Lake George

Oneida County, Wisconsin

Comprehensive Management Plan

November 2013

Sponsored by:

Lake George Lake Association

WDNR Grant Program

LPL-1469-12

Onterra, LLC
815 Prosper Road
De Pere, WI 54115
920.338.8860
www.onterra-eco.com

Onterra LLC
Lake Management Planning

Lake George

Oneida County, Wisconsin

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Created by: Dan Cibulka, Brenton Butterfield and Tim Hoyman
Onterra, LLC
De Pere, WI

Funded by: Lake George Lake Association
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This management planning effort was truly a team-based project and could not have been completed without the input of the following individuals:

Lake George Planning Committee

Joan May	Cal Ewert	Harold Versh
Jim Perra	Kathy Prondzinski	Mark Kafka
Neal Baudhuin	Patrick Kubeny	Ted Sperduto

Organization

Town of Pelican

Wisconsin Dept. of Natural Resources

Carol Warden
Kevin Gauthier
John Kubisiak

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1.0 INTRODUCTION

Lake George, Oneida County, is a 442-acre drainage lake with a maximum depth of 26 feet and a mean depth of 10.9 feet (Map 1). This eutrophic lake has a watershed that is eleven times larger than the lake itself. Lake George contains 42 native plant species, of which wild celery is the most common plant. No exotic plant species are known to exist in Lake George.

Field Survey Notes

Good mixture of substrates encountered during point-intercept survey. Numerous shallow, rocky areas present within lake as well as sand bars and mucky flats. Vasey's pondweed found in several locations. Many plant species located near outlet channel. Water stained a brown color.

Photograph 1.0-1 Lake George, Oneida County

Lake at a Glance - Lake George

Morphology	
Acreage	442
Maximum Depth (ft)	26
Mean Depth (ft)	10.9
Shoreline Complexity	4.3
Vegetation	
Curly-leaf Survey Date	May 31, 2012
Comprehensive Survey Date	June 28, 2012
Number of Native Species	42
Threatened/Special Concern Species	Vasey's Pondweed
Exotic Plant Species	None found
Simpson's Diversity	0.92
Average Conservatism	6.9
Water Quality	
Trophic State	Eutrophic
Limiting Nutrient	Phosphorus
Water Acidity (pH)	7.7
Sensitivity to Acid Rain	Not sensitive
Watershed to Lake Area Ratio	11:1

Lake George is fed by Lake George Creek, which flows from the north out of 402-acre Lake Thompson. Water then flows out of Lake George into the Pelican River, which eventually makes its way into the Wisconsin River just south of Rhinelander, WI. On its way out of Lake George, water flows over a small (3 ft tall, 5.2 ft wide) earthen dam located on the lake's outlet near East Lake George Rd. Records indicate the dam was constructed between May 1976 and May 1978 in order to maintain Lake George at or below the ordinary high water mark, 91.22 Wisconsin Department of Natural Resources (WDNR) datum. A May 1976 court order specified that the water level be held between 90.89 WDNR datum (max) and 90.56 DNR datum (min). The Town of Pelican, who has ownership over the dam, is responsible for maintaining the dam and keeping water levels within this specified range.

The Lake George Lake Association (LGLA) was "*incorporated in 2004 to preserve and protect Lake George in Oneida County, Wisconsin and its surroundings; and to enhance the water quality, fishery, boating safety, and aesthetics of Lake George as a recreational facility for today and future generations*." Since 2004, the group has been very active in a number of management activities. Volunteers have participated in the Clean Boats Clean Waters program at the lake's primary boat landing, donating 1,930 hours to inspect 3,682 watercraft between 2004 and 2011. Volunteers have also logged over 220 hours since 2003 monitoring the water quality in the lake through the WDNR Citizen Lake Monitoring Network. Since 2008, the LGLA has trapped and removed over 30,000 rusty crayfish in an effort to remove this aquatic invasive species. Since 2009, association volunteers have conducted a "Lake Monitoring Day" in June and August to collect samples of the aquatic vegetation from the lake and have them identified by a WDNR plant specialist. The LGLA has also partnered with local boat rental companies to encourage cleaning of rental boats prior to use on the lake in an effort to prevent the spread of aquatic invasive species. And twice per year, the LGLA includes educational articles regarding lake matters within the Lake George Gazette. This is distributed to all members of the association.

With several public access locations, nine resorts, one campground and two fishing tournaments occurring on this 442 acre lake, there is much desire amongst the LGLA to properly manage the lake for its ecological and recreational potential. The LGLA became interested in creating a management plan for two primary reasons. First, they wanted to expand and enhance their program to prevent introduction of aquatic invasive species. Currently, the only aquatic invasive species known to inhabit the lake include rusty crayfish (*Orconectes rusticus*) and Chinese mystery snail (*Cipangopalundina chinensis*). And second, they understood the value in gaining a better understanding of lake ecology and the overall condition of their lake.

In February of 2012, the LGLA submitted a grant proposal for funding under the WDNR's lake management planning grant program. The proposal was successful, and a project began that spring to study the ecology of Lake George and its watershed as well as integrate the interests of the stakeholders that care for and use the lake. In the document that follows, the results of these studies are presented, along with a detailed plan the LGLA will initiate to protect, preserve, and enhance Lake George.

2.0 STAKEHOLDER PARTICIPATION

Stakeholder participation is an important part of any management planning exercise. During this project, stakeholders were not only informed about the project and its results, but also introduced to important concepts in lake ecology. The objective of this component in the planning process is to accommodate communication between the planners and the stakeholders. The communication is educational in nature, both in terms of the planners educating the stakeholders and vice-versa. The planners educate the stakeholders about the planning process, the functions of their lake ecosystem, their impact on the lake, and what can realistically be expected regarding the management of the aquatic system. The stakeholders educate the planners by describing how they would like the lake to be, how they use the lake, and how they would like to be involved in managing it. All of this information is communicated through multiple meetings that involve the lake group as a whole or a focus group called a Planning Committee and the completion of a stakeholder survey.

The highlights of this component are described below. Materials used during the planning process can be found in Appendix A.

Kick-off Meeting
On June 30, 2012, a project kick-off meeting was held at the Pelican Town Hall to introduce the project to the general public. The meeting was announced through a mailing and personal contact by LGLA board members. The approximately 44 attendees observed a presentation given by Dan Cibulka, an aquatic ecologist with Onterra. Mr. Cibulka's presentation started with an educational component regarding general lake ecology and ended with a detailed description of the project including opportunities for stakeholders to be involved. The presentation was followed by a question and answer session.

Planning Committee Meeting I
On February 19, 2013, Dan Cibulka and Tim Hoyman met with several members of the Lake George Planning Committee for nearly four hours. In advance of the meeting, attendees were provided an early draft of the study report sections to facilitate better discussion. The primary focus of this meeting was the delivery of the study results and conclusions to the committee. All study components including water quality analyses, watershed modeling, aquatic plant inventories and fisheries data research were discussed at length. Several concerns were raised by the committee including dam operation, volunteer engagement within the association and keeping Lake George free of aquatic invasive species.

Planning Committee Meeting II
A second planning meeting was held on March 19, 2013 between Dan Cibulka, Tim Hoyman and the Lake George Planning Committee. At this meeting, the group underwent brainstorming exercises which helped to shape several management goals the committee wished to follow to better manage Lake George.

Project Wrap-up Meeting
On July 19th, 2013, the LGLA held the project Wrap-Up meeting at the Pelican Town Hall. Many association members as well as the general public attended. At this meeting, Dan Cibulka presented a general summary on the lake studies that were conducted during 2012, and described the management goals and actions the LGLA planning committee had decided to pursue in order

to manage Lake George. The presentation was followed by a question and answer session, where many comments regarding the lake's ecology, recreational use and further management were discussed.

Management Plan Review and Adoption Process

In early February 2013, a draft of the Results Section (Sections 2.0 and 3.0) of this management plan was provided to the Lake George Planning Committee for review and preparation for the first planning meeting. The Summary and Conclusions as well as the Implementation Plan of this report (Sections 4.0 and 5.0) were provided to the planning committee in April of 2013. The LGLA Board of Directors reviewed the report during May and June of 2013, providing a review to Onterra staff that was addressed during this time. The Board of Directors officially adopted the plan on May 23, 2013 (Appendix A). Following commentary provided by the committee, the report was updated and submitted to WDNR reviewers on July 12, 2013. On October 15, 2013, WDNR staff had completed their review and provided comments to Onterra staff and a LGLA representative. These comments were addressed and included within the final draft, which was produced in November of 2013.

Stakeholder Survey

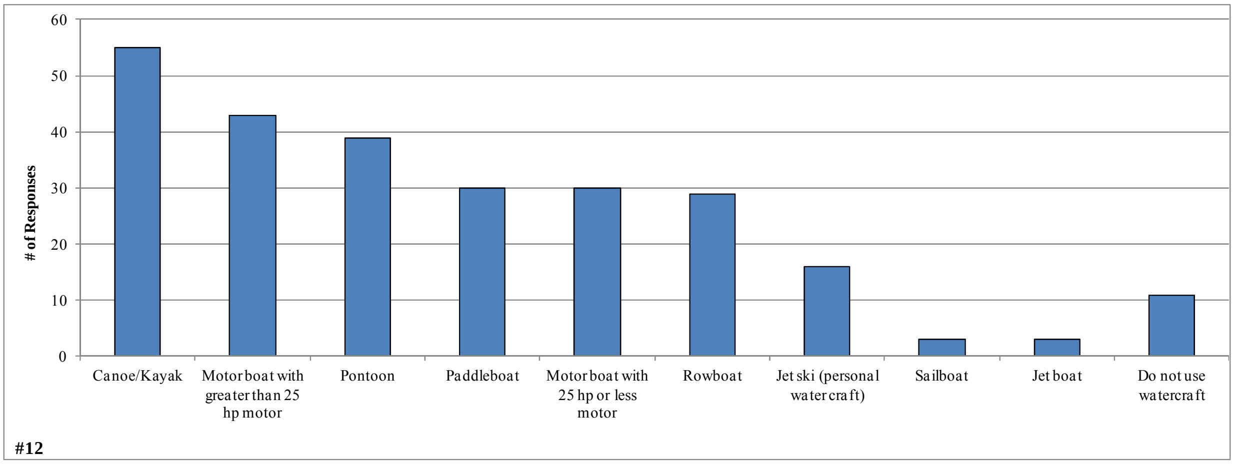
During late summer of 2012, the LGLA and Onterra drafted an eight-page, 34-question anonymous stakeholder survey. This survey was approved by a WDNR sociologist, and in August 2012 was mailed to 172 riparian property owners in the Lake George watershed. 60 percent of the surveys were returned and those results were entered into a spreadsheet by a member of the Lake George Planning Committee. The data were summarized and analyzed by Onterra for use at the planning meetings and within the management plan. The full survey and results can be found in Appendix B, while discussion of those results is integrated within the appropriate sections of the management plan and a general summary is discussed below.

Based upon the results of the Stakeholder Survey, much was learned about the people that use and care for Lake George. The majority of stakeholders (41%) are year-round residents, while 20% visit on weekends through the year and 15% live on the lake during the summer months only. 27% of stakeholders have owned their property for over 25 years, while a fair number of riparian property owners (35%) have owned their Lake George property for less than 10 years (Question #1).

The following sections (Water Quality, Watershed, Aquatic Plants and Fisheries Data Integration) discuss the stakeholder survey data with respect these particular topics. Figures 2.0-1 and 2.0-2 highlight several other questions found within this survey. More than half of survey respondents indicate that they use either a canoe or kayak on the lake (Question #12). Large (>25 hp motor) motor boats and pontoons were also popular options. On a lake that has a number of islands, irregular shorelines and rock bars such as Lake George, the importance of responsible boating activities is amplified. The need for responsible boating also increases during weekends, holidays, and during times of nice weather or good fishing conditions due to more watercraft being present on the lake. As seen on Question #13, many of the popular activities that take place on Lake George involve watercraft use. Although boat traffic was listed 5^{th} on a list of factors potentially impacting Lake George in a negative manner (Question #20), it was ranked with only moderate importance on a list of stakeholder's top concerns regarding the lake (Question #21).

Several concerns noted throughout the stakeholder survey (see Question #21 and survey comments – Appendix B) included aquatic invasive species, water quality degradation, septic system discharge and excessive aquatic plant growth. These topics are discussed in the appropriate Section (e.g. Water Quality, Aquatic Plants, etc.) of this report and within the Summary & Conclusions section as well as within the Implementation Plan.

Question #12: What types of watercraft do you currently use on Lake George?



Question #13: Please rank up to three activities that are important reasons for owning your property on or near Lake George.

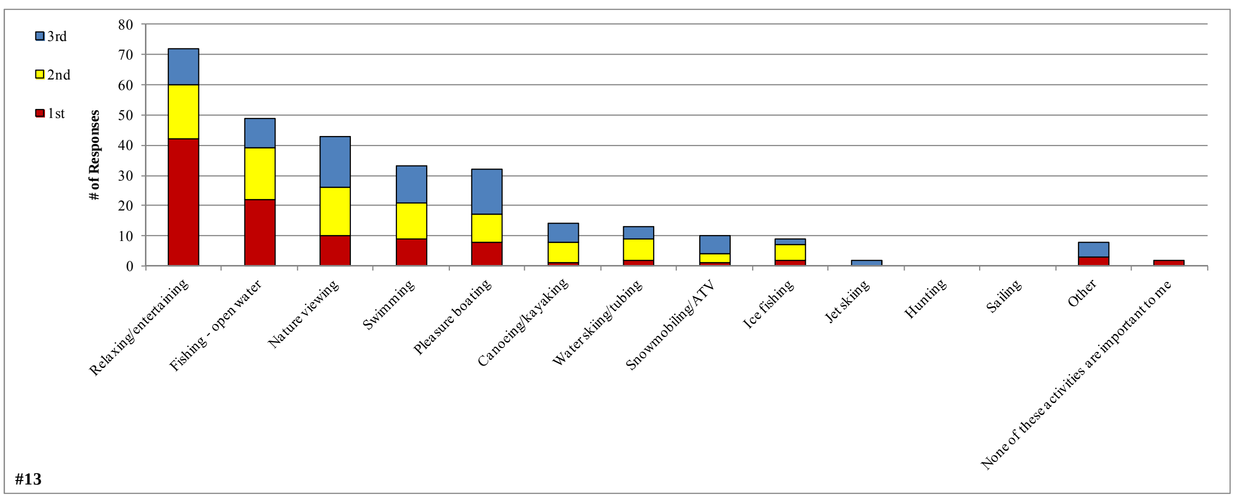
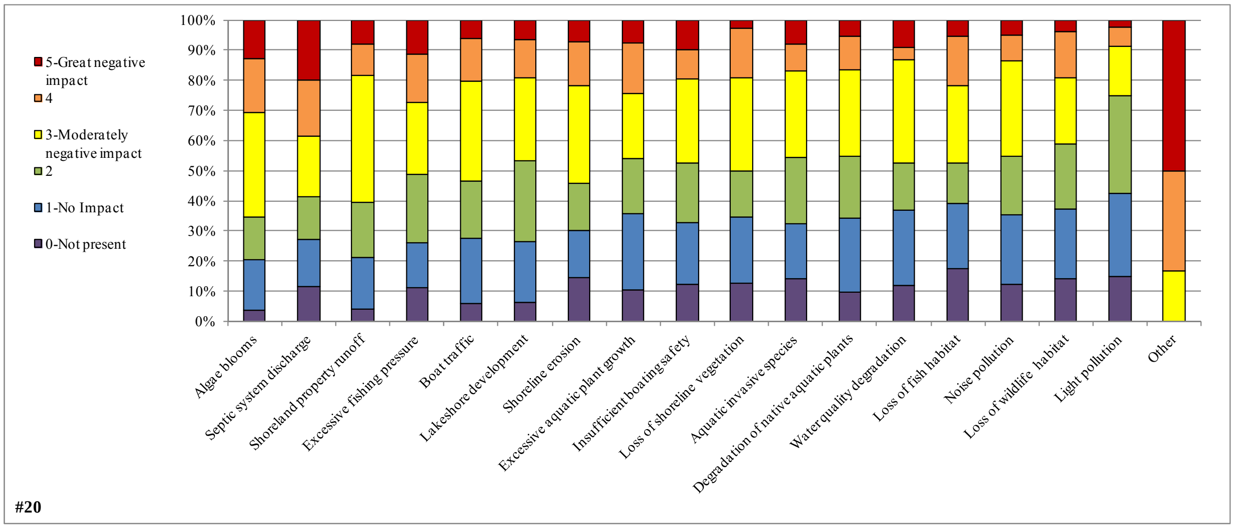


Figure 2.0-1. Select survey responses from the Lake George Stakeholder Survey. Additional questions and response charts may be found in Appendix B.

Question #20: To what level do you believe these factors may be negatively impacting Lake George?



Question #21: Please rank your top three concerns regarding Lake George.

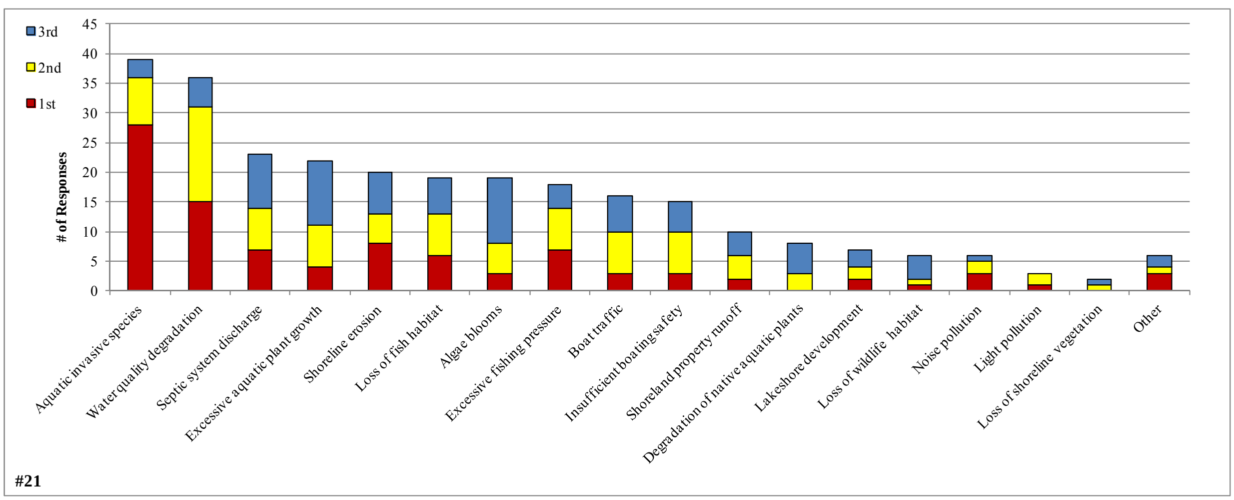


Figure 2.0-2. Select survey responses from the Lake George Stakeholder Survey, continued. Additional questions and response charts may be found in Appendix B.

3.0 RESULTS & DISCUSSION

3.1 Lake Water Quality

Primer on Water Quality Data Analysis and Interpretation

Reporting of water quality assessment results can often be a difficult and ambiguous task. Foremost is that the assessment inherently calls for a baseline knowledge of lake chemistry and ecology. Many of the parameters assessed are part of a complicated cycle and each element may occur in many different forms within a lake. Furthermore, water quality values that may be considered poor for one lake may be considered good for another because judging water quality is often subjective. However, focusing on specific aspects or parameters that are important to lake ecology, comparing those values to similar lakes within the same region and historical data from the study lake provides an excellent method to evaluate the quality of a lake's water.

Many types of analyses are available for assessing the condition of a particular lake's water quality. In this document, the water quality analysis focuses upon attributes that are directly related to the productivity of the lake. In other words, the water quality that impacts and controls the fishery, plant production, and even the aesthetics of the lake are related here. Specific forms of water quality analysis are used to indicate not only the health of the lake, but also to provide a general understanding of the lake's ecology and assist in management decisions. Each type of available analysis is elaborated on below.

As mentioned above, chemistry is a large part of water quality analysis. In most cases, listing the values of specific parameters really does not lead to an understanding of a lake's water quality, especially in the minds of non-professionals. A better way of relating the information is to compare it to lakes with similar physical characteristics and lakes within the same regional area. In this document, a portion of the water quality information collected on Lake George is compared to other lakes in the state with similar characteristics as well as to lakes within the northern region (Appendix C). In addition, the assessment can also be clarified by limiting the primary analysis to parameters that are important in the lake's ecology and trophic state (see below). Three water quality parameters are focused upon in the Lake George's water quality analysis:

> **Phosphorus** is the nutrient that controls the growth of plants in the vast majority of Wisconsin lakes. It is important to remember that in lakes, the term "plants" includes both algae and macrophytes. Monitoring and evaluating concentrations of phosphorus within the lake helps to create a better understanding of the current and potential growth rates of the plants within the lake.
>
> **Chlorophyll-*a*** is the green pigment in plants used during photosynthesis. Chlorophyll-*a* concentrations are directly related to the abundance of free-floating algae in the lake. Chlorophyll-*a* values increase during algal blooms.
>
> **Secchi disk transparency** is a measurement of water clarity. Of all limnological parameters, it is the most used and the easiest for non-professionals to understand. Furthermore, measuring Secchi disk transparency over long periods of time is one of the best methods of monitoring the health of a lake. The measurement is conducted by lowering a weighted, 20-cm diameter disk with alternating black and white quadrates (a Secchi disk) into the water and recording the depth just before it disappears from sight.

The parameters described above are interrelated. Phosphorus controls algal abundance, which is measured by chlorophyll-*a* levels. Water clarity, as measured by Secchi disk transparency, is directly affected by the particulates that are suspended in the water. In the majority of natural Wisconsin lakes, the primary particulate matter is algae; therefore, algal abundance directly affects water clarity. In addition, studies have shown that water clarity is used by most lake users to judge water quality – clear water equals clean water (Canter et al. 1994, Dinius 2007, and Smith et al. 1991).

Trophic State

Trophic states describe the lake's ability to produce plant matter (production) and include three continuous classifications: Oligotrophic lakes are the least productive lakes and are characterized by being deep, having cold water, and few plants. Eutrophic lakes are the most productive and normally have shallow depths, warm water, and high plant biomass. Mesotrophic lakes fall between these two categories.

Total phosphorus, chlorophyll-*a*, and water clarity values are directly related to the trophic state of the lake. As nutrients, primarily phosphorus, accumulate within a lake, its productivity increases and the lake progresses through three trophic states: oligotrophic, mesotrophic, and finally eutrophic. Every lake will naturally progress through these states and under natural conditions (i.e. not influenced by the activities of humans) this progress can take tens of thousands of years. Unfortunately, human influence has accelerated this natural aging process in many Wisconsin lakes. Monitoring the trophic state of a lake gives stakeholders a method by which to gauge the productivity of their lake over time. Yet, classifying a lake into one of three trophic states often does not give clear indication of where a lake really exists in its trophic progression because each trophic state represents a range of productivity. Therefore, two lakes classified in the same trophic state can actually have very different levels of production.

However, through the use of a trophic state index (TSI), an index number can be calculated using phosphorus, chlorophyll-*a*, and clarity values that represent the lake's position within the eutrophication process. This allows for a more clear understanding of the lake's trophic state while facilitating clearer long-term tracking. Carlson (1977) presented a trophic state index that gained great acceptance among lake managers.

Limiting Nutrient

The limiting nutrient is the nutrient which is in shortest supply and controls the growth rate of algae and some macrophytes within the lake. This is analogous to baking a cake that requires four eggs, and four cups each of water, flour, and sugar. If the baker would like to make four cakes, he needs 16 of each ingredient. If he is short two eggs, he will only be able to make three cakes even if he has sufficient amounts of the other ingredients. In this scenario, the eggs are the limiting nutrient (ingredient).

In most Wisconsin lakes, phosphorus is the limiting nutrient controlling the production of plant biomass. As a result, phosphorus is often the target for management actions aimed at controlling plants, especially algae. The limiting nutrient is determined by calculating the nitrogen to phosphorus ratio within the lake. Normally, total nitrogen and total phosphorus values from the surface samples taken during the summer months are used to determine the ratio. Results of this ratio indicate if algal growth within a lake is limited by nitrogen or phosphorus. If the ratio is greater than 15:1, the lake is considered phosphorus limited; if it is less than 10:1, it is considered nitrogen limited. Values between these ratios indicate a transitional limitation between nitrogen and phosphorus.

Temperature and Dissolved Oxygen Profiles

Temperature and dissolved oxygen profiles are created simply by taking readings at different water depths within a lake. Although it is a simple procedure, the completion of several profiles over the course of a year or more provides a great deal of information about the lake. Much of this information relates to whether the lake thermally stratifies or not, which is determined primarily through the temperature profiles. Lakes that show strong stratification during the summer and winter months need to be managed differently than lakes that do not. Normally, deep lakes stratify to some extent, while shallow lakes (less than 17 feet deep) do not.

> Lake stratification occurs when temperature gradients are developed with depth in a lake. During stratification the lake can be broken into three layers: The epilimnion is the top layer of water which is the warmest water in the summer months and the coolest water in the winter months. The hypolimnion is the bottom layer and contains the coolest water in the summer months and the warmest water in the winter months. The metalimnion, often called the thermocline, is the middle layer containing the steepest temperature gradient.

Dissolved oxygen is essential in the metabolism of nearly every organism that exists within a lake. For instance, fishkills are often the result of insufficient amounts of dissolved oxygen. However, dissolved oxygen's role in lake management extends beyond this basic need by living organisms. In fact, its presence or absence impacts many chemical process that occur within a lake. Internal nutrient loading is an excellent example that is described below.

Internal Nutrient Loading*

In lakes that support strong stratification, the hypolimnion can become devoid of oxygen both in the water column and within the sediment. When this occurs, iron changes from a form that normally binds phosphorus within the sediment to a form that releases it to the overlaying water. This can result in very high concentrations of phosphorus in the hypolimnion. Then, during the spring and fall turnover events, these high concentrations of phosphorus are mixed within the lake and utilized by algae and some macrophytes. This cycle continues year after year and is termed "internal phosphorus loading"; a phenomenon that can support nuisance algae blooms decades after external sources are controlled.

The first step in the analysis is determining if the lake is a candidate for significant internal phosphorus loading. Water quality data and watershed modeling are used to screen non-candidate and candidate lakes following the general guidelines below:

Non-Candidate Lakes

- Lakes that do not experience hypolimnetic anoxia.
- Lakes that do not stratify for significant periods (i.e. months at a time).
- Lakes with hypolimnetic total phosphorus values less than 200 μg/L.

Candidate Lakes

- Lakes with hypolimnetic total phosphorus concentrations exceeding 200 µg/L.
- Lakes with epilimnetic phosphorus concentrations that cannot be accounted for in watershed phosphorus load modeling.

Specific to the final bullet-point, during the watershed modeling assessment, the results of the modeled phosphorus loads are used to estimate in-lake phosphorus concentrations. If these estimates are much lower than those actually found in the lake, another source of phosphorus must be responsible for elevating the in-lake concentrations. Normally, two possibilities exist; 1) shoreland septic systems, and 2) internal phosphorus cycling.

If the lake is considered a candidate for internal loading, modeling procedures are used to estimate that load.

*Lack of summer months dissolved oxygen profiles and hypolimnetic phosphorus data prevents these analyses from being performed. The explanation provided under this heading is strictly for the information of the reader.

Comparisons with Other Datasets

The WDNR publication *Implementation and Interpretation of Lakes Assessment Data for the Upper Midwest* (PUB-SS-1044 2008) is an excellent source of data for comparing water quality from a given lake to lakes with similar features and lakes within specific regions of Wisconsin. Water quality among lakes, even among lakes that are located in close proximity to one another, can vary due to natural factors such as depth, surface area, the size of its watershed and the composition of the watershed's land cover. For this reason, the water quality of Lake George will be compared to lakes in the state with similar physical characteristics. The WDNR groups Wisconsin's lakes into 6 classifications (Figure 3.1-1).

First, the lakes are classified into two main groups: shallow (mixed) or deep (stratified). These lakes differ in many ways; for example, in their oxygen content and where aquatic plants may be found Shallow lakes tend to mix throughout or periodically during the growing season and as a result, remain well-oxygenated. Further, shallow lakes often support aquatic plant growth across most or all of the lake bottom. Deep lakes tend to stratify during the growing season and have the potential to have low oxygen levels in the bottom layer of water (hypolimnion). Aquatic plants are usually restricted to the shallower areas around the perimeter of the lake (littoral zone). An equation developed by Lathrop and Lillie (1980), which incorporates the maximum depth of the lake and the lake's surface area, is used to predict whether the lake is considered a shallow (mixed) lake or a deep (stratified) lake. The lakes are further divided into classifications based on their hydrology and watershed size:

> **Seepage Lakes** have no surface water inflow or outflow in the form of rivers and/or streams.
>
> **Drainage Lakes** have surface water inflow and/or outflow in the form of rivers and/or streams.
>
> > Headwater drainage lakes have a watershed of less than 4 square miles.
> >
> > Lowland drainage lakes have a watershed of greater than 4 square miles.

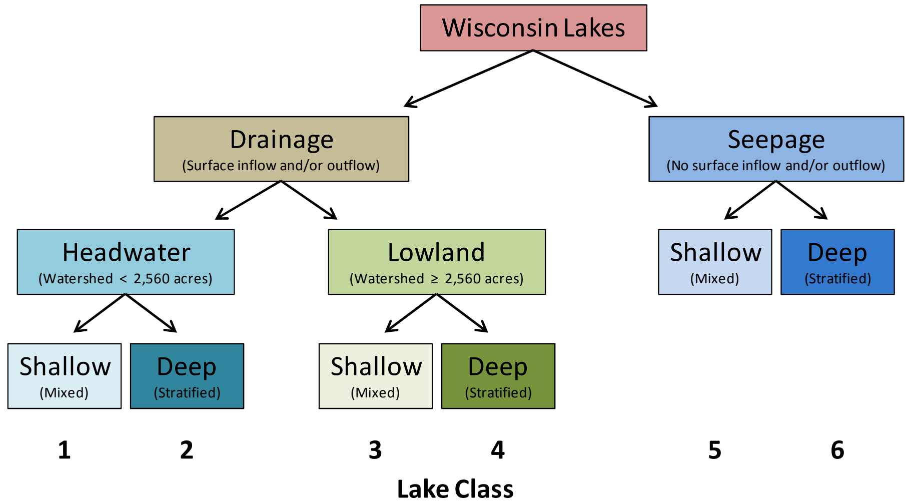


Figure 3.1-1. Wisconsin Lake Classifications. Lake George is classified as a shallow (mixed), lowland drainage lake (Class 3). Adapted from WDNR PUB-SS-1044 2008.

Lathrop and Lillie developed state-wide median values for total phosphorus, chlorophyll-*a*, and Secchi disk transparency for each of the six lake classifications. Though they did not sample sufficient lakes to create median values for each classification within each of the state's ecoregions, they were able to create median values based on all of the lakes sampled within each ecoregion (Figure 3.1-2). Ecoregions are areas related by similar climate, physiography, hydrology, vegetation and wildlife potential. Comparing ecosystems in the same ecoregion is sounder than comparing systems within manmade boundaries such as counties, towns, or states. Lake George is within the Northern Lakes and Forests ecoregion.

The Wisconsin 2010 Consolidated Assessment and Listing Methodology (WisCALM), created by the WDNR, is a process by which the general condition of Wisconsin surface waters are assessed to determine if they meet federal requirements in terms of water quality under the Clean Water Act (WDNR 2009). It is another useful tool in helping lake stakeholders understand the health of their lake compared to others within the state. This method incorporates both biological and physical-chemical indicators to assess a given waterbody's condition. In the report, they divided the phosphorus, chlorophyll-*a*, and Secchi disk transparency data of each lake class into ranked categories and assigned each a "quality" label from "Excellent" to "Poor". The categories were based on pre-settlement conditions of the lakes inferred from sediment cores and their experience.

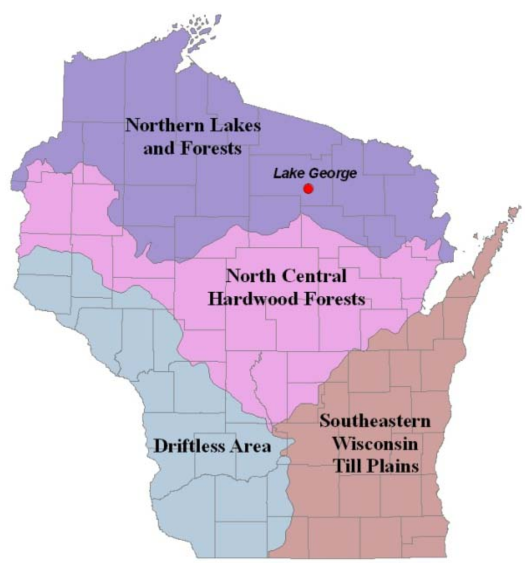


Figure 3.1-2. Location of Lake George within the ecoregions of Wisconsin. After Nichols 1999.

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These data along with data corresponding to statewide natural lake averages, historic, current, and average data from Lake George is displayed in Figures 3.1-3 - 3.1-7. Please note that the data in these graphs represent concentrations and depths taken only during the growing season (April-October) or summer months (June-August). Furthermore, the phosphorus and chlorophyll-*a* data represent only surface samples. Surface samples are used because they represent the depths at which algae grow and depths at which phosphorus levels are not greatly influenced by phosphorus being released from bottom sediments.

Lake George Water Quality Analysis

Lake George Long-term Trends

As a part of this study, Lake George stakeholders were asked about their perceptions of the lake's water quality. The majority (62%) of lake residents rated the water quality of Lake George as *Good* while 25% ranked the lake's water as *Fair* (Appendix B, Question #14). Roughly 55% of survey respondents stated that the water quality had *Remained the same* since they first visited the lake, while 24% indicated the water quality had *Somewhat degraded* and 10% believe it has *Somewhat improved* (Question #15). When asked "Do you believe that management actions specific to water quality are needed?", over half (62%) of respondents indicated either *Definitely yes* or *Probably yes* while 21% answered *Unsure* and 17% responded with *Probably no* or *Definitely no* (Question #16). Lake George survey respondents indicated that algae blooms, septic system discharge and shoreland property runoff were the top three factors that may be negatively impacting the overall health of the lake (Question #20). Water quality degradation and septic system discharge were listed as the second and third top concern, respectively, of Lake George stakeholders (Question #21).

It is often difficult to determine the status of a lake's water quality purely through observation. Anecdotal accounts of a lake "getting better" or "getting worse" can be difficult to judge because a) a lake's water quality may fluctuate from year to year based upon environmental conditions such as precipitation or lack thereof, and b) differences in observation and perception of water quality can differ greatly from person to person. It is best to analyze the water quality of a lake through scientific data as this gives a concrete indication as to the health of the lake, as whether the lake health has deteriorated or improved. Further, by looking at data for similar lakes regionally and statewide, one can determine what the status of the lake is by comparison.

Volunteers continue to collect data from Lake George through the Citizens Lake Monitoring Network (CLMN). Through this program, volunteers are trained to collect water quality data on their lake. Samples are analyzed through the State Lab of Hygiene in Madison, WI and data are entered into the Surface Water Integrated Monitoring System (SWIMS), an online database which allows for quick access to all current and historical water quality data. This process allows stakeholders to become directly engaged in protecting their lake, while producing reliable and comparable data that managers may recall through a streamlined website.

Volunteers have collected surface total phosphorus, chlorophyll-*a* and Secchi disk clarity data from Lake George since 2004. During this time, surface total phosphorus concentrations have fluctuated very little, holding steadily between 28.0 and 34.7 μg/L (Figure 3.1-3). A weighted summer average over all years was determined to be 28.8 μg/L. This value falls within the *Excellent* category for shallow, lowland drainage lakes within Wisconsin, and is just slightly higher than the median concentration for all lakes in the Northern Lakes and Forests ecoregion.

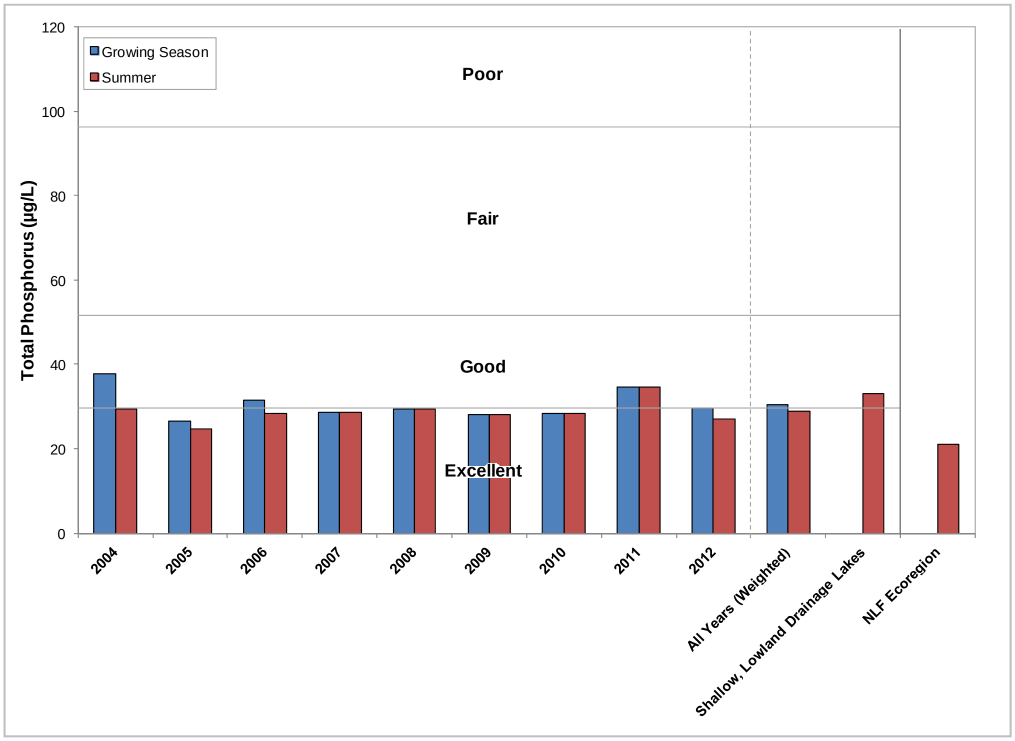

Figure 3.1-3. Lake George, state-wide class 3 lakes, and regional total phosphorus concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

There are many factors that determine algal abundance; nutrients, such as phosphorus and nitrogen, are a large factor because algae feed on these elements. However, water temperature, sunlight penetration (water clarity) and presence of very small crustaceans called zooplankton influence algal abundance as well. Water temperature will determine the overall biological activity (reproduction, nutrient-uptake rates, etc.) of algae. Algae species need to photosynthesize to create energy and thus are dependent upon sunlight. For this reason, algae are often most prevalent in the late summer when water temperatures are high and daylight hours are still long. During the summer months, the abundance of zooplankton typically increases as well. Many zooplankton species feed upon algae, so they regulate algal abundance through predator-prey interactions.

Chlorophyll-*a* concentration data collected from 2004-2012 show a bit of fluctuation (Figure 3.1-4). This fluctuation is most likely due to environmental factors such as those described above, which may change drastically from year to year. A weighted summer average over this time period was calculated to be 16.0 µg/L, which is higher than what is typically seen in shallow, lowland drainage lakes and in all lakes within the Northern Lakes and Forests ecoregion. Most summer averages and the weighted average over all years fall within the *Good* category for shallow, lowland drainage lakes. Despite this, Lake George residents did indicate on this project's stakeholder survey that they believe algae blooms are a factor potentially negatively impacting the lake (Appendix B, Question #20).

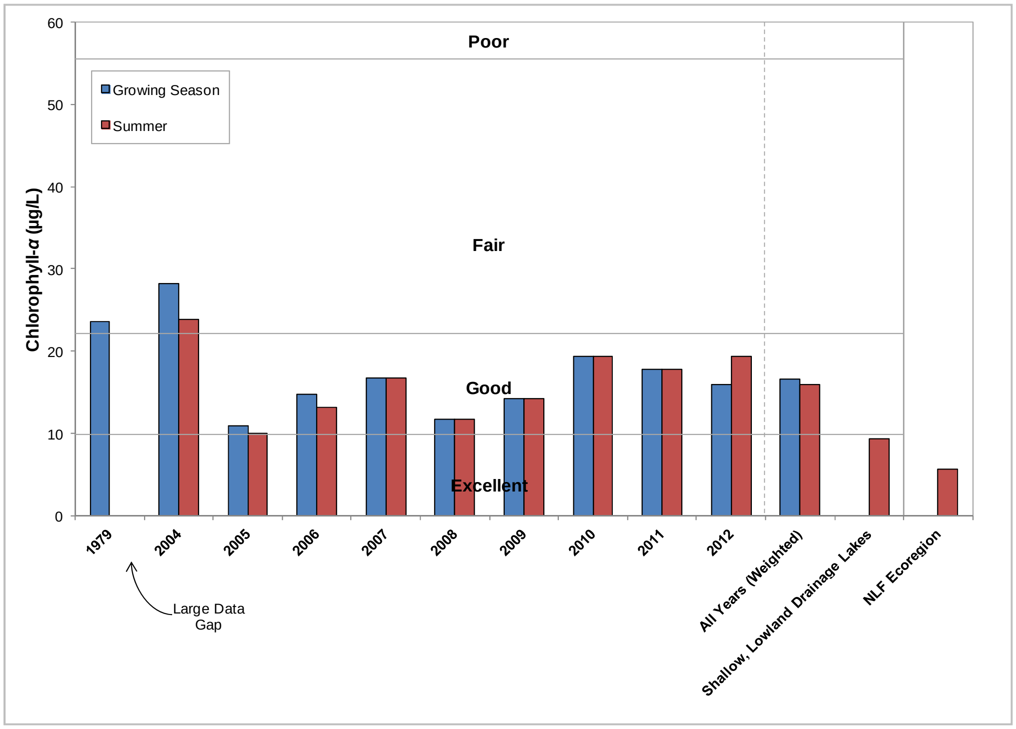

Figure 3.1-4. Lake George, state-wide class 3 lakes, and regional chlorophyll-*a* concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

The third primary water quality parameter, water clarity, is measured through the use of a Secchi disk. Essentially, the circular black and white disk is lowered into the water column until it disappears from sight, and this depth is recorded. The water clarity of a lake is heavily influenced by many characteristics. For example, water clarity is influenced by algal concentration; the more algae in the water column, the less visibility there is. This is an example of a non-dissolved substance that alters water clarity. As discussed further below, dissolved organic substances may reduce the clarity by changing the color of the water in a lake.

Summer average Secchi disk depths in Lake George have ranged between 3.8 and 6.9 feet from 2004-2012, while a weighted average over all years was calculated to be 5.2 feet (Figure 3.1-5). This value ranks as *Good* for shallow, lowland drainage lakes in Wisconsin, but is lower than the median value. Because algal concentrations are generally not excessive in Lake George (Figure 3.1-4), the clarity of the water is likely influenced more so by dissolved organic acids that are transported to the lake from the area's wetlands. These weak, natural acids (sometimes called "tannins") are the byproduct of decomposition of organic matter, particularly debris from pine trees. This is the cause of the reduced clarity and root beer color of Lake George's water.

"True color" measures the dissolved organic materials in water. Water samples collected in April of 2012 were measured for this parameter, and were found to be at 60 Platinum-cobalt units (Pt-co units, or PCU). Lillie and Mason (1983) categorized lakes with 0-40 PCU as having "low" color, 40-100 PCU as "medium" color, and >100 PCU as high color. In other words, the higher a PCU value is, the more a lake's water clarity may be impacted.

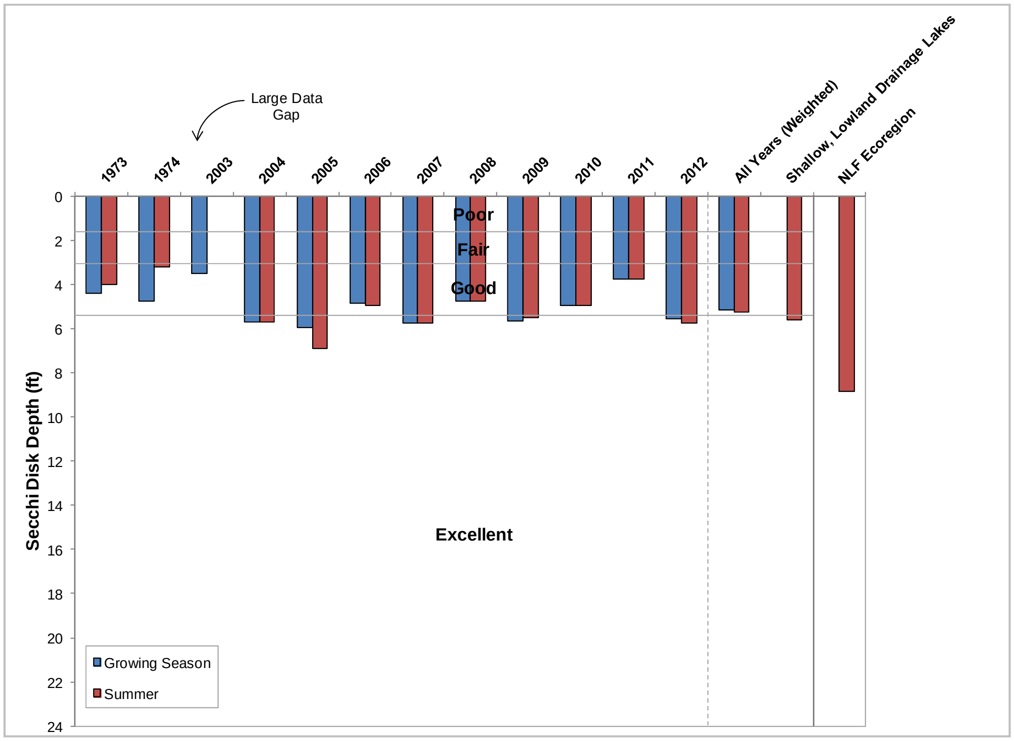

Figure 3.1-5. Lake George, state-wide class 3 lakes, and regional Secchi disk clarity values. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

Limiting Plant Nutrient of Lake George

Using midsummer nitrogen and phosphorus concentrations from Lake George, a nitrogen:phosphorus ratio of 27:1 was calculated. This finding indicates that Lake George is indeed phosphorus limited as are the vast majority of Wisconsin lakes. In general, this means that cutting phosphorus inputs may limit plant growth within the lake.

Lake George Trophic State

Figure 3.1-6 contain the TSI values for Lake George. The TSI values calculated with Secchi disk, chlorophyll-*a*, and total phosphorus values range in values spanning from upper mesotrophic to lower eutrophic. In general, the best values to use in judging a lake's trophic state are the biological parameters; therefore, relying primarily on total phosphorus and chlorophyll-*a* TSI values, it can be concluded that Lake George is in a lower eutrophic state.

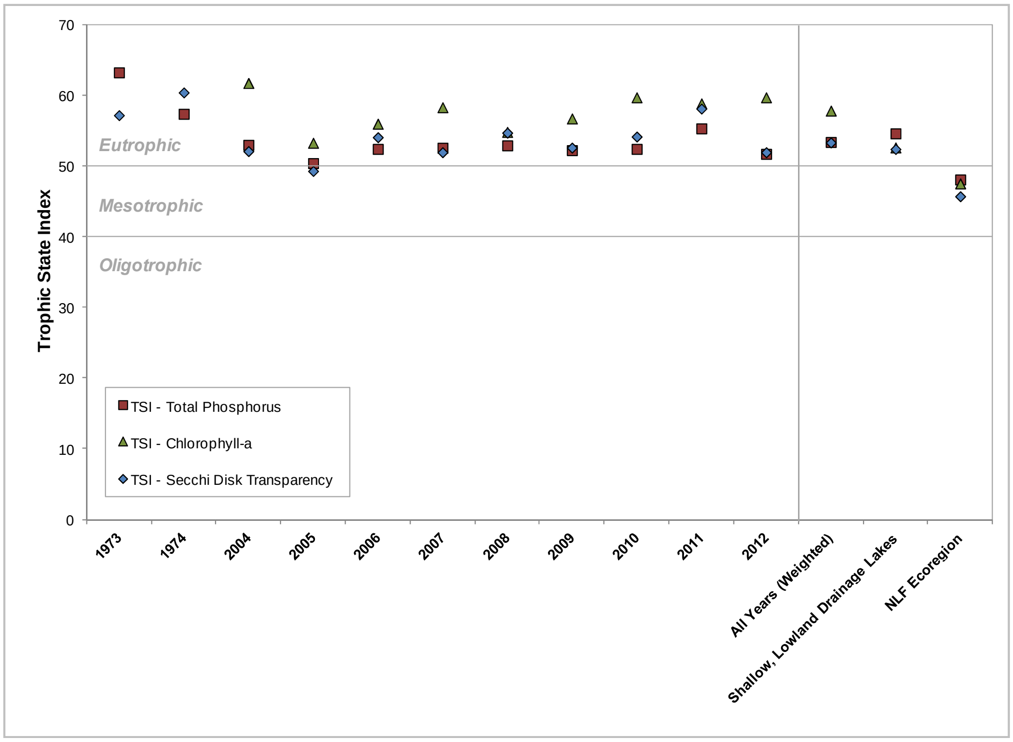

Figure 3.1-6. Lake George, state-wide class 3 lakes, and regional Trophic State Index values. Values calculated with summer month surface sample data using WDNR PUB-WT-193.

Dissolved Oxygen and Temperature in Lake George

Dissolved oxygen and temperature were measured during water quality sampling visits to Lake George by Onterra staff. Additionally, Lake George CLMN volunteers collected temperature data on three occasions during the summer of 2012. Profiles depicting these data are displayed in Figure 3.1-7. In April of 2012, Lake George was found to be completely mixed. Most Wisconsin lakes mix during the spring and fall, when changing water temperatures and winds break down any thermal differences that existed between the upper layers of water (epilimnion) and the bottom layers of water (hypolimnion). During the summer, the epilimnion will warm quickly, while the bottom of the lake does not receive the sun’s warmth. During this time, a temperature gradient may form. Summer winds may mix the water column at some point, and disperse these thermal gradients. Depending on the temperature and the size of the lake, this may occur once, many times, or not at all during the summer months. Lake George was not found to thermally stratify strongly in late May, July or August, but it is possible this stratification could occur during other times or in other years.

Most lakes will mix fully in the fall (October 2012) just as in the spring. During the winter, thermal stratification will occur except in the opposite manner as it does in the summer. Water is most dense at 4°C, so water of this temperature may be found at the bottom of the lake while the coldest water is found at the surface, in the solidified form we know as ice. Dissolved oxygen may decrease during this time as bacteria decompose organic material near the bottom of the lake. The ice cover reduces reintroduction of oxygen from the atmosphere. In February 2013, the lake had sufficient dissolved oxygen for warm water fish species found in Wisconsin lakes.

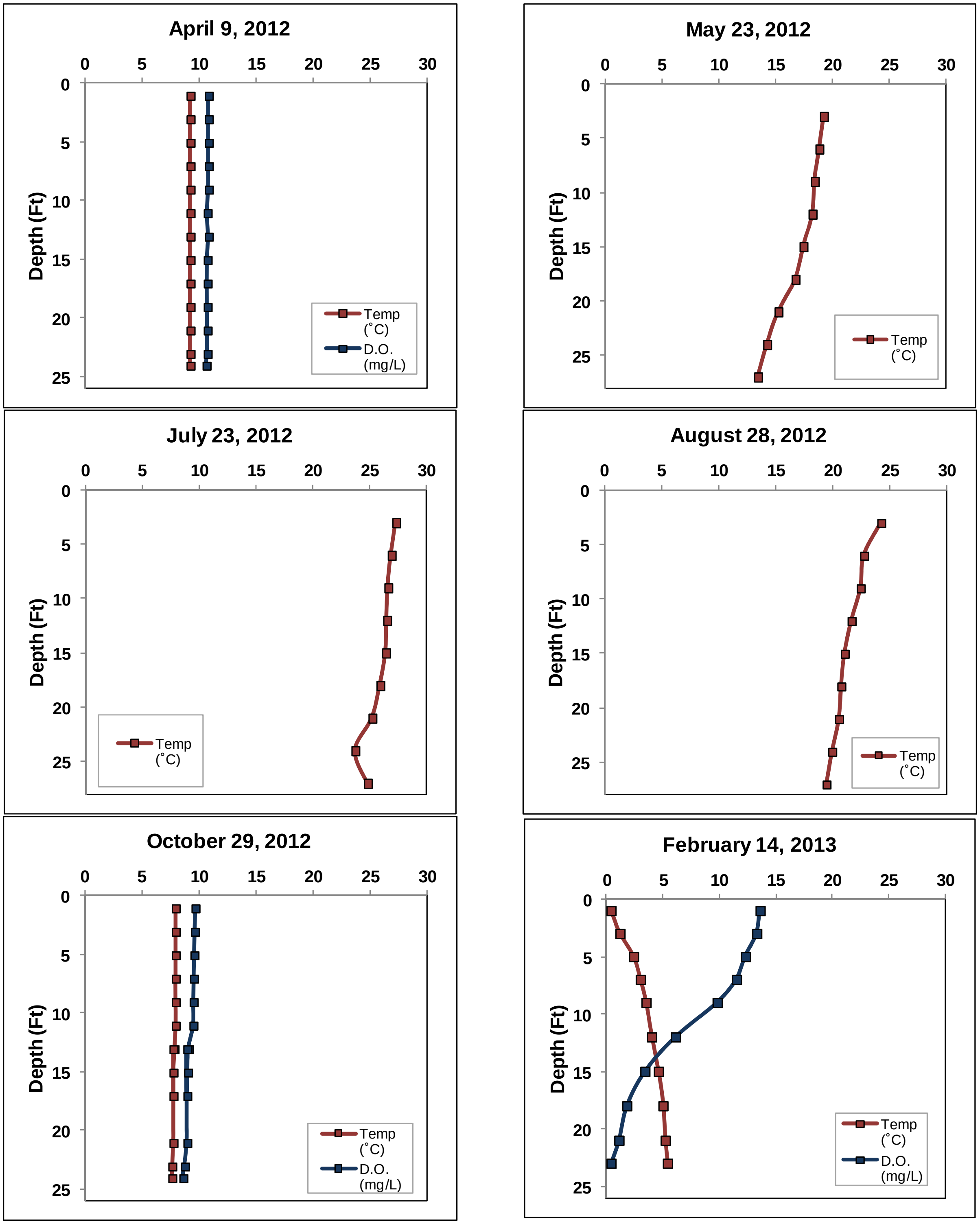

Figure 3.1-7. Lake George dissolved oxygen and temperature profiles. May, July and August profiles created using data collected by Lake George CLMN volunteers.

Additional Water Quality Data Collected at Lake George

The water quality section is centered on lake eutrophication. However, parameters other than water clarity, nutrients, and chlorophyll-*a* were collected as part of the project. These other parameters were collected to increase the understanding of Lake George's water quality and are recommended as a part of the WDNR long-term lake trends monitoring protocol. These parameters include; pH, alkalinity, and calcium.

The pH scale ranges from 0 to 14 and indicates the concentration of hydrogen ions (H^+) within the lake's water and is an index of the lake's acidity. Water with a pH value of 7 has equal amounts of hydrogen ions and hydroxide ions (OH^-), and is considered to be neutral. Water with a pH of less than 7 has higher concentrations of hydrogen ions and is considered to be acidic, while values greater than 7 have lower hydrogen ion concentrations and are considered basic or alkaline. The pH scale is logarithmic, meaning that for every 1.0 pH unit the hydrogen ion concentration changes tenfold. The normal range for lake water pH in Wisconsin is about 5.2 to 8.4, though values lower than 5.2 can be observed in some acid bog lakes and higher than 8.4 in some marl lakes. In lakes with a pH of 6.5 and lower, the spawning of some fish species such as walleye becomes inhibited (Shaw and Nimphius 1985). The surface water pH of Lake George was found to be 7.7, and falls within the normal range for Wisconsin lakes.

Alkalinity is a lake's capacity to resist fluctuations in pH by neutralizing or buffering against inputs such as acid rain. The main compounds that contribute to a lake's alkalinity in Wisconsin are bicarbonate (HCO_3^-) and carbonate (CO_3^-), which neutralize hydrogen ions from acidic inputs. These compounds are present in a lake if the groundwater entering it comes into contact with minerals such as calcite ($CaCO_3$) and/or dolomite ($CaMgCO_3$). A lake's pH is primarily determined by the amount of alkalinity. Rainwater in northern Wisconsin is slightly acidic naturally due to dissolved carbon dioxide from the atmosphere with a pH of around 5.0. Consequently, lakes with low alkalinity have lower pH due to their inability to buffer against acid inputs. Values between 2 and 10 mg/L as $CaCO_3$ are considered to be moderately sensitive to acid rain, while lakes with values of 10 to 25 mg/L as $CaCO_3$ are considered to have low sensitivity, and lakes above 25 mg/L as $CaCO_3$ are non-sensitive. The surface alkalinity in Lake George was measured at 32.4 (mg/L as $CaCO_3$), indicating that the lake has some capacity to resist fluctuations in pH and is not sensitive to acid rain.

Like associated pH and alkalinity, the concentration of calcium within a lake's water depends on the geology of the lake's watershed. Recently, the combination of calcium concentration and pH has been used to determine what lakes can support zebra mussel populations if they are introduced. The commonly accepted pH range for zebra mussels is 7.0 to 9.0, so Lake George's pH of 7.7 falls within this range. Lakes with calcium concentrations of less than 12 mg/L are considered to have very low susceptibility to zebra mussel establishment. The calcium concentration of Lake George was found to be 10.2 mg/L, falling below the optimal range for zebra mussels.

Researchers at the University of Wisconsin - Madison have developed an AIS suitability model called smart prevention (Vander Zanden and Olden 2008). In regards to zebra mussels, this model relies on measured or estimated dissolved calcium concentration to indicate whether a given lake in Wisconsin is suitable, borderline suitable, or unsuitable for sustaining zebra mussels. Within this model, suitability was estimated for approximately 13,000 Wisconsin waterbodies and is displayed as an interactive mapping tool (www.aissmartprevention.wisc.edu). Based upon this analysis, Lake George was considered not suitable for mussel establishment. Plankton tows were completed by Onterra staff during the summer of 2012 and these samples were processed by the WDNR for larval zebra mussels. WDNR staff processed these samples in 2013, and did not detect any larval zebra mussels within them.

3.2 Watershed Assessment

Watershed Modeling

> A lake's flushing rate is simply a determination of the time required for the lake's water volume to be completely exchanged. Residence time describes how long a volume of water remains in the lake and is expressed in days, months, or years. The parameters are related and both determined by the volume of the lake and the amount of water entering the lake from its watershed. Greater flushing rates equal shorter residence times.

Two aspects of a lake's watershed are the key factors in determining the amount of phosphorus the watershed exports to the lake; 1) the size of the watershed, and 2) the land cover (land use) within the watershed. The impact of the watershed size is dependent on how large it is relative to the size of the lake. The watershed to lake area ratio (WS:LA) defines how many acres of watershed drains to each surface-acre of the lake. Larger ratios result in the watershed having a greater role in the lake's annual water budget and phosphorus load.

The type of land cover that exists in the watershed determines the amount of phosphorus (and sediment) that runs off the land and eventually makes its way to the lake. The actual amount of pollutants (nutrients, sediment, toxins, etc.) depends greatly on how the land within the watershed is used. Vegetated areas, such as forests, grasslands, and meadows, allow the water to permeate the ground and do not produce much surface runoff. On the other hand, agricultural areas, particularly row crops, along with residential/urban areas, minimize infiltration and increase surface runoff. The increased surface runoff associated with these land cover types leads to increased phosphorus and pollutant loading; which, in turn, can lead to nuisance algal blooms, increased sedimentation, and/or overabundant macrophyte populations.

In systems with lower WS:LA ratios, land cover type plays a very important role in how much phosphorus is loaded to the lake from the watershed. In these systems the occurrence of agriculture or urban development in even a small percentage of the watershed (less than 10%) can unnaturally elevate phosphorus inputs to the lake. If these land cover types are converted to a cover that does not export as much phosphorus, such as converting row crop areas to grass or forested areas, the phosphorus load and its impacts to the lake may be decreased. In fact, if the phosphorus load is reduced greatly, changes in lake water quality may be noticeable, (e.g. reduced algal abundance and better water clarity) and may even be enough to cause a shift in the lake's trophic state.

In systems with high WS:LA ratios, like those 10-15:1 or higher, the impact of land cover may be tempered by the sheer amount of land draining to the lake. Situations actually occur where lakes with completely forested watersheds have sufficient phosphorus loads to support high rates of plant production. In other systems with high ratios, the conversion of vast areas of row crops to vegetated areas (grasslands, meadows, forests, etc.) may not reduce phosphorus loads sufficiently to see a change in plant production. Both of these situations occur frequently in impoundments.

Regardless of the size of the watershed or the makeup of its land cover, it must be remembered that every lake is different and other factors, such as flushing rate, lake volume, sediment type, and many others, also influence how the lake will react to what is flowing into it. For instance, a deeper lake with a greater volume can dilute more phosphorus within its waters than a less voluminous lake and as a result, the production of a lake is kept low. However, in that same lake, because of its low flushing rate (high residence time, i.e., years), there may be a buildup of phosphorus in the sediments that may reach sufficient levels over time that internal nutrient loading may become a problem. On the contrary, a lake with a higher flushing rate (low residence time, i.e., days or weeks) may be more productive early on, but the constant flushing of its waters may prevent a buildup of phosphorus and internal nutrient loading may never reach significant levels.

A reliable and cost-efficient method of creating a general picture of a watershed's affect on a lake can be obtained through modeling. The WDNR created a useful suite of modeling tools called the Wisconsin Lake Modeling Suite (WiLMS). Certain morphological attributes of a lake and its watershed are entered into WiLMS along with the acreages of different types of land cover within the watershed to produce useful information about the lake ecosystem. This information includes an estimate of annual phosphorus load and the partitioning of those loads between the watershed's different land cover types and atmospheric fallout entering through the lake's water surface. WiLMS also calculates the lake's flushing rate and residence times using county-specific average precipitation/evaporation values or values entered by the user. Predictive models are also included within WiLMS that are valuable in validating modeled phosphorus loads to the lake in question and modeling alternate land cover scenarios within the watershed. Finally, if specific information is available, WiLMS will also estimate the significance of internal nutrient loading within a lake and the impact of shoreland septic systems.

Lake George Watershed

The Lake George watershed consists of two sub-watersheds; a watershed that drains surface water into Lake Thompson and a watershed that drains surface water directly into Lake George (Map 2). Water draining into Lake Thompson makes its way into Lake George via Lake George Creek; therefore, Lake Thompson's 2,975-acre watershed is a part of Lake George's watershed. In fact, Lake Thompson's watershed accounts for 55% of the land that drains within Lake George's 5,405 acre watershed (Figure 3.2-1). Within Lake George's direct watershed, forested lands and wetlands are the primary land cover type, at 18% and 15% of the entire watershed, respectively. Lake George's surface covers 8% of the watershed, while pasture/grass and rural residential land types are found in small quantities as well. Overall, the watershed to lake area ratio of Lake George's entire watershed is 11:1. With this amount of land draining towards the lake, WiLMS calculated that Lake George is able to completely exchange its volume of water 1.05 times per year (lake flushing rate).

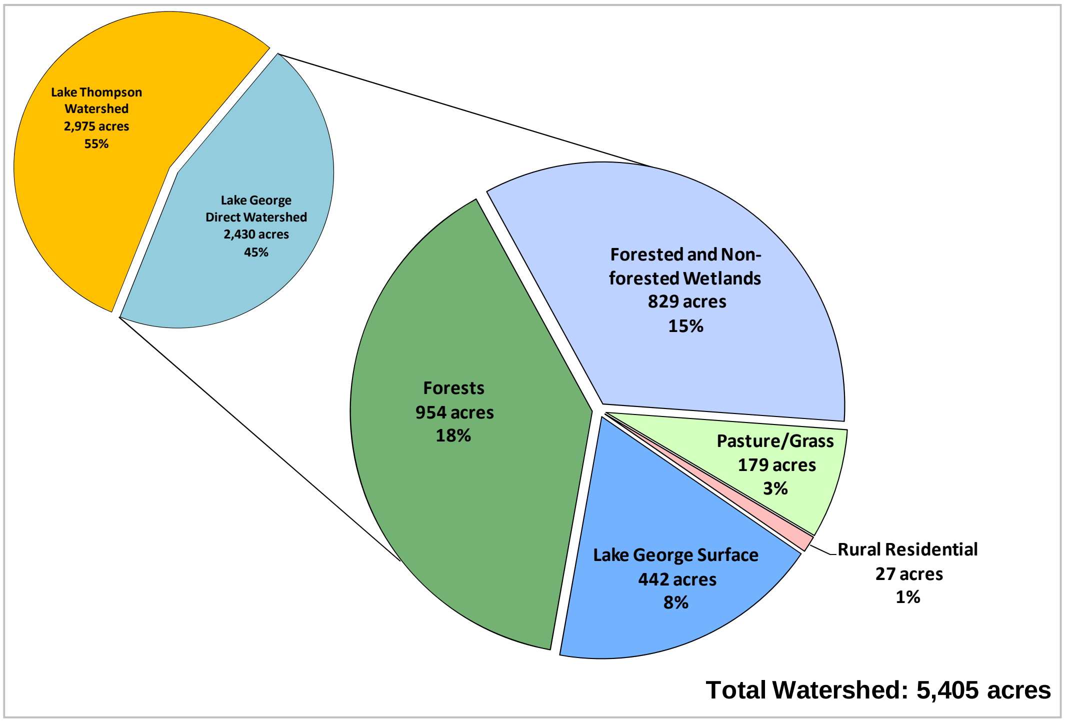

Figure 3.2-1. Lake George watershed land cover types in acres. Based upon National Land Cover Database (NLCD – Fry et. al 2011).

To determine the annual phosphorus load to Lake George, the Lake Thompson watershed was modeled first, as it is a substantial part of the Lake George watershed. WiLMS was utilized to determine 1) the phosphorus load to Lake Thompson, 2) the water discharge from Lake Thompson to Lake George and 3) the annual average phosphorus concentration and subsequent annual load from Lake Thompson to Lake George. These parameters were calculated utilizing hydrologic information for Oneida County that was built within WiLMS, Lake Thompson's calculated volume and Lake Thompson phosphorus data obtained through Citizens Lake Monitoring Network activities. WilMS determined that 375 lbs of phosphorus is delivered to Lake Thompson on an annual basis. Half of this phosphorus load is deposited within the lake, while the remaining 187 lbs flows through Lake George Creek into Lake George.

This phosphorus input was modeled within the Lake George WiLMS model (Appendix D). Overall, the input from Lake Thompson accounts for 35% of Lake George's phosphorus load (Figure 3.2-2). Modeling of the Lake George direct watershed indicates that the largest land cover types in this watershed, forests and wetlands, deliver 9% of the overall phosphorus load to Lake George each. The Lake George surface collects roughly 119 lbs (14% of the overall load) of phosphorus through atmospheric deposition, while pasture/grass and rural residential land cover types contribute 49 lbs and 2 lbs of phosphorus, respectively, to the lake each year. Septic sources were accounted for within the model, based upon the estimated number of residents living along Lake George and the amount of time they spend there – full time residents, seasonal, etc. These data were collected as a part of questions contained on the stakeholder survey associated with this project (Appendix B). Septic sources were estimated to contribute roughly 4% (21 lbs) of the annual phosphorus load to Lake George. Overall, modeling conducted on Lake George indicates approximately 530 lbs of phosphorus are loaded to the lake annually (Figure 3.2-2).

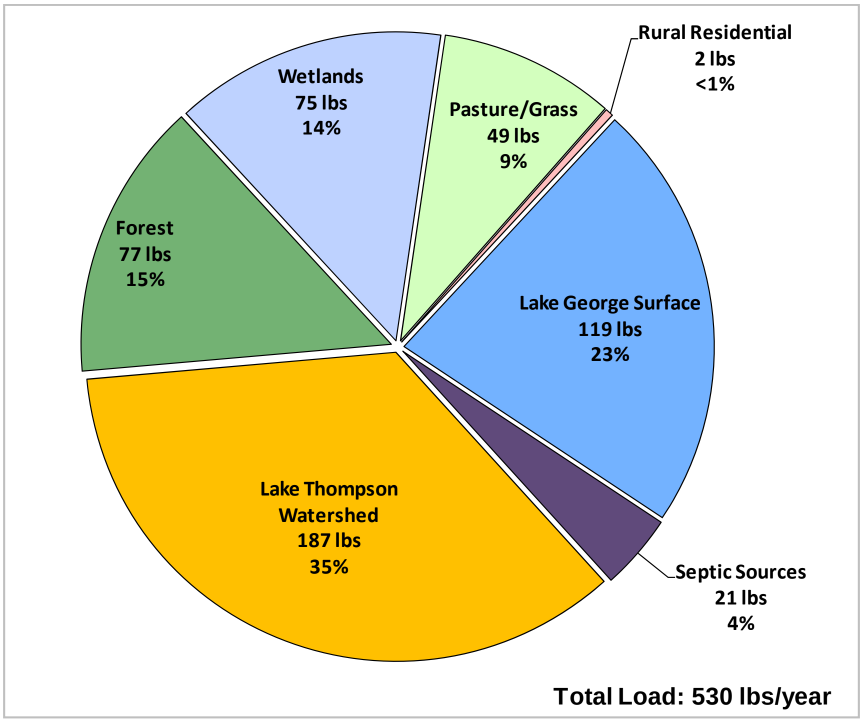

Figure 3.2-2. Lake George watershed phosphorus loading in pounds. Based upon Wisconsin Lake Modeling Suite (WiLMS) estimates.

During modeling procedures, WiLMS compares observed (measured in the field) and predicted (model-calculated) growing season mean and spring overturn phosphorus concentrations to determine the accuracy of the model. The growing season mean phosphorus concentration is defined as the mean of all surface water data collected from March 31-November 1. The spring overturn phosphorus concentration is defined as the concentration of phosphorus that is collected while the lake is completely mixed, as it was during the April 9, 2012 water quality visit by Onterra staff. This value is a good representation of the phosphorus content of the lake, because during this time the water is thoroughly mixed which means phosphorus is fairly similar within the entire water column.

Utilizing land cover types proportions and hydrologic data, WiLMS was able to predict what the phosphorus content of Lake George should be and then compare these values to observed values obtained through water quality sampling. A predictive equation within WiLMS (Canfield-Bachman, 1981) estimated that the growing season mean and spring overturn phosphorus value should be most likely 21 μg/L in Lake George, with an upper range of 28.0 μg/L. Comparatively, Lake George's observed growing season mean phosphorus concentration was found to be 30.3 μg/L. The observed value is higher than what is expected, given Lake George's volume and watershed specifics. Essentially this indicates that WiLMS modeling could not account for additional phosphorus that is present in Lake George. Back-calculations of Canfield Bachman's 1981 predictive equation indicate that roughly between 44 and 337 lbs of phosphorus is unaccounted-for within the Lake George WiLMS model, which would contribute an extra 8%-39% to the overall phosphorus load.

There are several possible sources that may be attributed to this unaccounted-for phosphorus load. These may include 1) development of the immediate shoreland, 2) septic systems located near the lake or 3) internal nutrient loading. As discussed in the Shoreland Assessment Section, Lake George's shoreland contains many developed areas. Developed shorelands allow more surface water runoff of nutrients and sediments to occur when compared to their natural counterparts. While it is likely that the developed shorelands surrounding Lake George are contributing additional phosphorus to the lake ecosystem, this was not quantified through this study. While quantification of this contribution is possible, these studies are often time consuming and costly.

Septic systems within the lake's watershed can leach phosphorus which may make its way into a lake. As mentioned earlier, septic sources were modeled within WiLMS from lake resident use numbers gathered through the stakeholder survey. The model indicated that Lake George receives approximately 21 pounds of phosphorus annually from septic tank outputs. As with all modeling procedures, this component is an estimate, and an assumption of this estimate is that the septic systems are properly functioning. Faulty septic systems may be present along Lake George, and if this were happening, the result would likely be localized blooms of algae or aquatic plants that are dissimilar from what is occurring lake-wide. Currently, 62% of residents have their septic tanks pumped every 2-4 years (Stakeholder Survey; Appendix B, Question #5) which should aid in the identification of the faulty system as well as reduce the impact of a faulty system. Another factor to consider with septic system inputs to a lake is the hydrology of the lake, both in terms of its groundwater and surface flow. Groundwater follows water table gradients much like surface water does. The groundwater flow typically, though not always, follows the general pattern of surface water flow. On Lake George there are many areas where groundwater flows towards the lake, and many areas where groundwater flows from the lake elsewhere. Portions of the lake often contribute groundwater in the direction of land; this essentially means that it is possible for groundwater (and septic leachate if it exists) to flow from residences away from the lake as opposed to into it.

As discussed within the Water Quality Section, some lakes experience a nutrient "recycling" called internal nutrient loading. Internal nutrient loading occurs when anoxia develops near the bottom sediments of a lake. Iron, which is naturally found in lake sediments and soil, will bind with phosphorus in the presence of oxygen. However, in an anoxic state, iron will release phosphorus into the overlying water. Often, this will occur when bacteria have depleted oxygen from the hypolimnion of the lake while the epilimnion still remains oxygen-rich; at this point the lake is stratified. The phosphorus will remain in the anoxic hypolimnion until the lake mixes. When it does so, phosphorus from the hypolimnion will be released into the epilimnion. Essentially, this recycles phosphorus once removed from the water column back into it.

In lakes that have internal nutrient loading, this process may occur every time a lake stratifies and then mixes. Depending on many factors such as lake depth and morphometry, a lake may mix twice a year, many times a year, or perhaps not at all. The Osgood Index is a measure relating a lake's volume to its surface area and is used to determine whether a lake is dimictic or polymictic. Dimictic lakes completely mix or turnover two times per year, once in spring and again in fall; while polymictic lakes have the potential to turn over multiple times per year depending upon air temperatures and wind events. The Osgood Index uses a ratio of mean depth to square root of lake surface area (mean depth (meters) divided by the square root of lake surface area (square kilometers)). Lakes with values exceeding 6 are considered strongly stratified and have little chance of destratification during summer months (dimictic). Lakes with lower values (less than 6) may stratify and turn over multiple times (polymictic). Lake George has a calculated Osgood Index value of 2.5, indicating that it is polymictic. Lakes that are polymictic may see problems associated with internal nutrient loading because additional phosphorus is added to the water column often during the open water months. However, this is greatly dependent upon the amount of phosphorus that is added to the water column.

At this time, it is suspected that internal nutrient loading may be playing a contributing role to the unaccounted-for phosphorus that is present in Lake George. However, there is unfortunately little evidence to point towards this phenomenon. For example, the water quality data that is present for Lake George largely consists of near-surface samples. Samples of water present within the hypolimnion are useful because elevated phosphorus levels within this area of the water column are a good indication of internal nutrient loading. Dissolved oxygen profiles collected during the summer months provide detail on how often a lake is going anoxic in this zone as well. These data were collected during the spring and fall of the open water season by Onterra staff, when the lake is fully mixed and no differences should be present between the epilimnion and hypolimnion oxygen or phosphorus content. However, summer samples from 2004-2012 have been collected at the surface only by Citizens Lake Monitoring Network volunteers, and dissolved oxygen data have not been collected during these times either.

Even though it is believed that there are unaccounted-for sources of phosphorus comprising a portion of the lake's annual phosphorus load, the known phosphorus load of 530 lbs is not extremely high, given Lake George's volume (roughly 4,800 acre-feet). Currently, residents largely believe the water quality is in good shape and has remained that way for some time (Stakeholder Survey; Appendix B, Question #14-15). And, as discussed in the Water Quality Section, phosphorus and chlorophyll-*a* concentrations are not excessively higher than what is typically seen in shallow, lowland drainage lakes in northern Wisconsin. However, survey respondents did rank water quality related issues highly in terms of potential impact (Question #20), and a top-three concern (Question #21). Furthermore, 62% of survey respondents stated *Definitely yes* or *Probably yes* when asked if they believe that management actions specific to water quality are needed on Lake George (Question #16).

In short, the available data and baseline-screening nature of this project fall short of providing a complete answer to the full sources of phosphorus to Lake George. Before a more in-depth knowledge of the nutrient sources to the lake can be obtained, further studies would need to be completed on the lake and its watershed to fully inventory potential sources and accurately quantify the amount of phosphorus being delivered from these sources. This would include a more rigorous sampling regime of epilimnetic and hypolimnetic phosphorus values throughout the year and the collection and analysis of sediment cores to determine phosphorus-release rates. Also, sampling near the mouth of the tributary stream would be required to determine a more accurate amount of phosphorus being delivered from Lake Thomspson's watershed.

3.3 Shoreland Condition

The Importance of a Lake's Shoreland Zone

One of the most vulnerable areas of a lake's watershed is the immediate shoreland zone (approximately from the water's edge to at least 35 feet shoreland). When a lake's shoreland is developed, the increased impervious surface, removal of natural vegetation, and other human practices can severely increase pollutant loads to the lake while degrading important habitat. Limiting these anthropogenic (man-made) effects on the lake is important in maintaining the quality of the lake's water and habitat.

The intrinsic value of natural shorelands is found in numerous forms. Vegetated shorelands prevent polluted runoff from entering lakes by filtering this water or allowing it to slow to the point where particulates settle. The roots of shoreland plants stabilize the soil, thereby preventing shoreland erosion. Shorelands also provide habitat for both aquatic and terrestrial animal species. Many species rely on natural shorelands for all or part of their life cycle as a source of food, cover from predators, and as a place to raise their young. Shorelands and the nearby shallow waters serve as spawning grounds for fish and nesting sites for birds. Thus, both the removal of vegetation and the inclusion of development reduces many forms of habitat for wildlife.

Some forms of development may provide habitat for less than desirable species. Disturbed areas are often overtaken by invasive species, which are sometimes termed "pioneer species" for this reason. Some waterfowl, such as geese, prefer to linger upon open lawns near waterbodies because of the lack of cover for potential predators. The presence of geese on a lake resident's beach may not be an issue; however the feces the geese leave are unsightly and pose a health risk. Geese feces may become a source of fecal coliforms as well as flatworms that can lead to swimmers itch. Development such as rip rap or masonary, steel or wooden seawalls completely remove natural habitat for most animals, but may also create some habitat for snails; this is not desirable for lakes that experience problems with swimmers itch, as the flatworms that cause this skin reaction utilize snails as a secondary host after waterfowl.

In the end, natural shorelines provide many ecological and other benefits. Between the abundant wildlife, the lush vegetation, and the presence of native flowers, shorelands also provide natural scenic beauty and a sense of tranquility for humans.

Shoreland Zone Regulations

Wisconsin has numerous regulations in place at the state level which aim to enhance and protect shorelands. Additionally, counties, townships and other municipalities have developed their own (often more comprehensive or stronger) policies. At the state level, the following shoreland regulations exist:

Wisconsin-NR 115: Wisconsin's Shoreland Protection Program

Wisconsin's shoreland zoning rule, NR 115, sets the minimum standards for shoreland development. First adopted in 1966, the code set a deadline for county adoption of January 1, 1968. By 1971, all counties in Wisconsin had adopted the code and were administering the shoreland ordinances it specified. Interestingly, in 2007 it was noted that many (27) counties had recognized inadequacies within the 1968 ordinance and had actually adopted more strict shoreland ordinances. Passed in February of 2010, the final NR 115 allowed many standards to remain the same, such as lot sizes, shoreland setbacks and buffer sizes. However, several standards changed as a result of efforts to balance public rights to lake use with private property rights. The regulation sets minimum standards for the shoreland zone, and requires all counties in the state to adopt shoreland zoning ordinances of their own. County ordinances may be more restrictive than NR 115, but not less so (though Act 170 allows for less restrictive standards for existing non-conforming structures). These policy regulations require each county to amend ordinances for vegetation removal on shorelands, impervious surface standards, nonconforming structures and establishing mitigation requirements for development. Minimum requirements for each of these categories are described below. Please note that at the time of this writing, NR 115 is under review by the State of Wisconsin and updates will likely occur in February of 2014.

- Contact the county's regulations/zoning department for county-specific requirements.

- <u>Vegetation Removal</u>: For the first 35 feet of property (shoreland zone), no vegetation removal is permitted except for: sound forestry practices on larger pieces of land, access and viewing corridors (may not exceed the lesser of 30 percent of the shoreline frontage), invasive species removal, or damaged, diseased, or dying vegetation. Vegetation removed must be replaced by replanting in the same area (native species only).

- <u>Impervious surface standards</u>: The amount of impervious surface is restricted to 15% of the total lot size, on lots that are within 300 feet of the ordinary high-water mark of the waterbody. A county may allow more than 15% impervious surface (but not more than 30%) on a lot provided that the county issues a permit and that an approved mitigation plan is implemented by the property owner.

- <u>Nonconforming structures</u>: Nonconforming structures are structures that were lawfully placed when constructed but do not comply with distance of water setback. Originally, structures within 75 ft of the shoreline had limitations on structural repair and expansion. New language in NR-115 allows construction projects on structures within 75 feet with the following caveats:
  - No expansion or complete reconstruction within 0-35 feet of shoreline
  - Re-construction may occur if no other build-able location exists within 35-75 feet, dependent on the county.
  - Construction may occur if mitigation measures are included either within the existing footprint or beyond 75 feet.
  - Vertical expansion cannot exceed 35 feet

- <u>Mitigation requirements</u>: New language in NR-115 specifies mitigation techniques that may be incorporated on a property to offset the impacts of impervious surface, replacement of nonconforming structure, or other development projects. Practices such as buffer restorations along the shoreland zone, rain gardens, removal of fire pits, and beaches all may be acceptable mitigation methods, dependent on the county.

Not all aspects of NR 115 may apply to existing properties. For example, properties that have been maintained with vegetation removed within the first 35 feet of property may continue to be maintained in this manner. However, with improvements to the property, owners may be required to bring their land up to code with respect to NR 115. Property owners are advised to contact the county's regulations/zoning department for all minimum requirements.

Wisconsin Act 31

While not directly aimed at regulating shoreland practices, the State of Wisconsin passed Wisconsin Act 31 in 2009 in an effort to minimize watercraft impacts upon shorelines. This act prohibits a person from operating a watercraft (other than personal watercraft) at a speed in excess of slow-no-wake speed within 100 feet of a pier, raft, buoyed area or the shoreline of a lake. Additionally, personal watercraft must abide by slow-no-wake speeds while within 200 feet of these same areas. Act 31 was put into place to reduce wave action upon the sensitive shoreland zone of a lake. The legislation does state that pickup and drop off areas marked with regulatory markers and that are open to personal watercraft operators and motorboats engaged in waterskiing/a similar activity may be exempt from this distance restriction. Additionally, a city, village, town, public inland lake protection and rehabilitation district or town sanitary district may provide an exemption from the 100 foot requirement or may substitute a lesser number of feet.

Shoreland Research

Studies conducted on nutrient runoff from Wisconsin lake shorelands have produced interesting results. For example, a USGS study on several Northwoods Wisconsin lakes was conducted to determine the impact of shoreland development on nutrient (phosphorus and nitrogen) export to these lakes (Graczyk et al. 2003). During the study period, water samples were collected from surface runoff and ground water and analyzed for nutrients. These studies were conducted on several developed (lawn covered) and undeveloped (undisturbed forest) areas on each lake. The study found that nutrient yields were greater from lawns than from forested catchments, but also that runoff water volumes were the most important factor in determining whether lawns or wooded catchments contributed more nutrients to the lake. Ground-water inputs to the lake were found to be significant in terms of water flow and nutrient input. Nitrate plus nitrite nitrogen and total phosphorus yields to the ground-water system from a lawn catchment were three or sometimes four times greater than those from wooded catchments.

A separate USGS study was conducted on the Lauderdale Lakes in southern Wisconsin, looking at nutrient runoff from different types of developed shorelands – regular fertilizer application lawns (fertilizer with phosphorus), non-phosphorus fertilizer application sites, and unfertilized sites (Garn 2002). One of the important findings stemming from this study was that the amount of dissolved phosphorus coming off of regular fertilizer application lawns was twice that of lawns with non-phosphorus or no fertilizer. Dissolved phosphorus is a form in which the phosphorus molecule is not bound to a particle of any kind; in this respect, it is readily available to algae. Therefore, these studies show us that it is a developed shoreland that is continuously maintained in an unnatural manner (receiving phosphorus rich fertilizer) that impacts lakes the greatest. This understanding led former Governor Jim Doyle into passing the Wisconsin Zero-Phosphorus Fertilizer Law (Wis Statue 94.643), which restricts the use, sale and display of lawn and turf fertilizer which contains phosphorus. Certain exceptions apply, but after April 1 2010, use of this type of fertilizer is prohibited on lawns and turf in Wisconsin. The goal of this action is to reduce the impact of developed lawns, and is particularly helpful to developed lawns situated near Wisconsin waterbodies.

Shorelands provide much in terms of nutrient retention and mitigation, but also play an important role in wildlife habitat. Woodford and Meyer (2003) found that green frog density was negatively correlated with development density in Wisconsin lakes. As development increased, the habitat for green frogs decreased and thus populations became significantly lower. Common loons, a bird species notorious for its haunting call that echoes across Wisconsin lakes, are often associated more so with undeveloped lakes than developed lakes (Lindsay et al. 2002). And studies on shoreland development and fish nests show that undeveloped shorelands are preferred as well. In a study conducted on three Minnesota lakes, researchers found that only 74 of 852 black crappie nests were found near shorelines that had any type of dwelling on it (Reed, 2001). The remaining nests were all located along undeveloped shoreland.

Emerging research in Wisconsin has shown that coarse woody habitat (sometimes called "coarse woody debris"), often stemming from natural or undeveloped shorelands, provides many ecosystem benefits in a lake. Coarse woody habitat describes habitat consisting of trees, limbs, branches, roots and wood fragments at least four inches in diameter that enter a lake by natural or human means. Coarse woody habitat provides shoreland erosion control, a carbon source for the lake, prevents suspension of sediments and provides a surface for algal growth which is important for aquatic macroinvertebrates (Sass 2009). While it impacts these aspects considerably, one of the greatest benefits coarse woody habitat provides is habitat for fish species.

Photograph 3.3-1. Lake George coarse woody habitat.

Coarse woody habitat has shown to be advantageous for fisheries in terms of providing refuge, foraging area as well as spawning habitat (Hanchin et al 2003). In one study, researchers observed 16 different species occupying coarse woody habitat areas in a Wisconsin lake (Newbrey et al. 2005). Bluegill and bass species in particular are attracted to this habitat type; largemouth bass stalk bluegill in these areas while the bluegill hide amongst the debris and often feed upon the many macroinvertebrates found in these areas, who themselves are feeding upon algae and periphyton growing on the wood surface. Newbrey et al. (2005) found that some fish species prefer different complexity of branching on coarse woody habitat, though in general some degree of branching is preferred over coarse woody habitat that has no branching.

With development of a lake's shoreland zone, much of the coarse woody habitat that was once found in Wisconsin lakes has disappeared. Prior to human establishment and development on lakes (mid to late 1800's), the amount of coarse woody habitat in lakes was likely much greater. However, with changes in the logging industry and increasing development along lake shorelands, coarse woody habitat has decreased substantially. Shoreland residents are removing woody debris to improve aesthetics or for recreational opportunities (boating, swimming, and, ironically, fishing).

National Lakes Assessment

Unfortunately, along with Wisconsin's lakes, waterbodies within the entire United States have shown to have increasing amounts of developed shorelands. The National Lakes Assessment (NLA) is an Environmental Protection Agency sponsored assessment that has successfully pooled together resource managers from all 50 U.S. states in an effort to assess waterbodies, both natural and man-made, from each state. Through this collaborative effort, over 1,000 lakes were sampled in 2007, pooling together the first statistical analysis of the nation's lakes and reservoirs.

Through the National Lakes Assessment, a number of potential stressors were examined, including nutrient impairment, algal toxins, fish tissue contaminants, physical habitat, and others. The 2007 NLA report states that "*of the stressors examined, poor lakeshore habitat is the biggest problem in the nations lakes; over one-third exhibit poor shoreline habitat condition*" (USEPA 2009). Furthermore, the report states that "*poor biological health is three times more likely in lakes with poor lakeshore habitat*".

The results indicate that stronger management of shoreline development is absolutely necessary to preserve, protect and restore lakes. This will become increasingly important as development pressures on lakes continue to steadily grow.

Native Species Enhancement

The development of Wisconsin's shorelands has increased dramatically over the last century and with this increase in development a decrease in water quality and wildlife habitat has occurred. Many people that move to or build in shoreland areas attempt to replicate the suburban landscapes they are accustomed to by converting natural shoreland areas to the "neat and clean" appearance of manicured lawns and flowerbeds. The conversion of these areas immediately leads to destruction of habitat utilized by birds, mammals, reptiles, amphibians, and insects (Jennings et al. 2003). The maintenance of the newly created area helps to decrease water quality by considerably increasing inputs of phosphorus and sediments into the lake. The negative impact of human development does not stop at the shoreland. Removal of native plants and dead, fallen timbers from shallow, near-shore areas for boating and swimming activities destroys habitat used by fish, mammals, birds, insects, and amphibians, while leaving bottom and shoreland sediments vulnerable to wave action caused by boating and wind (Jennings et al. 2003, Radomski and Goeman 2001, and Elias & Meyer 2003). Many homeowners significantly decrease the number of trees and shrubs along the water's edge in an effort to increase their view of the lake. However, this has been shown to locally increase water temperatures, and decrease infiltration rates of potentially harmful nutrients and pollutants. Furthermore, the dumping of sand to create beach areas destroys spawning, cover and feeding areas utilized by aquatic wildlife (Scheuerell and Schindler 2004).

Photograph 3.3-2. Example of a biolog restoration site.

In recent years, many lakefront property owners have realized increased aesthetics, fisheries, property values, and water quality by restoring portions of their shoreland to mimic its unaltered state. An area of shore restored to its natural condition, both in the water and on shore, is commonly called a shoreland buffer zone. The shoreland buffer zone creates or restores the ecological habitat and benefits lost by traditional suburban landscaping. Simply not mowing within the buffer zone does wonders to restore some of the shoreland's natural function.

Enhancement activities also include additions of submergent, emergent, and floating-leaf plants within the lake itself. These additions can provide greater species diversity and may compete against exotic species.

Cost

The cost of native, aquatic, and shoreland plant restorations is highly variable and depends on the size of the restoration area, the depth of buffer zone required to be restored, the existing plant density, the planting density required, the species planted, and the type of planting (e.g. seeds, bare-roots, plugs, live-stakes) being conducted. Other sites may require erosion control stabilization measures, which could be as simple as using erosion control blankets and plants and/or seeds or more extensive techniques such as geotextile bags (vegetated retaining walls), geogrids (vegetated soil lifts), or bio-logs (see above picture). Some of these erosion control techniques may reduce the need for rip-rap or seawalls which are sterile environments that do not allow for plant growth or natural shorelines. Questions about rip-rap or seawalls should be directed to the local Wisconsin DNR Water Resources Management Specialist. Other measures possibly required include protective measures used to guard newly planted area from wildlife predation, wave-action, and erosion, such as fencing, erosion control matting, and animal deterrent sprays. One of the most important aspects of planting is maintaining moisture levels. This is done by watering regularly for the first two years until plants establish themselves, using soil amendments (i.e., peat, compost) while planting, and using mulch to help retain moisture.

Most restoration work can be completed by the landowner themselves. To decrease costs further, bare-root form of trees and shrubs should be purchased in early spring. If additional assistance is needed, the lakefront property owner could contact an experienced landscaper. For properties with erosion issues, owners should contact their local county conservation office to discuss cost-share options.In general, a restoration project with the characteristics described below would have an estimated materials and supplies cost of approximately $1,400. The more native vegetation a site has, the lower the cost. Owners should contact the county's regulations/zoning department for all minimum requirements. The single site used for the estimate indicated above has the following characteristics:

- o Spring planting timeframe.
- o 100’ of shoreline and an upland buffer zone depth of 35’.
- o An access and viewing corridor 30’ x 35’ free of planting (recreation area).
- o Planting area of upland buffer zone 2- 35’ x 35’ areas
- o Site is assumed to need little invasive species removal prior to restoration.
- o Site has only turf grass (no existing trees or shrubs), a moderate slope, sandy-loam soils, and partial shade.
- o Trees and shrubs planted at a density of 1 tree/100 sq ft and 2 shrubs/100 sq ft, therefore, 24 native trees and 48 native shrubs would need to be planted.
- o Turf grass would be removed by hand.
- o A native seed mix is used in bare areas of the upland buffer zone.
- o An aquatic zone with shallow-water 2 - 5’ x 35’ areas.
- o Plant spacing for the aquatic zone would be 3 feet.
- o Site would need 70’ of erosion control fabric to protect plants and sediment near the shoreland (the remainder of the site would be mulched).
- o Soil amendment (peat, compost) would be needed during planting.
- o There is no hard-armor (rip-rap or seawall) that would need to be removed.
- o The property owner would maintain the site for weed control and watering.

Advantages	***Disadvantages***
• Improves the aquatic ecosystem through species diversification and habitat enhancement. • Assists native plant populations to compete with exotic species. • Increases natural aesthetics sought by many lake users. • Decreases sediment and nutrient loads entering the lake from developed properties. • Reduces bottom sediment re-suspension and shoreland erosion. • Lower cost when compared to rip-rap and seawalls. • Restoration projects can be completed in phases to spread out costs. • Once native plants are established, they require less water, maintenance, no fertilizer; provide wildlife food and habitat, and natural aesthetics compared to ornamental (non-native) varieties. • Many educational and volunteer opportunities are available with each project.	• Property owners need to be educated on the benefits of native plant restoration before they are willing to participate. • Stakeholders must be willing to wait 3-4 years for restoration areas to mature and fill-in. • Monitoring and maintenance are required to assure that newly planted areas will thrive. • Harsh environmental conditions (e.g., drought, intense storms) may partially or completely destroy project plantings before they become well established.

Lake George Shoreland Zone Condition

Shoreland Development

Lake George's shoreland zone can be classified in terms of its degree of development. In general, more developed shorelands are more stressful on a lake ecosystem, while definite benefits occur from shorelands that are left in their natural state. Figure 3.3-1 displays a diagram of shoreland categories, from "Urbanized", meaning the shoreland zone is completely disturbed by human influence, to "Natural/Undeveloped", meaning the shoreland has been left in its original state.

Urbanized: This type of shoreland has essentially no natural habitat. Areas that are mowed or unnaturally landscaped to the water's edge and areas that are rip-rapped or include a seawall would be placed in this category.

Developed-Unnatural: This category includes shorelands that have been developed, but only have small remnants of natural habitat yet intact. A property with many trees, but no remaining understory or herbaceous layer would be included within this category. Also, a property that has left a small (less than 30 feet), natural buffer in place, but has urbanized the areas behind the buffer would be included in this category.

Developed-Semi-Natural: This is a developed shoreland that is mostly in a natural state. Developed properties that have left much of the natural habitat in state, but have added gathering areas, small beaches, etc within those natural areas would likely fall into this category. An urbanized shoreland that was restored would likely be included here, also.

Developed-Natural: This category includes shorelands that are developed property, but essentially no modifications to the natural habitat have been made. Developed properties that have maintained the natural habitat and only added a path leading to a single pier would fall into this category.

Natural/Undeveloped: This category includes shorelands in a natural, undisturbed state. No signs of anthropogenic impact can be found on these shorelands. In forested areas, herbaceous, understory, and canopy layers would be intact.

Figure 3.3-1. Shoreland assessment category descriptions.

On Lake George, the development stage of the entire shoreland was surveyed during late summer of 2012, using a GPS unit to map the shoreland. During the survey, Onterra staff examined the shoreland for signs of development and assigned areas of the shoreland one of the five descriptive categories in Figure 3.3-2.

Lake George has stretches of shoreland that fit all of the five shoreland assessment categories. In all, 1.5 miles (24%) of natural/undeveloped and developed-natural shoreland were observed during the survey (Figure 3.3-2). These shoreland types provide the most benefit to the lake and should be left in their natural state if at all possible. During the survey, 1.9 miles (31%) of urbanized and developed–unnatural shoreland were observed. If restoration of the Lake George shoreland is to occur, primary focus should be placed on these shoreland areas as they currently provide little benefit to, and actually may harm, the lake ecosystem. Map 3 displays the location of these shoreland lengths around the entire lake.

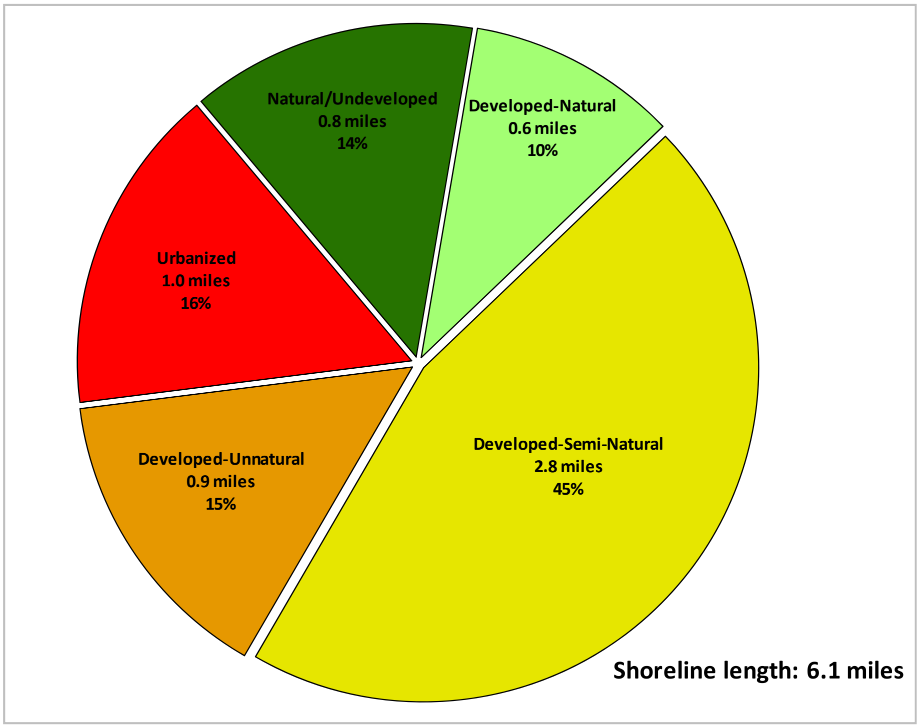

Figure 3.3-2. Lake George shoreland categories and total lengths. Based upon a late summer 2012 survey. Locations of these categorized shorelands can be found on Map 3.

While producing a completely natural shoreland is ideal for a lake ecosystem, it is not always practical from a human's perspective. However, riparian property owners can take small steps in ensuring their property's impact upon the lake is minimal. Choosing an appropriate landscape position for lawns is one option to consider. Placing lawns on flat, unsloped areas or in areas that do not terminate at the lake's edge is one way to reduce the amount of runoff a lake receives from a developed site. And, allowing tree falls and other natural habitat features to remain along a shoreline may result not only in reducing shoreline erosion, but creating wildlife habitat also.

Coarse Woody Habitat

A survey for coarse woody habitat was conducted in conjunction with the shoreland assessment (development) survey (Figure 3.3-3). Coarse woody habitat was identified, and classified in several size categories (2-8 inches diameter, >8 inches diameter and cluster) as well as four branching categories: no branches, minimal branches, moderate branches, and full canopy. As discussed earlier, research indicates that fish species prefer some branching as opposed to no branching on coarse woody habitat, and increasing complexity is positively correlated with higher fish species richness, diversity and abundance.

During this survey, 45 total pieces of coarse woody habitat were observed along 6.1 miles of shoreline, which gives Lake George a coarse woody habitat to shoreline mile ratio of 7:1. Locations of coarse woody habitat are displayed on Map 4. To put this into perspective, Wisconsin researchers have found that in completely undeveloped lakes, an average of 345 coarse woody habitat structures may be found per mile (Christensen et al. 1996).

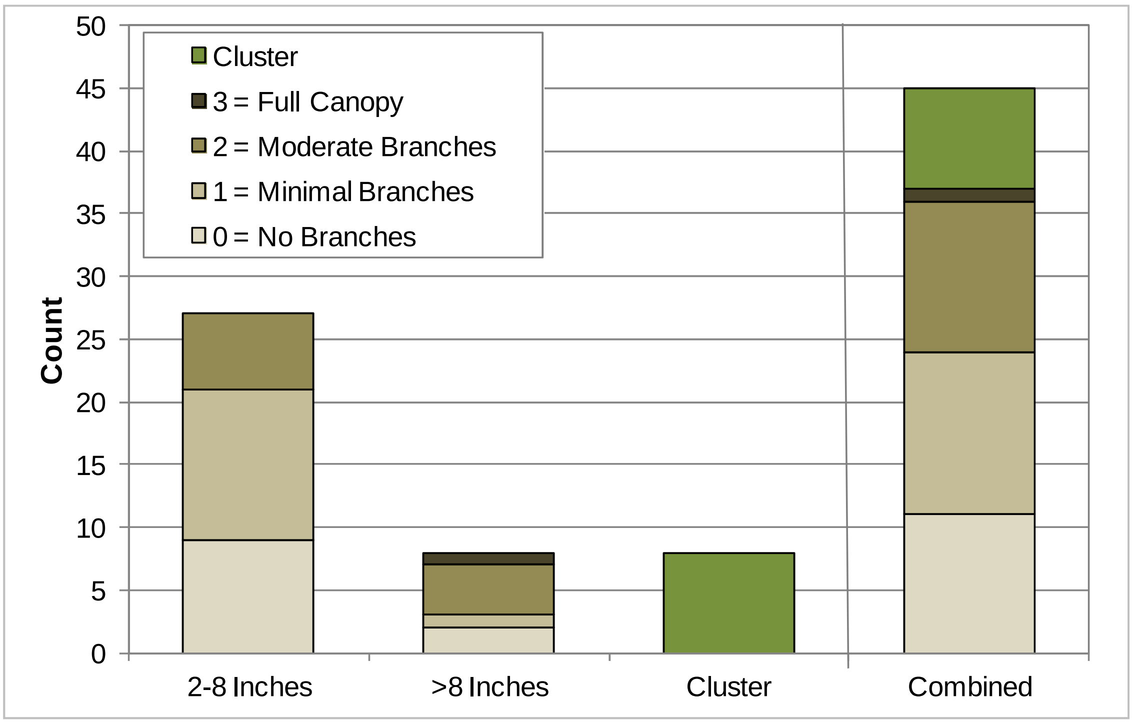

Figure 3.3-3. Lake George coarse woody habitat survey results. Based upon a late summer 2012 survey. Locations of Lake George coarse woody habitat can be found on Map 4.

3.4 Aquatic Plants

Introduction

Although the occasional lake user considers aquatic macrophytes to be "weeds" and a nuisance to the recreational use of the lake, the plants are actually an essential element in a healthy and functioning lake ecosystem. It is very important that lake stakeholders understand the importance of lake plants and the many functions they serve in maintaining and protecting a lake ecosystem. With increased understanding and awareness, most lake users will recognize the importance of the aquatic plant community and their potential negative effects on it.

Diverse aquatic vegetation provides habitat and food for many kinds of aquatic life, including fish, insects, amphibians, waterfowl, and even terrestrial wildlife. For instance, wild celery (*Vallisneria americana)* and wild rice (*Zizania aquatica* and *Z. palustris*) both serve as excellent food sources for ducks and geese. Emergent stands of vegetation provide necessary spawning habitat for fish such as northern pike (*Esox lucius*) and yellow perch (*Perca flavescens*) In addition, many of the insects that are eaten by young fish rely heavily on aquatic plants and the periphyton attached to them as their primary food source. The plants also provide cover for feeder fish and zooplankton, stabilizing the predator-prey relationships within the system. Furthermore, rooted aquatic plants prevent shoreland erosion and the resuspension of sediments and nutrients by absorbing wave energy and locking sediments within their root masses. In areas where plants do not exist, waves can resuspend bottom sediments decreasing water clarity and increasing plant nutrient levels that may lead to algae blooms. Lake plants also produce oxygen through photosynthesis and use nutrients that may otherwise be used by phytoplankton, which helps to minimize nuisance algal blooms.

Under certain conditions, a few species may become a problem and require control measures. Excessive plant growth can limit recreational use by deterring navigation, swimming, and fishing activities. It can also lead to changes in fish population structure by providing too much cover for feeder fish resulting in reduced predation by predator fish, which could result in a stunted pan-fish population. Exotic plant species, such as Eurasian water-milfoil (*Myriophyllum spicatum*) and curly-leaf pondweed (*Potamogeton crispus*) can also upset the delicate balance of a lake ecosystem by out competing native plants and reducing species diversity. These invasive plant species can form dense stands that are a nuisance to humans and provide low-value habitat for fish and other wildlife.

When plant abundance negatively affects the lake ecosystem and limits the use of the resource, plant management and control may be necessary. The management goals should always include the control of invasive species and restoration of native communities through environmentally sensitive and economically feasible methods. No aquatic plant management plan should only contain methods to control plants, they should also contain methods on how to protect and possibly enhance the important plant communities within the lake. Unfortunately, the latter is often neglected and the ecosystem suffers as a result.

Aquatic Plant Management and Protection

Many times an aquatic plant management plan is aimed at only controlling nuisance plant growth that has limited the recreational use of the lake, usually navigation, fishing, and swimming. It is important to remember the vital benefits that native aquatic plants provide to lake users and the lake ecosystem, as described above. Therefore, all aquatic plant management plans also need to address the enhancement and protection of the aquatic plant community. Below are general descriptions of the many techniques that can be utilized to control and enhance aquatic plants. Each alternative has benefits and limitations that are explained in its description. Please note that only legal and commonly used methods are included. For instance, the herbivorous grass carp (*Ctenopharyngodon idella*) is illegal in Wisconsin and rotovation, a process by which the lake bottom is tilled, is not a commonly accepted practice. Unfortunately, there are no "silver bullets" that can completely cure all aquatic plant problems, which makes planning a crucial step in any aquatic plant management activity. Many of the plant management and protection techniques commonly used in Wisconsin are described below.

Important Note:
Even though some of these techniques are not applicable to Lake George, it is still important for lake users to have a basic understanding of all the techniques so they can better understand why particular methods are or are not applicable in their lake. The techniques applicable to Lake George are discussed in Summary and Conclusions section and the Implementation Plan found near the end of this document.

Permits

The signing of the 2001-2003 State Budget by Gov. McCallum enacted many aquatic plant management regulations. The rules for the regulations have been set forth by the WDNR as NR 107 and 109. A major change includes that all forms of aquatic plant management, even those that did not require a permit in the past, require a permit now, including manual and mechanical removal. Manual cutting and raking are exempt from the permit requirement if the area of plant removal is no more than 30 feet wide and any piers, boatlifts, swim rafts, and other recreational and water use devices are located within that 30 feet. This action can be conducted up to 150 feet from shore. Please note that a permit is needed in all instances if wild rice is to be removed. Furthermore, installation of aquatic plants, even natives, requires approval from the WDNR.

Permits are required for chemical and mechanical manipulation of native and non-native plant communities. Large-scale protocols have been established for chemical treatment projects covering >10 acres or areas greater than 10% of the lake littoral zone and more than 150 feet from shore. Different protocols are to be followed for whole-lake scale treatments (≥160 acres or ≥50% of the lake littoral area). Additionally, it is important to note that local permits and U.S. Army Corps of Engineers regulations may also apply. For more information on permit requirements, please contact the WDNR Regional Water Management Specialist or Aquatic Plant Management and Protection Specialist.

Manual Removal

Manual removal methods include hand-pulling, raking, and hand-cutting. Hand-pulling involves the manual removal of whole plants, including roots, from the area of concern and disposing them out of the waterbody. Raking entails the removal of partial and whole plants from the lake by dragging a rake with a rope tied to it through plant beds. Specially designed rakes are available from commercial sources or an asphalt rake can be used. Hand-cutting differs from the other two manual methods because the entire plant is not removed, rather the plants are cut similar to mowing a lawn; however Wisconsin law states that all plant fragments must be removed. One manual cutting technique involves throwing a specialized "V" shaped cutter into the plant bed and retrieving it with a rope. The raking method entails the use of a two-sided straight blade on a telescoping pole that is swiped back and forth at the base of the undesired plants.

In addition to the hand-cutting methods described above, powered cutters are now available for mounting on boats. Some are mounted in a similar fashion to electric trolling motors and offer a 4-foot cutting width, while larger models require complicated mounting procedures, but offer an 8-foot cutting width. Please note that the use of powered cutters may require a mechanical harvesting permit to be issued by the WDNR.

When using the methods outlined above, it is very important to remove all plant fragments from the lake to prevent re-rooting and drifting onshore followed by decomposition. It is also important to preserve fish spawning habitat by timing the treatment activities after spawning. In Wisconsin, a general rule would be to not start these activities until after June 15th.

Cost

Commercially available hand-cutters and rakes range in cost from $85 to $150. Power-cutters range in cost from $1,200 to $11,000.

Advantages	*Disadvantages*
• Very cost effective for clearing areas around docks, piers, and swimming areas. • Relatively environmentally safe if treatment is conducted after June 15th. • Allows for selective removal of undesirable plant species. • Provides immediate relief in localized area. • Plant biomass is removed from waterbody.	• Labor intensive. • Impractical for larger areas or dense plant beds. • Subsequent treatments may be needed as plants recolonize and/or continue to grow. • Uprooting of plants stirs bottom sediments making it difficult to conduct action. • May disturb benthic organisms and fish-spawning areas. • Risk of spreading invasive species if fragments are not removed.

Bottom Screens

Bottom screens are very much like landscaping fabric used to block weed growth in flowerbeds. The gas-permeable screen is placed over the plant bed and anchored to the lake bottom by staking or weights. Only gas-permeable screen can be used or large pockets of gas will form under the mat as the result of plant decomposition. This could lead to portions of the screen becoming detached from the lake bottom, creating a navigational hazard. Normally the screens are removed and cleaned at the end of the growing season and then placed back in the lake the following spring. If they are not removed, sediments may build up on them and allow for plant colonization on top of the screen.

Cost
Material costs range between $.20 and $1.25 per square-foot. Installation cost can vary largely, but may roughly cost $750 to have 1,000 square feet of bottom screen installed. Maintenance costs can also vary, but an estimate for a waterfront lot is about $120 each year.

Advantages	***Disadvantages***
• Immediate and sustainable control. • Long-term costs are low. • Excellent for small areas and around obstructions. • Materials are reusable. • Prevents fragmentation and subsequent spread of plants to other areas.	• Installation may be difficult over dense plant beds and in deep water. • Not species specific. • Disrupts benthic fauna. • May be navigational hazard in shallow water. • Initial costs are high. • Labor intensive due to the seasonal removal and reinstallation requirements. • Does not remove plant biomass from lake. • Not practical in large-scale situations.

Water Level Drawdown

The primary manner of plant control through water level drawdown is the exposure of sediments and plant roots/tubers to desiccation and either heating or freezing depending on the timing of the treatment. Winter drawdowns are more common in temperate climates like that of Wisconsin and usually occur in reservoirs because of the ease of water removal through the outlet structure. An important fact to remember when considering the use of this technique is that only certain species are controlled and that some species may even be enhanced. Furthermore, the process will likely need to be repeated every two or three years to keep target species in check.

Cost
The cost of this alternative is highly variable. If an outlet structure exists, the cost of lowering the water level would be minimal; however, if there is not an outlet, the cost of pumping water to the desirable level could be very expensive. If a hydro-electric facility is operating on the system, the costs associated with loss of production during the drawdown also need to be considered, as they are likely cost prohibitive to conducting the management action.

Advantages	***Disadvantages***
• Inexpensive if outlet structure exists. • May control populations of certain species, like Eurasian water-milfoil for a few years. • Allows some loose sediment to consolidate, increasing water depth. • May enhance growth of desirable emergent species. • Other work, like dock and pier repair may be completed more easily and at a lower cost while water levels are down.	• May be cost prohibitive if pumping is required to lower water levels. • Has the potential to upset the lake ecosystem and have significant effects on fish and other aquatic wildlife. • Adjacent wetlands may be altered due to lower water levels. • Disrupts recreational, hydroelectric, irrigation and water supply uses. • May enhance the spread of certain undesirable species, like common reed and reed canary grass. • Permitting process may require an environmental assessment that may take months to prepare. • Non-selective.

Mechanical Harvesting

Aquatic plant harvesting is frequently used in Wisconsin and involves the cutting and removal of plants much like mowing and bagging a lawn. Harvesters are produced in many sizes that can cut to depths ranging from 3 to 6 feet with cutting widths of 4 to 10 feet. Plant harvesting speeds vary with the size of the harvester, density and types of plants, and the distance to the off-loading area. Equipment requirements do not end with the harvester. In addition to the harvester, a shore-conveyor would be required to transfer plant material from the harvester to a dump truck for transport to a landfill or compost site. Furthermore, if off-loading sites are limited and/or the lake is large, a transport barge may be needed to move the harvested plants from the harvester to the shore in order to cut back on the time that the harvester spends traveling to the shore conveyor. Some lake organizations contract to have nuisance plants harvested, while others choose to purchase their own equipment. If the latter route is chosen, it is especially important for the lake group to be very organized and realize that there is a great deal of work and expense involved with the purchase, operation, maintenance, and storage of an aquatic plant harvester. In either case, planning is very important to minimize environmental effects and maximize benefits.

Cost

Equipment costs vary with the size and features of the harvester, but in general, standard harvesters range between $45,000 and $100,000. Larger harvesters or stainless steel models may cost as much as $200,000. Shore conveyors cost approximately $20,000 and trailers range from $7,000 to $20,000. Storage, maintenance, insurance, and operator salaries vary greatly.

Advantages	*Disadvantages*
• Immediate results. • Plant biomass and associated nutrients are removed from the lake. • Select areas can be treated, leaving sensitive areas intact. • Plants are not completely removed and can still provide some habitat benefits. • Opening of cruise lanes can increase predator pressure and reduce stunted fish populations. • Removal of plant biomass can improve the oxygen balance in the littoral zone. • Harvested plant materials produce excellent compost.	• Initial costs and maintenance are high if the lake organization intends to own and operate the equipment. • Multiple treatments are likely required. • Many small fish, amphibians and invertebrates may be harvested along with plants. • There is little or no reduction in plant density with harvesting. • Invasive and exotic species may spread because of plant fragmentation associated with harvester operation. • Bottom sediments may be re-suspended leading to increased turbidity and water column nutrient levels.

Herbicide Treatment

The use of herbicides to control aquatic plants and algae is a technique that is widely used by lake managers. Traditionally, herbicides were used to control nuisance levels of aquatic plants and algae that interfere with navigation and recreation. While this practice still takes place in many parts of Wisconsin, the use of herbicides to control aquatic invasive species is becoming more prevalent. Resource managers employ strategic management techniques towards aquatic invasive species, with the objective of reducing the target plant's population over time; and an overarching goal of attaining long-term ecological restoration. For submergent vegetation, this largely consists of implementing control strategies early in the growing season; either as spatially-targeted, small-scale spot treatments or low-dose, large-scale (whole lake) treatments. Treatments occurring roughly each year before June 1 and/or when water temperatures are below 60°F can be less impactful to many native plants, which have not emerged yet at this time of year. Emergent species are targeted with foliar applications at strategic times of the year when the target plant is more likely to absorb the herbicide.

While there are approximately 300 herbicides registered for terrestrial use in the United States, only 13 active ingredients can be applied into or near aquatic systems. All aquatic herbicides must be applied in accordance with the product's US Environmental Protection Agency (EPA) approved label. There are numerous formulations and brands of aquatic herbicides and an extensive list can be found in Appendix F of Gettys et al. (2009).

Applying herbicides in the aquatic environment requires special considerations compared with terrestrial applications. WDNR administrative code states that a permit is required if "you are standing in socks and they get wet." In these situations, the herbicide application needs to be completed by an applicator licensed with the Wisconsin Department of Agriculture, Trade and Consumer Protection. All herbicide applications conducted under the ordinary high water mark require herbicides specifically labeled by the United States Environmental Protection Agency.

Aquatic herbicides can be classified in many ways. Organization of this section follows Netherland (2009) in which mode of action (i.e. how the herbicide works) and application techniques (i.e. foliar or submersed treatment) group the aquatic herbicides. The table below provides a general list of commonly used aquatic herbicides in Wisconsin and is synthesized from Netherland (2009).

The arguably clearest division amongst aquatic herbicides is their general mode of action and fall into two basic categories:

1. Contact herbicides act by causing extensive cellular damage, but usually do not affect the areas that were not in contact with the chemical. This allows them to work much faster, but in some plants does not result in a sustained effect because the root crowns, roots, or rhizomes are not killed.
2. Systemic herbicides act slower than contact herbicides, being transported throughout the entire plant and disrupting biochemical pathways which often result in complete mortality.

General Mode of Action		Compound	Specific Mode of Action	Most Common Target Species in Wisconsin
Contact		Copper	plant cell toxicant	Algae, including macro-algae (i.e. muskgrasses & stoneworts)
		Endothall	Inhibits respiration & protein synthesis	Submersed species, largely for curly-leaf pondweed; Eurasian water milfoil control when mixed with auxin herbicides
		Diquat	Inhibits photosynthesis & destroys cell membranes	Nusiance natives species including duckweeds, trageted AIS control when exposure times are low
Systemic	Auxin Mimics	2,4-D	auxin mimic, plant growth regulator	Submersed species, largely for Eurasian water milfoil
		Triclopyr	auxin mimic, plant growth regulator	Submersed species, largely for Eurasian water milfoil
	In Water Use Only	Fluridone	Inhibits plant specific enzyme, new growth bleached	Submersed species, largely for Eurasian water milfoil
	Enzyme Specific (ALS)	Penoxsulam	Inhibits plant-specific enzyme (ALS), new growth stunted	New to WI, potential for submergent and floating-leaf species
		Imazamox	Inhibits plant-specific enzyme (ALS), new growth stunted	New to WI, potential for submergent and floating-leaf species
	Enzyme Specific (foliar use only)	Glyphosate	Inhibits plant-specific enzyme (ALS)	Emergent species, including purple loosestrife
		Imazapyr	Inhibits plant-specific enzyme (EPSP)	Hardy emergent species, including common reed

Both types are commonly used throughout Wisconsin with varying degrees of success. The use of herbicides is potentially hazardous to both the applicator and the environment, so all lake organizations should seek consultation and/or services from professional applicators with training and experience in aquatic herbicide use.

Herbicides that target submersed plant species are directly applied to the water, either as a liquid or an encapsulated granular formulation. Factors such as water depth, water flow, treatment area size, and plant density work to reduce herbicide concentration within aquatic systems. Understanding concentration and exposure times are important considerations for aquatic herbicides. Successful control of the target plant is achieved when it is exposed to a lethal concentration of the herbicide for a specific duration of time. Much information has been gathered in recent years, largely as a result of an ongoing cooperative research project between the Wisconsin Department of Natural Resources, US Army Corps of Engineers Research and Development Center, and private consultants (including Onterra). This research couples quantitative aquatic plant monitoring with field-collected herbicide concentration data to evaluate efficacy and selectivity of control strategies implemented on a subset of Wisconsin lakes and flowages. Based on their preliminary findings, lake managers have adopted two main treatment strategies; 1) whole-lake treatments, and 2) spot treatments.

Spot treatments are a type of control strategy where the herbicide is applied to a specific area (treatment site) such that when it dilutes from that area, its concentrations are insufficient to cause significant affects outside of that area. Spot treatments typically rely on a short exposure time (often hours) to cause mortality and therefore are applied at a much higher herbicide concentration than whole-lake treatments. This has been the strategy historically used on most Wisconsin systems.

Whole-lake treatments are those where the herbicide is applied to specific sites, but when the herbicide reaches equilibrium within the entire volume of water (entire lake, lake basin, or within the epilimnion of the lake or lake basin); it is at a concentration that is sufficient to cause mortality to the target plant within that entire lake or basin. The application rate of a whole-lake treatment is dictated by the volume of water in which the herbicide will reach equilibrium. Because exposure time is so much longer, target herbicide levels for whole-lake treatments are significantly less than for spot treatments.

Cost
Herbicide application charges vary greatly between $400 and $1,500 per acre depending on the chemical used, who applies it, permitting procedures, and the size/depth of the treatment area.

Advantages	*Disadvantages*
• Herbicides are easily applied in restricted areas, like around docks and boatlifts. • Herbicides can target large areas all at once. • If certain chemicals are applied at the correct dosages and at the right time of year, they can selectively control certain invasive species, such as Eurasian water-milfoil. • Some herbicides can be used effectively in spot treatments. • Most herbicides are designed to target plant physiology and in general, have low toxicological effects on non-plant organisms (e.g. mammals, insects).	• All herbicide use carries some degree of human health and ecological risk due to toxicity. • Fast-acting herbicides may cause fishkills due to rapid plant decomposition if not applied correctly. • Many people adamantly object to the use of herbicides in the aquatic environment; therefore, all stakeholders should be included in the decision to use them. • Many aquatic herbicides are nonselective. • Some herbicides have a combination of use restrictions that must be followed after their application. • Overuse of same herbicide may lead to plant resistance to that herbicide.

Biological Controls

There are many insects, fish and pathogens within the United States that are used as biological controls for aquatic macrophytes. For instance, the herbivorous grass carp has been used for years in many states to control aquatic plants with some success and some failures. However, it is illegal to possess grass carp within Wisconsin because their use can create problems worse than the plants that they were used to control. Other states have also used insects to battle invasive plants, such as water hyacinth weevils (*Neochetina spp.*) and hydrilla stem weevil (*Bagous spp.*) to control water hyacinth (*Eichhornia crassipes*) and hydrilla (*Hydrilla verticillata)*, respectively. Fortunately, it is assumed that Wisconsin's climate is a bit harsh for these two invasive plants, so there is no need for either biocontrol insect.

However, Wisconsin, along with many other states, is currently experiencing the expansion of lakes infested with Eurasian water-milfoil and as a result has supported the experimentation and use of the milfoil weevil (*Euhrychiopsis lecontei*) within its lakes. The milfoil weevil is a native weevil that has shown promise in reducing Eurasian water-milfoil stands in Wisconsin, Washington, Vermont, and other states. Research is currently being conducted to discover the best situations for the use of the insect in battling Eurasian water milfoil. Currently the milfoil weevil is not a WDNR grant-eligible method of controlling Eurasian water milfoil.

Cost

Stocking with adult weevils costs about $1.20/weevil and they are usually stocked in lots of 1000 or more.

Advantages	***Disadvantages***
• Milfoil weevils occur naturally in Wisconsin. • Likely environmentally safe and little risk of unintended consequences.	• Stocking and monitoring costs are high. • This is an unproven and experimental treatment. • There is a chance that a large amount of money could be spent with little or no change in Eurasian water-milfoil density.

Wisconsin has approved the use of two species of leaf-eating beetles (*Galerucella calmariensis* and *G. pusilla*) to battle purple loosestrife. These beetles were imported from Europe and used as a biological control method for purple loosestrife. Many cooperators, such as county conservation departments or local UW-Extension locations, currently support large beetle rearing operations. Beetles are reared on live purple loosestrife plants growing in kiddy pools surrounded by insect netting. Beetles are collected with aspirators and then released onto the target wild population. For more information on beetle rearing, contact your local UW-Extension location.

In some instances, beetles may be collected from known locations (cella insectaries) or purchased through private sellers. Although no permits are required to purchase or release beetles within Wisconsin, application/authorization and release forms are required by the WDNR for tracking and monitoring purposes.

Cost

The cost of beetle release is very inexpensive, and in many cases is free.

Advantages	***Disadvantages***
• Extremely inexpensive control method. • Once released, considerably less effort than other control methods is required. • Augmenting populations many lead to long-term control.	• Although considered "safe," reservations about introducing one non-native species to control another exist. • Long range studies have not been completed on this technique.

Analysis of Current Aquatic Plant Data

Aquatic plants are an important element in every healthy lake. Changes in lake ecosystems are often first seen in the lake's plant community. Whether these changes are positive, such as variable water levels or negative, such as increased shoreland development or the introduction of an exotic species, the plant community will respond. Plant communities respond in a variety of ways. For example, there may be a loss of one or more species. Certain life forms, such as emergents or floating-leaf communities, may disappear from specific areas of the lake. A shift in plant dominance between species may also occur. With periodic monitoring and proper analysis, these changes are relatively easy to detect and provide very useful information for management decisions.

As described in more detail in the methods section, multiple aquatic plant surveys were completed on Lake George; the first looked strictly for the exotic plant, curly-leaf pondweed, while the others that followed assessed both native and non-native species. Combined, these surveys produce a great deal of information about the aquatic vegetation of the lake. These data are analyzed and presented in numerous ways; each is discussed in more detail below.

Primer on Data Analysis & Data Interpretation

Species List

The species list is simply a list of all of the species that were found within the lake, both exotic and native. The list also contains the life-form of each plant found, its scientific name, and its coefficient of conservatism. The latter is discussed in more detail below. Changes in this list over time, whether it is differences in total species present, gains and losses of individual species, or changes in life-forms that are present, can be an early indicator of changes in the health of the lake ecosystem.

Frequency of Occurrence

Frequency of occurrence describes how often a certain species is found within a lake. Obviously, all of the plants cannot be counted in a lake, so samples are collected from pre-determined areas. In the case of Lake George, plant samples were collected from plots laid out on a grid that covered the entire lake. Using the data collected from these plots, an estimate of occurrence of each plant species can be determined. In this section, two types of data are displayed: littoral frequency of occurrence and relative frequency of occurrence. Littoral frequency of occurrence is used to describe how often each species occurred in the plots that are less than the maximum depth of plant growth (littoral zone). Littoral frequency is displayed as a percentage. Relative frequency of occurrence uses the littoral frequency of occurrence for each species compared to the sum of the littoral frequency of occurrence from all species. These values are presented in percentages and if all of the values were added up, they would equal 100%. For example, if water lily had a relative frequency of 0.1 and we described that value as a percentage, it would mean that water lily made up 10% of the population.

In the end, this analysis indicates the species that dominate the plant community within the lake. Shifts in dominant plants over time may indicate disturbances in the ecosystem. For instance, low water levels over several years may increase the occurrence of emergent species while decreasing the occurrence of floating-leaf species. Introductions of invasive exotic species may result in major shifts as they crowd out native plants within the system.

Species Diversity and Richness

Species diversity is probably the most misused value in ecology because it is often confused with species richness. Species richness is simply the number of species found within a system or community. Although these values are related, they are far from the same because diversity also takes into account how evenly the species occur within the system. A lake with 25 species may not be more diverse than a lake with 10 if the first lake is highly dominated by one or two species and the second lake has a more even distribution.

A lake with high species diversity is much more stable than a lake with a low diversity. This is analogous to a diverse financial portfolio in that a diverse lake plant community can withstand environmental fluctuations much like a diverse portfolio can handle economic fluctuations. For example, a lake with a diverse plant community is much better suited to compete against exotic infestation than a lake with a lower diversity.

Simpson's diversity index is used to determine this diversity in a lake ecosystem. Simpson's diversity (1-D) is calculated as:

$$D = \sum (n/N)^2$$

where:
n = the total number of instances of a particular species
N = the total number of instances of all species and
D is a value between 0 and 1

A box plot or box-and-whisker diagram graphically shows data through five-number summaries: minimum, lower quartile, median, upper quartile, and maximum. Just as the median divides the data into upper and lower halves, quartiles further divide the data by calculating the median of each half of the dataset.

If a lake has a diversity index value of 0.90, it means that if two plants were randomly sampled from the lake there is a 90% probability that the two individuals would be of a different species. Between 2005 and 2009, WDNR Science Services conducted point-intercept surveys on 252 lakes within the state. In the absence of comparative data from Nichols (1999), the Simpson's Diversity Index values of the lakes within the WDNR Science Services dataset will be compared to Lake George. Comparisons will be displayed using boxplots that show median values and upper/lower quartiles of lakes in the same ecoregion (Water Quality section, Figure 3.1-2) and in the state. Please note for this parameter, the Northern Lakes and Forests Ecoregion data includes both natural and flowage lakes.

As previously stated, species diversity is not the same as species richness. One factor that influences species richness is the "development factor" of the shoreland. This is not the degree of human development or disturbance, but rather it is a value that attempts to describe the nature of the habitat a particular shoreland may hold. This value is referred to as the shoreland complexity. It specifically analyzes the characteristics of the shoreland and describes to what degree the lake shape deviates from a perfect circle. It is calculated as the ratio of lake perimeter to the circumference of a circle of area equal to that of the lake. A shoreland complexity value of 1.0 would indicate that the lake is a perfect circle. The further away the value gets from 1.0, the more the lake deviates from a perfect circle. As shoreland complexity increases, species richness increases, mainly because there are more habitat types, bays and back water areas sheltered from wind.

Floristic Quality Assessment

Floristic Quality Assessment (FQA) is used to evaluate the closeness of a lake's aquatic plant community to that of an undisturbed, or pristine, lake. The higher the floristic quality, the closer a lake is to an undisturbed system. FQA is an excellent tool for comparing individual lakes and the same lake over time. In this section, the floristic quality of Lake George will be compared to lakes in the same ecoregion and in the state (refer to the Water Quality Section, Figure 3.1-2).

> Ecoregions are areas related by similar climate, physiography, hydrology, vegetation and wildlife potential. Comparing ecosystems in the same ecoregion is sounder than comparing systems within manmade boundaries such as counties, towns, or states.

The floristic quality of a lake is calculated using its species richness and average species conservatism. As mentioned above, species richness is simply the number of species that occur in the lake, for this analysis, only native species are utilized. Average species conservatism utilizes the coefficient of conservatism values for each of those species in its calculation. A species coefficient of conservatism value indicates that species likelihood of being found in an undisturbed (pristine) system. The values range from one to ten. Species that are normally found in disturbed systems have lower coefficients, while species frequently found in pristine systems have higher values. For example, cattail, an invasive native species, has a value of 1, while common hard and softstem bulrush have values of 5, and Oakes pondweed, a sensitive and rare species, has a value of 10. On their own, the species richness and average conservatism values for a lake are useful in assessing a lake's plant community; however, the best assessment of the lake's plant community health is determined when the two values are used to calculate the lake's floristic quality. The floristic quality is calculated using the species richness and average conservatism value of the aquatic plant species that were solely encountered on the rake during the point-intercept survey and does not include incidental species or those encountered during other aquatic plan surveys.

Community Mapping

A key component of the aquatic plant survey is the creation of an aquatic plant community map. The map represents a snapshot of the important plant communities in the lake as they existed during the survey and is valuable in the development of the management plan and in comparisons with surveys completed in the future. A mapped community can consist of submergent, floating-leaf, or emergent plants, or a combination of these life-forms. Examples of submergent plants include wild celery and pondweeds; while emergents include cattails, bulrushes, and arrowheads, and floating-leaf species include white and yellow pond lilies. Emergents and floating-leaf communities lend themselves well to mapping because there are distinct boundaries between communities. Submergent species are often mixed throughout large areas of the lake and are seldom visible from the surface; therefore, mapping of submergent communities is more difficult and often impossible.

Exotic Plants

Because of their tendency to upset the natural balance of an aquatic ecosystem, exotic species are paid particular attention to during the aquatic plant surveys. Two exotics, curly-leaf pondweed and Eurasian water milfoil are the primary targets of this extra attention.

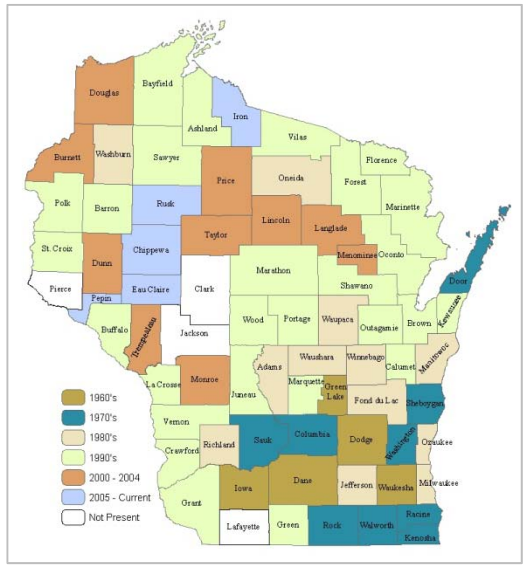

Figure 3.4-1. Spread of Eurasian water milfoil within WI counties. WDNR Data 2011 mapped by Onterra.

Eurasian water-milfoil is an invasive species, native to Europe, Asia and North Africa, that has spread to most Wisconsin counties (Figure 3.4-1). Eurasian water-milfoil is unique in that its primary mode of propagation is not by seed. It actually spreads by shoot fragmentation, which has supported its transport between lakes via boats and other equipment. In addition to its propagation method, Eurasian water-milfoil has two other competitive advantages over native aquatic plants, 1) it starts growing very early in the spring when water temperatures are too cold for most native plants to grow, and 2) once its stems reach the water surface, it does not stop growing like most native plants, instead it continues to grow along the surface creating a canopy that blocks light from reaching native plants. Eurasian water-milfoil can create dense stands and dominate submergent communities, reducing important natural habitat for fish and other wildlife, and impeding recreational activities such as swimming, fishing, and boating.

Curly-leaf pondweed is a European exotic first discovered in Wisconsin in the early 1900's that has an unconventional lifecycle giving it a competitive advantage over our native plants. Curly – leaf pondweed begins growing almost immediately after ice-out and by mid-June is at peak biomass. While it is growing, each plant produces many turions (asexual reproductive shoots) along its stem. By mid-July most of the plants have senesced, or died-back, leaving the turions in the sediment. The turions lie dormant until fall when they germinate to produce winter foliage, which thrives under the winter snow and ice. It remains in this state until spring foliage is produced in early May, giving the plant a significant jump on native vegetation. Like Eurasian water-milfoil, curly-leaf pondweed can become so abundant that it hampers recreational activities within the lake. Furthermore, its mid-summer die back can cause algal blooms spurred from the nutrients released during the plant's decomposition.

Because of its odd life-cycle, a special survey is conducted early in the growing season to inventory and map curly-leaf pondweed occurrence within the lake. Although Eurasian water milfoil starts to grow earlier than our native plants, it is at peak biomass during most of the summer, so it is inventoried during the comprehensive aquatic plant survey completed in mid to late summer.

Aquatic Plant Survey Results

As mentioned earlier, numerous aquatic plant surveys were completed as a part of this project. On May 31, 2012, an early-season aquatic invasive species (AIS) survey was completed on Lake George. While the intent of this survey is to locate any potential non-native species within the lake, it's primarily focused on locating any occurrences of curly-leaf pondweed which should be at or near its peak growth at this time. During this meander-based survey of the littoral zone, Onterra ecologists did not locate any occurrences of curly-leaf pondweed or any other non-native aquatic plant species.

The comprehensive aquatic plant point-intercept and aquatic plant community mapping surveys were conducted on Lake George on June 28 and August 8, 2012, respectively, by Onterra (data may be found in Appendix E). During these surveys, 42 species of aquatic plants were located in Lake George, none of which are considered to be non-native species (Table 3.4-1). One species, Vasey's pondweed (*Potamogeton vaseyi*), is listed by the Wisconsin Natural Heritage Inventory as a species of special concern in Wisconsin due to uncertainty regarding its distribution and abundance in Wisconsin. Many of these species have been found previously in the lake by LGLA volunteers through their AIS Monitoring Days program. As a part of this program, Lake George home owners collect aquatic plants near their property and work with WDNR officials to determine if the plants are native or non-native. The program is highly successful in that it not only provides inspection of the lake for aquatic invasive species, but educates residents on the diversity of native plants that Lake George holds.

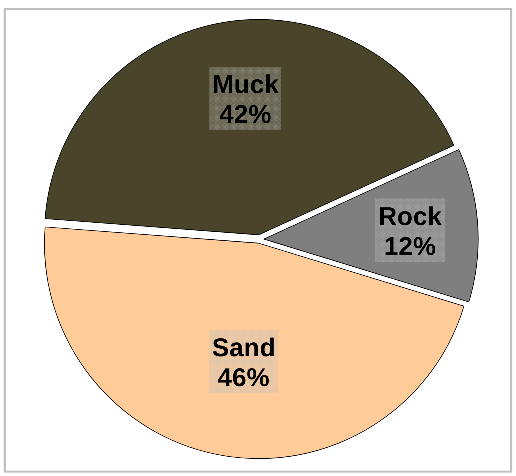

Figure 3.4-2. Lake George proportion of substrate types within littoral areas. Created using data from 2012 point-intercept survey.

As discussed in the previous section, sediment data was collected at each sampling location during the point-intercept survey. The data gathered shows that Lake George's littoral area is comprised of almost equal parts sand (46%) and fine organic sediments (42%), or muck. Areas dominated by rocks accounted for approximately 12% of the point-intercept sampling locations (Figure 3.4-2 and Map 5.). Most of the point-intercept locations that contained sand and rock were located in shallower, near-shore areas, while areas with muck were generally found within deeper areas of the littoral zone. Like terrestrial plants, different aquatic plant species are adapted to grow in certain substrate types; some species are only found growing in mucky substrates, others only in sandy areas, and some can be found growing in either. Lakes that have varying substrate types generally support a higher number of plant species because the different habitat types that are available.

Table 3.4-1. Aquatic plant species located in Lake George during summer 2012 surveys.

Life Form	Scientific Name	Common Name	Coefficient of Conservatism (c)	2012 (Onterra)
Emergent	*Bolboschoenus fluviatilis*	River bulrush	5	I
	Carex lasiocarpa	Wooly-fruit sedge	9	I
	Dulichium arundinaceum	Three-way sedge	9	X
	Eleocharis palustris	Creeping spikerush	6	X
	Equisetum fluviatile	Water horsetail	7	X
	Pontederia cordata	Pickerelweed	9	X
	Sagittaria latifolia	Common arrowhead	3	I
	Schoenoplectus acutus	Hardstem bulrush	5	X
	Scirpus cyperinus	Wool grass	4	I
	Typha spp.	Cattail spp.	1	I
FL	*Brasenia schreberi*	Watershield	7	X
	Nuphar variegata	Spatterdock	6	X
	Nymphaea odorata	White water lily	6	X
	Polygonum amphibium	Water smartweed	5	I
FL/E	*Sparganium eurycarpum*	Common bur-reed	5	I
	Sparganium fluctuans	Floating-leaf bur-reed	10	X
Submergent	*Bidens beckii*	Water marigold	8	X
	Ceratophyllum demersum	Coontail	3	X
	Ceratophyllum echinatum	Spiny hornwort	10	X
	Elodea canadensis	Common waterweed	3	X
	Elodea nuttallii	Slender waterweed	7	X
	Eriocaulon aquaticum	Pipewort	9	X
	Isoetes spp.	Quillwort species	8	I
	Myriophyllum tenellum	Dwarf water milfoil	10	X
	Najas flexilis	Slender naiad	6	X
	Nitella spp.	Stoneworts	7	X
	Potamogeton amplifolius	Large-leaf pondweed	7	X
	Potamogeton epihydrus	Ribbon-leaf pondweed	8	X
	Potamogeton gramineus	Variable pondweed	7	X
	Potamogeton natans	Floating-leaf pondweed	5	X
	Potamogeton praelongus	White-stem pondweed	8	X
	Potamogeton pusillus	Small pondweed	7	X
	Potamogeton richardsonii	Clasping-leaf pondweed	5	X
	Potamogeton robbinsii	Fern pondweed	8	X
	Potamogeton spirillus	Spiral-fruited pondweed	8	X
	*Potamogeton vaseyi**	Vasey's pondweed	10	X
	Potamogeton zosteriformis	Flat-stem pondweed	6	X
	Utricularia vulgaris	Common bladderwort	7	X
	Vallisneria americana	Wild celery	6	X
S/E	*Eleocharis acicularis*	Needle spikerush	5	X
	Sagittaria cristata	Crested arrowhead	9	X
FF	*Lemna turionifera*	Turion duckweed	2	X

FL = Floating Leaf; FL/E = Floating Leaf and Emergent; S/E = Submergent and Emergent; FF = Free Floating
X = Located on rake during point-intercept survey; I = Incidental Species
** = Species listed as 'special concern' in Wisconsin*

During the 2012 point-intercept survey, aquatic plants were found growing to a maximum depth of 11 feet. As was discussed within the Water Quality Section, the water in Lake George is heavily stained with dissolved organic compounds which limit the depth to which sunlight can penetrate. Thus, the growth of aquatic plants in Lake George is restricted to shallower areas where they can receive enough light to photosynthesize. Of the 299 point-intercept sampling locations that fell at or below the maximum depth of plant growth, 45% contained aquatic vegetation. Map 6 illustrates that the growth of aquatic vegetation is restricted to near-shore areas, and the majority occurs along the northeastern, eastern, and southeastern shores.

Of the 34 aquatic plant species located on the rake during the 2012 point-intercept survey, wild celery, stoneworts, and slender naiad were the three-most frequently encountered (Figure 3.4-3). Wild celery, or tape grass, has bundles of long submersed leaves that are flat and ribbon-like which emerge from a basil rosette and provide excellent structural habitat for aquatic organisms. Spreading rapidly via rhizomes, wild celery is often found growing in large colonies where their extensive root systems stabilize bottom sediments. In mid to late summer, the coiled flower stalks of wild celery can be observed at or near the surface, and following pollination, large banana-shaped seed pods can also be seen. These seed pods have been shown to be an important food source for waterfowl.

Stoneworts, the second-most frequently encountered aquatic plant in Lake George, are actually a genus of macroalgae. The stems and branches of these plants are often bright green and semi-transparent. These plants were found growing in large beds along the bottom in Lake George, where they are not likely seen from the surface. The fine, whorled branches of stoneworts provide excellent habitat for aquatic invertebrates and provide foraging and cover areas for fish. Slender naiad, the third-most common plant in Lake George, is one of three native naiad species that can be found in Wisconsin, and has whorls of fine leaves providing habitat for aquatic organisms. Slender naiad is an annual, and produces a high number of seeds on an annual basis which are important sources of food for a number of wildlife.

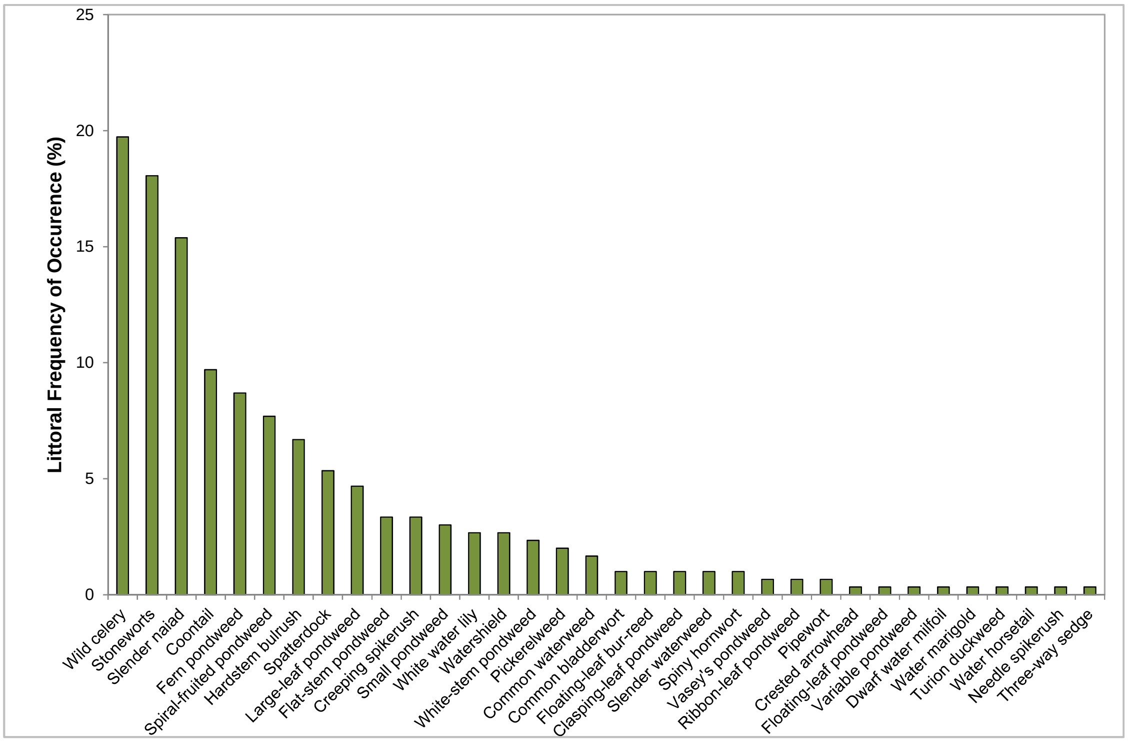

Figure 3.4-3. Lake George aquatic plant littoral frequency of occurrence. Created using data from 2012 point-intercept survey.

As mentioned earlier, a species listed as special concern in Wisconsin (Vasey's pondweed) was located at two point-intercept sampling locations in Lake George during the 2012 survey. This species is of special interest because it is relatively rare and its population and distribution in Wisconsin is not well known. The locations of Vasey's pondweed are currently being tracked by the Wisconsin Natural Heritage Inventory to determine if it requires further listing as either threatened or endangered. Vasey's pondweed has very fine and slender leaves which alternate on the stem (Photo 3.4-1). Upon reaching the surface, the plant produces small oval-shaped floating-leaves which aid in holding the flower stalk above the surface.


Photo 3.4-1. Vasey's pondweed (*Potamogeton vaseyi*). Pictures include entire plant (left) and close-up of floating-leaves and flower stalks (right).

While only the three-most frequently encountered species in Lake George were discussed, all of the native aquatic plant species encountered on the rake in 2012 are used in calculating Lake George's Floristic Quality Index (FQI). These calculations do not include species that were located "incidentally" during the 2012 surveys. For example, while a total of 42 aquatic plant species were located in Lake George during the 2012 surveys, 34 were physically encountered on the rake during the point-intercept survey. These native species encountered on the rake and their conservatism values were used to calculate the FQI of Lake George's aquatic plant community (equation shown below).

$$FQI = \text{Average Coefficient of Conservatism} * \sqrt{\text{Number of Native Species}}$$

Figure 3.4-4 compares the FQI components from Lake George calculated from the 2012 point-intercept survey to median values of lakes within the Northern Lakes and Forest Lakes (NLFL) Ecoregion as well as to lakes within the entire State of Wisconsin. As displayed in Figure 3.4-4, the native species richness (34) greatly surpasses the upper quartile of 20 for lakes in the ecoregion and the state. The aquatic plant community's average conservatism value (6.9) falls within the 75th percentile for lakes within the ecoregion and the state, and indicates that Lake George contains a higher number of sensitive aquatic plant species, or species that are not tolerant of environmental degradation. Combining Lake George's native species richness and average conservatism values yields an exceptionally high value of 40.5, greatly exceeding upper quartile values for lakes within the ecoregion and the state. The FQI analysis indicates that Lake George's aquatic plant community is of higher quality than the majority of lakes within the Northern Lakes and Forests Ecoregion and lakes throughout the State of Wisconsin.

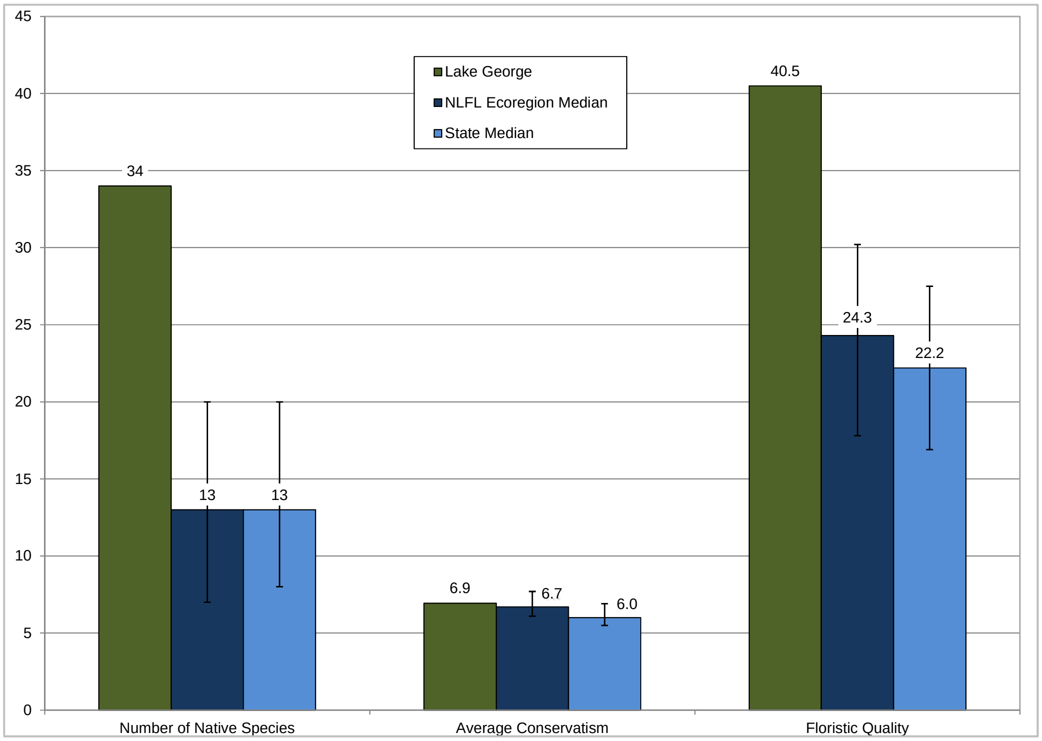

Figure 3.4-4. Lake George Floristic Quality Assessment. Created using data from 2012 point-intercept survey. Analysis following Nichols (1999) where NLFL = Northern Lakes and Forest Lakes Ecoregion. Error bars display 25th and 75th percentiles for regional and state data.

The high number of native aquatic plant species present in Lake George is surprising given the relatively small size of the lake's littoral area. However, as previously discussed, the variable substrate types within the littoral zone (sand, muck, and rock) provide differing habitat types that support a different composition of plant species. In addition, Lake George has high shoreline complexity. Shoreline complexity is an index that relates the area of the lake to the perimeter of its shoreline. If a lake were a perfect circle, its shoreline complexity value would be 1. The farther a lake deviates from a perfect circle, the higher its shoreline complexity value is. Lakes with higher shoreline complexity have more backwater areas that are sheltered from wind and wave action creating different habitats for aquatic plants. Lake George's high shoreline complexity (4.25) in combination with varying substrate types creates species-rich aquatic plant community.

As explained earlier, lakes with diverse aquatic plant communities have higher resilience to environmental disturbances and greater resistance to invasion by non-native plants. In addition, a plant community with a mosaic of species with differing morphological attributes provides zooplankton, macroinvertebrates, fish, and other wildlife with diverse structural habitat and various sources of food. Because Lake George contains a high number of native aquatic plant species, one may assume the aquatic plant community also has high species diversity. However, species diversity is also influenced by how evenly the plant species are distributed within the community.

While a method for characterizing diversity values of fair, poor, etc. does not exist, lakes within the same ecoregion may be compared to provide an idea of how Lake George's diversity value ranks. Using data obtained from WDNR Science Services, quartiles were calculated for 109 lakes within the NLFL Ecoregion (Figure 3.4-5). Using the data collected from the 2012 point-intercept survey, Lake George's aquatic plant community was shown to have exceptionally high species diversity with a Simpson's diversity value of 0.92. In other words, if two aquatic plants were randomly sampled from two different locations in Lake George, there would be a 92% probability that they would be of different species. This diversity value falls above the upper quartile for the lakes within the northern region and the state (Figure 3.4-5).

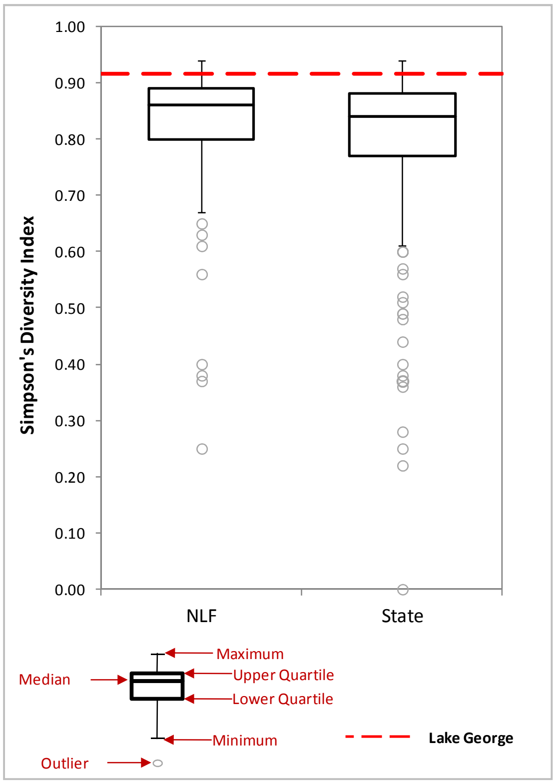

Figure 3.4-5. Lake George species diversity index. Created using data from 2012 aquatic plant surveys. Ecoregion data provided by WDNR Science Services.

Figure 3.4-6 displays the relative frequency of occurrence of aquatic plant species in Lake George from the 2012 point-intercept survey and illustrates relative abundance of species within the community to one another. If the aquatic plant community is dominated by a single or few species, there is a less-diverse plant community.

The diversity and quality of Lake George's aquatic plant community is also bolstered by its high-quality floating-leaf and emergent aquatic plant communities that occur in shallow, near-shore areas around the lake. The 2012 community map indicates that approximately 33 acres (7.5%) of the 442-acre lake contain these types of plant communities (Table 3.4-2 and Map 7). Sixteen floating-leaf and emergent species were located in Lake George (Table 3.4-1), which provide valuable structural habitat for invertebrates, fish, and other wildlife. These communities also stabilize bottom sediments and shoreline areas by dampening wave action from wind and watercraft. In this manner, they provide different benefits to a lake ecosystem than submergent plants and should be protected.

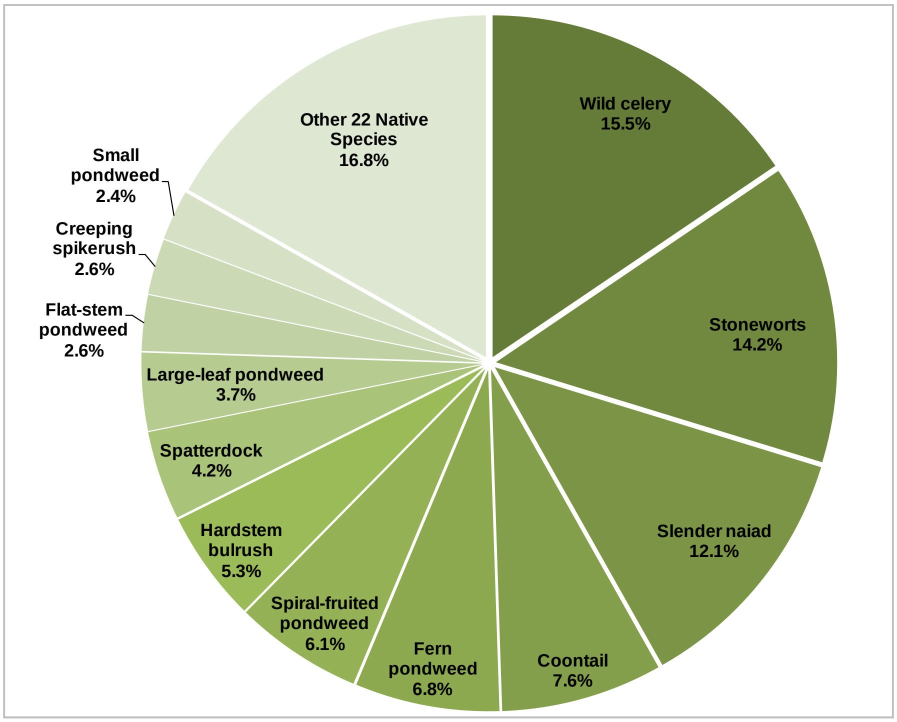

Figure 3.4-6. Lake George relative plant littoral frequency of occurrence. Created using data from 2012 surveys.

Table 3.4-2. Lake George acres of floating-leaf and emergent aquatic plant communities. Created from August 2012 community mapping survey.

Plant Community	Acres
Floating-leaf	12.8
Emergent	17.5
Mixed Floating-leaf & Emergent	2.8
Total	**33.1**

Because the community map represents a 'snapshot' of the important emergent and floating-leaf plant communities, a replication of this survey in the future will provide a valuable understanding of the dynamics of these communities within Lake George. This is important because these communities are often negatively affected by recreational use and shoreland development. Radomski and Goeman (2001) found a 66% reduction in vegetation coverage on developed shorelines when compared to the undeveloped shorelines in Minnesota lakes. Furthermore, they also found a significant reduction in abundance and size of northern pike (*Esox lucius*), bluegill (*Lepomis macrochirus*), and pumpkinseed (*Lepomis gibbosus*) associated with these developed shorelines.

3.5 Fisheries Data Integration

Fishery management is an important aspect in the comprehensive management of a lake ecosystem; therefore, a brief summary of available data is included here as reference. The following section is not intended to be a comprehensive plan for the lake's fishery, as those aspects are currently being conducted by the numerous fisheries biologists overseeing Lake George. The goal of this section is to provide an overview of some of the data that exists, particularly in regards to specific issues (e.g. spear fishery, fish stocking, angling regulations, etc) that were brought forth by the LGLA stakeholders within the stakeholder survey and other planning activities. Although current fish data were not collected, the following information was compiled based upon data available from the WDNR and the Great Lakes Indian Fish and Wildlife Commission (GLIFWC) (WDNR 2012 & GLIFWC 2012A and 2012B).

Lake George Fishery

Lake George Fishing Activity

Based on data collected from the stakeholder survey (Appendix B), fishing was the second highest ranked important or enjoyable activity on Lake George (Question #13). 73% of all survey respondents indicated that they have fished Lake George recently (Question #8). Walleye, crappie and bluegill/sunfish are the species Lake George anglers prefer to catch most (Question #9). Approximately 77% of these respondents believed that the quality of fishing on the lake was either fair or poor (Question #10). When asked how the fishing has changed since they first started fishing the lake, 42% indicated they believed the fishing had *Remained the same*, while 39% indicated that they believe the quality of fishing has gotten *Much worse* or *Somewhat worse* (Question #11).

Table 3.5-1 shows the popular game fish that are present in the system. When examining the fishery of a lake, it is important to remember what drives that fishery, or what is responsible for determining its mass and composition. The gamefish in Lake George are supported by an underlying food chain. At the bottom of this food chain are the elements that fuel algae and plant growth – nutrients such as phosphorus and nitrogen, and sunlight. The next tier in the food chain belongs to zooplankton, which are tiny crustaceans that feed upon algae and plants, and insects. Smaller fish called planktivores feed upon zooplankton and insects, and in turn become food for larger fish species. The species at the top of the food chain are called piscivores, and are the larger gamefish that are often sought after by anglers, such as bass and walleye.

Table 3.5-1. Gamefish present in the Lake George with corresponding biological information (Becker, 1983)**.**

Common Name	Scientific Name	Max Age (yrs)	Spawning Period	Spawning Habitat Requirements	Food Source
Black Bullhead	*Ictalurus melas*	5	April - June	Matted vegetation, woody debris, overhanging banks	Amphipods, insect larvae and adults, fish, detritus, algae
Black Crappie	*Pomoxis nigromaculatus*	7	May - June	Near *Chara* or other vegetation, over sand or fine gravel	Fish, cladocera, insect larvae, other invertebrates
Bluegill	*Lepomis macrochirus*	11	Late May - Early August	Shallow water with sand or gravel bottom	Fish, crayfish, aquatic insects and other invertebrates
Largemouth Bass	*Micropterus salmoides*	13	Late April - Early July	Shallow, quiet bays with emergent vegetation	Fish, amphipods, algae, crayfish and other invertebrates
Muskellunge	*Esox masquinongy*	30	Mid April - Mid May	Shallow bays over muck bottom with dead vegetation, 6 - 30 in.	Fish including other muskies, small mammals, shore birds, frogs
Northern Pike	*Esox lucius*	25	Late March - Early April	Shallow, flooded marshes with emergent vegetation with fine leaves	Fish including other pike, crayfish, small mammals, water fowl, frogs
Pumpkinseed	*Lepomis gibbosus*	12	Early May - August	Shallow warm bays 0.3 - 0.8 m, with sand or gravel bottom	Crustaceans, rotifers, mollusks, flatworms, insect larvae (terrestrial and aquatic)
Rock Bass	*Ambloplites rupestris*	13	Late May - Early June	Bottom of course sand or gravel, 1 cm - 1 m deep	Crustaceans, insect larvae, and other invertebrates
Smallmouth Bass	*Micropterus dolomieu*	13	Mid May - June	Nests more common on north and west shorelines over gravel	Small fish including other bass, crayfish, insects (aquatic and terrestrial)
Walleye	*Sander vitreus*	18	Mid April - early May	Rocky, wavewashed shallows, inlet streams on gravel bottoms	Fish, fly and other insect larvae, crayfish
Yellow Perch	*Perca flavescens*	13	April - Early May	Sheltered areas, emergent and submergent veg	Small fish, aquatic invertebrates

A concept called energy flow describes how the biomass of piscivores is determined within a lake. Because algae and plant matter are generally small in energy content, it takes an incredible amount of this food type to support a sufficient biomass of zooplankton and insects. In turn, it takes a large biomass of zooplankton and insects to support planktivorous fish species. And finally, there must be a large planktivorous fish community to support a modest piscovorous fish community. Studies have shown that in natural ecosystems, it is largely the amount of primary productivity (algae and plant matter) that drives the rest of the producers and consumers in the aquatic food chain. This relationship is illustrated in Figure 3.5-1.

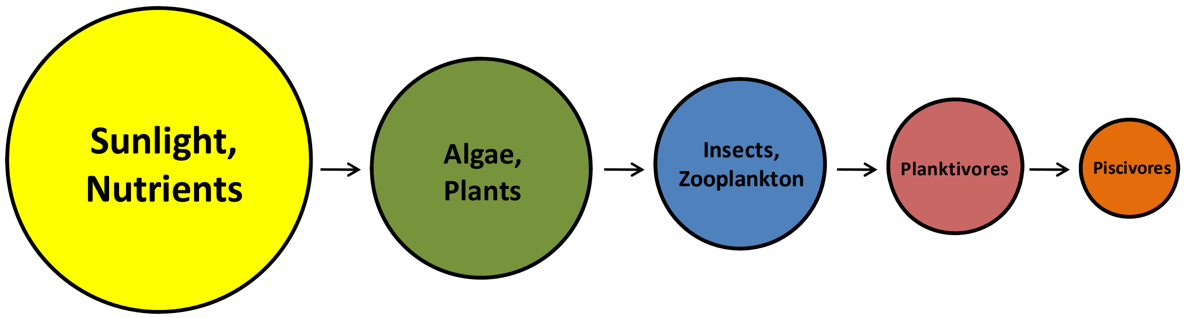

Figure 3.5-1. Aquatic food chain. Adapted from Carpenter et. al 1985.

As discussed in the Water Quality section, Lake George is a eutrophic system, meaning it has high nutrient content and thus relatively high primary productivity. Simply put, this means Lake George should be able to support sizable populations of predatory fish (piscivores) because the supporting food chain is relatively robust.

Lake George Spear Harvest Records

Approximately 22,400 square miles of northern Wisconsin was ceded to the United States by the Lake Superior Chippewa tribes in 1837 and 1842 (Figure 3.5-2). Lake George falls within the ceded territory based on the Treaty of 1837. This allows for a regulated open water spear fishery by Native Americans on specified systems. This highly structured process begins with an annual meeting between tribal and state management authorities. Reviews of population estimates are made for ceded territory lakes, and then a "total allowable catch" is established, based upon estimates of a sustainable harvest of the fishing stock (age 3 to age 5 fish). This figure is usually about 35% (walleye) or 27% (muskellunge) of the lake's known or modeled population, but may vary on an individual lake basis due

Figure 3.5-2. Location of Lake George within the Native American Ceded Territory (GLIFWC 2012A). This map was digitized by Onterra; therefore it is a representation and not legally binding.

to other circumstances. In lakes where population estimates are out of date by 3 years, a standard percentage is used. The total allowable catch number is then reduced by a percentage agreed upon by biologists that reflects the confidence they have in their population estimates for the particular lake. This number is called the "safe harvest level". The safe harvest is a conservative estimate of the number of fish that can be harvested by a combination of tribal spearing and state-licensed anglers. The safe harvest is then multiplied by the Indian communities claim percent. This result is called the declaration, and represents the maximum number of fish that can be taken by tribal spearers (Spangler, 2009). Daily bag limits for walleye are then reduced for hook-and-line anglers to accommodate the tribal declaration and prevent over-fishing. Bag limits reductions may be increased at the end of May on lakes that are lightly speared. The tribes have historically selected a percentage which allows for a 2-3 daily bag limit for hook-and-line anglers (USDI 2007).

Spearers are able to harvest muskellunge, walleye, northern pike, and bass during the open water season. The spear harvest is monitored through a nightly permit system and a complete monitoring of the harvest (GLIFWC 2010B). Creel clerks and tribal wardens are assigned to each lake at the designated boat landing. A catch report is completed for each boating party upon return to the boat landing. In addition to counting every fish harvested, the first 100 walleye (plus all those in the last boat) are measured and sexed. An updated nightly declaration is determined each morning by 9 a.m. based on the data collected from the successful spearers. Harvest of a particular species ends once the declaration is met or the season ends. In 2011, a new reporting requirement went into effect on lakes with smaller declarations. Starting with the 2011 spear harvest season, on lakes with a harvestable declaration of 75 or fewer fish, reporting of harvests may take place at a location other than the landing of the speared lake.

Records indicate that the Lac du Flambeau and Mole Lake tribes have harvested both walleye and muskellunge from Lake George since 1999 through this open water spearing. Walleye comprise the vast majority of this harvest; data from 1993 are provided in Figure 3.5-3. One common misconception is that the spear harvest targets the large spawning females. Figure 3.5-3 clearly shows that the opposite is true with only 6.7% of the total walleye harvest (85 fish) since 1999 comprising of female fish on Lake George. Tribal spearers may only take two walleyes over twenty inches per nightly permit; one between 20 and 24 inches and one of any size over 20 inches (GLIWC 2012B). This regulation limits the harvest of the larger, spawning female walleye.

Table 3.5-2 displays the Native American open water muskellunge spear harvest since 1996. The harvests have been minimal for this species in most years; nine muskellunge have been harvested between 1996 and 2011. The largest harvest came in 2010, when three muskellunge were harvested.

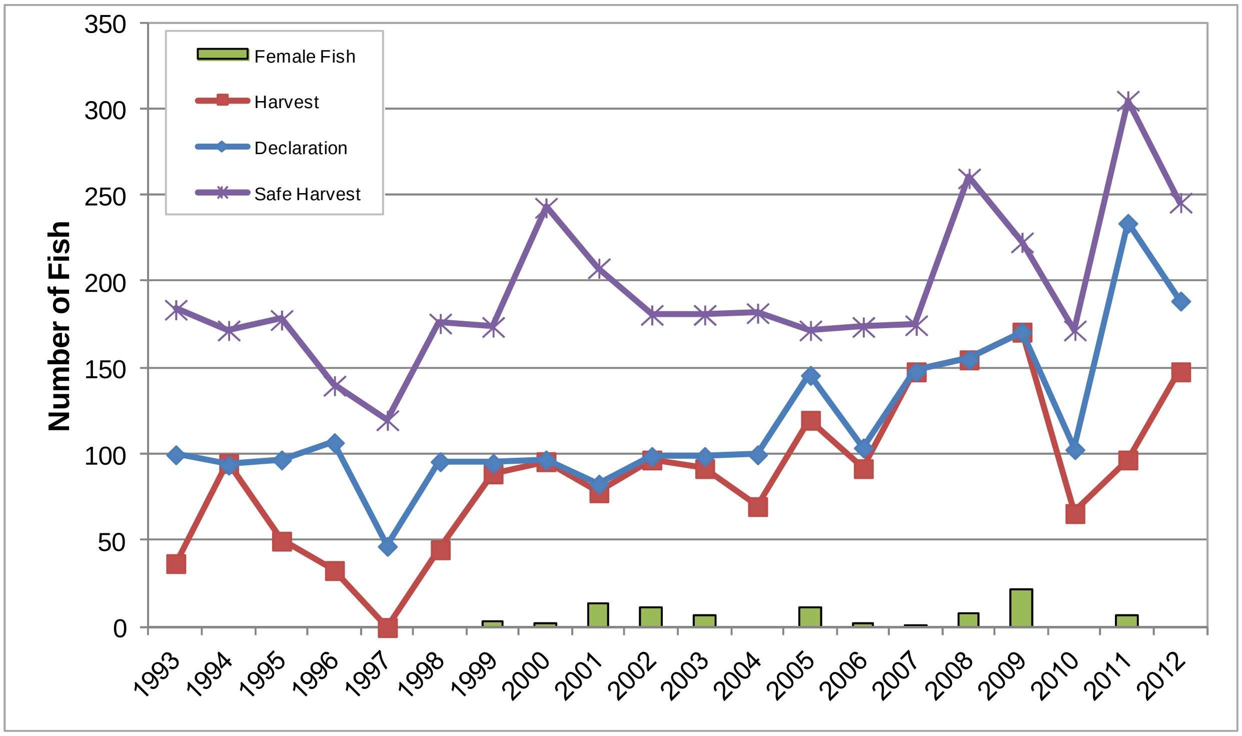

Figure 3.5-3. Lake George open water walleye spear harvest data. Annual safe harvest, tribal declaration and actual walleye harvest are displayed since 1993 from GLIFWC annual reports for Lake George (Krueger 1998-2011) and WDNR datasets (T. Cichosz, personal communication).

Table 3.5-2. Lake George open water muskellunge spear harvest data. (T. Cichosz, personal communication).

Year	Safe Harvest	Tribal Declaration	Total Harvest
1996	*n/a*	*n/a*	1
1997	*n/a*	*n/a*	-
1998	*n/a*	*n/a*	-
1999	11	5	1
2000	10	5	-
2001	10	5	1
2002	10	5	-
2003	11	5	-
2004	11	5	1
2005	11	6	1
2006	11	6	-
2007	11	6	-
2008	12	7	-
2009	12	7	-
2010	12	7	3
2011	12	7	1
2012	20	11	-

Lake George Creel Surveys

Periodically, the WDNR will conduct creel surveys on Wisconsin lakes to gather information on the fishery. Creel surveys are a series of short, informal interviews with fisherman and are conducted right on the lake of interest. They provide valuable information on sport angler activities and their impacts on the fish populations of a waterbody. From this data, fisheries managers can determine trends in total catch and harvest for the lake, and also estimate the number of hours it takes anglers to catch a particular species of fish.

Creel surveys have been conducted in 1995, 1999 and 2010 on Lake George. Table 3.5-3 indicates the total angler effort (total hours anglers spent fishing), the directed effort (total hours spent fishing for a certain species) catch, and harvest. These values are depicted in units per acre, which is a standardized way of describing this type of data. In 2010, anglers spent 22,288 hours (51.2 hours/acre) fishing Lake George. This is more than the Oneida County average of 37.6 hours/acre, and the statewide average of 33.6 hours/acre. Walleye are commonly sought after in Lake George, as are muskellunge and northern pike. A 2011 WDNR creel survey publication includes additional data for panfish and other species not reported within this report.

Table 3.5-3. Lake George WDNR Creel Survey Summary (WDNR 2012)

Species	Year	Total Angler Effort / Acre (Hours)	Directed Effort / Acre (Hours)	Catch / Acre	Harvest / Acre
Largemouth Bass	1995	59.2	2.3	0.2	0
	1999	57.8	2.5	0.2	0
	2010	51.2	3.5	0.4	0
Muskellunge	1995	59.2	12.6	0.5	0
	1999	57.8	10.4	0.2	0
	2010	51.2	11	0.7	0
Northern Pike	1995	59.2	21.7	6.3	0.2
	1999	57.8	10.8	5	0.9
	2010	51.2	8.3	1.1	0.3
Smallmouth Bass	1995	59.2	2.1	0.2	0
	1999	57.8	2.4	0.6	0
	2010	51.2	6.2	1.8	0.1
Walleye	1995	59.2	20.9	5.1	0.1
	1999	57.8	24.5	4.1	1.7
	2010	51.2	13.6	2.6	1.1

Lake George Walleye Population Estimates

As part of routine studies conducted on Ceded Territory Lakes, the WDNR will conduct surveys aimed at estimating the population of gamefish species. The mark-recapture methodology is commonly used for this type of study. Fish are collected through a number of sampling means, either in nets or by electro-shocking technology. The fish are collected and marked, typically by clipping a small portion off of one of the fins, and then released. Upon visiting the lake later on, more fish are collected and the number of marked individuals are counted. An estimate of the total population size can be obtained by applying mathematical concepts to the data collected. These estimates are used to determine the health of the lake's fishery, in addition to helping managers decide how to adjust open water spear and angling harvest limits or regulations for an individual lake.

Lake George has been visited numerous times by WDNR researchers to conduct population estimate studies. A summary for 1995, 1999 and 2010 walleye estimates is provided in Table 3.5-4, while a comprehensive report including other species sampled in 2010 is attached as Appendix F.

Table 3.5-4. Lake George WDNR walleye population estimates (WDNR 2012)

Year	Population Estimate	Walleye/Acre
1995	1,144	2.6
1999	1,981	4.6
2010	2,127	4.9

Because of the intensive efforts by the WDNR and GLIFWC in studying the fishery of Lake George, a wealth of information has been collected. As explained above, this helps managers determine regulations for the waterbody in terms of setting the safe harvest and quotas for tribal spearing, as well as setting hook and line angler bag and length limits on an annual basis. It allows for some general comparisons to be made regarding the activity on the lake.

Fisheries biologists use the term exploitation rate to describe the harvest that occurs with the adult population of a species. Tribal exploitation rates are determined by dividing the total tribal walleye harvest (all adult fish) by the estimated adult walleye population. Angler exploitation rates of adult fish are a little more complicated to assess. During years in which WDNR population estimates are made, creel survey studies are also typically conducted. Fish captured during population estimate surveys are given a mark, usually in the form of a fin clip, and are then released. When creel survey clerks interview anglers on the lake, they are able to estimate the number of marked fish that are recaptured. This allows biologists to calculate the angler exploitation rate of adult fish; this is done by dividing the estimated number of marked fish harvested by the total number of marked fish present in the lake. Essentially, this allows for a comparable exploitation rate to be made for tribal and angler harvest.

Figure 3.5-4 summarizes adult walleye exploitation rate data that have been calculated by the WDNR for Lake George. These data suggest that although both anglers and tribal members harvest walleye from the lake, the angler harvest is usually more significant on an annual basis. Tribal exploitation rates are very consistent during these three years (between ~3% and ~4.2%), while in 1995 the angler exploitation rate was considerably lower than in 1999 and 2010. WDNR biologist John Kubisiak stated that in 1995 angler catch rate of walleye was high, while harvest was lower. There may have been many smaller fish caught this year, which led to a higher release rate. This comparison analysis is typically not conducted for muskellunge because of the difficulties in achieving accurate population estimates and accurately measuring angler harvest.

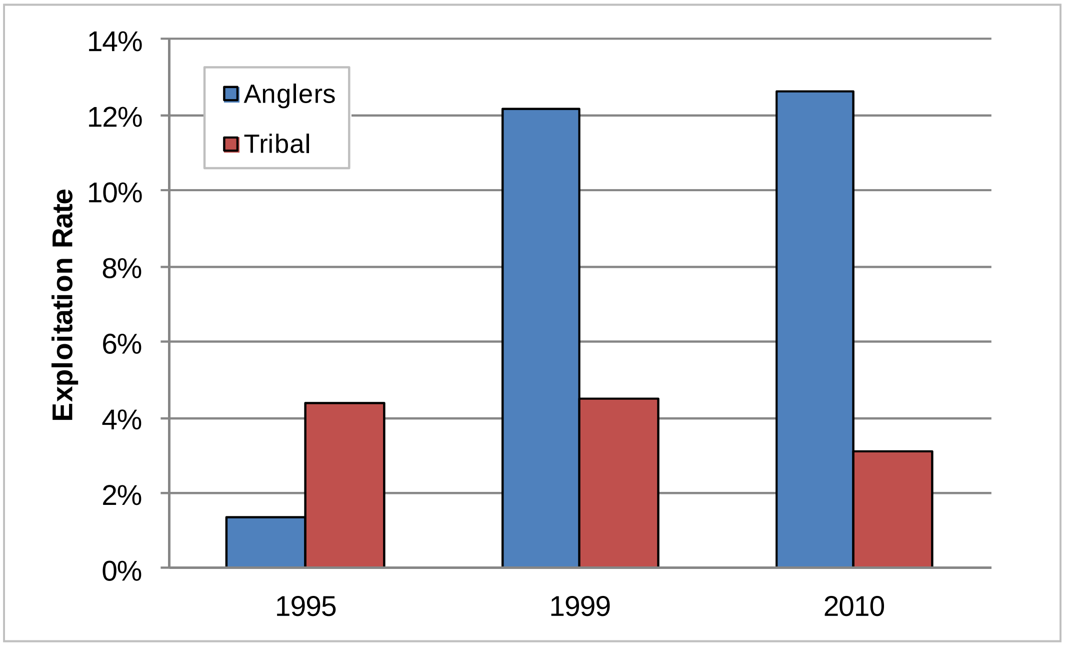

Figure 3.5-4. Lake George adult walleye exploitation rates. Rates are calculated by WDNR personnel through tribal spear harvest monitoring, population estimate surveys and creel survey counts. Data was provided by the WDNR (T. Cichosz, personal communication).

Lake George Fish Stocking and Management

To assist in meeting fisheries management goals, the WDNR may stock fish in a waterbody that were raised in nearby permitted hatcheries. Stocking of a lake is sometimes done to assist the population of a species due to a lack of natural reproduction in the system, or to otherwise enhance angling opportunities. Fish can be stocked as fry, fingerlings or even as adults.

Currently, walleye are not stocked in Lake George because surveys have shown there is strong recruitment (success rearing of young) for this species. As a result, there are usually plenty of small walleye within the lake. Muskellunge are the only species stocked in the lake by the WDNR. Muskellunge are stocked in even-numbered years, usually at a density of 0.5 fish per acre (Table 3.5-5). WDNR fish biologist John Kubisiak reported in personal communication that this strategy should allow for a higher density population with good top-end size potential.

Table 3.5-5. Lake George muskellunge stocking data. Data provided by the WDNR, 1972-2012 (WDNR 2012).

Year	Strain	# Stocked	Age Class
1972	Unspecified	900	Fingerling
1978	Unspecified	800	Fingerling
1982	Unspecified	800	Fingerling
1987	Unspecified	2,700	Fingerling
1989	Unspecified	400	Fingerling
1991	Unspecified	400	Fingerling
1992	Unspecified	400	Fingerling
1996	Unspecified	800	Fingerling
1998	Unspecified	400	Large Fingerling
2000	Unspecified	400	Large Fingerling
2002	Unspecified	217	Large Fingerling
2004	Unspecified	217	Large Fingerling
2006	Upper Wisconsin River	217	Large Fingerling
2008	Upper Wisconsin River	217	Large Fingerling
2010	Upper Wisconsin River	132	Large Fingerling
2012	Upper Wisconsin River	217	Large Fingerling

Because Lake George is located within ceded territory, special fisheries regulations may occur, specifically in terms of walleye. An adjusted walleye bag limit pamphlet is distributed each year by the WDNR which explains the more restrictive bag or length limits that may pertain to Lake George. In 2012-2013, the daily bag limit was set at two walleye. On Lake George, there is no minimum length limit on walleye, but only one fish over 14" is allowed. This regulation is in place to allow harvest on abundant small fish while offering some protection and reduced harvest on larger fish.

Lake George is in the northern Muskellunge and Northern Pike Management Zone. At this time, no more than a single muskellunge may be kept per day, and the length limit on this species is 40". A daily bag limit of five fish exists for northern pike, with no minimum length limit. For bass species, the first Saturday in May through the third Saturday in June is reserved for a catch and release season only. Following the third Saturday in June, five bass of either species may be harvested, with a minimum length of 14". Please note that the above regulations are applicable to the 2012-2013 fishing season, and that regulations may change in 2014. Statewide regulations apply for all other fish species.

Lake George Substrate and Near Shore Habitat

Just as forest wildlife require proper trees and understory growth to flourish, fish prefer certain substrates and habitat types to nest, spawn, escape predators, and search for prey. Indeed, lakes with primarily a silty/soft substrate and much aquatic plants and coarse woody debris may produce a completely different fishery than lakes that are largely sandy and contain few aquatic plant species or coarse woody habitat.

According to the point-intercept survey conducted by Onterra, 46% of the substrate sampled in the littoral zone on Lake George was sand, while 42% was classified as muck and the remaining 12% classified as rock (Map 5). Substrate and habitat are critical to fish species that do not provide parental care to their eggs, in other words, the eggs are left after spawning and not tended to by the parent fish. Muskellunge is one species that does not provide parental care to its eggs (Becker 1983). Muskellunge broadcast their eggs over woody debris and detritus, which can be found above sand or muck. This organic material suspends the eggs above the substrate, so the eggs are not buried in sediment and suffocate as a result. Walleye is another species that does not provide parental care to its eggs. Walleye preferentially spawn in areas with gravel or rock in places with moving water or wave action, which oxygenates the eggs and prevents them from getting buried in sediment. Fish that provide parental care are less selective of spawning substrates. Species such as bluegill tend to prefer a harder substrate such as rock, gravel or sandy areas if available, but have been found to spawn in muck as well.

As discussed in the Shoreland Condition Section, the presence of coarse woody habitat is important for many stages of a fish's life cycle, including nesting or spawning, escaping predation as a juvenile, and hunting insects or smaller fish as an adult. Unfortunately, as development has increased on Wisconsin lake shorelines in the past century, this beneficial habitat has often been the first to be removed from the natural shoreland zone.

4.0 SUMMARY AND CONCLUSIONS

The design of this project was intended to fulfill three objectives;

1) Collect baseline data to increase the general understanding of the Lake George ecosystem.
2) Collect detailed information regarding invasive plant species within the lake, should any be found.
3) Collect sociological information from Lake George stakeholders regarding their use of the lake and their thoughts pertaining to the past and current condition of the lake and its management.

Through the course of over a year of scientific studies and direct discussions regarding Lake George, much has been learned about the lake's ecosystem, the desires of the people who live nearby and care for the lake, and what needs to be done to manage and protect the Lake George ecosystem.

The study began with an anonymous written survey of Lake George residents, both association members and non-members. Much was learned regarding how these stakeholders utilize the lake, and what issues they see as concern for the lake's health. Overall, residents of Lake George believe they have a healthy lake ecosystem that they are interested in protecting. While differing recreational activities may cause some uneasiness amongst those that use the lake, it is important to remember that Lake George is a public resource that all may enjoy as they see fit; that is, without expense to the lake's health or the safety of other lake users. In order to be a good lake steward, it is important that Lake George residents and visitors express concern not only for the lake environment but also other watercraft users, anglers, property owners, etc.

This project included many scientific investigations aimed at understanding the ecosystem through the analysis of baseline data. Through water quality sampling and analysis, it was found that Lake George has exceptional water chemistry. Phosphorus, a nutrient of major concern to lakes across Wisconsin and the United States, was found to be in moderate abundance within Lake George. Every lake requires some phosphorus, as this essential nutrient is needed for algae and aquatic plant growth. Algae and plants are in turn necessary to provide food and habitat for insects, fish, mammals, etc. However, the amount of phosphorus found in the water column of Lake George is sufficient to produce a healthy amount of algae and aquatic plants, but not an excess amount that might lead to algae and plant problems.

A lake's water quality and quantity is often a reflection of the surrounding drainage basin, or watershed. Thus is the case for Lake George. Modeling of the Lake George watershed indicates that a minimal to moderate phosphorus load enters the lake on an annual basis. This is largely because of the advantageous land cover types that are within the lake. The immediate shoreline, however, is one area of slight concern regarding the lake's watershed. Studies conducted in 2012 determined that roughly 31% of the shoreline consists of urbanized or developed-unnatural areas, and a further 45% is in a semi-natural state. Past and present research has indicated that the immediate shoreline provides many ecological services due to its being located at the interface between the aquatic and terrestrial environment. In regards to protecting Lake George, conserving the existing natural shoreline and restoring areas of disturbed shoreline is one of the best ways the LGLA can preserve their lake at this time.

The aquatic plant community is a good indicator of the overall lake's health; and to this respect, all indications are that Lake George is exceptionally healthy. 42 species of native aquatic plants were found in Lake George in 2012, including one species of special concern and no invasive aquatic plant species. The species-rich and diverse plant community is the result of good water quality, a varied substrate and many different niches (habitats such as deep water, shallow water, back bays, point, etc.) that are found on the lake. In a comparative analysis, Lake George had a higher species richness, higher conservatism value and higher floristic quality than most lakes within the Northern Lakes and Forests Lakes ecoregion and within the state of Wisconsin. The importance of a high quality aquatic plant community cannot be understated; these diverse groups of plants are responsible for providing food and habitat for many types of wildlife such as fish, insects, mammals, birds, etc. Additionally, a diverse and fully functional aquatic plant community is thought to be a good defense against the establishment of non-native invasive aquatic species. The fact that no invasive species were encountered during 2012 surveys is further testament to the health of the lake.

No comprehensive investigation into a lake ecosystem is complete without consideration of what may be most riparian property owners' favorite element of the lake – the fishery. Although no fisheries data were collected as a direct result of this study, Onterra staff worked with WDNR fisheries staff to share data and knowledge regarding elements of the lake's fishery. Additionally, Onterra's studies regarding the substrate, aquatic plants and shoreland condition of the lake produced valuable data concerning the available habitat for fish. And finally, lake residents' thoughts on the fishery were polled through the use of an anonymous stakeholder survey. As a result, much was learned regarding the perceptions and desires of the individuals who fish Lake George as well as information pertaining to the management of the fishery and the challenges that it may face. Though fishing pressure poses a challenge to the fishery, probably the most critical issue the lake is facing is the loss of habitat through shoreland development. In order to reach full fishery potential, the LGLA needs to work with state and local organizations to protect natural areas of shoreland, restore areas that have become excessively developed, and improve the coarse woody habitat of the lake's littoral zone.

The LGLA has committed many hours towards protecting and monitoring Lake George through Clean Boats Clean Waters watercraft inspections, Citizens Lake Monitoring Network activities, rusty crayfish removal, the Aquatic Invasive Species Monitoring Days program and various educational efforts involving association members, non-member lake residents and local businesses and government entities. Additionally, realizing the need for a comprehensive investigation of the ecosystem, the group decided in 2011 to undertake a lake management planning project. In summary, the results of this project indicate that Lake George is in a healthy condition. However the need for restoration and, more importantly, protection efforts do exist. The Implementation Plan below discusses the role of education and communication in managing a shared resource, and how the LGLA will implement these tools to manage Lake George in an environmentally and recreationally responsible manner.

5.0 IMPLEMENTATION PLAN

The Implementation Plan presented below was created through the collaborative efforts of the Lake George Planning Committee and ecologist/planners from Onterra. It represents the path the LGLA will follow in order to meet their lake management goals. The goals detailed within the plan are realistic and based upon the findings of the studies completed in conjunction with this planning project and the needs of the Lake George stakeholders as portrayed by the members of the Planning Committee, the returned stakeholder surveys, and numerous communications between Planning Committee members and the lake stakeholders. The Implementation Plan is a living document in that it will be under constant review and adjustment depending on the condition of the lake, the availability of funds, level of volunteer involvement, and the needs of the stakeholders.

Management Goal 1: Maintain Current Water Quality Conditions

Management Action: Continue monitoring of Lake George's water quality through the WDNR Citizen Lake Monitoring Network.

Timeframe: Continuation of current effort.

Facilitator: Board of Directors

Description: Monitoring water quality is an important aspect of every lake management planning activity. Collection of water quality data at regular intervals aids in the management of the lake by building a database that can be used for long-term trend analysis. Early discovery of negative trends will likely aid in an earlier definition of what may be causing the trend.

The Citizen Lake Monitoring Network (CLMN) is a WDNR program in which volunteers are trained to collect water quality information on their lake. In fact, within this study a more complete analysis was able to be conducted on Lake George's water quality because of the extended dataset that is available. Volunteers from the LGLA have collected Secchi disk clarities and water chemistry samples during this project and in the past through the CLMN. It is the responsibility of the Board of Directors to coordinate new volunteers as needed. When a change in the collection volunteer occurs, it will be the responsibility of the Board of Directors to contact Sandra Wickman or the appropriate WDNR/UW-Extension staff to ensure the proper training occurs and the necessary sampling materials are received by the new volunteer. It is also important to note that as a part of this program, the data collected are automatically added to the WDNR database and available through their Surface Water Integrated Monitoring System (SWIMS) by the volunteer.

Action Steps:

1. Board of Directors recruits volunteer coordinator (or selects existing volunteer).
2. Coordinator directs water quality monitoring program efforts.
3. Coordinator reports results to WDNR and LGLA members during annual meeting.

Management Action: Investigate unaccounted-for phosphorus in Lake George.

Timeframe: Initiate with Management Plan Update.

Facilitator: Board of Directors

Description: As discussed within the Watershed Section, modeling conducted on Lake George's watershed and water phosphorus concentrations indicates that there may be more phosphorus present in Lake George than what would be expected. This discrepancy was discovered when comparing modeled phosphorus concentrations against what was observed through water quality monitoring. When the model was calibrated to the phosphorus concentrations observed in the lake, it indicated that roughly between 44 and 337 lbs of phosphorus is unaccounted-for within the Lake George WiLMS model, which would contribute an extra 8%-39% to the overall phosphorus load. Unfortunately due to the baseline nature of this study, quantifying the phosphorus content more accurately and pinpointing the source of this phosphorus input was unable to be achieved.

While the unaccounted for phosphorus is scientifically intriguing, it is not a worrisome issue at this time. All indications are that the lake is in good health, with quantifiable good water quality and documented good perception of the water quality by lake stakeholders. While the Lake George Planning Committee is interested in finding out the source of this phosphorus and to what extent it is present in Lake George, it is not an immediate concern in terms of the health condition of the lake.

During the planning meeting discussions that were held in winter of 2013, it was decided upon by the Lake George Planning Committee that during a management plan update, to take place in five to seven years, that more in-depth studies would be built into the project which would serve to better quantify the phosphorus budget in the lake. Specifically, these studies would include sampling of the hypolimnion phosphorus concentration through the summer months, as well as monitoring of dissolved oxygen content in the entire water column. Study design may include monitoring of Lake George Creek as well.

Action Steps:

1. Apply for management planning grant in 2018-2020 to update studies conducted in 2012-2013.
2. Ensure planning update methodology includes phosphorus budgeting components.
3. Retain professional consultant to conduct studies on Lake George.

Management Action: Restore highly developed shoreland areas on Lake George.

Timeframe: Initiate 2013.

Facilitator: Board of Directors

Description: As discussed within the Shoreland Condition Section, the shoreland zone of a lake is highly important to the ecology of a lake. When shorelands are developed, the resulting impacts on a lake range from a loss of biological diversity to impaired water quality. Because of its proximity to the waters of the lake, even small disturbances to a natural shoreland area can produce ill effects. In 2012, the shoreland assessment survey indicated that 1.9 miles (31%) of Lake George's shoreline holds Urbanized or Developed-Unnatural areas.

Fortunately, restoration of the shoreland zone can be less expensive, less time-consuming and much easier to accomplish than restoration efforts in other parts of the watershed. Cost-sharing grants and Oneida County staff devoted to these types of projects give private property owners the funds and information resources to restore quality shoreland habitat to their lakeside residence.

Map 3 indicates the locations of Urbanized and Developed-Unnatural shorelands on Lake George that should be prioritized for restoration. A Board of Directors appointed person will work with appropriate entities such as the Oneida County Land & Water Conservation Department to research grant programs, shoreland restoration techniques and other pertinent information that will help the LGLA restore portions of the Lake George shoreland. Because property owners may have little experience with or be uncertain about restoring a shoreland, properties with restoration on their shorelands on nearby lakes could serve as demonstration sites. Lake George property owners could have the opportunity to view a shoreland that has been restored to a more natural state, and learn about the maintenance, labor and cost-sharing opportunities that exist with these projects. The Board of Directors appointee will oversee/plan demonstration tours on neighboring lakes through the assistance of Oneida County Land and Water Conservation Department staff as well as be a point-of-contact for Lake George property owners that require more information on this topic.

Action Steps:

1. Recruit facilitator.
2. Facilitator serves as contact person for shoreland restoration questions and directs interested property owners to Oneida County Land & Water Conservation Department officials.
3. Property owners complete an Oneida County Cost Share application.
4. Conservation specialist with Oneida County works with property owners to determine site eligibility, design plans, etc.
5. LGLA seeks riparian permission to use completed project as a demonstration site.

<u>Management Action:</u> Protect natural shoreland zones along Lake George.

Timeframe: Initiate 2013.

Facilitator: Board of Directors

Description: Despite the ample developed shoreland that surrounds Lake George, a fair amount (1.5 miles or 24%) of natural and developed-natural shorelands are present as well. It is therefore very important that owners of these properties become educated on the benefits their shoreland is providing to Lake George, and that these shorelands remain in a natural state.

Map 3 indicates the locations of Natural and Developed-Natural shorelands on Lake George. These shorelands should be prioritized for education initiatives and physical preservation. A Board of Directors appointed person will work with appropriate entities to research grant programs and other pertinent information that will aid the LGLA in preserving the Lake George shoreland. This would be accomplished through education of property owners, or direct preservation of land through implementation of conservation easements or land trusts that the property owner would approve of.

Valuable resources for this type of conservation work include the WDNR, UW-Extension and Oneida County Land & Water Conservation Department. Several websites of interest include:

- Wisconsin Lakes website: www.wisconsinlakes.org/shorelands)
- Conservation easements or land trusts: (www.northwoodslandtrust.org)
- UW-Extension Shoreland Restoration: http://www.uwex.edu/ces/shoreland/Why1/whyres.htm)
- WDNR Shoreland Zoning website: (http://dnr.wi.gov/topic/ShorelandZoning/)

Action Steps:

1. Recruit facilitator.
2. Facilitator gathers appropriate information from sources described above. This includes biological research as well as grant/funding opportunities.
3. Facilitator assists residents that are interested in protecting shoreland areas by answering questions or directing residents to appropriate source.

Management Goal 2: Increase LGLA's Capacity to Communicate with and Educate Lake Stakeholders

<u>Management Action:</u> Support an Education Committee to promote safe boating, water quality, public safety and quality of life on Lake George.

Timeframe: Begin summer 2013

Facilitator: Board of Directors

Description: Education represents an effective tool to address issues that impact water quality such as lake shore development, lawn fertilization, and other issues such as air quality, noise pollution, and boating safety. An Education Committee will be created to promote lake protection through a variety of educational efforts.

Currently, the LGLA has several educational initiatives in place for Lake George stakeholders. The association distributes the Lake George Gazette newsletter twice per year (through mail and e-mail) which conveys important information regarding Lake George management, upcoming association events, and other pertinent information. The association does not currently have a website to disseminate this information, but has discussed this possibility. The association also hosts an annual summer meeting. As discussed in the Introduction, the LGLA has, since 2009, conducted a "hands on" educational initiative called "Lake Monitoring Day". The primary purpose of this event is to search the lake for aquatic invasive species. As a side component of the event, native species are collected and stakeholders work with WDNR personnel to identify them.

By forming an Education Committee, the LGLA will be have a group of stakeholders dedicated to coming up with new and innovative ways of educating George Lake stakeholders on the ecology of their lake, rules and regulations regarding activities on the lake, and what they may do to protect or restore Lake George. Example educational topics include:

- Aquatic invasive species monitoring updates
- Boating safety and ordinances (slow-no-wake zones and hours)
- Catch and release fishing
- Littering
- Noise, air, and light pollution
- Shoreland restoration and protection
- Septic system maintenance
- Fishing Rules
- Issues concerning the dam
- Other topics

The committee will be responsible for reaching out to state or local affiliates which can provide them with educational pamphlets, other materials or ideas. These partners may be some of those included in the table found under Management Goal 3.

Action Steps:

1. Recruit volunteers to form Educational Committee
2. Investigate if WDNR small-scale Lake Planning Grant would be appropriate to cover initial setup costs.
3. The LGLA Board of Directors will identify a base level of annual financial support for educational activities to be undertaken by the Educational Committee.

Management Action: Engage stakeholders on priority education items

Timeframe: Begin summer 2013

Facilitator: Board of Directors

Description: Education of lake stakeholders on all matters is important, however during conversations with the LGLA Planning Committee it became apparent that certain topics require additional time and focused effort. These topics have direct implication on the ecology and health of the lake, as well as its navigational safety.

1. Regulation of the Lake George Dam: Lake George has a small dam structure located at its outlet on its southeast side that is owned by the Town of Pelican. This dam was created strictly for recreational purposes – to retain the levels of Lake George at or below an ordinary high watermark. A court order (Appendix G) indicates the specifics about maintaining the dam. During the planning process, members of the LGLA indicated that area residents had been tampering with the dam by removing and replacing boards. While Gerald Roou, Town of Pelican Town Chair, has heard of this happening, he indicated in correspondence with Onterra that some residents had differing views maintaining the dam. Regardless of how the dam impacts the lake (as described in the Aquatic Plant Section) and the personal feelings of riparian owners, the dam is operated in accordance with its 1976 court order. The LGLA will notify all lake property owners of this fact, and direct questions about its maintenance and observations of misuse to Town of Pelican Town Chair Gerald Roou.

2. Clean Boats Clean Waters Protocols: Members of the LGLA have continuously participated in the Clean Boats Clean Waters (CBCW) program since 2004. Annually, the association wishes to work with CBCW administrators and local AIS coordinator Michele Saduaskas to train new recruits and update CBCW methodology where appropriate. Part of this educational campaign will be to inform LGLA members of CBCW activities

(hours spent in service, boats examined, etc.) through the Lake George Gazette and announcements at association meetings.

3. Shoreland buffers: The LGLA realizes the important role that shoreland buffers play in maintaining the water quality and habitat within Lake George. In coordination with Management Goal 1, the LGLA will make shoreland buffer education a priority for all lake residents. In addition to educational tools, the LGLA will provide access to the expertise of local and state professionals for further information on shoreland restoration and protection projects should property owners request it.

4. Navigational safety: The LGLA acknowledges that a variety of recreational activities take place on Lake George. While allowing all stakeholders to enjoy Lake George the way they see fit, the LGLA wishes to ensure that all recreationalists are displaying a high level of safety and awareness at all times, and are obeying all boating regulations. The LGLA will work to keep all lake residents and visitors aware of navigational hazards and regulations that exist on Lake George. This will be done through appropriate postings in the Lake George Gazette, announcements at association meetings, signage at the lake's public access point, and bouys placed within the lake. Management Goal 4 contains more information about this topic.

Action Steps:

1. See above description.

Management Goal 3: Strengthen Association Relationships, Effectiveness and Lake Management Capability

Management Action: Enhance LGLA's involvement with other entities that have a hand in managing Lake George.

Timeframe: Continuation of existing efforts

Facilitator: Board of Directors

Description: The waters of Wisconsin belong to everyone and therefore this goal of protecting and enhancing these shared resources is also held by other entities. It is important that the LGLA actively engage with all management entities to enhance the association's understanding of common management goals and to participate in the development of those goals. This also helps all management entities reduce the duplication of efforts. While not an inclusive list, the pertinent parties for Lake George range from those located locally (Town of Pelican, Lake Thompson Lake Association) to those at the County level (Oneida County AIS Coordinator, Lakes & Rivers Association) and at the level of the State of Wisconsin (WDNR). Each entity is specifically addressed in the table below.

Partner	Contact Person	Role	Contact Frequency	Contact Basis
Lake Thompson Lake Association	President (Frosty Smith – 715-369-0520 or frosty@newnorth.net)	Lake Thompson is located upstream of Lake George, less than one mile away.	As needed.	The LTLA may be contacted for collaborative project ideas or to share knowledge of local lake management.
Oneida County Lakes & Rivers Association (OCLRA)	Secretary (Connie Anderson – 715.282.5798)	Protects Oneida Co. waters through facilitating discussion and education.	Twice a year or as needed.	Become aware of training or education opportunities, partnering in special projects, or networking on other topics pertaining to Oneida Co. waterways.
Oneida County AIS Coordinator	AIS Coordinator (Michele Saduaskas – 715.365.2750)	Oversees AIS monitoring and prevention activities locally.	Twice a year or more as issues arise.	Spring: AIS training and ID, AIS monitoring techniques Summer: Report activities to Ms. Saduaskas.
Oneida County Land and Water Conservation Department	Conservation specialist (Jean Hansen – 715-365-2750)	Oversees conservation efforts for land and water projects.	Twice a year or more as needed.	Contact for shoreland remediation techniques and cost-share procedures, wildlife damage programs, education and outreach documents.
Town of Pelican	Town Chair (Gerald Roou – 715-362-3517)	Oversees ordinances and other items pertaining to town.	As needed.	Town staff may be contacted regarding ordinance reviews or questions, and for information on community events.
Wisconsin Department of Natural Resources	Fisheries Biologist (John Kubisiak – 715.365.8919)	Manages the fishery of Lake George.	Once a year, or more as issues arise.	Stocking activities, scheduled surveys, survey results, volunteer opportunities for improving fishery.
	Lakes Coordinator (Kevin Gauthier – 715.365.8937)	Oversees management plans, grants, all lake activities.	Every 5 years, or more as necessary.	Information on updating a lake management plan (every 5 years) or to seek advice on other lake issues.
	Warden (Jim Jung – 715.365.8950)	Oversees regulations handed down by the state.	As needed. May call the WDNR violation tip hotline for anonymous reporting (1-800-847-9367, 24 hours a day).	Contact regarding suspected violations pertaining to recreational activity on Lake George, include fishing, boating safety, ordinance violations, etc.
	Citizens Lake Monitoring Network contact (Sandra Wickman – 715.365.8951)	Provides training and assistance on CLMN monitoring, methods, and data entry.	Twice a year or more as needed.	Late winter: arrange for training as needed, in addition to planning out monitoring for the open water season. Late fall: report monitoring activities.
Wisconsin Lakes	General staff (800.542.5253)	Facilitates education, networking and assistance on all matters involving WI lakes.	As needed. May check website (www.wisconsinlakes.org) often for updates.	LGLA members may attend WL's annual conference to keep up-to-date on lake issues. WL reps can assist on grant issues, AIS training, habitat enhancement techniques, etc.

During the planning process associated with this project, discussions were had regarding a list of other groups/individuals that play an important role in Lake George's health and functionality. Several of these entities were identified at the Planning Meeting II:

1. New lake residents: New residents may be unfamiliar with their neighbors, the LGLA or the tremendous effort that has gone into protecting the health of Lake George. A volunteer from the LGLA will pay a personal visit to each new lake resident for a friendly introduction. During this visit, the LGLA member may discuss the matters the association is involved with, as well as how the new resident may manage their property to have minimal impact on Lake George.

2. Realtors, construction workers and landscapers: The Northwoods of Wisconsin is well known for its natural beauty and freshwater lakes and streams. Realtors often use these attractions as selling points for properties located in this region. The LGLA will work to inform local realtors on the proactive role the association takes in protecting the scenic and natural beauty of Lake George and its watershed. Local construction/landscaping companies will be informed of the LGLA's efforts as well, demonstrating demand for these companies to keep their practices "environmentally friendly" with respect to the lake and surrounding area. While it may be inappropriate for the LGLA to endorse specific companies, the association may elect to award "water friendly contractors" or "water friendly landscapers" as it sees fit.

3. Local watercraft rental groups: Any time a watercraft is transferred from one waterbody to another, the opportunity exists for movement of aquatic invasive species to occur if the proper precautions are not taken. Companies that rent watercraft have a responsibility to clean the watercraft they rent on a regular basis, and also to inform their customers of proper cleaning protocols. The LGLA has in the past contacted nearby rental companies to encourage this transfer of information. In the spring of each year, the association will continue its proactive approach to preventing the spread of aquatic invasive species by sending thank-you letters to these companies. These letters will thank the company in advance for taking precautions in reducing the spread of aquatic species between lakes through cleaning their watercraft.

Action Steps:

1. Refer to management entity table and contact partners as necessary.
2. Board of Directors select a volunteer to discuss lake-friendly property management and watercraft maintenance with above named groups.

Management Action: Increase volunteerism within LGLA

Timeframe: Begin Summer 2013

Facilitator: Board of Directors

Description: Even through lake associations consist of individuals who are passionate about the lake they reside upon, it is often difficult to recruit volunteers to complete the tasks that are necessary to protect that lake. Many lake association members are elderly and retired, so sometimes labor intensive volunteer jobs are difficult to perform. Other residents may only visit the lake several times during the year, often on weekends to "get away" from the pressures of the work-week back home. Some have cut back on volunteering because of recent economic downturns, have concerns over the time commitment involved with various volunteer tasks, while others may simply have not been asked to lend their services.

Those that have volunteered in the past and have had a poor experience may be hesitant to volunteer again. Without good management, volunteers may become underutilized. Some may have been turned off by an impersonal, tense or cold atmosphere. Volunteers want to feel good about themselves for helping out, so every effort must be made by volunteer managers to see to it that the volunteer crews enjoy their tasks and their co-volunteers.

The LGLA is proud of their active role in preserving Lake George for all stakeholders; however, they are in constant need of volunteers to continue this high level of commitment. As a result of this lake management planning project, the association is now in need of additional help to increase the level of protection the LGLA wishes to provide for the lake. In order to retain volunteer help and recruit more volunteers for these tasks, the LGLA will undertake a volunteer recruitment strategy as outlined below. While volunteer recruitment for a lake association may be difficult, the following tips will be helpful in the LGLA's efforts to solicit help for lake-related efforts.

Action Steps:

1. Board of directors appoints a volunteer coordinator. This should be a friendly, outgoing person who is able to engage people they may know or not know. The volunteer coordinator's duties are to recruit, train, supervise and recognize volunteers. Building and maintaining a volunteer database with names, contact information, tasks, hours completed, etc. will be necessary.
2. Coordinator will initially recruit volunteers through personal means, not via telephone, email or newsletter notification. Engaging a person in a friendly atmosphere through a personal invitation is more likely to result in a successful recruitment than through an impersonal email.

3. Coordinator will have duties outlined prior to recruiting volunteers. A volunteer's time should not be wasted! Work descriptions, timeframes and other specifics should be known by each worker prior to their shift.
4. Coordinator will be flexible in allowing volunteers to contribute towards project designs and implementation. Recruiting new leaders through delegating tasks will empower volunteers and give them reason to continue volunteering.
5. The board of directors will recognize volunteers through incentives and appreciation. Snacks, beverages, public acknowledgement and other means of expressing appreciation are encouraged.

Management Action: Coordinate annual volunteer monitoring for aquatic invasive species

Timeframe: Begin Summer 2013

Facilitator: Board of Directors

Description: Through the LGLA's AIS Monitoring Days program, which it holds in June and August of each year, the group has been diligent in monitoring their lake for aquatic invasive species. While this program has good intentions, the possibility exists that some areas of the littoral zone (area in which plants grow) are not monitored. The LGLA wishes to adopt a monitoring design that maximizes their volunteer's time as well as maximizes the amount of littoral area that is covered.

One way that lake residents can spot aquatic invasive species is through conducting "Lake Sweeps" on their lake. During a lake sweep, volunteers monitor the entire littoral zone in search of non-native plant species. This program uses an "adopt-a-shoreline" approach where volunteers survey specified, assigned areas.

In order for accurate data to be collected during these sweeps, volunteers must be able to identify non-native species such as Eurasian water milfoil and curly-leaf pondweed. Distinguishing these plants from native look-a-likes is very important. Additionally, the collection of suspected plants is important. A specimen of the plant would need to be collected for verification, and, if possible, GPS coordinates should be collected. Oneida County AIS coordinator Michele Saduaskas is an excellent resource to contact for assistance in developing monitoring techniques, identifying invasive aquatic plants and logging pertinent monitoring information.

Action Steps:

1. Volunteers from the LGLA update their skills by attending a training session conducted by Oneida County AIS Coordinator Michele Saduaskas.
2. Trained volunteers recruit and train additional association members.
3. Complete lake surveys following designated protocols.
4. Report results to WDNR, Oneida County AIS Coordinator and LGLA.

Management Action: Increase awareness of slow-no-wake zones in southwestern corner of Lake George.

Timeframe: Begin Summer 2013

Facilitator: Board of Directors

Description: As indicated in the stakeholder survey (Appendix B), Lake George plays host to a variety of recreational watercraft and recreational activities throughout the year (Questions #12 and #13). This mix of recreational uses has caused some "clashes" amongst lake users (Stakeholder survey comments, Appendix B). While approving of the diversity of recreational activities that occur on Lake George, the LGLA wishes to ensure that state and local watercraft regulations are being followed and that navigational hazards such as shallow rock piles are brought to the attention of watercraft users.

Currently, the placement of bouys are used to identify several shallow areas within the lake. Discussions were held at the planning meetings associated with this project to determine if bouys might be placed along the west side of the larger of two islands in the lake's southwest corner. There is concern amongst some LGLA members that watercraft are operating too close to shore in this area, which would be a violation of state regulation. Wisconsin Act 31 states that it is illegal to operate a boat at a speed faster than slow-no-wake while within 100 feet, or a personal watercraft within 200 feet, from a shoreline, pier, raft or buoyed area. As indicated on Map 8, watercraft traveling between the mainland and each of the lake's two islands are within the 200 foot zones which restrict speeds to only slow-no-wake. Please note that the map indicates distances from the shoreline, not piers or other structures. Though the 100 foot zones from the mainland and island do not reach each other, watercraft must also travel at slow-no-wake speed within 100 feet of docks, piers, rafts or other structures. This likely makes travel at greater than slow-no-wake speed through this channel illegal with respect to Wisconsin Act 31.

The LGLA, wishing to make this knowledge more readily available to watercraft users, will utilize Map 8 in an appropriate manner such as posting at public access location, within resorts and campgrounds, etc. The LGLA will explore other options to notify watercraft operators of the slow-no-wake conditions in this area as they arise.

Action Steps:

1. Distribute Map 8 as appropriate.
2. Draft resolution to propose at LGLA association meeting which would support placement of slow-no-wake alerts in or around channel between mainland and large island.

Management Goal 4: Maximize Knowledge of and Habitat for Lake George's Fishery

Management Action: Work with fisheries managers to understand and enhance fishery while communicating aspects of fishery studies to LGLA members.

Timeframe: Ongoing.

Facilitator: Board of Directors.

Description: Fishing, a hobby that is no stranger to Wisconsin residents, was ranked as the second most important activity by Lake George stakeholders in a 2012 survey (Appendix B, Question #13). 50% of survey respondents indicated that they have fished the lake for a period longer than 15 years (Question #7), and indicated that walleye, crappie and other panfish species were their favorite to fish for (Question #9).

While many LGLA members stated the fishery is *Fair* to *Good* and believe it has been this way for some time (Questions #10 and #11), the group now wishes for fishing conditions in the lake to remain the same or improve. To keep realistic expectations about the Lake George fishery, an understanding of the habitat and population dynamics must be obtained. Fortunately, Lake George is studied often by WDNR and GLIFWC biologists.

The LGLA would like to continue to strengthen its relationship with these biologists, and learn of the monitoring studies each entity is conducting. A representative of the Board of Directors will be appointed to contact WDNR biologist John Kubisiak on an annual basis. The purpose of the contact would be to go over any surveys that are occurring that particular year, obtaining results from previous surveys, etc. The LGLA volunteer may ask for a WDNR representative to come to a LGLA meeting and deliver a short presentation on the fishery status of Lake George, perhaps on an annual basis. Additionally, the LGLA may discuss options for improving the fishery in Lake George, which may include changes in angling regulations, habitat enhancements, or private stocking. While the LGLA is enthusiastic about maintaining this relationship and Lake George's fishery, they understand that because WDNR biologists have many lakes and streams to oversee in Oneida County, annual meeting attendance and immediate responses to lake association requests cannot be expected.

Action Steps:

1. See above description.

Management Action: Work with WDNR fisheries biologist to implement coarse woody habitat project

Timeframe: Begin in 2013.

Facilitator: Board of Directors.

Description: As a result of the coarse woody habitat survey, it was discovered that 45 total pieces of coarse woody habitat were observed along 6.1 miles of shoreline. This makes for a very small coarse woody habitat to shoreline mile ratio of 7:1. In contrast, some undeveloped lakes may have several hundred pieces of coarse woody habitat per mile of lake shoreland. The benefits of coarse woody habitat are well researched, and have implications for many organisms in the aquatic food web, including algae, insects, amphibians and fish.

In order to improve fishery habitat on Lake George, the LGLA wishes to create coarse woody habitat in appropriate areas of the lake. This would be a coordinated effort between the LGLA, private landowners, WDNR fisheries biologists and potentially the Oneida County Land and Water Conservation Department.

Action Steps:

1. LGLA representative discusses potential project with WDNR fisheries biologist John Kubisiak to determine feasibility.
2. LGLA representative discusses grant funding opportunities with Oneida County Land and Water Conservation Department and WDNR lakes coordinator Kevin Gauthier to determine applicability.
3. LGLA solicits interest from lake residents through newsletter or association meetings. WDNR fisheries biologist must determine potential sites are suitable for introduction of coarse woody habitat structure.

6.0 METHODS

Lake Water Quality

Baseline water quality conditions were studied to assist in identifying potential water quality problems in Lake George (e.g., elevated phosphorus levels, anaerobic conditions, etc.). Water quality was monitored at the deepest point on the lake that would most accurately depict the conditions of the lake (Map 1). Samples were collected using WDNR Citizen Lake Monitoring Network (CLMN) protocols which occurred once in spring and three times during the summer. In addition to the samples collected by LGLA members, professional water quality samples were collected at subsurface (S) and near bottom (B) depths once in spring, winter, and fall. Although LGLA members collected a spring total phosphorus sample, professionals also collected a near bottom sample to coincide with the bottom total phosphorus sample. Winter dissolved oxygen was determined with a calibrated probe and all samples were collected with a 3-liter Van Dorn bottle. Secchi disk transparency was also included during each visit.

All samples that required laboratory analysis were processed through the Wisconsin State Laboratory of Hygiene (SLOH). The parameters measured, sample collection timing, and designated collector are contained in the table below.

	Spring		June	July	August	Fall		Winter	
Parameter	**S**	**B**	**S**	**S**	**S**	**S**	**B**	**S**	**B**
Total Phosphorus	■♦	■	♦	♦	♦	■	■	■	■
Dissolved Phosphorus	■	■						■	■
Chlorophyll-*a*	■		♦	♦	♦	■			
Total Kjeldahl Nitrogen	■	■	●	●	●	■		■	■
Nitrate-Nitrite Nitrogen	■	■	●	●	●	■		■	■
Ammonia Nitrogen	■	■	●	●	●	■		■	■
Laboratory Conductivity	■	■							
Laboratory pH	■	■							
Total Alkalinity	■	■							
Total Suspended Solids	■	■				■	■	■	■
Calcium	■								

♦ indicates samples collected as a part of the Citizen Lake Monitoring Network.
● indicates samples collected by volunteers under proposed project.
■ indicates samples collected by consultant under proposed project.

Watershed Analysis

The watershed analysis began with an accurate delineation of Lake George's drainage area using U.S.G.S. topographic survey maps and base GIS data from the WDNR. The watershed delineation was then transferred to a Geographic Information System (GIS). These data, along with land cover data from the National Land Cover Database (NLCD – Fry et. al 2011) were then combined to determine the watershed land cover classifications. These data were modeled using the WDNR's Wisconsin Lake Modeling Suite (WiLMS) (Panuska and Kreider 2003)

Aquatic Vegetation

Early Season Aquatic Invasive Species Survey

Surveys of aquatic invasive species were completed on Lake George during a May 31, 2012 field visit. Visual inspections for aquatic invasive species were completed throughout the lake by completing a meander survey by boat.

Comprehensive Macrophyte Surveys

Comprehensive surveys of aquatic macrophytes were conducted on Lake George to characterize the existing communities within the lake and include inventories of emergent, submergent, and floating-leaved aquatic plants within them. The point-intercept method as described in the Wisconsin Department of Natural Resource document, Recommended Baseline Monitoring of Aquatic Plants in Wisconsin: Sampling Design, Field and Laboratory Procedures, Data Entry, and Analysis, and Applications (WDNR PUB-SS-1068 2010) was used to complete this study on MacrophyteFieldVistitDate. A point spacing of 51 meters was used resulting in approximately 699 points.

Community Mapping

During the species inventory work, the aquatic vegetation community types within Lake George (emergent and floating-leaved vegetation) were mapped using a Trimble GeoXT Global Positioning System (GPS) with sub-meter accuracy. Furthermore, all species found during the point-intercept surveys and the community mapping surveys were recorded to provide a complete species list for the lake.

Representatives of all plant species located during the point-intercept and community mapping survey were collected and vouchered by the University of Wisconsin – Stevens Point Herbarium. A set of samples was also provided to the LGLA.

7.0 LITERATURE CITED

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