia: 56 days
Default Areal Sediment Phosphorus Release Rates:

	Low	Most Likely	High
	6	14	24
Internal Load: (Lb)	44	102	176
Internal Load: (kg)	20	46	80

Internal Load Comparison (Percentages are of the Total Estimate Load)
Total External Load: 94 Lb   43 kg

	Lb	kg	%
From A Complete Mass Budget:	-7	-3	-8.2
From Growing Season In Situ Phosphorus Increases:	-4	-2	-4.1
From In Situ Phosphorus Increases In The Fall:	70	32	42.6
From Phosphorus Release Rate and Anoxic Area:	102	46	52.2

Predicted Water Column Total Phosphorus Concentration (ug/l)

	Low	Most Likely	High
Nurnberg+ 1984 Total Phosphorus Model:	2	88	256

Osgood, 1988 Lake Mixing Index: 11.6
Phosphorus Loading Summary:

	Low	Most Likely	High
Internal Load (Lb):	-7	32.9	102
Internal Load (kg):	-3	14.9	46
External Load (Lb):	42	94	240
External Load (kg):	19	43	109

Total Load (Lb):	35	127	342
Total Load (kg):	16	58	155

Phosphorus Prediction and Uncertainty Analysis Module
Date: 2/4/2013   Scenario: 7
Observed spring overturn total phosphorus (SPO): 31.0 mg/m^3
Observed growing season mean phosphorus (GSM): 18.2 mg/m^3
Back calculation for SPO total phosphorus: 129.17 mg/m^3
Back calculation GSM phosphorus: 75.83 mg/m^3
% Confidence Range: 70%
Nurenberg Model Input - Est. Gross Int. Loading: 88 kg

Lake Phosphorus Model	**Low** Total P (mg/m^3)	**Most Likely** Total P (mg/m^3)	**High** Total P (mg/m^3)	**Predicted** -Observed (mg/m^3)	**% Dif.**
Walker, 1987 Reservoir	17	38	97	20	110
Canfield-Bachmann, 1981 Natural Lake	15	24	42	6	33
Canfield-Bachmann, 1981 Artificial Lake	16	24	37	6	33
Rechow, 1979 General	4	9	24	-9	-49
Rechow, 1977 Anoxic	26	57	147	39	214
Rechow, 1977 water load<50m/year	6	14	36	-4	-22
Rechow, 1977 water load>50m/year	N/A	N/A	N/A	N/A	N/A
Walker, 1977 General	22	48	123	17	55
Vollenweider, 1982 Combined OECD	16	31	67	6	24
Dillon-Rigler-Kirchner	17	38	96	7	23
Vollenweider, 1982 Shallow Lake/Res.	13	26	58	1	4
Larsen-Mercier, 1976	17	39	99	8	26
Nurnberg, 1984 Oxic	345	362	412	344	1890

Lake Phosphorus Model	**Confidence** Lower Bound	**Confidence** Upper Bound	**Parameter** Fit?	**Back** Calculation (kg/year)	**Model** Type
Walker, 1987 Reservoir	21	76	Tw	85	GSM
Canfield-Bachmann, 1981 Natural Lake	7	69	FIT	295	GSM
Canfield-Bachmann, 1981 Artificial Lake	7	69	FIT	524	GSM
Rechow, 1979 General	5	19	qs	348	GSM
Rechow, 1977 Anoxic	33	115	FIT	56	GSM
Rechow, 1977 water load<50m/year	8	29	FIT	229	GSM
Rechow, 1977 water load>50m/year	N/A	N/A	N/A	N/A	N/A
Walker, 1977 General	23	102	FIT	114	SPO
Vollenweider, 1982 Combined OECD	15	61	FIT	182	ANN

Dillon-Rigler-Kirchner	22	76	P qs p	146	SPO
Vollenweider, 1982 Shallow Lake/Res.	12	52	FIT	210	ANN
Larsen-Mercier, 1976	23	77	P Pin	142	SPO
Nurnberg, 1984 Oxic	230	553	P	-341	ANN

Water and Nutrient Outflow Module
Date: 2/4/2013 Scenario: 2
Average Annual Surface Total Phosphorus: 19.7mg/m^3
Annual Discharge: 2.16E+002 AF => 2.66E+005 m^3
Annual Outflow Loading: 11.0 LB => 5.0 kg

Expanded Trophic Response Module
Date: 2/4/2013 Scenario: 4
Total Phosphorus: 18.2 mg/m^3
Growing Season
Chlorophyll a: 1.8 mg/m^3
Secchi Disk Depth: 5.41 m
Carlson TSI Equations:
TSI (Total Phosphorus): 46 TSI (Chlorophyll a): 36 TSI (Secchi Disk Depth): 36

Expanded Trophic Response Module
Date: 2/4/2013 Scenario: 5
Total Phosphorus: 18.2 mg/m^3
Growing Season
Chlorophyll a: 1.8 mg/m^3
Secchi Disk Depth: 5.41 m
Wisconsin Statewide Prediction Equations:

	Natural Lakes		Impoundments	
	Stratified	Mixed	Stratified	Mixed
Secchi Disk Depth using Chlorophyll a:	4.5	3.7	3.0	2.3
Secchi Disk Depth using Total Phosphorus:	2.3	1.6	1.8	1.3
Chlorophyll a using Total Phosphorus:	7.1	8.6	9.4	8.8

Expanded Trophic Response Module
Date: 2/4/2013 Scenario: 6
Total Phosphorus: 18.2 mg/m^3
Growing Season
Chlorophyll a: 1.8 mg/m^3
Secchi Disk Depth: 5.41 m
Wisconsin Regional Prediction Equations:

	Stratified	Mixed

	Region	Seepage	Drainage	Seepage	Drainage
Use Chlorophyll a To Predict	South	3.4	3.8	1.4	1.9
Secchi Disk Depth (m)	Central	3.9	5.3	9.5	No Data
	North	4.4	4.6	3.9	2.0
Use Total Phosphorus To	South	2.1	1.8	1.0	0.9
Predict Secchi Disk Depth (m)	Central	2.9	1.4	1.6	No Data
	North	2.5	2.3	1.9	1.5
Use Total Phosphorus To	South	6.3	9.0	7.8	9.1
Predict Chlorophyll a (mg/m^3))	Central	6.1	16.3	9.0	No Data
	North	6.5	6.8	8.0	10.0

Expanded Trophic Response Module
Date: 2/4/2013 Scenario: 7
Total Phosphorus: 18.2 mg/m^3
Growing Season
Chlorophyll a: 1.8 mg/m^3
Secchi Disk Depth: 5.41 m
Other Prediction Equations:
Rast and Lee, 1978: Chlorophyll a = 5.0 mg/m^3 Secchi Disk Depth = 4.8 m
Bartsch and Gaksatter, 1978: Chlorophyll a = 6.7 mg/m^3

User Defined: Chlorophyll a - Total Phosphorus Regression::
Use Total Phosphorus To Predict Chlorophyll a = 0.0 x 18.2^0.0 = 0.0 mg/m^3
Use Chlorophyll a To Predict Secchi Disk Depth = 0.0 x 1.8^0.0 = 0.0 m

Expanded Trophic Response Module
Date: 2/4/2013 Scenario: 8
Total Phosphorus: 18.2 mg/m^3
Growing Season
Chlorophyll a: 1.8 mg/m^3
Secchi Disk Depth: 5.41 m
Chlorophyll a Nuisance Frequency
Chla Mean Min: 5
Chla Mean Max: 100
Chla Mean Increment: 5
Chla Temporal CV: 0.62
Chla Nuisance Criterion: 20

Mean	**Freq %**
5	0.5
10	7.7

15	21.9
20	37.8
25	52.0
30	63.5
35	72.3
40	79.0
45	84.1
50	87.9
55	90.7
60	92.8
65	94.4
70	95.6
75	96.6
80	97.3
85	97.8
90	98.3
95	98.6
100	98.9

Summary Trophic Response Module
Date: 2/4/2013   Scenario: 2
Average Spring Mixed Total Phosphorus: 31 mg/m^3
Growing Season Chlorophyll a: 12.4 mg/m^3
Average Growing Season Chlorophyll a: 1.8 mg/m^3

Natural Lake Secchi Depth (m)		**Impoundment Secchi Depth (m)**	
Mixed	Stratified	Mixed	Stratified
3.71	4.45	2.35	3.04

Wisconsin Trophic State Index (TSI)

Total Phosphorus:	18.2 mg/m^3	TSI = 51
Chlorophyll a:	1.8 mg/m^3	TSI = 39
Secchi Disc Depth:	5.41 m	TSI = 36

Date: 6/10/2013   Scenario: 65

Lake Id: Church Pine
Watershed Id: 3

Hydrologic and Morphometric Data

Tributary Drainage Area: 286.4 acre
Total Unit Runoff: 8.00 in.
Annual Runoff Volume: 190.9 acre-ft
Lake Surface Area <As>: 91.0 acre
Lake Volume <V>: 2093.9 acre-ft
Lake Mean Depth <z>: 23.0 ft
Precipitation - Evaporation: 3.3 in.
Hydraulic Loading: 216.0 acre-ft/year
Areal Water Load <qs>: 2.4 ft/year
Lake Flushing Rate <p>: 0.10 1/year
Water Residence Time: 9.70 year
Observed spring overturn total phosphorus (SPO): 31.0 mg/m^3
Observed growing season mean phosphorus (GSM): 18.2 mg/m^3
% NPS Change: -5%
% PS Change: 0%

NON-POINT SOURCE DATA

Land Use	Acre (ac)	Low	Most Likely	High	Loading %	Low	Most Likely	High
		|---- Loading (kg/ha-year) ----|				|----- Loading (kg/year) ----|		
Row Crop AG	17.5	0.50	1.00	3.00	16.3	3	7	20
Mixed AG	0.0	0.30	0.80	1.40	0.0	0	0	0
Pasture/Grass	0.0	0.10	0.30	0.50	0.0	0	0	0
HD Urban (1/8 Ac)	3.8	1.00	1.50	2.00	5.3	1	2	3
MD Urban (1/4 Ac)	41.9	0.30	0.50	0.80	19.5	5	8	13
Rural Res (>1 Ac)	23.1	0.05	0.10	0.25	2.1	0	1	2
Wetlands	4.4	0.10	0.10	0.10	0.4	0	0	0
Forest	195.8	0.05	0.09	0.18	16.4	4	7	14
Lake Surface	91.0	0.10	0.30	1.00	26.8	4	11	37

POINT SOURCE DATA

Point Sources	Water Load (m^3/year)	Low (kg/year)	Most Likely (kg/year)	High (kg/year)	Loading %

SEPTIC TANK DATA

Description		Low	Most Likely	High	Loading %
Septic Tank Output (kg/capita-year)		0.30	0.50	0.80	
# capita-years	108.0				
% Phosphorus Retained by Soil		98.0	90.0	80.0	
Septic Tank Loading (kg/year)		0.65	5.40	17.28	

13.1

TOTALS DATA

Description	Low	Most Likely	High	Loading %
Total Loading (lb)	40.5	90.9	233.8	100.0
Total Loading (kg)	18.4	41.2	106.0	100.0
Areal Loading (lb/ac-year)	0.44	1.00	2.57	
Areal Loading (mg/m^2-year)	49.86	112.01	287.92	
Total PS Loading (lb)	0.0	0.0	0.0	0.0
Total PS Loading (kg)	0.0	0.0	0.0	0.0
Total NPS Loading (lb)	30.9	54.7	114.5	86.9
Total NPS Loading (kg)	14.0	24.8	51.9	86.9

Water and Nutrient Outflow Module

Date: 6/10/2013   Scenario: 6
Average Annual Surface Total Phosphorus: 19.7mg/m^3
Annual Discharge: 2.16E+002 AF => 2.66E+005 m^3
Annual Outflow Loading: 11.0 LB =>   5.0 kg

Date: 6/10/2013   Scenario: 68

Lake Id: Wind Lake
Watershed Id: 2

Hydrologic and Morphometric Data

Tributary Drainage Area: 68.6 acre
Total Unit Runoff: 8.00 in.
Annual Runoff Volume: 45.7 acre-ft
Lake Surface Area <As>: 38.0 acre
Lake Volume <V>: 551.0 acre-ft
Lake Mean Depth <z>: 14.5 ft
Precipitation - Evaporation: 3.3 in.
Hydraulic Loading: 271.8 acre-ft/year
Areal Water Load <qs>: 7.2 ft/year
Lake Flushing Rate <p>: 0.49 1/year
Water Residence Time: 2.03 year
Observed spring overturn total phosphorus (SPO): 39.0 mg/m^3
Observed growing season mean phosphorus (GSM): 21.2 mg/m^3
% NPS Change: 0%
% PS Change: 0%

NON-POINT SOURCE DATA

Land Use	Acre (ac)	Low	Most Likely	High	Loading %	Low	Most Likely	High
		Loading (kg/ha-year)				Loading (kg/year)		
Row Crop AG	4.3	0.50	1.00	3.00	8.4	1	2	5
Mixed AG	0.0	0.30	0.80	1.40	0.0	0	0	0
Pasture/Grass	0.0	0.10	0.30	0.50	0.0	0	0	0
HD Urban (1/8 Ac)	0.0	1.00	1.50	2.00	0.0	0	0	0
MD Urban (1/4 Ac)	25.4	0.30	0.50	0.80	24.7	3	5	8
Rural Res (>1 Ac)	15.4	0.05	0.10	0.25	3.0	0	1	2
Wetlands	0.8	0.10	0.10	0.10	0.2	0	0	0
Forest	22.7	0.05	0.09	0.18	4.0	0	1	2
Lake Surface	38.0	0.10	0.30	1.00	22.1	2	5	15

POINT SOURCE DATA

Point Sources	Water Load (m^3/year)	Low (kg/year)	Most Likely (kg/year)	High (kg/year)	Loading %

SEPTIC TANK DATA

Description		Low	Most Likely	High	Loading %
Septic Tank Output (kg/capita-year)		0.30	0.50	0.80	
# capita-years	57.0				
% Phosphorus Retained by Soil		98.0	90.0	80.0	
Septic Tank Loading (kg/year)		0.34	2.85	9.12	

13.7

TOTALS DATA

Description	Low	Most Likely	High	Loading %
Total Loading (lb)	14.6	45.9	90.8	100.0
Total Loading (kg)	6.6	20.8	41.2	100.0
Areal Loading (lb/ac-year)	0.39	1.21	2.39	
Areal Loading (mg/m^2-year)	43.19	135.47	267.92	
Total PS Loading (lb)	0.0	11.0	0.0	24.0
Total PS Loading (kg)	0.0	5.0	0.0	24.0
Total NPS Loading (lb)	10.5	18.5	36.8	62.3
Total NPS Loading (kg)	4.8	8.4	16.7	62.3

Date: 6/10/2013   Scenario: 67

Lake Id: Wind Lake
Watershed Id: 2

Hydrologic and Morphometric Data

Tributary Drainage Area: 68.6 acre
Total Unit Runoff: 8.00 in.
Annual Runoff Volume: 45.7 acre-ft
Lake Surface Area <As>: 38.0 acre
Lake Volume <V>: 551.0 acre-ft
Lake Mean Depth <z>: 14.5 ft
Precipitation - Evaporation: 3.3 in.
Hydraulic Loading: 271.8 acre-ft/year
Areal Water Load <qs>: 7.2 ft/year
Lake Flushing Rate <p>: 0.49 1/year
Water Residence Time: 2.03 year
Observed spring overturn total phosphorus (SPO): 39.0 mg/m^3
Observed growing season mean phosphorus (GSM): 21.2 mg/m^3
% NPS Change: -10%
% PS Change: -5%

NON-POINT SOURCE DATA

Land Use	Acre (ac)	Low	Most Likely	High	Loading %	Low	Most Likely	High
		Loading (kg/ha-year)				Loading (kg/year)		
Row Crop AG	4.3	0.50	1.00	3.00	7.9	1	2	5
Mixed AG	0.0	0.30	0.80	1.40	0.0	0	0	0
Pasture/Grass	0.0	0.10	0.30	0.50	0.0	0	0	0
HD Urban (1/8 Ac)	0.0	1.00	1.50	2.00	0.0	0	0	0
MD Urban (1/4 Ac)	25.4	0.30	0.50	0.80	23.5	3	5	7
Rural Res (>1 Ac)	15.4	0.05	0.10	0.25	2.8	0	1	1
Wetlands	0.8	0.10	0.10	0.10	0.1	0	0	0
Forest	22.7	0.05	0.09	0.18	3.8	0	1	1
Lake Surface	38.0	0.10	0.30	1.00	23.4	2	5	15

POINT SOURCE DATA

Point Sources	Water Load (m^3/year)	Low (kg/year)	Most Likely (kg/year)	High (kg/year)	Loading %

SEPTIC TANK DATA

Description		Low	Most Likely	High	Loading %
Septic Tank Output (kg/capita-year)		0.30	0.50	0.80	
# capita-years	57.0				
% Phosphorus Retained by Soil		98.0	90.0	80.0	
Septic Tank Loading (kg/year)		0.34	2.85	9.12	

14.4

TOTALS DATA

Description	Low	Most Likely	High	Loading %
Total Loading (lb)	13.6	43.5	87.1	100.0
Total Loading (kg)	6.2	19.7	39.5	100.0
Areal Loading (lb/ac-year)	0.36	1.15	2.29	
Areal Loading (mg/m^2-year)	40.09	128.41	257.06	
Total PS Loading (lb)	0.0	10.5	0.0	24.1
Total PS Loading (kg)	0.0	4.8	0.0	24.1
Total NPS Loading (lb)	9.4	16.6	33.1	61.5
Total NPS Loading (kg)	4.3	7.5	15.0	61.5

Water and Nutrient Outflow Module

Date: 6/10/2013   Scenario: 7
Average Annual Surface Total Phosphorus: 25.1mg/m^3
Annual Discharge: 2.72E+002 AF => 3.35E+005 m^3
Annual Outflow Loading: 17.6 LB =>   8.0 kg

Date: 2/5/2013   Scenario: Wind Lake 16% Reduction

Lake Id: Wind Lake
Watershed Id: 2

Hydrologic and Morphometric Data

Tributary Drainage Area: 68.6 acre
Total Unit Runoff: 8.00 in.
Annual Runoff Volume: 45.7 acre-ft
Lake Surface Area <As>: 38.0 acre
Lake Volume <V>: 266.0 acre-ft
Lake Mean Depth <z>: 7.0 ft
Precipitation - Evaporation: 3.3 in.
Hydraulic Loading: 56.2 acre-ft/year
Areal Water Load <qs>: 1.5 ft/year
Lake Flushing Rate <p>: 0.21 1/year
Water Residence Time: 4.73 year
Observed spring overturn total phosphorus (SPO): 39.0 mg/m^3
Observed growing season mean phosphorus (GSM): 21.2 mg/m^3
% NPS Change: -16%
% PS Change: 0%

NON-POINT SOURCE DATA

Land Use	Acre (ac)	Low	Most Likely	High	Loading %	Low	Most Likely	High
		Loading (kg/ha-year)				Loading (kg/year)		
Row Crop AG	4.3	0.50	1.00	3.00	10.1	1	1	4
Mixed AG	0.0	0.30	0.80	1.40	0.0	0	0	0
Pasture/Grass	0.0	0.10	0.30	0.50	0.0	0	0	0
HD Urban (1/8 Ac)	0.0	1.00	1.50	2.00	0.0	0	0	0
MD Urban (1/4 Ac)	25.4	0.30	0.50	0.80	29.8	3	4	7
Rural Res (>1 Ac)	15.4	0.05	0.10	0.25	3.6	0	1	1
Wetlands	0.8	0.10	0.10	0.10	0.2	0	0	0
Forest	22.7	0.05	0.09	0.18	4.8	0	1	1
Lake Surface	38.0	0.10	0.30	1.00	31.8	2	5	15

POINT SOURCE DATA

Point Sources	Water Load (m^3/year)	Low (kg/year)	Most Likely (kg/year)	High (kg/year)	Loading %

SEPTIC TANK DATA

Description		Low	Most Likely	High	Loading %
Septic Tank Output (kg/capita-year)		0.30	0.50	0.80	
# capita-years	57.0				
% Phosphorus Retained by Soil		98.0	90.0	80.0	
Septic Tank Loading (kg/year)		0.34	2.85	9.12	

19.7

TOTALS DATA

Description	Low	Most Likely	High	Loading %
Total Loading (lb)	13.0	32.0	84.9	100.0
Total Loading (kg)	5.9	14.5	38.5	100.0
Areal Loading (lb/ac-year)	0.34	0.84	2.24	
Areal Loading (mg/m^2-year)	38.23	94.25	250.54	
Total PS Loading (lb)	0.0	0.0	0.0	0.0
Total PS Loading (kg)	0.0	0.0	0.0	0.0
Total NPS Loading (lb)	8.8	15.5	30.9	80.3
Total NPS Loading (kg)	4.0	7.0	14.0	80.3

Date: 2/4/2013   Scenario: Big Lake Current Conditions
Lake Id: Big Lake
Watershed Id: 1

Hydrologic and Morphometric Data

Tributary Drainage Area: 1522.7 acre
Total Unit Runoff: 8.00 in.
Annual Runoff Volume: 1015.1 acre-ft
Lake Surface Area <As>: 243.0 acre
Lake Volume <V>: 4131.0 acre-ft
Lake Mean Depth <z>: 17.0 ft
Precipitation - Evaporation: 3.3 in.
Hydraulic Loading: 1082.0 acre-ft/year
Areal Water Load <qs>: 4.5 ft/year
Lake Flushing Rate <p>: 0.26 1/year
Water Residence Time: 3.82 year
Observed spring overturn total phosphorus (SPO): 33.0 mg/m^3
Observed growing season mean phosphorus (GSM): 25.2 mg/m^3
% NPS Change: 0%
% PS Change: 0%

NON-POINT SOURCE DATA

Land Use	Acre (ac)	Low	Most Likely	High	Loading %	Low	Most Likely	High
		|---- Loading (kg/ha-year) ----|				|----- Loading (kg/year) ----|		
Row Crop AG	288.6	0.50	1.00	3.00	49.8	58	117	350
Mixed AG	34.0	0.30	0.80	1.40	4.7	4	11	19
Pasture/Grass	80.7	0.10	0.30	0.50	4.2	3	10	16
HD Urban (1/8 Ac)	0.0	1.00	1.50	2.00	0.0	0	0	0
MD Urban (1/4 Ac)	99.9	0.30	0.50	0.80	8.6	12	20	32
Rural Res (>1 Ac)	134.6	0.05	0.10	0.25	2.3	3	5	14
Wetlands	417.513	0.10	0.10	0.10	7.2	17	17	17
Forest	467.5	0.05	0.09	0.18	7.3	9	17	34
Lake Surface	243.0	0.10	0.30	1.00	12.6	10	30	98

POINT SOURCE DATA

Point Sources	Water Load (m^3/year)	Low (kg/year)	Most Likely (kg/year)	High (kg/year)	Loading %

SEPTIC TANK DATA

Description	**Low**	**Most Likely**	**High**	**Loading %**
Septic Tank Output (kg/capita-year)	0.30	0.50	0.80	

# capita-years	159				
% Phosphorus Retained by Soil		98.0	90.0	80.0	
Septic Tank Loading (kg/year)		0.95	7.95	25.44	3.4

TOTALS DATA

Description	Low	Most Likely	High	Loading %
Total Loading (lb)	259.7	517.3	1337.5	100.0
Total Loading (kg)	117.8	234.6	606.7	100.0
Areal Loading (lb/ac-year)	1.07	2.13	5.50	
Areal Loading (mg/m^2-year)	119.78	238.60	616.92	
Total PS Loading (lb)	0.0	0.0	0.0	0.0
Total PS Loading (kg)	0.0	0.0	0.0	0.0
Total NPS Loading (lb)	235.9	434.7	1064.6	96.6
Total NPS Loading (kg)	107.0	197.2	482.9	96.6

Wisconsin Internal Load Estimator

Date: 2/4/2013 Scenario: 9

Method 1 - A Complete Total Phosphorus Mass Budget

Method 1 - A Complete Total Phosphorus Mass Budget 29.57 mg/m^3
Phosphorus Inflow Concentration: 175.8 mg/m^3
Areal External Loading: 238.6 mg/m^2-year
Predicted Phosphorus Retention Coefficient: 0.77
Observed Phosphorus Retention Coefficient: 0.83
Internal Load: -29 Lb -13 kg

Method 2 - From Growing Season In Situ Phosphorus Increases

Start of Anoxia

Average Hypolimnetic Phosphorus Concentration: 40.5 mg/m^3
Hypolimnetic Volume: 363.53 acre-ft
Anoxia Sediment Area: 145.41 acres

Just Prior To The End of Stratification

Average Hypolimnetic Phosphorus Concentration: 48 mg/m^3
Hypolimnetic Volume: 872.46 acre-ft
Anoxia Sediment Area: 145.41 acres
Time Period of Stratification: 49 days
Sediment Phosphorus Release Rate: 1.2 mg/m^2-day 3.16E-003 lb/acre-day
Internal Load: 74 Lb 33 kg

Method 3 - From In Situ Phosphorus Increases In The Fall

Start of Anoxia

Average Hypolimnetic Phosphorus Concentration: 40.5 mg/m^3

Hypolimnetic Volume: 363.53 acre-ft
Anoxia Sediment Area: 145.41 acres
Just Prior To The End of Stratification
Average Water Column Phosphorus Concentration: 48 mg/m^3
Lake Volume: 4131.0 acre-ft
Anoxia Sediment Area Just Before Turnover: 145.41 acres
Time Period Between Observations: 14 days
Sediment Phosphorus Release Rate: 27.5 mg/m^2-day   7.47E-002 lb/acre-day
Internal Load: 499 Lb   226 kg

Method 4 - From Phosphorus Release Rate and Anoxic Area
Start of Anoxia Anoxic Sediment Area: 145.41 acre
End of Anoxia Anoxic Sediment Area: 145.41 acre
Phosphorus Release Rate As Calculated In Method 2: 1.2 mg/m^2-day
Phosphorus Release Rate As Calculated In Method 3: 1.2 mg/m^2-day
Average of Methods 2 and 3 Release Rates: 14.3 mg/m^2-day
Period of Anoxia: 49 days
Default Areal Sediment Phosphorus Release Rates:

	Low	Most Likely	High
	6	14	24
Internal Load: (Lb)	116	271	465
Internal Load: (kg)	53	123	211

Internal Load Comparison (Percentages are of the Total Estimate Load)
Total External Load: 517 Lb   235 kg

	Lb	kg	%
From A Complete Mass Budget:	-29	-13	-6.0
From Growing Season In Situ Phosphorus Increases:	74	33	12.5
From In Situ Phosphorus Increases In The Fall:	499	226	49.1
From Phosphorus Release Rate and Anoxic Area:	271	123	34.4

Predicted Water Column Total Phosphorus Concentration (ug/l)

	Low	Most Likely	High
Nurnberg+ 1984 Total Phosphorus Model:	10	137	195

Osgood, 1988 Lake Mixing Index: 5.2
Phosphorus Loading Summary:

	Low	Most Likely	High
Internal Load (Lb):	-29	286.5	271
Internal Load (kg):	-13	130.0	123
External Load (Lb):	260	517	1338
External Load (kg):	118	235	607

Total Load (Lb):	230	804	1609
Total Load (kg):	104	365	730

Phosphorus Prediction and Uncertainty Analysis Module

Date: 2/4/2013 Scenario: 5

Observed spring overturn total phosphorus (SPO): 33.0 mg/m^3

Observed growing season mean phosphorus (GSM): 25.2 mg/m^3

Back calculation for SPO total phosphorus: 97.06 mg/m^3

Back calculation GSM phosphorus: 74.12 mg/m^3

% Confidence Range: 70%

Nurenberg Model Input - Est. Gross Int. Loading: 137 kg

Lake Phosphorus Model	**Low** Total P (mg/m^3)	**Most Likely** Total P (mg/m^3)	**High** Total P (mg/m^3)	**Predicted** -Observed (mg/m^3)	**% Dif.**
Walker, 1987 Reservoir	23	46	120	21	83
Canfield-Bachmann, 1981 Natural Lake	24	38	70	13	52
Canfield-Bachmann, 1981 Artificial Lake	23	34	55	9	36
Rechow, 1979 General	9	18	47	-7	-28
Rechow, 1977 Anoxic	50	99	256	74	294
Rechow, 1977 water load<50m/year	16	31	81	6	24
Rechow, 1977 water load>50m/year	N/A	N/A	N/A	N/A	N/A
Walker, 1977 General	35	70	181	37	112
Vollenweider, 1982 Combined OECD	25	44	96	15	52
Dillon-Rigler-Kirchner	22	43	111	10	30
Vollenweider, 1982 Shallow Lake/Res.	20	37	86	8	27
Larsen-Mercier, 1976	30	60	154	27	82
Nurnberg, 1984 Oxic	123	142	205	117	464

Lake Phosphorus Model	**Confidence** Lower Bound	**Confidence** Upper Bound	**Parameter** Fit?	**Back** Calculation (kg/year)	**Model** Type
Walker, 1987 Reservoir	27	94	Tw	375	GSM
Canfield-Bachmann, 1981 Natural Lake	12	109	FIT	658	GSM
Canfield-Bachmann, 1981 Artificial Lake	11	98	FIT	1111	GSM
Rechow, 1979 General	10	37	FIT	964	GSM
Rechow, 1977 Anoxic	60	200	FIT	176	GSM
Rechow, 1977 water load<50m/year	18	64	FIT	553	GSM
Rechow, 1977 water load>50m/year	N/A	N/A	N/A	N/A	N/A
Walker, 1977 General	35	149	FIT	326	SPO
Vollenweider, 1982 Combined OECD	22	87	FIT	526	ANN

Dillon-Rigler-Kirchner	26	87	P qs	532	SPO
Vollenweider, 1982 Shallow Lake/Res.	18	75	FIT	615	ANN
Larsen-Mercier, 1976	37	120	P Pin	383	SPO
Nurnberg, 1984 Oxic	89	225	P	-169	ANN

Water and Nutrient Outflow Module
Date: 2/4/2013 Scenario: 1
Average Annual Surface Total Phosphorus: 29.57mg/m^3
Annual Discharge: 1.08E+003 AF => 1.33E+006 m^3
Annual Outflow Loading: 82.9 LB => 37.6 kg

Expanded Trophic Response Module
Date: 2/4/2013 Scenario: 3
Total Phosphorus: 25.2 mg/m^3
Growing Season
Chlorophyll a: 4.75 mg/m^3
Secchi Disk Depth: 2.25 m
Chlorophyll a Nuisance Frequency
Chla Mean Min: 5
Chla Mean Max: 100
Chla Mean Increment: 5
Chla Temporal CV: 0.62
Chla Nuisance Criterion: 20

Mean	Freq %
5	0.5
10	7.7
15	21.9
20	37.8
25	52.0
30	63.5
35	72.3
40	79.0
45	84.1
50	87.9
55	90.7
60	92.8
65	94.4
70	95.6
75	96.6
80	97.3

85	97.8
90	98.3
95	98.6
100	98.9

Summary Trophic Response Module

Date: 2/4/2013   Scenario: 1

Average Spring Mixed Total Phosphorus: 33 mg/m^3

Growing Season Chlorophyll a: 13.0 mg/m^3

Average Growing Season Chlorophyll a: 4.75 mg/m^3

Natural Lake Secchi Depth (m)		Impoundment Secchi Depth (m)	
Mixed	Stratified	Mixed	Stratified
2.26	2.82	1.64	2.23

Wisconsin Trophic State Index (TSI)

Total Phosphorus:	25.2 mg/m^3	TSI = 53
Chlorophyll a:	4.75 mg/m^3	TSI = 46
Secchi Disc Depth:	2.25 m	TSI = 48

Date: 6/10/2013   Scenario: 69

Lake Id: Big Lake
Watershed Id: 1

Hydrologic and Morphometric Data

Tributary Drainage Area: 218.2 acre
Total Unit Runoff: 8.00 in.
Annual Runoff Volume: 145.5 acre-ft
Lake Surface Area <As>: 243.0 acre
Lake Volume <V>: 4131.0 acre-ft
Lake Mean Depth <z>: 17.0 ft
Precipitation - Evaporation: 3.3 in.
Hydraulic Loading: 1316.7 acre-ft/year
Areal Water Load <qs>: 5.4 ft/year
Lake Flushing Rate <p>: 0.32 1/year
Water Residence Time: 3.14 year
Observed spring overturn total phosphorus (SPO): 33.0 mg/m^3
Observed growing season mean phosphorus (GSM): 25.2 mg/m^3
% NPS Change: -16%
% PS Change: 0%

NON-POINT SOURCE DATA

Land Use	Acre (ac)	Low	Most Likely	High	Loading %	Low	Most Likely	High
		|---- Loading (kg/ha-year) ----|				|----- Loading (kg/year) ----|		
Row Crop AG	6.9	0.50	1.00	3.00	1.3	1	2	7
Mixed AG	0.0	0.30	0.80	1.40	0.0	0	0	0
Pasture/Grass	0.0	0.10	0.30	0.50	0.0	0	0	0
HD Urban (1/8 Ac)	0.0	1.00	1.50	2.00	0.0	0	0	0
MD Urban (1/4 Ac)	98.0	0.30	0.50	0.80	9.5	10	17	27
Rural Res (>1 Ac)	30.8	0.05	0.10	0.25	0.6	1	1	3
Wetlands	0.1	0.10	0.10	0.10	0.0	0	0	0
Forest	82.4	0.05	0.09	0.18	1.4	1	3	5
Lake Surface	243.0	0.10	0.30	1.00	16.8	10	30	98

POINT SOURCE DATA

Point Sources	Water Load (m^3/year)	Low (kg/year)	Most Likely (kg/year)	High (kg/year)	Loading %

SEPTIC TANK DATA

Description		Low	Most Likely	High	Loading %
Septic Tank Output (kg/capita-year)		0.30	0.50	0.80	
# capita-years	159.0				
% Phosphorus Retained by Soil		98.0	90.0	80.0	
Septic Tank Loading (kg/year)		0.95	7.95	25.44	

4.5

TOTALS DATA

Description	Low	Most Likely	High	Loading %
Total Loading (lb)	52.6	386.7	364.0	100.0
Total Loading (kg)	23.9	175.4	165.1	100.0
Areal Loading (lb/ac-year)	0.22	1.59	1.50	
Areal Loading (mg/m^2-year)	24.28	178.38	167.89	
Total PS Loading (lb)	0.0	254.4	0.0	65.8
Total PS Loading (kg)	0.0	115.4	0.0	65.8
Total NPS Loading (lb)	28.9	49.7	91.1	29.7
Total NPS Loading (kg)	13.1	22.6	41.3	29.7

Date: 6/10/2013   Scenario: 70

Lake Id: Big Lake
Watershed Id: 1

Hydrologic and Morphometric Data

Tributary Drainage Area: 218.2 acre
Total Unit Runoff: 8.00 in.
Annual Runoff Volume: 145.5 acre-ft
Lake Surface Area <As>: 243.0 acre
Lake Volume <V>: 4131.0 acre-ft
Lake Mean Depth <z>: 17.0 ft
Precipitation - Evaporation: 3.3 in.
Hydraulic Loading: 1316.7 acre-ft/year
Areal Water Load <qs>: 5.4 ft/year
Lake Flushing Rate <p>: 0.32 1/year
Water Residence Time: 3.14 year
Observed spring overturn total phosphorus (SPO): 33.0 mg/m^3
Observed growing season mean phosphorus (GSM): 25.2 mg/m^3
% NPS Change: -25%
% PS Change: 0%

NON-POINT SOURCE DATA

Land Use	Acre (ac)	Low	Most Likely	High	Loading %	Low	Most Likely	High
		|---- Loading (kg/ha-year) ----|				|----- Loading (kg/year) ----|		
Row Crop AG	6.9	0.50	1.00	3.00	1.2	1	2	6
Mixed AG	0.0	0.30	0.80	1.40	0.0	0	0	0
Pasture/Grass	0.0	0.10	0.30	0.50	0.0	0	0	0
HD Urban (1/8 Ac)	0.0	1.00	1.50	2.00	0.0	0	0	0
MD Urban (1/4 Ac)	98.0	0.30	0.50	0.80	8.6	9	15	24
Rural Res (>1 Ac)	30.8	0.05	0.10	0.25	0.5	0	1	2
Wetlands	0.1	0.10	0.10	0.10	0.0	0	0	0
Forest	82.4	0.05	0.09	0.18	1.3	1	2	5
Lake Surface	243.0	0.10	0.30	1.00	17.1	10	30	98

POINT SOURCE DATA

Point Sources	Water Load (m^3/year)	Low (kg/year)	Most Likely (kg/year)	High (kg/year)	Loading %

SEPTIC TANK DATA

Description		Low	Most Likely	High	Loading %
Septic Tank Output (kg/capita-year)		0.30	0.50	0.80	
# capita-years	159.0				
% Phosphorus Retained by Soil		98.0	90.0	80.0	
Septic Tank Loading (kg/year)		0.95	7.95	25.44	

4.6

TOTALS DATA

Description	Low	Most Likely	High	Loading %
Total Loading (lb)	49.6	381.4	354.2	100.0
Total Loading (kg)	22.5	173.0	160.7	100.0
Areal Loading (lb/ac-year)	0.20	1.57	1.46	
Areal Loading (mg/m^2-year)	22.86	175.93	163.39	
Total PS Loading (lb)	0.0	254.4	0.0	66.7
Total PS Loading (kg)	0.0	115.4	0.0	66.7
Total NPS Loading (lb)	25.8	44.4	81.3	28.7
Total NPS Loading (kg)	11.7	20.1	36.9	28.7

Appendix G

Meeting Agendas and Materials

Church Pine, Round, and Big Lakes Management Plan
Water Quality Committee Meeting 1

Monday, February 11th, 2013
6-8 pm
Alden Town Hall

Agenda

6:00 Introductions – roles and responsibilities (LWRD)

6:10 Schedule future meetings – *bring your calendar*
- March
- April
- May
- Spring Informational Meeting (Saturday, May 18th)?
- June

6:20 What is a lake management plan?
Review grant requirements (LWRD)
What do you want the plan to accomplish? (Committee)
What questions do you hope to have answered? (Committee)

6:40 Identify concerns
- Survey results (LWRD)
- Brainstorm concerns (Committee)

7:10 Initial study results – what did we learn about the three lakes? (LWRD)

7:40 Additional concerns following the presentation?
Prioritize concerns/issues for further discussion (Committee)

8:00 Adjourn

General Meeting Agenda

Background information for selected issues
Discuss potential goals and objectives
Discuss available tools and activities

Katelin Holm, (715) 485-8637, katelin.holm@co.polk.wi.us

Jeremy Williamson, (715) 485-8639, jeremyw@co.polk.wi.us

Lake Management Plan Development Rules and Roles

Overall Objective

Develop a Lake Management Plan for Church Pine, Round, and Big Lakes

A management plan outlines strategies that everyone can live with and may guide new activities and grant funded projects

Ground Rules

RESPECT

CIVILITY

FOLLOW AGENDA TO STAY ON TRACK

It is important to **listen** to what others are saying

Don't interrupt when others are speaking

Everyone will have an opportunity for input

Water Quality Committee Role

Attend every meeting or make provisions for input outside of missed meeting

Share your knowledge of the lakes

Share your concerns about the lakes

Help develop lake management strategies

Review background information

Review draft documents

Decide when draft document is ready to forward to board for approval

Advisor Role

Bring information to assist in decision-making

Help committee understand natural systems

Help committee understand constraints of rules and regulations

Consultant Role

Guide meeting topics and flow

Keep discussion on track (may need to interrupt to keep discussion focused)

Establish procedure for discussion (suggestions appreciated, but only outside of meetings)

Bring background information

Ensure that public input is adequate for plan approval – provide public opportunity to comment

Write goals, objectives, and action items for the plan

Write draft and final plan documents

District Role

Participate as part of the committee

Review draft lake plan

Approve draft lake plan to forward to the WI DNR <u>or</u> disapprove draft plan and return to committee with elements that are not acceptable and suggestions for modifications

Adopted from a document by: Cheryl Clemens, Harmony Environmental

Purpose of the Study

Lakes are a product of the landscape they are situated in and of the actions that take place on the land which surrounds them. Due to this fact, lakes situated within feet of others can differ profoundly in the uses they support.

Factors such as lake size, lake depth, water sources to a lake, and geology all cause inherent differences in lake quality.

Additionally, humans, by changing the landscape, can bring about changes in a lake. This arises because rain and melting snow eventually end up in lakes and streams through surface runoff or groundwater infiltration. Rain and melting snow entering a lake is not inherently problematic. However, water has the ability to carry nutrients, bacteria, sediment, and chemicals into a lake. These inputs can impact aquatic organisms such as insects, fish, and wildlife and—especially in the case of the nutrient phosphorus—fuel problematic algae blooms.

The landscape can be divided into watersheds and subwatersheds, which define the land area that drains into a particular lake, stream, or river. Watersheds that preserve native vegetation and forestland and minimize impervious surfaces (cement, concrete, and other materials that water can't permeate) are less likely to cause negative impacts on lakes, rivers, and streams.

Lake studies often examine the underlying factors that impact a lake's health (such as lake size, depth, and water sources) and the land use in a lakes watershed. Many forms of data can be collected and analyzed to gauge a lake's health including: physical data (oxygen, temperature, etc.), chemical data (including nutrients such a phosphorus and nitrogen), biological data (algae and zooplankton), and land use within a lake's watershed. By compiling this data, lakes can be classified based on their nutrient status and clarity levels.

Three categories commonly used are: oligotrophic, mesotrophic, and eutrophic.

- ✓ Oligotrophic lakes are generally clear, deep, and free of weeds and large algae blooms.
- ✓ Mesotrophic lakes lie between oligotrophic and eutrophic lakes. They usually have good fisheries and occasional algae blooms.
- ✓ Eutrophic lakes are generally high in nutrients and support a large number of plant and animal populations. They are usually very productive and subject to frequent algae blooms.

Lake studies often identify strengths, opportunities, challenges, and threats to a lake's health. These studies can identify practices already being implemented by lake residents to improve water quality and areas providing benefits to a lake's ecosystem. Additionally, these studies often quantify practices or areas on the landscape that have the potential to negatively impact the health of a lake.

The end product of a lake study is a Lake Management Plan, which identifies goals, objectives, and action items to either maintain or improve the health of a lake. These goals should be realistically based on inherent lake characteristics (lake size, depth, etc.) and should align with lake resident's goals.

Included is a summary of the data and conclusions drawn from a 2012 lake study completed by the Polk County Land and Water Resources Department. This study collected and analyzed the following data to aid in the creation of a Lake Management Plan for Church Pine, Round, and Big Lakes:

- ✓ Lake resident opinions
- ✓ Lake level and precipitation data
- ✓ In lake physical and chemical data
- ✓ Algae and zooplankton data
- ✓ Shoreline land use results
- ✓ Tributary monitoring results
- ✓ Watershed land use

This study also included a number of opportunities for members of the Church Pine, Round, and Big Lakes District including:

- ✓ Pontoon classrooms
- ✓ A shoreline restoration workshop
- ✓ A series of five meetings to review the data collected and develop a Lake Management Plan

Summary

Lake information

Church Pine Lake is a 107 acre drainage lake with a mean depth of 23 feet; Round (Wind) Lake is a 38 acre drainage lake with a maximum depth of 22 feet; and Big Lake is a 259 acre seepage lake with a mean depth of 24 feet. Church Pine Lake and Round Lake are located entirely in the Town of Alden; whereas, Big Lake is located in the Towns of Alden and Garfield.

Church Pine Lake is the headwaters of this three lake system, with water flowing from Church Pine, to Round, and then to Big Lake. There are two inflows to this three lake system, both of which are located on Big Lake. The main inflow, North Creek, is located on the north side of the lake. North Creek is classified as an Area of Special Natural Resource Interest due to its classification as a trout water. Big Lake also receives intermittent flow from a culvert located on County Road K on the east side of the lake.

The outlet for this three lake system, Forest Creek, is located on the west side of Big Lake and drains to Horse Creek. A dam on Forest Creek regulates water level on Big Lake.

Two locations on Church Pine Lake and four locations on Big Lake are classified as sensitive areas that merit special protection. Additionally, Round Lake is designated as a priority navigable water due to its size being less than 50 acres.

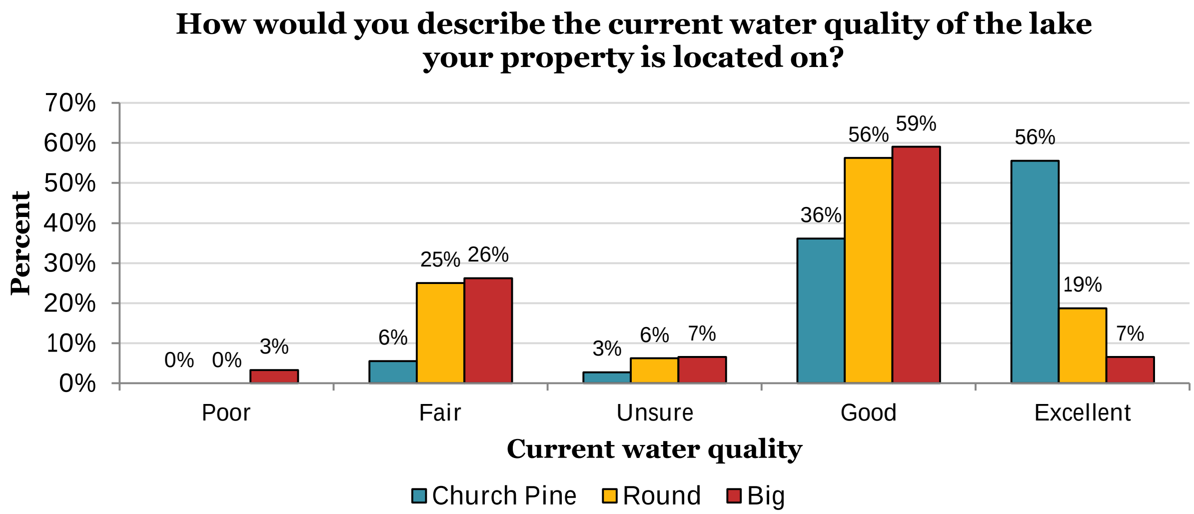
All three lakes are large and highly developed.

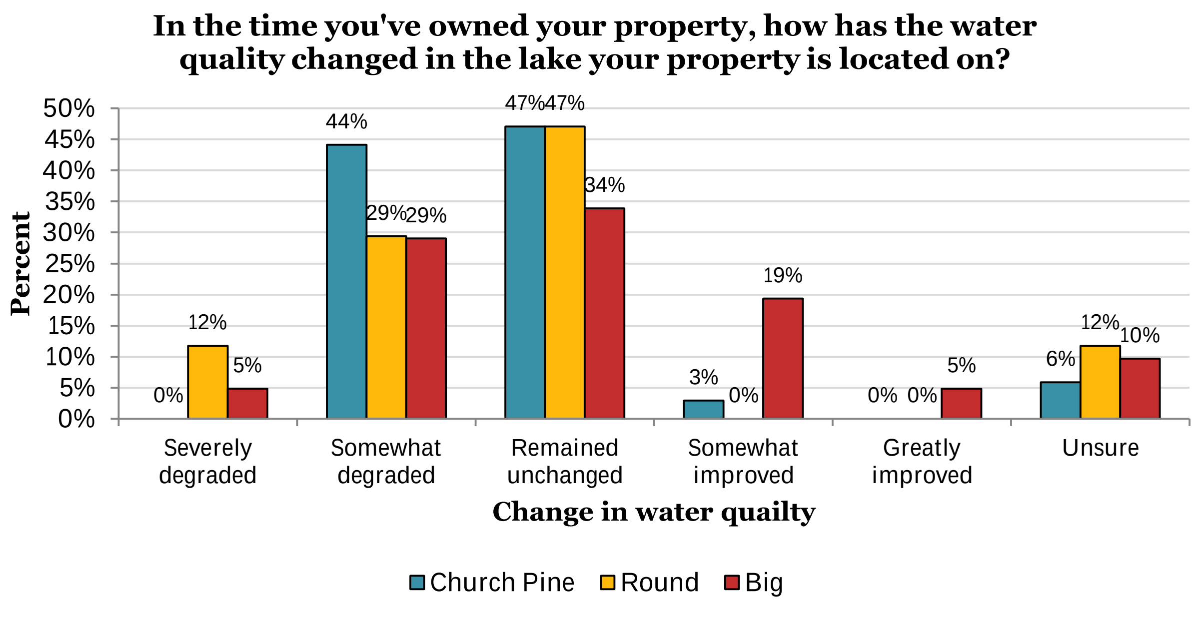
The drainage basin: lake area ratio (DB: LA) compares the size of a lake's watershed to the size of a lake. If a lake has a relatively large DB: LA then surface water inflow (containing nutrients and sediments) occurs from a large area of land relative to the area of the lake. The DB: LA ratio is largest for Big Lake (15.32), followed by Church Pine Lake (3.92) and Round Lake (3.43).

Survey results

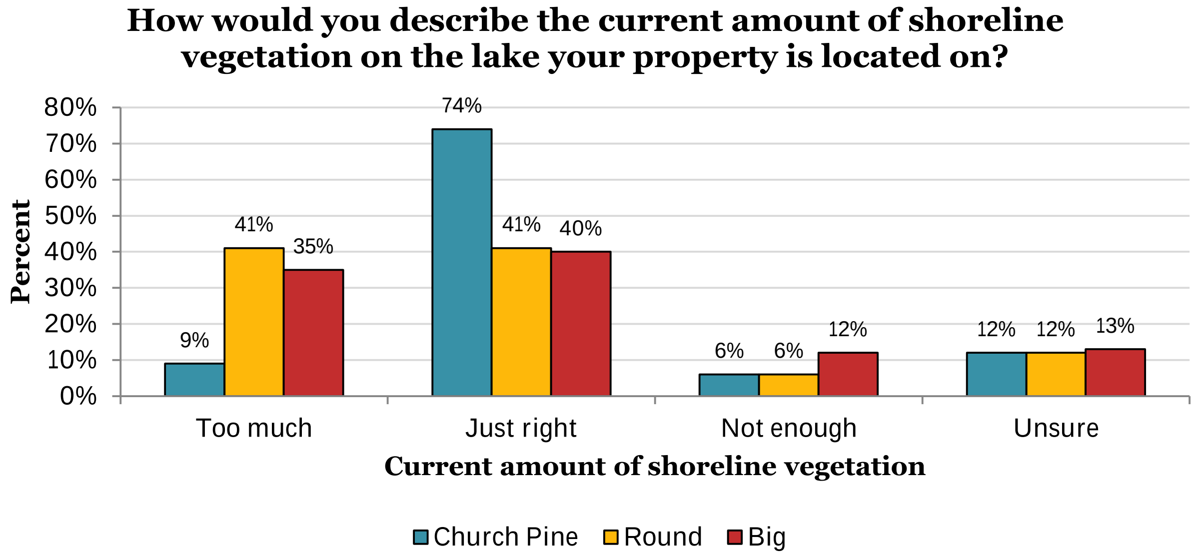
One hundred sixteen members of the Church Pine, Round, and Big Lakes Protection and Rehabilitation District completed a survey regarding the three lake system (52% response rate). In this survey property values and/or taxes ranked as the 1^{st} concern for Church Pine, Round, and Big Lakes, followed by invasive species in 2^{nd}, and pollution and aquatic plants which tied for 3^{rd}.

Overall the majority of survey respondents felt that current water quality was good to excellent on the three lake system and that water quality has remained unchanged or somewhat degraded in the time since they have owned property. In general, more respondents felt that water quality on Church Pine Lake was excellent and more respondents felt that water quality on Round and Big Lakes was good.





Across all three lakes most survey respondents feel that the amount of shoreline vegetation on the three lake system is just right. Additionally, more respondents feel that there is too much shoreline vegetation as compared to not enough. Although a combined 78% of respondents felt that shoreline buffers, rain gardens, and native plants are very important or somewhat important to water quality, half (50%) of respondents are not interested in installing a shoreline buffer or rain garden on their property.



Overall, survey respondents are making educated decisions when applying fertilizer to their property. Over half of respondents (58%) do not use fertilizer on their property and over a third (35%) use zero phosphorus fertilizer. Very few respondents (5%) use fertilizer but are unsure of its phosphorus content and an extremely small percentage (2%) use fertilizer on their property that contains phosphorus.

Survey respondents were asked to choose all of the management practices they felt should be used to maintain or improve the water quality of Church Pine, Round, and Big Lake from a list of eight options. Three-fourths of respondents (75%) felt that the in-lake water quality data should continue to be collected and that enhanced efforts to monitor for new populations of aquatic invasive species should be implemented. Other management practices supported by many respondents were information and education opportunities (46%), cost-sharing assistance for the installation of shoreline buffers and rain gardens (44%), and establishment of slow-no-wake zones to protect aquatic plants and fisheries habitat (41%).

Management practices to improve water quality	Percent
Continued collection of in-lake water quality data	75%
Enhanced efforts to monitor for new populations of aquatic invasive species	75%
Information and education opportunities	46%
Cost-sharing assistance for the installation of shoreline buffers and rain gardens	44%
Establishment of slow-no-wake zones to protect aquatic plants and fisheries habitat	41%
Collection of sediment cores to provide information concerning historical lake conditions	33%
Practices to enhance fisheries, such as the introduction of coarse woody habitat	29%
Cost-sharing assistance for the installation of farmland conservation practices (nutrient management plans, contour strips, conservation tillage)	27%

Lake level and precipitation data

Seasonal precipitation totaled twenty-three inches on Church Pine Lake, twenty inches on Round Lake, and twenty-four inches on Big Lake. Shortly following precipitation events, the lake levels on Church Pine, Round, and Big Lake increased. Over the course of the 2012 sampling season, lake levels on all three lakes dropped nearly a foot.

Sampling procedure

Physical and chemical data were collected in-lake at the deep hole of Church Pine, Round, and Big Lake from May 7th, 2012 through September 5th, 2012. Spring turnover samples were taken on April 3rd, 2012. However, since ice-out occurred around a month early, the lakes had already begun to stratify by this date. Fall turnover samples were taken on October 15th, 2012.

Turnover

Turnover events in lakes occur two times a year in Wisconsin. At spring and fall turnover, the temperature and density of the water is constant from the top to the bottom. This uniformity in density allows a lake to completely mix. As a result, oxygen is brought to the bottom of a lake, and nutrients are re-suspended from the sediments.

As the sun's rays warm the surface waters in the spring, the water becomes less dense and remains at the surface. Warmer water is mixed deeper into the water column through wind and wave action. However, these forces can only mix water to a depth of approximately twenty to thirty feet. Generally, in a shallow lake (Round and Big Lakes), the water may remain mixed all summer. However, a deeper lake (Church Pine Lake) usually experiences layering called stratification.

In stratified lakes, warmer surface waters are prevented from mixing with cooler bottom waters. As a result, nutrients can actually become trapped in the bottom waters of a lake that stratifies. Additionally, because mixing is one of the main ways oxygen is distributed throughout a lake, lakes that stratify have the potential to have very low levels of oxygen in the hypolimnion.

Chemical data

A "healthy" limit of water column phosphorus is set at 0.02 mg/L total phosphorus to prevent nuisance algae blooms. The growing season average (excludes turnover) total phosphorus was below the healthy limit (0.0182 mg/L) for Church Pine Lake, slightly above the healthy limit (0.0212 mg/L) for Round Lake, and slightly above the healthy limit (0.0252 mg/L) for Big Lake.

Nitrate/nitrite and ammonium are all inorganic forms of nitrogen which can be used by aquatic plants and algae. Inorganic nitrogen concentrations above 0.3 mg/L can support summer algae blooms. Inorganic nitrogen concentrations were well below the healthy limit that can support summer algae blooms in all lakes at all sample dates with the exception of Big Lake at spring turnover (0.51 mg/L). Nitrate/nitrite levels were below the limit of detection in all lakes on all sample dates with the exception of Round and Big Lake at spring turnover (0.2 mg/L and 0.4 mg/L respectively).

The total nitrogen to total phosphorus ratio (TN: TP) is a calculation that depicts which nutrients limit algae growth in a lake. The total nitrogen to total phosphorus ratio for Church Pine, Round, and Big Lakes indicates a phosphorus limited state at all sample dates. The ratio indicates that Church Pine Lake experienced the greatest phosphorus limitation, followed by Round, and Big Lakes.

Physical data

A water quality standard for dissolved oxygen in warm water lakes and streams is set at 5 mg/L. This standard is based on the minimum amount of oxygen required by fish for survival and growth. Oxygen levels in all three lakes remained above 5 mg/L near the surface but dropped below this threshold in the bottom waters. In Church Pine and Big Lakes bottom waters were anoxic (<1 mg/L) during the majority of the sampling season.

Church Pine Lake had the greatest water clarity, as measured with a secchi disk, as compared to Round and Big Lake over the entire sampling season (with the exception of spring turnover). Early in the year, Big Lake had greater water clarity as compared to Round Lake. Around July, this trend reversed with Round Lake exhibiting greater water clarity as compared to Big Lake.

Chlorophyll a seems to have the greatest impact on water clarity when levels exceed 0.03 mg/L. Lakes which appear clear generally have chlorophyll a levels less than 0.015 mg/L. In Church Pine, Round, and Big Lakes, chlorophyll a levels at all sampling dates were well below 0.03 mg/L and 0.015 mg/L.

Trophic state index

Trophic State Index (TSI) data indicates that in 2012 Church Pine Lake was oligotrophic, Round Lake was mesotrophic, and Big Lake was mildly eutrophic. Historic TSI data classifies Church Pine Lake as oligotrophic/mesotrophic and Round and Big Lakes as mesotrophic/mildly eutrophic.

Shoreline survey

A characterization of the entire three lake system shoreline inventory shows that the greatest land use at the ordinary high water mark is natural (60%), followed by rip rap (30%), lawn (7%), sand (2%), and structure (1%). A characterization of the entire three lake system shoreline buffer composition inventory shows that the greatest land use is natural (64%), followed by lawn (23%), hard surface (6%), landscaping (5%), and bare soil (2%).

Tributary monitoring

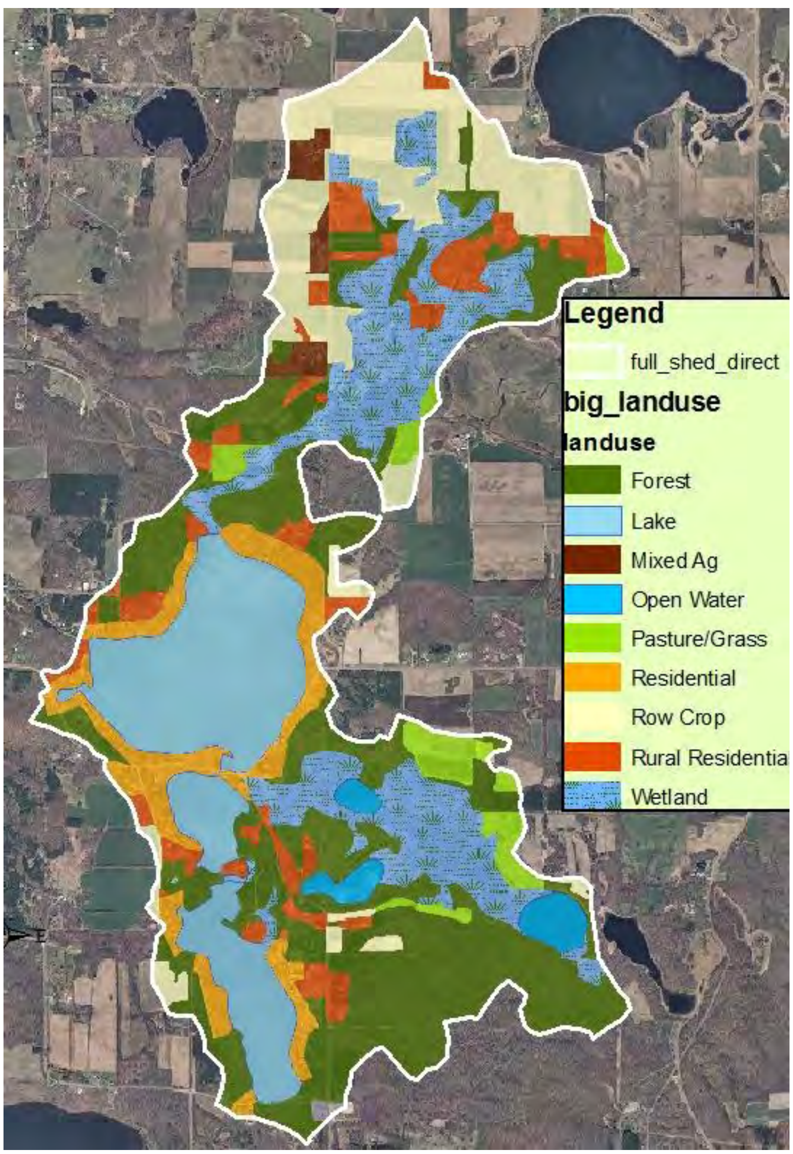
The tributary contributing the most phosphorus to Church Pine, Round, and Big Lakes is North Creek (251 pounds phosphorus/year). The total phosphorus concentration in North Creek is approximately two times greater when compared with the County Road K culvert. However, the instantaneous load of phosphorus in North Creek is approximately fifteen times greater when compared with the County Road K culvert. The differences in these values relates primarily to the differences in discharge between North Creek and County Road K culvert. The volume of water flowing from North Creek is nearly seven times the amount flowing through the County Road K culvert.

The values for the Big Lake outlet are highlighted in red to serve as a reminder that these values represent the amount of phosphorus leaving the three lake system via the outlet.

Site	Total Phosphorus (mg/L)	Discharge (l/s)	Instantaneous Load Phosphorus (mg/s)	Instantaneous Load Phosphorus (lb/yr)
County Road K	0.043	0.006	0.241	16.755
North Creek	0.087	0.041	3.603	250.633
Big Lake Outlet	0.024	0.045	1.077	74.942

Lake watershed

The Church Pine Lake Watershed is 377.5 acres in size, the Round Lake Watershed is 106.6 acres in size and the Big Lake Watershed is 1765.8 acres in size.



Watershed land use and phosphorus loading

The Wisconsin Lakes Modeling Suite (WiLMS) was used to model current conditions for Church Pine, Round, and Big Lakes, verify monitoring, and estimate land use nutrient loading for the watershed. Phosphorus is the key parameter in the modeling scenarios used in WiLMS because it is the limiting nutrient for algal growth in most lakes.

Forest makes up over half (52%) of the land use in the Church Pine Lake Watershed. Other land uses include the lake surface (24%), medium density urban (11%), rural residential (6%), row crop (5%), high density urban (1%), and wetlands (1%). The largest contributor of phosphorus to Church Pine Lake is the lake surface (26%), followed by medium density urban (20%), forest and row crop (each 17%), high density urban (5%), rural residential (2%), and wetlands (less than 1%). Additionally, the model predicts that septic systems are contributing 13% of the phosphorus load to Church Pine Lake.

Church Pine Lake

	Total acres	Percent acres	Total Loading (lb P /year)	Percent loading
Row crop	17.5	5%	15.6	16.6%
High density urban	3.8	1%	5.1	5.4%
Medium density urban	41.9	11%	18.7	19.9%
Rural residential	23.1	6%	2.1	2.2%
Wetlands	4.4	1%	0.4	0.4%
Forest	195.8	52%	15.8	16.8%
Lake surface	91	24%	24.4	26.0%
Septic			11.9	12.70%

The largest land use in the Round Lake Watershed is the lake itself (36%), followed by medium density urban (24%), forest (21%), rural residential (14%), row crop (4%), and wetlands (1%). The largest contributor of phosphorus is medium density urban (33%), the lake surface (29%), row crop (11%), forest (5%), rural residential (4%), and wetlands (less than 1%). Additionally, the model predicts that septic systems are contributing 18% to the phosphorus load to Round Lake.

Round Lake

	Total acres	Percent acres	Total Loading (lb P/year)	Percent loading
Row crop	4.3	4%	3.8	11.0%
Medium density urban	25.4	24%	11.3	32.5%
Rural residential	15.4	14%	1.4	3.9%
Wetlands	0.8	1%	0.1	0.2%
Forest	22.7	21%	1.8	5.2%
Lake surface	38	36%	10.2	29.1%
Septic			6.3	18.0%

The largest land uses in the Big Lake Watershed are forest (26%) and wetlands (24%). Other land uses include row crop (16%), the lake itself (14%), rural residential (8%), medium density urban (6%), pasture/grass (5%), and mixed agriculture (2%). The largest contributor of phosphorus is row crop (50%) followed by the lake surface (13%), medium density urban (9%), wetlands and forest (each 7%), mixed agriculture (5%), pasture/grass (4%), and rural residential (2%). Additionally, the model predicts that septic systems are contributing 3% of the phosphorus load to Big Lake.

Big Lake

	Total acres	Percent acres	Total Loading (lb P/year)	Percent loading
Row crop	288.6	16%	257.6	49.8%
Mixed agriculture	34	2%	24.3	4.7%
Pasture/grass	80.7	5%	21.7	4.2%
Medium density urban	99.9	6%	44.5	8.6%
Rural residential	134.6	8%	11.9	2.3%
Wetlands	417.513	24%	37.2	7.2%
Forest	467.5	26%	37.8	7.3%
Lake surface	243	14%	65.2	12.6%
Septic			17.6	3.4%

Church Pine, Round, and Big Lakes Management Plan
Water Quality Committee Meeting 1 Minutes

Monday, February 11th, 2013, Alden Town Hall, 6-8 pm

Overview

Scheduled future meetings, reviewed grant requirements and purpose of lake management plans, public survey results, water quality study results, identified concerns and questions

Future meeting dates

- March 25th
- April 22nd
- May 18th *present plan goals at Spring Informational Meeting*
- June 3rd

All meetings will take place at the Alden Town Hall from 7-9 **(note time change)**

Identified committee concerns

- Algae is the primary concern the plan should address
- Controlling/reducing phosphorus
    - Education of residents
    - Reduction in North Creek phosphorus input
- Boats turning up nutrients
    - No wake
- Concerns over impervious surfaces and impact on water quality
- Continued lake monitoring
- Trout—2 story?
- Education—rain gardens and conservation of existing water
- Irrigation of lawns using lake water
- How to get neighbors and farmers not on the lake to get involved?
- Submergent plant control; lily pad control (addressed in Aquatic Plant Management Plan)

Questions to be answered at future meetings?

- How to address internal loading; more information on alum
- Nutrient budget
- Define the state of the lakes—specific changes to result in specific improvements
- Quantify the return on investment and costs of various practices
- More information on algae
- More information on fish habitat, fish sticks

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Jeremy Williamson, (715) 485-8639, jeremyw@co.polk.wi.us

Church Pine, Round, and Big Lakes Management Plan
Water Quality Committee Meeting 2

Monday, March 25th, 2013
7-9 pm
Alden Town Hall

Agenda

7:00 Introductions

7:10 Initial study results continued (nutrient budget)

7:40 Explore options for lake management

8:00 Review and discuss draft plan vision, guiding principle, goals, and objectives

9:00 Adjourn

Katelin Holm, (715) 485-8637, katelin.holm@co.polk.wi.us

Jeremy Williamson, (715) 485-8639, jeremyw@co.polk.wi.us

Enclosed are two documents for review for Monday's meeting:

1. A document providing examples of plan vision statements, guiding principles, goals, objectives, and actions. This is by no means a comprehensive list and may include options that are not priorities for Church Pine, Round, and Big Lakes and may be lacking options that are priorities for Church Pine, Round, and Big Lakes. The purpose of this document is solely to provide examples from other Lake Management Plans.

2. A document called Choosing Management Strategies for Lakes which was initially prepared for Portage County lakes. This document provides additional information on the wide range of management strategies available for lakes.

Vision *an overall statement for what you want the lakes to look like*

Church Pine, Round, and Big Lake are clear lakes, free of unsightly algae blooms

Church Pine, Round, and Big Lake provide a healthy environment for people, wildlife, and plants

Church Pine, Round, and Big Lake are clear lakes with moderate nutrient levels and diverse fish, wildlife, and plants

Guiding Principle *provides guidance on how the lake management plan will be implemented*

An understanding of data drives lake management decisions

Lake management decisions are driven by what is best for the resource

Communication regarding lake management is easy to understand, concise, and frequent

Lake residents and users are provided information to understand the ever evolving nature of lake management, the complexity of issues, the status of projects and activities, the costs and benefits of actions, and the opportunity and techniques to reduce or prevent any negative consequences of lake use and lakeside living

Financial decisions are made in cooperation with Lake District members

Goals *broad statements of direction*

Objectives *measurable steps towards goals*

Actions *activities to accomplish objectives*

Information and education opportunities can show up as goals, objectives, actions, or any combination of the three.

Goals and Objectives

Maintain and improve current water quality and in-lake nutrient levels

Reduce nutrient pollution to the lakes

Reduce runoff of nutrients and sediment from the watershed

Objectives may include:

- Engage residential owners in reducing runoff
- Reduce phosphorus loading from residential sources by X% or X pounds
- Support installation of residential best management practices/practices that reduce runoff to the lake

- Engage agricultural producers in reducing runoff
- Reduce phosphorus loading from agricultural sources by X% or X pounds
- Support installation of agricultural best management practices/practices that reduce runoff to the lake

Actions may include: providing technical assistance for property owners, cost sharing installation of best management practices, considering purchase of highly erodible/ecologically sensitive land if option arises, free evaluation of septic systems, education initiative

Encourage lake processes that minimize the release of nutrients from within the lakes

Objectives may include:

- Engage stakeholders in reducing internal loading
- Reduce internal loading by X%
- Support practices that reduce internal loading
- Conduct further studies to better understand internal loading

Actions may include: study to determine phosphorus release from CLP die off, slow-no wake to minimize disturbance of sediments, increase native aquatic plant rooting depth, sediment phosphorus release study to quantify internal load, education initiative

Protect, maintain, and enhance the lakes fishery

Protect, maintain, and enhance fish and wildlife habitat

Objectives may include:

- Maintain desirable levels of game fish in the lakes
- Assess and improve fish habitat
- Balance fish populations to encourage zooplankton
- Increase understanding of options for attracting wildlife to property
- Protect existing natural areas with native vegetation
- Enhance shoreline vegetation

Actions may include: fish stocking, installation of fish habitat, communication with DNR, cost sharing shoreline buffers, purchase of ecologically sensitive land, conservation easements to preserve undeveloped lands, establishment of slow-no wake zones, enforcement of current slow-no wake requirements, education initiative

Maintain and enhance the natural beauty of the lakes

Promote the preservation and restoration of natural vegetation along the shoreline

Objectives may include:

- Maintain undeveloped natural areas where feasible
- Enhance natural beauty of developed areas
- Create areas for public use

Actions may include: incentives to encourage restoration/maintenance of buffers, conservation easements, installation of public fishing piers, creation of public parks with walking trails, establishment of public swimming beach

Continue to collect in-lake water quality data

Measure lake management progress by collecting in-lake water quality data

Evaluate the progress of lake management efforts through monitoring

Objectives may include:

- Continue current data collection efforts
- Expand data collection efforts to include…provide a list
- Consider additional studies to quantify/update a nutrient budget

Actions may include: citizen lake monitoring data collection (secchi, chlorophyll a, total phosphorus), tributary sampling, track installation and effectiveness of watershed practices, quantify internal loading on Big Lake, quantify impact of the outlet drying up on Big Lake, consider a sediment core on Church Pine, Round, and Big Lake

Increase information and education opportunities

Provide education regarding lake management

Expand education efforts emphasizing the following topics: …provide a list

Objectives and actions may include a list of avenues and methods to communicate information

For example:

Newsletter
Publish x times per year
Seek assistance from agency staff for appropriate articles

Manage native and invasive aquatic plants according to the goals, objectives, and actions outlined in the Aquatic Plant Management Plan

Implement the goals of the Aquatic Plant Management Plan

Prevent introduction of aquatic invasive species and pursue any new introduction aggressively

Reduce the population and spread of curly leaf pondweed, purple loosestrife, and other invasive aquatic plants

Maintain navigable routes for boating

Preserve diverse native aquatic plant community

Reduce runoff of nutrients and sediment from the lake's watershed

Educate the public regarding aquatic plant management

Choosing Management Strategies for Lakes

A diversity of management strategies exist for lake protection. A review of water quality data, an understanding of lake users' perceptions, and the identification of concerns for a lake can guide which management strategies should be implemented for a particular body of water.

Each lake is unique in its physical characteristics (depth, size, location in the landscape), chemical characteristics (phosphorus, nitrogen, pH), assemblage of living and non-living organisms (fish, birds, wildlife, plants, sediments), and human uses (swimming, boating, fishing, scenic beauty). Additionally, lake users represent a diversity of perceptions and values related to concerns for a specific lake. Ultimately, for management strategies to be effective they must take into account scientific data and be supported by the majority of lake users. Management strategies must also align with current state and local regulations and ordinances and take into account availability of funding and volunteers. As a result, it is unlikely that two lakes will choose to pursue identical management strategies.

Despite the uniqueness of lakes and the people that represent them, management strategies do exist that will benefit all lakes. When considering management strategies to adopt, start with this list of best management practices that will benefit all lakes:

Nutrients (phosphorus and nitrogen) are a major source of lake water quality problems, so:
Eliminate applications of lawn fertilizers. If fertilizing, use zero phosphorus fertilizers. In Polk County it is illegal to apply lawn fertilizers within 300 feet of a river/stream and 1,000 feet of a lake/pond/flowage
Choose phosphorus free detergents and cleaning products
Clean up and properly dispose of pet waste
Don't burn leaves near the lake or rake yard waste into the lake
Use natural vegetation, rain gardens, or landscaping to keep runoff from directly entering the lake
If you are a farmer, request help from the Polk County Land and Water Resources Department to develop water quality-based best management practices for farmland that may impact the lake through surface runoff or groundwater inputs
Join other landowners and lake users to establish a water quality monitoring program for your lake. WDNR provides Citizen Lake Monitoring training and data analysis at no cost

Fish and other aquatic life depend on natural vegetation near and on the lake shore, so:
Maintain a natural vegetation buffer—including grasses/forbs, shrubs, and trees—of at least 35 feet from the lake
Don't remove aquatic plants, logs, or brush in front of your property unless absolutely necessary for lake access and recreational activities. Native aquatic plants help stop harmful aquatic invasive plants from becoming established. Follow state aquatic plant removal regulations and obtain permits when needed
Learn to identify aquatic invasive plant species, watch for them near your property and public landings, and help stop their spread. Check with WDNR for aquatic invasive plant removal rules

Check Wisconsin Department of Natural Resources regulations: http://dnr.wi.gov/topic/Waterways/

Strategies are adapted from the publication: Choosing Management Strategies for Portage County Lakes by Byron Shaw, Nancy Turyk, Jen McNelly, Buzz Sorge, and Chris Mechenich.

Septic systems contribute nutrients and other chemicals to groundwater and lakes, even if they are working properly, so:
✔ Locate your drain field as far from the lake shore as possible
✔ Pump your septic tank at least once every three years
✔ Consider installing an alternative or additional wastewater treatment system that can remove nitrogen and phosphorus, or explore community or other group wastewater treatment options
✔ Use household chemicals sparingly, try to choose less harmful products, and be mindful that chemicals put into a septic system could end up in the lake or your drinking water

The following management strategies should be implemented if they are applicable for your particular body of water.

Does your lake have areas less than 8 feet deep? These areas:	
May have these problems	**and may benefit from**
Sediment disturbance from boat motors	✔ No-wake speeds or electric motors only
Wind disturbance of sediments	✔ Moderate growth of aquatic plants to hold sediments in place
High density of aquatic plants	✔ Strategies to improve recreational access ✔ Tools from the phosphorus management toolbox
Shallow lakes may suffer from a lack of dissolved oxygen in winter	

Does your lake have a high percentage of its areas more than 18 feet deep? Deep lakes:	
May have these problems	**and may benefit from**
• Few aquatic plants • Biomass dominated by algae • Lack of oxygen near bottom • Release of phosphorus from sediments during low oxygen conditions	✔ Tools from the phosphorus management toolbox ✔ Minimizing near shore vegetation disturbance to provide habitat and protect water quality♻
The two storied fisheries of deep lakes, which include trout and walleye in cool, deep waters as well as panfish and bass in shallow waters, require management to stay in balance	

Is your lake a deep bowl protected from the wind? Lakes in deep bowls:	
May have these problems	**and may benefit from**
Runoff from steep shoreline areas	✔ Houses being set back from steep slopes ✔ Meandering, not direct, access to the lake ✔ Vegetative buffers to prevent erosion along slopes ✔ Shoreline buffers to intercept erosion and runoff ✔ Additional tools from the runoff management toolbox
Lack of mixing and oxygenation	✔ Monitoring dissolved oxygen concentrations ✔ Using mechanical aeration when necessary

♻ Check Wisconsin Department of Natural Resources regulations: http://dnr.wi.gov/topic/Waterways/

Strategies are adapted from the publication: Choosing Management Strategies for Portage County Lakes by Byron Shaw, Nancy Turyk, Jen McNelly, Buzz Sorge, and Chris Mechenich.

Does your lake have wetlands along its shore? Lakes with adjacent wetlands:	
May have these problems	**and may benefit from**
Nutrient addition when water levels rise	✔ Retaining natural wetland vegetation and minimizing nutrient flow to wetlands
Natural limit to residential growth and development	✔ Appropriate zoning ordinances to avoid developing wetland areas ✔ Maintaining vegetative buffers around wetlands
Wet soils and wetland vegetation in areas that people cross to access the lake	✔ Avoiding wet areas or installing a boardwalk over them to reduce disturbance
Compared to lakes without wetlands, these lakes may have more water quality fluctuations and more diverse wildlife habitat	

Does your lake experience natural water level fluctuations? Such lakes:	
May have these problems	**and may benefit from**
Aquatic invasive plant species that become established on bare sediments or in shallower, warmer water	✔ Looking for and removing aquatic invasive plants during low water periods. Check with WDNR for aquatic invasive plant removal rules
Damage to unique habitats by human use during low water periods	✔ Establishing barriers to prevent vehicle access to the dry lake bed during low water periods
Sensitivity to changes in groundwater recharge	✔ Use of swales, rain gardens, and other management tools to encourage infiltration of rainwater and snowmelt
A large area less than 8 feet deep during some parts of the year	✔ No-wake speeds or electric motor only zoning
Winter fish kills	✔ Adding oxygen when necessary by mechanical aeration or by plowing snow off the lake surface to encourage plant growth
Flooding of septic systems during high water periods	✔ As great a septic system setback from the lake as possible ✔ Use of mound systems
Shoreline erosion during high water periods	✔ Maintaining native vegetation and unmowed/uncropped buffer strips near the water's edge
Removal of woody material, leading to loss of potential habitat for fish during periods of high water	✔ Leaving fallen trees, logs, or branches in place or adding them to the exposed lake bed during low water periods

Does your lake have dissolved oxygen concentrations of less than 5 ppm (mg/l) in the upper one-third of the water column during winter? These lakes:	
May have these problems	**and may benefit from**
Winter fish kills	✔ Monitoring dissolved oxygen concentrations ✔ Adding oxygen when necessary by mechanical aeration or by plowing off the lake surface to encourage plant growth

Check Wisconsin Department of Natural Resources regulations: http://dnr.wi.gov/topic/Waterways/

Strategies are adapted from the publication: Choosing Management Strategies for Portage County Lakes by Byron Shaw, Nancy Turyk, Jen McNelly, Buzz Sorge, and Chris Mechenich.

Does your lake have water hardness of more than 150 ppm as CaCO3? If so, marl may form. Marl lakes:	
May have these problems	**and may benefit from**
High density of aquatic plants in shallow sediments	✔ Strategies to improve recreational access
Decreased water clarity caused by resuspension of marl by wind and boats	✔ Slow no wake zones at water depths of less than 8 feet (municipal rules may apply)
Gradual filling with marl	✔ Dredging to deepen parts of the lake ♻
These lakes usually have good water clarity because marl formation removes phosphorus that would otherwise be used by algae	

Does your lake have water hardness of less than 90 ppm as CaCO3? These lakes:	
May have these problems	**and may benefit from**
Low calcium concentrations, leading to greater response by algae to phosphorus additions	✔ Tools from the phosphorus management toolbox

Does your lake have water hardness of less than 25 ppm as CaCO3? These lakes:	
May have these problems	**and may benefit from**
Higher mercury, aluminum, and zinc solubility when rainfall is acidic	✔ Efforts at personal, regional, and national scales to reduce electricity use and fossil fuel consumption
These lakes usually are less productive than other lakes, but often have the most diverse aquatic macrophyte communities	

Do the inorganic forms of nitrogen in your lake exceed 0.3 mg/l (as N) in spring? Lakes with these high nitrogen loads	
May have these problems	**and may benefit from**
Excessive near shore aquatic plants and attached algae and toxicity to some aquatic animals	✔ Eliminating nitrogen fertilizer applications by farmers and homeowners or limiting applications based on soil tests ✔ Alternative or additional wastewater treatment systems designed to remove nitrogen

What is the total phosphorus concentration in your lake between July 15th and September 15th (average of at least three surface samples)? Consult the following table to compare this value to the proposed criteria values for your lake type.
Stratified, two story fishery lakes, 15 µg/L
Stratified seepage lakes, 20 µg/L
Church Pine Lake, Stratified drainage lakes, 30 µg/L
Big and Round Lakes, Non stratified drainage and seepage lakes, 40 µg/L

♻ Check Wisconsin Department of Natural Resources regulations: http://dnr.wi.gov/topic/Waterways/

Strategies are adapted from the publication: Choosing Management Strategies for Portage County Lakes by Byron Shaw, Nancy Turyk, Jen McNelly, Buzz Sorge, and Chris Mechenich.

Has your lake reached its criteria value for total phosphorus? Such lakes:	
May have these problems	**and may benefit from**
• Excessive weeds and algae, including some that are toxic to animals • Winter fish kills • Poor aesthetics—green, turbid, smelly water	✔ Reducing phosphorus concentrations by implementing tools from the phosphorus toolbox ✔ Conducting an in-depth study of lake management and rehabilitation alternatives to control internal and external nutrient loading ✔ Establishing a water quality monitoring program

Phosphorus Management Toolbox
Implement one or more of the following tools to lower total phosphorus concentrations, or to keep concentrations from increasing:
✔ Eliminate phosphorus fertilizer use on your lawn or farm fields, or limit it based on soil test results. In Polk County it is illegal to apply lawn fertilizers within 300 feet of a river/stream and 1,000 feet of a lake/pond/flowage
✔ Don't burn leaves near the lake or rake yard waste into the lake
✔ Implement agricultural best land management practices based on water quality
✔ Install and maintain vegetative buffers, rain gardens, and filter strips that cause stormwater to infiltrate and limit runoff to the lake
✔ Choose phosphorus free automatic dishwater detergent and other "green" household cleaning products if your wastewater re-enters the soil through a septic system
✔ Install alternative or additional wastewater treatment systems designed to remove phosphorus, or consider options for connection to a community or other group wastewater treatment system, especially in areas where groundwater discharges to the lake.
✔ Check the runoff management toolbox and protection tools in the lake management toolbox for more community-based action and solutions.

Is your lake currently free of aquatic invasive species? Such lakes will benefit from:
✔ Protecting and maintaining native plant and animal communities
✔ Knowing how to identify invasive species and actively monitoring for them
✔ Using signs, newsletters, or more active methods to educate boaters and anglers and to encourage them to clean boats and trailers before launch

Does your lake already have aquatic invasive species? Such lakes will benefit from:
✔ Using the tools from the box above
✔ Encouraging boaters and anglers to clean boats and trailers after use to prevent the spread of the invasive species to other lakes
✔ Developing and following an aquatic plant management plan that contains and controls the invasive species

Check Wisconsin Department of Natural Resources regulations: http://dnr.wi.gov/topic/Waterways/

Strategies are adapted from the publication: Choosing Management Strategies for Portage County Lakes by Byron Shaw, Nancy Turyk, Jen McNelly, Buzz Sorge, and Chris Mechenich.

Are there signs that your lake's ecosystem is out of its natural balance? Such lakes:	
May have these problems	**and may benefit from**
Geese on shoreline	✓ Maintaining a natural vegetation buffer onshore ✓ Avoiding mowing or cropping to the water's edge
Eroding shoreline	✓ Vegetative buffers to prevent erosion on slopes ✓ Shoreline buffers to intercept erosion and runoff ✓ Other shoreline stabilization methods such as rocks ⊛ ✓ Maintaining in-lake aquatic plants to act as baffles and reduce the influence of waves ✓ Creating meanders rather than direct paths to the lake
Nuisance-level aquatic plant growth	✓ Creating an aquatic plant management plan

Is your lake's fishery dependent on stocking? Such lakes:	
May have these problems	**and may benefit from**
Lack of fish habitat	✓ Addition of woody material to the nearshore lake bottom
Lack of fish spawning areas or amphibian habitat	✓ Protection of native aquatic vegetation; avoid raking of the lake bottom or removal of vegetation ✓ Awareness of critical habitat locations and actively protecting them from disturbances
Stunted fish, rough fish, dominance of non-game fish	✓ Catch and release fishing ✓ Consulting a WDNR or other professional fishery manager

Are motorized watercraft used on your lake? Such lakes:	
May have these problems	**and may benefit from**
Conflicts between use	✓ Placing limits on motorized watercraft use by time or day, no-wake zones, and/or motor type ✓ Spatial/local boating ordinances to protect critical habitat
• Lake sediment disturbances in shallow water during high-use periods • Disturbance of plant beds and littoral vegetation • Decreased water clarity	✓ Selecting a boat launch area and parking lot appropriate to the lake's carrying capacity and meeting WDNR standards for access ✓ Using no-wake speeds or zoning for electric motors only ✓ Protecting shallow water vegetation and natural materials that keep sediments in place
Increase risk of invasive species introduction	✓ Using signs or more active methods to educate boaters and anglers and to encourage them to clean boats and trailers before launch ✓ Monitoring areas near boat landings to identify and control aquatic invasive species that do get established

⊛ Check Wisconsin Department of Natural Resources regulations: http://dnr.wi.gov/topic/Waterways/

Strategies are adapted from the publication: Choosing Management Strategies for Portage County Lakes by Byron Shaw, Nancy Turyk, Jen McNelly, Buzz Sorge, and Chris Mechenich.

Does your lake have a public park or boat landing? Such lakes:	
May have these problems	**and may benefit from**
Increased nutrient runoff linked to vegetation disturbances	✔ Enhancing infiltration using native vegetation, including unmowed buffer strips
Water runoff from roofs, parking areas, and other paved, compacted, or impervious areas	✔ Directing runoff from these areas into a vegetated strip or rain garden away from the lake
Septic systems that experience heavy use	✔ Constructing these systems with as great a setback as feasible, on the soils that have the greatest capacity to adsorb nitrogen and phosphorus, and regularly inspecting, monitoring, and maintaining them ✔ Installing additional or alternative wastewater treatment systems that remove nitrogen and phosphorus, or exploring community or other group wastewater treatment options ✔ Installing water and energy-conserving plumbing fixtures and devises

Does your lake currently have residential development on it, or is residential development likely in the future? Such lakes:	
May have these problems	**and may benefit from**
Nitrogen and phosphorus loading from fertilized lawns	✔ Eliminating fertilizer applications or limiting them based on soil test results ✔ Using natural buffers that include native vegetation between the lawn and lake ✔ Minimizing amount of manicured lawn ✔ Using tools from the runoff toolbox
Nutrient loading from septic systems	✔ Using greater system setbacks from the lake whenever possible ✔ Encouraging or requiring the use of alternative or additional wastewater treatment systems that remove nutrients whenever systems are installed or replaced, or exploring community or other group wastewater treatment options
Destruction of shoreline vegetation and habitat	✔ Providing education for new landowners on keeping vegetated shorelines intact ✔ Restoring natural shoreline buffers and protecting critical habitat areas
Runoff that carries nutrients to the lake	✔ Using tools from the runoff toolbox ✔ Using protection tools from the lake management toolbox

Does your lake's watershed have off-lake residential development, or is such development likely in the future? Such lakes may benefit from:
✔ Using tools from the runoff management toolbox
✔ Using protection tools from the lake management toolbox

- Check Wisconsin Department of Natural Resources regulations: http://dnr.wi.gov/topic/Waterways/

Strategies are adapted from the publication: Choosing Management Strategies for Portage County Lakes by Byron Shaw, Nancy Turyk, Jen McNelly, Buzz Sorge, and Chris Mechenich.

Does your lake have agricultural land uses near the shore or in the watershed? Such lakes:	
May have these problems	**and may benefit from**
• Sediment and nutrient runoff inputs of nitrate or pesticides through groundwater • Increases in algae • Decreases in dissolved oxygen • Other water quality impacts	✔ Crops that require little nitrogen input ✔ Development and implementation of livestock grazing and manure spreading and storage plants and practices that protect water quality ✔ Vegetative filter strips along lakes, streams, and wetlands to limit runoff inputs and channelized flow to the lake ✔ Public support for county efforts to educate farmers and develop nutrient management plans based on water quality goals ✔ Public support for farmers who implement practices to protect water quality

Runoff Management Toolbox for Lake Watersheds
Implement one or more of the following tools to minimize the amount of surface runoff that carries nutrients and sediments to lakes:
✔ Implement road and building construction practices that meet Polk County erosion standards
✔ Implement agricultural best management practices to minimize runoff
✔ Use the local zoning ordinance to limit impervious surfaces that create runoff
✔ Install and maintain vegetative buffers and filter strips that cause stormwater to infiltrate and to limit runoff to the lake
✔ Use stormwater management practices, which may include rain gardens, streets without curb and gutter, and retention basins

Protection Tools in the Lake Management Toolbox
Implement one or more of the following tools to manage land to protect lakes:
Use legal tools, including:
✔ Zoning that limits potentially damaging land uses and implements the overall density provided for in the land use plan
✔ Overlay zoning that identifies special protections beyond those in the basic zoning ordinance, including shoreland setbacks, impervious surface limits, shoreland buffers, and mitigation measures
✔ Zoning standards adjusted for specific lakes or groups of lakes with similar physical characteristics
✔ Subdivision ordinances
Use voluntary tools, including:
✔ Purchase of development rights that permanently protect landscapes while retaining private ownership
✔ Conservation easements to restrict development or uses of land
✔ Purchase of land by state and local governments or not-for-profit organizations
✔ Conservation design which modifies subdivision ordinances to require protection of open space

Check Wisconsin Department of Natural Resources regulations: http://dnr.wi.gov/topic/Waterways/

Strategies are adapted from the publication: Choosing Management Strategies for Portage County Lakes by Byron Shaw, Nancy Turyk, Jen McNelly, Buzz Sorge, and Chris Mechenich.

Church Pine, Round, and Big Lakes Management Plan
Water Quality Committee Meeting 2 Minutes
Monday, March 25th, 2013, Alden Town Hall, 7-9 pm

Overview

Presentations on watershed modeling and options for lake management; reviewed and discussed draft plan vision, guiding principles, goals, and objectives

Next meeting

Monday, April 22nd
Alden Town Hall
7-9 pm

Plan vision, guiding principles, goals and objectives drafted at the meeting:

Vision

Church Pine, Round, and Big Lake are clear lakes with ideal nutrient levels which are free of algae blooms and provide a healthy environment that supports a diversity of fish, birds, wildlife, plants, and human uses.

Guiding Principles

- Lake management decisions are driven by what is best for the lakes according to past, present, and future data.
- Lake residents and users are provided information to understand:
  - the ever evolving nature of lake management
  - the complexity of issues
  - the status of projects and activities
  - the costs and benefits of actions, and;
  - the opportunity and techniques to reduce or prevent any negative consequences of lake use and lakeside living.
- Communication regarding lake management is easy to understand, concise, and frequent.
- Financial decisions are made in cooperation with Lake District members.

Goals and Objectives

I. Maintain and improve current water quality and in-lake nutrient levels by reducing watershed runoff

A. Ensure that stakeholders understand watershed runoff and how it can be reduced
B. Engage stakeholders in reducing nutrient and sediment runoff
C. Reduce watershed phosphorus runoff by X%
D. Support installation of best management practices, or practices that reduce runoff to the lake

II. Maintain and improve current water quality and in-lake nutrient levels by reducing internal loading

A. Consider further studies to better understand internal loading
B. Ensure that stakeholders understand internal loading and how it can be reduced
C. Engage stakeholders in reducing internal loading
D. Reduce internal phosphorus loading by X%
E. Support practices that reduce internal loading

III. Protect, maintain, and enhance fish, bird, and wildlife habitat

Balancing fish, bird, and wildlife habitat can impact zooplankton populations, which can in turn impact algae populations.

A. Maintain desirable levels of game fish in the lakes
B. Increase understanding of options for attracting desirable wildlife to property
C. Protect existing natural areas with native vegetation
D. Enhance native shoreline vegetation

IV. Maintain and enhance the natural beauty of the lakes

Definition includes wildlife, plants, trees, clear water, quite solitude, a variety of scenery, and views of the lake. Where development occurs, it is preferable to have minimal views of buildings.

A. Maintain undeveloped natural areas where feasible
B. Enhance natural beauty of developed areas
C. Increase opportunities for silent sports

V. Evaluate the progress of lake management efforts

A. Continue current data collecting efforts
B. Expand data collection efforts depending on needs
C. Consider additional studies to answer significant questions

VI. Increase knowledge and participation

A. Increase information and education opportunities
B. Provide education regarding lake management
C. Expand education efforts emphasizing the following topics: …provide a list
D. Explore options for recruiting, retaining, and recognizing volunteers

VII. Implement the goals of the Aquatic Plant Management Plan

A. Prevent introduction of aquatic invasive species and pursue any new introduction aggressively
B. Reduce the population and spread of curly leaf pondweed, purple loosestrife, and other invasive aquatic plants
C. Maintain navigable routes for boating
D. Preserve diverse native aquatic plant community
E. Reduce runoff of nutrients and sediment from the lake's watershed
F. Educate the public regarding aquatic plant management

Church Pine, Round, and Big Lake Management Plan
Water Quality Committee Meeting 3

Monday, April 22nd, 2013
7-9 pm
Alden Town Hall

Agenda

7:00 Introductions
Discuss Spring Informational Meeting and June meeting date

7:10 Open Q&A time in response to emailed questions. Please come with any questions you may have (i.e. modeling, role of North Creek, direct drainage from properties, and internal loading).

7:30 Initial study results continued: algae data

7:40 Refine draft plan goals and objectives (if necessary)
Review and discuss draft action items (in italics on first document)

9:00 Adjourn

Katelin Holm, (715) 485-8637, katelin.holm@co.polk.wi.us

Jeremy Williamson, (715) 485-8639, jeremyw@co.polk.wi.us

Enclosed are two documents for review for Monday's meeting:

1. The first document is what we have come up with as a group so far for: vision, guiding principles, goals, and objectives. Also included are draft action items for consideration. Please review for any edits/additions/removals prior to Monday's meeting.

2. The second document is a draft of what LWRD has prepared so far for the Lake Management Plan. Keep in mind it may still have grammatical errors and there are still sections of the report that need to be added. This report is lengthy and much of the information was already presented at previous meetings. Review as you find time.

Church Pine, Round, and Big Lake Management Plan
Water Quality Committee Meeting 4

Monday, June 3rd, 2013
7-9 pm
Alden Town Hall

Agenda

7:00 Comment on and finalize vision, guiding principles, goals, objectives, and actions

7:30 Complete Implementation Plan

Please review the following documents for changes/comments. At the meeting we will work to fill in the blanks of the Implementation Plan table. The table has been started to give an idea of how the blanks can be filled in. In preparation for the meeting, start thinking about when various projects should be started and who might be the responsible parties.

Katelin Holm, (715) 485-8637, katelin.holm@co.polk.wi.us

Jeremy Williamson, (715) 485-8639, jeremyw@co.polk.wi.us

Vision

Church Pine, Round, and Big Lake are clear lakes with ideal nutrient levels which are free of algae blooms and provide a healthy environment that supports a diversity of fish, birds, wildlife, plants, and human uses.

Guiding Principles

- Lake management decisions are driven by what is best for the lakes according to past, present, and future data
- Communication regarding lake management is easy to understand and concise
- Financial decisions are made in cooperation with Lake District members

5-10 Year Implementation Plan Goals

- Reduce algae and phosphorus in the three lake system by reducing watershed runoff
- Evaluate the progress of lake management efforts
- Protect, maintain, and enhance fish habitat
- Increase knowledge and participation
- Support the goals of the Aquatic Plant Management Plan

<u>Goal 1:</u> Reduce algae and phosphorus in the three lake system by reducing watershed runoff

The area of land that drains to a lake is called a watershed. The Church Pine Lake Watershed is 247 acres in size, the Round Lake Watershed is 69 acres in size, and the Big Lake Watershed is 1,523 acres in size.

<u>Church Pine Lake</u>: Reduce watershed runoff by 5% to ensure current water quality is maintained. Nutrient levels are lowest in Church Pine Lake; therefore, reductions will likely result in small impacts on water quality. Reductions on Church Pine Lake will also positively impact Round and Big Lakes.

Shoreline property owners contribute the greatest amount of phosphorus runoff to Church Pine Lake

- Identify shoreline landowners willing to install shoreline buffers, rain gardens, and water diversions on their property
- Provide technical assistance and cost sharing for implementation of projects
- Recognize landowners that have taken steps to reduce watershed runoff

Partner with the West Immanuel Lutheran Church to install rain gardens and water diversions

<u>Round Lake:</u> Reduce watershed runoff by 10-15%. Nutrient levels are moderate in Round Lake; therefore, reductions will likely result in moderate impacts on water quality. Reductions on Round Lake will also positively impact Big Lake.

Shoreline property owners contribute the greatest amount of phosphorus runoff to Round Lake.

- Identify shoreline landowners willing to install shoreline buffers, rain gardens, and water diversions on their property
- Provide technical assistance and cost sharing for implementation of projects
- Recognize landowners that have taken steps to reduce watershed runoff

<u>Big Lake</u>: Reduce watershed runoff by 15-25%. Nutrient levels are highest in Big Lake; therefore, reductions will likely result in larger impacts on water quality.

North Creek contributes the greatest amount of phosphorus runoff to Big Lake (63%) followed by shoreline property owners (31%).

- Support the work of the Horse Creek Watershed Farmer Lead Council
- Work with Polk County LWRD/consultant to identify best management practices to reduce the phosphorus load from North Creek
- Examine the economic feasibility and effectiveness of a sediment pond on North Creek

- Identify shoreline landowners willing to install shoreline buffers, rain gardens, and water diversions on their property
- Provide technical assistance and cost sharing for implementation of projects
- Recognize landowners that have taken steps to reduce watershed runoff

Partner with the Big Lake Store to install rain gardens and water diversions

Goal 2: Evaluate the progress of lake management efforts

Continue current data collection efforts

Ensure that Citizen Lake Monitoring volunteer is in place for each year

Contact WDNR in Spooner for more information and sampling materials

Expand data collection efforts depending on needs

Monitor tributaries to document reductions in watershed runoff

Goal 3: Protect, maintain, and enhance fish habitat

Balancing fish can impact zooplankton populations, which can impact algae populations

Maintain desirable levels of game fish in the lakes

Assess and improve fish habitat i.e. woody habitat

Communicate with WDNR to make informed decisions and encourage assessment and management

Continue monetarily supporting fish stocking based on expert recommendations

Goal 4: Increase knowledge and participation

Watershed residents and lake users are provided information to understand:

- the ever evolving nature of lake management
- the complexity of issues
- the status of projects and activities
- the costs and benefits of actions
- the opportunity and techniques to reduce or prevent any negative consequences of lake use and lakeside living

Methods for communicating information
Website
Annual Meeting
Spring Informational Meeting
Tour to view installed best management practices
Contest for best rain garden, shoreline restoration, etc

Goal 5: Support the goals of the Aquatic Plant Management Plan

- Prevent introduction of aquatic invasive species and pursue any new introduction aggressively
- Reduce the population and spread of curly leaf pondweed, purple loosestrife, and other invasive aquatic plants
- Maintain navigable routes for boating
- Preserve diverse native aquatic plant community
- Reduce runoff of nutrients and sediment from the lake's watershed
- Educate the public regarding aquatic plant management

Further considerations

1. Consider further studies to quantify internal loading, or the nutrients released back into the water column through sediment disturbance or plant die back
2. Consider a sediment core on Church Pine, Round, and Big Lake to gather historical data (i.e. 100-200 years)

Implementation Plan

Goal 1: Reduce algae and phosphorus in the three lake system by reducing watershed runoff

Action	Timeline	Cost Estimate	Volunteer Hours	Responsible Parties	Funding Sources
Identify shoreline landowners willing to install shoreline buffers, rain gardens, and water diversions on their property	2013, ongoing			Board	
Provide technical assistance and cost sharing for implementation of projects		$50,000		Board Consultant	WDNR Lake Protection Grant
Recognize landowners that have taken steps to reduce watershed runoff	Ongoing			Board	
Partner with the West Immanuel Lutheran Church to install rain gardens and water diversions	2014			Board Consultant	WDNR Lake Protection Grant
Support the work of the Horse Creek Watershed Farmer Lead Council	2015, ongoing	Up to $2,500	0 hours	Board LWRD	
Work with Polk County LWRD/consultant to identify best management practices to reduce the phosphorus load from North Creek	2014, ongoing			Board LWRD Consultant	
Examine the economic feasibility and effectiveness of a sediment pond on North Creek	2015	$2,500		Board Consultant	WDNR Lake Protection Grant
Partner with the Big Lake Store to install rain gardens and water diversions		$7,000		Board Consultant	WDNR Lake Protection Grant

Goal 2: **Evaluate the progress of lake management efforts**

Action	Timeline	Cost Estimate	Volunteer Hours	Responsible Parties	Funding Sources
Ensure that Citizen Lake Monitoring volunteer is in place for each year	Ongoing	$0	30	Board	WDNR Citizen Lake Monitoring Network
Contact WDNR in Spooner for more information and sampling materials	Ongoing	$0	1	Board	
Monitor tributaries to document reductions in watershed runoff	Ongoing	$81/ sample		Board Consultant	

Goal 3: **Protect, maintain, and enhance fish habitat**

Action	Timeline	Cost Estimate	Volunteer Hours	Responsible Parties	Funding Sources
Assess and improve fish habitat i.e. woody habitat				Board WDNR LWRD	WDNR Lake Protection Grant
Communicate with WDNR to make informed decisions and encourage assessment and management	Ongoing			Board WDNR	
Continue monetarily supporting fish stocking based on expert recommendations	Ongoing			Board WDNR	

<u>Goal 4:</u> Increase knowledge and participation

Methods for communicating information	Timeline	Cost Estimate	Volunteer Hours	Responsible Parties	Funding Sources
Website	Ongoing				
Annual Meeting	Ongoing				
Spring Informational Meeting	Ongoing				
Tour to view installed best management practices					
Contest for best rain garden, shoreline restoration, etc					

Appendix H

Public Comments

Draft Lake Management Plan for Church Pine, Round (Wind), and Big Lake available for public review and comment

The public is invited to review and provide comments on the Lake Management Plan for Church Pine, Round (Wind), and Big Lake. A hard copy of the plan is available at the Osceola Public Library and the Amery Public Library and an online version is available on the Church Pine, Round, and Big Lake District website (www.bigroundpine.com) and the Polk County Land and Water Resources Department website (www.co.polk.wi.us/landwater/reports.asp). Comments and suggestions should be submitted in writing or email and received by August 1st, 2013 to ensure that they are given proper consideration in the final plan. No telephone messages will be considered. Anyone interested in providing input should contact Jeremy Williamson or Katelin Holm at 100 Polk County Plaza-Ste 120, Balsam Lake, WI 54810; jeremyw@co.polk.wi.us; or katelin.holm@co.polk.wi.us.

Public comments/concerns 1

- Adoption of an Ordinance to regulate water traffic (slow no wake), especially on Round Lake
- Adoption of boating hour restrictions
- Prohibiting bright spot lights

Public comments/concerns 2

Noticeable changes:

- 1. Size and speed of **water craft** (increase)
- 2. **Light and noise** pollution (increase)
- 3. Loss of shoreline natural habitat (decrease)
- 4. Traffic on County K (increase)
- 5.People less likely to honor “quiet” times in morning and evenings
- 6. More aquatic vegetation

Some things we would like to see for the lakes- especially Round (Wind) lake:

- Designate Round Lake and the north point of Church Pine Lake as no wake OR consider no wake hours, size restrictions, and speed restrictions
- Limit permanent lights and type of lights
- 4th of July fireworks are too big, close, and loud
- Leave the natural shorelines alone for wildlife habitat, and runoff.

Appendix I

Presentations

Big, Round (Wind), and Church Pine Lake Planning Grant
Award: $21,825.10

Polk County Land and Water Resources Department
Katelin Holm
4.16.12

District Obligations

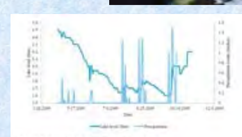
- Up to $5,000 and 300 volunteer hours
- What can count towards $5,000
  - Postage/printing costs
    - Survey
    - Newsletters with grant information
  - Pontoon use
  - Extra volunteer hours
    - Value of $12/hour

Components of the study

- Physical and chemical data
  - In lake (3 sites)
  - Inlets (4 sites)
- Phytoplankton
- Zooplankton
- Watershed delineation
- Lake level/precipitation
- Sociological survey
- Shoreline survey
- Meetings and education
- Final plan generation

Lake level/precipitation

- Volunteer needs
  - Daily collection
  - One data collector/lake
- Volunteer hours
  - 3 lakes*40 hours each = 120 hours

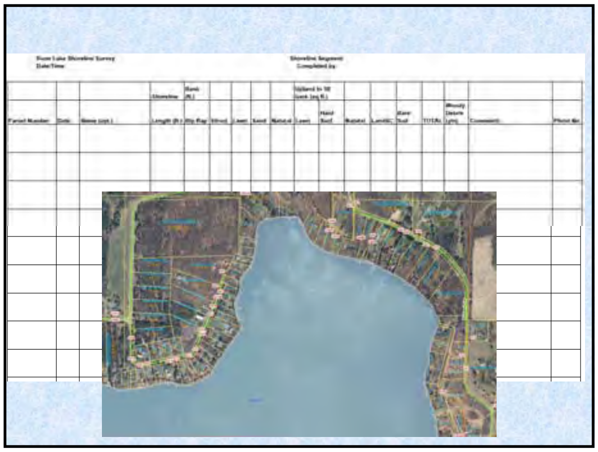


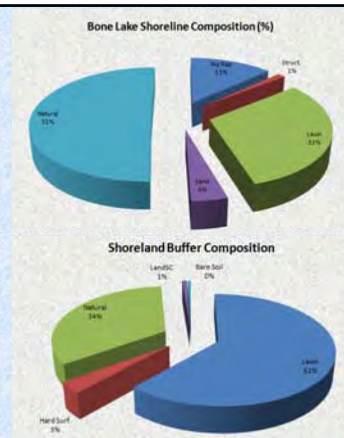
Sociological survey

- Volunteer needs
  - Survey review
  - Survey distribution
- Volunteer hours
  - 24 hours
- Why do a survey?
  - Public input for final plan
  - Meaningful data

Shoreline survey

- Volunteer needs
  - 3 to 4 people
  - Late summer to fall
- Volunteer hours
  - 32 hours





Meetings and education

- Volunteer needs
  - Water quality committee
  - Attendees of education events
- Volunteer hours
  - 5 meetings *12 hours = 60 hours
  - Pontoon classroom = 36 hours
  - Shoreline restoration workshop = 24 hours

Final plan generation

- Volunteer needs
  - Reviewers of plan
  - Post for review and comment
    - Newsletter, website, paper, etc
- Volunteer hours
  - 24 hours

Totals

- Lake level/precipitation = 120 hours
- Sociological survey = 24 hours
- Shoreline survey = 32 hours
- Meetings/education = 120 hours
- Final plan generation = 24 hours

320 hours

Church Pine, Big, and Round Lake Water Quality and Biological Assessment

This project will be funded through a WDNR Lake Planning Grant. The grant award of $21,825 makes up 67% of the total project costs. The remaining 33% of the project costs are made up through volunteer hours, equipment use, and a District match of up to $5,000.

Project activities:

- Physical and chemical data
  - In lake (3 lakes)
  - Tributary sampling (4 sites)
- Lake level and precipitation monitoring
- Phytoplankton (algae) monitoring
- Zooplankton monitoring
- Shoreline assessment
- Mapping and watershed delineation
- Sociological survey
- Educational programs
  - Shoreline restoration workshop
  - Pontoon classroom
  - Series of 5 meetings
- Final plan generation: Lake Management Plan

Project activities requiring volunteers:

- Lake level and precipitation monitoring: *This project is currently being completed by three volunteers: Gary Ovick (Church Pine), Jerry Tack (Round), and Heidi Hazzard (Big). These volunteers record any precipitation events and lake level using a staff gauge (photo on right) on a daily basis.*

- Sociological survey: *The survey was reviewed by the Board of Commissioners and the WDNR and was mailed to members of the District on May 1st.*

- Shoreline assessment: *This project will take place in late summer/early fall and will involve assessing the shoreline from the water. Volunteers will determine the land use (lawn, natural area, structure, riprap, etc.) of the shoreline (ft) and the first 35 feet of shoreline (ft^2). Volunteers are still needed for this project.*

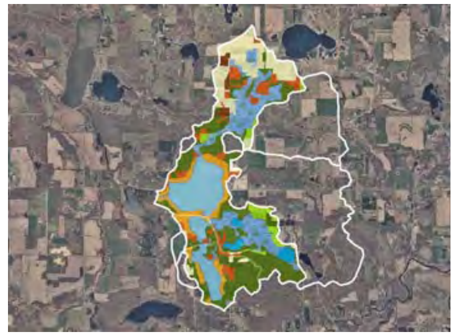
- Educational programs: *These events will take place later in the season. For now the only tasks are to determine the best time to hold educational programs and to generate interest in the programs. The series of five meetings will work towards generating the final Lake Management Plan. Ideally, these meetings would be attended by members of the water quality committee.*

Thank you to all the volunteers who have already put time into these projects and to those who have already returned their sociological survey!

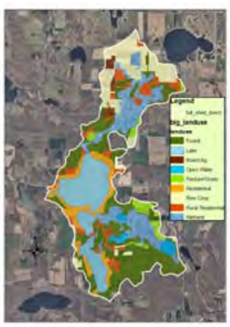
Big, Round, & Church Pine Lakes Water Quality

Jeremy Williamson
Water Quality Specialist
Polk County LWRD

Watershed Modeling



Watershed Modeling



Church Pine Lake				
	Total acres	**Percent acres**	**Total Loading (lb P /year)**	**Percent loading**
Row crop	17.5	5%	15.6	16.6%
High density urban	3.8	1%	5.1	5.4%
Medium density urban	41.9	11%	**18.7**	**19.9%**
Rural residential	23.1	6%	2.1	2.2%
Wetlands	4.4	1%	0.4	0.4%
Forest	195.8	52%	15.8	16.8%
Lake surface	91	24%	24.4	26.0%
Septic			11.9	12.70%

Watershed Modeling

Reckhow 1977 Lakes < 50 meters model: $P = \frac{L}{\left(\frac{18z}{10+z}\right) + 1.05\left(\frac{z}{T_w}\right)e^{0.012 z/T_w}}$

Nurnberg total phosphorus model: $P = \frac{L_{ext}}{q_s}(1-R) + \frac{L_{int}}{q_s}$ where $R = \frac{15}{18+q_s}$

Osgood Lake mixing index: $OI = z/\sqrt{km^2}$

Essentially all models are wrong, but some are useful.

- George E. P. Box

Watershed Modeling

Reckhow 1977 Lakes < 50 meters model: $P = \frac{L}{\left(\frac{18z}{10+z}\right) + 1.05\left(\frac{z}{T_w}\right)e^{0.012 z/T_w}}$

Watershed modeling have proven problematic

- Big Lake: P = 48.04 µg/L
- Big Lake no internal load: P=31.52 µg/L
- Big Lake actual: P=33.00 µg/L

- Wind Lake: P = 29.28 µg/L
- Wind Lake no internal load: P=17.28 µg/L
- Wind Lake actual: P=21.20 µg/L

- Church Pine Lake: P = 15.91 µg/L
- Church Pine Lake no internal load: P=7.65 µg/L
- Church Pine Lake actual: P=18.20 µg/L

Watershed Modeling

Reckhow 1977 Lakes < 50 meters model: $P = \frac{L}{\left(\frac{18z}{10+z}\right) + 1.05\left(\frac{z}{T_w}\right)e^{0.012 z/T_w}}$

Watershed modeling 16 % non-point source reduction

- Big Lake: P = 27.28 µg/L or 13.45% mixed water column P reduction
- Wind Lake: P = 27.81 µg/L or 5.02% mixed water column P reduction
- Church Pine Lake: P = 15.16 µg/L or 4.71% mixed water column P reduction

Watershed Modeling

Reckhow 1977 Lakes < 50 meters model: $P = \frac{L}{\left(\frac{18z}{10+z}\right) + 1.05\left(\frac{z}{T_w}\right)e^{0.012z/T_w}}$

Watershed modeling 25 % non-point source reduction

– Big Lake: P = 24.90 µg/L or 21.00% mixed water column P reduction

– Wind Lake: P = 26.99 µg/L or 7.82% mixed water column P reduction

– Church Pine Lake: P = 14.74 µg/L or 7.35% mixed water column P reduction

Watershed Modeling

Reckhow 1977 Lakes < 50 meters model: $P = \frac{L}{\left(\frac{18z}{10+z}\right) + 1.05\left(\frac{z}{T_w}\right)e^{0.012z/T_w}}$

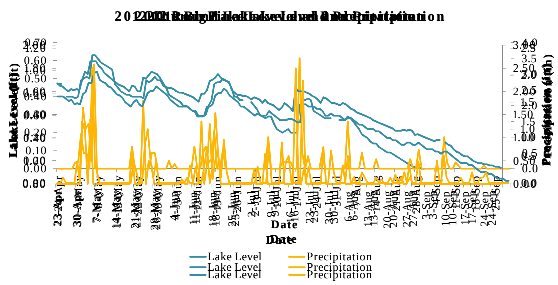
Watershed modeling 40 % non-point source reduction

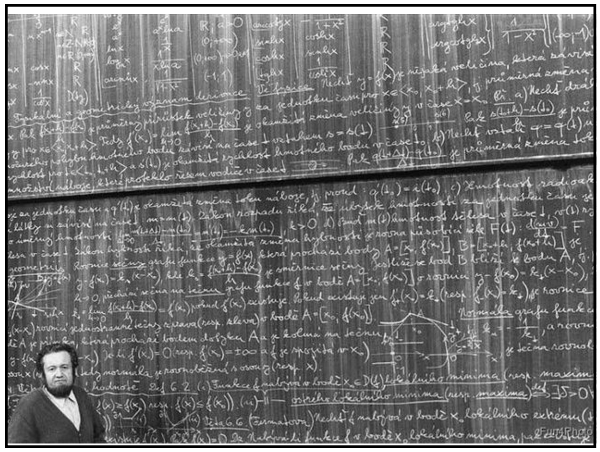
– Big Lake: P = 20.92 µg/L or 33.63% mixed water column P reduction

– Wind Lake: P = 25.62 µg/L or 12.5% mixed water column P reduction

– Church Pine Lake: P = 14.04 µg/L or 11.75% mixed water column P reduction

Lake Levels

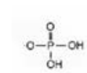


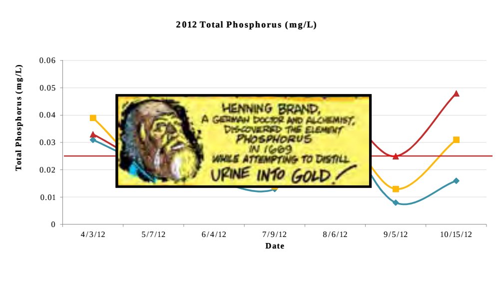


Tributary Monitoring

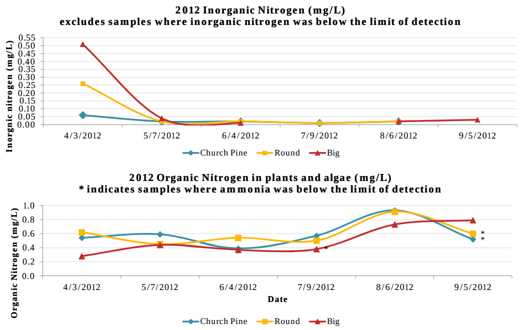
Site	Total Phosphorus (mg/L)	Discharge (l/s)	Instantaneous Load Phosphorus (mg/s)	Instantaneous Load Phosphorus (lb/yr)
County Road K	0.043	0.006	0.241	16.755
North Creek	0.087	0.041	3.603	250.633
Big Lake outlet	0.024	0.045	1.077	74.942

Total Phosphorus

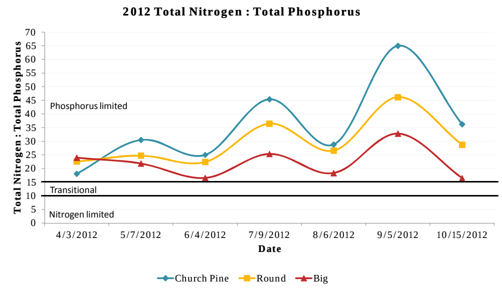




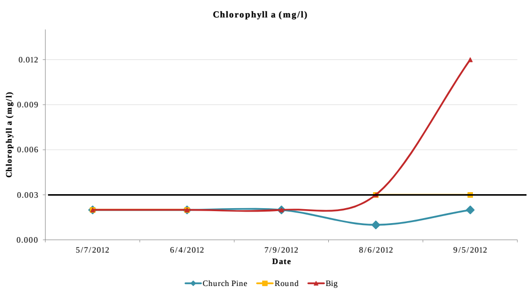
Nitrogen



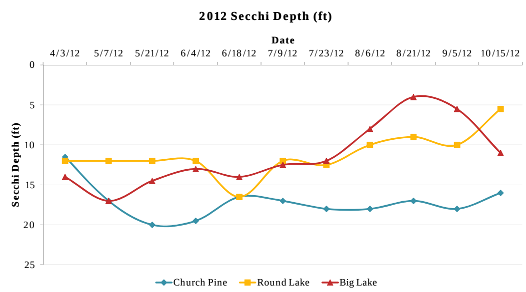
TN:TP ratio



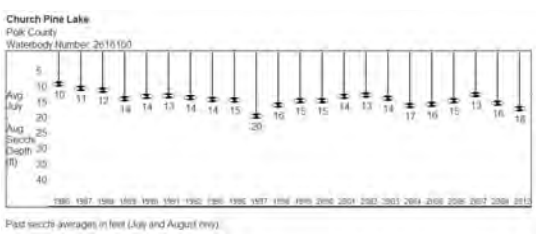
Chlorophyll *a*



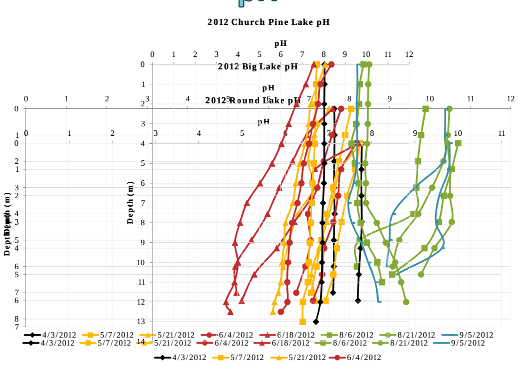
Secchi Disc



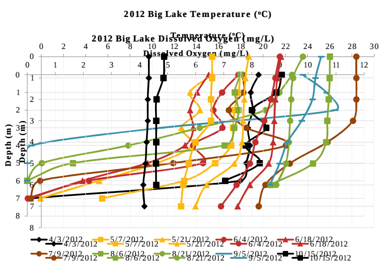
Secchi Disc



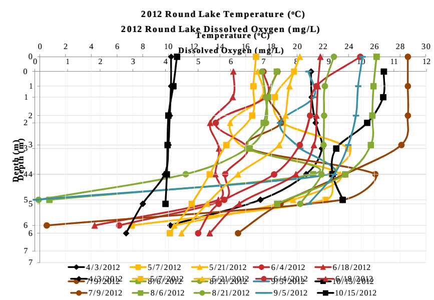
pH



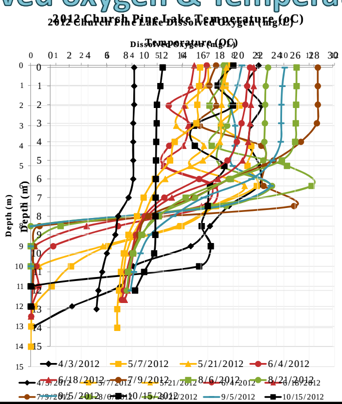
Dissolved oxygen & Temperature



Dissolved oxygen & Temperature

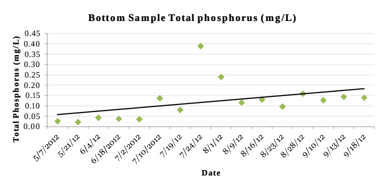


Dissolved oxygen & Temperature

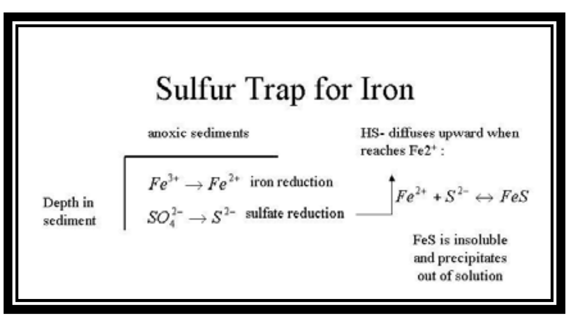


Sediment Chemistry

- P:Fe ratio 1:10
  - Indicates internal loading



Sediment Chemistry



Take Home Messages

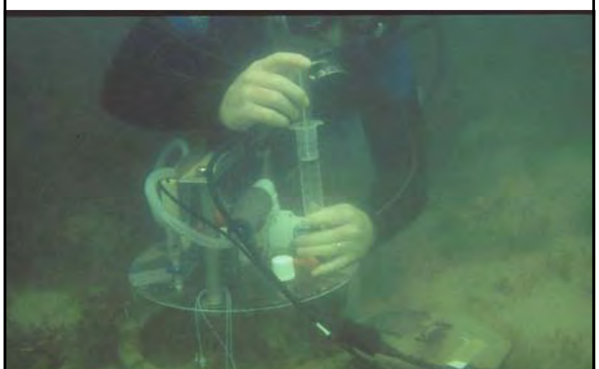
Lakes are very close in Trophic State Index

- CP Lake 39
- Wind Lake 44
- Big Lake 51

TSI	General Description
<30	Oligotrophic; clear water, high dissolved oxygen throughout the year/lake
30-40	Oligotrophic; clear water, possible periods of oxygen depletion in the lower depths of the lake
40-50	Mesotrophic; moderately clear water, increasing chance of anoxia near the bottom of the lake in summer, fully acceptable for all recreation/aesthetic uses
50-60	Mildly eutrophic; decreased water clarity, anoxic near the bottom, may have macrophyte problem, warm-water fisheries only
60-70	Eutrophic; blue-green algae dominance, scums possible, prolific aquatic plant growth, full body recreation may be decreased
70-80	Hypereutrophic; heavy algal blooms possible throughout the summer, dense algae and macrophytes
>80	Algal scums, summer fish kills, few aquatic plants due to algal shading, rough fish dominate

Take Home Messages

- **Annual non-point source load: 316.4-1668.1 pounds of P**
- **Annual external load from lots directly adjacent to B, R, & CP Lakes: 72.55 pounds of P**
- **Annual internal load must be quantified**
- **Internal load from curly-leaf pondweed (CLP) die off is maybe 15.762 pounds P**



Take Home Messages

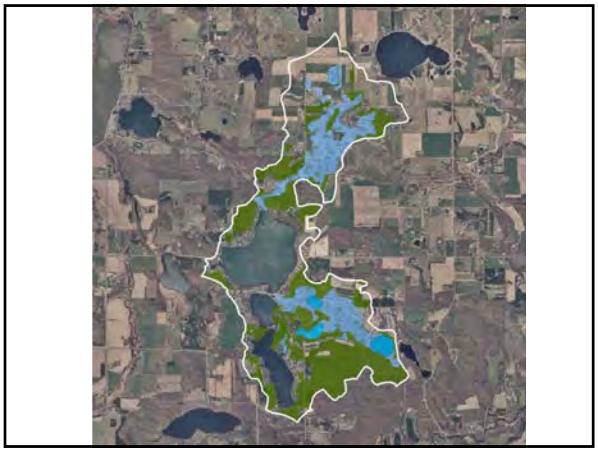
- **North Creek is a significant contributor to Big Lake**
- **Cyanobacteria (blue-green) algae could dominate system with increased loading (internal or external)**
- **Modeling shows Big Lake could be significantly improved with even a 16% reduction in P**

Zooplankton & Algae

Should Be here soon.

What to do?

- **Shoreland Buffers**
- **Rain Gardens**
- **Sediment Ponds on Inlets**
- **Stormwater practices at church**
- **Nutrient management**
- **No till**
- **Other agriculture BMPs**
- **Land acquisition**




Questions?

Big, Round, & Church Pine Lakes Nutrient Budget

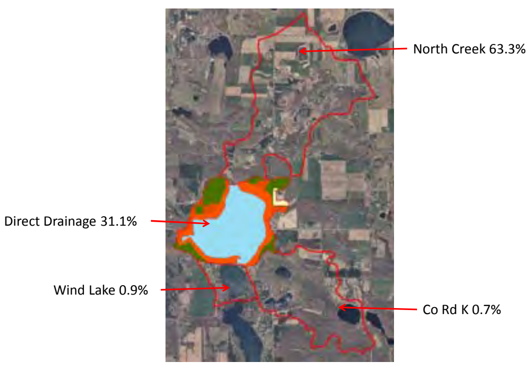
Jeremy Williamson
Water Quality Specialist
Polk County LWRD

Nutrient Budget Big Lake

External

- North Creek 113.7 kg/yr (250 lbs/yr) 63.3%
- Wind (Round Lake) 1.7 kg/yr (3.75 lbs/yr) 0.9%
- Co Rd K 1.25 kg/yr (2.75 lbs/yr) 0.7%
- Big Lake Direct Drainage 26.9 kg/yr (59.3 lbs/yr) 31.1 %
- Atmospheric deposition 5.98 kg/yr (13.18 lbs/yr) 4%

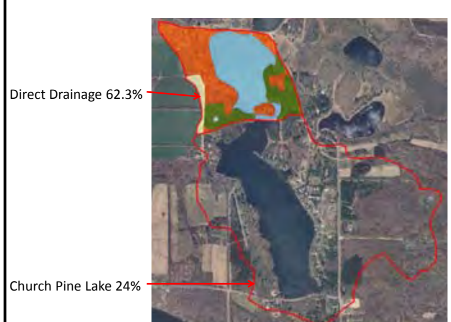
Big Lake Subwatersheds



Nutrient Budget Wind Lake

- Church Pine Lake 5 kg/yr (11.02 lbs/yr) 24%
- Direct Drainage 8.4 kg/yr (18.52 lbs/yr) 62.3%
- Atmospheric Deposition 7.4 kg/yr (16.31 lbs/yr) 35.6%

Wind Lake Subwatersheds



Nutrient Budget Church Pine Lake

- Direct Drainage 26.1 kg/yr (57.54 lbs/yr) 87.3%
- Atmospheric Deposition 11.1 kg/yr (24.47 lbs/yr) 29.8%

Church Pine Lake Watershed

Internal Loading

Reckhow 1977 Lakes < 50 meters model:

$$P = \frac{L}{\left(18z/_{10+z}\right) + 1.05\left(z/_{T_w}\right)e^{0.012z/_{T_w}}} \rightarrow L_{ext} \text{ vs. } L_{int}$$

- Big Lake ~10%
- Wind Lake ~27%
- Church Pine Lake ~28%

Watershed Modeling Big Lake

Reckhow 1977 Lakes < 50 meters model: $P = \frac{L}{\left(18z/_{10+z}\right) + 1.05\left(z/_{T_w}\right)e^{0.012z/_{T_w}}}$

- Model predicts current 25.38 µg/l P
- 16% direct drainage reduction + 20% Reduction North Creek = 21.86 µg/l P or 13.87% reduction P

$$[chl.a] = 0.55([P]_i/(1+\sqrt{\tau_w})^{0.76}$$

- 10.75% reduction in chlorophyll a

Watershed Modeling Wind Lake

Reckhow 1977 Lakes < 50 meters model: $P = \frac{L}{\left(18z/_{10+z}\right) + 1.05\left(z/_{T_w}\right)e^{0.012z/_{T_w}}}$

- Model predicts current 25.06 µg/l P
- 16% direct drainage reduction = 23.82 µg/l P or 4.9% reduction P
- 25% direct drainage reduction = 23.23 µg/l P or 7.3% reduction P

$$[chl.a] = 0.55([P]_i/(1+\sqrt{\tau_w})^{0.76}$$

- 3.79% reduction in chlorophyll a
- 5.62% reduction in chlorophyll a

Watershed Modeling Church Pine Lake

Reckhow 1977 Lakes < 50 meters model: $P = \frac{L}{\left(18z/_{10+z}\right) + 1.05\left(z/_{T_w}\right)e^{0.012z/_{T_w}}}$

- Model predicts current 19.63 µg/l P
- 16% direct drainage reduction = 18.24 µg/l P or 7.1% reduction P
- 25% direct drainage reduction = 17.46 µg/l P or 11.05% reduction P

$$[chl.a] = 0.55([P]_i/(1+\sqrt{\tau_w})^{0.76}$$

- 5.45% reduction in chlorophyll a
- 8.46% reduction in chlorophyll a

Questions?

Church Pine, Round, and Big Lake Membership Survey

116 surveys

Church Pine 36

Round 17

Big 62

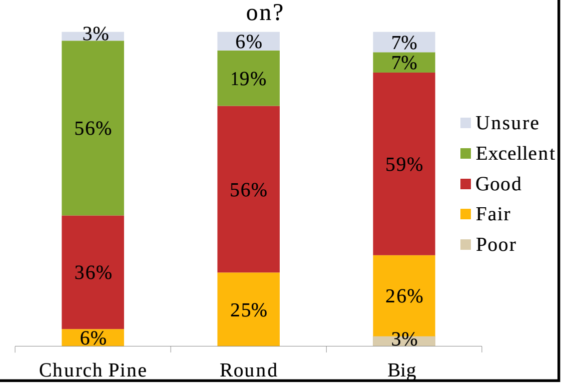
52% response rate

Property Ownership

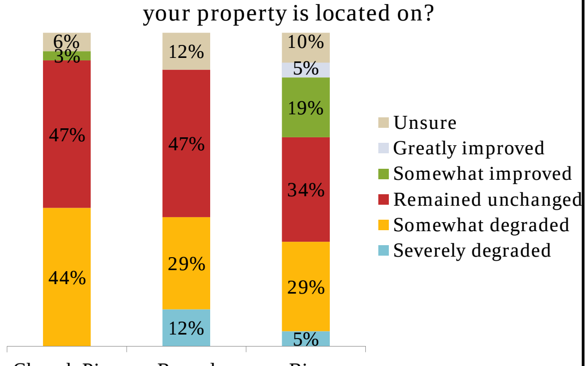
- Owned 22 years
- 44% year round
- 46% weekend, vacation, holiday

Concerns for Church Pine, Round, and Big Lake	Rank	Points
Property values and/or taxes	1st	119
Invasive species *(Eurasian water milfoil, zebra mussels, curly leaf, purple loosestrife)*	2nd	117
Aquatic plants *(not including algae)*	3rd	80
Pollution *(chemical inputs, septic systems, agriculture, erosion, storm water runoff)*	3rd	80
Water clarity *(visibility)*	4th	64
Algae blooms	5th	39
Quality of life	6th	34
Water levels *(loss of lake volume)*	7th	33
Water recreation safety *(boat traffic, no wake zone)*	8th	31
Quality of fisheries	9th	30
Development *(population density, loss of wildlife habitat)*	10th	29
Other, please describe *(noise/light, preservation of recreational water sports)*	11th	3

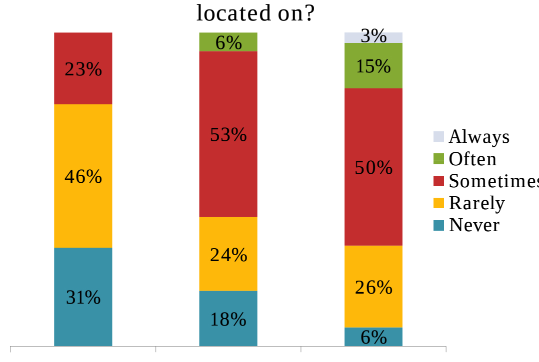
How would you describe the current water quality of the lake your property is located on?



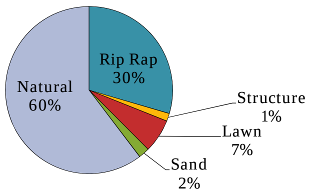
In the time you've owned your property, how has the water quality changed in the lake your property is located on?



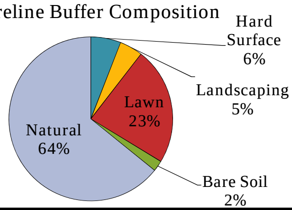
How often does algae negatively impact your enjoyment of the lake your property is located on?



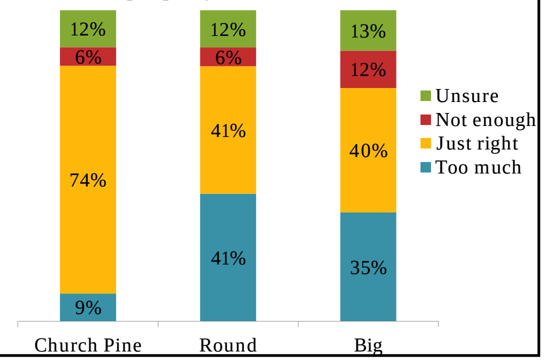
Shoreline Composition



Shoreline Buffer Composition



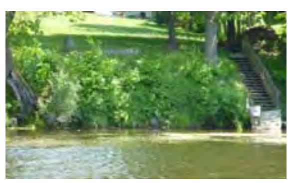
How would you describe the current amount of shoreline vegetation on the lake your property is located on?



Importance of buffers, rain gardens, and native plants

- 46% very important
- 32% somewhat important

- However...
- 50% not interested
- 32% installed
- 7% interested
- 14% unsure



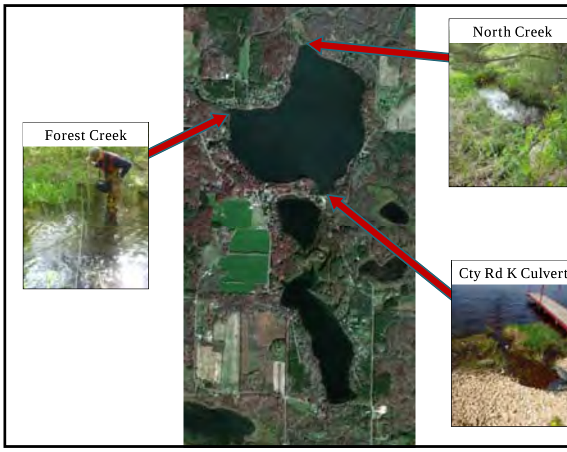
Fertilizer use

- 58% do not use fertilizer
- 35% use zero phosphorus fertlizer
- 5% unsure
- 2% use phosphorus fertilizer

Management practices to improve water quality	**Percent**
Continued collection of in-lake **water quality data**	75%
Enhanced efforts to monitor for new populations of aquatic **invasive species**	75%
Information and education opportunities	46%
Cost-sharing assistance for the installation of **shoreline buffers and rain gardens**	44%
Establishment of **slow-no-wake** zones to protect aquatic plants and fisheries habitat	41%
Collection of **sediment cores** to provide information concerning historical lake conditions	33%
Practices to **enhance fisheries**, such as the introduction of coarse woody habitat	29%
Cost-sharing assistance for the installation of **farmland conservation practices** (nutrient management plans, contour strips, conservation tillage)	27%

Water Quality

Katelin Holm
Polk County LWRD
May 18th 2013 Spring Informational Meeting



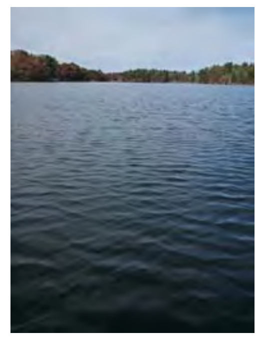
Membership Survey

116 surveys
Church Pine 36
Round 17
Big 62

52% response rate

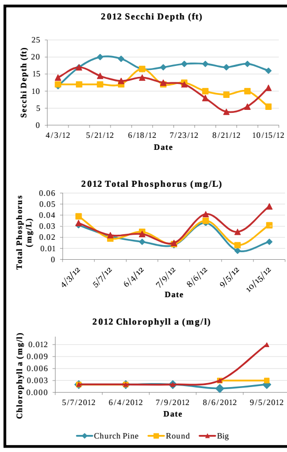
Member Concerns

- Top Three
  1. Property values/taxes
  2. Invasive species
  3. Pollution
     Aquatic plants



Supported Management Practices

- In-lake data collection
- Monitoring for AIS
- Information and education
- Cost-sharing shoreline buffers and rain gardens



1. Secchi depth
2. Total phosphorus
3. Chlorophyll a

Data is combined into 1 equation to describe a lake

Trophic State Index

Church Pine Lake Round Lake Big Lake

Church Pine: 39

Round: 45

Big: 51

TSI	General Description
<30	Oligotrophic; clear water, high dissolved oxygen throughout the year/lake
30-40	Oligotrophic; clear water, possible periods of oxygen depletion in the lower depths of the lake
40-50	Mesotrophic; moderately clear water, increasing chance of anoxia near the bottom of the lake in summer, fully acceptable for all recreation/aesthetic uses
50-60	Mildly eutrophic; decreased water clarity, anoxic near the bottom, may have macrophyte problem; warm-water fisheries only
60-70	Eutrophic; blue-green algae dominance, scums possible, prolific aquatic plant growth. Full body recreation may be decreased
70-80	Hypereutrophic; heavy algal blooms possible throughout the summer, dense algae and macrophytes
>80	Algal scums, summer fish kills, few aquatic plants due to algal shading, rough fish dominate

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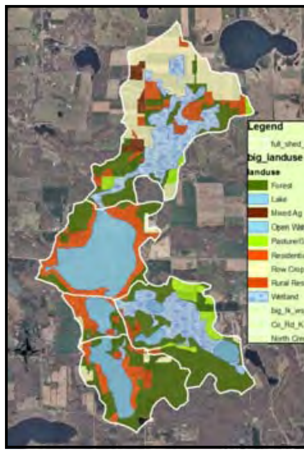
Algae

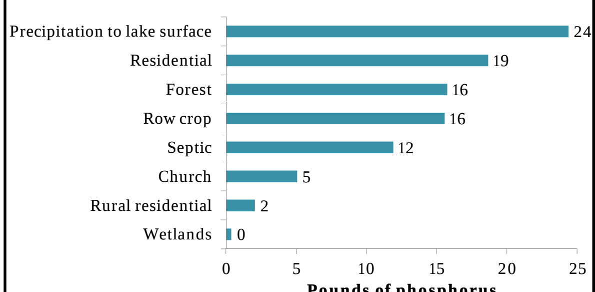
- Why are we concerned with algae?
  - Blue green algae can produce toxins
  - All three lakes = low risk of toxin production



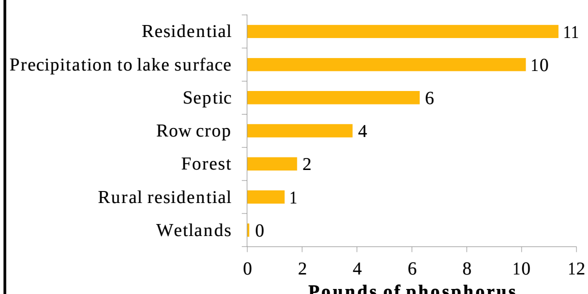
Watershed size

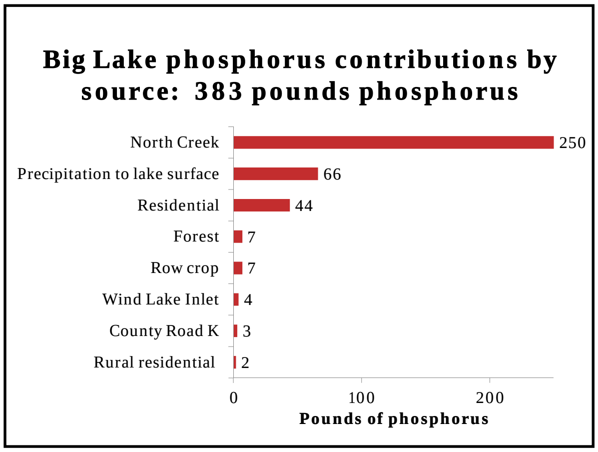
- Church Pine Lake: 378 acres
- Round Lake: 107 acres
- Big Lake: 1,766 acres

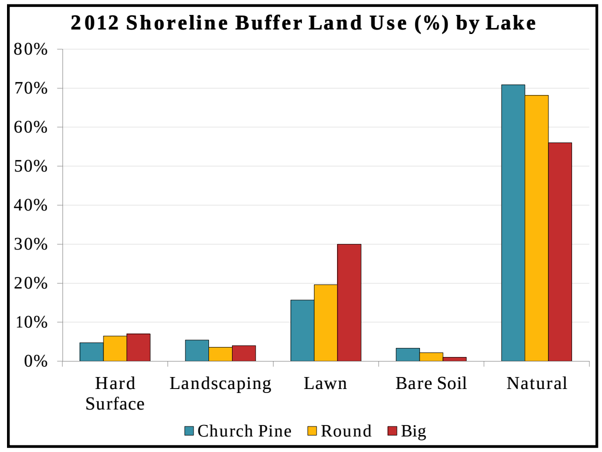
Church Pine Lake phosphorus contributions by source: 94 pounds phosphorus



Round Lake phosphorus contributions by source: 35 pounds phosphorus







Goals

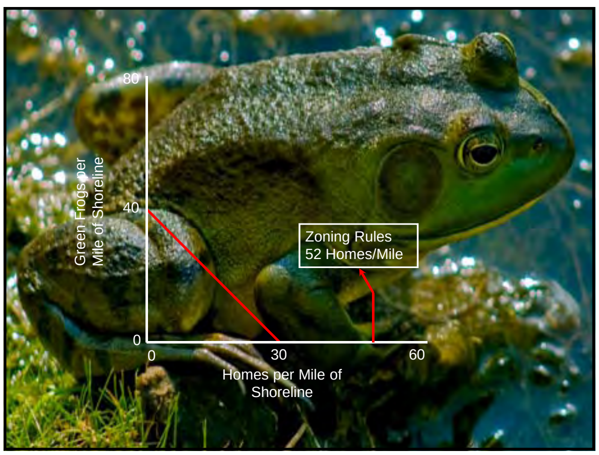
- Reduce algae and phosphorus in the three lake system by reducing watershed runoff
- Evaluate the progress of lake management efforts
- Protect, maintain, and enhance fish habitat
- Increase knowledge and participation
- Support the goals of the Aquatic Plant Management Plan

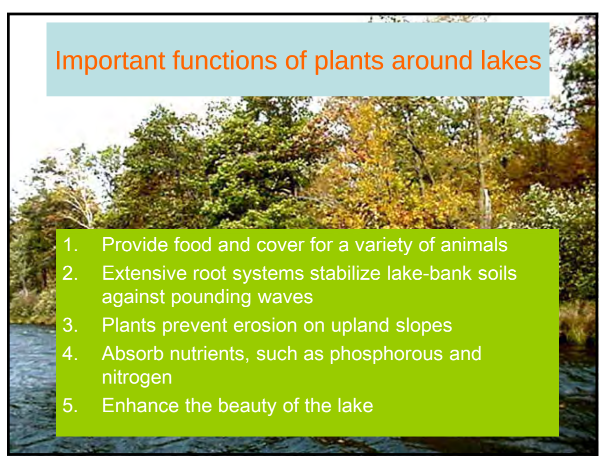
Next Steps

- June 2013: Final Committee Meeting
  Public comment on draft plan
  Finalize plan
- July 2013: Submit plan to DNR for approval (60 days)
- May 1st 2014: Lake Protection Grants due


Shoreline Restoration
Improving water quality and wildlife habitat


Problems with Traditional Lakeshores
• Shoreline erosion and sedimentation
• Excessive plant growth and algal blooms
• Loss of wildlife habitat
• Nuisance animals
• Loss of leisure time


Green Frogs per Mile of Shoreline
80
40
0
0
30
60
Homes per Mile of Shoreline
Zoning Rules
52 Homes/Mile

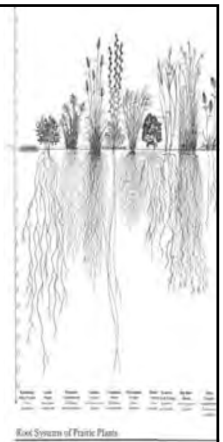

Important functions of plants around lakes
1. Provide food and cover for a variety of animals
2. Extensive root systems stabilize lake-bank soils against pounding waves
3. Plants prevent erosion on upland slopes
4. Absorb nutrients, such as phosphorous and nitrogen
5. Enhance the beauty of the lake

Root Systems

- Stabilize banks
- Stabilize shoreline
- Absorbsion of nutrients
- Absorbsion of water

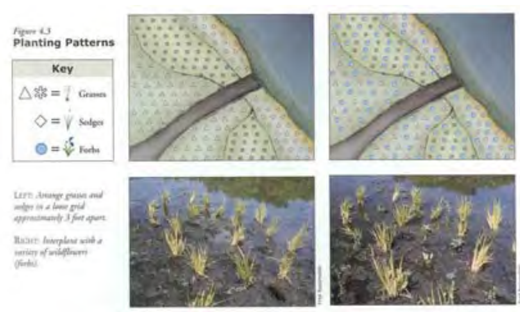
Why it works

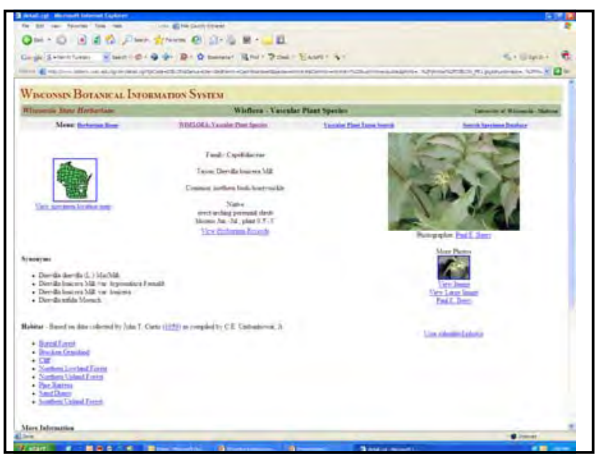
- In turf grass (i. e. lawn) water can only evaporate 0.4 meters out of the soil
- Native vegetation will evapotranspirate water from 2 meters or more from the soil.
- Wet Sponge vs. Dry Sponge



Design

- ✓ Involve landowner as much as possible
- ✓ Clump plants together
- ✓ Use native plants – RESEARCH THIS!
- ✓ Use reputable greenhouse/seed provider
- ✓ Use plenty of shrubs and trees






Shoreline Stabilization

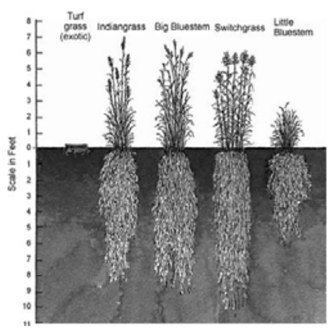
Questions?

Rain Gardens

Rain Gardens

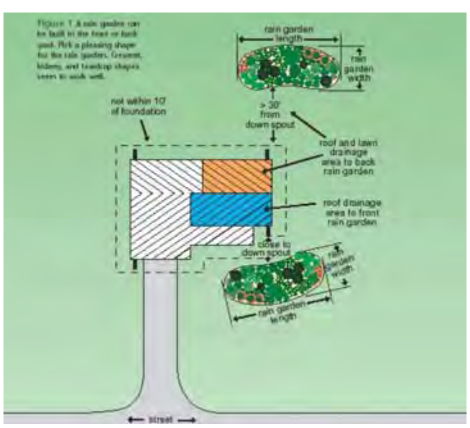
- Increases the amount of water filtering into ground
- Recharges groundwater
- Provides wildlife habitat
- Enhances beauty of yard and neighborhood
- Protects against flooding and drainage problems
- Protects lakes from damaging flows and reduces erosion
- Reduces the need for costly municipal stormwater treatment structures

Why They Work



Where Should the Rain Garden Go?

- At least 10 feet from house
- Flat area
- Below down spouts
- Not over septic system or sewer lateral
- Not where yard is wet
- Not directly under a large tree
- Not high traffic area



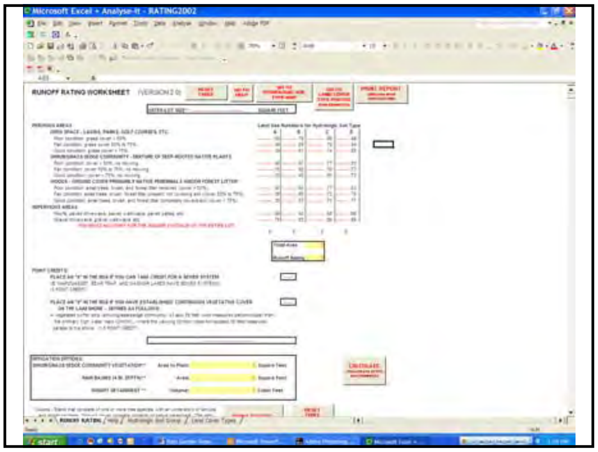
How Big should the Rain Garden Be?

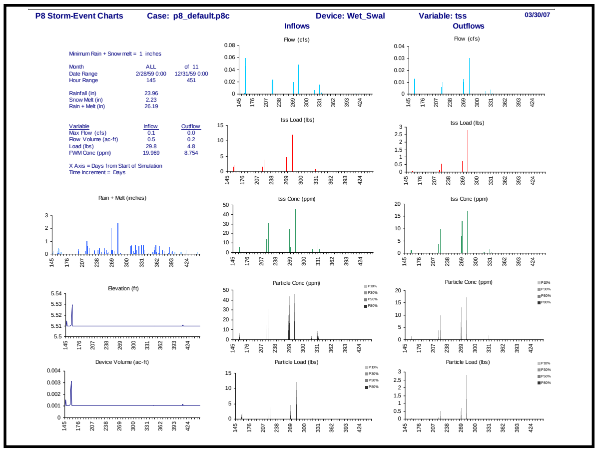
- How deep?
- What type of soil?
- How much roof and lawn drain to it?

Rain Garden Size Factor

	less than 30 ft from down spout			more than 30 ft from down spout
Soil	3-5 in. deep	6-7 in. deep	8 in. deep	All Depths
Sand	0.19	0.15	0.08	0.03
Loamy	0.34	0.25	0.16	0.06
Clayey	0.43	0.32	0.2	0.1

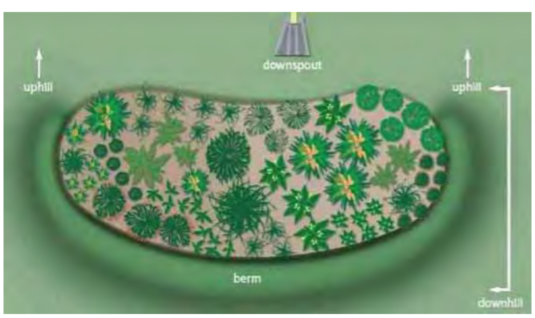
*If the recommended rain garden area is much more than 300 ft. divide it into smaller rain gardens





Design

- Water should flow evenly across the entire length
- Length should be perpendicular to slope and downspouts
- Rain gardens should have a maximum length of 15 ft (esp. on 8% slope or more)



Notice Length is Perpendicular

Burnsville

Maplewood

Plant Selection

- **Native**
- **Soil**
- **Sun/Shade**
- **Incorporate plenty of grasses, sedges and, rushes (allows for normal growth patterns)**
- Height of plant
- Bloom time
- Color

Example Plant List: Well Drained Soils

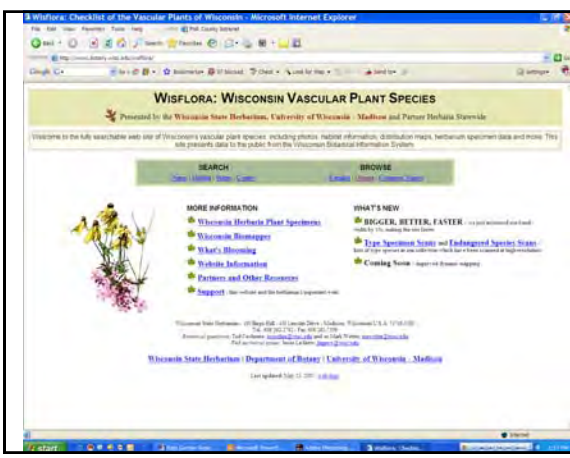
New England aster *Aster novae-angliae*
Spotted Joe-Pye weed *Eupatorium maculatum*
Sneezeweed *Helenium autumnale*
Torrey's rush *Juncus torreyi*
Prairie blazing star *Liatris pycnostachya*
Cardinal flower *Lobelia cardinalis*
Great blue lobelia *Lobelia siphilitica*
Wild bergamot *Monarda fistulosa*
Mountain mint *Pycanthemum virginianum*
Green bulrush *scirpus atrovirens*
Stiff goldenrod *Solidago rigida*
Culver's root *Veronicastrum virginicum*
Golden Alexander *Zizia aurea*

Example Plant List: Clay Soils

Sweet flag *Acorus calamus*
Swamp milkweed *Asclepias incarnata*
Water plantain *Alisma subcordatum*
Bottle brush sedge *Carex comosa*
Fox sedge *Carex vulpinoidea*
Wild blue flag iris *Iris virginica shrevei*
Torrey's rush *Juncus torreyi*
Cardinal flower *Lobelia cardinalis*
False dragon's head *Physostegia virginiana*
Arrowhead *Sagittaria latifolia*
Green bulrush *Scirpus atrovirens*
River bulrush *Scirpus fluviatilis*
Soft-stemmed bulrush *Scirpus validus*

Example Plant List: Shady Areas

Caterpiller Sedge *Carex crinita*
Cardinal Flower* *Lobelia cardinalis*
Ostrich Fern* *Matteuccia struthiopteris*
Virginia Bluebells *Mertensia virginica*
Sensitive Fern *Onoclea sensibilis*
Black Chokeberry *Aronia melanocarpa*
Red Osier Dogwood *Cornus serecia*
Low Bush Honeysuckle *Diervilla lonicera*
Pussy Willow *Salix caprea*
Blue Arctic Willow *Salix purpurea* Nanna



Special Case: Shoreland Area

- Should not replace native shoreland vegetation
- Should help protect riparian veg. from excessive flow and debris

Questions?

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