
Black Oak Lake Watershed Protection Program: Adaptive Management Plan

(Land O' Lakes Township, Vilas County, Wisconsin)

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CHAPTER 1

What Is the Black Oak Lake Adaptive Management Plan?

The Black Oak Lake Watershed Protection Program is an ongoing endeavor of the Black Oak Lake Preservation Foundation (hereafter, the Foundation). The program is composed of phases that collectively contribute to the overall vision. In Phase 1, participants learned about the lake and the landscape and created the first version of the ***Black Oak Lake Adaptive Management Plan***. In Phase 2, we continued to gather new and existing information about the lake and history and created an important component of the Adaptive Management Plan: an ***Aquatic Plant Management Plan***. In Phase 3, we conducted a qualitative, quantitative, and photographic documentation of the condition of the littoral and riparian zones of Black Oak Lake. In Phase 4, we identified candidate areas within the riparian area of Black Oak Lake where vegetative restoration would benefit habitat and water quality. In Phase 5, we explored issues of lake stage (water level) and water clarity and chemistry. In Phase 6 (the current phase), we analyzed additional aquatic plant data, updated the Aquatic Plant Management Plan, studied the groundwater relation to Black Oak Lake, interpreted the biotic history of Black Oak Lake sediment, and re-worked the entire Adaptive Management Plan.

Success of future phases depends on a coalition of participants, each carrying out appropriate tasks and communicating needs and findings to other team members. The Foundation has been the lead organization in this long-range effort. White Water Associates (White Water) has been the science consultant through all six project phases. The Wisconsin Department of Natural Resources (WDNR) has contributed funding and natural resources advice and oversight throughout the process.

This document integrates products of Phases 1 through 6 of the Black Oak Lake Watershed Protection Program. This program has received funding from six WDNR Lake Planning Grants awarded to the Foundation. The vision of the Black Oak Lake Watershed Protection Program is to ensure the perpetuation of a healthy Black Oak Lake and its surrounding landscape ecosystem far into the future. Participants in program believe that the tool by which to realize this vision is a protection-oriented adaptive management plan for Black Oak Lake and its watershed.

Project participants embrace the concept of “adaptive management” in their approach to Black Oak Lake stewardship. Simply stated, adaptive management uses findings from planned

monitoring activities to inform future management actions and periodic refinement of the plan. An adaptive management plan accommodates new findings by integrating this information into successive versions of the comprehensive plan. The plan will therefore be a dynamic entity, successively evolving and improving to fit the needs of Black Oak Lake and the Foundation. A central premise of adaptive management is that scientific knowledge about natural ecosystems is uncertain and incomplete. It follows that a practical management plan allows for ongoing adjustments in management designed to “adapt” to changing conditions and new information or understanding. Monitoring the outcomes of plan implementation is essential to the process of adaptive management.

Besides this introductory chapter, this plan is organized in seven additional chapters. Chapter 2 describes the audience for the *Black Oak Lake Adaptive Management Plan*. Chapter 3 addresses why there should be a plan and discusses adaptive management and the underlying assumptions of the approach. Chapter 4 details how the plan was created, including the methodology used. Chapter 5 presents the findings from efforts to gather existing and new information about Black Oak Lake and its environs by providing summaries of information in fifteen subsections. Chapter 6 (*What Goals Guide the Plan?*) presents the desired future condition and goals established by the Foundation and the plan writers. Chapter 7 (*What Objectives and Actions Move Us Toward the Goals?*) offers a logical menu of practical management actions ready to be adopted and adapted by those interested in taking an active role in caring for Black Oak Lake and its surroundings.

Thirteen appendices complete this document. Appendix A contains literature cited. Appendix B contains the *Black Oak Lake Aquatic Plant Management Plan*. Appendix C presents the *Review of Water Quality*. Appendix D includes the *Black Oak Lake History*. Appendix E is a summary of *Black Oak Lake fisheries*. Appendix F consists of the *Review of Water Regulations and Planning Relevant to Black Oak Lake*. Appendix G presents results from the *Qualitative Assessment of the Littoral Zone and Riparian Area*. Appendix H presents methods and results from the *Quantitative Assessment of Littoral Zone and Riparian Area*. Appendix I includes *Study Site Photos for the Quantitative Assessment*. Appendix J includes the Phase 4 Report (*Shoreland Restoration*). Appendix K includes the Phase 5 Report (*Water Quality and Lake Stage Monitoring*). Appendix L includes reports on analyses of the *Black Oak Lake Sediment Core*. Finally, Appendix M contains a report on the *Black Oak Lake Groundwater Study*.

CHAPTER 2

Who Is the Audience for the Black Oak Lake Adaptive Management Plan?

The title of Chapter 3 poses the question: “Why Have the *Black Oak Lake Adaptive Management Plan*?” The short answer is “Because we care!” We believe that people working together in the stewardship of this lake can make a difference. We can protect and restore a healthy ecosystem if we take a long-term, strategic approach. That approach is presented in this adaptive plan. It is an adaptive plan in the sense that it will grow and evolve. Implemented actions will be monitored. The plan will be evaluated. It will be reviewed and refined as years go by – as new generations take up their stewardship responsibility.

People who care about the Black Oak Lake Watershed are the most direct audience for this plan. They will be the implementers and evaluators of the plan. They will be the reviewers and future plan writers. Many of them live in or near the watershed. These are the “grassroots” – the constituency most connected to Black Oak Lake and the surrounding landscape. People who care are also those who live beyond the watershed boundaries. Some of these people visit Black Oak Lake for recreation and enjoyment. But the audience also includes foundations and other funding agencies, resource and regulatory agencies concerned with environmental quality, and other citizens that are working on their watersheds.

For those in the “grassroots” camp, this plan is intended to provide a practical approach to carrying out protection and restoration of Black Oak Lake. The plan does not have all the answers (it doesn’t even have all the questions). It does not recommend every conceivable rehabilitation or protection action. But the plan does provide plenty with which to get started and leaves room for ideas and contributions from others. Our recipe mixes a pinch of the theoretical with a cupful of the practical. Those of you who are “hands-on” have plenty to do.

The mixed audience of this plan challenges the authors to present a plan that is scientifically grounded and technically oriented, but at the same time accessible and understandable by the public who will in large part be responsible for its implementation. Although scientists are the primary authors of the plan, the writing is aimed at non-scientists. We define terms where clarity is needed and cite other literature for those interested in the source of a statement, or in learning more about the topic. The Foundation has interacted with the plan

writers throughout the process and reviewed draft components of the plan. The Foundation has encouraged our practical approach so that applications of the plan are conspicuous.

We will end this chapter with our strongest management recommendation:

Approach lake and watershed management with humility.

Lake and watershed ecosystems are enormously complex. Our understanding of how they work is not complete. This is even truer when aquatic invasive species are part of the mix. Our ability to predict outcomes from specific actions is uncertain. New discoveries are made every day that have important implications for future watershed management. We may never know all we need, but that fact can't stop us from starting work on Black Oak Lake today. The fact that ecosystems are inherently resilient is to our great advantage. They are able to rebound from disturbance and repair themselves from injury. In fact, some of today's best watershed managers state that "...successful restoration usually has less to do with skillful manipulation of ecosystems than it does with staying out of nature's way" (Williams et al., 1997). This plan is intended to complement nature's own processes.

CHAPTER 3

Why Have the Black Oak Lake Adaptive Management Plan?

Why have the *Black Oak Lake Adaptive Management Plan*? The gut-level answer (“because we care”) was offered in Chapter 2, but the question deserves more thoughtful reflection – the focus of this chapter. This requires consideration of environment, economy, history, and culture. This chapter also defines some important terms and presents the process and underlying assumptions.

Part 1 - Why Should We Care?

The health of a watershed and the health of local economies like those that exist in the Black Oak Lake Watershed are highly integrated. A sustainable economy depends on a healthy environment. In fact all social and economic benefits are based on the biological and physical properties of watersheds (Williams et al., 1997). In fact, our economy should be viewed as being nested inside our environment (Lanoo, 1996).

This link between a healthy environment and the economy is true at several scales. For example, most property owners on Black Oak Lake have invested in an ecosystem. The reasons that they have purchased the property are typically linked to the quality of the environment. The economic value of their investment is linked to the health of the lake and surroundings. If ecological health declines, so does the value of the property.

At a slightly larger scale, this same principal linking the environment and economy applies to municipalities. The surrounding community is caretaker of many ecosystems including Black Oak Lake. The long-term economic health of the municipality is tied to the health of Black Oak Lake and other lakes and streams in the area. At even larger scales yet, this applies to Land O’Lakes Township, Vilas County, the State of Wisconsin, and so on.

The Foundation and this plan aspire to cultivate a deep connection to the lake and its surroundings. It is the people of the watershed that will make the management plan work. Lake and watershed stewardship must be a cultural imperative. In some ways, watershed restoration is about cultural restoration – rejuvenating citizens’ civic responsibility to care for the environment in which they live. This is what Aldo Leopold referred to as “...the oldest task in human history: to live on a piece of land without spoiling it” (Leopold, 1948).

People need to feel vital by working to improve, beautify, or build. Sometimes that need is expressed by gardening, caring for a lawn, or volunteering on civic projects. The Foundation and this plan endeavor to harness that energy and apply it to restoration and protection actions focused on Black Oak Lake and its landscape. Education, rehabilitation, and protection become outlets for this creative energy.

Why should you care about creating and implementing a practical resource plan? Because we realize the economy and the economic options available to citizens in the watershed are tied to a healthy environment. Because we are all connected to the Black Oak Lake landscape in some way. Because we feel a civic responsibility to care for the lake. Because we realize Black Oak Lake potentially affects other lakes. Because we can feel vital by doing meaningful work in the watershed. Because future generations depend on us to hand down a healthy Black Oak Lake ecosystem for them to enjoy and use.

The adaptive management plan will be successful if it allows and organizes meaningful stewardship work for Black Oak Lake. It needs to make provision for different kinds of approaches and different kinds of people who want to be part of the process. It has to be strategic and integrated so that various actions complement one another, and are consistent with the lake's natural processes. The plan should help avoid management actions that work at cross-purposes or whose outcomes are undesirable.

Part 2 - What Is an Adaptive Management Plan?

An adaptive management process (Walters, 1986) is an appropriate model to use in lake and watershed management. In adaptive management, a plan is made and implemented based on the best available information and well-defined goals and objectives. Outcomes of management actions are monitored to ascertain whether they are effective in meeting stated goals and objectives. Based on this evaluation the plan is adapted (modified) in a process of continuous learning and refining.

Adaptive management concedes and confronts a truth that resource managers are sometimes reluctant to acknowledge – uncertainty. Because natural systems are so diverse, so complex, and so variable, almost all management actions will have uncertain outcomes. An adaptive management approach essentially takes a position that says, “We will make our best attempt and get better as we go along. We’ll listen to what the natural system tells us.” In adaptive management, monitoring is crucial. Adaptive management uses information from monitoring to continually evaluate and refine management practices. Monitoring measures the success of restoration or management. Well-designed monitoring should indicate how effectively

management measures are working and give us new insights into ecosystem structure and function. Monitoring should provide needed information to adapt management goals.

The *Black Oak Lake Adaptive Management Plan* can be implemented through five kinds of management actions: protection, rehabilitation, enhancement, education, and research. Research actions have a special subset called “monitoring actions” that serve all of the management actions. Each kind of action is summarized in the following bullets.

- Protection actions are used when high quality areas or ecosystem are identified and need to be safeguarded. Since aspects of Black Oak Lake and its surroundings are quite pristine, part of the Black Oak Lake adaptive management could fall under this kind of action. There are numerous forms that protection actions can take including protecting water quality, conservation easements, buffer zones to prevent runoff into the lake, and so on.
- Rehabilitation actions are those that manipulate site-specific elements of ecosystems in order to repair some past impact. Examples include planting lakeside natural vegetation in areas of erosion, placing fish structure where large woody material has been removed from the lake, or healing an area of active erosion. Individual rehabilitation actions contribute to overall lake and watershed restoration.
- Enhancement actions are intended to improve some function or value of the ecosystem. In some cases, these actions are meant to benefit human users of the lake (for example, enhancing recreation values by planting fish or creating new fish habitat).
- Education actions are those activities that serve to promote lake stewardship and inform people about natural ecosystems. This includes this management plan as an education piece. These actions also include installation of interpretive kiosks or incorporation of Black Oak Lake biology in curricula of area schools. Every person that visits Black Oak Lake is an opportunity for education about healthy ecosystems and impacts to them.
- Research actions are employed to learn about the system being managed. Often we know very little about the plants, animals, habitats, ecosystems, and processes that our management actions are affecting. Research actions on water quality have been ongoing in Black Oak Lake by collecting basic water quality measures. More recently, surveys for aquatic plants have contributed to our understanding of the water resources in Black Oak Lake. Monitoring actions (a subset of research actions) are those that serve to evaluate the outcomes of protection, rehabilitation, enhancement, and education actions. Monitoring actions guide future management.

One word of caution is warranted. Our society typically thinks a long-term planning horizon is twelve months. Unfortunately, this is out of synchrony with the way an ecosystem functions. An ecological clock ticks off time in years, decades, centuries, and even millennia. Lake and watershed management and restoration must be viewed from this perspective. In fact, the final outcomes of some of the good work put in place today might not be apparent until a new generation of lake stewards is on the scene.

Part 3 - What Are the Plan's Underlying Assumptions?

As an adaptive plan, a basic assumption is that the management actions will change over time under the influence of stakeholders. Through iterative refinement, the plan will more closely reflect the needs of the lake and the people who care about it. This plan has assumed a desired condition of sustainable lake health. The plan attempts to reflect the collective vision of the people and organizations that are concerned with the lake and the surroundings. The Foundation, Vilas County Land & Water Conservation Department, the Wisconsin Department of Natural Resources, the community of Land O' Lakes, and those living and recreating in the Black Oak Lake watershed are among these stakeholders.

The Vilas County Land & Water Conservation Department provides a variety of land information and related services including: natural resource and water quality protection information, AIS information and assistance, geographic information, rural addressing, Public Land Survey System and surveying data, property ownership and tax assessment information and mapping products. This office can provide important assistance during subsequent phases of Black Oak Lake stewardship.

At a larger geographic scale, the WDNR published the *Headwaters Basin Integrated Management Plan* (WDNR et al., 2002) that provides a snapshot of current conditions of resources in the larger drainage basin that includes Black Oak Lake. The Plan outlines nineteen issues of concern to the basin, including: control of exotic species, shoreline development, resource inventory and monitoring, habitat loss, user conflicts, and protection of endangered, special concern, or unique species. The Plan identifies Black Oak Lake as an “outstanding resource water” and outlines the various offices and their authorities over the resources in the region (WDNR et al., 2002).

The integrating feature of this lake management plan is Black Oak Lake and its surroundings. The plan assumes that proper planning in the beginning of the process will save time and money throughout the life of the program and can be accomplished by managing the causes rather than (or at least, in addition to) managing the symptoms of any impairments.

CHAPTER 4

How Was the Black Oak Lake Management Plan Made?

In this chapter, we describe the methods that were employed to accomplish these tasks and objectives. A team of consulting scientists (White Water) in consultation with the Foundation prepared this adaptive management plan. The methods that were used followed the goals, objectives, and tasks that were described in grant proposals submitted to the WDNR for various project phases. We describe these methods in this section under descriptive paragraph headings. In cases where a project phase report is included as an appendix, more detailed methodology is included when clarification is needed.

In addition to collecting new data on Black Oak Lake, the overall effort has included gathering, reviewing, and summarizing existing information. This kind of data is found in many repositories and forms: anecdotal accounts of residents, resource agency reports and memos, municipal planning and zoning documents, scientific reports, old and new photographs, best guesses of knowledgeable people, and government records. Not all of the existing information is of equivalent value in the planning process. Some is not verifiable or the methods by which it was collected are unknown.

1. Watershed - Black Oak Lake watershed analysis included delineating the Black Oak Lake watershed area, mapping land cover/use and soils of the watershed; and digital elevation models. This information is discussed further in the *Black Oak Lake Aquatic Plant Management Plan*. We used existing layers of geographic information available from the WDNR and other sources and manipulated these data using geographical information system technology.

2. History – A geologic and human history of the Black Oak Lake area was a significant undertaking in an earlier program phase. It involved (1) researching geologic, glacial, and human history of the area; (2) reviewing original survey records and early homesteading of the watershed; (3) collecting historic photographs; (4) interviewing of lake residents; (5) inventorying existing written information about the Black Oak Lake community; and (6) integrating these findings into a written history. Paul McLeod (Preservation Foundation member and local historian) was responsible for carrying out the tasks in this objective.

3. Water Quality – Over the course of the Black Oak Lake Watershed Protection Program, we have gathered, consolidated, assessed, managed, and interpreted information about Black Oak Lake water quality and potential risks to water quality. Some of this data existed in databases or other records and some was collected as part of various phases of this program.

4. Fisheries - Another project objective was to gather and summarize information about Black Oak Lake fisheries. This objective was fulfilled by reviewing WDNR fisheries reports and interviewing the Vilas County area WDNR fisheries biologists. White Water biologists then summarized this information for inclusion in this adaptive management plan.

5. Aquatic Plants and Aquatic Plant Management Plan - Aquatic plant surveys were conducted on Black Oak Lake in 2006 (by White Water and WDNR) and 2011 (WDNR and lake volunteers) using the WDNR's point-intercept protocol. The data from these surveys allow calculation of ecological metrics such as species richness (number of species), number of sites where a plant species is found, relative percent frequency of species occurrence, frequency of occurrence within vegetated areas, frequency of occurrence at all sites, and maximum depth at which plants are found, Simpson's Diversity Index, and Floristic Quality Index. This data and the subsequent analyses were used in the creation of the *Aquatic Plant Management Plan* component of the *Black Oak Lake Adaptive Management Plan*. The original aquatic plant management plan was prepared in an earlier program phase. In Phase 6, we add an interpretation of the 2011 data and update the entire plan.

6. Rare Species – A consideration of the presence of rare plant and animal species and their habitats is reviewed as part of the overall program.

7. Aquatic Invasive Species – We searched WDNR databases and other accounts for records of aquatic invasive species (AIS) in Black Oak Lake. We also evaluated the lake as potential habitat for AIS based on water quality characteristics.

8. Water Regulations and Planning Relevant to Black Oak Lake - Because other organizations are involved with water resources planning and management in northern Wisconsin, an objective of the planning component of the project was to review recommendations from existing plans (for example, *Headwaters Basin Integrated Management Plan* and/or *Vilas County Land & Water Resources Management Plan*) and review these in the *Black Oak Lake Adaptive*

Management Plan where appropriate. We also reviewed federal, state, and local regulations and ordinances that serve to protect water quality.

9. Black Oak Lake Special Attributes – We have consolidated a list of Black Oak Lake environmental, cultural, and aesthetic attributes that combine to make Black Oak Lake unique. This was developed through collaboration with the Foundation and other Black Oak Lake area stakeholders.

10. Environmental Threats – We outline potential threats to high quality attributes of Black Oak Lake. Some of these threats come from outside influences and some originate closer to home. All are intended to help stakeholders realize where they might have influence in the health of Black Oak Lake.

11. Condition of the Littoral Zone and Riparian Area – In Phase 3, White Water and Black Oak Lake volunteers worked to document the condition of the littoral zone and riparian area of the lake. With assistance from White Water staff, Black Oak Lake volunteers systematically documented the littoral zone and riparian area condition of Black Oak Lake using digital photography. Latitude and longitude coordinates were captured with each photo along with qualitative information about shoreline condition. White Water staff integrated the photos and data into an interactive electronic archive. Also during Phase 3, White Water staff conducted a quantitative assessment of the littoral zone and riparian area of Black Oak Lake using an established USEPA Lake Assessment Procedure combined with the Wisconsin Department of Natural Resources Supplemental Lakeshore Assessment (USEPA. 2007). Following the USEPA procedure, White Water scientists established ten physical habitat (“P-Hab”) stations around Black Oak Lake prior to visiting the field. White Water scientist Dean Premo (assisted by Preservation Foundation member Bob Beedie) recorded measurements. White Water managed and analyzed the data from the quantitative habitat assessment.

12. Protection & Restoration of Riparian Shorelines – Phase 4 of the Black Oak Lake Watershed Protection Program selected sites and formulated plans for several demonstration shoreland restoration projects on Black Oak Lake. This was done by reviewing and analyzing the photographic, qualitative, and quantitative data collected during Phase 3, field visits, and consultation with other resource professionals and stakeholders.

13. Long-term Water Quality & Stage Monitoring – Phase 5 of the Black Oak Lake Watershed Protection Program undertook two main activities: (1) development and implementation of a long-term lake level (lake stage) monitoring program and (2) a review and analysis of recent water chemistry and water transparency data.

14. Collecting and Interpreting Lake Sediment – Aquatic organisms are good indicators of a lake's water quality because they are in direct contact with the water and are strongly affected by the chemical composition of their surroundings. Because of their hard siliceous cell walls, the algae known as diatoms can be identified in the sediment long after they die. In July 2012, Paul Garrison (WDNR) and several Black Oak Lake volunteers collected a sediment core in the deep area (81 feet) of Black Oak Lake. The length of the core was 54 cm. It is assumed that the upper sample represents present day conditions while the deeper sample is indicative of water quality conditions at least 100 years ago. Garrison analyzed the diatom community in two sections of this sample.

15. Ground Water Relations – As part of Phase 6, volunteer lake steward Walt Bates conducted a study of groundwater inflow and outflow from Black Oak Lake. The main tool of this elegant study was a piezometer (actually several piezometers) that Walt fabricated from common hardware store materials including steel conduit, carriage bolts, clear vinyl tubing, electrical tape, and a tape measure/ruler. The piezometers were able to measure the pressure (either negative or positive) of groundwater at a specific point. Walt deployed piezometers at many places around the shoreline of Black Oak Lake to detect areas where ground water was flowing into the lake and areas where it was seeping out of the lake.

An ongoing objective of the Black Oak Lake Watershed Protection Program is to support the educational program efforts. To this end, White Water staff has been available for phone consultation with members of the Foundation and other stakeholders. We endeavored to increase support, capacity, and involvement of the Foundation and other stakeholders in long-term stewardship of Black Oak Lake through communication of project progress and findings.

CHAPTER 5

What is the State of Black Oak Lake and its Watershed?

An understanding of the features and conditions of Black Oak Lake and its landscape is the foundation for developing and implementing strategies that seek to protect and restore the biological health of the area. Over the several year course of the Black Oak Lake Watershed Protection Program, we have sought information useful to devising the lake's adaptive management plan. Future phases will collect and incorporate additional information.

This chapter is intended to teach us about Black Oak Lake. What is the lake like? What is the surrounding landscape? What organisms live here? How healthy is the lake? How have humans contributed to (or detracted from) that health? Do threats to watershed health exist? This chapter identifies and organizes existing information and reports on new findings

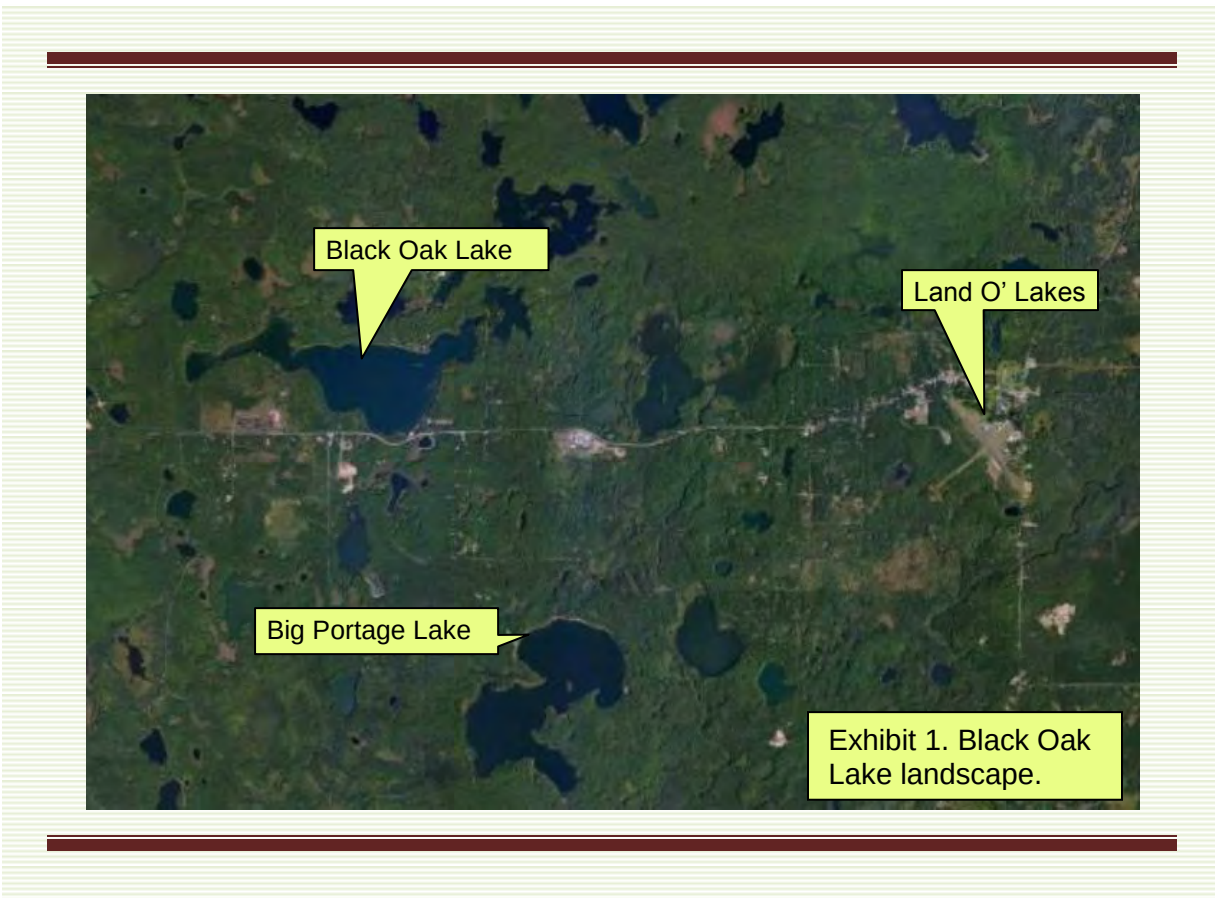
If you are new to Black Oak Lake and its surroundings, this chapter will make you familiar with features and conditions that exist here and provide some insight as to why things are the way they are. If you are a life-long resident of the Black Oak Lake area, you may be familiar with parts of the discussion in this chapter. You may have things to contribute or correct. This would be a welcome response. Become engaged! Improve the understanding of the watershed by adding your knowledge in future iterations of this plan.

We present Chapter 5 in fifteen Parts, each part reflecting the following topics: the lake and surroundings, history, water quality, fisheries, aquatic plants, rare species, aquatic invasive species, water regulations and planning, special attributes, environmental threats, littoral zone and riparian area, protection and restoration of shoreline riparian areas, long-term water quality and stage monitoring, lake sediments, and groundwater relations. Various appendices are referenced from the text.

Part 1. Black Oak Lake and the Surrounding Area

Black Oak Lake is in Vilas County, Wisconsin about 4 miles west of Land O' Lakes, Wisconsin and about 1 mile south of the Michigan-Wisconsin border. Other lakes, both large and small, are in this landscape. This interconnected water landscape is a target for migrating and breeding waterfowl and other birds. Black Oak Lake has value and function in this larger landscape as well as its own watershed.

Black Oak Lake has a 7.4 mile shoreline and 564 acres surface area. There is no State of Wisconsin ownership on the lake. An improved boat ramp allows public access. The lake is fairly developed with permanent homes and cottages, although areas of more natural riparian area also exist. Exhibit 1 shows the Black Oak Lake area and identifies major landmarks. Additional information is contained in the Aquatic Plant Management Plan (Appendix B).



Part 2. Geologic, glacial, and Human History of the Lake

Knowing what Black Oak Lake and the surrounding area were like under more or less natural conditions allows us to better understand the ecosystem. History provides insights as to what conditions are reasonable to establish as goals. This is not to say that this plan aspires to turn back the clock to a time when humans were absent. Humans are here to stay and the plan recognizes that condition. In the past, the Black Oak Lake landscape was molded and influenced by natural disturbances such as fires, blowdowns, floods, beaver, insect outbreaks, and climate. Today's landscape is the result of the combined interaction of human and natural processes, with humans nowadays serving as the most significant agents of change.

During Phase 1 of the Watershed Protection Program, Paul McLeod (Preservation Foundation member and local historian) prepared a history of Black Oak Lake. In Phase 2, Mr. McLeod integrated newly discovered information and photographs into the human and geological history description. The product of this effort is included as Appendix C.

Part 3. Water Quality

Black Oak Lake is listed as an “outstanding resource water (ORW)” by the Wisconsin Legislature. It has a max depth of 85 feet and a complex bathymetry (Exhibit 2). The shoreline development index is a quantitative expression derived from the shape of a lake. It is defined as the ratio of the shoreline length to the length of the circumference of a circle of the same area as the lake. A perfectly round lake has an index of 1. Increasing irregularity of shoreline in the form of embayments and projections of the shore is shown by numbers greater than 1. For example, fjord lakes with extremely irregularly shaped shorelines sometimes have SDI’s exceeding 5. The SDI for Black Oak Lake is 2.2. This number indicates that the lake has a moderate amount of potentially productive littoral zone habitat (shallow water habitat) relative to the overall size of the lake. The littoral zone habitat is important for fish species and other aquatic animals present in the Black Oak Lake ecosystem, and the quality of the littoral zone should be maintained.

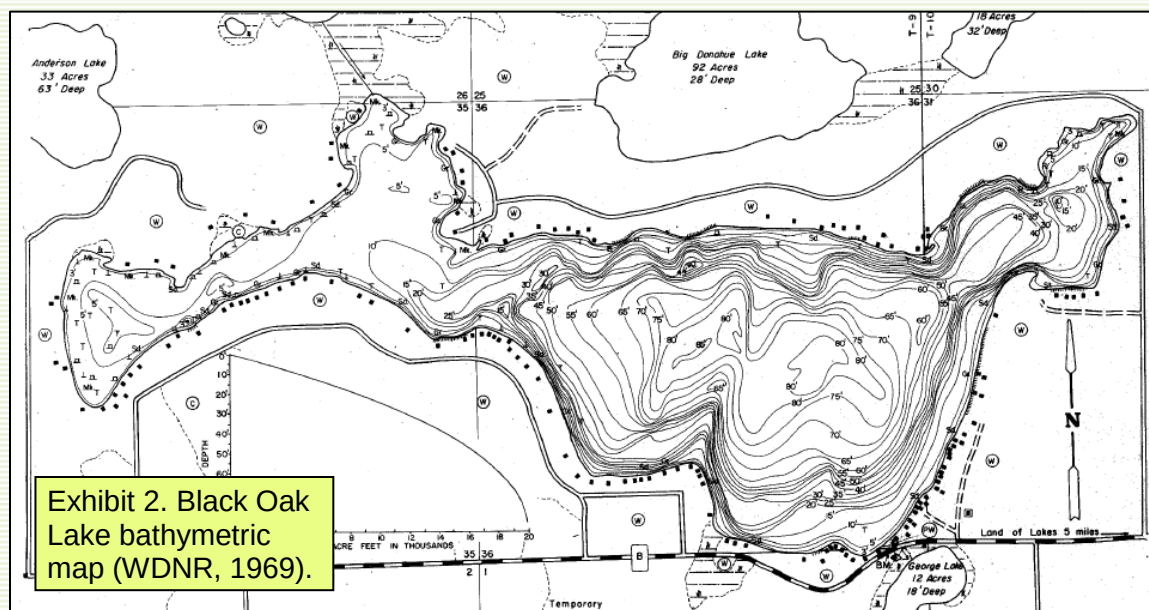


Exhibit 3. Trophic Status

Trophic state of a lake is an indicator of water quality. Lakes are typically divided into three categories of trophic state: oligotrophic, eutrophic, and mesotrophic.

Oligotrophic lakes are clear, deep, and free of weeds or large algal blooms. They are low in nutrients and do not support large fish populations, but they can develop a food web capable of sustaining a desirable fishery.

Eutrophic lakes are high in nutrients and support large biomass (plants and animals). They are usually either weedy or subject to large algal blooms or both. Eutrophic lakes can support large fish populations, but are also susceptible to oxygen depletion. Small, shallow, eutrophic lakes are especially vulnerable to winterkill.

Mesotrophic lakes are intermediate between the oligotrophic and eutrophic. The deepest levels become devoid of oxygen in late summer and limit coldwater fish. Anoxic conditions at the water-sediment interface causes phosphorus to be released from the sediments.

Over long periods of time, lakes go through natural aging from oligotrophic through mesotrophic to eutrophic. As part of this process, they begin to fill in. This aging process can be sped up by introductions of sediments and nutrients. (Shaw et al., 2004).

Existing water quality data has been retrieved from the WDNR SWIMS database from 1973 to 1975, 1984, 1989, and from 2002 to present. Secchi disk measurements were taken by Citizen Lake Monitoring Network (CLMN) volunteers from 2002 to present. Water quality information is briefly summarized in this section, but more fully interpreted in Appendix D.

Temperature and dissolved oxygen showed stratification in Black Oak Lake in the ice-free season. Average water clarity is considered “excellent” and user perception of Black Oak Lake aesthetic quality is generally regarded as “beautiful, could not be nicer.” Turbidity is generally low. The trophic state is oligotrophic. Such lakes (Exhibit

3) typically have low nutrients. They generally cannot support large fish populations, but can develop a food web capable of sustaining a desirable fishery. Oligotrophic lakes are usually clear, deep and free of weeds or large algal blooms. Water quality would be classified as “very good” with respect to phosphorus concentrations. Chlorophyll *a* (a measure of the amount of algae) nitrogen, chloride, hardness, alkalinity, conductivity, calcium, magnesium, sodium, and potassium are considered low. The pH of Black Oak Lake is considered neutral (7.2).

Part 4. Black Oak Lake Fisheries

Black Oak Lake has a diverse fish community including walleye, largemouth bass, smallmouth bass, brown trout, lake trout, cisco, northern pike, bluegill, pumpkinseed, yellow perch, rock bass, white sucker, bluntnose minnow, and black bullhead. Like most lakes, the

natural fish community has been augmented by stocking. Available stocking records (see Appendix E) for Black Oak Lake extend back to 1951. Introduced fish species includes lake trout, brown trout, rainbow trout, brook trout, coho salmon, splake, walleye, largemouth bass, smallmouth bass, bluegills, yellow perch, and black crappie. Many of these species are not native to the lake. Walleye have been the most aggressively managed fish in Black Oak Lake (documentation in Appendix E). The primary recruitment source for this fish is from stocking and recent surveys indicate that there is a fairly high density of large adult fish. The high density of this piscivorous fish has a significant effect on other fish species in the lake, through both direct predation and competition for food.

Black Oak Lake is one of two lakes in Wisconsin (nearby Trout Lake is the other) that harbors inland populations of self-sustaining lake trout (Piller et al. 2005). These two populations represent the only two extant populations of lake trout indigenous to the Upper Mississippi River Basin. Recent genetic testing has shown the Black Oak Lake population to be genetically distinct from all others. Thus, the Black Oak Lake's population of lake trout represents an absolutely unique part of the world's biodiversity.

This recent genetic testing of lake trout from Black Oak Lake (see Piller et al 2005) indicates that the strain has remained pure in spite of continued introduction of non-native lake trout strains. The management implications of these findings are significant. The genetically distinct population of lake trout in Black Oak Lake should be given a high level of protection (Piller et al 2005) and a strong effort should be undertaken to guard against additional human-caused impacts (over-fishing, habitat loss, and genetic degradation by way of lake trout stocking).

In an effort to safeguard the unique lake trout of Black Oak Lake the WDNR netted fish in the fall of 2005 and collected gametes (eggs and milt) prior to releasing the fish. The eggs were fertilized and raised to fry in the hatchery. Fry were then planted in Big Carr Lake (Oneida County), Long Lake (Vilas County), and Lucerne Lake (Forest County).

Black Oak Lake's lake trout population receives management attention through management effort directed specifically at Black Oak Lake and through statewide lake trout management planning. Appendix E contains documentation for these efforts. Population estimates for lake trout in Black Oak Lake are uncertain (latest estimates put the population at under 1,000 individuals). Recaptured marked individuals demonstrated very slow growth rates. There is some concern by the WDNR that the increasing walleye populations (especially those fish over 20 inches) will significantly compete with lake trout for forage (primarily ciscoes) and will directly consume juvenile lake trout. A 2003 Fisheries Rule Development Proposal (see

Appendix E) called for an increased size limit on lake trout in Black Oak Lake in order to protect a greater proportion of the population from harvest. The 2002 Lake Trout Management Report for Black Oak Lake (see Appendix E) states that, “Preservation of this unique lake trout resource should be the top management priority for Black Oak Lake. Walleye stocking may need to be re-evaluated should the lake trout population begin to decline.”

The Foundation has been keenly interested in lake trout management on Black Oak Lake. The organization articulated its position in a letter (8/12/05) to Wes Jahns (WDNR Fisheries). The letter was reviewed at the August 11, 2005 meeting of the Foundation Board of Directors the Board voted 10-0 to support this position. The letter is reprinted in Appendix E.

As of late fall 2006, e-mail correspondence of WDNR Fish Biologist Stephen Gilbert (contained in Appendix E) stated the goal of needing to balance the lake trout and walleye fisheries with the available forage (ciscoes) in Black Oak Lake. He stated that the best way to do this is with fishing regulations and controlling walleye stocking. The WDNR goal is to maintain the Lake Trout adult numbers at 0.5 or better per acre and keep the adult walleye numbers more in the 1.5 per acre range. By this approach, the WDNR hopes to maintain the trout fishery, provide a trophy walleye fishery, and keep the cisco population healthy. WDNR and Great Lakes Indian Fish & Wildlife Commission conduct periodic surveys to monitor walleye. This monitoring helps the WDNR determine status of the fishery and decide walleye stocking levels and/or regulations.

Part 5. Aquatic Plants and Aquatic Plant Management Plan

As far as we can determine, no systematic or large-scale plant management activity has ever taken place in Black Oak Lake. Over the years, no particular aquatic plant nuisance issues have demanded control action. Aquatic plant surveys were conducted on Black Oak Lake in 2006 and in 2011 by White Water (2006) and WDNR (2006 and 2011) biologists. In both surveys, the aquatic plant community was diverse and had high floristic quality. These findings support the contention that the Black Oak Lake plant community is healthy and diverse. The surveys are discussed in more detail in the Black Oak Lake Aquatic Plant Management Plan (APMP), including tables, figures, and maps. The APMP is provided in Appendix B.

Part 6. Rare Species

Black Oak Lake provides habitat for rare species such as common loon, bald eagle, and Farwell milfoil (a native aquatic plant). Common loons frequently use the lake as a fishery during the nesting season and often several individuals are seen on the lake actively feeding. An active and historically successful bald eagle nest exists in the riparian area of Black Oak Lake and the adults and juveniles use the lake for fishing. As mentioned in the previous section, a Wisconsin Special Concern plant, Farwell's water milfoil (*Myriophyllum farwellii*) was identified in a 2001 aquatic vegetation survey, but not located in 2006. Perhaps the most unique biotic element of the Black Oak Lake ecosystem is the indigenous strain of lake trout. The presence of these rare elements is an additional indicator of the high quality of Black Oak Lake and strengthens the case for why the lake should have a plan in place that protects this unusual and healthy ecosystem.

Part 7. Aquatic Invasive Species

Since 1990, only one aquatic invasive species has been found in Black Oak Lake: rusty crayfish (*Orconectes rusticus*). Rusty crayfish are native to parts of Ohio, Tennessee, Kentucky and Indiana, and were likely introduced to Wisconsin waters by fishermen using the crayfish as bait (Gunderson, 2008). Rusty crayfish negatively affect other native crayfish species, cause destruction to aquatic plant beds, reduce fish populations by eating eggs, and cause shoreland owners recreational problems (Gunderson, 2008). It is illegal to possess both live crayfish and angling equipment simultaneously on any inland Wisconsin water (except Mississippi River) (WDNR, 2012). It is also illegal to release crayfish into a water body without a permit (WDNR, 2012). The water chemistry is such that successful zebra mussel colonization would be unlikely. The review of water quality (Appendix C) provides more discussion on the suitability of Black Oak Lake for zebra mussel colonization. No aquatic invasive plant species have been found in Black Oak Lake. The Aquatic Plant Management Plan provides a rapid response plan for the discovery of an aquatic invasive plant species.

Part 8. Water Resource Regulations and Planning Relevant to Black Oak Lake

For the purposes of this plan we reviewed documents of other organizations involved with water resources regulations, planning, and management in northern Wisconsin. Appendix F contains our documentation of these reviews and provides substantive information on (1) federal, state, and county regulations and ordinances that influence water quality, (2) WDNR programs that strive to preserve and restore land and water resources (including Fisheries Management and

Habitat Protection, Watershed, Wastewater, Nonpoint Source Pollution Abatement, Drinking and Groundwater, Wildlife, Endangered Resources, and Forestry), and (3) a review of the *Vilas County Land & Water Resource Management Plan* (Vilas County Land & Water Conservation Department, 2009). These reviews discuss federal, state, and local agencies and the mechanisms by which they protect water resources. The discussion ranges from the federal Clean Water Act of 1972 to Wisconsin's NR115 to Vilas County ordinances.

Part 9. Black Oak Lake Area Special Attributes

Black Oak Lake and the surroundings harbor special attributes that make the area attractive to both humans and other organisms. Environmental quality attributes can be organized in three categories: (1) environmental (ecological), (2) cultural and (3) aesthetic (Redding, 1973). Some resources may display all three conditions and others may contain only one. More complete definitions (Redding, 1973) of the three categories are as follows:

1. Environmental (ecological) attributes are components of the environment and the interactions among all its living and nonliving components that directly or indirectly sustain dynamic, diverse, and viable ecosystems. Included are functional and structural aspects of the environment.
2. Cultural attributes are evidence of past and present habitation that can be used to reconstruct or preserve human lifeways. Included are structures, sites, artifacts, and environments.
3. Aesthetic attributes are perceptual stimuli that provide diverse and pleasant surroundings for human annulment and appreciation. Included are sights, sounds, scents, tastes, and tactile impressions.

The first two attributes (ecological and cultural) are more tangible than the third but aesthetic attributes are important when it comes to how people feel about a feature and are compelled to protect a feature or otherwise act as stewards. The importance of preserving aesthetic resources is emphatically expressed in the National Environmental Policy Act 1969 that requires the "Federal Government to use all practicable means (to) assure for all Americans safe, healthful, productive, and aesthetically and culturally pleasing surroundings... and to... preserve important historic, cultural, and natural aspects of our national heritage, and maintain, wherever possible, an environment which supports diversity and variety of individual choice" (NEPA Sec. 101 (b) (2, 4)). Aesthetic quality is a subjective attribute. What has high aesthetic value for one person may not receive the same consideration from another. Some hold

high aesthetic value in a manicured lawn where others prefer a more natural ground cover. Aldo Leopold (1948) expresses his love for nature and its beauty and the need for a land ethic to protect natural beauty and “quality of life.”

As has been outlined in various parts of this Adaptive Management Plan, Black Oak Lake is a high quality ecosystem with respect to components of water quality, aquatic plants, fish community, and wildlife habitat. These attributes combine to influence a high aesthetic quality. The next part outlines some of the potential environmental threats to this high quality.

Part 10. Environmental Threats

These environmental attributes of Black Oak Lake combine to make it a unique and special place. Black Oak Lake and its surroundings, however, are subject to environmental threats from a variety of sources. We outline some of these threats in this part of the Black Oak Lake plan.

Recreational pressure – Black Oak Lake is a well-known and much-loved fishing and water recreation lake for people from near and far. An expanding base of admirers will result in increasing recreational pressures. Increased traffic in and out of the lake increases opportunities for AIS.

Development pressure – Black Oak Lake has some areas of residential development as well as areas with predominantly natural vegetation and broad and diverse riparian areas. In some areas of the lake, old-style lawns, cropped short and in close proximity to the shore indicate a need for some educational effort to inform residents about more ecologically friendly waterfront vegetation. Likewise, well-intended activities meant to “clean up” the shoreline or shallow water zone of the lake diminishes the habitat quality for invertebrates and fish.

Water quality inputs – The water quality and aquatic ecosystem functioning of Black Oak Lake is affected by all inputs of water (groundwater, precipitation, and overland runoff). All of these sources have potential to carry pollutants of various kinds to Black Oak Lake. Black Oak Lake has outstanding water quality and a long record of water quality monitoring. Non-point source pollution (see next paragraph) remains an important threat to Black Oak Lake water quality.

Non-point source pollution – Surface runoff from the land, roadways, parking lots and other surfaces flows into Black Oak Lake. This runoff carries with it sediment, nutrients (for example, from fertilizers) and contaminants (for example, herbicides) that can have detrimental effects on the Black Oak Lake ecosystem. Known as non-point source pollution (because it does not

emanate from a discrete point like an effluent pipe from a paper mill), this kind of runoff can come from lawns, agricultural fields, clear-cuts, and impervious surfaces (for example, roads and paved parking lots). Sometimes the impact is physical, such as sediment covering gravel spawning areas. Sometimes it is chemical such as excess phosphorus from lawn fertilizers that might invoke an algal bloom. This type of pollution can be best controlled through education and protection of riparian buffers (natural vegetation near the waterways that absorb the pollutants before they reach the water).

Aquatic invasive species – Non-native plant and animal species have become a grave concern for aquatic, wetland, and terrestrial ecosystems. When it comes to non-native aquatic plant invaders, the best defense against establishment is a healthy community of native plants. A diverse native plant community presently exists in Black Oak Lake. Effective education and diligent monitoring are important factors in avoiding establishment of aquatic invasive species.

Riparian ecosystem integrity – Healthy riparian areas (the naturally vegetated land near the water) provide numerous important functions and values to Black Oak Lake. For example, they serve as habitat for many species, contribute important habitat to the lake (e.g., large wood), filter out non-point source pollution from entering the lake, and armors the shores against erosion. Educating riparian owners around Black Oak Lake as to the importance of riparian areas is crucial to the maintenance of these critical areas.

Littoral zone ecosystem quality – Much of the productivity of a lake comes from the shallow water areas known as the littoral zone. This is where plants grow, invertebrates live, fishes spawn, and aquatic birds and mammals spend much of their time. The presence of good aquatic vegetation, diverse substrate, and dead woody material (logs and branches) is crucial to this littoral zone ecosystem. Sometimes the human temptation is to “clean up” these areas, but in fact this process diminishes the habitat quality greatly. It is important to educate landowners and others about how to protect the littoral zone from degradation. Piers and swimming areas impact the littoral zone as well, but can coexist with a quality shallow water habitat if kept to a reasonable level.

Habitat degradation of nearby aquatic and wetland habitats (ponds, streams) – The wetland habitats, streams, small lakes, and ponds in the vicinity of Black Oak Lake all contribute to the high quality of the lake. These smaller ecosystems can be overlooked in terms of their importance and therefore deserve some special attention. One of the first protective measures to

take is to identify where these features are and characterize their size and ecological composition. This informs future protection and restoration efforts.

Part 11. Condition of Littoral Zone and Riparian Area

In Phase 3 of the Black Oak Lake Watershed Protection Program, lake volunteers and White Water scientists documented the condition of the littoral zone and riparian area by photography, qualitative assessment, and quantitative assessment. The results of these efforts are reported in Appendix G (qualitative findings), and Appendix H (quantitative findings), and Appendix I (photos of quantitative study plots).

Part 12. Protection & Restoration of Riparian Shorelines

Phase 4 of the Black Oak Lake Watershed Protection Program identified areas of potential riparian area restoration for protecting Black Oak Lake water quality and habitat. This Phase also developed restoration plans for several candidate sites. The entire Phase 4 report is contained in Appendix J. Subsequent discussions involving WDNR, White Water Associates, and the Foundation have resulted in a decision to refine the plans further before an implementation phase.

Part 13. Long-term Water Quality and Stage Monitoring

Phase 5 of the Black Oak Lake Watershed Protection Program undertook two important activities: (1) development and implementation of a long-term lake level (lake stage) monitoring program and (2) a review and analysis of recent water chemistry and water transparency data. The entire Phase 5 report is contained in Appendix K.

Part 14. Reading the Story in Black Oak Lake Sediments

WDNR scientist Paul Garrison interpreted sediment samples and prepared reports of his findings for both phytoplankton (diatoms) and zooplankton. These reports are included in Appendix L.

Part 15. Ground Water Relations

A report of the piezometer ground water study is provided in Appendix M.

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CHAPTER 6

What Goals Guide the Black Oak Lake Adaptive Management Plan?

“Protect the Best and Restore the Rest” has become the credo of successful watershed managers across the country. This simple phrase acknowledges that watershed management is more than identifying the worst areas and trying to rehabilitate them. It recognizes that of equal or greater importance is identifying those areas that are of high or moderate quality in the watershed and establishing mechanisms to maintain that quality. “Protect the Best and Restore the Rest” also implies the importance of identifying imminent threats to watershed health and working to eliminate them. This simple principal is founded on the restoration ecology fact that the most certain way to successfully restore the structure and function of part of a broken watershed ecosystem is to rely on intact areas of the watershed to serve as the donors of healthy “parts” (such as aquatic insect species or good quality water). “Protecting the Best” allows us to “Restore the Rest” more effectively and economically. But, protecting the best is prerequisite.

The primary goal of the *Black Oak Lake Adaptive Management Plan* is to perpetuate the quality of Black Oak Lake and its watershed ecosystem into the future. Sometimes this will mean protecting what is good about the lake and its surroundings and sometimes it may mean restoring some feature that has been degraded. Restoration is reestablishment of the structure and function of an ecosystem including its natural diversity (Cairns, 1988; National Research Council, 1992). It implies rehabilitating and protecting sufficient components of the ecosystem so that it functions in a more or less natural way, provides habitat for native plants and animals, and supports reasonable human uses.

The *Black Oak Lake Adaptive Management Plan* offers several supporting goals. In an adaptive plan, new goals can be adopted as the plan evolves. We conclude this chapter by presenting these goals organized under topical headings.

Restoration – Apply rehabilitation, protection, and education actions under the direction of specific objectives identified for specific areas in the Black Oak Lake watershed.

Research – Gather information that is useful in planning and monitoring restoration actions and devising education programs.

Monitoring – Establish a monitoring system in the Black Oak Lake watershed that will provide data that reveals the quality of the system and establishes methods to evaluate the effectiveness of management efforts.

Cultural Climate – Encourage a cultural and political atmosphere that allows and promotes good watershed stewardship including cooperation between citizens, businesses, public agencies, and municipalities.

Sustainable Economy – Foster an environment that promotes a sustainable economy, provides a diversity of economic options for the residents of the watershed, and does not diminish opportunities for future generations of watershed residents.

Recreation – Promote a sustainable recreation in Black Oak Lake where all citizens (now and in the future) can enjoy the opportunities of the natural and human-sustained environment while respecting the environment and the rights of fellow citizens.

Program Maintenance – Foster a stewardship culture that engages people to donate time, talent, and money sufficient to support the implementation and periodic update of the *Black Oak Lake Adaptive Management Plan*.

In the final chapter of this plan, we present possible objectives and actions that will serve to move toward these goals. This is not an exhaustive treatment, but a starting point, integrated with monitoring so that adaptive management can take place in subsequent years.

CHAPTER 7

What Objectives and Actions Move Us Toward Our Goals?

The Black Oak Lake watershed is healthy, diverse, and productive. Our challenge through this adaptive management plan is to perpetuate that condition into the future. The challenge will be met by a capable set of program partners that are prepared to devote themselves to Black Oak Lake stewardship. These partners include the members of the Foundation, the Vilas County Land & Water Conservation Department, the ecological scientists of White Water Associates, Inc., the WDNR, and others who care about Black Oak Lake.

Abraham Lincoln is attributed with the following wisdom: “If I had an hour to cut down a tree, I’d spend the first 45 minutes sharpening my ax.” Planning and preparation are important for any task, but especially when working with a system as complex as a lake or watershed. The vision and goals described in the previous chapter provide the basis for developing objectives and actions to achieve the desired future for the Black Oak Lake watershed. In keeping with the spirit of an adaptive management plan, we present several actions and associated objectives that can be undertaken as human and financial resources allow in subsequent phases of the program. Desired outcomes of each action are also stated. The actions, objectives, and outcomes each need to be further developed so that appropriate methodology and accurate estimates of required effort can be described. The Foundation is in control of the plan. The plan is flexible and allows the insertion of new actions at any point along the path of lake management. The pace of implementation of the plan is also flexible and will be influenced by availability of volunteer time, grant monies, and other factors.

Recommended Actions for the Black Oak Lake Adaptive Management Plan

Action (Research): Conduct several temperature and dissolved oxygen profiles over the annual cycle in Black Oak Lake.

Objective: To develop a better understanding of available and usable lake trout habitat in Black Oak Lake.

Monitoring: The Preservation Foundation oversees activity and maintains data.

Status: Ongoing.

Action (Education): Work closely with the WDNR to understand and manage the lake trout population in Black Oak Lake. Support the WDNR in the goal of not introducing new genetic material into the lake in the form of outside lake trout strains.

Objective: To support scientific and aggressive protection of lake trout in Black Oak Lake.

Monitoring: Document the meetings and other contacts made to the WDNR and others.

Status: Ongoing.

Action (Research): Conduct an assessment of rusty crayfish distribution and population within Black Oak Lake. This could be conducted by an advanced science project at Conserve School or graduate student project.

Objective: To understand the potential impact represented by this exotic species.

Monitoring: A written report should document the findings.

Status: WDNR conducted this assessment and it is documented on the Foundation website.

Action (Research): Conduct a survey of amphibians that use Black Oak Lake and its riparian area as habitat.

Objective: To fulfill an information deficit for the Black Oak Lake area on amphibians.

Monitoring: A written report should document the findings.

Status: Not yet undertaken.

Action (Education): Establish a kiosk at the public beach/boat launch that describes the dangers of non-native species introductions to Black Oak Lake and outlines how such introductions can be minimized.

Objective: Prevent new introductions of non-native species to Black Oak Lake.

Monitoring: Document that the kiosk is maintained with literature and educational material.

Status: Completed.

Recommended Actions for the Black Oak Lake Adaptive Management Plan

Action (Research): Conduct periodic assessments of Black Oak Lake for non-native aquatic plants.

Objective: To provide an early warning of introductions of non-native plant species to allow rehabilitation actions to occur when populations are still small.

Monitoring: Document the number and timing of surveys and maintain record of findings.

Status: Ongoing.

Action: (Research): Conduct an assessment of aquatic invertebrates in the littoral zone (shallow water) habitats of Black Oak Lake.

Objective: To determine the diversity of the aquatic invertebrate community and help establish a baseline for future monitoring of this important component of the Black Oak Lake ecosystem.

Monitoring: A written report should document the findings.

Status: Completed as part of the 2008 project.

Action: (Research): Conduct a survey of small littoral zone fishes (minnows and game fish young) in Black Oak Lake by major lake areas.

Objective: To understand the diversity of this component of the fish community and assess how it contributes to the lake ecosystem (for example as food for larger fish).

Monitoring: A written report should document the findings.

Status: Not yet undertaken.

Action (Research): Conduct careful mapping of selected patches of aquatic macrophytes, including species present and relative abundances. As an example, the population of purple bladderwort would be an appropriate subject for this kind of focused study.

Objective: To establish a baseline for monitoring changes in aquatic vegetation in the lake.

Monitoring: A written report should document the findings along with a methodology for follow up monitoring.

Status: The baseline efforts for this action were completed as part of the point-intercept plant surveys.

Action (Research): Periodically repeat point-intercept aquatic plant surveys.

Objective: To monitor changes in aquatic vegetation in the lake.

Monitoring: A written report should document the findings along with a methodology for follow up monitoring.

Status: Anticipated in 2016.

Recommended Actions for the Black Oak Lake Adaptive Management Plan

Action (Research): Continue to track Secchi Depth transparencies.

Objective: To understand the causes of an apparent dramatic increase in lake transparency.

Monitoring: A written report should document the findings along with a methodology for follow up monitoring.

Status: Ongoing.

Action (Research): Identify and map (with inclusion in the GIS project) important wetlands within the Black Oak Lake watershed.

Objective: To protect and monitor the health of important wetlands that influence Black Oak Lake.

Monitoring: A written report should document the findings along with a methodology for follow up monitoring. The findings should be databased in the GIS project.

Status: Not yet undertaken.

Action (Support): Develop a system that helps to organize and coordinate the many kinds of actions that will take place on the Black Oak Lake.

Objective: To organize and track projects and archive findings in a single repository.

Monitoring: The Preservation Foundation should oversee and document this process.

Status: Not yet undertaken.

Action (Research): Document the state of development of the Black Oak Lake Shoreline using digital photography. This documentation should include a count of piers along the Black Oak Lake shoreline.

Objective: To create a baseline for today's state of shoreline development against which to monitor long term changes.

Monitoring: The findings should be documented in a report.

Status: Completed in 2008.

Action (Research): Document the plant species in the riparian area of Black Oak Lake.

Objective: To establish a baseline of the native and non-native plant species present in the landscape and assist future monitoring of alien plant establishment.

Monitoring: The findings should be documented in a report and databased in the GIS project.

Status: Not yet undertaken, although qualitatively addressed in the 2008 project.

Recommended Actions for the Black Oak Lake Adaptive Management Plan

Action (Rehabilitation): In consultation with the WDNR (Mike Meyer), check on the feasibility of adding loon nesting habitat in the form of artificial floating island(s) to appropriate site(s) in Black Oak Lake. If feasible, install.

Objective: To encourage use of Black Oak Lake for breeding of common loons.

Monitoring: Monitor loon use of the artificial island(s).

Status: Not yet undertaken.

Action (Education): Establish an award or recognition of riparian owners that preserve or rehabilitate “natural shoreline” habitat on their property. This could be recognized in the Preservation Foundation newsletter along with an article about the ecological benefits of natural shorelines.

Objective: To encourage good shoreline stewardship by riparian owners.

Monitoring: Monitor by general awareness of landowners and changes in shoreline maintenance behavior.

Status: Not yet undertaken.

Action (Research): Undertake additional research on habitat, life history, and population structure of the lake trout in Black Oak Lake. (Most likely undertaken by WDNR or university researchers).

Objective: To understand more about the viability and threats to this rare population.

Monitoring: Results would be documented in agency reports or peer-reviewed publications.

Status: Not yet undertaken.

Action (Research): Continue with the volunteer lake monitoring program.

Objective: To establish a long-term record of basic water quality in Black Oak Lake.

Monitoring: Results will be documented in WDNR reports.

Status: Ongoing.

Action (Research): Periodically summarize and analyze the Self Help water quality data for Black Oak Lake to keep up-to-date.

Objective: To understand the long-term basic water quality in Black Oak Lake and plan any necessary remediation if poor water quality trends are observed.

Monitoring: Results will be reported in future iterations of the adaptive management plan.

Status: Appendix C of this report updates the water quality information through 2013.

Recommended Actions for the Black Oak Lake Adaptive Management Plan

Action (Protection): Develop limnological, ecological, and sociological indicators for future monitoring. This was originally planned for Phase 1, but is recommended for the future phases as additional information is available.

Objective: To establish measurable benchmarks against which long term monitoring can be measured.

Monitoring: Develop a written protocol describing indicators and how they are to be measured and monitored.

Status: Not yet undertaken.

Action (Research): Integrate new information into the GIS project where appropriate.

Objective: To store and analyze geographically based environmental data.

Monitoring: Each year new map products and information reports can be produced to monitor progress.

Status: Not yet undertaken.

Action (Research): Continue to monitor lake stage and input data in SWIMS database.

Objective: To track and understand long term lake levels.

Monitoring: Periodically summarize data. Maintain correspondence with WDNR regarding innovations in stage level monitoring protocol.

Status: Ongoing.

Action (Research): Investigate possible analyses of Black Oak Lake sediment core sample taken in July 2012.

Objective: To relate historical data found in Black Oak Lake sediment to understanding current conditions (especially as it relates to trophic state and water clarity issues).

Monitoring: New findings from sediment core analyses should be reported on a periodic basis.

Status: A sediment core sample taken in July 2012. Appendix L of this Adaptive Plan reports the results.

Recommended Actions for the Black Oak Lake Adaptive Management Plan

Action (Research): Design and implement a food chain study for Black Oak Lake that focuses on primary producers (algae) and herbivores (zooplankton) as a way of further understanding the dynamics of water transparency in the lake.

Objective: To further understand dynamics of water transparency in Black Oak Lake.

Monitoring: Document the investigation in reports to be included in future versions of the Adaptive Management Plan.

Status: Not yet undertaken.

Action (Education): Plan and deliver a workshop to Black Oak Lake stewards on riparian and littoral zone ecology and health.

Objective: To inform lake stewards and residents about the importance of riparian and littoral zone to the lake ecosystem.

Monitoring: Summarize workshop content and outcome in Adaptive Management Plan.

Status: Not yet undertaken.

Action (Protection): Continue Clean Boats / Clean Waters program on Black Oak Lake.

Objective: To minimize opportunities for AIS to be introduced and establish in the lake and to educate boaters and recreationists about AIS transfer and impacts.

Monitoring: Input collected data on CB/CW at Black Oak Lake into the WDNR database for periodic review.

Status: Ongoing.

Action (Rehabilitation): Continue to work with the WDNR on possible implementation of restoration projects (initially recommended in Phase 4 of the program).

Objective: To rehabilitate riparian and shoreline habitat and protect water quality and habitat of Black Oak Lake.

Monitoring: As projects are implemented monitor establishment of plantings and efficacy of the outcome. Report in future iterations of the Adaptive Management Plan.

Status: Not yet undertaken.

Recommended Actions for the Black Oak Lake Adaptive Management Plan

Action (Research): Create and distribute a Black Oak Lake user survey.

Objective: To better understand Black Oak Lake stakeholders' understanding of the lake, impressions of lake attributes and individual views of a desired future condition for Black Oak Lake.

Monitoring: User survey findings should be analyzed and reported in future iterations of the Adaptive Management Plan.

Status: Not yet undertaken.

Action (Protection): Adopt and implement the Aquatic Plant Management Plan prepared as result of the current project.

Objective: To protect and maintain a high quality aquatic plant community in Black Oak Lake, and reduce opportunities for introduction of aquatic invasive plant species.

Outcome: A healthy, diverse Black Oak Lake aquatic plant community and a human community that is actively engaged in monitoring and protecting native aquatic plants.

Status: Action included Adaptive Management Plan. The Aquatic Plant Management Plan is intended for adoption in 2014.

Future phases of Black Oak Lake Stewardship will build on the foundation established in this *Adaptive Management Plan*. Additional aspects of the Black Oak Lake watershed ecosystem will be explored. Future phases will include revisions to the lake management plan, and the aquatic plant management plan.

Black Oak Lake and its watershed serve its human residents well. But, in order for future generations to enjoy all that the watershed can provide, this adaptive plan should be embraced, developed, and implemented. It may seem slow at first, but considerable momentum already exists because of the hard work that has already occurred.

Appendix A

Literature Cited

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Literature Cited

- Cairns, J. Jr. 1988. *Increasing diversity by restoring damaged ecosystems*. Pages 333-343 in E.O. Wilson, editor. *Biodiversity*. National Academy Press, Washington, DC.
- Gunderson, Jeff. 2008. *Rusty Crayfish: A Nasty Invader*. Minnesota Sea Grant. Retrieved 2013. <http://www.seagrant.umn.edu/ais/rustycrayfish_invader>
- Lanoo, Michael J. 1996. *Okoboji Wetlands – A Lesson in Natural History*. University of Iowa Press. 156 pages.
- Leopold, Aldo. 1948. *A Sand County Almanac and Sketches Here and There*. Oxford University Press, New York.
- National Environmental Policy Act (NEPA). 1969. Public Law 91-190, 83 Stat. 852-856.
- National Research Council. 1992. *Restoration of aquatic ecosystems: science, technology, and public policy*. National Academy Press, Washington, DC
- Piller, Kyle R., Chris C. Wilson, Carol Eunmi Lee, and John Lyons. 2005. Conservation Genetics of Inland Lake Trout in the Upper Mississippi River Basin: Stocked or Native Ancestry? *Transactions of the American Fisheries Society* 134:789–802. At: http://www.selu.edu/Academics/Faculty/kpiller/pdfs/Piller_et_al_2005.pdf.
- Redding, Martin J. 1973. *Aesthetics in Environmental Planning*. Office of Research and Development. U.S. EPA EPA-600/5-73-009.
- Shaw, B. Mechenich, C, and Klessig, L. 2004. *Understanding Lake Data (G3582)*. Board of Regents of the University of Wisconsin System. Madison, WI.
- USEPA. 2007. Survey of the Nation's Lakes. Field Operations Manual. EPA 841-B-07-004. U.S. Environmental Protection Agency, Washington, DC.).

Vilas County Land & Water Conservation Department. September 2009. *Vilas County Land and Water Resource Management Plan*. Retrieved 2014.

<http://www.ncwrpc.org/vilas/lwrmp/2010-2015_LWRM_plan_NoMaps.pdf>

Walters, C. 1986. *Objectives, constraints, and problem bounding*. In W.M. Getz, ed., *Adaptive Management of Renewable Resources*. Macmillan Publishing Company. New York. p. 13+.

Williams, Jack E., Christopher A. Wood, and Michael P. Dombeck, eds. 1997. *Watershed Restoration: Principles and Practices*. American Fisheries Society, Bethesda, Maryland.

Wisconsin Department of Natural Resources. 1969. *Lake Survey Map-Black Oak Lake*. Retrieved 2013. <<http://dnr.wi.gov/lakes/maps/DNR/1630100a.pdf>>

Wisconsin Department of Natural Resources, Headwaters Basin Partnership Team and Stakeholders--DRAFT. 2002. *Headwaters Basin Integrated Management Plan*. Retrieved 2013. 259 pages. <<http://dnr.wi.gov/water/basin/upwis/>>

Wisconsin Department of Natural Resources. 2012. *Rusty Crayfish-Round Lake*. Retrieved 2013. <<http://dnr.wi.gov/lakes/invasives/AISDetail.aspx?roiseq=22588740>>



Appendix B

Black Oak Lake Aquatic Plant Management Plan

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Black Oak Lake Watershed Protection Program:

Black Oak Lake Aquatic Plant Management Plan

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Black Oak Lake Watershed Protection Program: Black Oak Lake Aquatic Plant Management Plan

**This plan is a product of a WDNR Large Scale Lake
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CHAPTER 1

Introduction

The ***Black Oak Lake Watershed Protection Program*** results from the efforts of the Black Oak Lake Preservation Foundation (formerly the Black Oak Lake Riparian Owners Association). The Black Oak Lake Preservation Foundation (BOLPF) views lake stewardship as an ongoing endeavor that considers not just the lake, but all that potentially influences it. This perspective accommodates the appropriate range of geographic scales from which to approach lake stewardship: from “lake specific” to a waterscape-wide awareness.

This aquatic plant management plan addresses Black Oak Lake through a waterscape perspective. This is especially important when it comes to preventing introduction and establishment of aquatic invasive species (AIS). The closely related ***Black Oak Lake Adaptive Management Plan*** (Premo et al., 2014) provides additional overarching waterscape level examination that allows greater opportunity and efficiency in water resource management and education. This plan updates the 2007 aquatic plant management plan.

Systematic surveys of Black Oak Lake aquatic plants have been conducted in 2006 and 2011 using the Wisconsin Department of Natural Resources (WDNR) “point-intercept” method. These surveys are the basis for this aquatic plant management plan. An analysis of the plant data along with water quality and other information inform this plan. Earlier professional aquatic plant surveys were conducted on Black Oak Lake in 2001 and 2005. Both focused on Eurasian water milfoil. None of these surveys has located Eurasian water milfoil in Black Oak Lake.

Aquatic plants rarely get the respect they merit, although this is slowly changing. We still call an aquatic plant bed a “weed bed.” Many aquatic plants have “weed” in their names (e.g., duckweed, pondweed, or musky weed). Likely this term was borrowed from “seaweed” and not intended as derogatory, but in today’s use, “weed” connotes an unwanted, aggressively growing plant. Such is not the case for the vast majority of aquatic plants. In fact, aquatic plants are a vital part of a lake ecosystem, recycling nutrients, providing vertical and horizontal structure, and creating habitat for animal life. Invertebrates, including crustaceans and insects, live on or within this “aquatic forest.” Fish find food and shelter within aquatic plant beds. Waterfowl eat parts of plants directly as well as feed on invertebrates associated with the plants. Muskrats eat aquatic plants and particularly love cattails and bulrushes. Otter and mink hunt invertebrates and small

vertebrates within the shelter of submergent and emergent beds. In shallow water, great blue herons find fishes among the plants.

In lakes that receive an excess of nutrients (particularly from fertilizers or leaking septic tanks), plant growth can become too lush or dominated by only a few species. As these abundant plants die, their decomposition can depress dissolved oxygen levels and diminish suitability for fish. Algae can respond rapidly to nutrient influxes and create nuisance conditions. These phenomena can cause humans to view all aquatic plants in a negative light.

On another negative front, non-native plant species, transported on boats and trailers or dumped from home aquariums, private ponds and water gardens may come to dominate a water body to the exclusion of native species. Eurasian water-milfoil (*Myriophyllum spicatum*) is one of the better known examples of these so-called aquatic invasive plant species.

For most lakes, native aquatic plants are an overwhelmingly positive attribute, greatly enhancing the aesthetics of the lake and providing good opportunities for fishing, boating, swimming, snorkeling, sight-seeing, and hunting.

When it comes to aquatic plant management, it is useful to heed the mantra of the medical profession: “First, do no harm.” It is both a social and scientific convention that aquatic plant management is more effective and beneficial when a lake is considered as an entire and integrated ecosystem. Be aware that a permit may be required to remove, add, or control aquatic plants. In addition, anyone using Wisconsin’s lakes must comply with the “Boat Launch Law” that addresses transport of aquatic plants on boat trailers and other equipment. A good review of the laws, permits, and regulations that affect management and behavior surrounding aquatic plants can be found in the WDNR guidelines called ***Aquatic Plant Management in Wisconsin***.¹

In preparing this plan, we followed guidelines in ***Aquatic Plant Management in Wisconsin***. The resulting plan is an adaptive plan (Walters, 1986). Simply put, it will be modified as new information becomes available. The WDNR Guidance document outlines three objectives that may influence preparation of an aquatic plant management plan:

- **Protection** - preventing the introduction of nuisance or invasive species into waters where these plants are not currently present;
- **Maintenance** - continuing the patterns of recreational use that have developed historically on and around a lake; and
- **Rehabilitation** - controlling an imbalance in the aquatic plant community leading to the dominance of a few plant species, frequently associated with the introduction of AIS.

¹ <http://www4.uwsp.edu/cnr/uwexlakes/ecology/APM/APMguideFull2010.pdf>

Currently, the motivation for this plan lies in the first two objectives. Black Oak Lake is a high quality resource with excellent water quality and a diverse and interesting community of aquatic plants. It also has a recreational history and current human use that has caused only moderate degradation to the ecosystem.

During projects with the WDNR Planning Grant Program and through past efforts, BOLPF has followed the seven-step plan outlined in the Guidance Document for developing an aquatic plant management plan:

1. Goal setting – Getting the effort organized, identifying problems to be addressed, and agreeing on the goals;
2. Inventory – Collecting baseline information to define the past and existing conditions;
3. Analysis – Synthesizing the information, quantifying and comparing the current conditions to desired conditions, researching opportunities and constraints, and setting directions to achieving the goals;
4. Alternatives – Listing possible management alternatives and evaluating their strengths, weaknesses and general feasibility;
5. Recommendations – Prioritizing and selecting preferred management options, setting objectives, drafting the plan;
6. Implementation – Formally adopting the plan, lining up funding, and scheduling activities for taking action to achieve the goals;
7. Monitor & Modify – Developing a mechanism for tracking activities and adjusting the plan as it evolves.

This plan updates the original aquatic plant management plan that was prepared in 2007. Besides this introductory chapter, this plan is organized in six Chapters. The study area is described in Chapter 2. Chapter 3 states the purpose and goals for the plan. Chapter 4 presents an inventory and analysis of information that pertain to the plan including the results of the aquatic plant survey. Chapter 5 provides recommendations that support the overall goals and establish the stewardship component of plan. Finally, Chapter 6 presents actions and objectives for implementing the plan. Three appendices complete this document. Appendix 1 contains literature cited, Appendix 2 contains tables and figures for the aquatic plant survey, and Appendix 3 contains a *Review of Black Oak Lake Water Quality*.

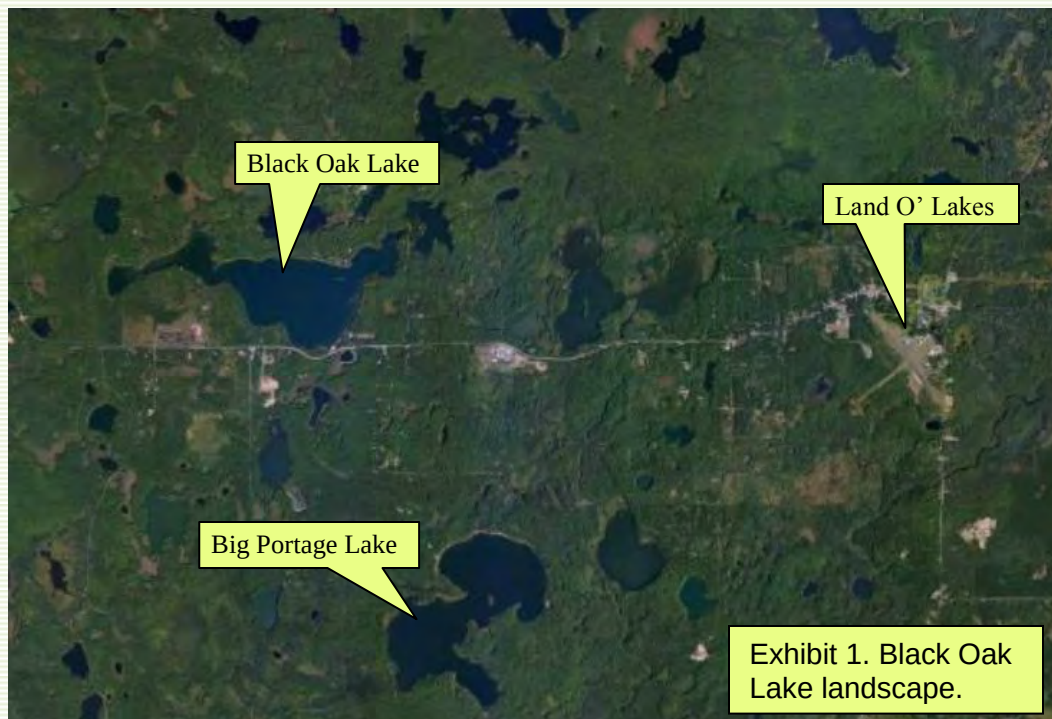
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CHAPTER 2

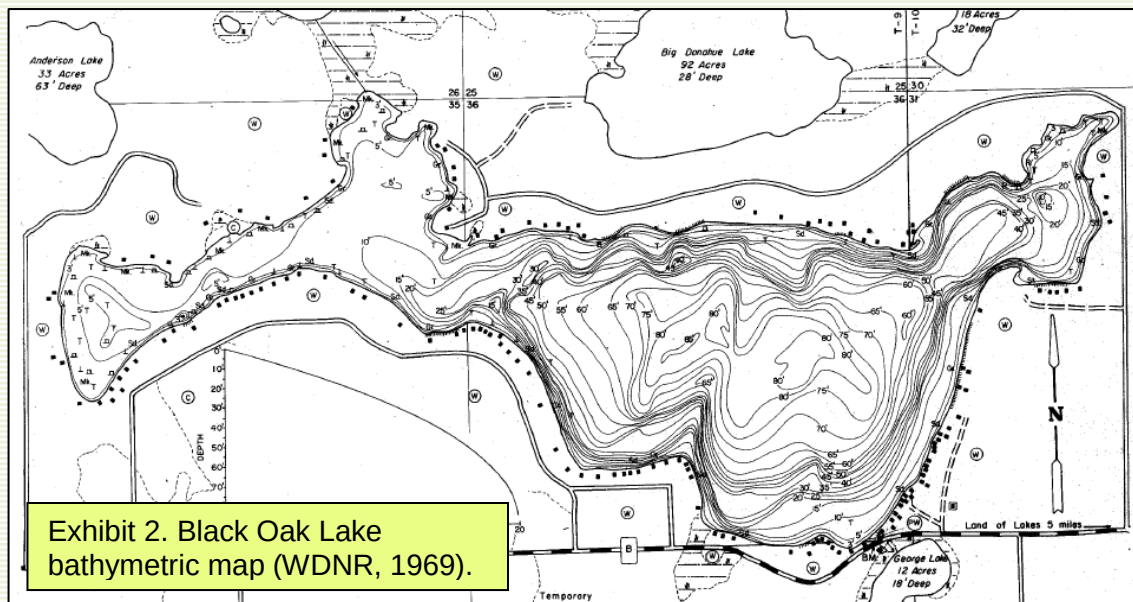
Study Area

Black Oak Lake is in Vilas County, Wisconsin about 4 miles west of Land O' Lakes, Wisconsin, and one mile south of the Michigan-Wisconsin border. The water body identification code (WBIC) is 1630100. Other lakes and streams are in this landscape. Exhibit 1 is an aerial view of the Black Oak Lake landscape showing a few other water features. This water landscape is a target for migrating and breeding waterfowl and other birds. Black Oak Lake has value and function in this larger landscape as well as its own watershed.



Black Oak Lake has a 7.41 mile shoreline and 564 acres surface area. One improved boat ramp allows public access. The lake is moderately developed with permanent homes and

cottages, although areas of more natural riparian area also exist. Black Oak Lake is listed as an outstanding resource water (ORW) (State of Wisconsin Legislature). An ORW is a body of water that does not typically have any point sources discharging pollutants directly into the water, though it may receive runoff from nonpoint sources. Also, new discharges may be permitted only if their effluent quality is equal to or better than the background water quality of that waterway at all times—no increases of pollutant levels are allowed (WDNR, 2013). Black Oak Lake is classified as oligotrophic, and has a complex bathymetry (Exhibit 2).



Descriptive parameters for Black Oak Lake are in Exhibit 3. It is a seepage lake of about 564 acres and maximum depth of 85 feet. It has an average shoreline development index compared to other lakes in the area. The shoreline development index is a quantitative expression derived from the shape of the lake. The shoreline development index is defined as the ratio of the shoreline length to the length of the circumference of a circle of the same area as the lake. A perfectly round lake would have an index of 1. Increasing irregularity of shoreline development in the form of bays and projections of the shore is shown by numbers greater than 1. For example, fjord lakes with extremely irregularly shaped shorelines sometimes have SDI's

exceeding 5. A higher shoreline development index indicates that a lake has relatively more productive littoral zone habitat.

Exhibit 3. Water Body Parameters	
Water Body Name	Black Oak Lake
County	Vilas
Township/Range/Section	T42N-R09E-S1;T43N-R09E-S26,35,36;T43N-R10E-S31
Water Body Identification Code	1630100
Lake Type	Seepage
Surface Area (acres)	564
Maximum Depth (feet)	85
Maximum Length (miles)	2.3
Maximum Width (miles)	0.7
Shoreline Length (miles)	7.4
Shoreline Development Index	2.2
Total Number of Piers (2009 aerial)	106
Number of Piers / Mile of Shoreline	14.3
Total Number of Homes (2009 aerial)	112
Number of Homes / Mile of Shoreline	15.1

Black Oak Lake has one public access site. We observe a total of 106 piers on the shoreline of Black Oak Lake from a 2009 aerial photograph or about 14.3 piers per mile of shoreline. The riparian area consists of both upland and wetland areas (Exhibit 4).



CHAPTER 3

Purpose and Goal Statements

This plan approaches aquatic plant management with a healthy dose of humility. We do not always understand the causes of environmental phenomena or the effects of our actions to manage the environment. With that thought in mind, we have crafted a statement of purpose for this plan:

Black Oak Lake has a healthy and diverse aquatic plant community that has been documented by two point-intercept aquatic plant surveys. This plant community is essential to, and part of, a high quality aquatic ecosystem that benefits the human community with its recreational and aesthetic features. The purpose of this aquatic plant management plan is to maintain the aquatic plant community in its present high quality state.

Supporting this purpose, the goals of this aquatic plant management plan are:

- (1) Monitor and protect the native aquatic plant community;*
- (2) Prevent establishment of AIS and nuisance levels of native plants;*
- (3) Promote and interpret APM efforts; and*
- (4) Educate riparian owners and lake users on preventing AIS introduction, reducing nutrient inputs that potentially alter the plant community, and minimizing physical removal of native riparian and littoral zone plants.*

The purpose and goals are the foundation for the aquatic plant management plan presented in this document. They inform the objectives and actions outlined in Chapter 5 and are the principal motivation of Black Oak Lake stewards.

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CHAPTER 4

Information and Analysis

Our efforts in the Black Oak Lake Watershed Protection Program have compiled information about historical and current conditions of the Black Oak Lake ecosystem and its surrounding watershed. Of particular importance to this aquatic plant management plan is the aquatic plant survey that was conducted in using the ***WDNR Protocol for Aquatic Plant Survey, Collecting, Mapping, Preserving, and Data Entry*** (Hauxwell et al., 2010). The results of this comprehensive “point-intercept” survey along with relevant components of other information are presented in this chapter under nine respective subheadings: watershed, aquatic plant management history, aquatic plant community description, fish community, water quality and trophic status, water use, riparian area, wildlife, and stakeholders.

Part 1. Watershed

Black Oak Lake and its watershed are very small components of a large-scale watershed landscape. The continental United States is divided into 18 watershed regions (Exhibit 5). Two watershed regions lie within Wisconsin: the Upper Mississippi and Great Lakes regions. Black Oak Lake is located in the Upper Mississippi watershed region (Exhibit 5). The Upper Mississippi region is also made up of many sub-regions. The Wisconsin sub-region (more specifically the Wisconsin River sub-region) (HUC#070700) contains Black Oak Lake. The Wisconsin River sub-region includes the Upper Wisconsin watershed, where Black Oak Lake is located (Exhibit 6). The Upper Wisconsin watershed (HUC#07070001) (Exhibit 7) covers parts of Vilas (including Black Oak Lake), Forest, Langlade, Lincoln, Oneida, Price, and Taylor counties in Wisconsin, and parts of Gogebic, and Iron County in Michigan. Exhibit 8 displays Portage Creek sub-watershed where Black Oak Lake is located (HUC#070700010301).



Exhibit 6. Wisconsin River sub-regional watershed. The Upper Wisconsin sub-basin is also visible (USEPA, 2009).



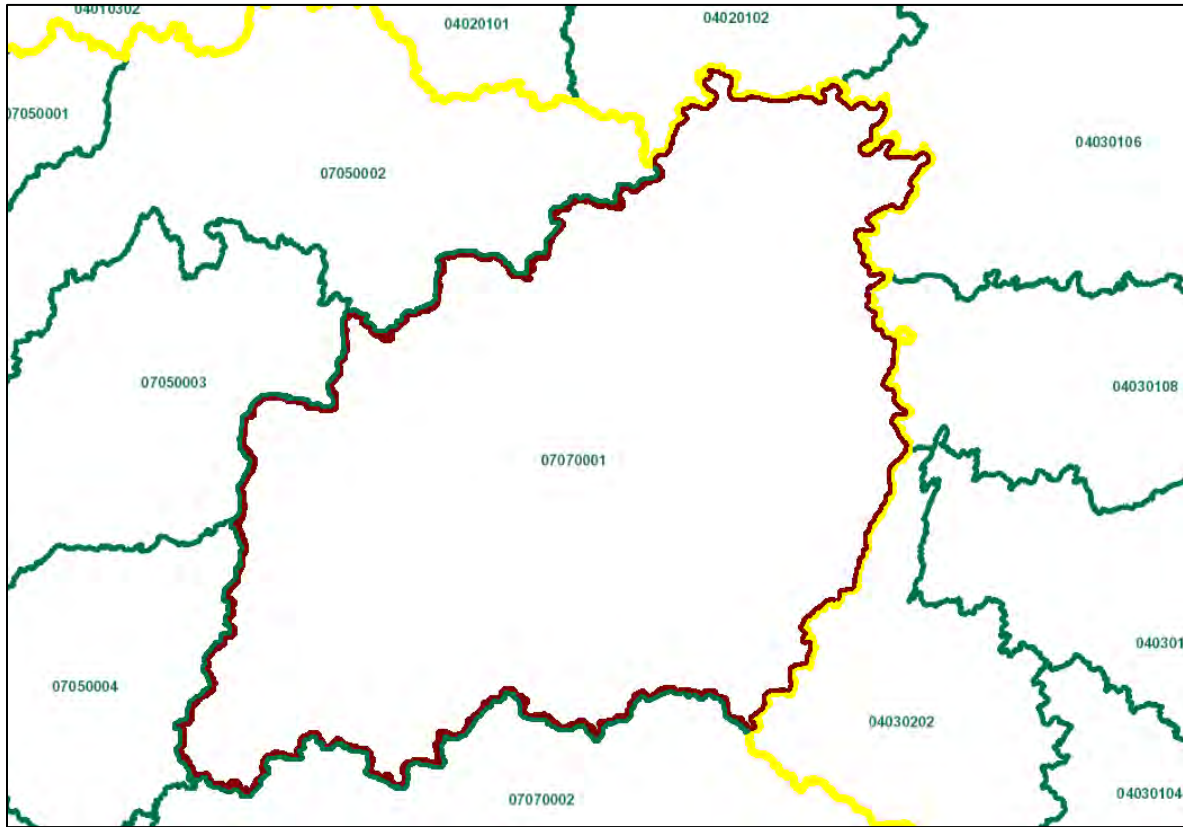


Exhibit 7. Upper Wisconsin watershed (red) lies on the border of the Upper Mississippi Region (numbers starting with 07) and the Great Lakes Region (number starting with 04) (WDNR, 2014b).

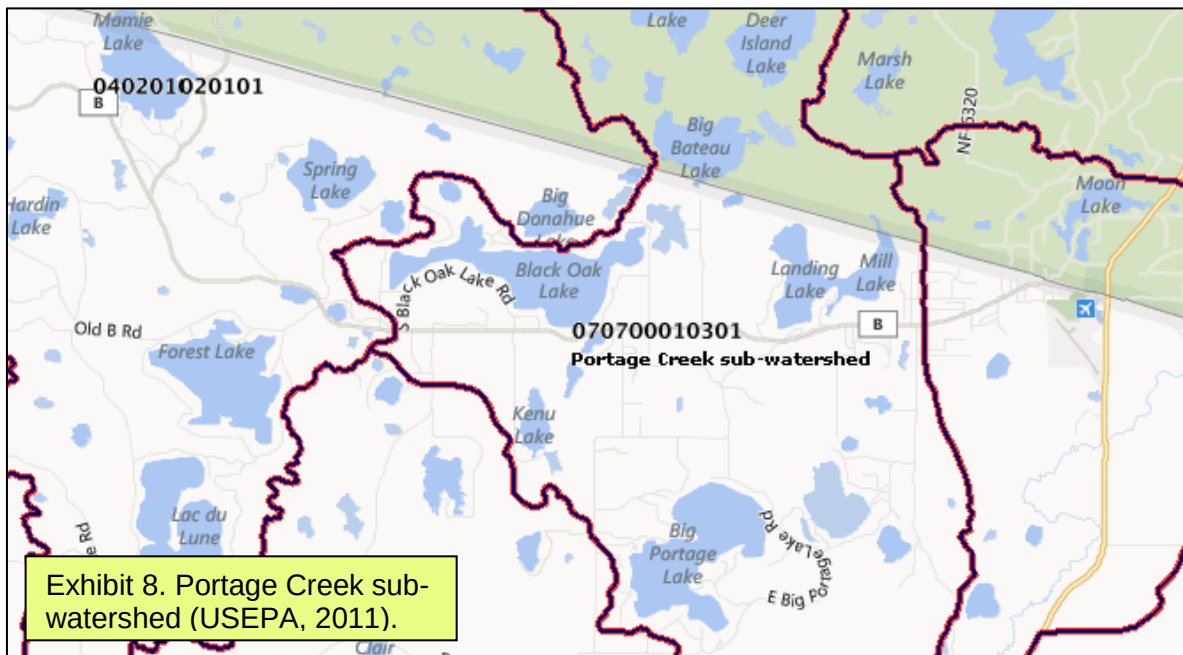


Exhibit 8. Portage Creek sub-watershed (USEPA, 2011).

The watershed (drainage basin) is all of the land and water areas that drain toward a particular river or lake. A water body is greatly influenced by its watershed. Watershed size, topography, geology, land use, soil fertility and erodibility, and vegetation are all factors that influence water quality. The Black Oak Lake watershed is nested in the Portage Creek Subwatershed and has an area of about 1,300 acres. The cover types in the watershed are presented in Exhibit 9. Forest and surface water comprise the largest components. Soil groups B and D are present in nearly equal acreages. Soil group A represents less than 10% of the watershed. Soil group A has the highest infiltration capacity, and the lowest runoff potential. Conversely, soil group D has the lowest infiltration capacity, and the highest runoff potential. The watershed to lake area ratio is 2:1. Water quality often decreases with an increasing ratio of watershed area to lake area. As the watershed to lake area increases there are more sources and amounts of runoff. In larger watersheds, runoff water can leach more minerals and nutrients and carry them to the lake. The runoff to a lake (such as after a rainstorm or snowmelt) differs greatly among land uses. Forest cover is the most protective as it exports much less soil (through erosion) and nutrients (such as phosphorus and nitrogen) to the lake than agricultural or urban land use.

Exhibit 9. Cover Types and Soil Groups of the Black Oak Lake Watershed.

Cover Type			Acres	Percent
Agriculture			0	0
Commercial			0	0
Forest			526.6	40.6
Grass/Pasture			0	0.1
High-density Residential			0	0
Low-density Residential			94.3	7.3
Water			676.5	52.1
Total			1297.4	100.0
Soil Group	Acres	Percent	Hydrologic Soil Groups - Soils are classified by the Natural Resource Conservation Service into four Hydrologic Soil Groups* based on the soil's runoff potential. The four Hydrologic Soils Groups are A, B, C and D. Where A has the smallest runoff potential and D the greatest.	
A	122.0	9.4	Group A is sand, loamy sand or sandy loam types of soils. It has low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sands or gravels and have a high rate of water transmission.	
B	546.8	42.1	Group B is silt loam or loam. It has a moderate infiltration rate when thoroughly wetted and consists chiefly or moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures.	
C	0.0	0.0	Group C soils are sandy clay loam. They have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine structure.	
D	628.6	48.5	Group D soils are clay loam, silty clay loam, sandy clay, silty clay or clay. This soil has the highest runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface and shallow soils over nearly impervious material.	

*(USDA, Natural Resources Conservation Service, 1986)

Part 2. Aquatic Plant Management History

As far as we can determine, no systematic or large-scale plant management activity has ever taken place in Black Oak Lake. Over the years, no particular nuisance issues have demanded control action. In 2006, an aquatic plant survey was conducted on Black Oak Lake by the White Water Associates working with Dr. Susan Knight (WDNR). The most recent aquatic plant survey was conducted by Dr. Knight in 2011. Findings from the 2006 and 2011 surveys are discussed in the next section (Part 3).

Part 3. Aquatic Plant Community Description

Why do lakes need aquatic plants? In many ways, they are underwater forests. Aquatic plants provide vertical and horizontal structure in the lake just like the many forms and variety of trees do in a forest. Imagine how diminished a forest's biodiversity becomes in the advent of a clear-cut. Similarly, a lake's biodiversity in large part depends on a diversity of plants.

Aquatic plants are beneficial in many ways. Areas with plants produce more food for fish (insect larvae, snails, and other invertebrates). Aquatic vegetation offers fish shelter and spawning habitat. Many submerged plants provide food for waterfowl and habitat for insects on which some waterfowl feed. Aquatic plants further benefit lakes by producing oxygen and absorbing nutrients (phosphorus and nitrogen) from runoff. Aquatic plants also protect shorelines and lake bottoms by dampening wave action and stabilizing sediments.

The distribution of plants within a lake is generally limited by light availability, which is, in turn, controlled by water clarity. Aquatic biologists often estimate the depth to which rooted aquatic plants can exist as about two times the average Secchi clarity depth. For example, if the average Secchi depth is eight feet then it is fairly accurate to estimate that rooted plants might exist in water as deep as sixteen feet. At depths greater than that (in our hypothetical example), light is insufficient for rooted plants to grow. In addition to available light, the type of substrate influences the distribution of rooted aquatic plants. Plants are more likely to be found in muddy or soft sediments containing organic matter, and less likely to occur where the substrate is sand, gravel, or rock. Finally, water chemistry influences which plants are found in a body of water. Some species prefer alkaline lakes and some prefer more acidic lakes. The presence of nutrients like phosphorous and nitrogen also influence plant community composition.

As mentioned earlier, non-native invasive plant species can reach high densities and wide distribution within a lake. This diminishes the native plant community and the related habitat. At times, even a native plant species can reach nuisance levels with respect to certain kinds of human recreation. These cases may warrant some kind of plant management.

Aquatic plant surveys have been conducted on Black Oak Lake by White Water Associates and WDNR biologists and Black Oak Lake volunteers in 2006 and in 2011. In each of these surveys, WDNR point-intercept protocol and methodology was followed. This formal survey assesses the plant species composition on a grid of several hundred points distributed evenly over the lake. Using latitude-longitude coordinates and a handheld GPS unit, scientists navigate to the points and use a rake mounted on a pole or rope to sample plants. Plants are identified, recorded and put into a dedicated spreadsheet for storage and data analysis. This systematic survey

provides baseline data about the lake. In 2006, there were 739 points on the Black Oak Lake grid with 55 meters between points. In 2011, the number of sampling points was increased to 1,036 and the corresponding distance between sampling points was 47 meters. Wisconsin DNR biologist, co-developer of the point-intercept survey method, and botanist for the 2006 and 2011 Black Oak Lake studies, Dr. Susan Knight, reasoned that this increase in sampling points would more accurately characterize the plants in the narrow littoral zone around the main basin of the lake (Knight, 2013).

Because Black Oak Lake has been surveyed twice, we can identify changes in the plant community. Changes in a lake environment might manifest as loss of species, change in species abundance or distribution, difference in the relative composition of various plant life forms (emergent, floating leaf, or submergent plants), and/or appearance of an AIS or change in its population size. Monitoring can track changes and provide valuable insight on which to base management decisions. In the remainder of this section (Part 3) we provide a report of the findings of the 2011 point-intercept aquatic plant survey, and provide a summary of the aquatic plant survey conducted in 2006. Supporting tables and figures for the aquatic plant surveys are provided in Appendix 2, and are labeled –a and –b for respective years.

Species richness refers to the total number of species recorded. Thirty-five species of aquatic plants were observed in 2011. Of these, 23 were collected at sampling sites and the others were observed from the boat. Table 1b displays summary statistics for the survey. Table 2b provides a list of the species encountered, including common and scientific name along with summarizing statistics.² The number of species encountered at any given sample point ranged from 0 to 5 and 343 sample points were found to have aquatic vegetation present. The average number of species encountered at these vegetated sites was 1.56. The actual number of species encountered at each of the vegetated sites is graphically displayed in Figure 1b. Plant density is estimated by a “rake fullness” metric (3 being the highest possible density). These densities (considering all species) are displayed for each sampling site on Figure 2 (no rake fullness data was collected in 2006).

The maximum depth of plant colonization was 22.0 feet (Table 1b and Figure 3b). Rooted vegetation was found at 343 of the 450 sample sites with depth $\leq$ the maximum depth of plant colonization (76.2% of sites). These sites are displayed as a black dot within a circle on Figure 4b. This indicates that although availability of appropriate depth may limit the distribution of

² If you are interested in learning more about the plant species found in the lake, visit the University of Wisconsin Steven Point Freckmann Herbarium website at: <http://wisplants.uwsp.edu/> or obtain a copy of “Through the Looking Glass (A Field Guide to the Aquatic Plants in Wisconsin).”

plants, it is not the only habitat factor involved. Substrate is another feature that influences plant distribution (e.g., soft substrate often harbors more plants than hard substrate). Figure 5b presents the substrates encountered during the aquatic plant survey (mud, sand, or rock).

Table 2b provides information about the frequency of occurrence of the plant species recorded in the lake. Several metrics are provided, including total number of sites in which each species was found and frequency of occurrence at sites $\leq$ the maximum depth of rooted vegetation. This frequency metric is standardized as a “relative frequency” (also shown in Table 2b) by dividing the frequency of occurrence for a given species by the sum of frequency of occurrence for all plants and multiplying by 100 to form a percentage. The resulting relative frequencies for all species total 100%. The relative frequencies for the plant species collected with a rake are graphically displayed in descending order on Figure 6b. This display shows that fern pondweed (*Potamogeton robbinsii*) had the highest relative frequency followed by dwarf water-milfoil (*Myriophyllum tenellum*). The lowest relative frequencies are at the far right of the graph. As examples of individual species distributions, we show the occurrences of a few of the most frequently and least frequently encountered plants in Figures 8b-15b.

Species richness (total number of plants recorded at the lake) is a measure of species diversity, but it doesn’t tell the whole story. As an example, consider the plant communities of two hypothetical ponds each with 1,000 individual plants representing ten plant species (in other words, richness is 10). In the first pond each of the ten species populations is comprised of 100 individuals. In the second pond, Species #1 has a population of 991 individuals and each of the other nine species is represented by one individual plant. Intuitively, we would say that first pond is more diverse because there is more “even” distribution of individual species. The “Simpson Diversity Index” takes into account both richness and evenness in estimating diversity. It is based on a plant’s relative frequency in a lake. The closer the Simpson Diversity Index is to 1, the more diverse the plant community. The Simpson Diversity Index for Black Oak Lake aquatic plants is 0.77 (Table 1b) which indicates a moderately diverse aquatic plant community.

Another measure of floristic diversity and quality is the *Floristic Quality Index* (FQI). Floristic quality is an assessment metric designed to evaluate the closeness that the flora of an area is to that of undisturbed conditions (Nichols, 1999). Among other applications, it forms a standardized metric that can be used to compare the quality of different lakes (or different locations within a single lake) and monitor long-term changes in a lake’s plant community (an indicator of lake health). The FQI for a lake is determined by using the average *coefficient of conservatism* times the square root of the number of native plant species present in the lake.

Knowledgeable botanists have assigned to each native aquatic plant a *coefficient of conservatism* representing the probability that a plant is likely to occur in pristine environments (relatively unaltered from presettlement conditions). The coefficients range from 0 to 10, with 10 being assigned to those species most sensitive to disturbance. As more environmental disturbance occurs, the less conservative species become more prevalent.

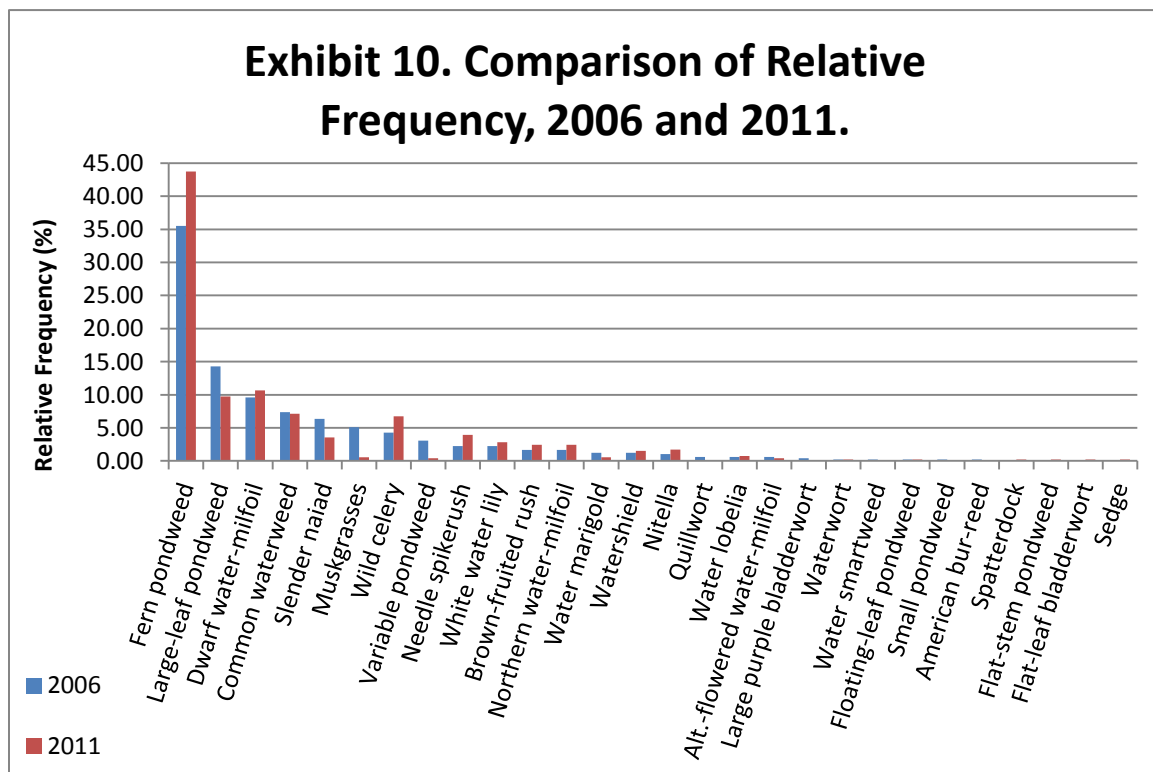
Nichols (1999) analyzed aquatic plant community data from 554 Wisconsin Lakes to ascertain geographic (ecoregional) characteristics of the FQI metric. This is useful for considering how the Black Oak Lake FQI (33.0) compares to other lakes and regions. The statewide medians for number of species and FQI are 13 and 22.2, respectively. Black Oak Lake values are high compared to these statewide values. Nichols (1999) determined that there are four ecoregional-lake type groups in Wisconsin: (1) Northern Lakes and Forests lakes, (2) Northern Lakes and Forests flowages, (3) North Central Hardwoods and Southeastern Till Plain lakes and flowages, and (4) Driftless Area and Mississippi River Backwater lakes. Black Oak Lake is located in the Northern Lakes and Forests lakes group. Nichols (1999) found species numbers for the Northern Lakes and Forests lakes group had a median value of 13. Black Oak Lake data is consistent with that find. Finally, the Black Oak Lake FQI (33.0) is higher than the median value for the Northern Lakes and Forests lakes group (24.3). These findings support the contention that the Black Oak Lake plant community is healthy and diverse.

No aquatic invasive plants have been found in Black Oak Lake during the two point-intercept surveys or in specific AIS surveys. No native plants have been found at densities or locations that might be considered a nuisance. The 2011 aquatic plant survey did record an observation of marsh thistle (*Cirsium palustre*). This species is considered a *Restricted* wetland species in Vilas County, WI. A *Restricted* species is one that has already been established in the state and causes or has the potential to cause significant environmental or economic harm or harm to human health (WDNR, 2012). Future surveying and monitoring of this species should be conducted. No state or federally listed species were observed.

In the 2006 aquatic plant survey conducted by White Water and WDNR biologists, 24 species were observed with an average of 1.95 species per site. No visual or boat survey species were recorded during the 2006 survey. We see that the number of species found per site decreased which may be due to the fact that there were more sites sampled in 2011. The maximum depth of plants was 24 feet in 2006 and 22 feet in 2011 (Figure 3a and 3b). In 2006, the frequency of occurrence of plants at sites shallower than the maximum depth of plants was 84.5% (Figure 4a). This percentage is slightly higher than that found in 2011 (76.2%). In 2006,

fern pondweed (*Potamogeton robbinsii*) had the highest relative frequency followed by large-leaf pondweed (*Potamogeton amplifolius*) (Figure 6a). The Simpson Diversity Index, which takes into account both richness and evenness in estimating diversity, was 0.83 in 2006, meaning that the lake had a diverse aquatic plant community. In 2011, the SDI decreased to 0.77 (Table 1a). This is likely due to the fact that in 2011, one species dominated while other species represented only a small percent of the overall community. In 2006, the FQI was 34.9, which is higher than state average, the regional average and the FQI from the 2011 survey (33.0) (Table 1a and 1b). The slight decline in the 2011 FQI is likely due to the decrease of species with high *coefficient of conservatism* values or the introduction of species with low *C* values. A comparison of 2006 and 2011 aquatic plant statistics can be viewed in Table 3.

Exhibit 10 displays the relative frequency of plants found in 2006 and 2011. It is evident that fern pondweed dominated the Black Oak Lake plant community in 2006 and in 2011. Because the relative frequency (of fern pondweed) increased in 2011 (and therefore decreased the relative frequency of other species), the SDI decrease slightly since 2006 (from 0.83 to 0.77).



Part 4. Fish Community

The WDNR Lake Pages website (<http://dnr.wi.gov/lakes/lakepages/>) indicates that the bottom is comprised of 50% sand, 30% gravel, 15% rock, and 5% muck and that fish species present include panfish, largemouth bass, smallmouth bass, northern pike, trout and walleye. Appendix E of the Black Oak Lake Adaptive Management Plan contains fisheries information.

Part 5. Water Quality and Trophic Status

Black Oak Lake is a 564 acre seepage lake with a maximum depth of 85 feet. It is a designated outstanding resource water, or ORW (State of Wisconsin Legislature). Existing water quality information includes data retrieved from the WDNR SWIMS database from 1973 to 1975, 1984, 1989, and from 2002 to present. Secchi disk measurements were taken by Citizen Lake Monitoring Network (CLMN) volunteers from 2002 to present. White Water and Conserve School students have also collected water quality data. Black Oak Lake water quality information is briefly summarized in this section, but more fully interpreted in Appendix 3.

Temperature and dissolved oxygen showed stratification in Black Oak Lake in the ice-free season. Black Oak Lake aesthetic quality is generally regarded as “beautiful, could not be nicer.” Turbidity is generally low. The water is very transparent (as measured by Secchi depth). In fact, the average Secchi depth of Black Oak Lake has increased significantly since 2004. Possible reasons for this are considered in Appendix K of the Black Oak Lake Adaptive Management Plan. Water quality would be classified as “very good” with respect to phosphorus concentrations. Chlorophyll *a* (a measure of the amount of algae), nitrogen, chloride, hardness, alkalinity, conductivity, calcium, magnesium, sodium, and potassium are considered low. The trophic state is oligotrophic. The pH of Black Oak Lake is considered neutral (7.2).

Part 6. Water Use

Black Oak Lake has one public access site, and is used by riparian owners and recreationists for a variety of activities. No land surrounding Black Oak Lake is owned by the State of Wisconsin.

Part 7. Riparian Area

Part 1 (Watershed) describes the larger riparian area context of Black Oak Lake. The near shore riparian area can be appreciated by viewing Exhibits 2 and 4. The lake is moderately developed with a fairly intact forested riparian zone that extends for hundreds of feet back from

the lake. The forest is a mixture of coniferous and deciduous trees and shrubs. Our review of 2009 aerial photography reveals 112 houses on the lake. This intact riparian area provides numerous important functions and values to the lake. It effectively filters runoff to the lake. It provides excellent habitat for birds and mammals. Trees that fall into the lake from the riparian zone contribute important habitat elements to the lake. Educating riparian owners as to the value of riparian areas is important to the maintenance of these critical areas.

Part 8. Wildlife

A study of wildlife was beyond the scope of the current study, but would be valuable to study and interpret in future iterations of the plan. This would be especially true of wetland and water oriented wildlife such as frogs, waterfowl, fish-eating birds, aquatic and semi-aquatic mammals, and invertebrate animals. In the future, it would be desirable to monitor indicator species of wildlife such as common loons, bald eagles, and osprey. Also of special importance would be monitoring for the presence aquatic invasive wildlife species (for example, spiny water flea, or zebra mussel) and fish species (for example, rainbow smelt or common carp).

Black Oak Lake currently designated as an *area of special natural resource interest (ASNRI)* for endangered, threatened or special concern species (WDNR, 2014a). A water body designated as an Area of Special Natural Resource Interest can be any of the following: WDNR trout streams; Outstanding or Exceptional Resource Waters (ORW/ERW); waters or portions of waters inhabited by endangered, threatened, special concern species or unique ecological communities; wild rice waters; waters in ecologically significant coastal wetlands along Lake Michigan and Superior; or federal or state waters designated as wild or scenic rivers (WDNR, 2014a). In the case of Black Oak Lake, it is designated as ASNRI because of its OWR status and because it inhabits state or federally designated threatened or endangered species. See the *Black Oak Lake Adaptive Management Plan* for more information about rare species and communities found near Black Oak Lake.

Part 9. Stakeholders

At this juncture in the ongoing aquatic plant management planning process, the BOLPF members have represented Black Oak Lake stakeholders. Additional interested citizens are invited to participate as the plan is refined and updated in order to broaden input, build consensus, and encourage participation in stewardship. No contentious direct plant management actions (for example, harvesting or use of herbicides) are a component of the current plan.

CHAPTER 5

Recommendations, Actions, and Objectives

In this chapter we provide recommendations for specific objectives and associated actions to support the APM Plan’s goals stated in Chapter 3 and re-stated here for convenient reference:

- (1) Monitor and protect the native aquatic plant community;*
- (2) Prevent establishment of AIS and nuisance levels of native plants;*
- (3) Promote and interpret APM efforts; and*
- (4) Educate riparian owners and lake users on preventing AIS introduction, reducing nutrient inputs that potentially alter the plant community, and minimizing physical removal of native riparian and littoral zone plants.*

Since Black Oak Lake is a healthy and diverse ecosystem, we could simply recommend an alternative of “no action.” In other words, Black Oak Lake continues without any effort or intervention on part of lake stewards. Nevertheless, we consider the “no action” alternative imprudent. Many forces threaten the quality of the lake and Black Oak Lake Watershed Protection Program and The BOLPF feels a great responsibility to minimize the threats. We therefore outline in this section a set of actions and related management objectives that will actively engage lake stewards in the process of management.

The actions are presented in tabular form. Each “action” consists of a set of four statements: (1) a declarative “action” statement that specifies the action (2) a statement of the “objective” that the action serves, (3) a “monitoring” statement that specifies the party responsible for carrying out the action and maintaining data, and (4) a “status” statement that suggests a timeline/calendar and indicates status (not yet started, ongoing, or completed).

Recommended Actions for the Black Oak Lake APM Plan

Action #1: Formally adopt the Aquatic Plant Management Plan.

Objective: To provide foundation for long-term native plant community conservation and stewardship and to be prepared for response to AIS introductions.

Monitoring: The BOLPF (Black Oak Lake Protection Foundation) oversees activity and maintains the plan.

Status: Planned for 2014.

Action #2: Monitor water quality.

Objective: Continue with collection and analysis of water quality parameters to detect trends in parameters such as nutrients, chlorophyll *a*, and water clarity.

Monitoring: The BOLPF oversees activity and maintains data.

Status: Ongoing.

Action #3: Monitor the lake for aquatic invasive plant species.

Objective: To understand the lake's biotic community, provide for early detection of AIS and continue monitoring any existing populations of AIS.

Monitoring: The BOLPF oversees activity and maintains data.

Status: Ongoing.

Action #4: Monitor the lake for aquatic invasive animal species.

Objective: To understand the lake's biotic community, provide for early detection of AIS and continue monitoring any existing populations of AIS.

Monitoring: The BOLPF oversees activity and maintains data.

Status: Ongoing.

Action #5: Form an Aquatic Invasive Species Rapid Response Team and interface with the AIS Rapid Response Coordinator.

Objective: To be prepared for AIS discovery and efficient response.

Monitoring: The BOLPF coordinates activity.

Status: Planned for 2015.

Recommended Actions for the Black Oak Lake APM Plan

Action #6: Conduct quantitative plant survey every five years using WDNR Point-Intercept Methodology.

Objective: To watch for changes in native species diversity, floristic quality, plant abundance, and plant distribution and to check for the occurrence of non-native, invasive plant species.

Monitoring: BOLPF oversees and maintains data; copies to WDNR.

Status: Anticipated in 2016.

Action #7: Update the APM plan approximately every five years or as needed to reflect new plant information from plant surveys and monitoring.

Objective: To have current information and management science included in the plan.

Monitoring: The BOLPF oversees and maintains data; copies to WDNR.

Status: Ongoing.

Action #8: Continue the efforts of the BOLPF citizen lake monitoring network (principally the Milfoil Vigilante Program and the Clean Boats, Clean Waters Program) that establishes volunteer monitors for Black Oak Lake that monitor for and educate about aquatic invasive plant species.

Objective: To monitor recreational traffic in and out of the lake checking for possible introduction of invasive aquatic plants on boats, engines, and trailers and to educate recreational users of Black Oak Lake regarding aquatic invasives and the special features of Black Oak Lake.

Monitoring: The BOLPF oversees activity and provides reports.

Status: Ongoing.

Action #9: Become familiar with and recognize the water quality and habitat values of ordinances and requirements on boating, septic, and property development.

Objective: To protect native aquatic plants, water quality, and riparian habitat.

Monitoring: Lake residents and other stakeholders.

Status: Ongoing.

Recommended Actions for the Black Oak Lake APM Plan

Action #10: Create an education plan for the property owners and other stakeholders that will address issues of healthy aquatic and riparian plant communities.

Objective: To educate stakeholders about issues and topics that affect the lake's aquatic and riparian plant communities, including topics such as: (1) the importance of the aquatic plant community; (2) no or minimal mechanical removal of plants along the shoreline is desirable and that any plant removal should conform to Wisconsin regulations; (3) the value of a natural shoreline in protecting the aquatic plant community and lake health; (4) nutrient sources to the lake and the role excess nutrients play in degradation of the aquatic plant community; (5) the importance of reducing or eliminating use of fertilizers on lake front property; (6) the importance of minimizing transfer of AIS to the lake by having dedicated watercraft and cleaning boats that visit the lake.

Monitoring: BOLPF oversee(s) activity and assesses effectiveness.

Status: Anticipated to begin in 2015.

Action #11: Monitor the lake watershed for purple loosestrife and other species of wetland invasive plants.

Objective: Identify invasive wetland species populations before they reach large size.

Monitoring: The BOLPF oversees activity.

Status: Anticipated in 2015.

CHAPTER 6

Contingency Plan for AIS

Unfortunately, sources of aquatic invasive plants and other AIS are numerous in Wisconsin. Some infested lakes are quite close to Black Oak Lake. There is an increasing likelihood of accidental introduction of AIS to Vilas County Lakes through conveyance of life stages by boats, trailers, and other vectors. It is important for the BOLPF and other lake stewards to be prepared for the contingency of aquatic invasive plant species colonization.

For riparian owners and users of a lake ecosystem, the discovery of AIS is an event that elicits an immediate desire to “fix the problem.” Although strong emotions may be evoked by such a discovery, a deliberate and systematic approach is required to appropriately and effectively address the situation. An aquatic plant management plan (one including a contingency plan for AIS) is the best tool by which the process can be navigated. In fact the APM plan is a requirement in Wisconsin for some kinds of aquatic plant management actions. One of the actions outlined in the previous chapter was to establish an Aquatic Invasive Species Rapid Response Team. This team and its coordinator are integral to the management process. It is important for this team to be multi-dimensional (or at least have ready access to the expertise that may be required). AIS invade not just a single lake, but an entire region since the new infestation is an outpost from which the AIS can more easily colonize other nearby water bodies. For this reason it is strategic for the Rapid Response Team to include representation from regional stakeholders (such as a County AIS Coordinator).

Exhibit 11 provides a flowchart outlining an appropriate rapid response to the suspected discovery of an aquatic invasive plant species. The response will be most efficient if an AIS Rapid Response Team has already been established and is familiar with the contingency plan. In the remainder of this chapter we further describe the approach.

When a suspect aquatic invasive plant species is found, either the original observer or a member of the Rapid Response Team (likely the coordinator) should collect an entire plant specimen including roots, stems, and flowers (if present). The sample should be placed in a sealable bag with a small amount of water to keep it moist. Place a label in the bag written in pencil with date, time, collector’s name, lake name, location, town, and county. Attach a lake

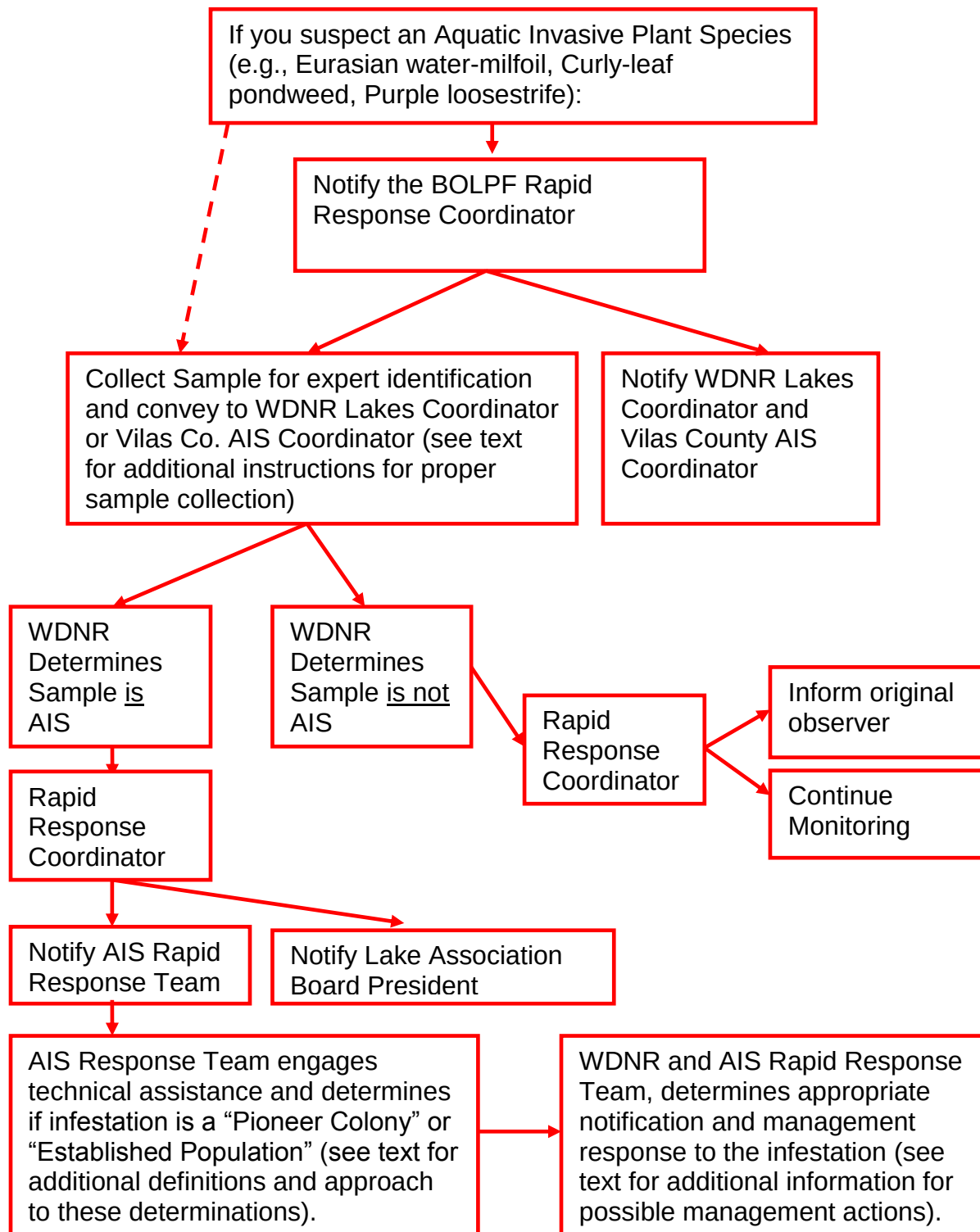
map to the bag that has the location of the suspect AIS marked and GPS coordinates recorded (if GPS is available). The sample should be placed on ice in a cooler or in a refrigerator. Deliver the sample to the WDNR Lakes Management Coordinator (Kevin Gauthier in Woodruff) or the Vilas County AIS Coordinator (Ted Ritter) as soon as possible (at least within three days). The WDNR or their botanical expert(s) will determine the species and confirm whether or not it is an aquatic invasive plant species.

If the suspect specimen is determined to be an invasive plant species, the next step is to determine the extent and density of the population since the management response will vary accordingly. The Rapid Response Team should conduct (or have its consultant conduct) a survey to define the colony's perimeter and estimate density. If less than five acres (or <5% of the lake surface area), it is designated a "Pioneer Colony." If greater than five acres (or >5% of the lake surface area) then it is designated an "Established Population." Once the infestation is characterized, "at risk" areas should also be determined and marked on a map. For example, nearby boat landing sites and areas of high boat traffic should be indicated.

When "pioneer" or "established" status has been determined, it is time to consult with the WDNR Lakes Coordinator to determine appropriate notifications and management responses to the infestation. Determining whether hand-pulling or chemical treatment will be used is an important and early decision. Necessary notifications of landowners, governmental officials, and recreationists (at boat landings) will be determined. Whether the population's perimeter needs to be marked with buoys will be decided by the WDNR. Funding sources will be identified and consultants and contractors will be contacted where necessary. The WDNR will determine if further baseline plant survey is required (depending on type of treatment). A post treatment monitoring plan will be discussed and established to determine the efficacy of the selected treatment.

Once the Rapid Response Team is organized, one of its first tasks is to develop a list of contacts and associated contact information (phone numbers and email addresses). At a minimum, this contact list should include: the Rapid Response Coordinator, members of the Rapid Response Team, County AIS Coordinator, WDNR Lakes Management Coordinator, Lake Association Presidents (or other points of contact), local WDNR warden, local government official(s), tribal contacts, other experts, chemical treatment contractors, and consultant(s).

Exhibit 11. Aquatic Invasive Plant Species Rapid Response



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Appendix 1

Literature Cited

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LITERATURE CITED

- Hauxwell, J., S. Knight, K. Wagner, A. Mikulyuk, M. Nault, M. Porzky and S. Chase. 2010. *Recommended baseline monitoring of aquatic plants in Wisconsin: sampling design, field and laboratory procedures, data entry and analysis, and applications*. Wisconsin Department of Natural Resources Bureau of Science Services, PUB-SS-1068 2010. Madison, WI.
- Knight, Susan. 2013. *Questions about Black Oak Lake (2011 PI Survey)*. E-mail.
- Nichols, Stanley A. 1999. *Floristic Quality Assessment of Wisconsin Lake Plant Communities with Example Applications*. *Journal of Lake and Reservoir Management* 15(2): 133-141.
- Premo, Dean, Angie Stine, Caitlin Clarke, and Kent Premo. 2014. *Black Oak Lake Adaptive Management Plan*. White Water Associates, Inc. Amasa, MI.
- State of Wisconsin Legislature. NR 102. Wisc. Admin. Code § 102.10. *Outstanding Resource Waters*. Page 16-1.
- US Environmental Protection Agency. 2011. *Map Projects by Watershed*. Retrieved 2014. <<http://iaspub.epa.gov/pls/grts/f?p=110:95:0::NO::>>
- US Department of Agriculture, Natural Resources Conservation Service. June 1986. *Urban Hydrology for Small Watersheds*. Technical Release-55.
- US Geological Survey. 2014. *Locate your watershed*. Retrieved 2014. <http://water.usgs.gov/wsc/map_index.html>
- Walters, C. 1986. *Objectives, constraints, and problem bounding*. In W.M. Getz, ed., *Adaptive Management of Renewable Resources*. Macmillan Publishing Company. New York, NY.
- Wisconsin Department of Natural Resources. 1969. *Lake Survey Map*. Retrieved 2014. <<http://dnr.wi.gov/lakes/maps/DNR/1630100a.pdf>>

Wisconsin Department of Natural Resources. 2012. *Invasive Rule – NR 40 Terminology*. Retrieved 2014. <<http://dnr.wi.gov/topic/Invasives/terminology.html>>

Wisconsin Department of Natural Resources. 2013. *Outstanding and Exceptional Resource Waters*. Retrieved 2014. <<http://dnr.wi.gov/topic/surfacewater/orwerw.html>>

Wisconsin Department of Natural Resources. 2014a. *About Designated Waters*. Retrieved 2014. <http://dnr.wi.gov/topic/surfacewater/datasets/designated_waters/asnri.html>

Wisconsin Department of Natural Resources. 2014b. *Surface Water Data Viewer*. Retrieved 2014. <<http://dnrmapping.wi.gov/sl/?Viewer=SWDV>>

Appendix 2

Aquatic Plant Survey Tables and Figures

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Figure 8-15.	Distribution of plant species for 2006 and 2011.

Table 1a. Summary statistics for the 2006 point-intercept aquatic plant surveys for Black Oak Lake.

Summary Statistic	Value	Notes
Total number of sites on grid	739	Total number of sites on the original grid (not necessarily visited)
Total number of sites visited	303	Total number of sites where the boat stopped, even if much too deep to have plants.
Total number of sites with vegetation	251	Total number of sites where at least one plant was found
Total number of sites shallower than maximum depth of plants	297	Number of sites where depth was less than or equal to the maximum depth where plants were found. This value is used for Frequency of occurrence at sites shallower than maximum depth of plants.
Frequency of occurrence at sites shallower than maximum depth of plants	84.51	Number of times a species was seen divided by the total number of sites shallower than maximum depth of plants.
Simpson Diversity Index	0.83	A nonparametric estimator of community heterogeneity. It is based on Relative Frequency and thus is not sensitive to whether all sampled sites (including non-vegetated sites) are included. The closer the Simpson Diversity Index is to 1, the more diverse the community.
Maximum depth of plants (ft.)	24.0	The depth of the deepest site sampled at which vegetation was present.
Number of sites sampled with rake on rope	80	
Number of sites sampled with rake on pole	223	
Average number of all species per site (shallower than max depth)	1.65	
Average number of all species per site (vegetated sites only)	1.95	
Average number of native species per site (shallower than max depth)	1.65	Total number of species collected. Does not include visual sightings.
Average number of native species per site (vegetated sites only)	1.95	Total number of species collected including visual sightings.
Species Richness	24	
Species Richness (including visuals)	24	
Floristic Quality Index (FQI)	34.9	

Table 1b. Summary statistics for the 2011 point-intercept aquatic plant surveys for Black Oak Lake.

Summary Statistic	Value	Notes
Total number of sites on grid	1036	Total number of sites on the original grid (not necessarily visited)
Total number of sites visited	597	Total number of sites where the boat stopped, even if much too deep to have plants.
Total number of sites with vegetation	343	Total number of sites where at least one plant was found
Total number of sites shallower than maximum depth of plants	450	Number of sites where depth was less than or equal to the maximum depth where plants were found. This value is used for Frequency of occurrence at sites shallower than maximum depth of plants.
Frequency of occurrence at sites shallower than maximum depth of plants	76.22	Number of times a species was seen divided by the total number of sites shallower than maximum depth of plants.
Simpson Diversity Index	0.77	A nonparametric estimator of community heterogeneity. It is based on Relative Frequency and thus is not sensitive to whether all sampled sites (including non-vegetated sites) are included. The closer the Simpson Diversity Index is to 1, the more diverse the community.
Maximum depth of plants (ft.)	22.0	The depth of the deepest site sampled at which vegetation was present.
Number of sites sampled with rake on rope	120	
Number of sites sampled with rake on pole	368	
Average number of all species per site (shallower than max depth)	1.19	
Average number of all species per site (vegetated sites only)	1.56	
Average number of native species per site (shallower than max depth)	1.19	Total number of species collected. Does not include visual sightings.
Average number of native species per site (vegetated sites only)	1.56	Total number of species collected including visual sightings.
Species Richness	23	
Species Richness (including visuals)	35	
Floristic Quality Index (FQI)	33.0	

Table 2a. Plant species recorded and distribution statistics for the 2006 Black Oak Lake aquatic plant survey.

Common name	Scientific name	Frequency of occurrence at sites less than or equal to maximum depth of plants	Frequency of occurrence within vegetated areas (%)	Relative Frequency (%)	Number of sites where species found	Number of sites where species found (including visuals)	Average Rake Fullness
Fern pondweed	<i>Potamogeton robbinsii</i>	58.59	69.32	35.51	174	174	2.07
Large-leaf pondweed	<i>Potamogeton amplifolius</i>	23.57	27.89	14.29	70	72	1.11
Dwarf water-milfoil	<i>Myriophyllum tenellum</i>	15.82	18.73	9.59	47	47	1.13
Common waterweed	<i>Elodea canadensis</i>	12.12	14.34	7.35	36	36	1.06
Slender naiad	<i>Najas flexilis</i>	10.44	12.35	6.33	31	31	1.03
Muskgrasses	<i>Chara</i> sp.	8.42	9.96	5.10	25	25	1.12
Wild celery	<i>Vallisneria americana</i>	7.07	8.37	4.29	21	21	1.10
Variable pondweed	<i>Potamogeton gramineus</i>	5.05	5.98	3.06	15	16	1.07
Needle spikerush	<i>Eleocharis acicularis</i>	3.70	4.38	2.24	11	11	1.36
White water lily	<i>Nymphaea odorata</i>	3.70	4.38	2.24	11	12	1.18
Brown-fruited rush	<i>Juncus pelocarpus</i> f. <i>submersus</i>	2.69	3.19	1.63	8	8	1.00
Northern water-milfoil	<i>Myriophyllum sibiricum</i>	2.69	3.19	1.63	8	8	1.25
Water marigold	<i>Bidens beckii</i> (formerly <i>Megalodonta</i>)	2.02	2.39	1.22	6	6	1.17
Watershield	<i>Brasenia schreberi</i>	2.02	2.39	1.22	6	9	1.00
Nitella	<i>Nitella</i> sp.	1.68	1.99	1.02	5	5	1.00
Quillwort	<i>Isoetes</i> sp.	1.01	1.20	0.61	3	3	1.00
Water lobelia	<i>Lobelia dortmanna</i>	1.01	1.20	0.61	3	5	1.00
Alternate-leaved water-milfoil	<i>Myriophyllum alterniflorum</i>	1.01	1.20	0.61	3	3	1.33
Large purple bladderwort	<i>Utricularia purpurea</i>	0.67	0.80	0.41	2	2	1.00
Waterwort	<i>Elatine minima</i>	0.34	0.40	0.20	1	1	1.00
Water smartweed	<i>Polygonum amphibium</i>	0.34	0.40	0.20	1	4	1.00
Floating-leaf pondweed	<i>Potamogeton natans</i>	0.34	0.40	0.20	1	2	1.00
Small pondweed	<i>Potamogeton pusillus</i>	0.34	0.40	0.20	1	1	1.00
American bur-reed	<i>Sparganium americanum</i>	0.34	0.40	0.20	1	1	1.00

Frequency of occurrence within vegetated areas (%): Number of times a species was seen in a vegetated area divided by the total number of vegetated sites.

Table 2b. Plant species recorded and distribution statistics for the 2011 Black Oak Lake aquatic plant survey.

Common name	Scientific name	Frequency of occurrence at sites less than or equal to maximum depth of plants	Frequency of occurrence within vegetated areas (%)	Relative Frequency (%)	Number of sites where species found	Number of sites where species found (including visuals)	Average Rake Fullness
Fern pondweed	<i>Potamogeton robbinsii</i>	52.00	68.22	43.74	234	235	1.85
Dwarf water-milfoil	<i>Myriophyllum tenellum</i>	12.67	16.62	10.65	57	57	1.12
Large-leaf pondweed	<i>Potamogeton amplifolius</i>	11.56	15.16	9.72	52	78	1.42
Common waterweed	<i>Elodea canadensis</i>	8.44	11.08	7.10	38	38	1.08
Wild celery	<i>Vallisneria americana</i>	8.00	10.50	6.73	36	40	1.19
Needle spikerush	<i>Eleocharis acicularis</i>	4.67	6.12	3.93	21	22	1.10
Slender naiad	<i>Najas flexilis</i>	4.22	5.54	3.55	19	19	1.05
White water lily	<i>Nymphaea odorata</i>	3.33	4.37	2.80	15	28	1.40
Brown fruited rush	<i>Juncus pelocarpus</i> f. <i>submersus</i>	2.89	3.79	2.43	13	14	1.08
Northern water-milfoil	<i>Myriophyllum sibiricum</i>	2.89	3.79	2.43	13	13	1.31
Nitella	<i>Nitella</i> sp.	2.00	2.62	1.68	9	9	1.67
Watershield	<i>Brasenia schreberi</i>	1.78	2.33	1.50	8	23	1.38
Water lobelia	<i>Lobelia dortmanna</i>	0.89	1.17	0.75	4	4	1.00
Water marigold	<i>Bidens beckii</i> (formerly <i>Megalodonta</i>)	0.67	0.87	0.56	3	3	1.00
Muskgrasses	<i>Chara</i> sp.	0.67	0.87	0.56	3	3	1.00
Alternate-leaved water-milfoil	<i>Myriophyllum alterniflorum</i>	0.44	0.58	0.37	2	6	1.00
Variable pondweed	<i>Potamogeton gramineus</i>	0.44	0.58	0.37	2	2	1.50
Waterwort	<i>Elatine minima</i>	0.22	0.29	0.19	1	2	1.00
Spatterdock	<i>Nuphar variegata</i>	0.22	0.29	0.19	1	3	1.00
Floating-leaf pondweed	<i>Potamogeton natans</i>	0.22	0.29	0.19	1	2	1.00
Flat-stem pondweed	<i>Potamogeton zosteriformis</i>	0.22	0.29	0.19	1	1	1.00
Flat-leaf bladderwort	<i>Utricularia intermedia</i>	0.22	0.29	0.19	1	1	1.00
Sedge	<i>Carex</i> sp.	0.22	0.29	0.19	1	1	1.00
Narrow-leaved bur-reed	<i>Sparganium angustifolium</i>				Visual	6	
Three-way sedge	<i>Dulichium arundinaceum</i>				Visual	4	

Frequency of occurrence within vegetated areas (%): Number of times a species was seen in a vegetated area divided by the total number of vegetated sites.

Table 2b. Continued.

Common name	Scientific name	Frequency of occurrence at sites less than or equal to maximum depth of plants	Frequency of occurrence within vegetated areas (%)	Relative Frequency (%)	Number of sites where species found	Number of sites where species found (including visuals)	Average Rake Fullness
Arrowhead	<i>Sagittaria</i> sp.				Visual	3	
Pickernelweed	<i>Pontederia cordata</i>				Visual	2	
Softstem bulrush	<i>Schoenoplectus tabernaemontani</i>				Visual	2	
Common rush	<i>Juncus effusus</i>				Visual	2	
Pipewort	<i>Eriocaulon aquaticum</i>				Visual	1	
Quillwort	<i>Isoetes</i> sp.				Visual	1	
Water smartweed	<i>Polygonum amphibium</i>				Visual	1	
Bur-reed	<i>Sparganium</i> sp.				Visual	1	
Bog St. John's-wort	<i>Triadenum fraseri</i>				Visual	1	
Grass-leaved rush	<i>Juncus marginatus</i>				Visual	1	
Marsh thistle	<i>Cirsium palustre</i>				Boat Survey		
Cattail	<i>Typha</i> sp.				Boat Survey		
Large purple bladderwort	<i>Utricularia purpurea</i>				Boat Survey		
Creeping spikerush	<i>Eleocharis palustris</i>				Boat Survey		
Common bladderwort	<i>Utricularia vulgaris</i>				Boat Survey		
Forget-me-not*	<i>Myosotis</i> sp.				Boat Survey		

Frequency of occurrence within vegetated areas (%): Number of times a species was seen in a vegetated area divided by the total number of vegetated sites.

Marsh thistle is considered a *Restricted* invasive species in Vilas County.

*Some species of forget-me-not are considered *Restricted* invasive species, while some species are considered *Special Concern* species.
In this survey, the plant was not identified to genus or specific epithet.

Table 3. Comparison of summary statistics for 2006 and 2011 point-intercept aquatic plant surveys in Black Oak Lake.

Summary Statistic	2006	2011
Total number of sites on grid	739	1036
Total number of sites visited	303	597
Total number of sites with vegetation	251	343
Total number of sites shallower than maximum depth of plants	297	450
Frequency of occurrence at sites shallower than maximum depth of plants	84.51	76.22
Simpson Diversity Index	0.83	0.77
Maximum depth of plants (ft.)	24.0	22.0
Number of sites sampled with rake on rope	80	120
Number of sites sampled with rake on pole	223	368
Average number of all species per site (shallower than max depth)	1.65	1.19
Average number of all species per site (vegetated sites only)	1.95	1.56
Average number of native species per site (shallower than max depth)	1.65	1.19
Average number of native species per site (vegetated sites only)	1.95	1.56
Species Richness	24	23
Species Richness (including visuals)	24	35
Floristic Quality Index (FQI)	34.9	33.0

Figure 1a. Number of plant species recorded at sample sites,
Black Oak Lake (2006).

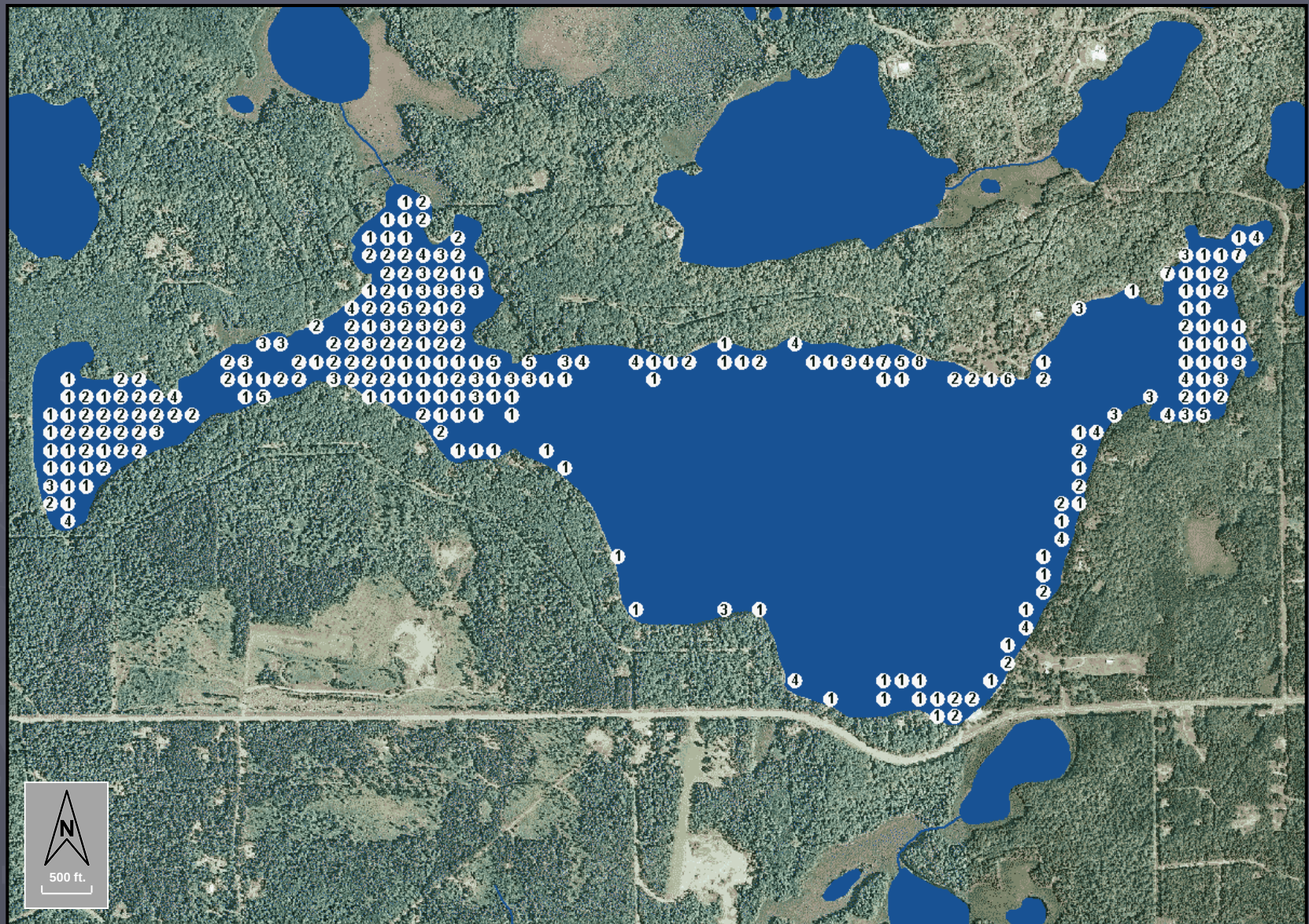
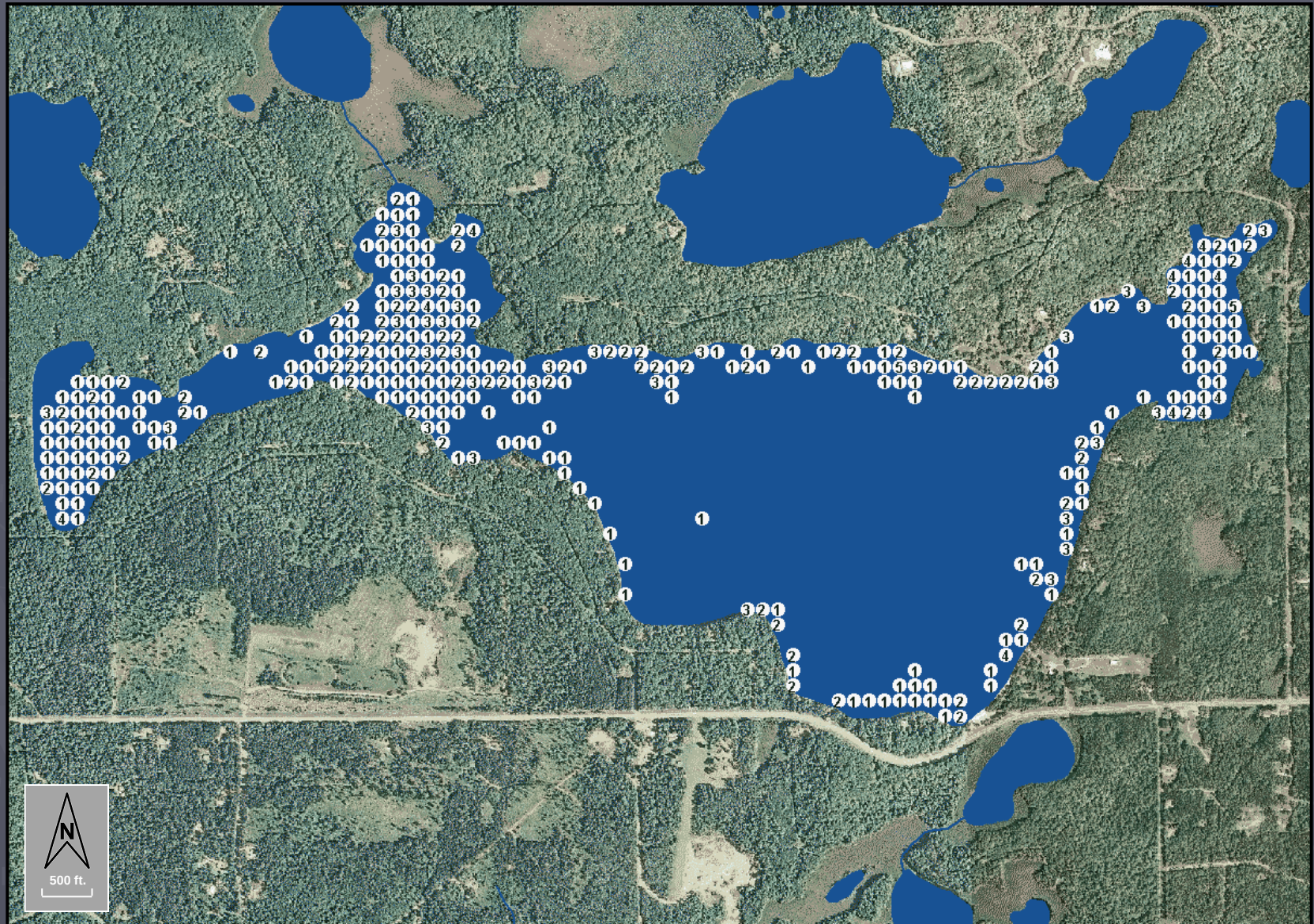


Figure 1b. Number of plant species recorded at sample sites,
Black Oak Lake (2011).



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Figure 2. Rake fullness ratings for sample sites, Black Oak Lake (2011).

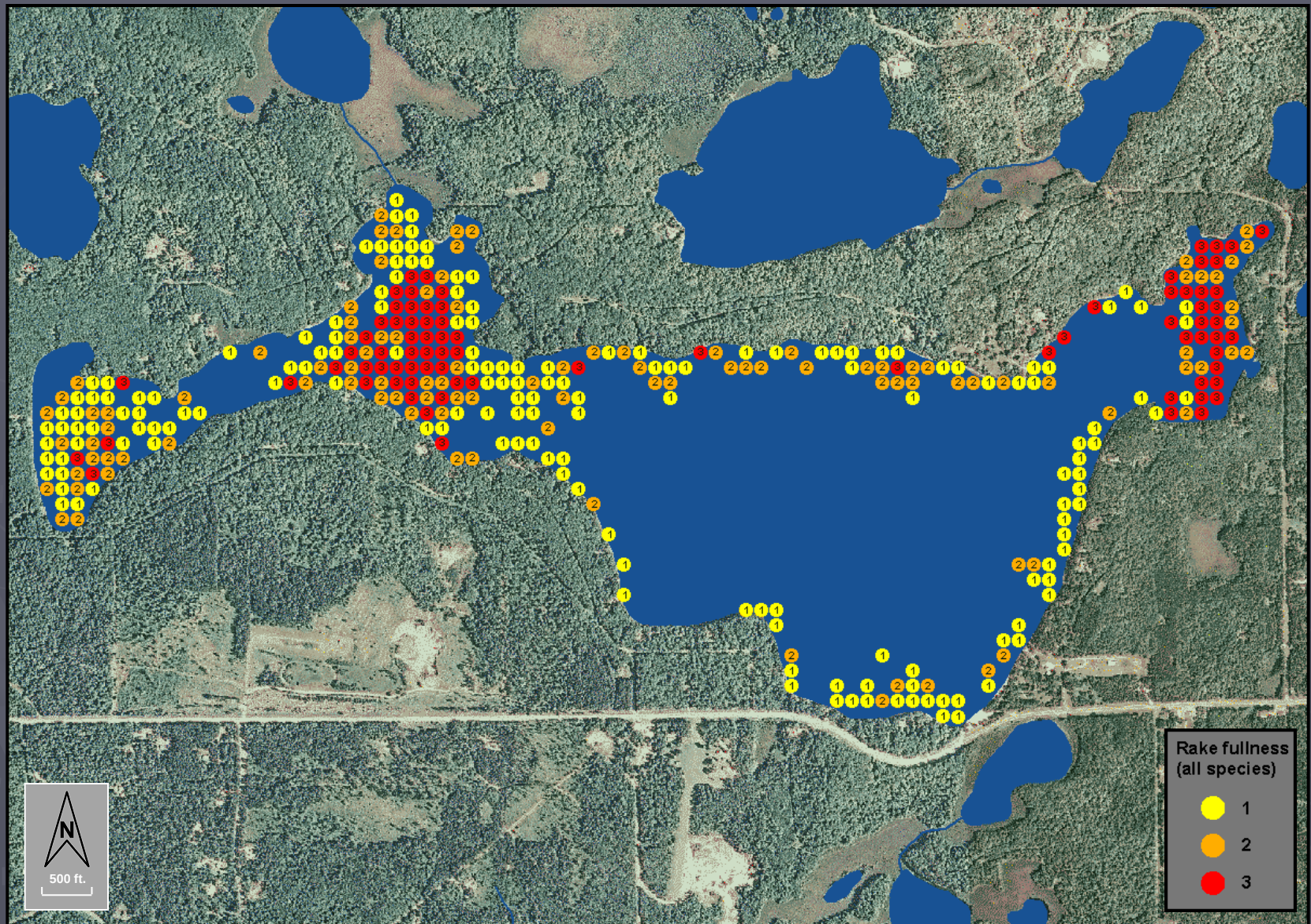


Figure 3a. Maximum Depth of Plant Colonization in Black Oak Lake, 2006.

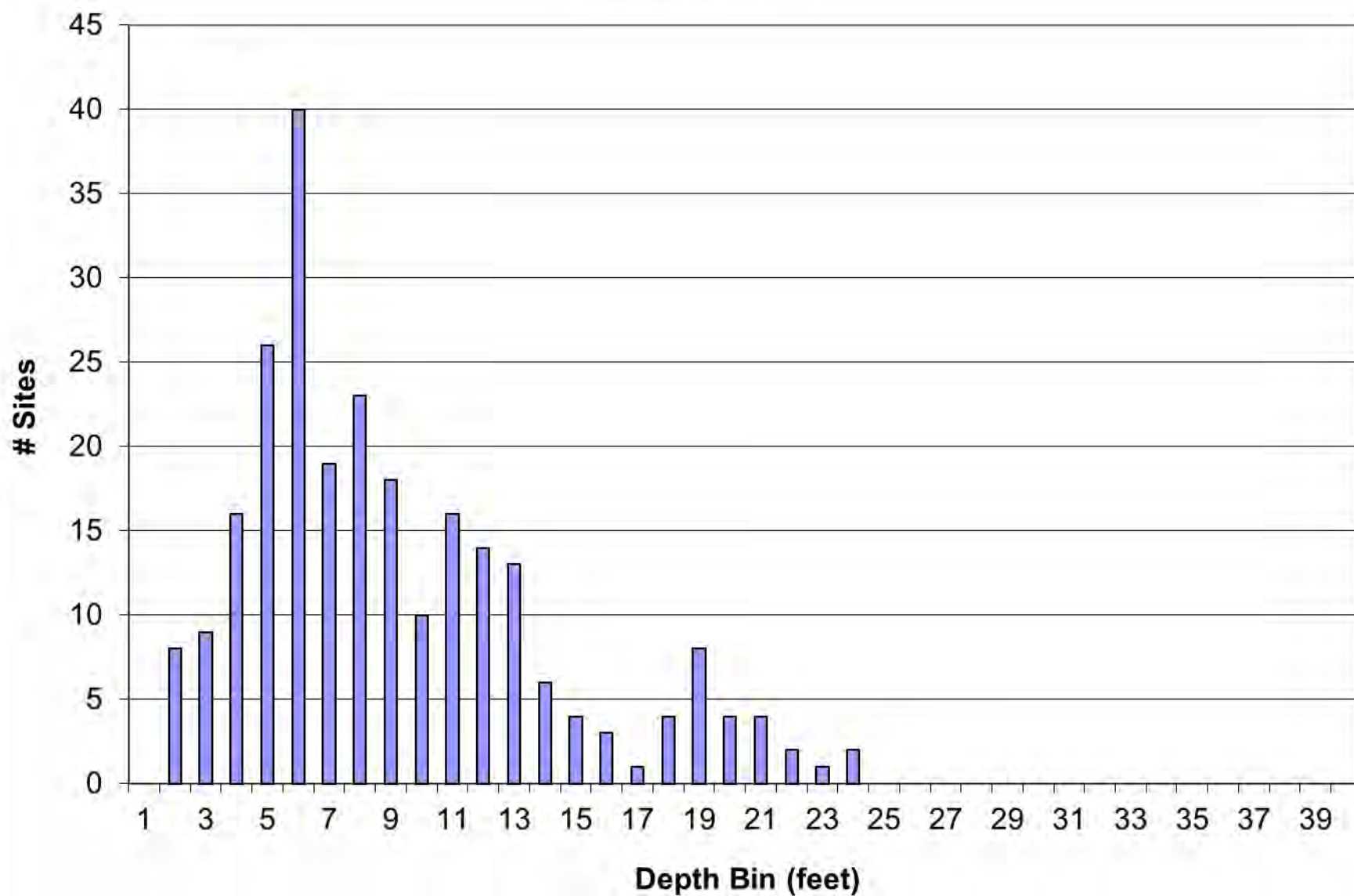


Figure 3b. Maximum Depth of Plant Colonization in Black Oak Lake, 2011.

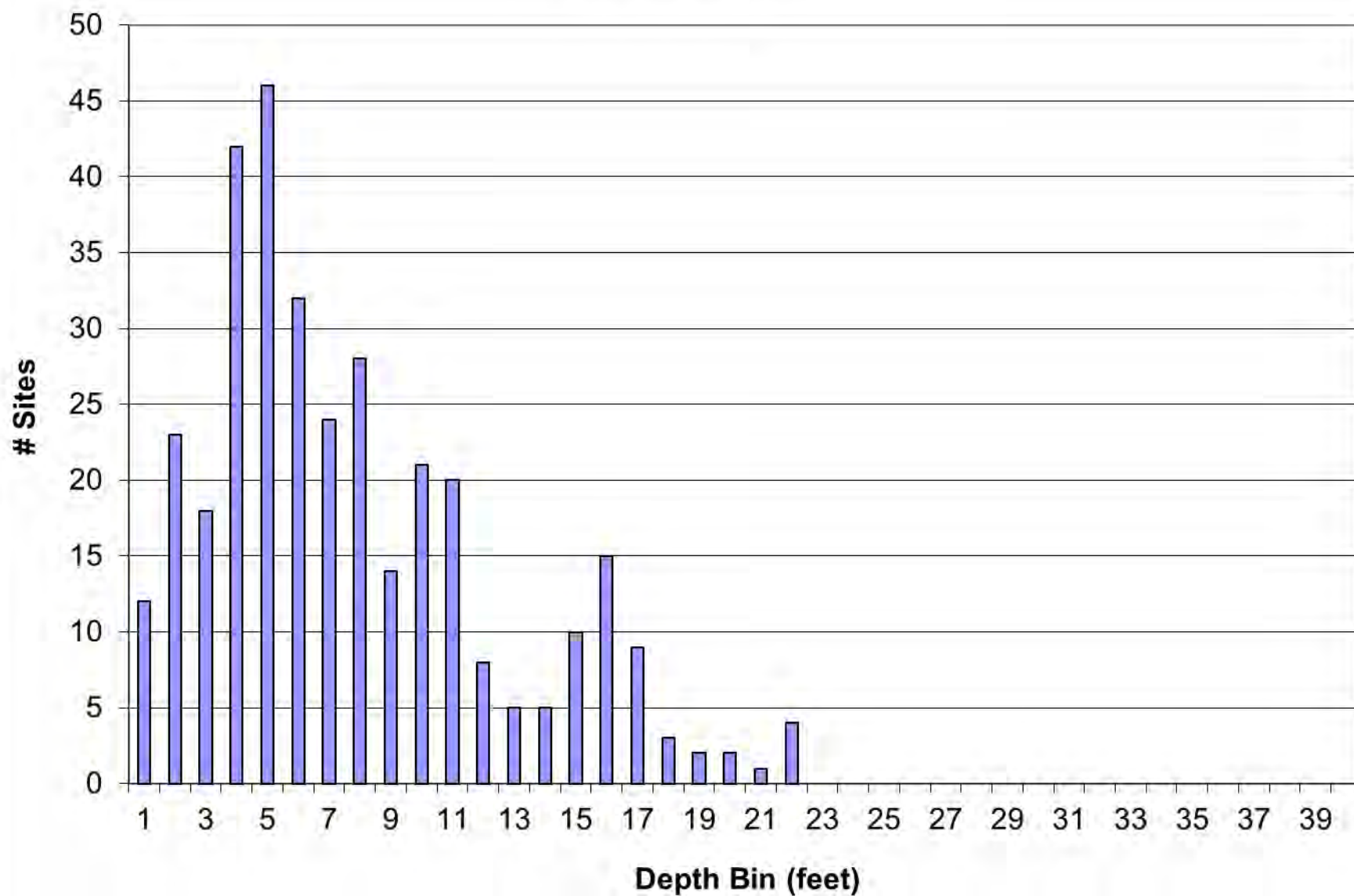


Figure 4a. Sample sites with depths less than or equal to maximum for rooted vegetation, Black Oak Lake (2006).

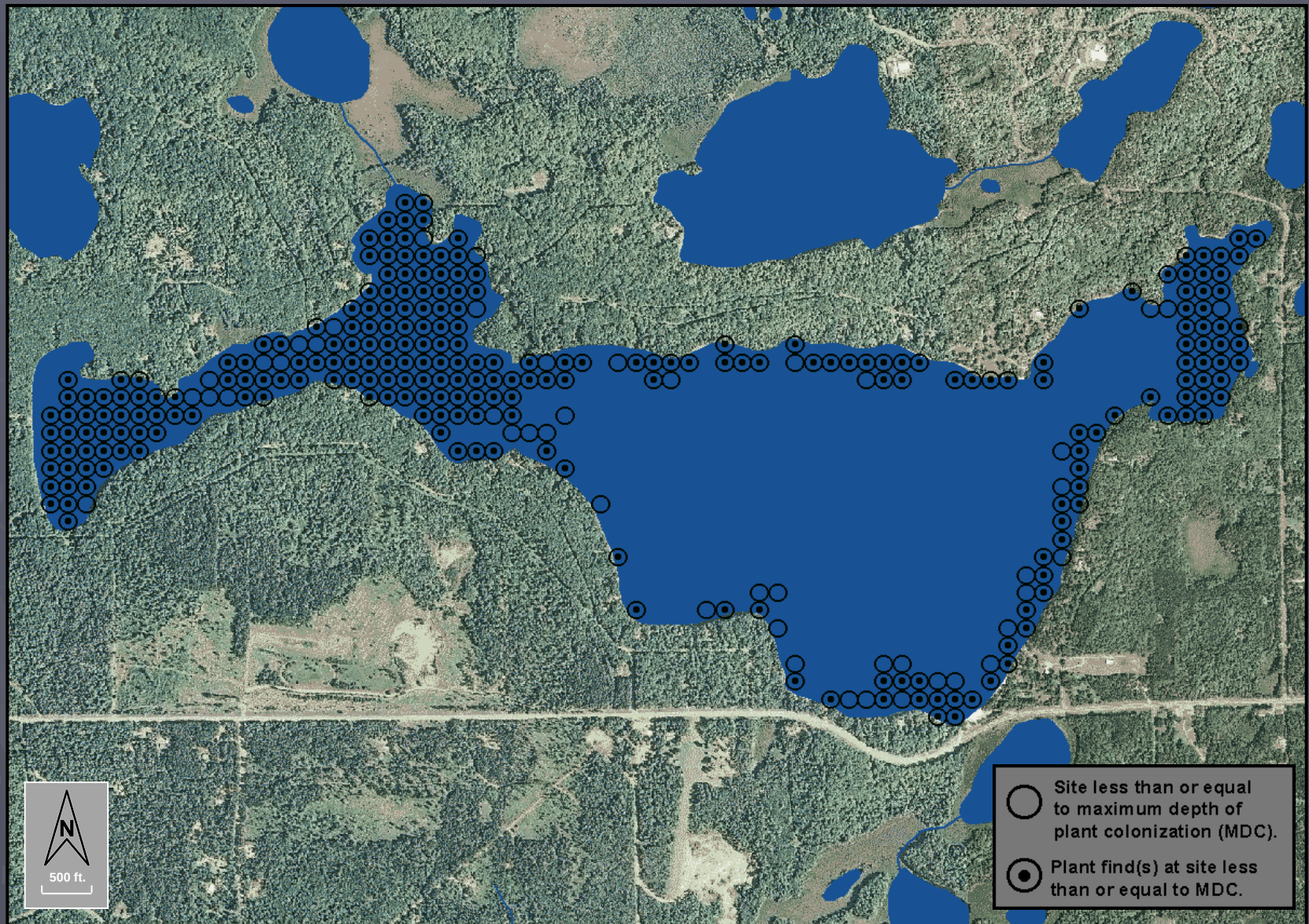


Figure 4b. Sample sites with depths less than or equal to maximum for rooted vegetation, Black Oak Lake (2011).

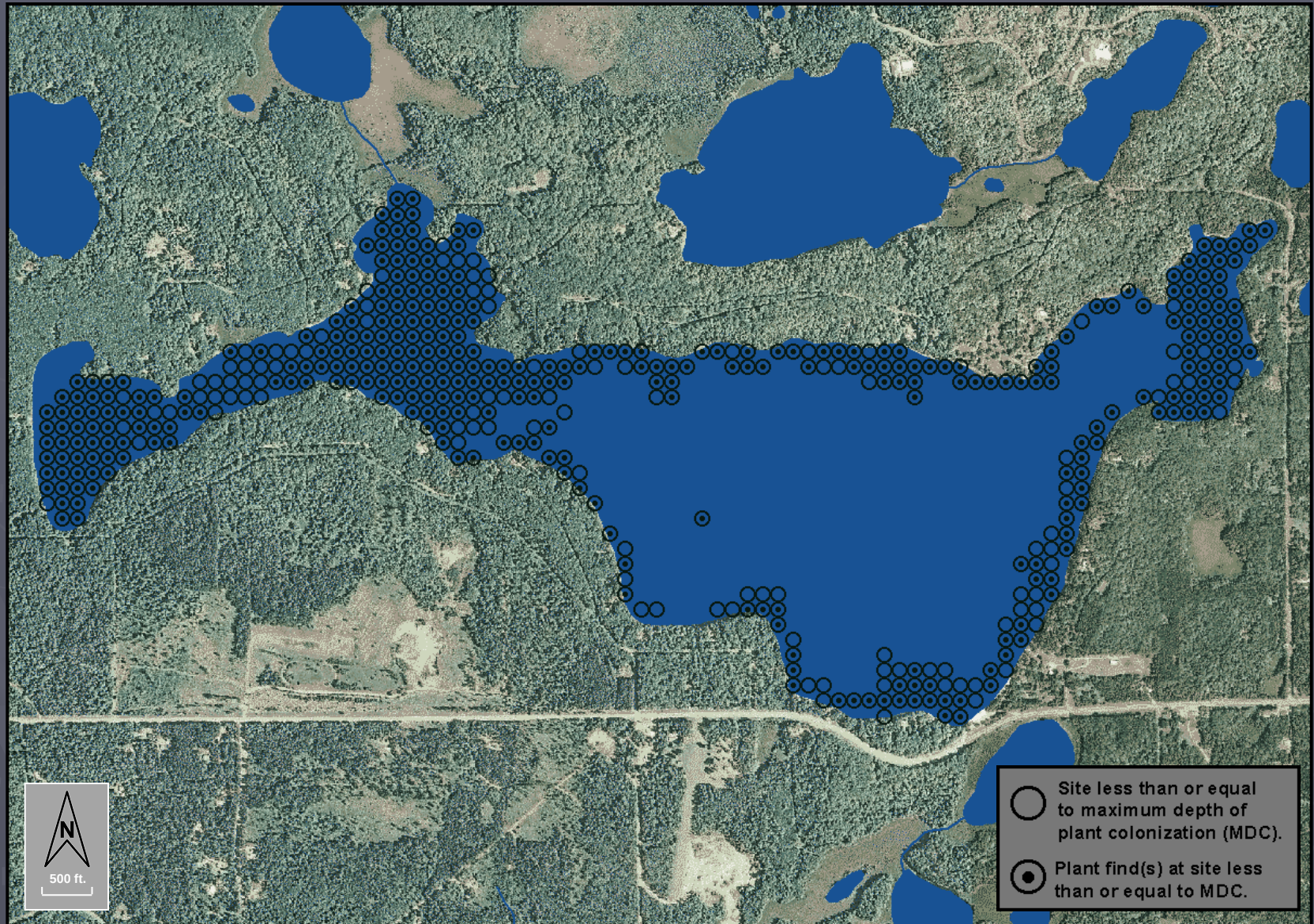


Figure 5a. Substrate encountered at sample sites, Black Oak Lake (2006).

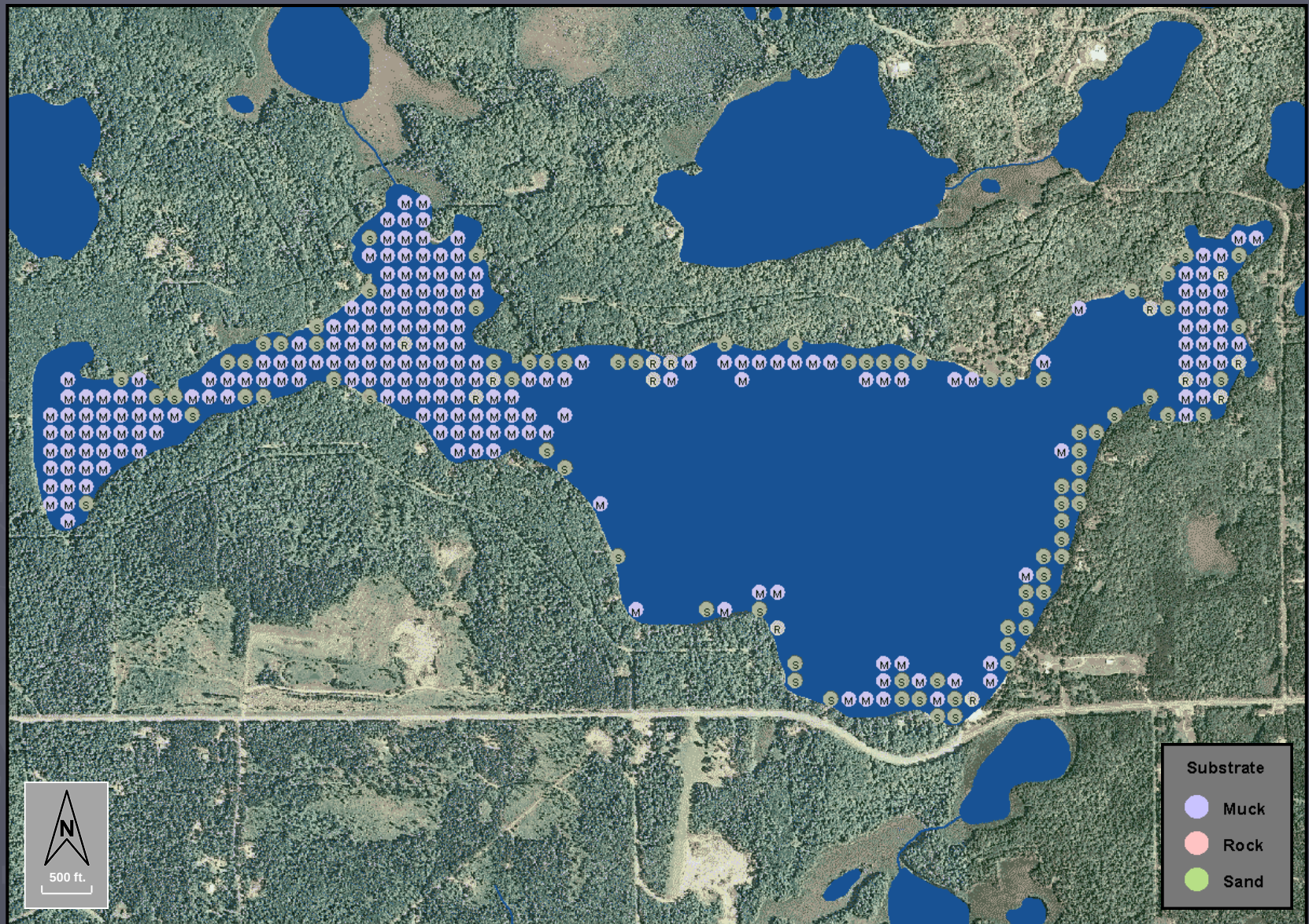


Figure 5b. Substrate encountered at sample sites,
Black Oak Lake (2011).

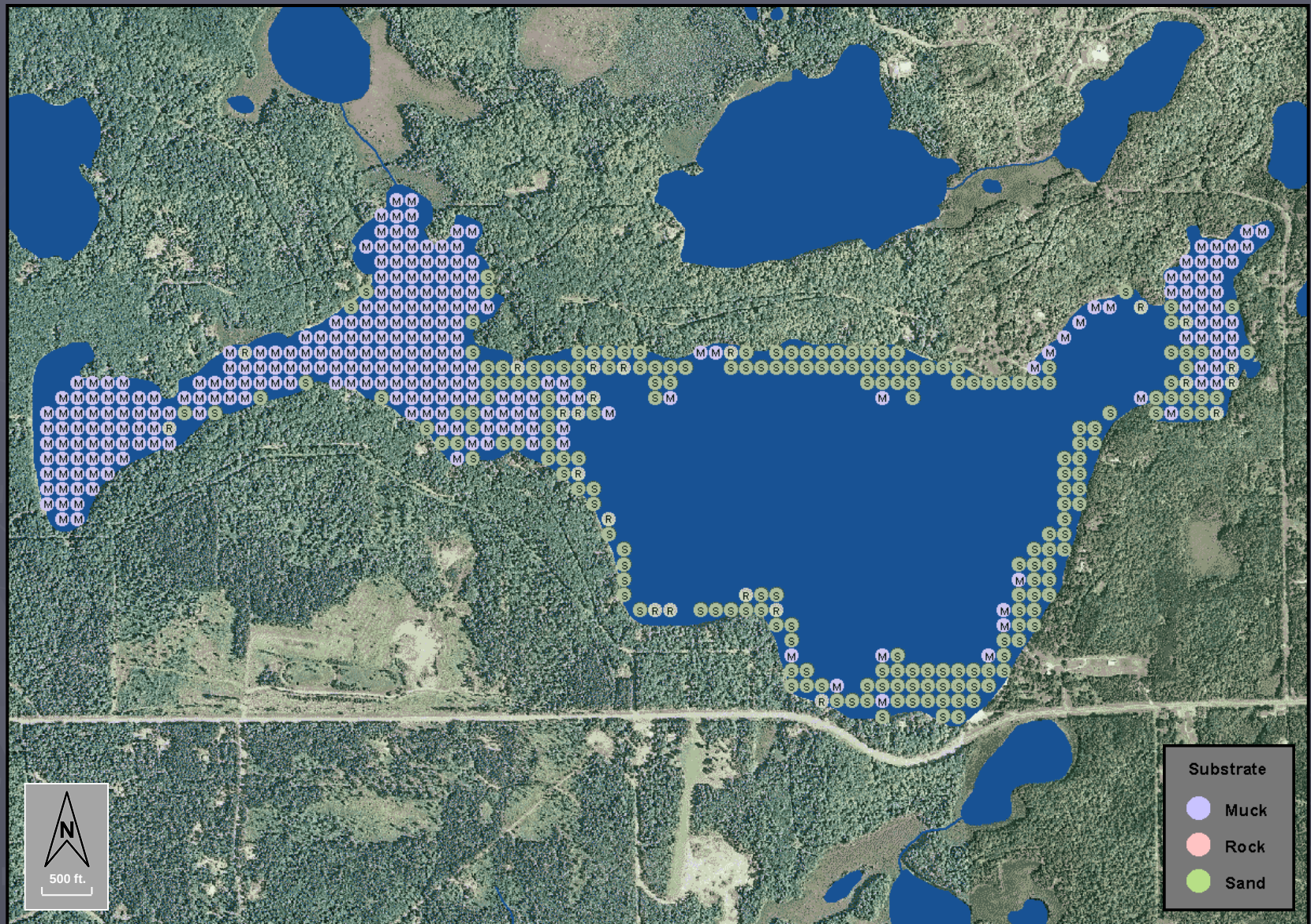


Figure 6a. Black Oak Lake aquatic plant occurrences for 2006 point-intercept survey data.

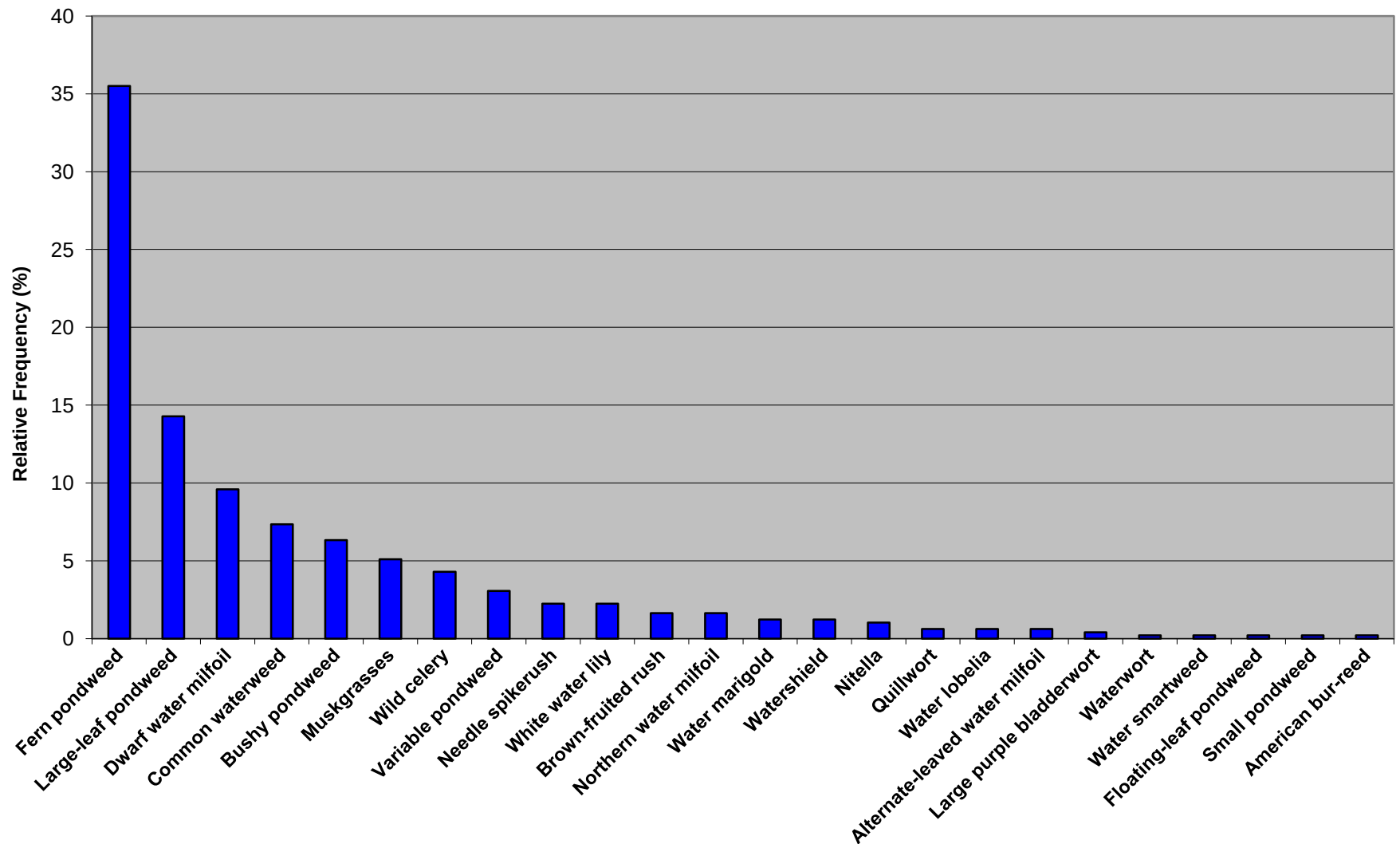


Figure 6b. Black Oak Lake aquatic plant occurrences for 2011 point-intercept survey data.

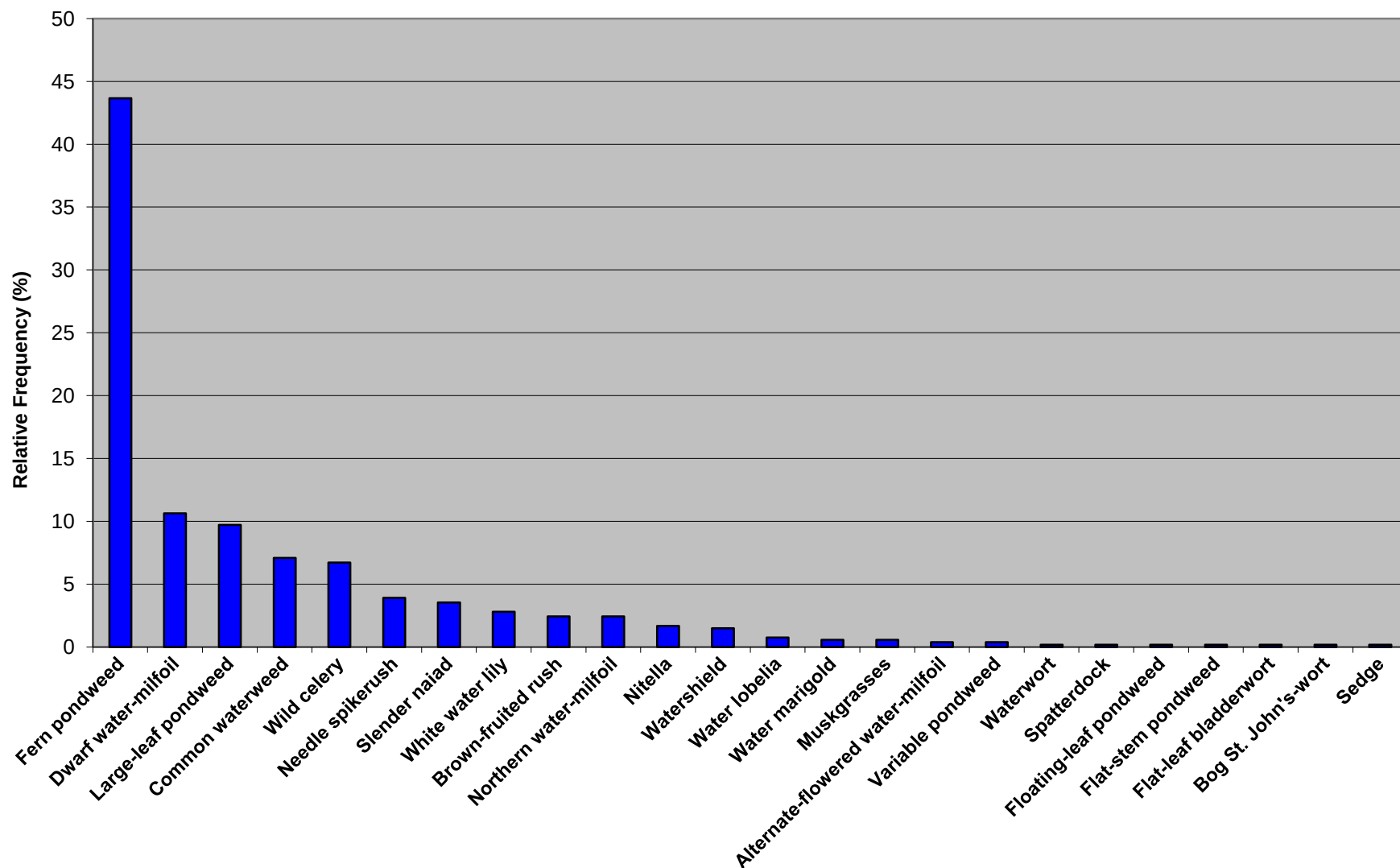


Figure 7a. Sample sites with emergent and floating aquatic plants, Black Oak Lake (2006).

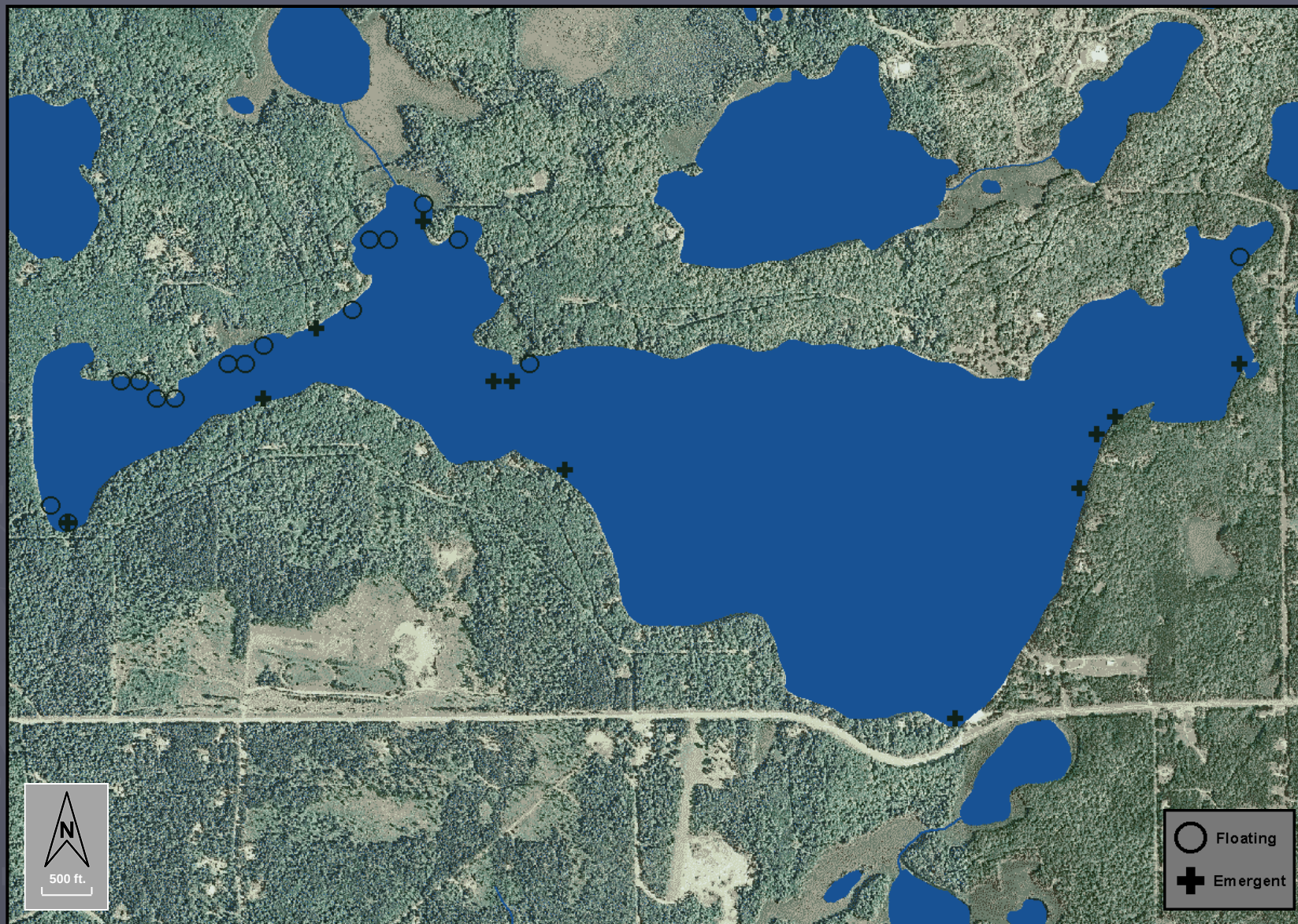


Figure 7b. Sample sites with emergent and floating aquatic plants, Black Oak Lake (2011).



Figure 8a. Distribution of plant species, Black Oak Lake (2006).

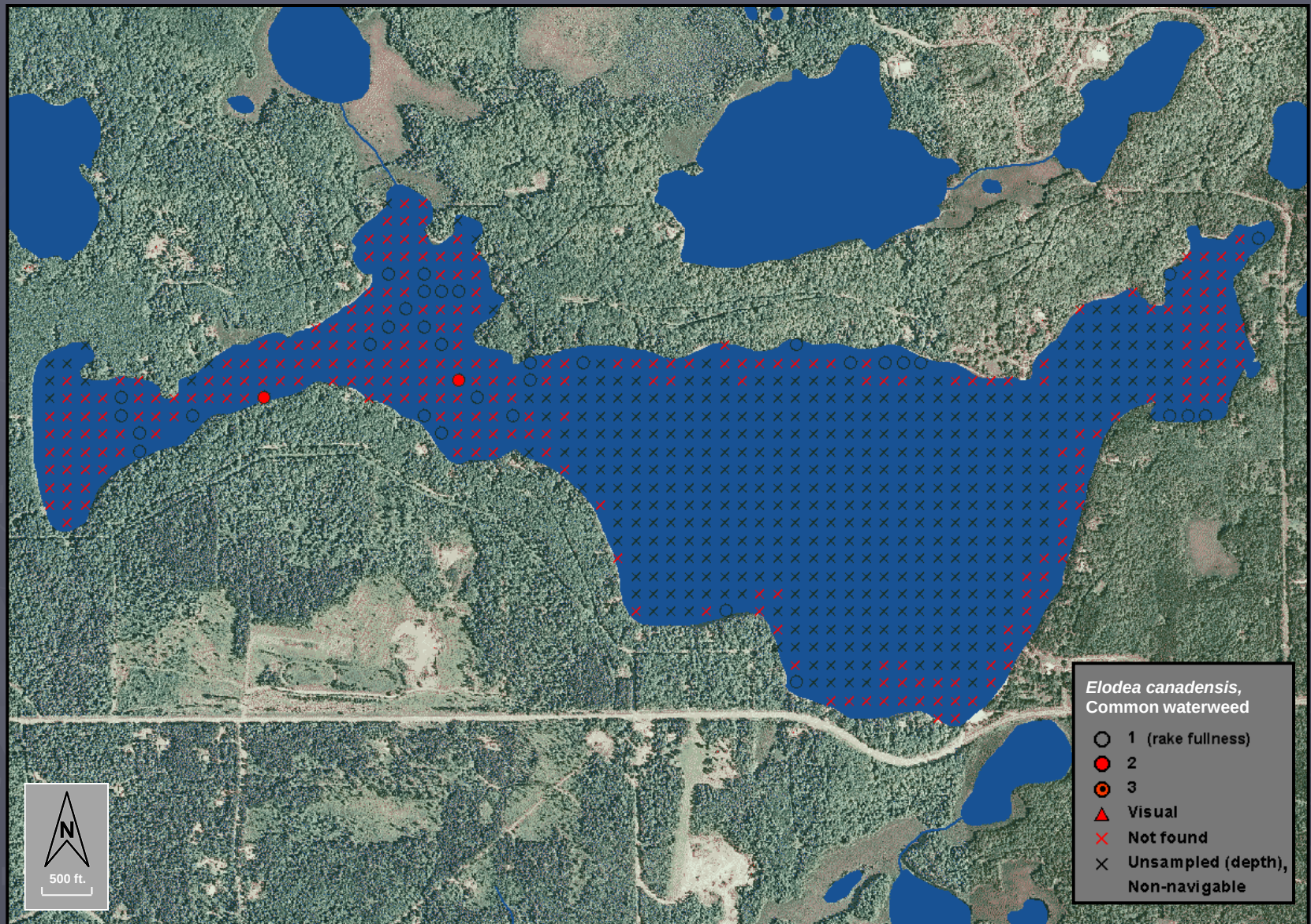


Figure 8b. Distribution of plant species, Black Oak Lake (2011).

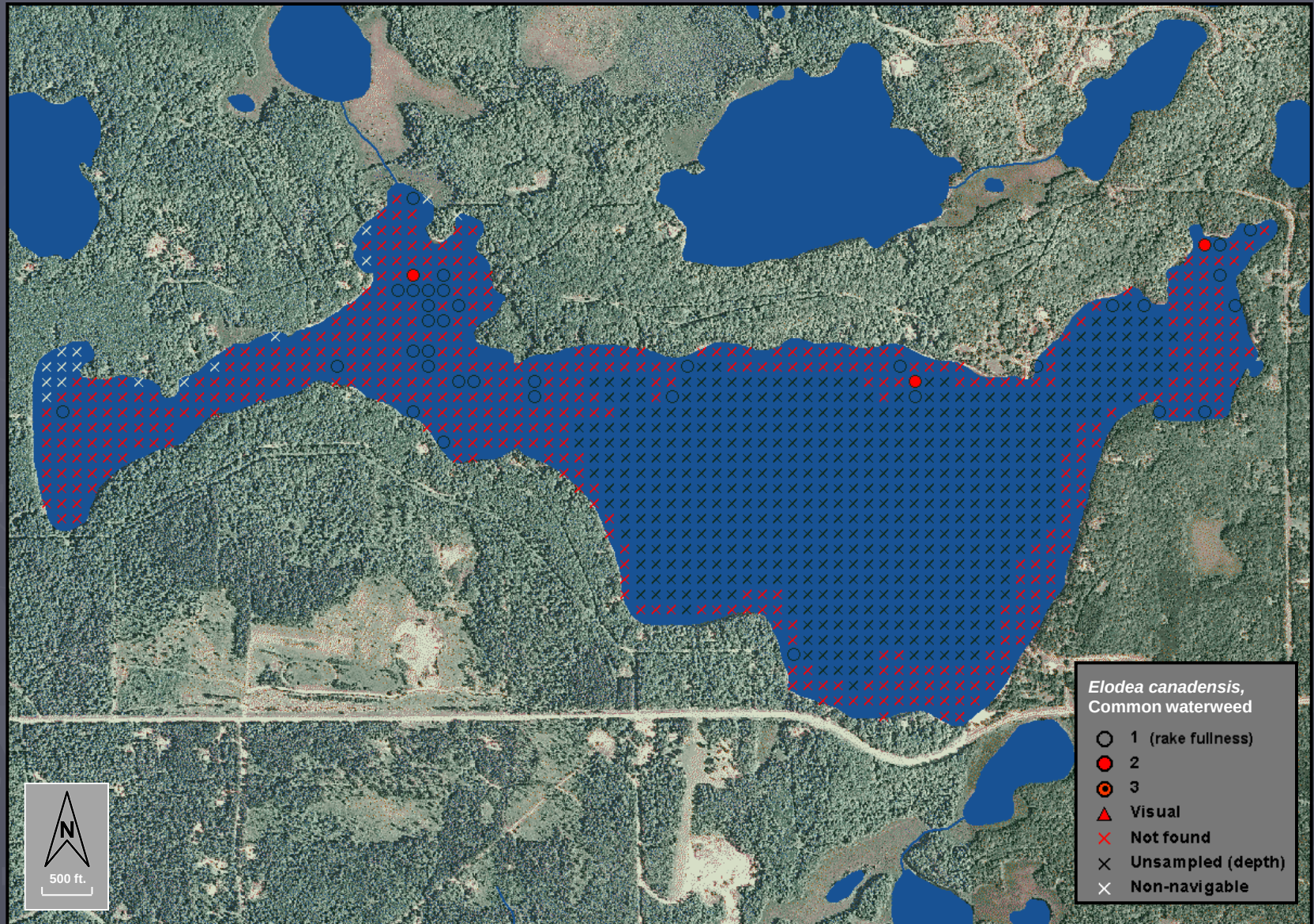


Figure 9a. Distribution of plant species, Black Oak Lake (2006).

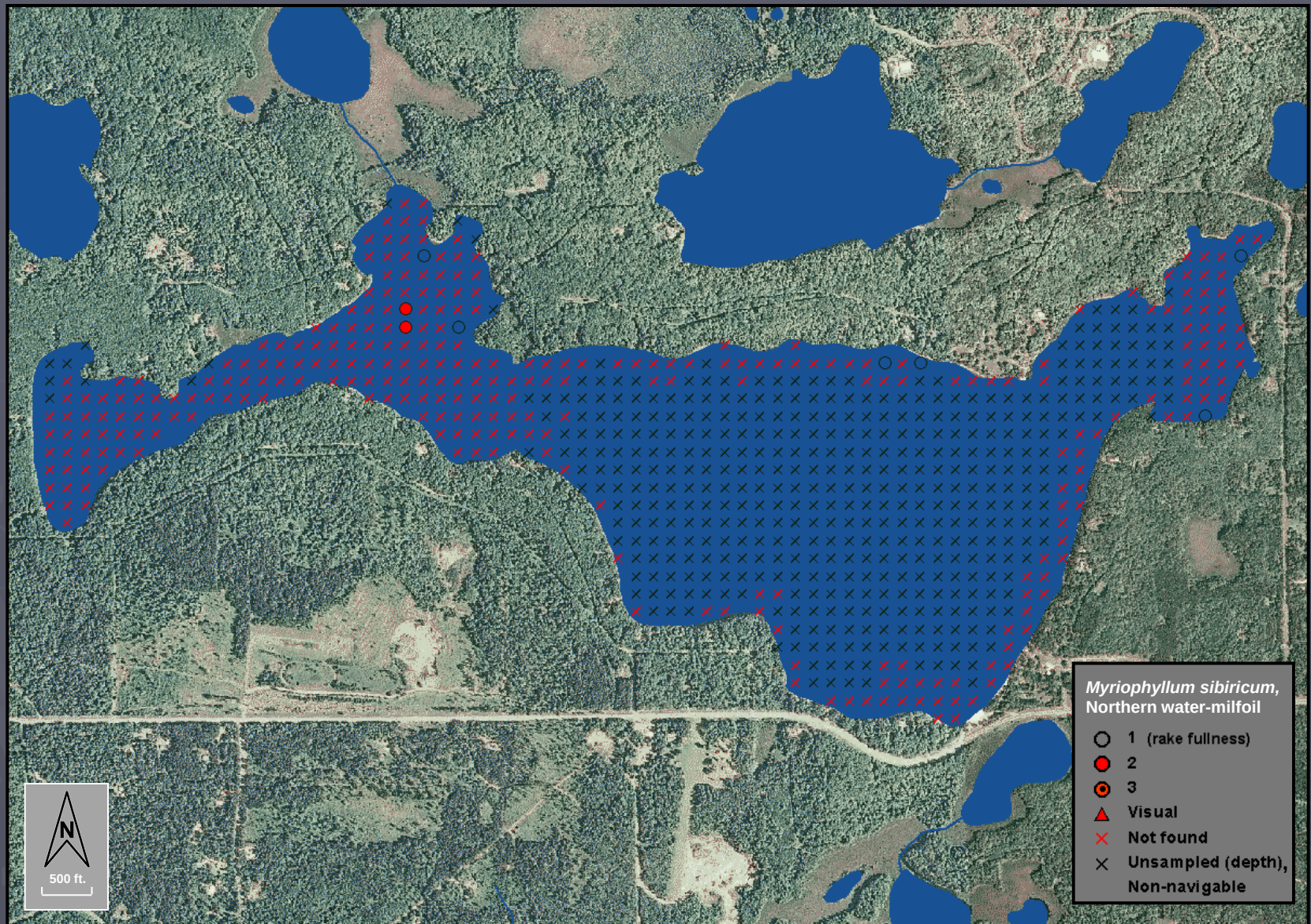


Figure 9b. Distribution of plant species, Black Oak Lake (2011).

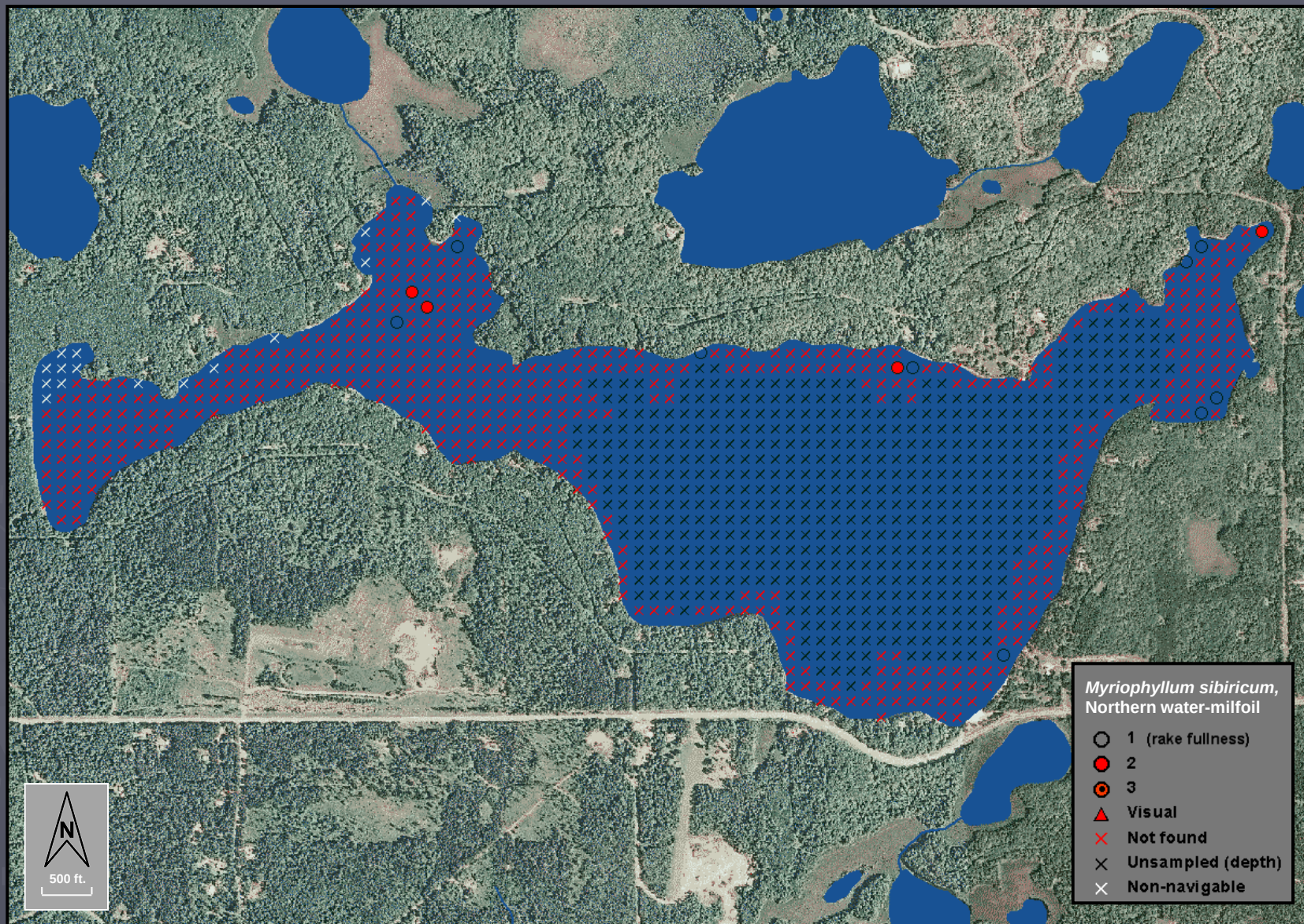


Figure 10a. Distribution of plant species, Black Oak Lake (2006).

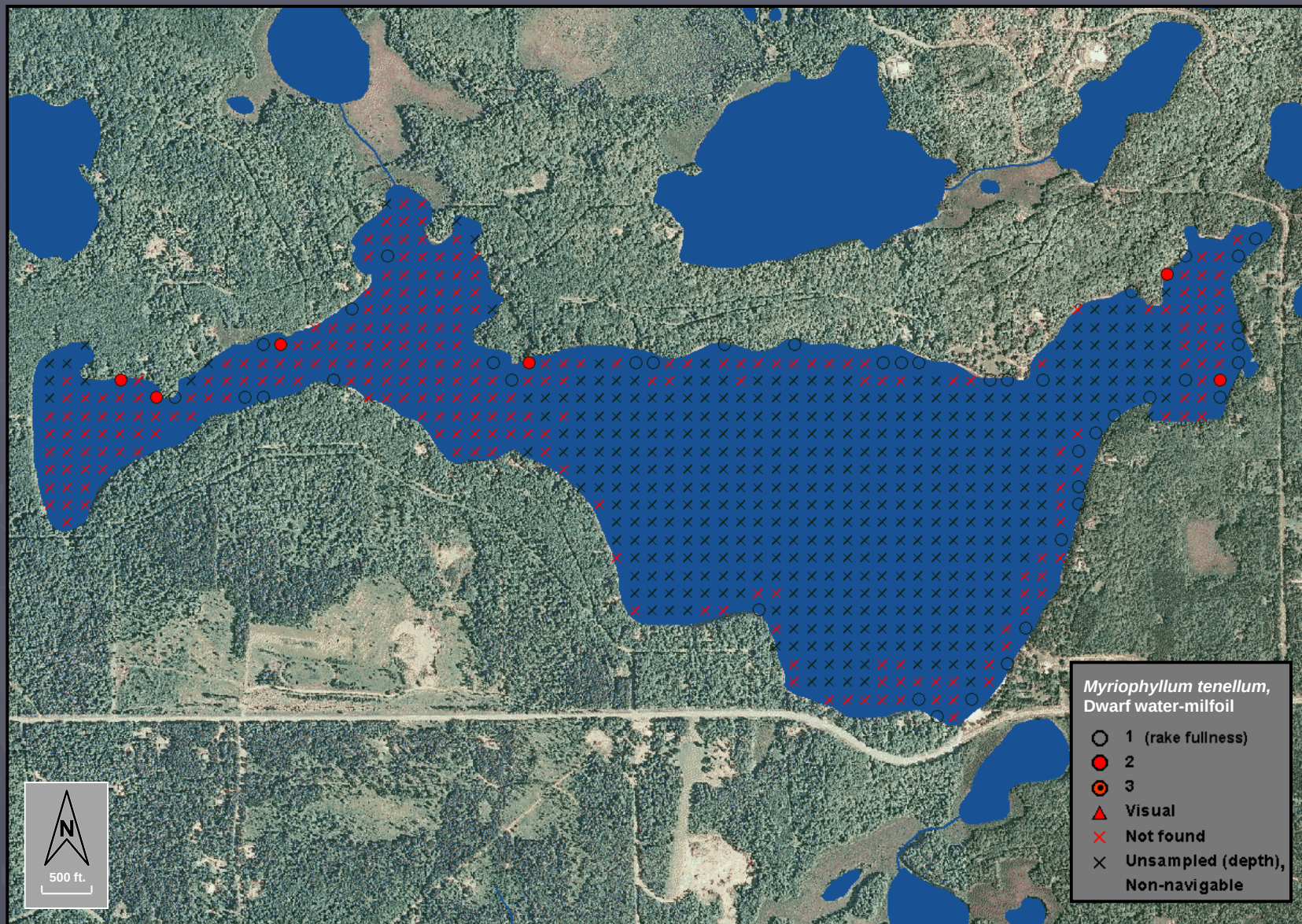


Figure 10b. Distribution of plant species, Black Oak Lake (2011).

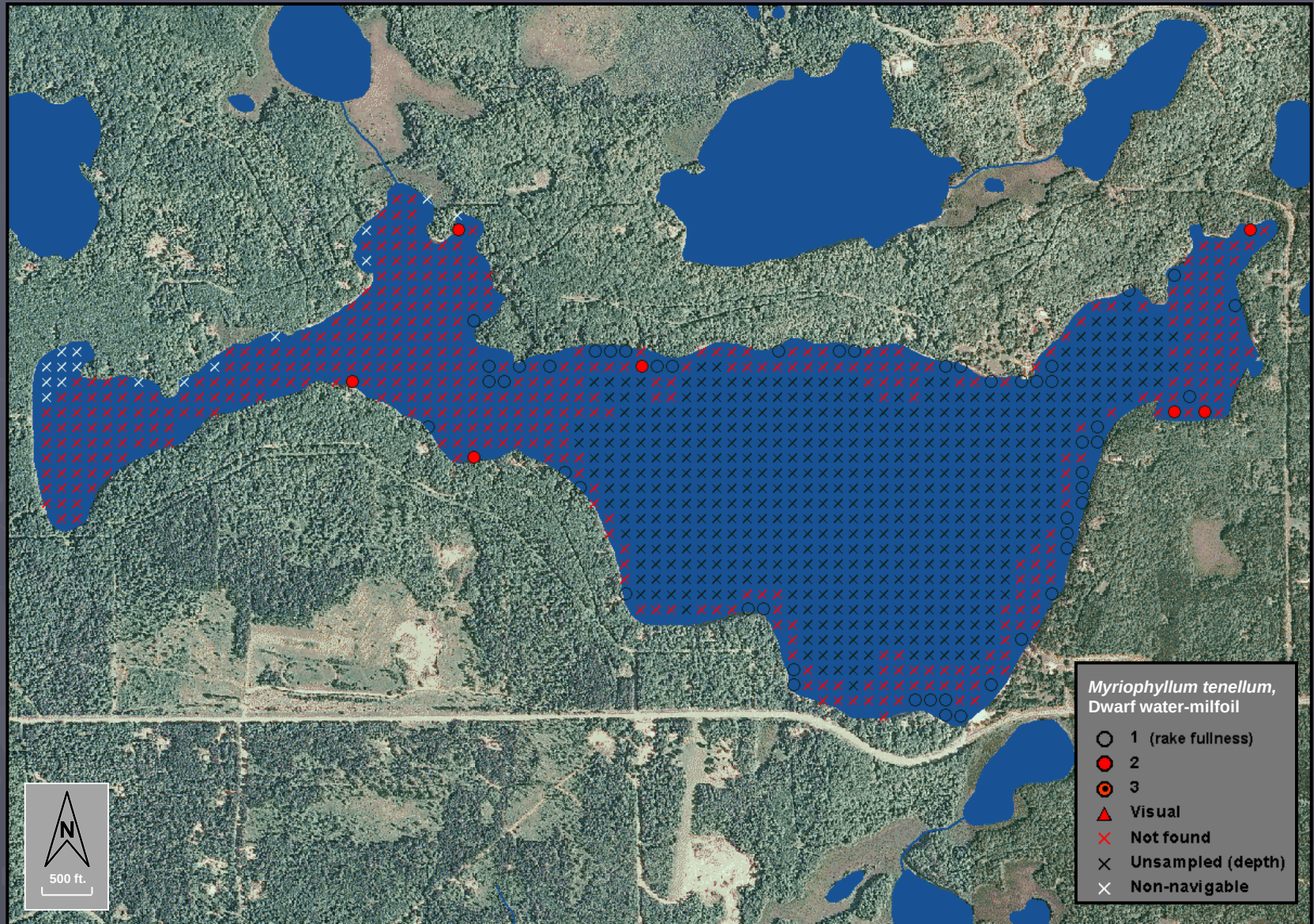


Figure 11a. Distribution of plant species, Black Oak Lake (2006).

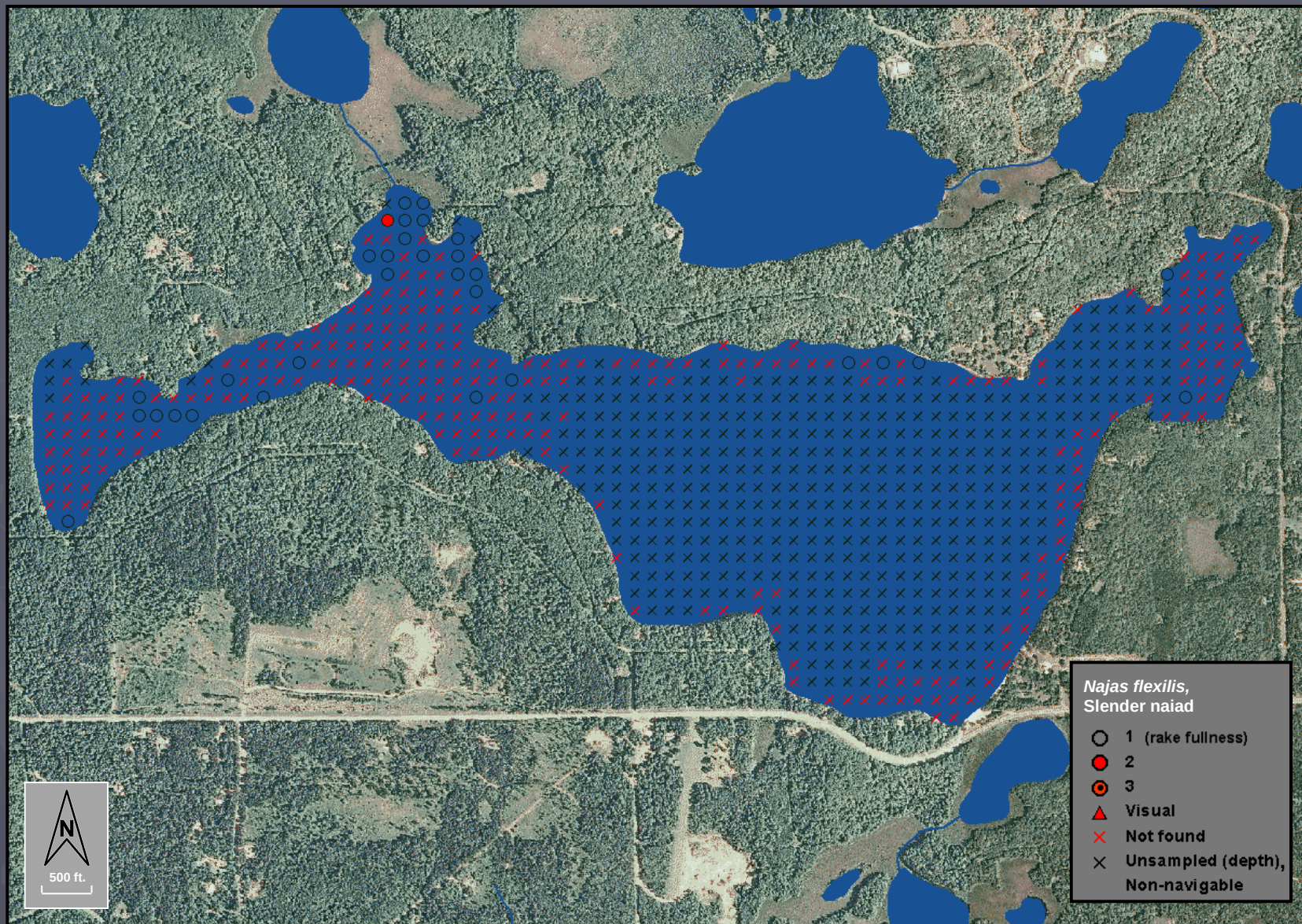


Figure 11b. Distribution of plant species, Black Oak Lake (2011).

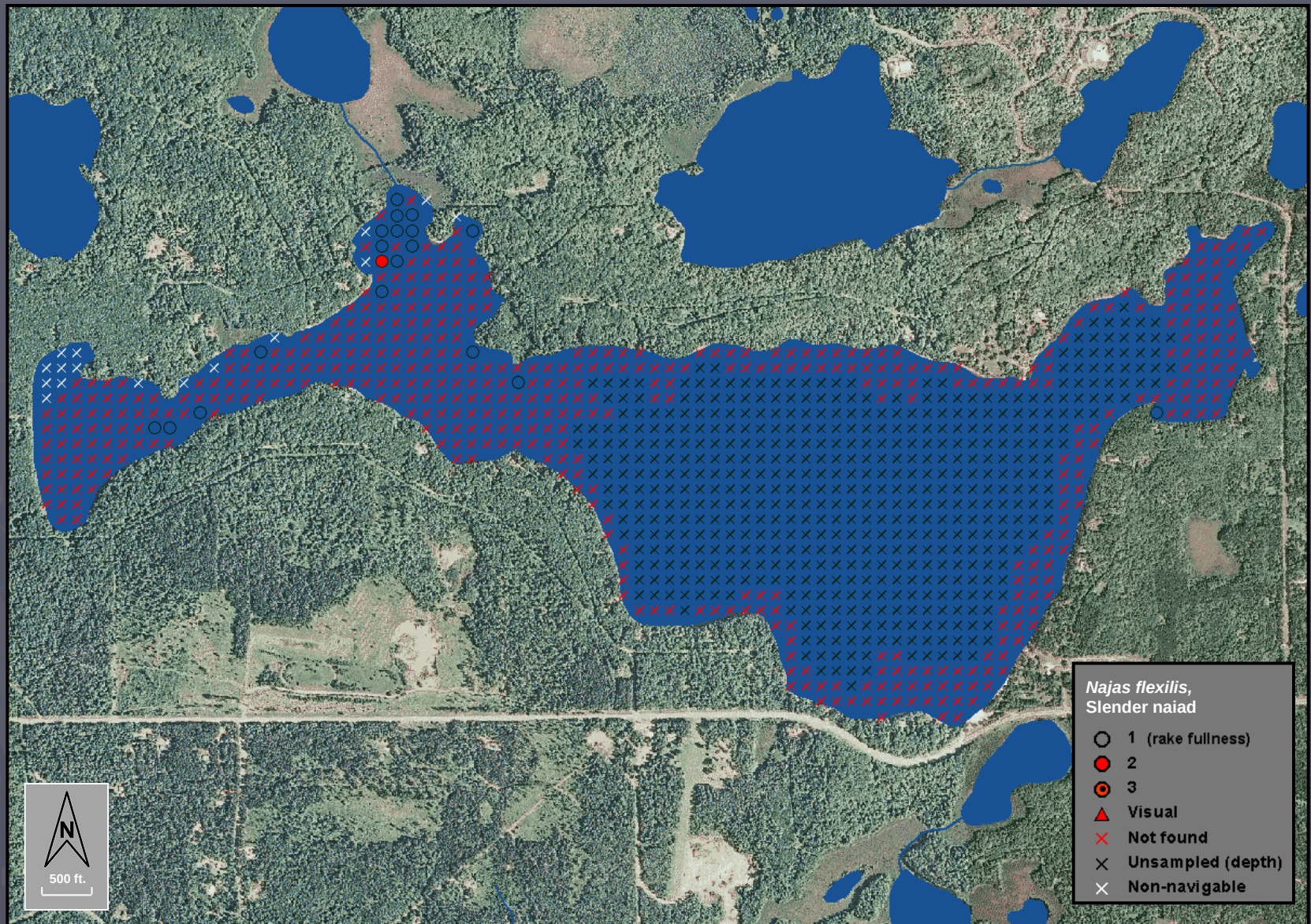


Figure 12a. Distribution of plant species, Black Oak Lake (2006).

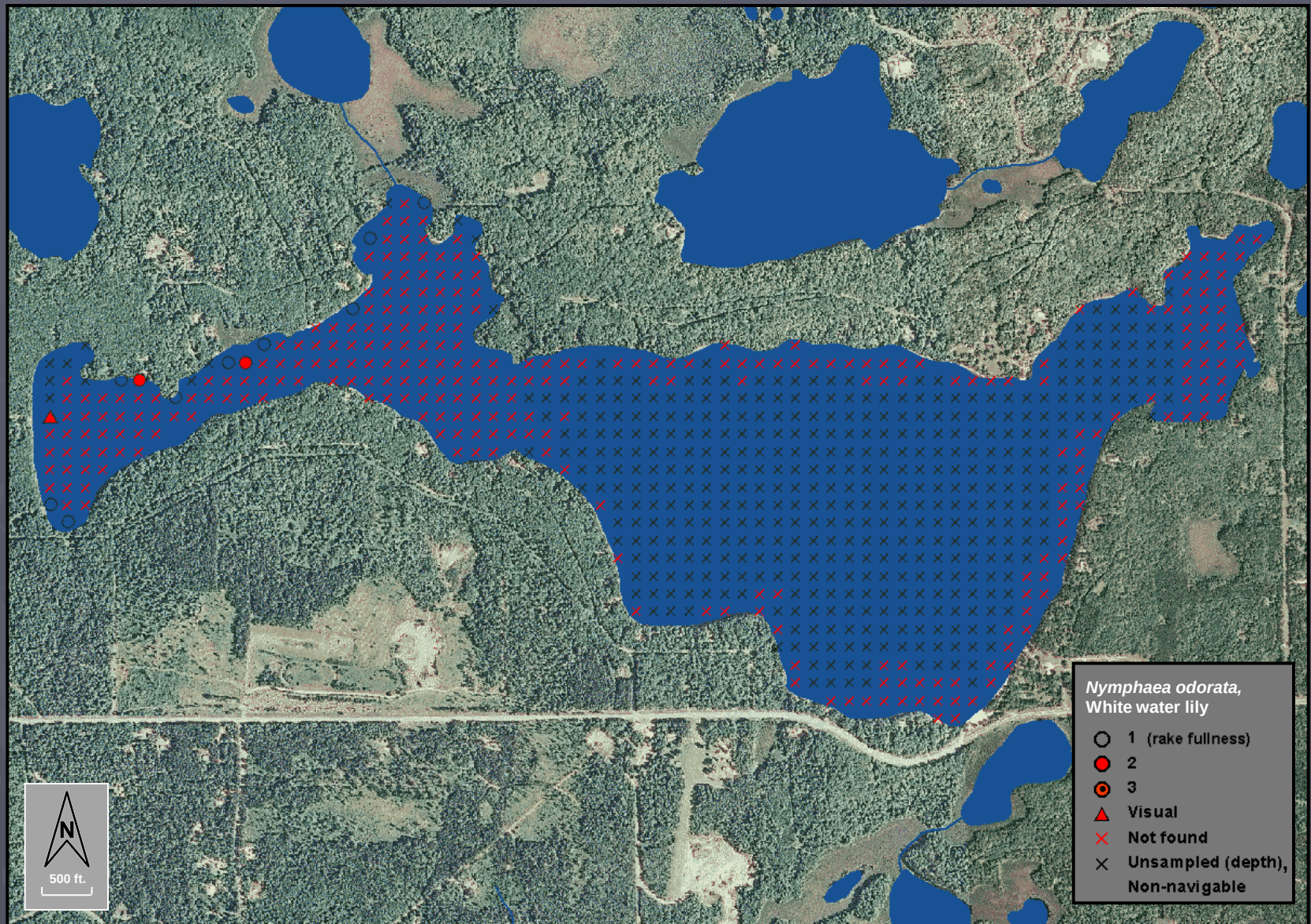


Figure 12b. Distribution of plant species, Black Oak Lake (2011).

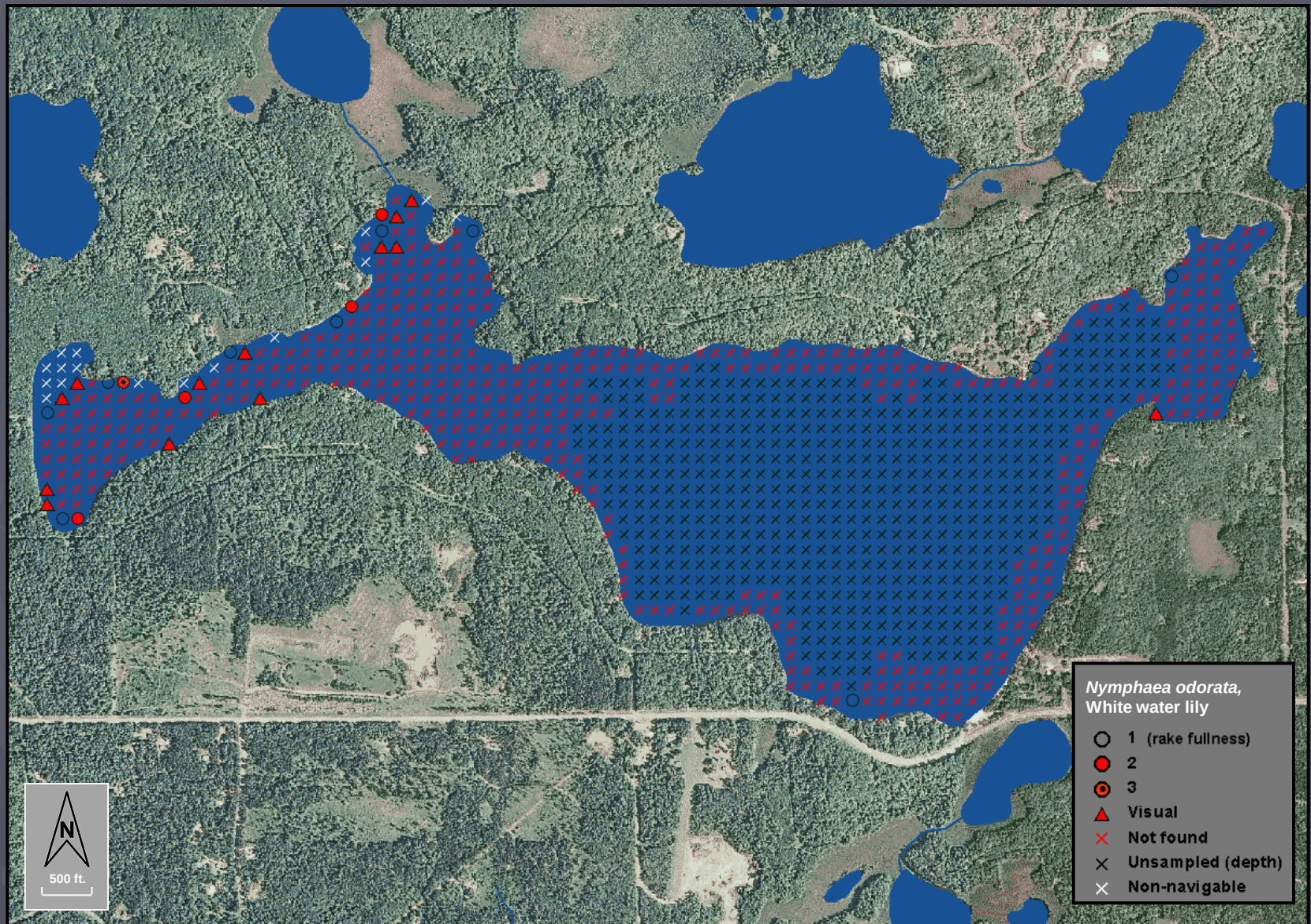


Figure 13a. Distribution of plant species, Black Oak Lake (2006).

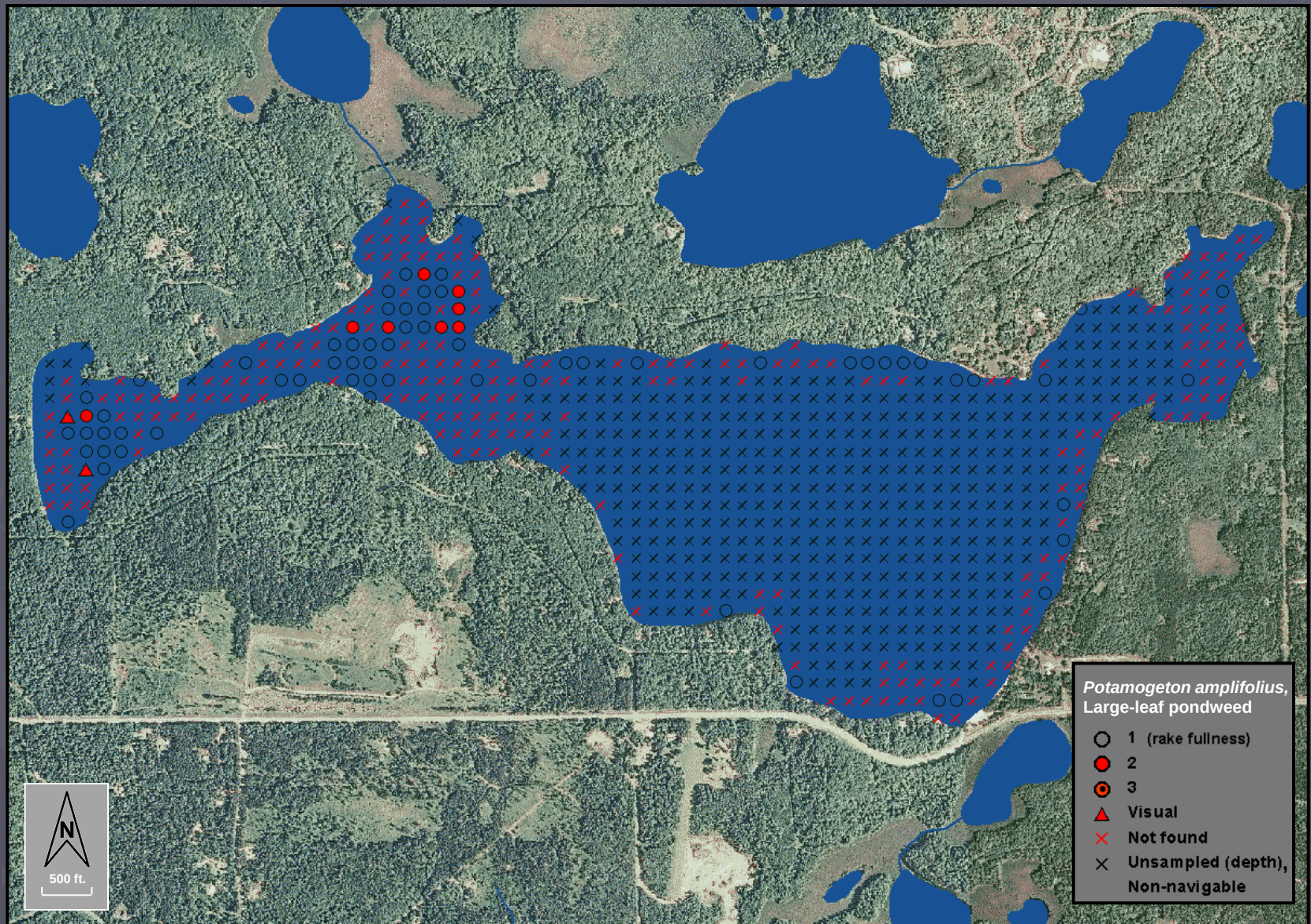


Figure 13b. Distribution of plant species, Black Oak Lake (2011).

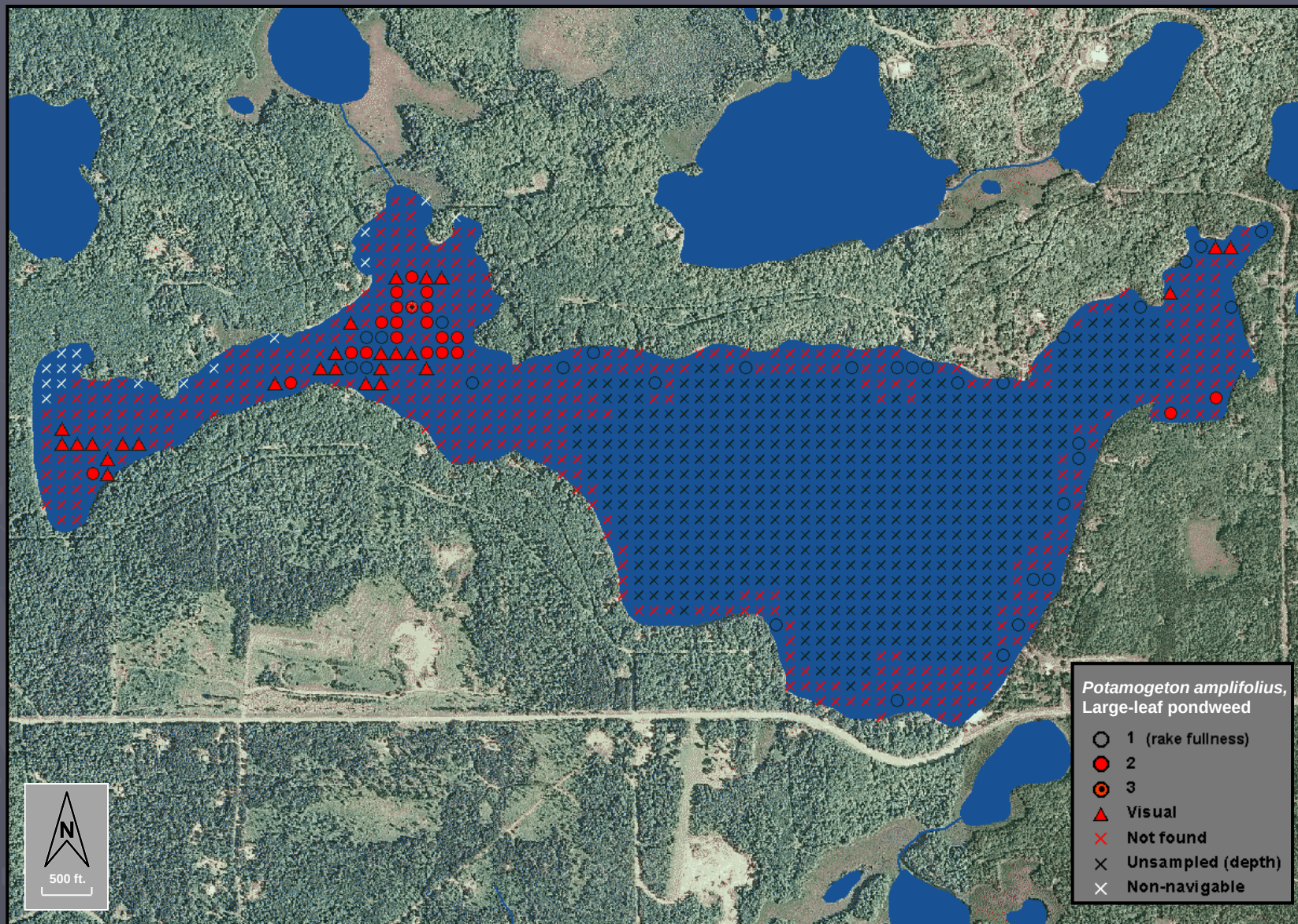


Figure 14a. Distribution of plant species, Black Oak Lake (2006).

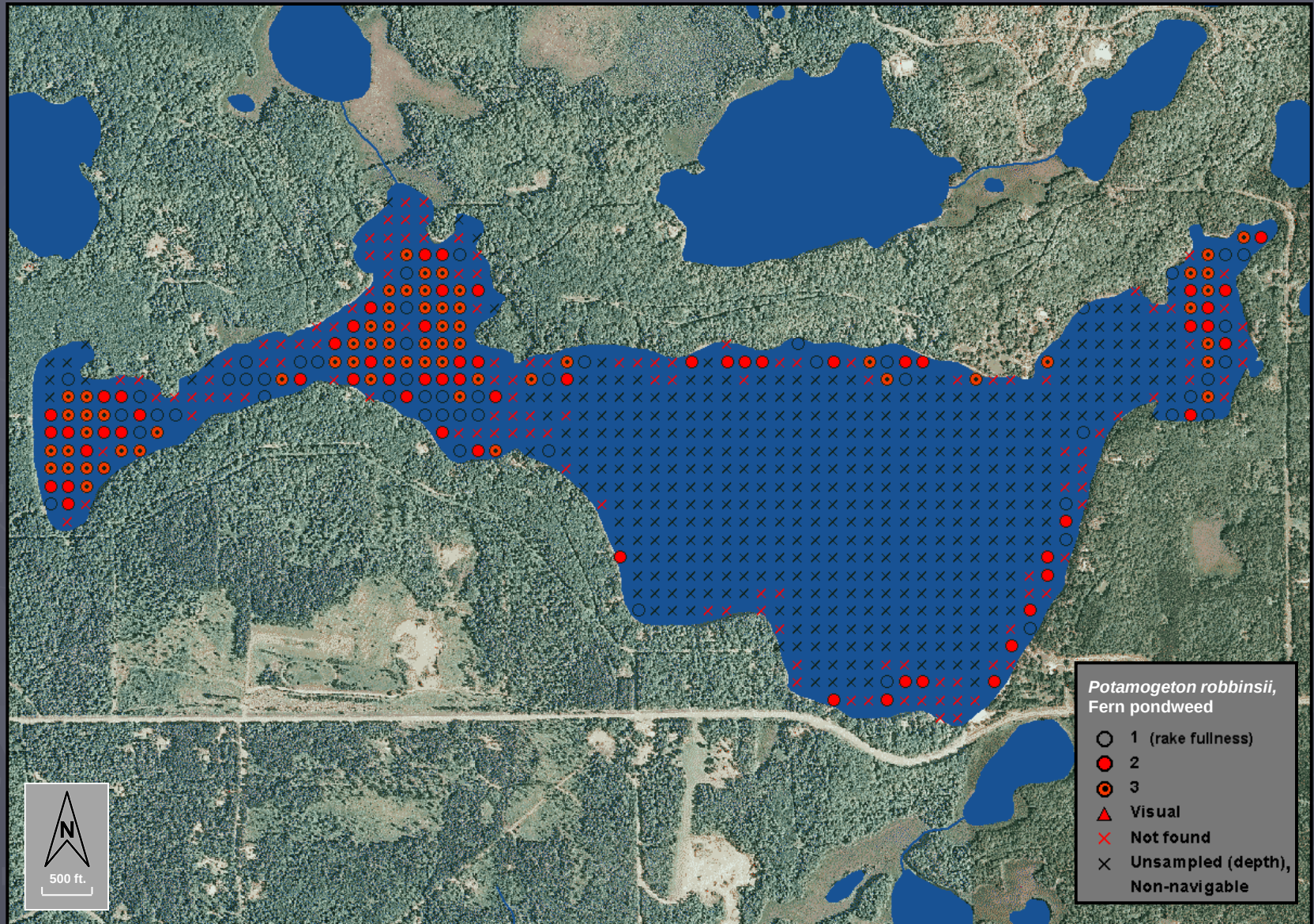


Figure 14b. Distribution of plant species, Black Oak Lake (2011).

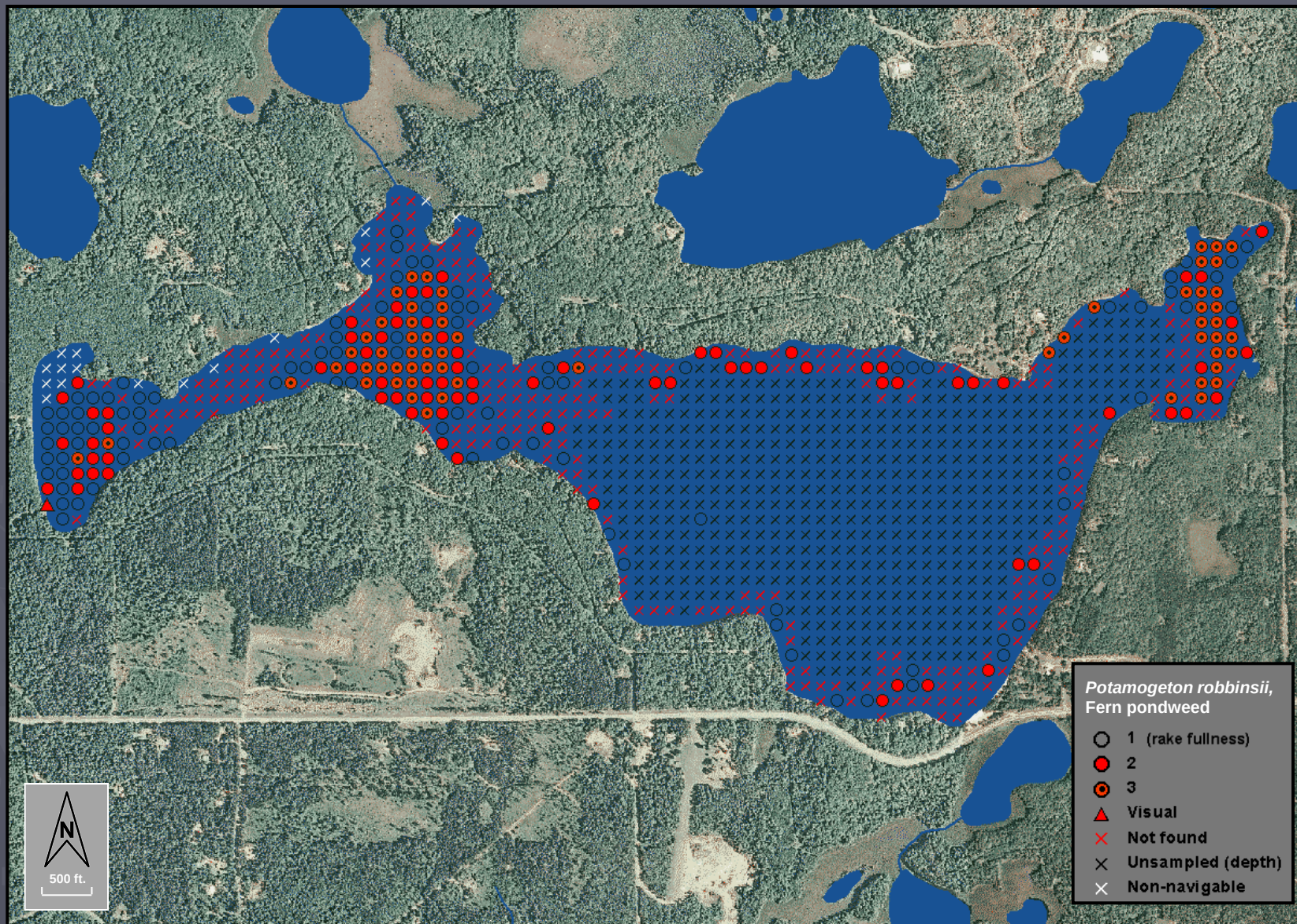


Figure 15a. Distribution of plant species, Black Oak Lake (2006).

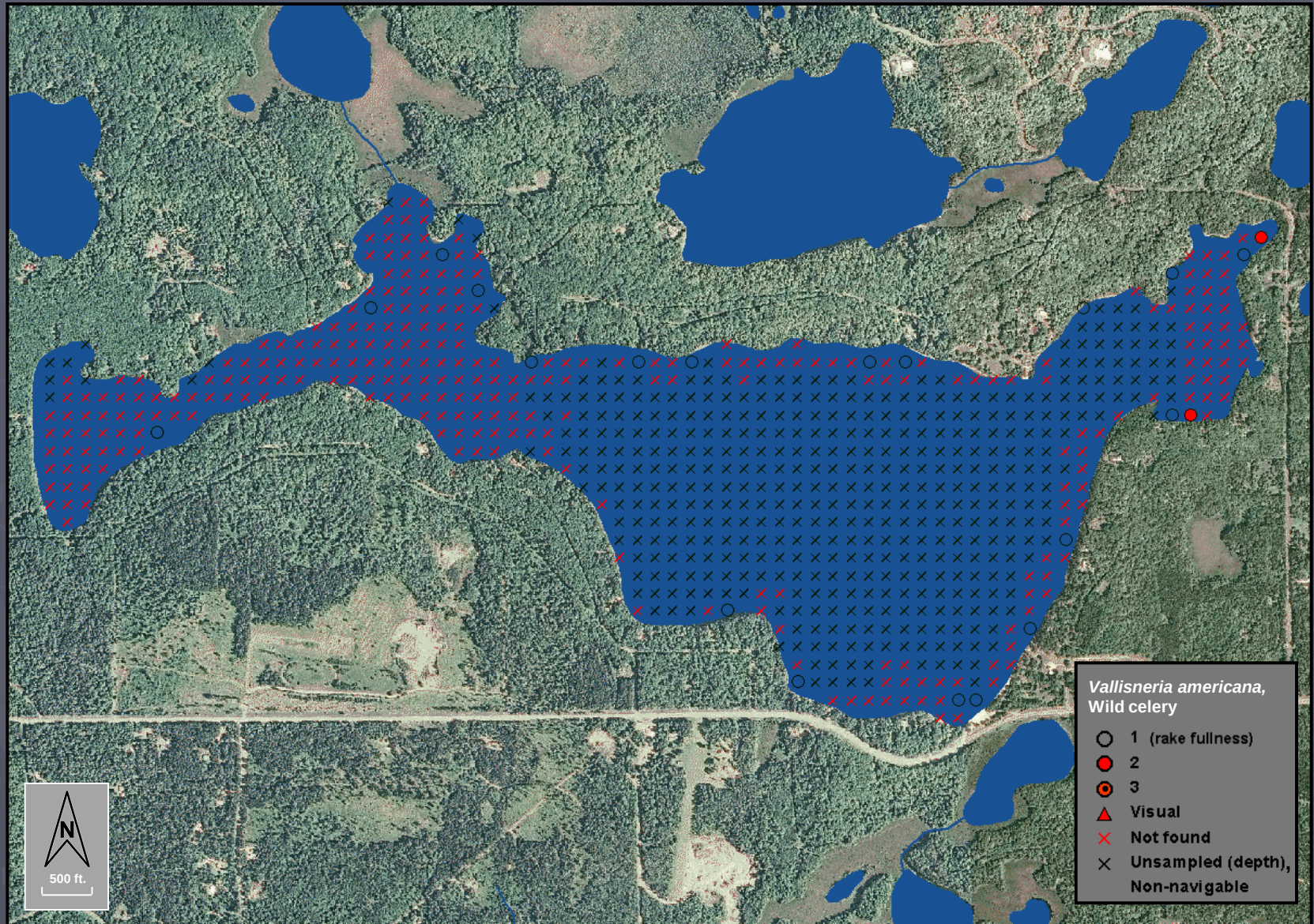
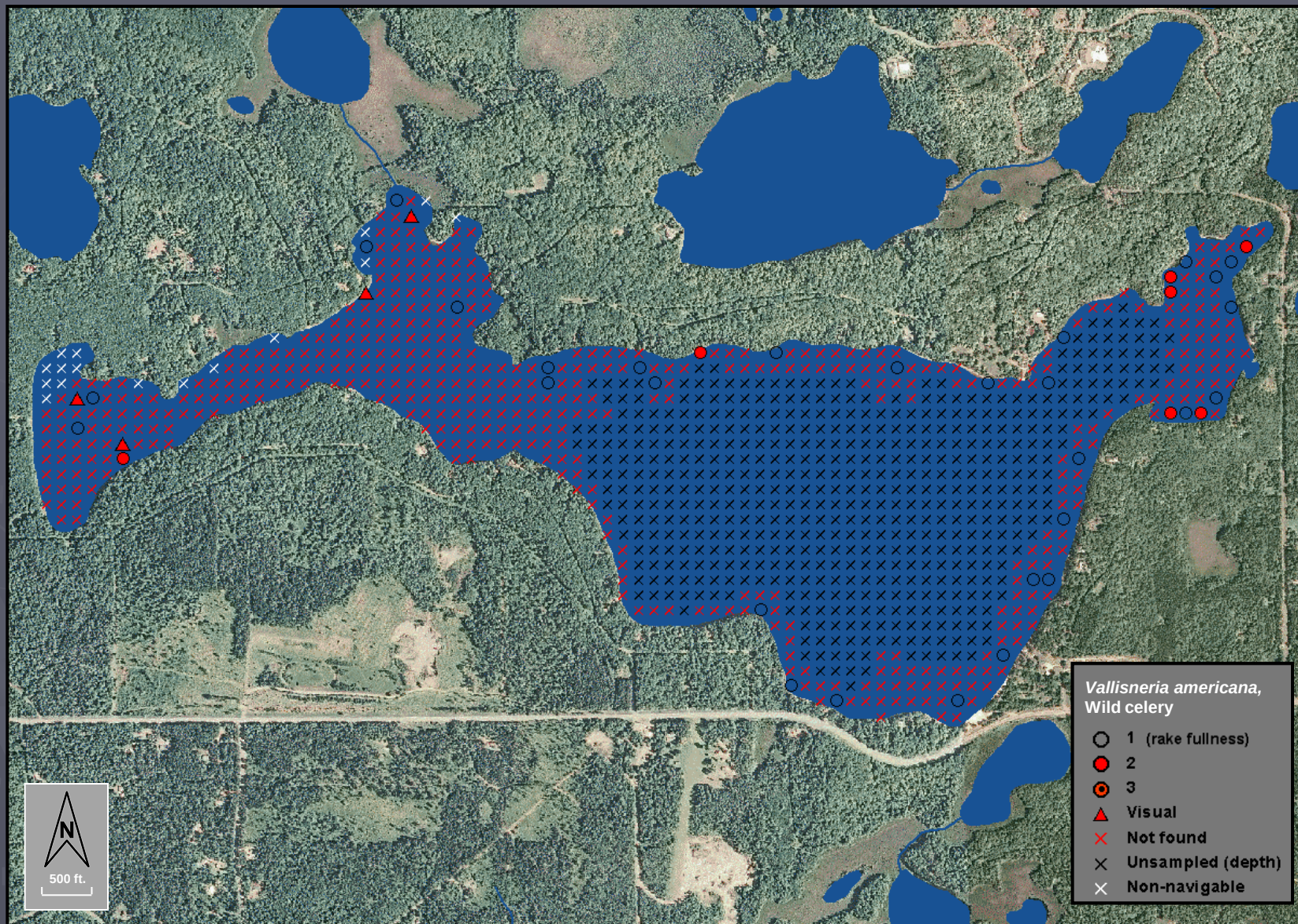


Figure 15b. Distribution of plant species, Black Oak Lake (2011).



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Appendix 3

Review of Black Oak Lake Water Quality

Note: This document is available as Appendix C of the
Black Oak Lake Adaptive Management Plan
(starts on following page)

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Appendix C

Review of Water Quality

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Appendix C

Review of Lake Water Quality

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Review of Black Oak Lake Water Quality

Prepared by Angie Stine, B.S., and Caitlin Clarke, B.S., White Water Associates, Inc.

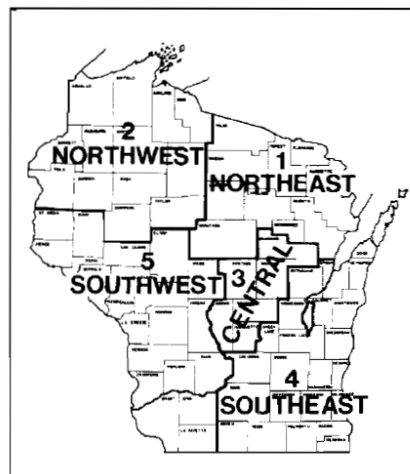
Introduction

Black Oak Lake is located in Vilas County, Wisconsin. It is a 564 acre seepage lake with a maximum depth of 85 feet. The Waterbody Identification Code (WBIC) is 1630100. It is considered “outstanding resource water” (State of Wisconsin Legislature). The purpose of this review is to document the baseline data available for Black Oak Lake. Existing water quality information includes data retrieved from the Wisconsin Department of Natural Resources (WDNR) SWIMS database from 1973 to 1975, 1984, 1989, and from 2002 to present. Secchi disk measurements were taken by Citizen Lake Monitoring Network (CLMN) volunteers from 2002 to present. White Water Associates and Conserve School students (Conserve School is located near Black Oak Lake) have also collected water quality data.

Comparison of Black Oak Lake with other datasets

Lillie and Mason’s *Limnological Characteristics of Wisconsin Lakes* (1983) is a good source to compare lakes within our region to a subset of lakes that have been sampled in Wisconsin. For comparing water quality findings, Wisconsin is divided into five regions. Vilas County lakes are in the Northeast Region (Figure 1) and were among 243 lakes randomly selected and analyzed for water quality.

Figure 1. Wisconsin regions in terms of water quality.



Temperature

Measuring the temperature of a lake at different depths will determine the influence it has on the physical, biological, and chemical aspects of the lake. Lake water temperature influences the rate of decomposition, nutrient recycling, lake stratification, and dissolved oxygen (D.O.) concentration. Temperature can also affect the distribution of fish species throughout a lake. Figures 2-5 show the June, July, August, and September temperature profiles. Black Oak Lake shows stratification in these months.

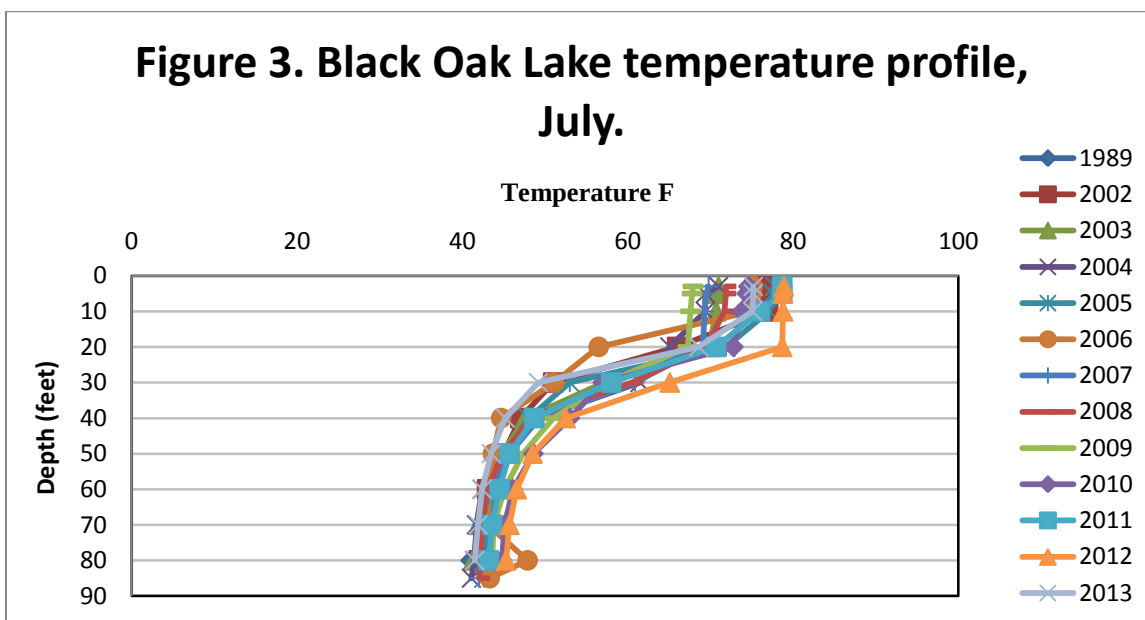
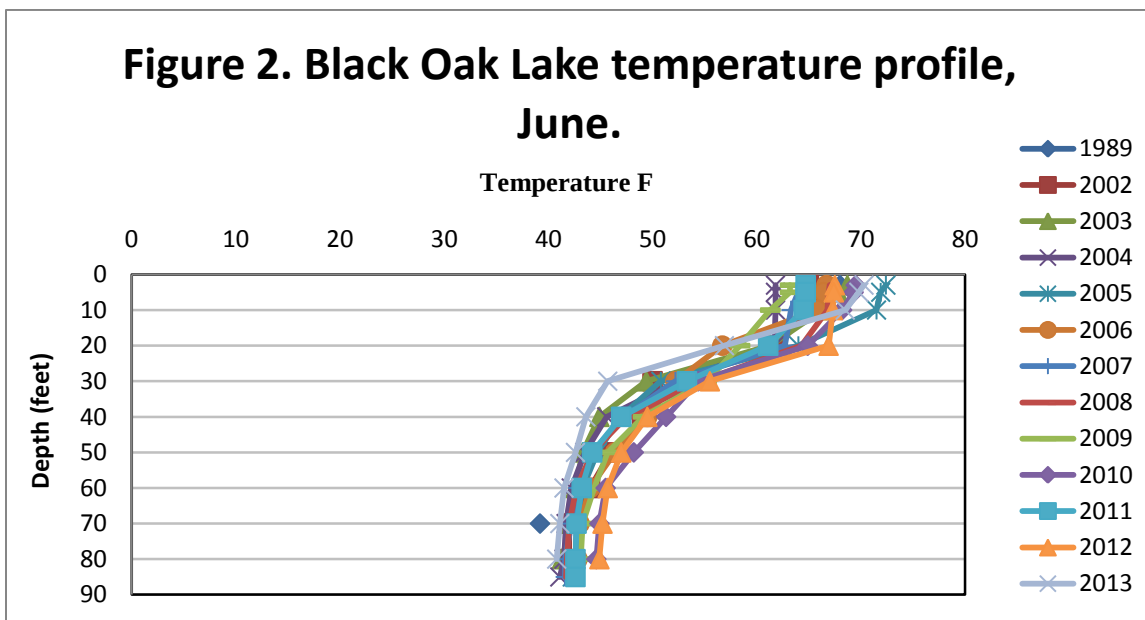


Figure 4. Black Oak Lake temperature profile, August.

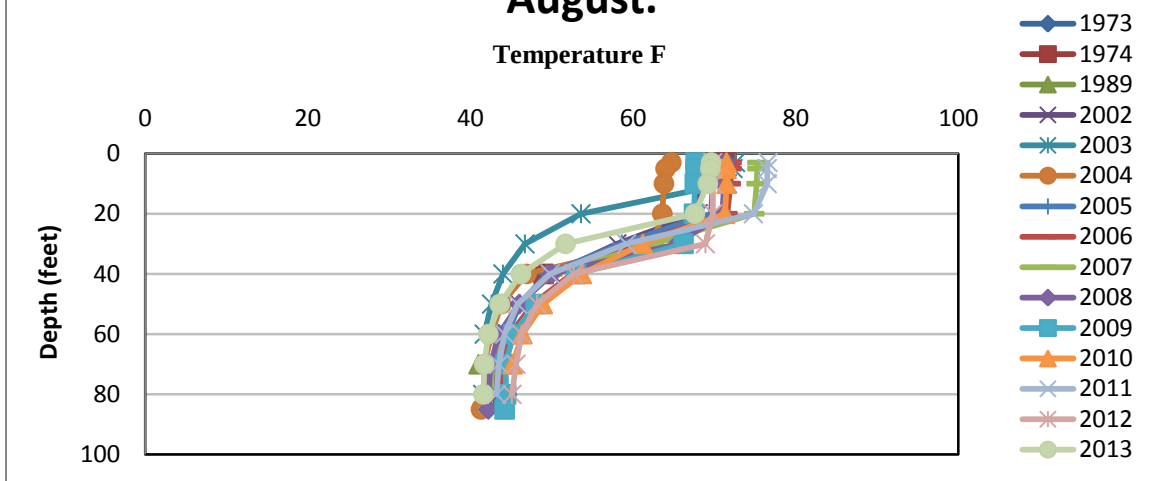
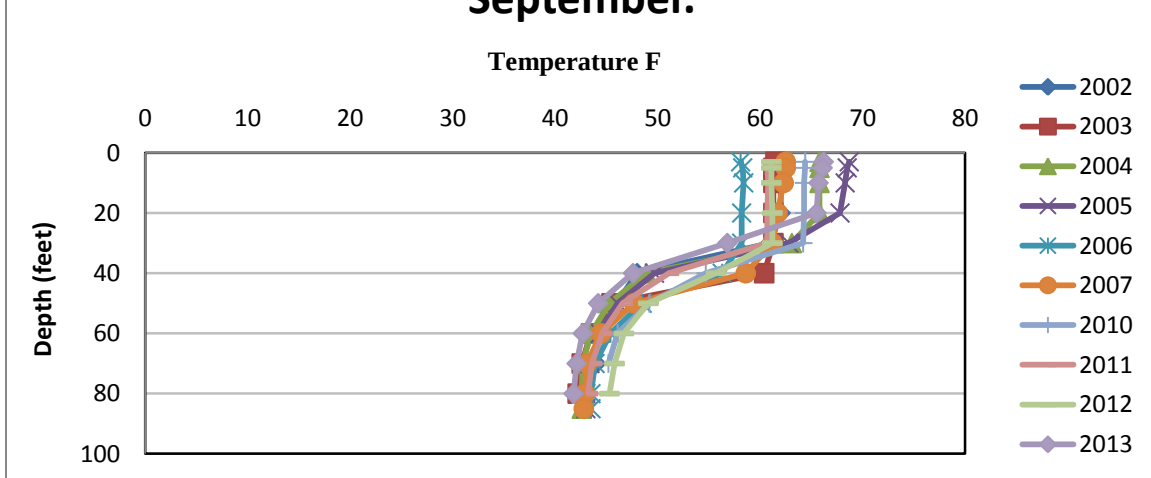


Figure 5. Black Oak Lake temperature profile, September.



Dissolved Oxygen

The dissolved oxygen (D.O.) content of lake water is vital in determining presence of fish species and other aquatic organisms. Dissolved oxygen also has a strong influence on the chemical and physical conditions of a lake. The amount of dissolved oxygen is dependent on the water temperature, atmospheric pressure, and biological activity. Oxygen levels are increased by aquatic plant photosynthesis, but reduced by respiration of plants, decomposer organisms, fish, and invertebrates. The amount of dissolved oxygen available in a lake, particularly in the deeper parts of a lake, is critical to overall health. Dissolved oxygen profiles for Black Oak Lake are shown for February, March and April (Figure 6), May (Figure 7), June (Figure 8), July (Figure

9), August (Figure 10), September (Figure 11) and October, November, and December (Figure 12). Even at 60 feet deep, there is a sufficient amount of dissolved oxygen for fish survival.

In February and March, D.O. levels began tapering off around 50 feet deep. In April, D.O. levels remained fairly consistent from the surface to 80 feet deep. Over many years, May D.O. levels have remained consistent, tapering off at about 60 feet. In June, July and August D.O. levels spike from depths of 20-40 feet, and then drop. In some years, D.O. levels spiked in September, however most years the level remained similar from the surface to approximately 40 feet. In some sample years, October and November levels stratified, however, most November and December profiles showed no stratification.

Figure 6. Black Oak Lake dissolved oxygen profile, February, March, and April.

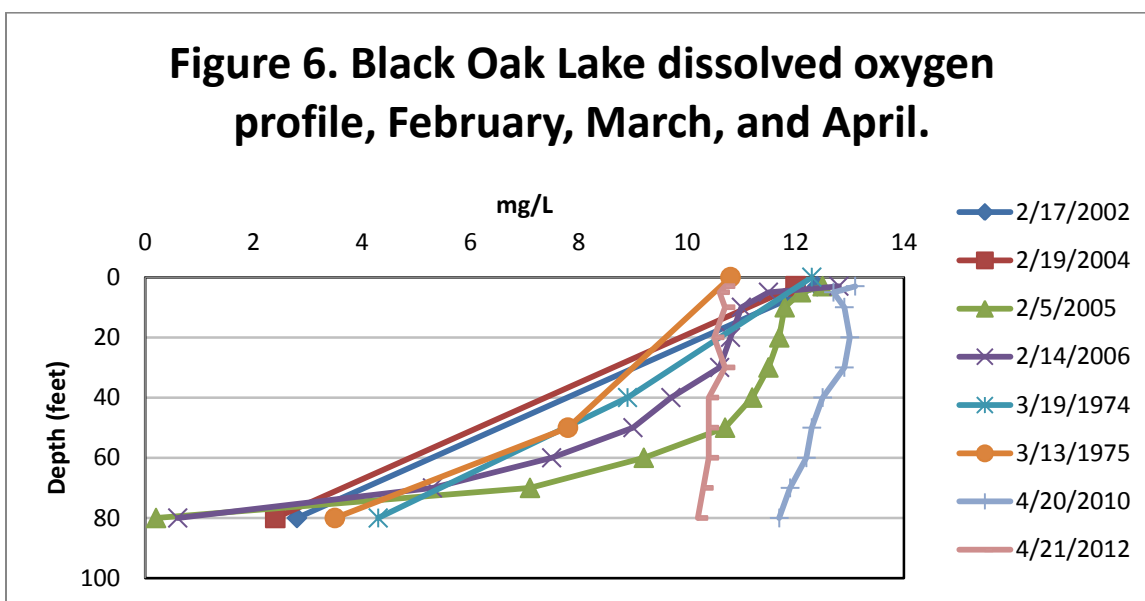


Figure 7. Black Oak Lake dissolved oxygen profile, May.

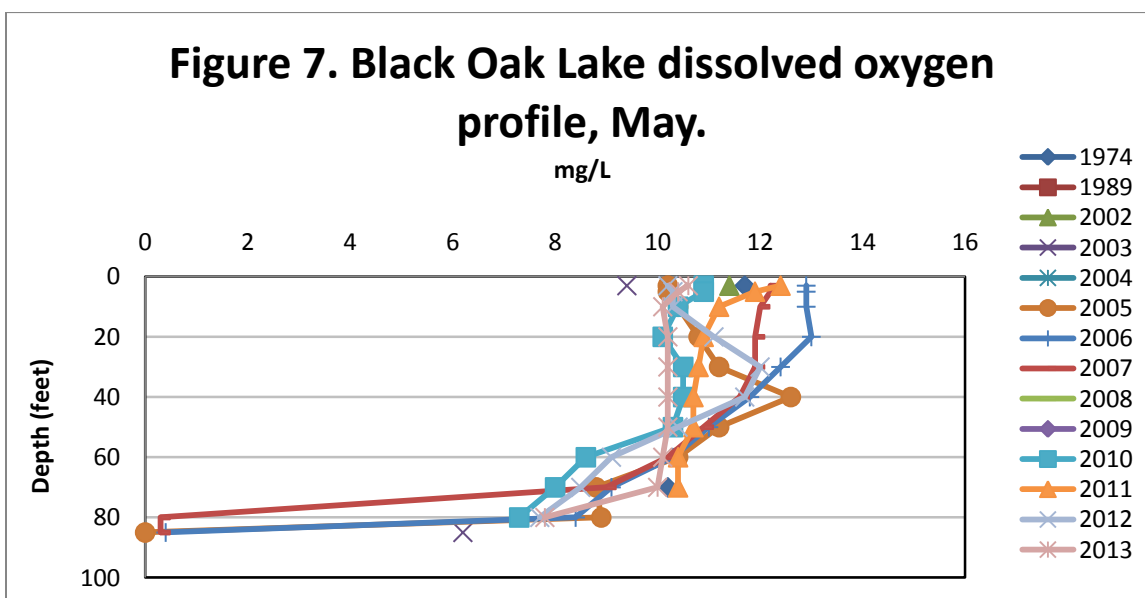


Figure 8. Black Oak Lake dissolved oxygen profile, June.

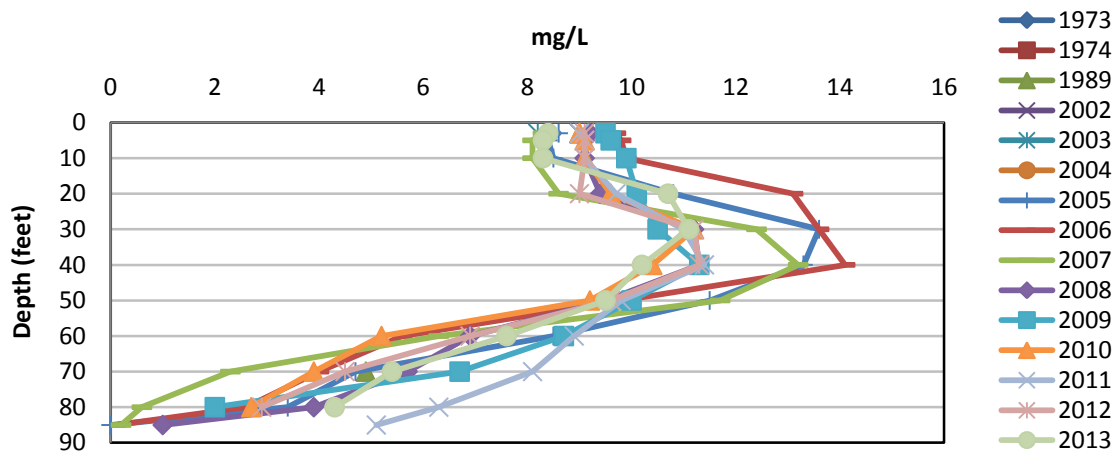


Figure 9. Black Oak Lake dissolved oxygen profile, July.

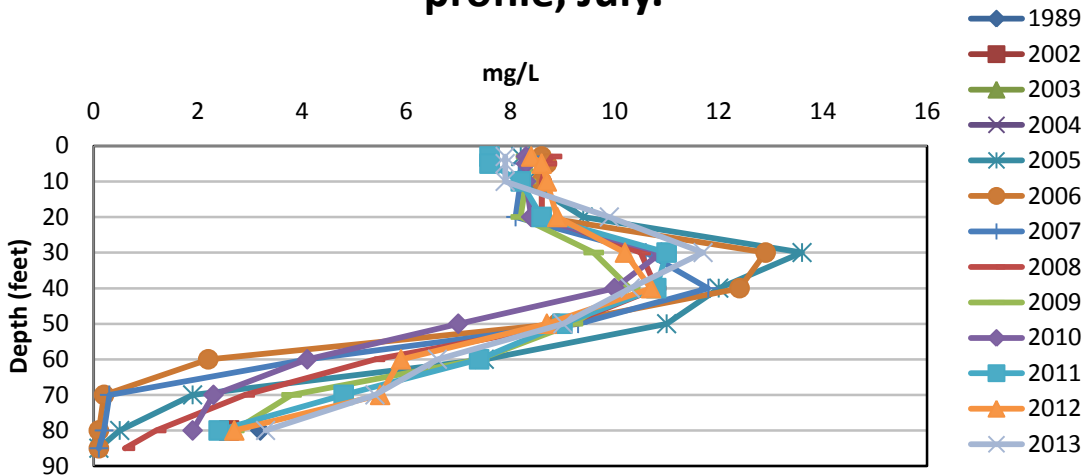


Figure 10. Black Oak Lake dissolved oxygen profile, August.

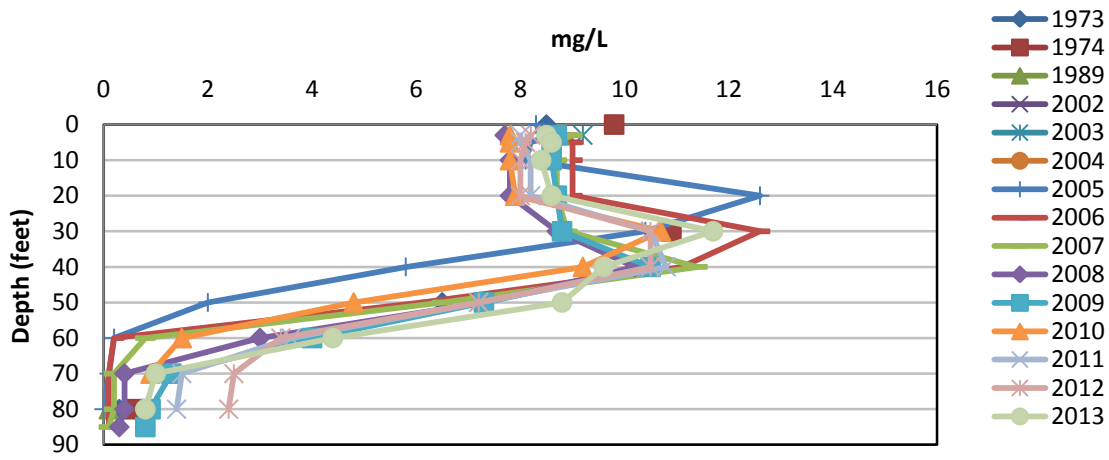


Figure 11. Black Oak Lake dissolved oxygen profile, September.

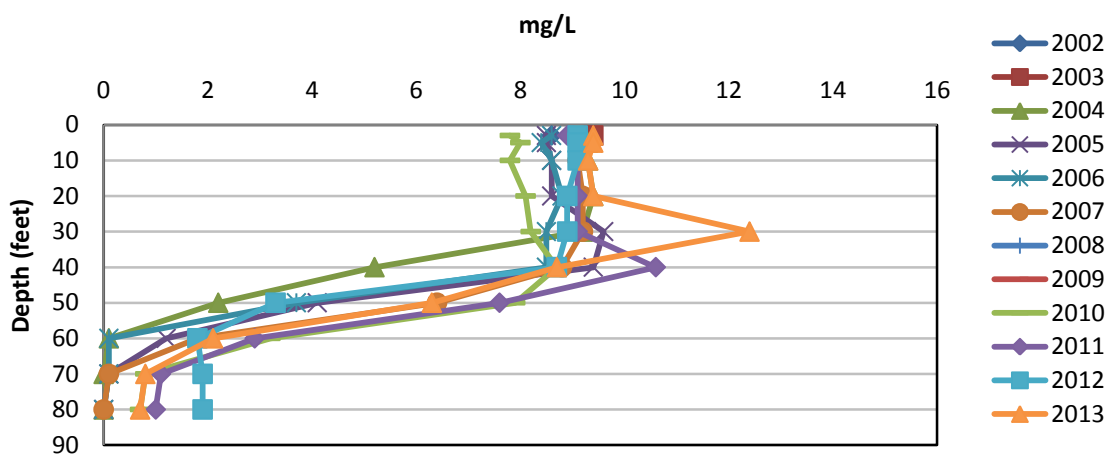
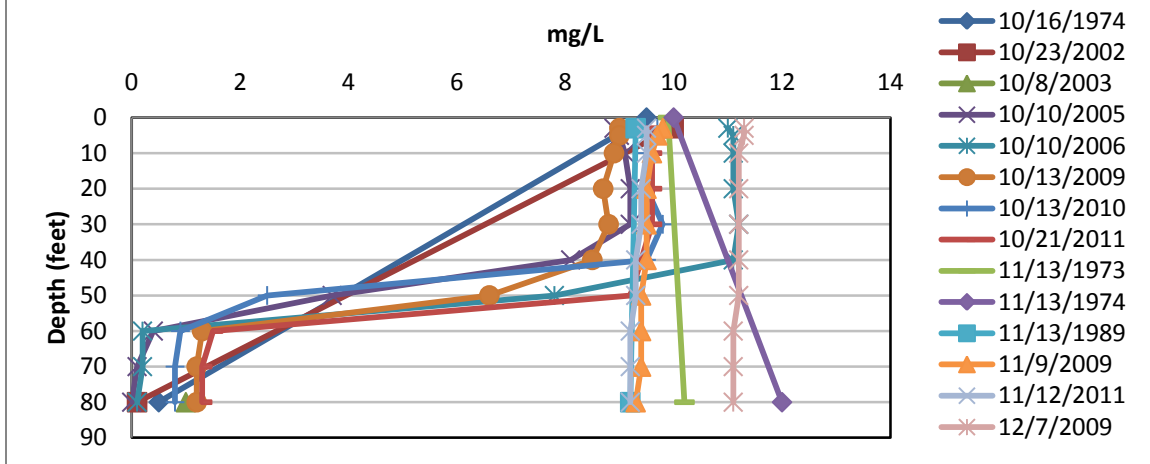


Figure 12. Black Oak Lake dissolved oxygen profile, October, November, and December.



Water Clarity

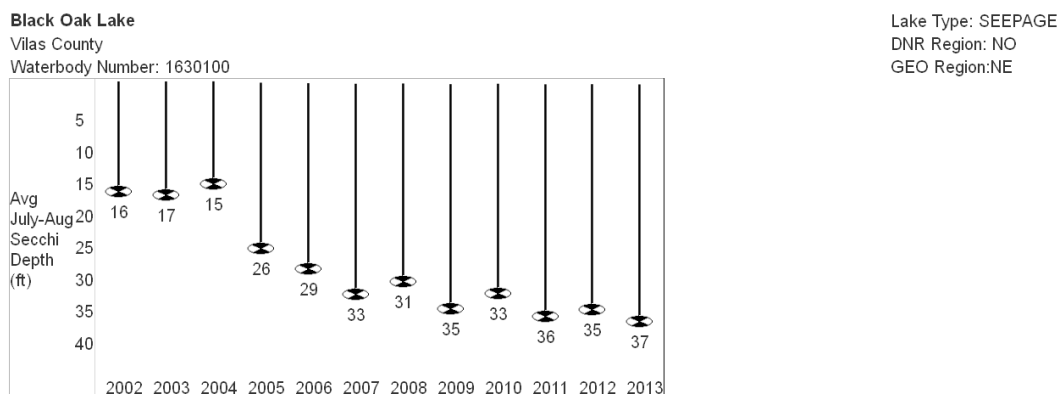
Water clarity has two main components: turbidity (suspended materials such as algae and silt) and true color (materials dissolved in the water) (Shaw et al., 2004). Water clarity gives an indication of the overall water quality in a lake. Water clarity is typically measured using a Secchi disk (black and white disk) that is lowered into the water column on a tether. In simple terms, the depth at which the disk is no longer visible is recorded as the Secchi depth.

Figures 13 and 14 show the July and August mean Secchi depths from 2002 to 2013. As can be seen Secchi depth increased drastically over a short period of time (between 2004 and 2005) and continued to increase through 2013. This increase in water clarity is discussed at length in Appendix K of the Black Oak Lake Adaptive Management Plan. According to Table 1, Black Oak Lake's 2013 average Secchi depth rates the lake as "excellent."

Table 1. Water clarity index (Shaw et al., 2004).

Water clarity	Secchi depth (ft.)
Very poor	3
Poor	5
Fair	7
Good	10
Very good	20
Excellent	32

Figure 13. Black Oak Lake Secchi depth averages (July and August only).



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

(WDNR, 2014)

Figure 14. Black Oak Lake's July and Aug. Secchi Data: Mean, Min, Max, and Count (2002-13).

Year	Secchi Mean	Secchi Min	Secchi Max	Secchi Count
2002	16.5	16	17	2
2003	17.1	16	17.5	4
2004	15.3	15	15.5	2
2005	25.5	24	27	2
2006	28.7	26	36	7
2007	32.8	26	38	6
2008	30.8	28	38	5
2009	35	27.5	44	22
2010	32.6	29.5	36.5	9
2011	36.1	31.5	42	12
2012	35.1	32	40	12
2013	37	28.5	47	19

Report Generated: 11/27/2013

(WDNR, 2014)

Turbidity

Turbidity is another measure of water clarity, but is caused by suspended particulate matter rather than dissolved organic compounds (Shaw et al., 2004). Particles suspended in the water dissipate light and reduce the depth at which the light can penetrate. This affects the depth at which plants can grow. Turbidity also affects the aesthetic quality of water. Water that runs off the watershed into a lake can increase turbidity by introducing suspended materials. Turbidity caused by algae is the most common reason for low Secchi readings (Shaw et al., 2004). In terms of biological health of a lake ecosystem, measurements less than 10 Nephelometric Turbidity Units (NTU) represent healthy conditions for fish and other organisms. Black Oak Lake historically has low turbidity values (Figure 15). While collecting turbidity samples, CLMN volunteers rate the water clarity and describe the water as “clear” or “murky.” From 2002 to 2013, 99% of volunteers rated the water as “clear” (Figure 16).

Figure 15. Black Oak Lake turbidity.

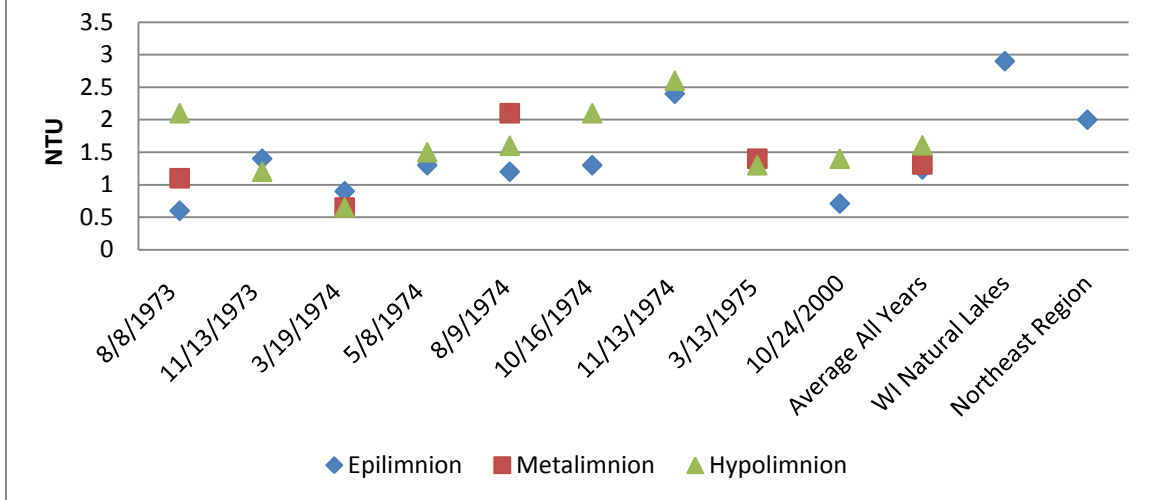
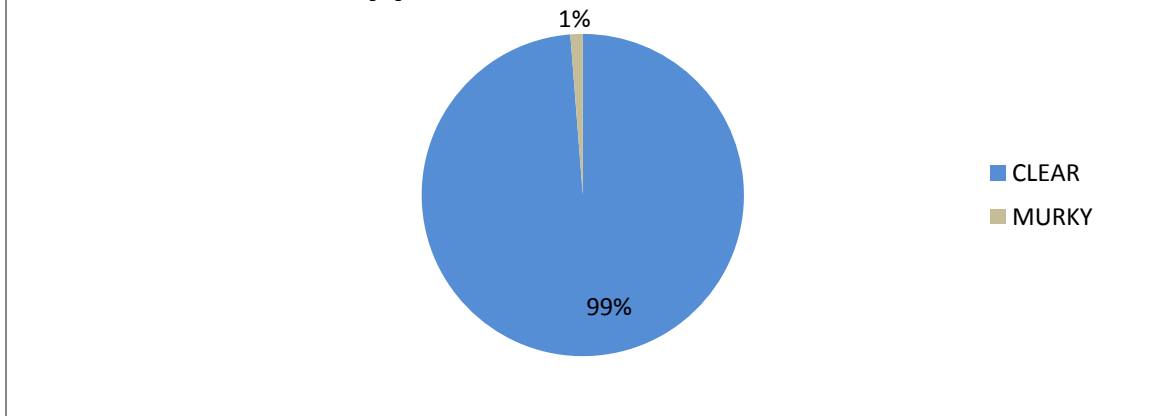


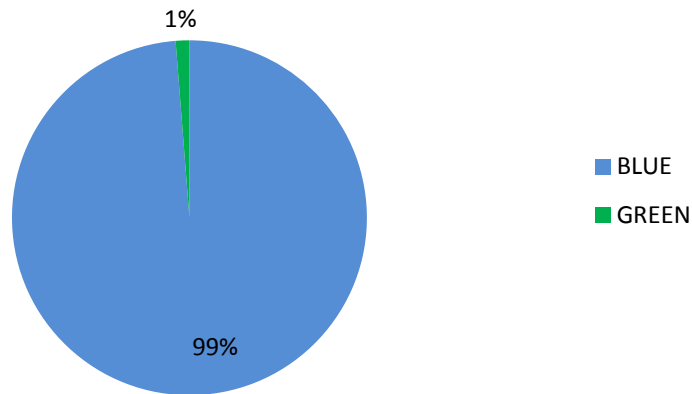
Figure 16. Black Oak Lake water column appearance, 2002-2013.



Water Color

Color of lake water is related to the type and amount of dissolved organic chemicals. Its main significance is aesthetics, although it may also influence light penetration and in turn affect aquatic plant and algal growth. Many lakes have naturally occurring color compounds from decomposition of plant material in the watershed (Shaw et al., 2004). Units of color are determined from the platinum-cobalt scale and are therefore recorded as Pt-Co units. Shaw states that a water color between 0 and 40 Pt-Co is low. Black Oak Lake water color was 10 Pt-Co in October, 1984 and was <5 Pt-Co in November, 1989. The mean color for Northeast Wisconsin lakes is 46 color units. CLMN volunteers recorded their perceptions as “brown,” “blue,” or “green.” Nearly all volunteers viewed Black Oak Lake as having “blue” water (Figure 17).

Figure 17. Black Oak Lake visual water color, 2002-2013.



Water Level

When CLMN volunteers collect Secchi depth readings, they also record the lake level as “high,” “normal,” or “low.” Figure 18 shows that from 2002 to 2006, the majority of volunteers viewed Black Oak Lake as having “normal” water levels. From 2007 to 2011 100% of volunteers viewed the level as “low.” A Black Oak Lake volunteer has measured water levels since 2001. Depth readings were taken immediately after ice out and just before freeze up each year (Figure 19). The lake stage measurement process is described fully in Appendix K of the Black Oak Lake Adaptive Management Plan.

Figure 18. Black Oak Lake water level, 2002-2011.

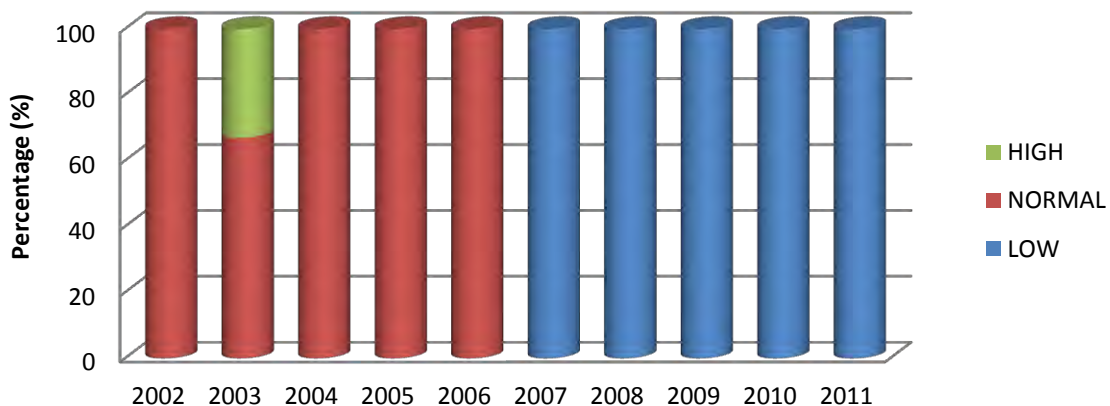
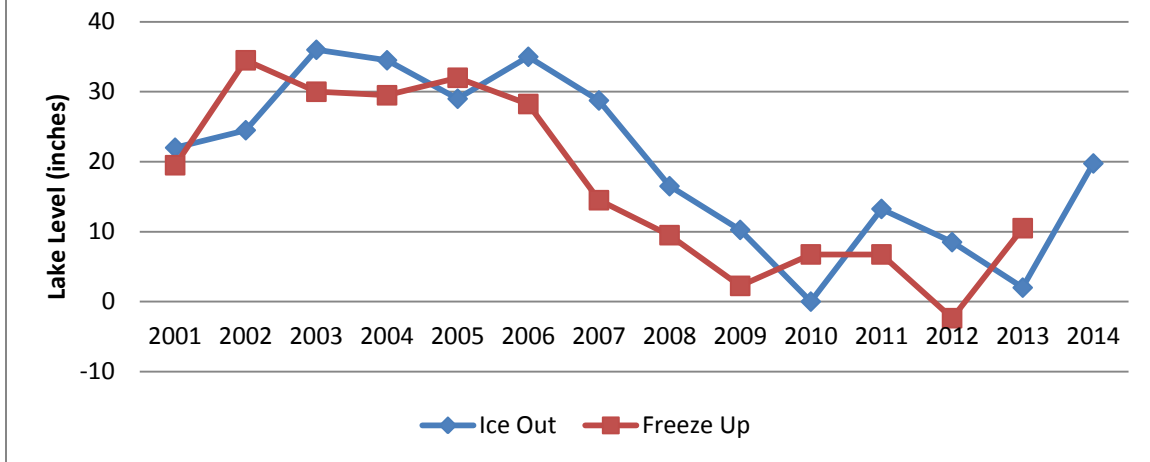


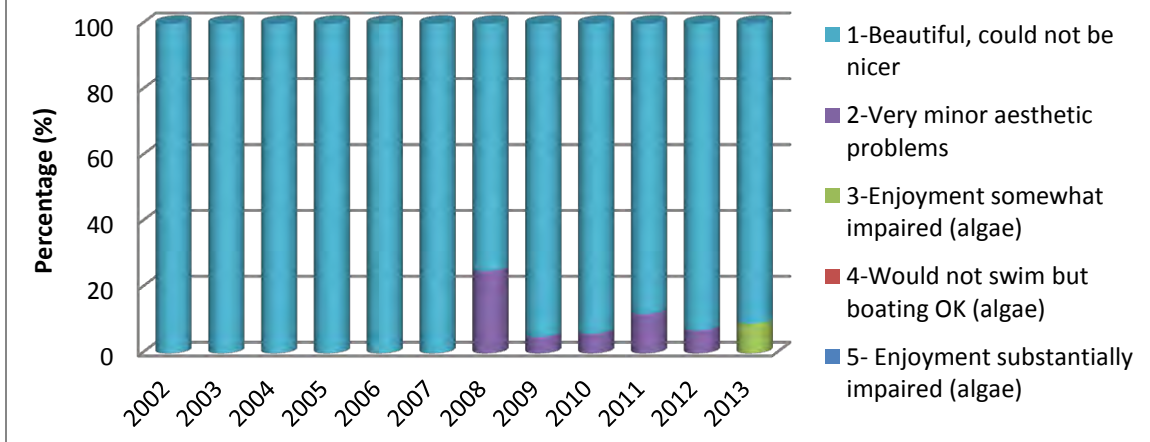
Figure 19. Black Oak Lake water level, 2001-2014 (BOL, 2014).



User Perceptions

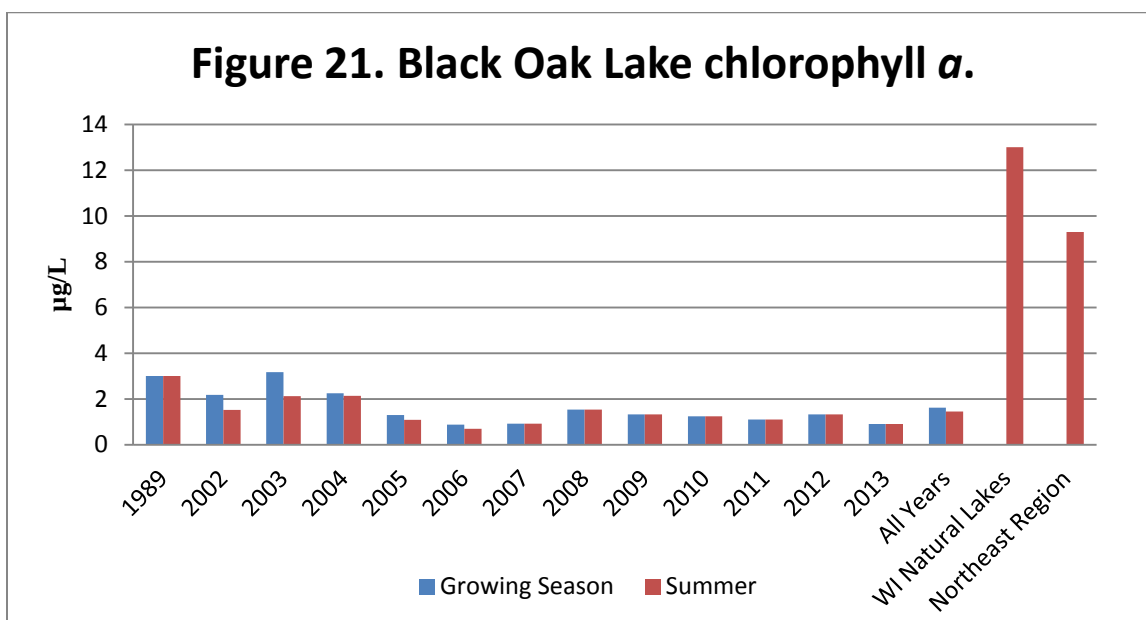
When Secchi depth readings are collected, CLMN volunteers record their perceptions of the water, based on the physical appearance and the recreational suitability. These perceptions can be compared to water quality parameters to see how the lake user would experience the lake at that time. When interpreting the transparency data, we see that when the Secchi depth decreases, the rating of the lake's physical appearance also decreases. These perceptions of recreational suitability are displayed by year in Figure 20. Only recently (2013), was the aesthetic value "somewhat impaired by algae."

Figure 20. Black Oak Lake aesthetic value, 2002-2013.



Chlorophyll *a*

Chlorophyll *a* is the photosynthetic pigment that makes plants and algae green. Chlorophyll *a* in lake water is therefore an indicator of the amount of algae. Chlorophyll *a* concentrations greater than 10 µg/L are perceived as a mild algae bloom, while concentrations greater than 20 µg/L are perceived as a nuisance. Chlorophyll *a* has been monitored in Black Oak Lake extensively (Figure 21). Please note that the data in this graph represents concentrations taken only during growing season (April-October) or summer months (June-August). Black Oak Lake has had low chlorophyll *a* values compared to the Northeastern region.



Phosphorus

In more than 80% of Wisconsin's lakes, phosphorus is the key nutrient affecting the amount of algae and plant growth. If phosphorus levels are high, excessive aquatic plant growth can occur.

Phosphorus originates from a variety of sources, many of which are related to human activities. Major sources include human and animal wastes, soil erosion, detergents, septic systems and runoff from farmland or lawns (Shaw et al., 2004). Phosphorus provokes complex reactions in lakes. An analysis of phosphorus often includes both soluble reactive phosphorus and total phosphorus. Soluble reactive phosphorus dissolves in the water and directly influences plant growth (Shaw et al., 2004). Its concentration varies in most lakes over short periods of time as plants take it up and release it. Total phosphorus is considered a better indicator of a lake's nutrient status than soluble reactive phosphorus because its levels remain more stable (Shaw et al., 2004). Total phosphorus includes soluble phosphorus and the phosphorus in plant and animal fragments suspended in lake water. Ideally, soluble reactive phosphorus concentrations should be 10 µg/L or less at spring turnover to prevent summer algae blooms (Shaw et al., 2004). A

concentration of total phosphorus below 20 µg/L for lakes should be maintained to prevent nuisance algal blooms (Shaw et al., 2004).

The total phosphorus values were low in Black Oak Lake (Figure 22). Please note that the data in this graph represents concentrations taken only during growing season (April-October) or summer months (June-August). The average total phosphorus for sampled years (7.18 µg/L) is lower than the average for Wisconsin natural lakes (25 µg/L) and Northeast Regional lakes (19 µg/L). According to Figure 23, Black Oak Lake is considered “very good” with respect to its average total phosphorus.

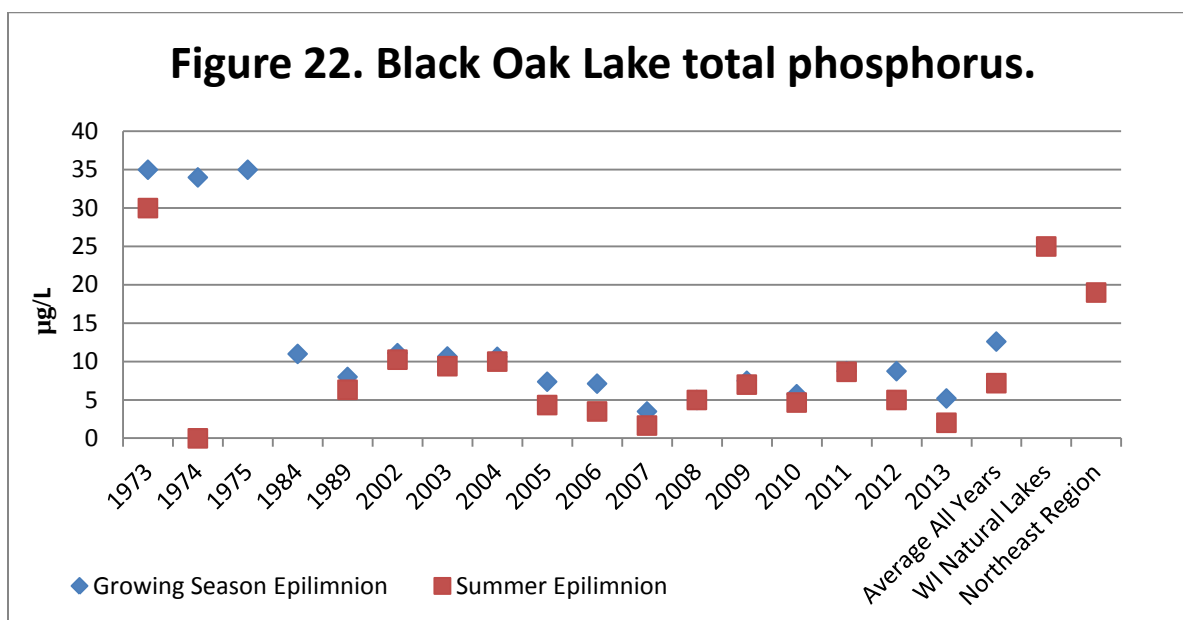
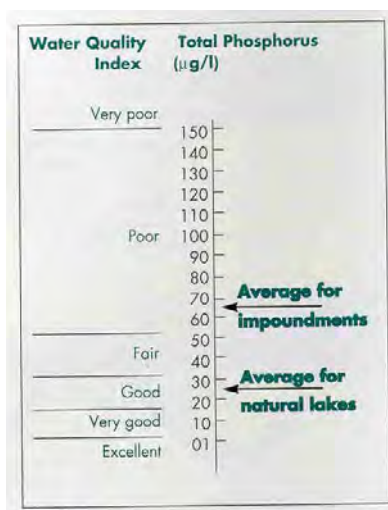


Figure 23. Total phosphorus concentrations for Wisconsin’s natural lakes and impoundments (Shaw et al., 2004).



Trophic State

Trophic state is another indicator of water quality (Carlson, 1977). Lakes can be divided into three categories based on trophic state – oligotrophic, mesotrophic, and eutrophic. These categories reflect a lake’s nutrient and clarity levels (Shaw et al., 2004).

Researchers use various methods to calculate the trophic state of lakes. Common characteristics used to make the determination are: total phosphorus (important for algae growth), chlorophyll *a* concentration (a measure of the amount of algae present), and Secchi disk readings (an indicator of water clarity) (Shaw et al., 2004) (Table 2).

Table 2. Trophic classification of Wisconsin Lakes based on chlorophyll *a*, water clarity measurements, and total phosphorus values (Shaw et al., 2004).

Trophic class	Total phosphorus µg/L	Chlorophyll <i>a</i> µg/L	Secchi Disk (ft.)
Oligotrophic	3	2	12
	10	5	8
Mesotrophic	18	8	6
	27	10	6
Eutrophic	30	11	5
	50	15	4

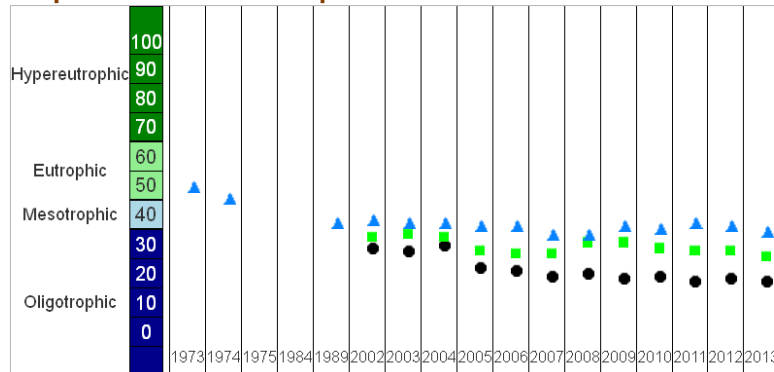
Trophic State Index (TSI) was calculated by the WDNR using Secchi measurements collected from the CLMN. The July and August average TSI in the North Basin is shown in Figure 24. These values classify Black Oak Lake as “oligotrophic” (Table 3).

Table 3. Trophic State Index.	
30-40	Oligotrophic: clear, deep water; possible oxygen depletion in lower depths; few aquatic plants or algal blooms; low in nutrients; large game fish usual fishery
40-50	Mesotrophic: moderately clear water; mixed fishery, esp. panfish; moderate aquatic plant growth and occasional algal blooms; may have low oxygen levels near bottom in summer
50-60	Mildly Eutrophic: decreased water clarity; anoxic near bottom; may have heavy algal bloom and plant growth; high in nutrients; shallow eutrophic lakes may have winterkill of fish; rough fish common
60-70	Eutrophic: dominated by blue-green algae; algae scums common; prolific aquatic plant growth; high nutrient levels; rough fish common; susceptible to oxygen depletion and winter fishkill
70-80	Hypereutrophic: heavy algal blooms through most of summer; dense aquatic plant growth; poor water clarity; high nutrient levels

(WDNR, 2014)

Figure 24. Black Oak Lake, North Basin Trophic State Index (1973-2013).

Trophic State Index Graph



Monitoring Station: Black Oak Lake - Deep Hole, Vilas County
 Past Summer (July-August) Trophic State Index (TSI) averages.

● = Secchi ■ = Chlorophyll ▲ = Total Phosphorus	
TSI(Chl) = TSI(TP) = TSI(Sec)	It is likely that algae dominate light attenuation.
TSI(Chl) > TSI(Sec)	Large particulates, such as Aphanizomenon flakes dominate
TSI(TP) = TSI(Sec) > TSI(Chl)	Non-algal particulate or color dominate light attenuation
TSI(Sec) = TSI(Chl) >= TSI(TP)	The algae biomass in your lake is limited by phosphorus
TSI(TP) > TSI(Chl) = TSI(Sec)	Zooplankton grazing, nitrogen, or some factor other than phosphorus is limiting algae biomass

(WDNR, 2014)

Nitrogen

Nitrogen is second only to phosphorus as an important nutrient for aquatic plant and algae growth (Shaw et al., 2004). Human activities on the landscape greatly influence the amount of nitrogen in a lake. Nitrogen may come from lawn fertilizer, septic systems near the lake, or from agricultural activities in the watershed. Nitrogen may enter a lake from surface runoff or groundwater sources.

Nitrogen exists in lakes in several forms. Black Oak Lake has been analyzed for total Kjeldahl nitrogen (Figure 25), organic nitrogen (Figure 26), total nitrogen (Figure 27), ammonia nitrogen (Figure 28) and nitrate-nitrite (Figure 29). Nitrogen is a major component of all organic (plant and animal) matter. Decomposing organic matter releases ammonia, which is converted to nitrate if oxygen is present (Shaw et al., 2004). All inorganic forms of nitrogen can be used by aquatic plants and algae (Shaw et al., 2004). If these inorganic forms of nitrogen exceed 0.3 mg/L (as N) in spring, there is sufficient nitrogen to support summer algae blooms (Shaw et al., 2004). Elevated concentrations of ammonium, nitrate, and nitrite, derived from human activities, can stimulate or enhance the development, maintenance and proliferation of primary producers (phytoplankton, benthic algae, macrophytes), contributing to the widespread phenomenon of the cultural (human-made) eutrophication of aquatic ecosystems (Camargo et al., 2007). The nutrient enrichment can cause important ecological effects on aquatic communities, since the overproduction of organic matter, and its subsequent decomposition, usually lead to low

dissolved oxygen concentrations in bottom waters, and sediments of eutrophic and hypereutrophic aquatic ecosystems with low turnover rates (Camargo et al., 2007). Black Oak Lake nitrogen levels are low.

Figure 25. Black Oak Lake total Kjeldahl nitrogen.

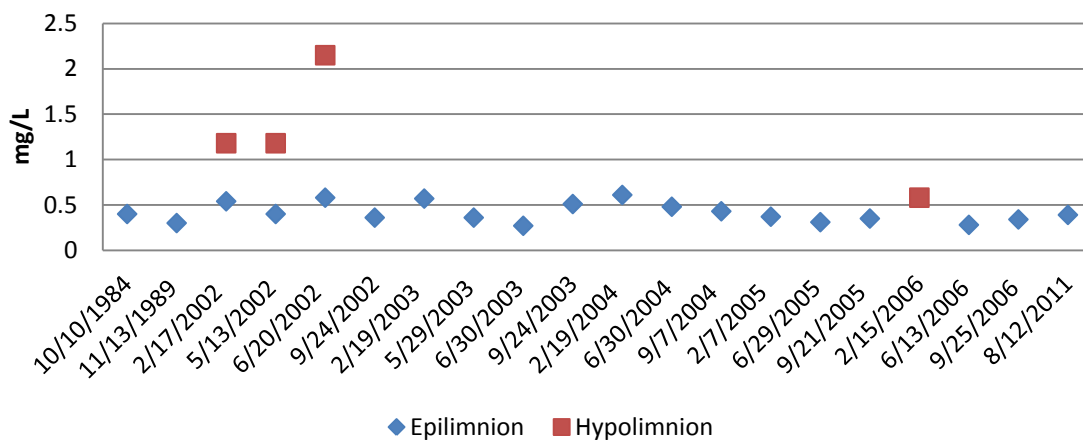


Figure 26. Black Oak Lake organic nitrogen.

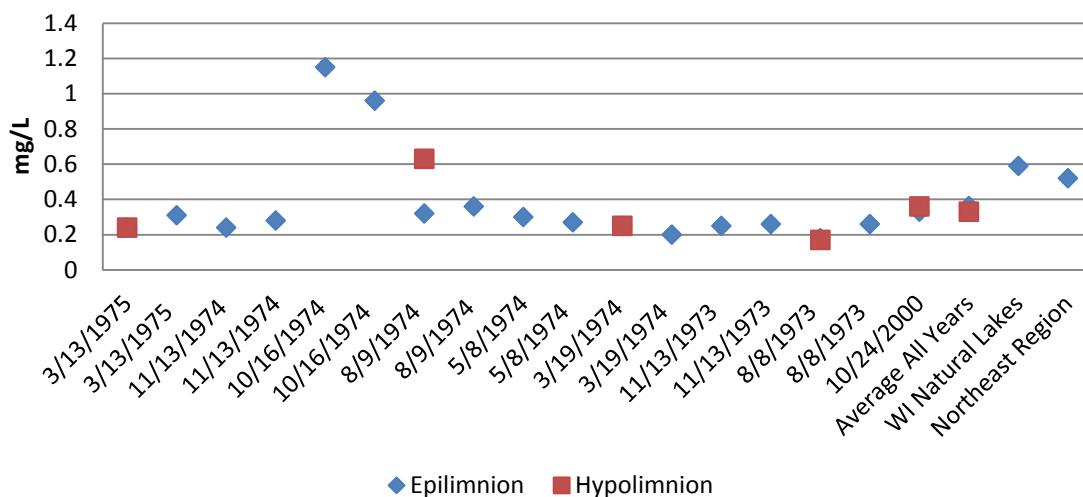


Figure 27. Black Oak Lake total nitrogen.

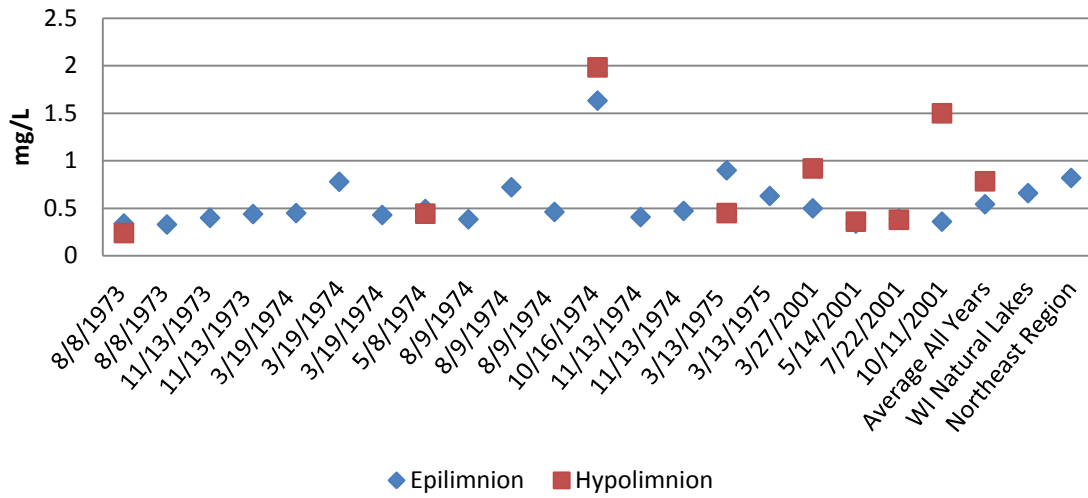
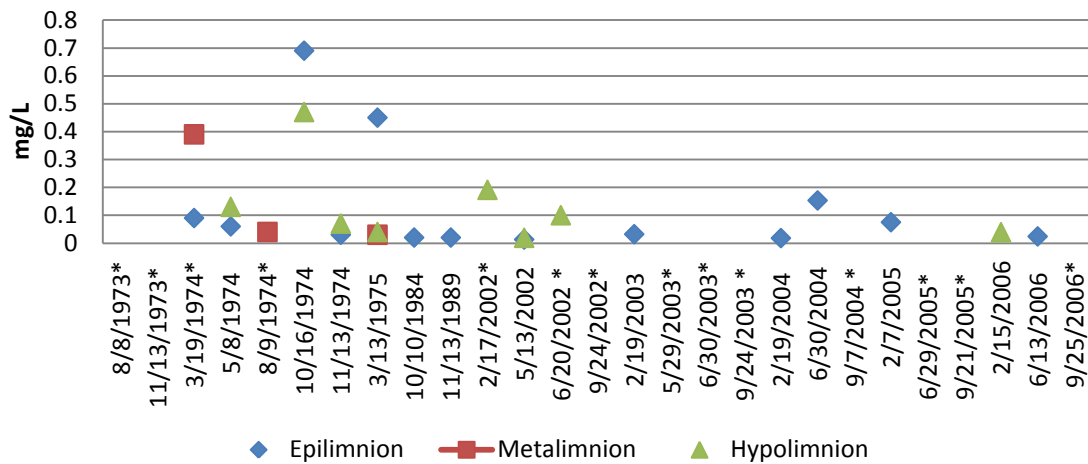
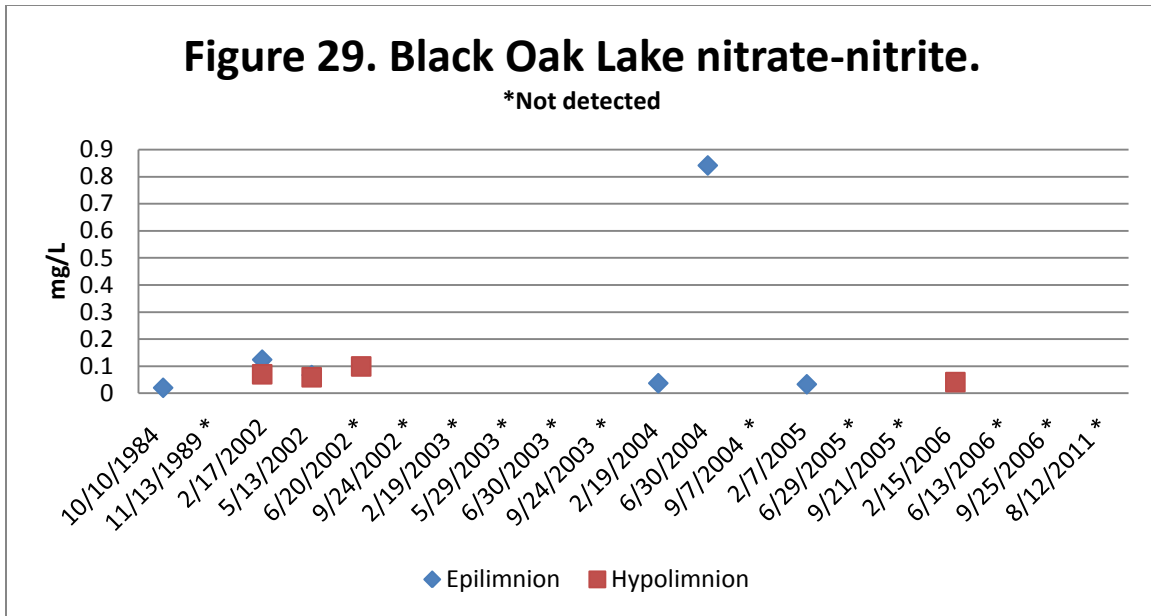


Figure 28. Black Oak Lake ammonia nitrogen.

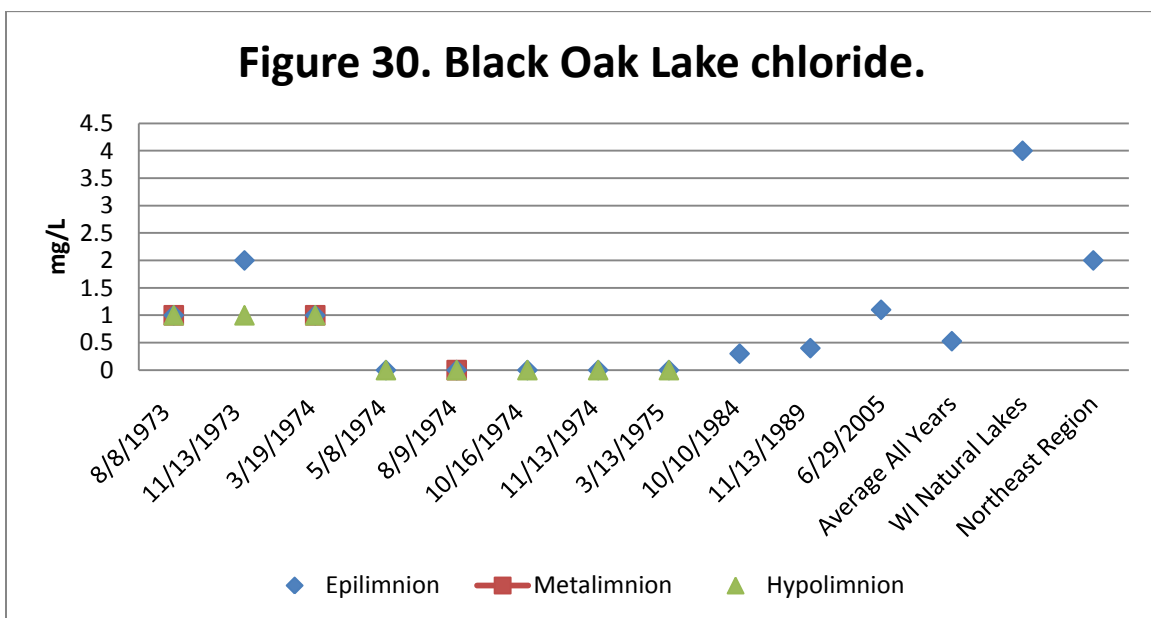
*Not detected





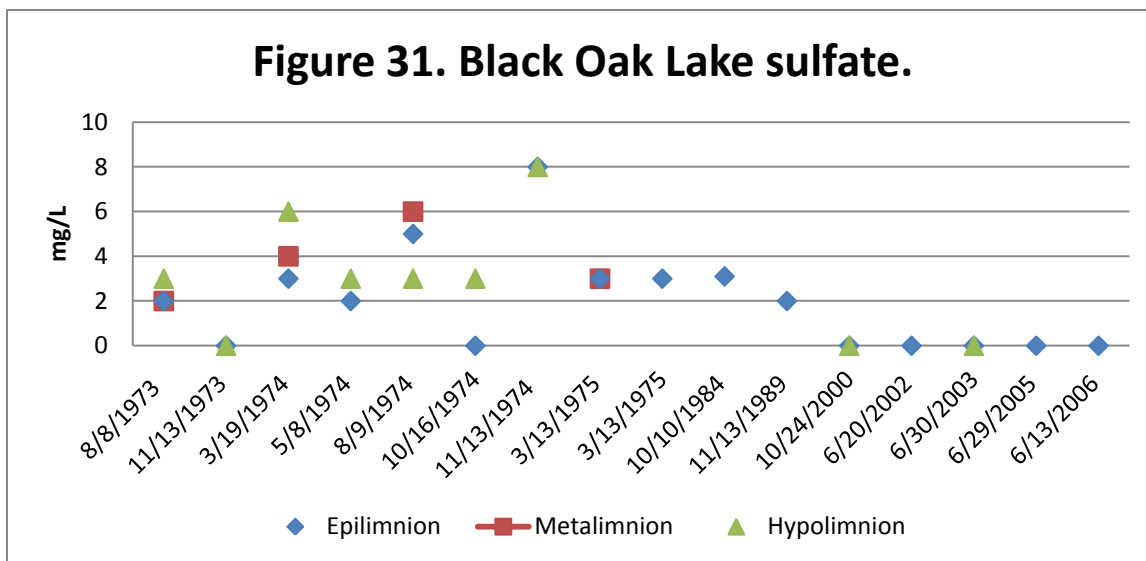
Chloride

The presence of chloride (Cl^-) where it does not occur naturally indicates possible water pollution (Shaw et al., 2004). Chloride does not affect plant and algae growth and is not toxic to aquatic organisms at most of the levels found in Wisconsin (Shaw et al., 2004). Chloride values were low for Black Oak Lake (Figure 30). The average chloride is much lower than Wisconsin natural lakes and the Northeast region.



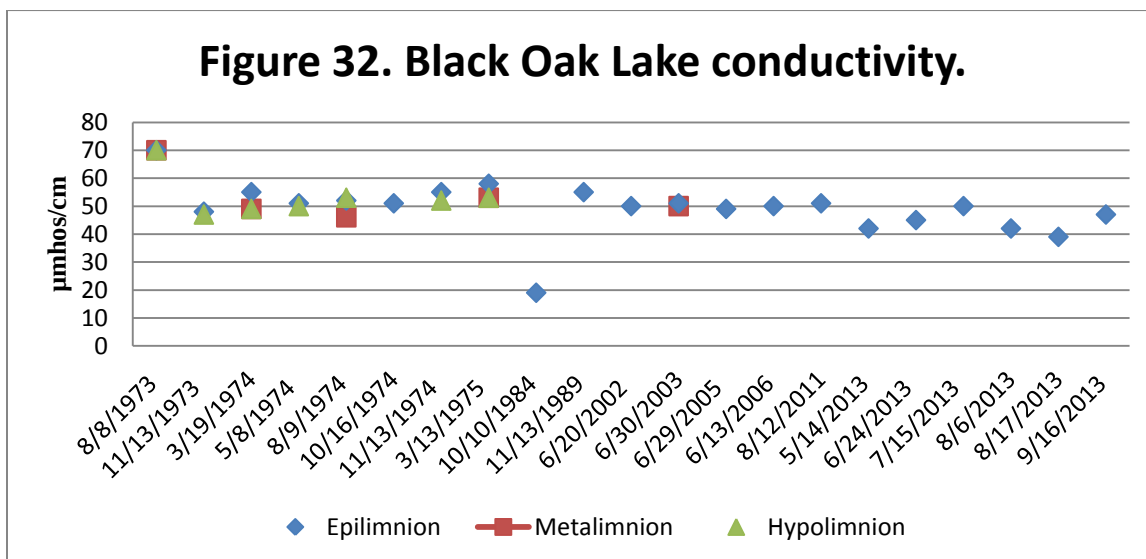
Sulfate

Sulfate in lake water is primarily related to the types of minerals found in the watershed, and to acid rain (Shaw et al., 2004). Sulfate concentrations are noted to be less than 10 mg/L in Vilas County (Lillie and Mason, 1983). Historic sulfate levels for Black Oak Lake are low (Figure 31).



Conductivity

Conductivity is a measure of the ability of water to conduct an electric current. Conductivity is reported in micromhos per centimeter ($\mu\text{mhos/cm}$) and is directly related to the total dissolved inorganic chemicals in the water. Usually, values are two times the water hardness, unless the water is receiving high concentrations of human-induced contaminants (Shaw et al., 2004). Conductivity of Black Oak Lake is shown in Figure 32.



pH

The acidity level of a lake's water regulates the solubility of many minerals. A pH level of 7 is considered neutral. The pH level in Wisconsin lakes ranges from 4.5 in acid, bog lakes to 8.4 in hard water, marl lakes (Shaw et al., 2004). Natural rainfall in Wisconsin averages a pH of 5.6. Some minerals become available under low pH (especially aluminum, zinc, and mercury) and can inhibit fish reproduction and/or survival. Mercury and aluminum are not only toxic to many kinds of wildlife, but also to humans (especially those that eat tainted fish). The pH scale is logarithmic, so every 1.0 unit change in pH increases the acidity tenfold. Water with a pH of 6 is 10 times more acidic than water with pH of 7. A lake's pH level is important for the release of potentially harmful substances and affects plant growth, fish reproduction and survival. A lake with neutral or slightly alkaline pH is a good lake for fish and plant survival. Figure 33 indicates that the average pH for Black Oak Lake is close to neutral (7.4).

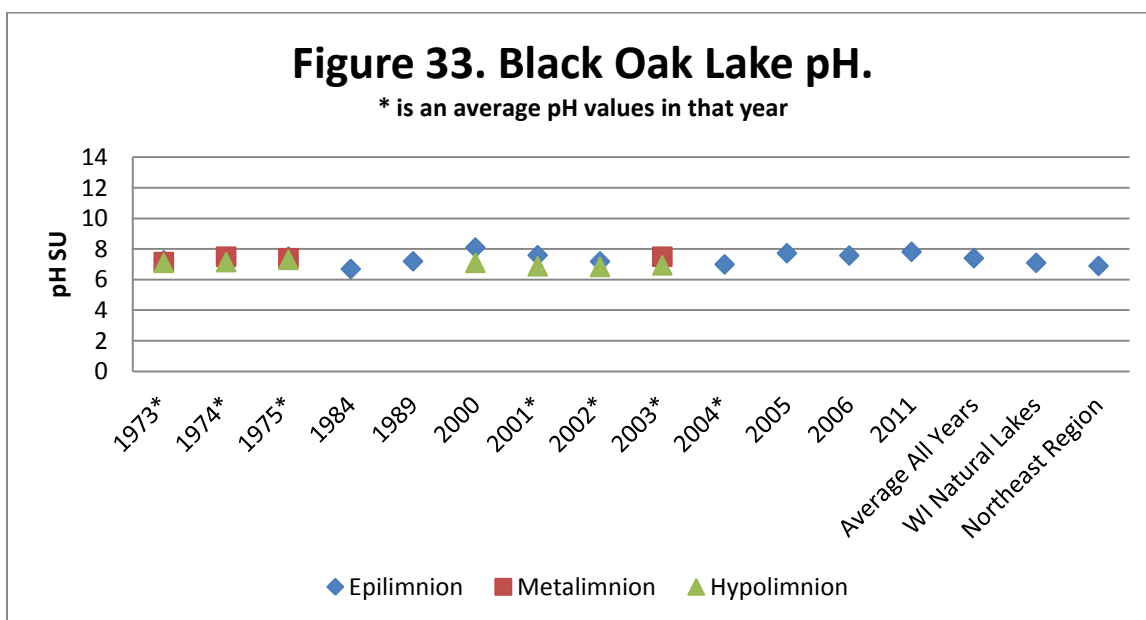


Table 4 indicates the effects pH levels less than 6.5 will have on fish. While moderately low pH does not usually harm fish, the metals that become soluble under low pH can be important. In low pH waters, aluminum, zinc, and mercury concentrations increase if they are present in lake sediment or watershed solids (Shaw et al., 2004).

Table 4. Effects of acidity on fish species (Olszyk, 1980).

<i>Water pH</i>	<i>Effects</i>
6.5	Walleye spawning inhibited
5.8	Lake trout spawning inhibited
5.5	Smallmouth bass disappear
5.2	Walleye & lake trout disappear
5	Spawning inhibited in most fish
4.7	Northern pike, sucker, bullhead, pumpkinseed, sunfish & rock bass disappear
4.5	Perch spawning inhibited
3.5	Perch disappear
3	Toxic to all fish

Alkalinity

Alkalinity levels in a lake are affected by the soil minerals, bedrock type in the watershed, and frequency of contact between lake water and these materials (Shaw et al., 2004). Alkalinity is important in a lake to buffer the effects of acidification from the atmosphere. Acid rain has long been a problem with lakes that have low alkalinity levels and high potential sources of acid deposition. Figure 34 indicates alkalinity recorded for Black Oak Lake. Table 5 suggests that the average alkalinity of Black Oak Lake means it has a “low sensitivity” to acid rain.

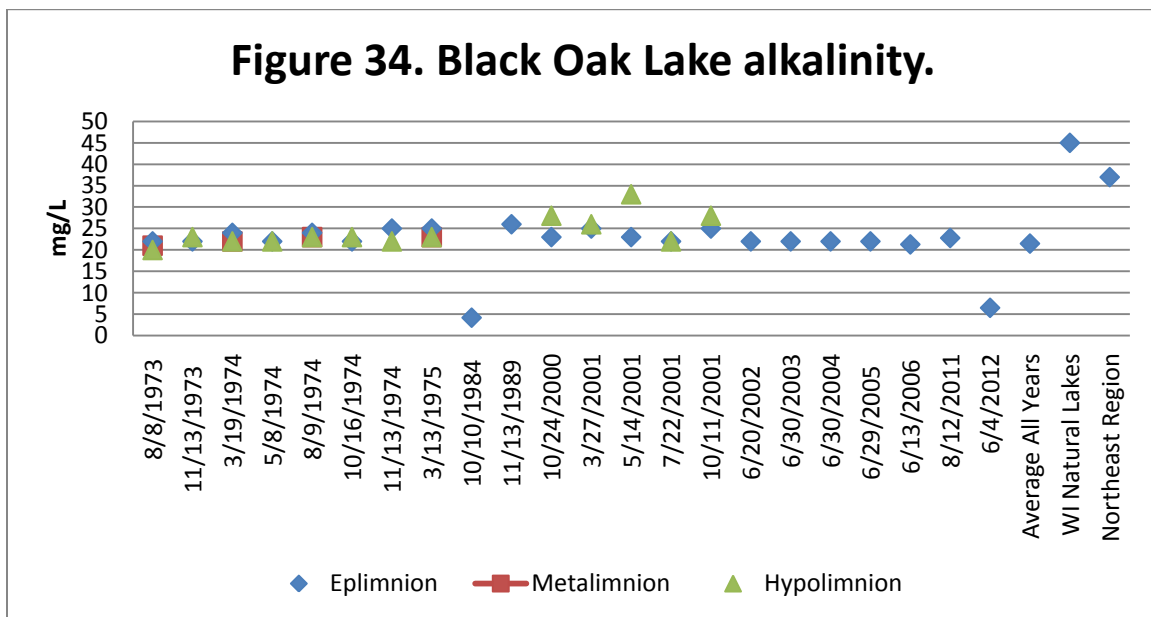


Table 5. Sensitivity of Lakes to Acid Rain (Shaw et al., 2004)	
<i>Sensitivity to acid rain</i>	<i>Alkalinity value (mg/L or ppm CaCO₃)</i>
High	0-2
Moderate	2-10
Low	10-25
Non-sensitive	>25

Hardness

Hardness levels in a lake are affected by the soil minerals, bedrock type in the watershed, and frequency of contact between lake water and these materials (Shaw et al., 2004). One method of evaluating hardness is to test for calcium carbonate (CaCO₃) (Figure 35). The average hardness for Black Oak Lake is 29 mg/L CaCO₃. Based on the average hardness value, Table 6 classifies Black Oak Lake as having “soft water.”

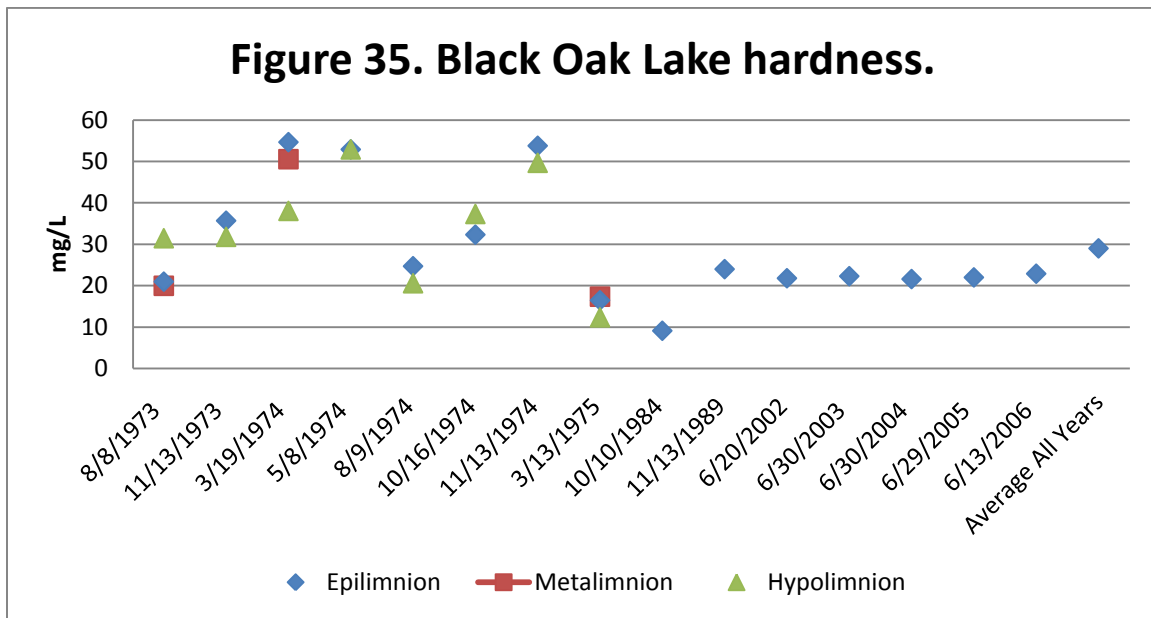


Table 6. Categorization of hardness (mg/L of calcium carbonate (CaCO₃)) (Shaw et al., 2004).	
Soft water	0-60
Moderately hard water	61-120
Hard water	121-180
Very hard water	>180

Calcium and Magnesium Hardness

The carbonate system provides acid buffering through two alkaline compounds: bicarbonate and carbonate. These compounds are usually found with two hardness ions: calcium and magnesium (Shaw et al., 2004). Calcium is the most abundant cation found in Wisconsin lakes. Its abundance is related to the presence of calcium-bearing minerals in the lake watershed (Shaw et al., 2004). Aquatic organisms such as native mussels use calcium in their shells. The aquatic invasive zebra mussel tends to need calcium levels greater than 20 mg/L to maintain shell growth. Black Oak Lake calcium levels are low (<10 mg/L) which is an indication that zebra mussels may not flourish, if introduced (Figure 36). Magnesium levels (Figure 37) are low compared to the Northeast region and Wisconsin natural lakes.

Figure 36. Black Oak Lake calcium.

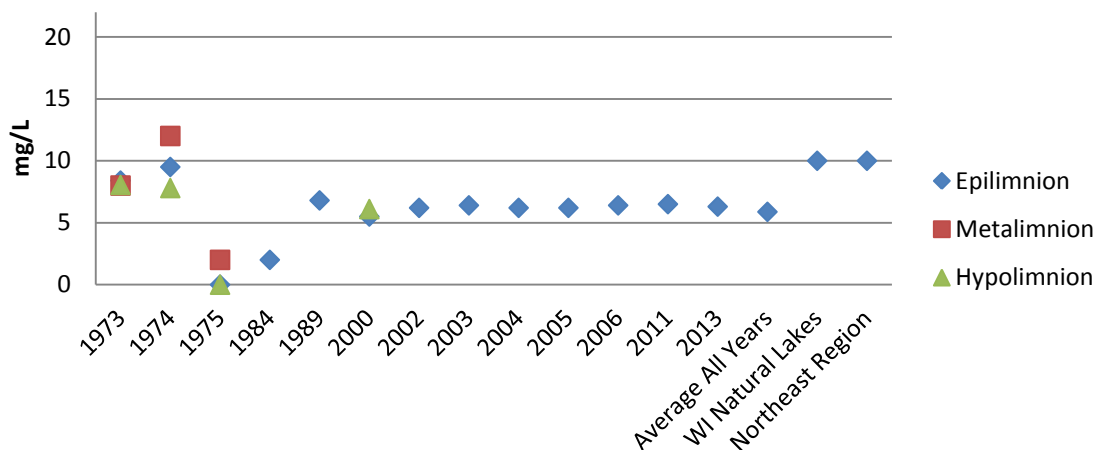
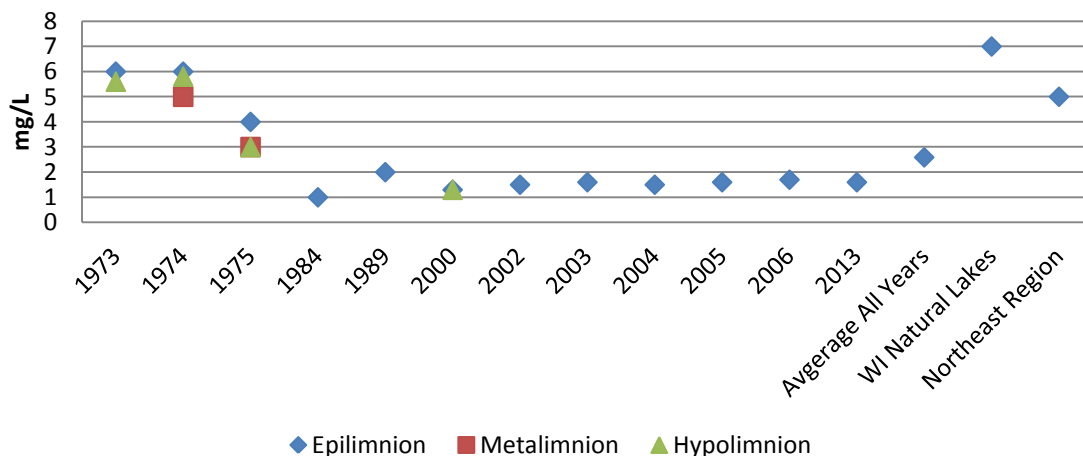
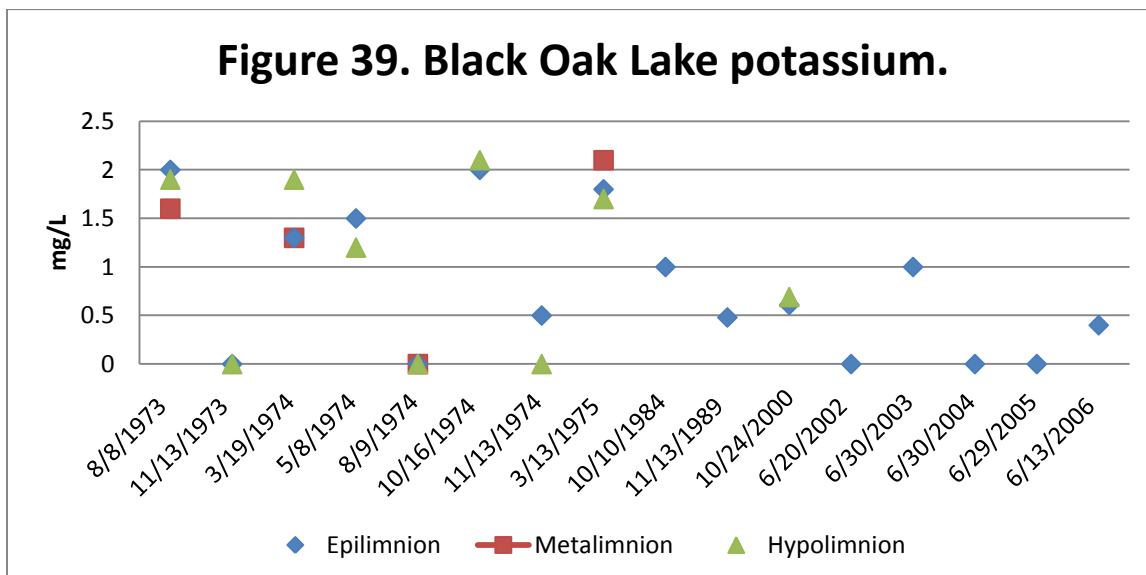
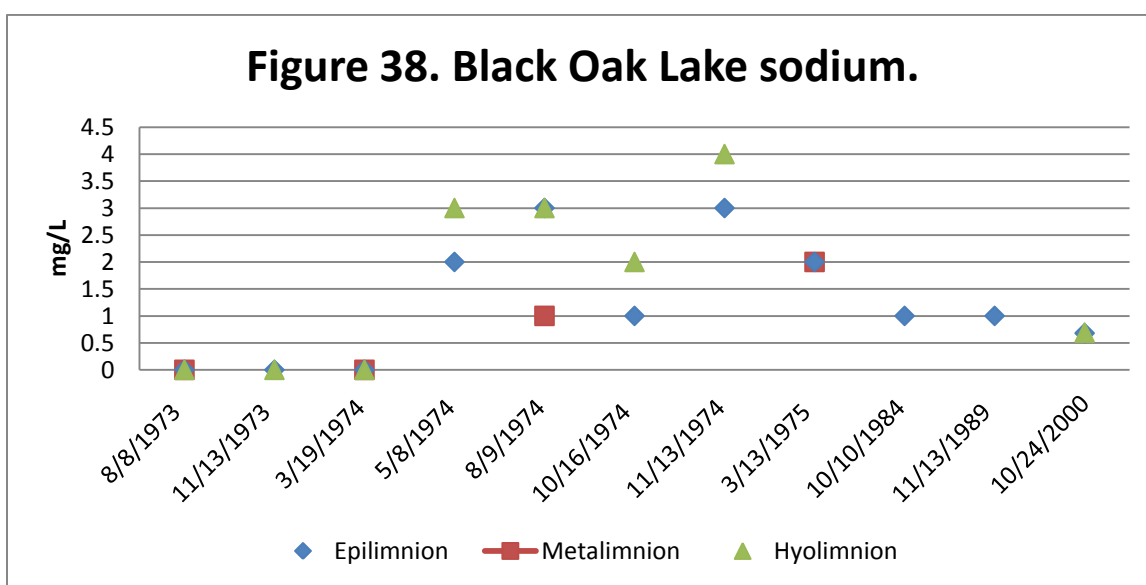


Figure 37. Black Oak Lake magnesium.



Sodium and Potassium

Sodium and potassium are possible indicators of human pollution in a lake, since naturally occurring levels of these ions in soils and water are very low. Sodium is often associated with chloride and gets into lakes from road salting, fertilizations, and human and animal waste (Shaw et al., 2004). Potassium is the key component of commonly-used potash fertilizer, and is abundant in animal waste. Both of these elements are held by soils to a greater extent than is chloride or nitrate; therefore, they are not as useful as indicators of pollution impacts (Shaw et al., 2004). Although not normally toxic themselves, they provide a strong indication of possible contamination by more damaging compounds (Shaw et al., 2004). Historic sodium (Figure 38) and potassium (Figure 39) values are shown below.



Dissolved Organic Carbon

Dissolved Organic Carbon (DOC) is a food supplement, supporting growth of microorganisms, and plays an important role in global carbon cycle through the microbial loop (Kirchman et al., 1991). In general, organic carbon compounds are a result of decomposition processes from dead organic matter such as plants. When water contacts highly organic soils, these components can drain into rivers and lakes as DOC. DOC is also extremely important in the transport of metals in aquatic systems. Metals form extremely strong complexes with DOC, enhancing metal solubility while also reducing metal bioavailability. Base flow concentrations of DOC in undisturbed watersheds generally range from 1 to 20 mg/L carbon. In August, 2013, the DOC was 3.6 mg/L.

Silica

The earth's crust is abundant with silicates or other compounds of silicon. The water in lakes dissolves the silica and pH can be a key factor in regulating the amount of silica that is dissolved. Silica concentrations are usually within the range of 5 to 25 mg/L. Generally lakes that are fed by groundwater have higher levels of silica. Black Oak Lake silica was 0.4 mg/L in November, 1989. More recent silica measurements should be collected.

Aluminum

Aluminum occurs naturally in soils and sediments. In low pH (acidic) environments aluminum solubility increases greatly. With a low pH and increased aluminum values, fish health can become impaired. This can have impacts on the entire food web. Aluminum also plays an important role in phosphorus cycling in lakes. When aluminum precipitates with phosphorus in lake sediments, the phosphorus will not dissolve back into the water column as readily. Aluminum was 5 µg/L in October, 1984 and 25 µg/L in November, 1989. New aluminum values should be collected.

Iron

Iron also forms sediment particles that bind with and store phosphorus when dissolved oxygen is present. When oxygen concentration gets low (for example, in winter or in the deep water near sediments) the iron and phosphorus dissolve in water. This phosphorus is available for algal blooms. Black Oak Lake iron levels were analyzed by the Conserve School teacher, Jill Graff on October 24th, 2000. Iron was not detected at the surface, but was 1.5 mg/L near the sediment.

Manganese

Manganese is a mineral that occurs naturally in rocks and soil. In lakes, manganese is usually in particulate form. When the dissolved oxygen levels decrease, manganese can convert from an insoluble form to soluble ions. A manganese concentration of 0.05 mg/L can cause color and staining problems. Manganese data was analyzed by the Conserve School teacher Jill Graff on October 24, 2000. Manganese was 3.7 mg/L at the surface and was 160 mg/L at the bottom.

These values appear high and may be caused due to the low dissolved oxygen levels at the bottom which causes the manganese to leach out of the soil. Stratification will slow down manganese being released.

Sediment

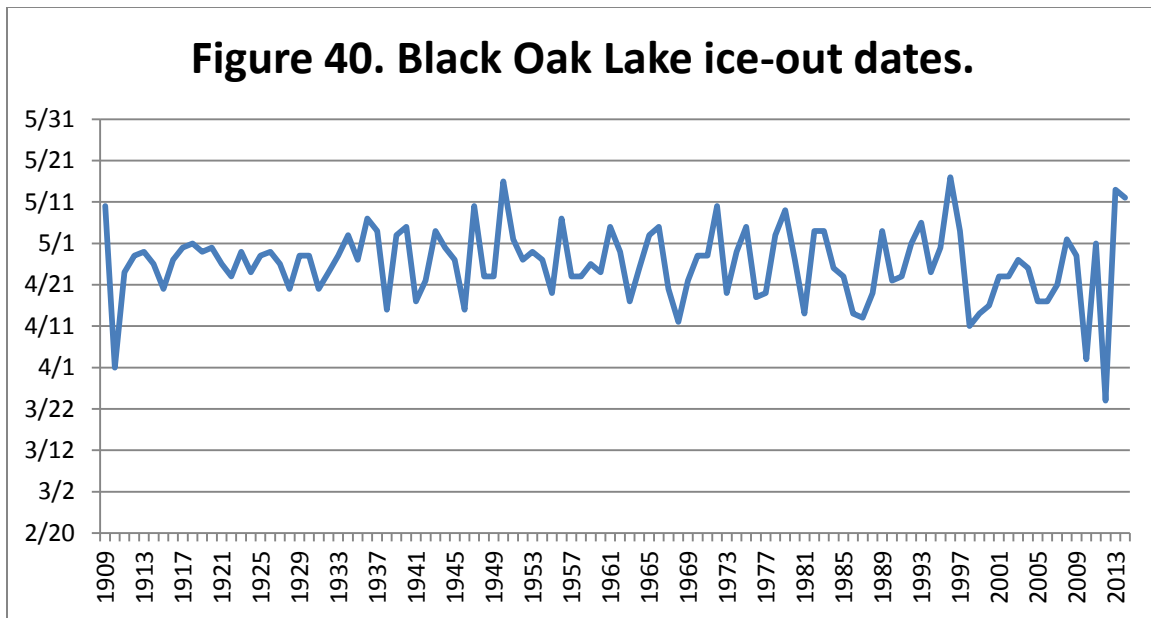
Lake bottom sediments are sometimes analyzed for chemical constituents that they contain. This is especially true for potentially toxic metals such as mercury, chromium, selenium, and others. Lake sediments also tend to record past events as particulates settle down and become part of the sediment. Biological clues for the historic conditions in the lake can be gleaned from sediment samples. Examples include analysis of pollen or diatoms that might help understand past climate or trophic states in the lake. Sediment chemistry data has not been collected for Black Oak Lake. A sediment core was collected for analysis of diatoms and zooplankton remains (reports provided in Appendix L of the Black Oak Lake Adaptive Management Plan).

Total Suspended Solids

Total suspended solids are all particles suspended in lake water. Silt, plankton, and wastes are examples of these solids and can come from runoff of agricultural land, erosion, and can be produced by bottom-feeding fish. As the suspended solid levels increase, they absorb heat from sunlight which can increase the water temperature. They can also block the sunlight that plants need for photosynthesis. These events can in turn affect the amount of dissolved oxygen in the lake. Lakes with total suspended solids levels less than 20 mg/L are considered “clear,” while levels between 40 and 80 mg/L are “cloudy.” Total suspended solids were not detected in November, 2000 or August, 2011.

Ice-Out

The Black Oak Lake website (2014) describes ice-out as follows: The Department of Natural Resource’s definition of “ice-out” is the first date that all ice is gone. Ice-out has been recorded on Black Oak Lake since 1909. Emil Wiese, who lived in Barber’s Bay (then called Wiese Bay); recorded ice-out dates from 1909 to 1921. Janet Vineyard’s family, the Handlos’, then recorded ice-out dates through 1965. Jim Lowenstine took over until 1997. Presently, John Annin and Walt Bates have recorded the Black Oak Lake ice-out dates (BOL, 2014). The earliest ice-out date was March 24, 2012 and the latest date was May 17, 1996 (Figure 40) (BOL, 2014). The overall average ice-out date is April 26 (BOL, 2014).



Aquatic Invasive Species

One invasive species is present in Black Oak Lake: rusty crayfish (*Orconectes rusticus*). Rusty crayfish have been in Black Oak Lake since 1990. Rusty crayfish are native to parts of Ohio, Tennessee, Kentucky and Indiana, and were likely introduced to Wisconsin waters by fishermen using the crayfish as bait (Gunderson, 2008). Rusty crayfish negatively affect other native crayfish species, cause destruction to aquatic plant beds, reduce fish populations by eating eggs, and cause shoreland owners recreational problems (Gunderson, 2008). It is illegal to possess both live crayfish and angling equipment simultaneously on any inland Wisconsin water (except Mississippi River) (WDNR, 2012). It is also illegal to release crayfish into a water body without a permit (WDNR, 2012).

The University of Wisconsin-Madison's Aquatic Invasive Species Smart Prevention program classifies Black Oak Lake as "borderline suitable" for zebra mussels, based on calcium and conductivity levels found in the lake (UW-Madison). Zebra mussel veliger tows were conducted in July and September, 2009 with no finds. Also in July and September, 2009 a spiny water flea and fish hook water flea survey was conducted, but there were no finds. CLMN volunteers looked for a variety of AIS in 2008, and from 2010 to 2013 with no new finds.

Clean Boats Clean Waters (CBCW) is a program that inspects boats for aquatic invasive species and in the process educates the public on how to help stop the spread of these species. Black Oak Lake has been a part of this program since 2008. Figures 41-43 show results of the CBCW program from 2010 to 2013.

Figure 41. Clean Boats Clean Waters Black Oak Lake (WDNR, 2013).



Figure 42. Clean Boats Clean Waters Black Oak Lake (WDNR, 2013).

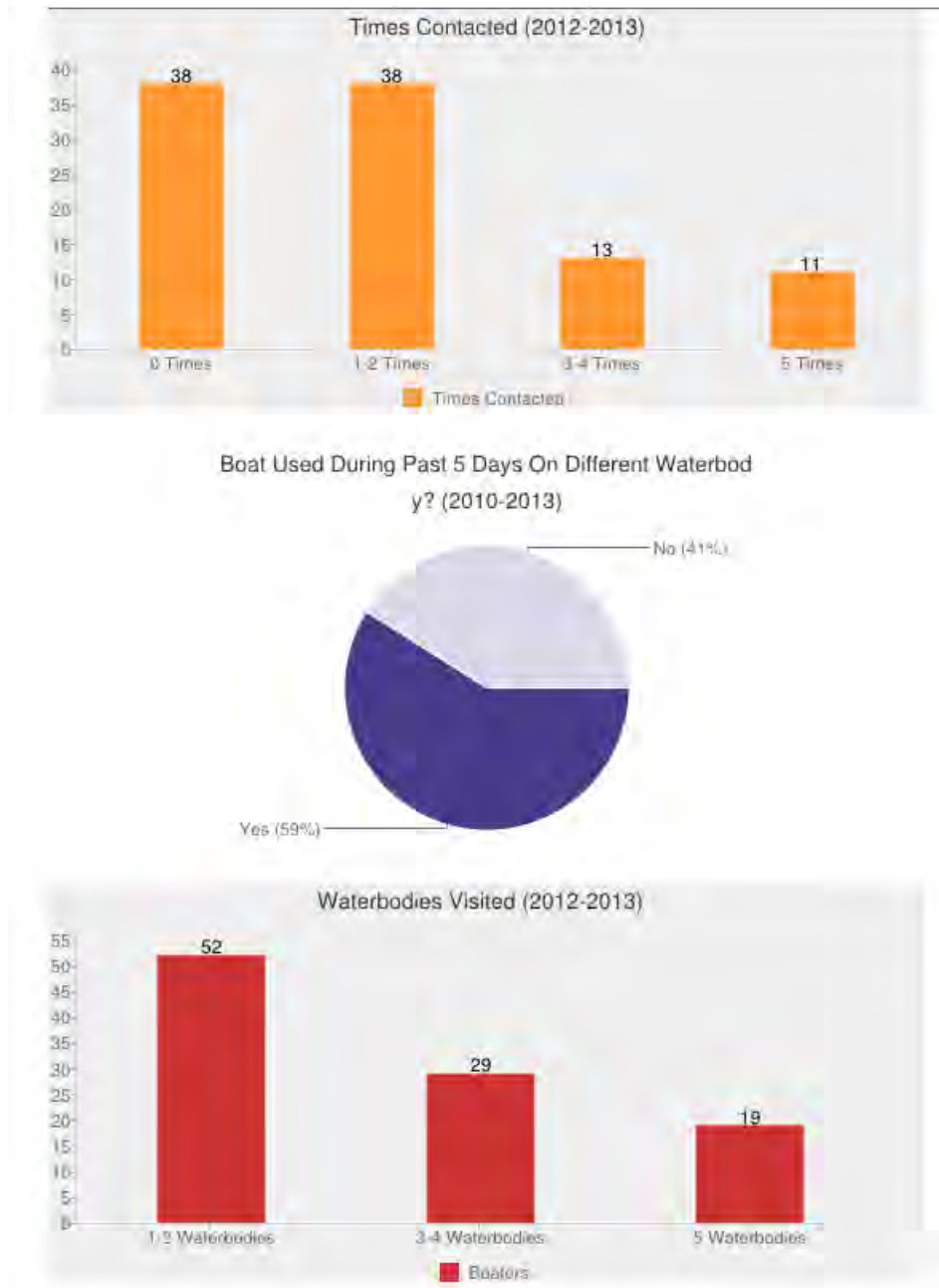
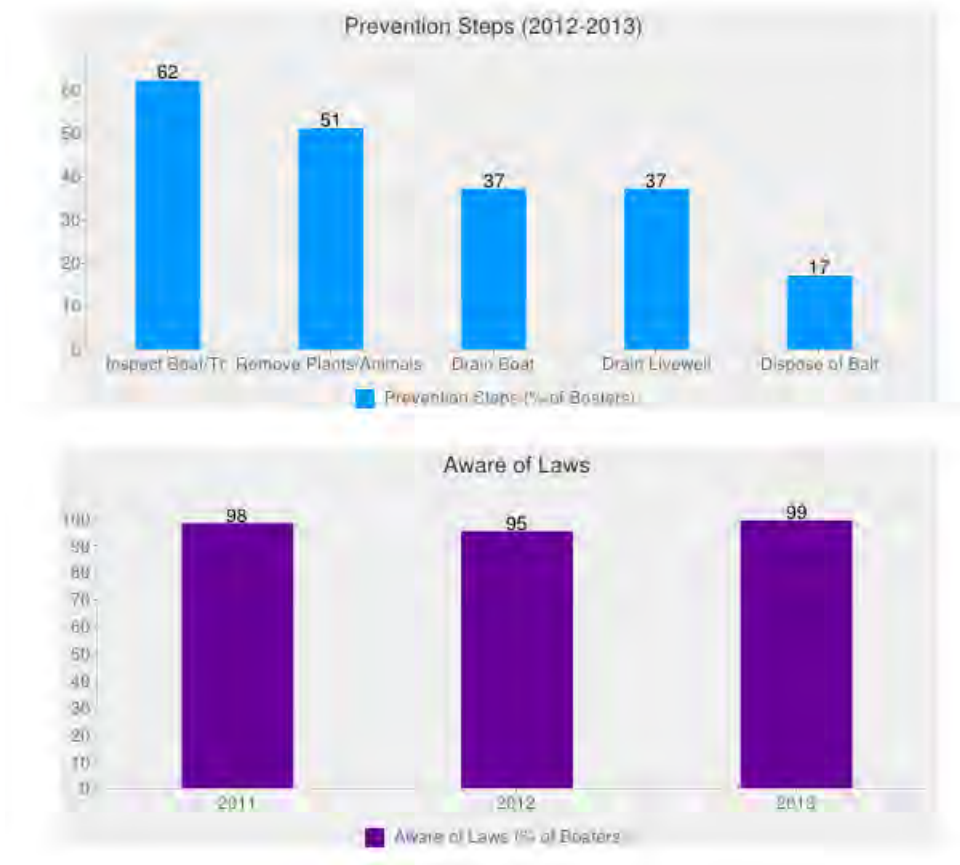


Figure 43. Clean Boats Clean Waters Black Oak Lake (WDNR, 2013).



Literature Cited

- Camargo, Julio A., Álvaro Alonso (Lead Author); Raphael D. Sagarin (Topic Editor). 02 April 2007. *Inorganic nitrogen pollution in aquatic ecosystems: causes and consequences*. In: Encyclopedia of Earth. Eds. Cutler J. Cleveland (Washington, D.C.: Environmental Information Coalition, National Council for Science and the Environment). Retrieved 2014. <http://www.eoearth.org/article/Inorganic_nitrogen_pollution_in_aquatic_ecosystems:_causes_and_consequences>
- Black Oak Lake Website. 2014. *Ice Out Dates on Black Oak Lake*. Black Oak Lake Preservation Foundation. Land O' Lakes, Wisconsin. Retrieved 2014. <<http://www.blackoaklake.com>>
- Carlson, R.E. 1977. *A Trophic State Index for Lakes*. Limnology and Oceanography. 22: 361-369.
- Gunderson, Jeff. 2008. *Rusty Crayfish: A Nasty Invader*. Minnesota Sea Grant. Retrieved 2014. <http://www.seagrant.umn.edu/ais/rustycrayfish_invader>
- Kirchman, David L.; Suzuki, Yoshimi, Garside, Christopher, Ducklow, Hugh W. (15). 1991. *High turnover rates of dissolved organic carbon during a spring phytoplankton bloom*. Nature 352 (6336): 612–614. Doi:10.1038/352612a0. Retrieved 2014. <<http://www.nature.com/nature/journal/v352/n6336/abs/352612a0.html>>
- Lillie, R. A. and J. W. Mason. 1983. *Limnological Characteristics of Wisconsin Lakes*. Wis. Dept. of Natural Resources Tech. Bull. Page 138. Madison, WI.
- Olszyk, D. 1980. *Biological Effects of Acid Rain*. Testimony, Wis. Public Service Commission Docket No. 05-EP-2. 5 pp.
- Shaw, B. Mechenich, C, and Klessig, L. 2004. *Understanding Lake Data (G3582)*. Board of Regents of the University of Wisconsin System. Madison, WI.

University of Wisconsin-Madison, Center for Limnology, Vander Zanden Lab. 2009. *Aquatic Invasive Species Smart Prevention*. Retrieved 2014.
<<http://www.aissmartprevention.wisc.edu/>>

Wisconsin Department of Natural Resources. 2012. *Rusty Crayfish*. Retrieved 2014.
<<http://dnr.wi.gov/lakes/invasives/AISDetail.aspx?roiseq=>>

Wisconsin Department of Natural Resources. 2013. *Clean Boats, Clean Waters*. Retrieved 2014.
<<http://dnr.wi.gov/lakes/cbcw/>>

Wisconsin Department of Natural Resources. 2014. *Surface Water Integrated Monitoring Systems (SWIMS) Database*. Retrieved 2014. <<http://dnr.wi.gov/topic/surfacewater/swims/>>

Appendix D

Black Oak Lake History

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A History of Black Oak Lake

by Paul McLeod

Ancient bedrock more than 2 billion years old lies beneath Black Oak Lake. Geologists have never seen that bedrock, but they have created complex geologic maps using geophysical techniques (Fig 1). Schists, gneisses, and granites lie at depths of around 100 to 200 feet below the ground surface and are overlain by young glacial sands and gravels. The bedrock is also cut by a series of northwest trending strike-slip faults. A reverse fault bounds Black Oak Lake on its south side, although the structural geology of the bedrock probably bears little relation to the shape and position of the lake.

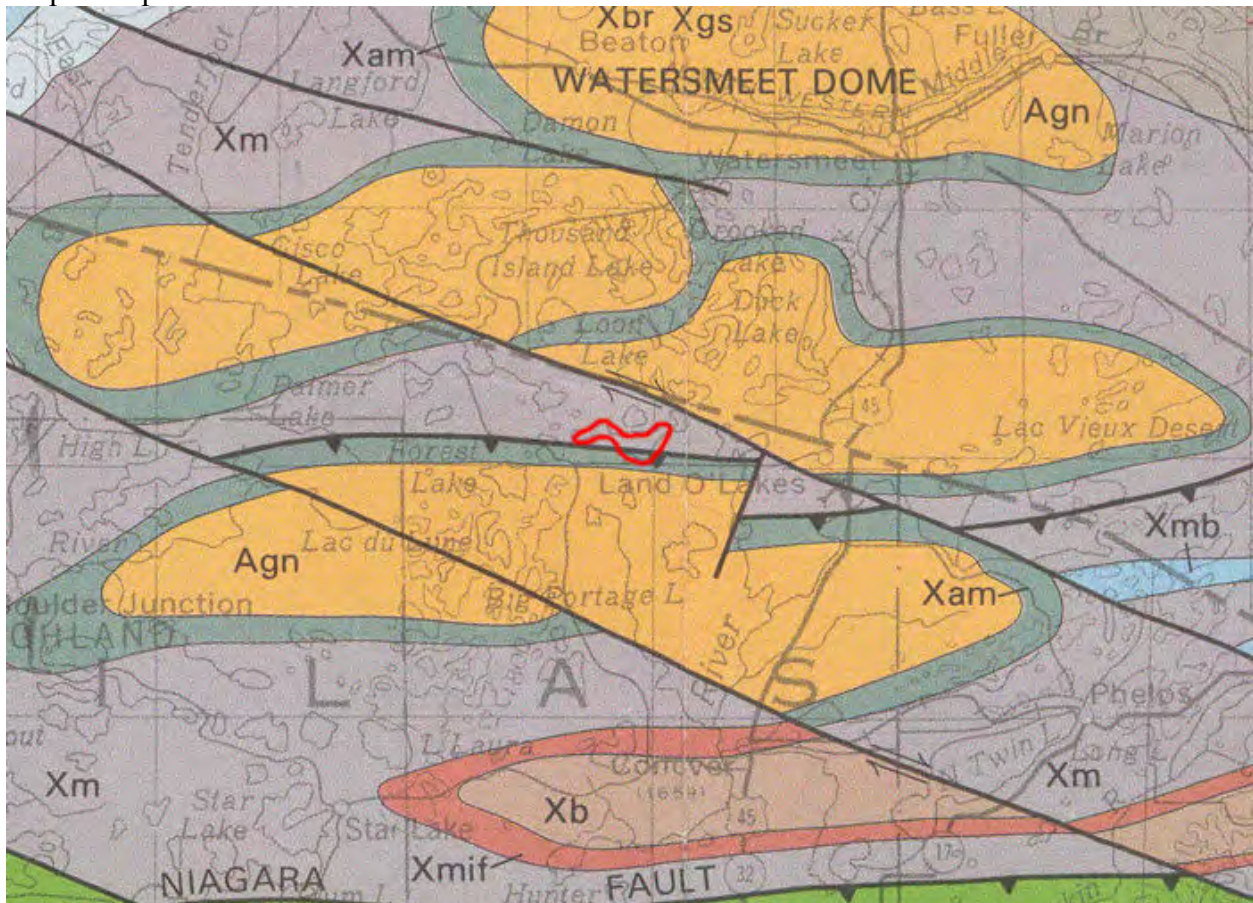


Figure 1. Bedrock geology of the Black Oak Lake area (lake outlined in red) (Simms, 1992).

The Wisconsin-aged Glacier advanced into southern Wisconsin around 25,000 years ago. A climate change beginning around 10,000 years ago caused the glacier to retreat to the north. One final short-lived advance during that retreat left an east-west trending band of poorly sorted sands and gravels called the Winegar Moraine (shown as the green color on the map below, Fig 2). That moraine bounds Black Oak Lake on its north side, indicating that is the spot where the glacier paused for a few hundred years in its retreat north. The pink color south of Black Oak Lake indicates the well-sorted sands of the glacial outwash carried by streams flowing off the front of the glacier. The elongate east-west shape of Black Oak Lake is probably directly related to the east-west trend of the glacial moraine.



Figure 2. Glacial geology of the Black Oak Lake area (Attig, 1985).

The earliest detailed mapping of the lake began during the summer of 1860 when the Federal government's General Land Office survey reached the Black Oak Lake area (Fig 3). At that time, the logging boom had not yet reached northernmost Wisconsin, and the purpose of the survey was simply to establish townships. The government surveyors were not in the business of naming lakes, and while they were the first to carefully map the lake's shape, the lake remained unnamed into the 1880s.

Following the survey, the land was opened to homesteading and purchase from the government, and the earliest land seekers staked their claims on area lands in 1872. It is unclear whether the first three men who patented land on Black Oak Lake (Allen Lovejoy, W.P. Rounds, and Augustus Haight) actually settled in the area, or whether they were land speculators. In fact, the great rush to patent the Black Oak Lake area did not begin until the arrival of the Milwaukee, Lake Shore & Western Railroad to State Line in 1883. More than a dozen patents were issued to a variety of land speculators within two or three years of that date. Some of those patents were on homestead claims, therefore some of the men probably built small-scale cabins near the lake at that time. Cabin building proceeded in order to satisfy the requirements of the Homestead Act, and it is unlikely that any of the men intended to settle in the area permanently.

Most of the Vilas County lakes carry names today which are different than the names they carried during the 19th century. Some lakes have had three or four different names. There is no evidence that Black Oak Lake has ever had any other name. The earliest known reference to the name dates to around 1887, but the name probably dates to the homestead rush of 1883. Botanists note that there are no known Black Oak trees near the lake, but the early land owners were not botanists, so they probably misidentified the local oak species.



Figure 3. General Land Office survey of the yet unnamed Black Oak Lake, 1860 (Board of Commissioners of Public Lands)



Figure 4. Franklin Newcomb mapped Black Oak Lake in 1887. He made editorial changes and additions to his own map creating a palimpsest covering the years 1887-1903 (Roberta Marling).

Rudolph Otto (1844-1898) and partners established the earliest known saw mill in the area on the south shore of Mill Lake around 1886. At that time, logging companies began selectively cutting the big white pines throughout the area and transporting them to Otto's sawmill by sled. Franklin Newcomb (1858-1925) was one of the early Black Oak Lake area homesteaders and speculators who documented the area with a series of hand-drawn maps (Fig 4). One map shows that Otto had established a logging camp on the Wisconsin/Michigan border within a mile of Black Oak Lake by 1887 to log his own lands (the five-mile distance between the Otto camp and

his mill suggests the land that Otto purchased near Black Oak Lake must have hosted some particularly large and numerous white pines). Government documents show that the Cutler & Savidge Lumber Co. of Michigan purchased 312 acres on Black Oak Lake in 1885, although it is unclear whether logging proceeded on their lands at that time.

There were probably several logging camps built along the Black Oak Lake shores during the 1880s-90s, and the remains of at least one of those camps is preserved on the lake's north shore on Dirk Meyer's property (Fig 5). This particular spot is well suited to the movement of logs from the area north of Black Oak Lake onto the frozen lake owing to the presence of a gently-inclined, north-trending, topographic trough. Most of the north shore of Black Oak Lake rises at least 20 feet above the lake-level creating a steep drop-off to the lake. Loggers could not easily move logs across the 20' drop-off to the lake, therefore they sought out the places along the lakeshore where ancient glacial drainages created troughs allowing the easy movement of logs onto the lake. Today it is possible to see the remains of at least eight buildings that sat in this particular trough. The dimensions of those buildings, together with the associated surface artifacts suggest bunkhouses, a stable, a cook house, an office, and other buildings associated with the logging camp.

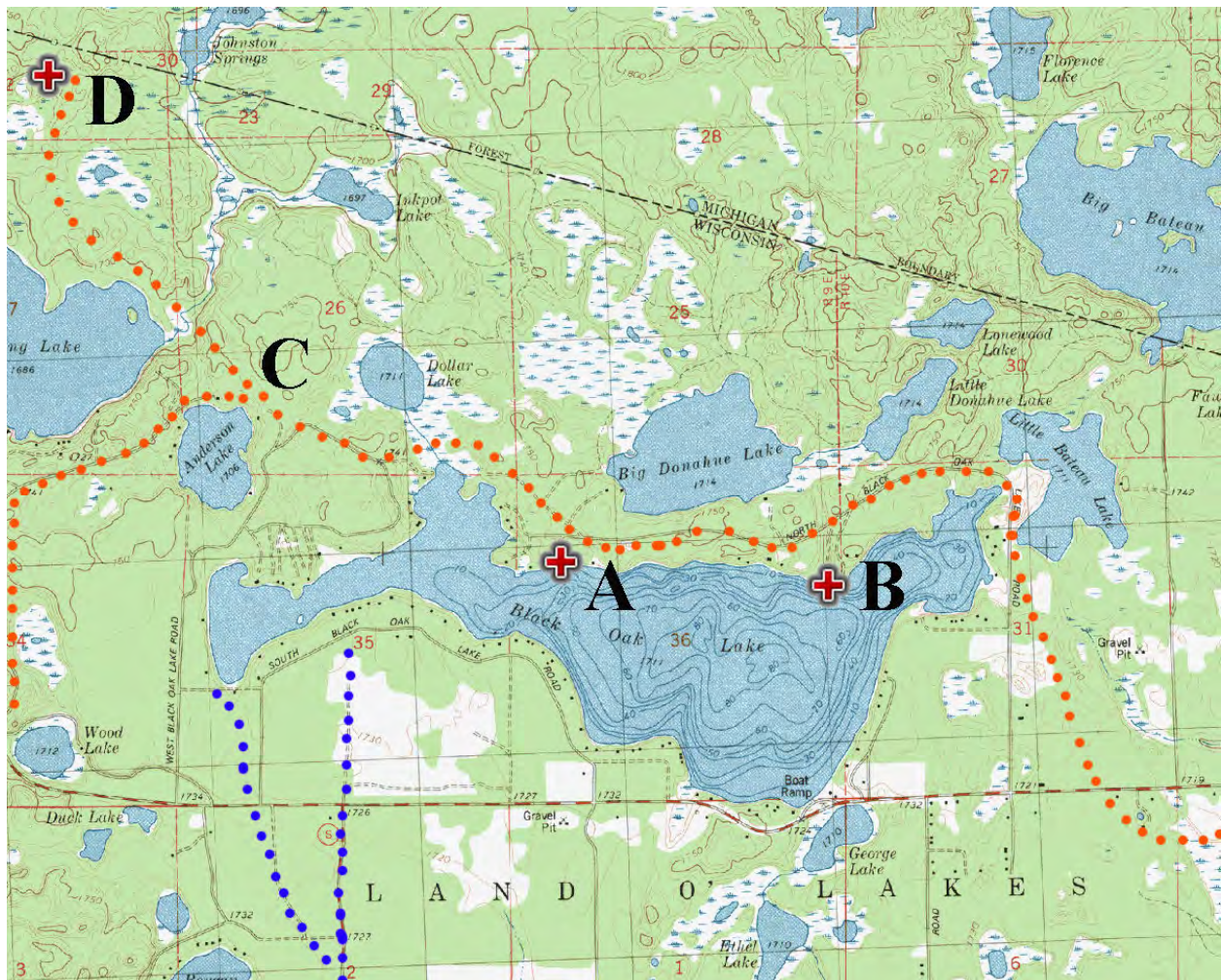


Figure 5. Topographic map of the Black Oak Lake area. The red dotted-line indicates the path of the Brown Brothers logging railroad (c. 1900-1909). The blue dotted-line indicates the approximate path of the Salsich & Wilson logging railroad (c. 1898-1910). "A" indicates the location of the historic logging camp on Dirk Meyer's

property, while “B” indicates the probable location of the logging camp on the Lowenstine property. “C” is the fork in the railroad which is pictured in Fig 7, and “D” is the location of the Brown Brothers logging camp in Fig 8.

During the years 1885-1900, loggers loaded logs onto sleds on the lakeshore, and teamsters hauled the logs across the icy lake over a well-worn trail to the Otto Mill (Fig 6). A second spot along the north shore where the glaciers left an inclined trough leading down to the lake, sat on the historic Woodhull/Lowenstine property. Development on the Woodhull/Lowenstine property during the 1920s and 1930s obliterated any remains of historic logging camps, but it seems probable that the area did host a logging camp and log landing during the 1880s-90s.

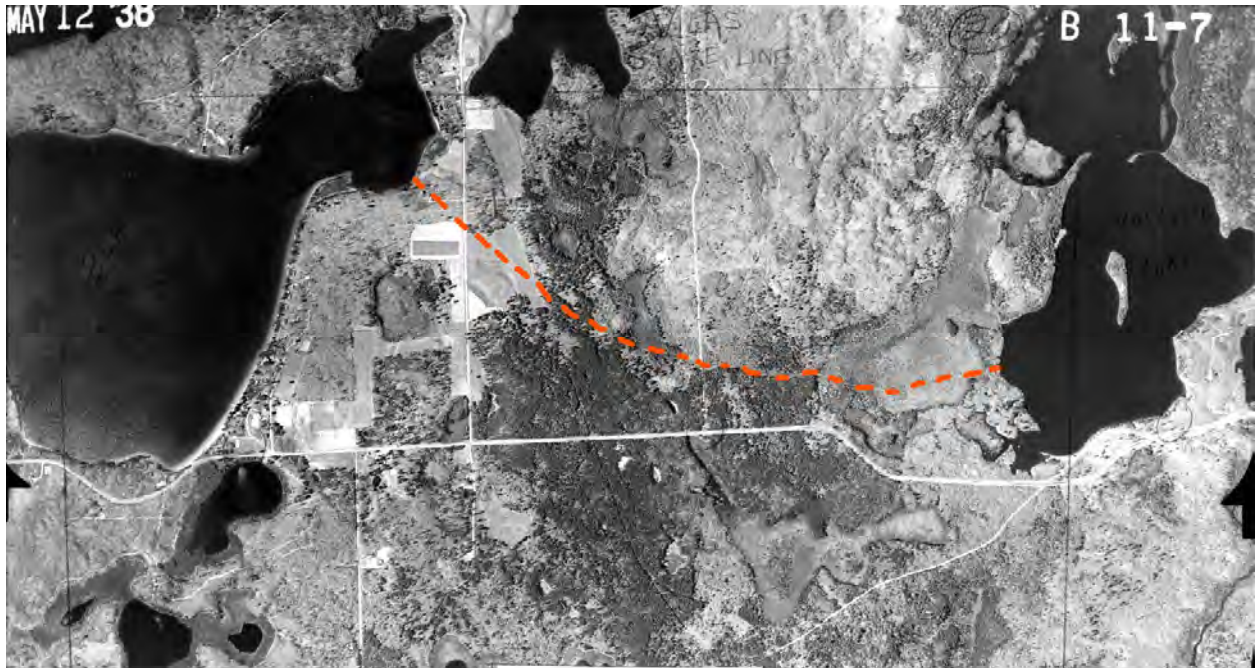


Figure 6. This airborne photo of the east Black Oak Lake area shot on May 12, 1938 preserves the trace of the sled road connecting Black Oak Lake with Mill/Landing Lake. All logs cut in the Black Oak Lake area during the years 1885-1900 traveled to the Otto Mill via this sled road. After 1900, the logging railroads rendered this sled road obsolete (Vilas County Foresters Office).

Around the time that Rudolph Otto died in 1898, logging in the Land O' Lakes area picked-up in intensity. Mary Otto, Rudolph's daughter, and her future husband, Charles Mather took over the Otto Mill and continued logging in the Black Oak Lake area. At the same time, the Brown Brothers Lumber Co. began purchasing homestead claims from private land-owners in the Black Oak, Anderson, Spring, and Forest Lake areas with a plan to begin large-scale logging operations. At the same time, the Salsich & Wilson Lumber Co. began acquiring logging rights to the lands south of Black Oak Lake. The 160-acre parcels that homesteading speculators purchased for \$1.25/acre during the 1880s sold to the logging companies for over \$1000, and the price frequently went above \$2000 if land agents got involved as middle-men. Some of the land agencies at work in the Black Oak Lake area at this time included the Northern Blue Grass Land Co., the Wisconsin Blue Grass Land Co., and the Home Investment Co.

In the quest for logs, the owners of the old Otto Mill moved away from the Black Oak Lake area after 1900 and turned their attention to unlogged tracts near Duck Lake in Michigan. The Brown Brothers and Salsich & Wilson companies focused their efforts on the Black Oak Lake area after 1900 and anticipated working in that area for a period of several years. Around 1900

both companies strategically located logging railroads in the Black Oak Lake area and built new logging camps, as well (Figs 6,7,8). Both companies employed the subcontractor Langley & Alderson, of Merrill, WI to carry out the logging operations (by 1900, logging companies increasingly began using subcontractors as a way to boost their falling profit margins). The Brown Brothers sent its logs from the north side of Black Oak Lake to its sawmill in Rhinelander, while Salsich & Wilson sent its logs from the south side of the lake to the mill at Star Lake.



Figure 7. The Brown Brothers Lumber Co. logged most of the lands on the north side of Black Oak Lake. Subcontractor Langley & Alderson managed the Brown Brothers' logging railroad and operations. This photo was shot at the fork in the logging railroad on the north side of Anderson Lake during summer, 1908 (Janet Vineyard).

The Black Oak Lake logging operations were so distant from the newspaper offices in Eagle River, that neither the *Eagle River Review* nor the *Vilas County News* carried many news items on logging activity during the early 1900s. The Salsich & Wilson Logging Company's Black Oak Lake area camp sat on its logging railroad line between Moccasin Lake and Black Oak Lake. The Brown Brothers established a large camp housing perhaps 100 men at the terminus of its logging railroad north of Spring Lake (Fig 8). It seems likely that the Brown Brothers also re-activated the logging camp on the Dirk Meyer property, although probably not for its strategic location on the lake, but because of the collection of buildings already sitting on the site. The newspapers mention that Langley & Alderson maintained their offices along the Brown Brothers' rail line, so it is also possible that Langley & Alderson established their offices at the site of the old logging camp on the Black Oak lakeshore.

Several hundred meters east of the logging camp on the Dirk Meyer property lay the remains of what may be the oldest house on Black Oak Lake (Fig 9). Little is known about the house, because courthouse documents specify neither the builder nor the owner, and because the house

predates the memories of the oldest area residents. Myrtle Lloyd, who played near the house as a girl during the late teens, recalls that the house was already vacant and in disrepair at that time. The logging activity north of the lake during the 1890s, together with the difficult access to the area, suggests that the homeowner may have been involved in area logging during the 1890s.



Figure 8. The Brown Brothers logging camp sat on the Wisconsin side of the state border immediately north of Spring Lake. The camp operated from 1900 to 1909. The photo was shot during summer, 1908 (Janet Vineyard).



Figure 9. These unidentified ruins on the north shore of Black Oak Lake may be the remains of the earliest house on the lake. Evidence suggests the house was built during the 1890s (Paul McLeod).

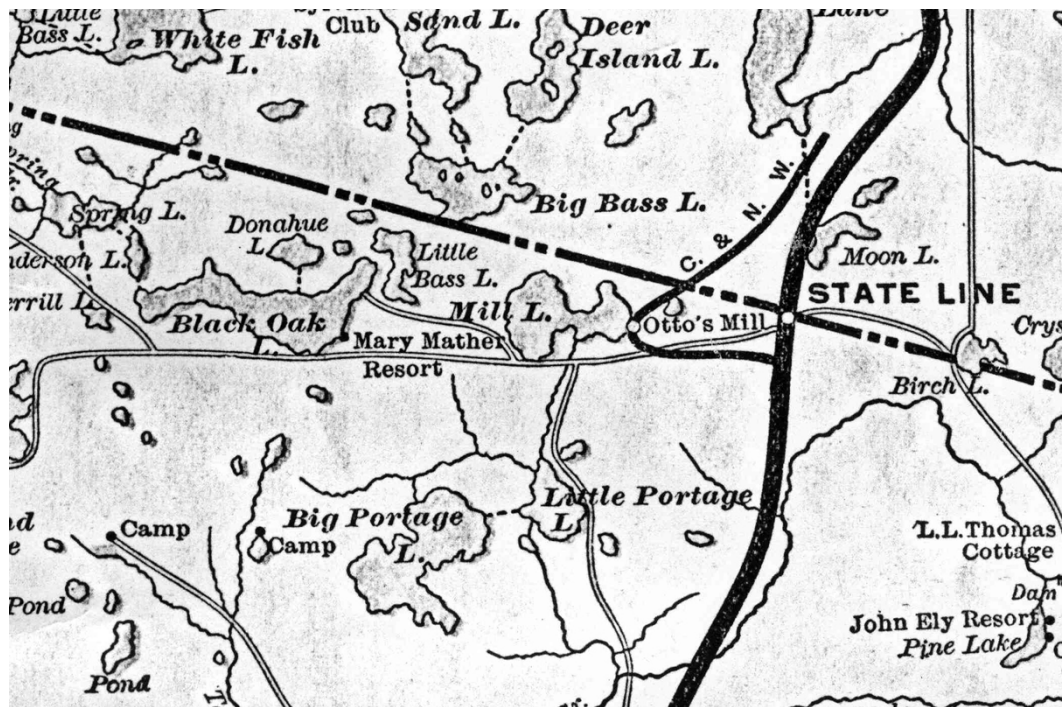


Figure 10. The Chicago & Northwestern's 1903 map shows its spur to the Otto sawmill as well as the wagon road skirting Black Oak Lake on its south side and the sled road connecting Black Oak Lake with Mill Lake. The logging railroads were in place by this time but are not included on this map (LOLHS).

During the 1890s the Eagle River newspapers made occasional reference to tourists traveling to Black Oak Lake specifically for fishing opportunities. Businessman R.D. McLeod traveled to Black Oak Lake during May, 1899, and the *Vilas County News* noted that he caught a 14 ½ pound trout. The Black Oak Lake area seems to have been experiencing a bit of schizophrenia at that time as fishermen valued the lake for its fishing opportunities and its natural beauty, while logging companies valued it for its pines, maples, hemlocks, cedars, basswood, and oaks. In 1899, the Chicago & Northwestern (successor to the M,LS & W RR) began service on its “Fish Train” to allow Chicago residents to travel to the Vilas County area to fish on weekends. The service remained popular for several decades and was a boon to the area tourist trade.

Census data and early maps show that at least as early as 1900, Mary Otto (Mather) operated a camp or “resort” on the southeast corner of Black Oak Lake (Fig 10). During June, 1900 the camp was occupied by approximately 70 men involved in area logging. A stagecoach operated between the State Line depot and Black Oak Lake, and it probably served both loggers and tourists (Fig 11). That stage line probably stopped at the Mary Otto resort (and later at the St. Clair resort) and probably also went out to Bent’s Camp, which had been established in 1896.

By 1909 the tree supply in the Black Oak Lake area had been exhausted, and both the Brown Brothers and Langley & Alderson companies had fallen on hard finances. The logging railroads were removed around 1909, and both companies went out of business during the next few years. The lands surrounding Black Oak Lake had been heavily cut during the first decade of the 20th century, and while the lands held little future value for logging companies, they began to interest summer tourists (Fig 12).



Figure 11. A stagecoach operated between State Line and Black Oak Lake around the turn of the century. That may be Mary Otto Mather standing at right, who operated a camp at the southeast corner of the lake. Photo ca. 1905 (Vilas County Historical Society).

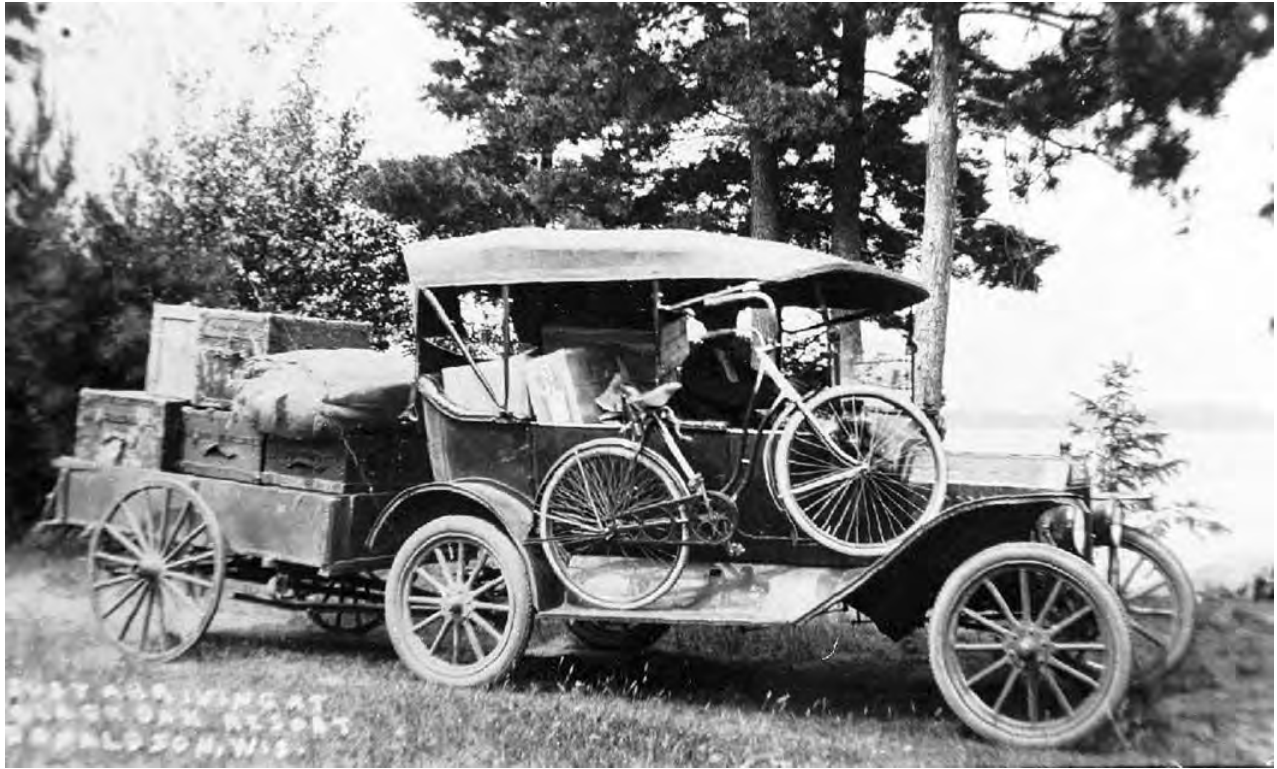


Figure 12. Black Oak Lake had been a popular tourist destination from the 1890s, but by 1910 tourists began arriving for the summer, and some of them even began building summer houses. Photo ca. 1915-20 (Vilas County Historical Society)

The earliest known reference to a residence on Black Oak Lake is an announcement carried by the *Eagle River Review* on May 8, 1908 indicating that Lee & Belle Barber were building a \$5000 house immediately north of the Black Oak Lake resort. The Barber house (extant but heavily remodeled) seems to have initiated the era of house-building along the lakeshore. A series of photographs of the Black Oak Lake area shot during the summer of 1908, which may have been commissioned by the Barbers, capture the recently completed Barber house (Fig 13). The photographs also capture that transitional period at the end of the logging era and the beginning of the summer recreation era (Fig 14). The heyday of the logging had passed, but a small group of loggers continued to harvest the last of the area trees, while at the same time the new residents on the lake were attracted by the natural setting, the serenity, and the recreational opportunities. During the period 1908-1912 a number of summer pioneers bought lots on the south and east shores of Black Oak Lake and built rustic homes including Dr. James Ely, Lee W. Barber, Emil Weisse, A.J. Keefe, and Dr. Wallace Grosvenor (Fig 15).



Figure 13. Images of the Lee Barber house and family. The house was completed during the summer of 1908, and the photographs were shot in August, 1908 (Paul McLeod).

By 1908, real estate tycoon, George T. Halbert, with his office in Minneapolis, MN, began purchasing cutover lands for resale. He began systematically surveying, platting, and marketing lakefront property on Black Oak Lake (and other area lakes) and achieved modest success during the teens and 1920s as more and more people began building on the south and east shores of Black Oak Lake (Fig. 16). By the middle 1920s, homeowners on the lake included A.J. Bates, Harvey Crooker, Archibald Patterson, O.G. Knecht, George Fagg, R. Knute, G.C. Williams, C.E. Search, E. Walker, Ed Lindsten, Dr. Craig, H.H. Barnum, B. Schroeder, Frank Ferry, and Frank Hoffman.

Halbert acquired much of the real estate he was marketing from the Brown Brothers Lumber Co., but the Brown Brothers retained a majority of its own cutover lands simply because nobody wanted those lands. After the Brown Brothers Lumber Co. went out of business in 1916, a subsidiary of that company continued in business strictly to deal with its large cutover land holdings. The Brown Brothers tried to market some of its cutover lands on the north shore of Black Oak Lake as building lots during the 1920s and 1930s, but the venture was a failure, and the entire block of lots was eventually acquired by the Crown family in the mid-1930s (Fig. 17). The property remains undeveloped today and is still locally referred to as “the Crown property”.



Figure 14. The only known photograph of the Brown Brothers logging railroad as it crosses the bog separating Black Oak and Dollar Lakes (August, 1908). After tearing out the rails in 1909, the grade became a road, and cars crossed the bog on this road until 1956 when James Lowenstine acquired the property and closed access to traffic (Paul McLeod).

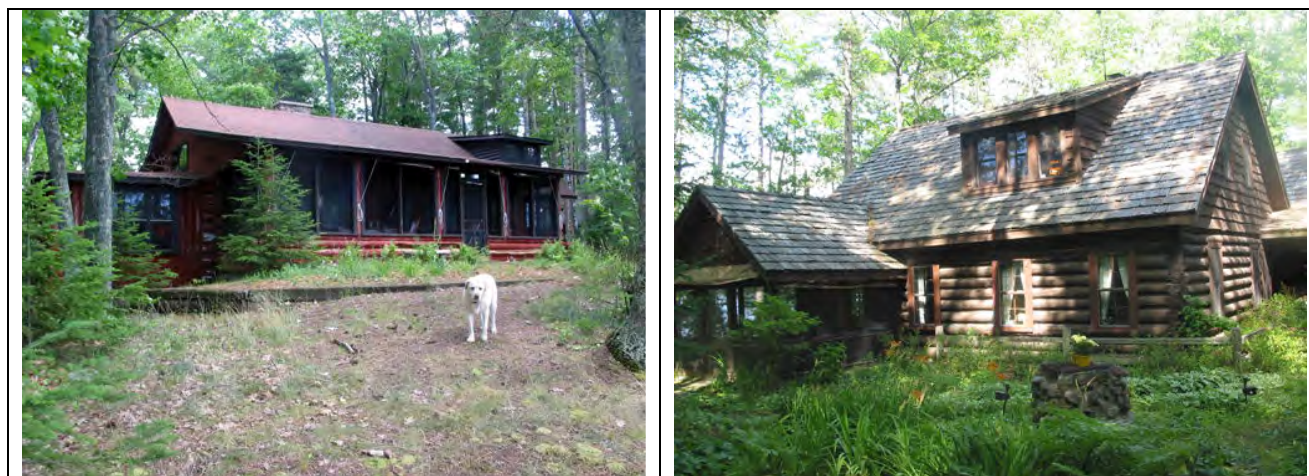


Figure 15. James Ely built an early house (1910) currently owned by George & Cathy Gelb (left). Jim and Ann Bates remodeled the A.J. Keefe house (1912) (right) (Paul McLeod).

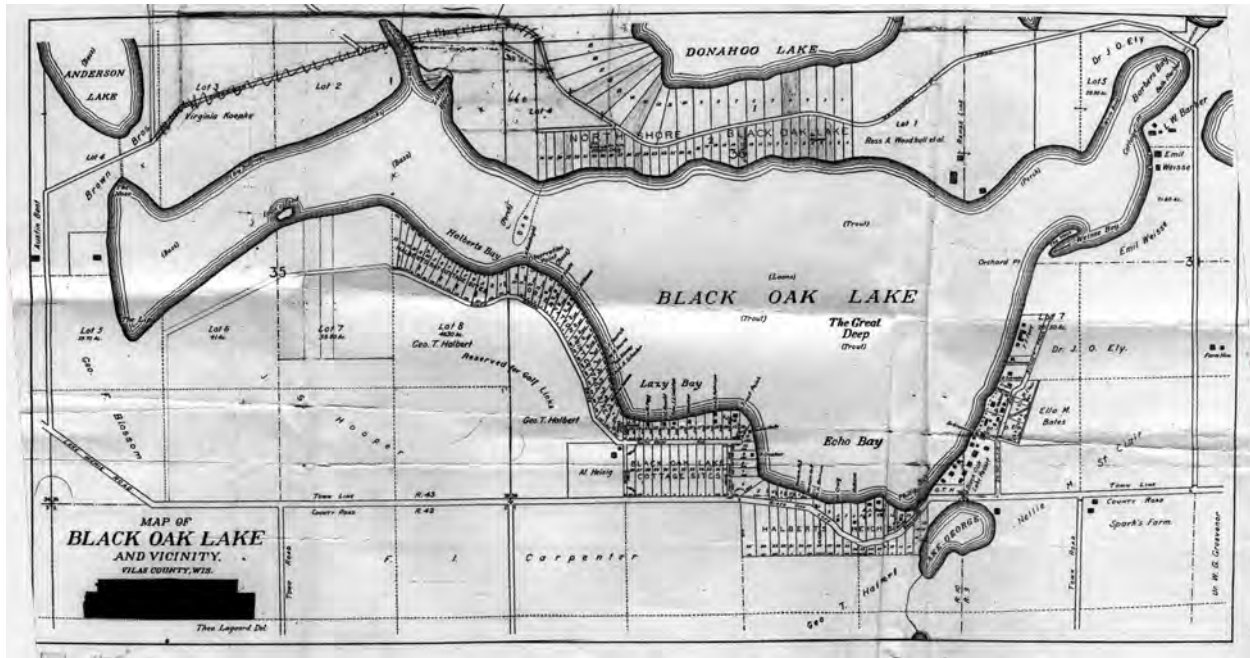


Figure 16. Around 1910, real estate tycoon George Halbert began marketing Black Oak Lake lots to Chicago area residents. The earliest development proceeded on the south and east shores. Map ca. 1926 (Tom Allman)

Chicago businessmen Ross Woodhull (1878-1944) and Mandel “Nick” Lowenstine (1882-1956) both purchased adjoining parcels of cutover land from the Brown Brothers on the north shore of Black Oak Lake in 1921. Aside from a handful of small 1880s homestead cabins, Woodhull and Lowenstine built the first large home on the lake’s north shore. They called it “Hullwood”, and it was completed in 1921 (Fig 15). Lowenstine owned Central Steel & Wire Co., while Woodhull served as a Chicago alderman and president of the board of trustees of the Chicago Sanitary District. The lifelong friends had grown up together in Valparaiso, Indiana. Lowenstine and Woodhull initially shared the house, but Lowenstine’s 1921 marriage led to his desire to build his own house immediately east of Hullwood (Fig. 19).

EDWARD O. BROWN, PRES.
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BROWN BROS. LUMBER CO.

MANUFACTURERS & WHOLESALEERS
SPECIALIZING IN WHITE PINE LUMBER
WESTERN TIMBER, ETC.

OWNERS AND DEALERS IN
WISCONSIN CUTOVER LANDS
AND LAKE FRONTAGE

RHINELANDER, WIS.

April 17, 1935.

Mr. C. E. Search,
Milwaukee, Wis.

Dear Mr. Search:

You, as a summer resident and property owner on Black Oak, will without doubt be interested in keeping the ownership on the lake among your friends and associates. Brown Brothers, as you perhaps know, have held extensive frontage along the north shore since the days of the virgin pine without exerting any effort to push sales. This company, however, have chosen 1935 as the year to exert a real sales effort with this lake frontage, principally because of the publicity the Government has of late given Conservation especially from the recreational angle.

Realizing the desirability of having your friends and associates as your summer neighbors, we are giving you "Pioneers" on Black Oak the first opportunity to increase your holdings or a chance to get your friends and associates interested in this most attractive lake of your choice.

We are glad to be able to inform you that George St. Clair, an acquaintance and neighbor sympathetic to the idea expressed, will be found in Chicago at the Highway 45 Booth in the Outdoor Life Exposition* between the dates of April 22nd and 27th. He will be very glad to talk over any wooded piece in either the platted or unplatted area marked as unsold on the enclosed ownership map of the lake. If you are not able to make the contact mentioned write direct to our office and we will be glad to make arrangements to show you locations.

It is our earnest endeavor to cooperate and help you locate people of your choice, consequently we will welcome any suggestions you have or act on any people or list that you are interested in having on the lake.

Very truly yours,

*HOTEL SHERMAN

BROWN BROTHERS LUMBER CO.

By

Secretary

ACB GN

Figure 17. Brown Brothers marketing the Black Oak Lake cutover, 1935 (Sally Lippert)



Figure 18. Ross Woodhull built Hullwood around 1921, one of the few early homes on the lake not built in the log cabin style. Photo ca. 1925 (Mark Siegworth).



Figure 19. Mandel “Nick” Lowenstine built Lowenwood next door to his best friend, Ross Woodhull. The original house, built around 1923, was heavily remodeled in the 1970s (Paul McLeod).



Figure 20. Ross Woodhull (in cowboy hat) and Nick Lowenstine (in baseball cap) began inviting Valparaiso, Indiana friends up to their houses every summer beginning in the early 1920s. The photo, dating to around 1923, may have been shot during the construction of the Lowenstine house (Jane Lohmeyer).



Figure 21. Summer, 1943 at Lowenwood. (Left to Right: Maurice Lowenstine, Nick Lowenstine, Daisy Lowenstine, Justin Shauer, Ethel Shauer, Miriam Lowenstine, Ross Woodhull, Bud Lowenstine). The trophy house, which was demolished in the 1970s, housed Nick Lowenstine's fishing trophies (LOLHS).



Figure 22. Every spring, Nick Lowenstine invited his friends up for the opening week of fishing season. Left to Right: David “Mac” MacFarland (Nick’s bodyguard), C.L. Bartholomew (Valparaiso Mayor and undertaker), unid, Jim Lowenstine, Nick Lowenstine, Henry Lowenstine, and Justin Shauer (seated). Photo ca. 1946 (LOLHS)

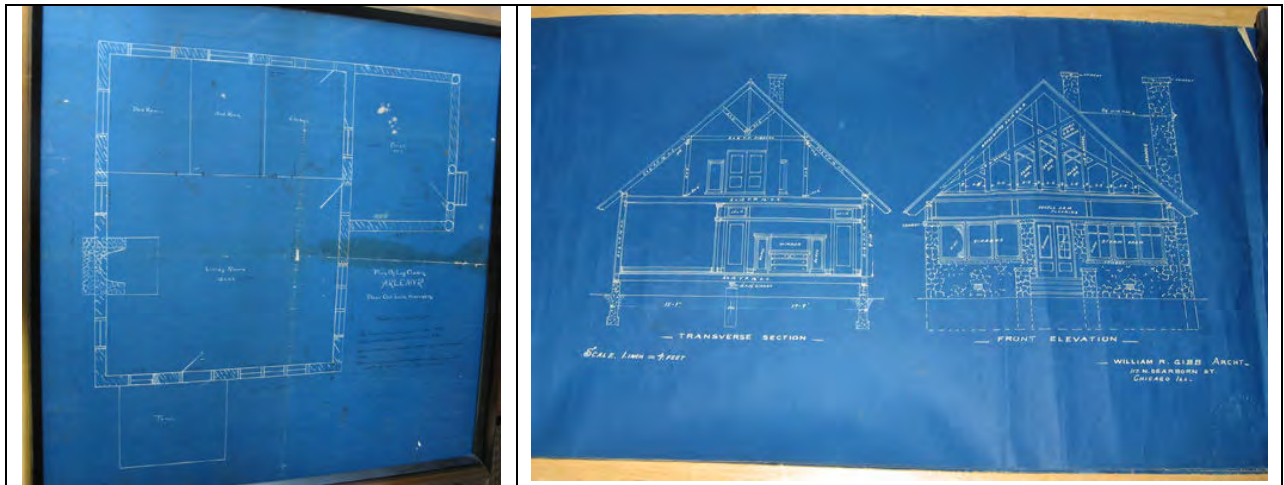


Figure 23. Simple architectural plans for the Patterson house, “Arlemyr”, built by George Fagg in 1919 (left), contrasted with complex plans for the Lowenstine house, c. 1923, William Gibb, architect (right) (Barbara Knaak, Conserve School).



Figure 24. Interior of Ross Woodhull's "Hullwood", ca. 1924 (Mary Lou Oldham)



Figure 25. "Arlemyr" interior, photographed in 1926 compared with the same well-preserved interior today. Notice the use of birch-bark in the wall decoration. "Arlemyr" was the home of Archibald Patterson and is currently owned by his granddaughter, Barbara Knaak. (Barbara Knaak, Paul McLeod)

The Brown Brothers logging railroad followed the north shore of Black Oak Lake. After the rails were torn out in 1909, the grade became a dirt road called "Ontonagon Trail" on early maps. Woodhull and Lowenstine accessed their property by way of this road. The driveway that connected Hullwood to the Ontonagon Trail appears to have been a spur of the old logging railroad. The broad, flat site on the north shore of Black Oak Lake which had been an ideal site for a logging camp and log landing was also an ideal location for the Woodhull house. West of

Hullwood, the Ontonagon Trail followed the old railroad grade across the bog separating Black Oak Lake and Dollar Lake. Residents were able to drive their cars across this grade until James Lowenstine acquired that property in 1956 and closed that portion of the road (Fig 14). Today it is not possible to drive around Black Oak Lake, and it has not been possible since 1956. The closure of that road probably inhibited residential growth on the lake's north side.

While nearly all of the homes built on Black Oak Lake during the period 1908-1928 followed a rustic log style, Lowenstine and Woodhull built sturdy, sophisticated bungalows that did not really blend in with the prevailing lake architecture. Both houses were designed by Chicago architect William R. Gibb, who may have worked for Woodhull on Chicago civic projects. Most of the other residences on Black Oak Lake were more modest in scale and materials, and most were probably not designed by professional architects. At least one rustic Black Oak Lake house dating to around 1916 (currently owned by Nancy and Elizabeth Eaton) shows evidence of having been ordered from a catalog and assembled on-site.

Both the Woodhull and Lowenstine houses were designed to accommodate large groups of Valparaiso friends (mostly men) who vacationed on Black Oak Lake from the 1920s through the 1950s (Figs 20,21,22). The largest regular group arrived early in May for the start of the fishing season and stayed for a couple of weeks each year. The annual gatherings dwindled after Nick Lowenstine's death in 1956. Woodhull's niece, Laura Chapman, who inherited Hullwood in 1944, developed tensions with the Lowenstine family which led to the establishment of a formal boundary between the two properties. James Lowenstine later bought the Woodhull property from Laura Chapman and demolished the house following her death in 1989.

Archibald Patterson, a dentist from Joliet, IL, commissioned "Arlemyr" on the south shore of Black Oak Lake. The name of the house was an anagram of Archibald, his wife Leona, and their daughter, Myrtle. The family planned the modest cabin with the builder, George Fagg around 1919, and Fagg built the house from logs cut on or near the building site (Fig. 23). The rustic interior was captured in a 1926 photo, and today the house retains much of its architectural integrity (Fig. 25). By contrast, the plans for the Lowenstine house are extensive and detailed and specify a variety of imported building materials including steel beams. Both Lowenstine and Woodhull commissioned a variety of interior and exterior photos of their houses, and while those interiors suggest a rustic flavor, the furnishings are expensive and showy (Fig. 24).

The Torres family began traveling to the Vilas county area from Evanston, IL during the late teens, and they purchased a small cabin on the far west end of Black Oak Lake from Walter Dickman in 1922 (Fig 26). Ed Torres, who began spending summers at the cabin as a child in 1922, continues to spend time at the cabin to this day. Among Ed's recollections of life on the west end of the lake are his memories of harvesting buckets full of berries to make large quantities of fruit jam. In a 1923 photo the family poses next to the fruit-filled, Mason jars with a comical sign reading "No fish but loads of berries". When the logging companies clearcut the forest around the lake, blackberry and raspberry plants were among the first opportunist species to sprout. Those plants apparently thrived into the 1920s. Among the first tree species to regrow along the lakeshore were the birches and aspens. Many old timers fondly remember the abundance of birches, and they commonly speak about a blight that killed the birches. In fact, most of those birches probably died of old age during the 1970s and 1980s.



Figure 26. The Torres cabin at the west end of Black Oak Lake. The Torres family acquired the cabin from Walter Dickman in 1922, and while the cabin was rebuilt in the 1940s, the family still owns the property (Ed Torres).



Figure 27. Ed Torres (center with hands over head) recalls that acres of berry bushes covered the clearcuts on the west end of Black Oak Lake, and during the 1920s the family harvested buckets of berries to make jam. In this 1923 photo, the sign says “No fish but loads of berries” (Ed Torres).



Figure 28. Black Oak Lake hosts a variety of unusual boat houses dating to the era 1915-1940 (Paul McLeod).

At least 15 unusual and architecturally significant boathouses still dot the Black Oak Lake shoreline. While regulations no longer permit shoreline construction, these boathouses reflect a time when it was the norm. The most significant boathouses date to the era 1915-1940 and cover a variety of architectural styles and construction materials (Fig 28).

One locally important industry which centered on Black Oak Lake was ice harvesting (Fig 29). Local men probably began cutting ice on a small scale on Black Oak Lake shortly after 1900, but increasing demands for the ice made ice-cutting a healthy business in the years before World War II. Crews of men cut the ice with hand-saws, and they stacked the large ice blocks onto horse-drawn sleds. Teamsters hauled the blocks to the ice houses of local clients or to the railroad depot for shipment to points south. Jim Ort reports that his family continued to use Black Oak Lake ice at the Mockesair Lodge ice house as late as 1960. The demand for ice dropped sharply during the 1950s, as more and more area residents purchased electric refrigerators. George St. Clair was one of the biggest ice buyers on Black Oak Lake. Many lake residents had ice houses, but most of those ice houses have been demolished. The log ice house associated with the Keefe house still stands and still retains its architectural integrity (Fig 30).



Figure 29. Ice cutters harvested the lake's ice beginning at least as early as 1910, and continued cutting ice until the late 1950s. This photo, shot around 1925, looks east from a spot near the central part of the north shore (Jim Ort).



Figure 30. Before WWII, there were dozens of ice houses around Black Oak Lake, but few survive today. This log cabin associated with the Keefe house allegedly served as an ice house (Paul McLeod).

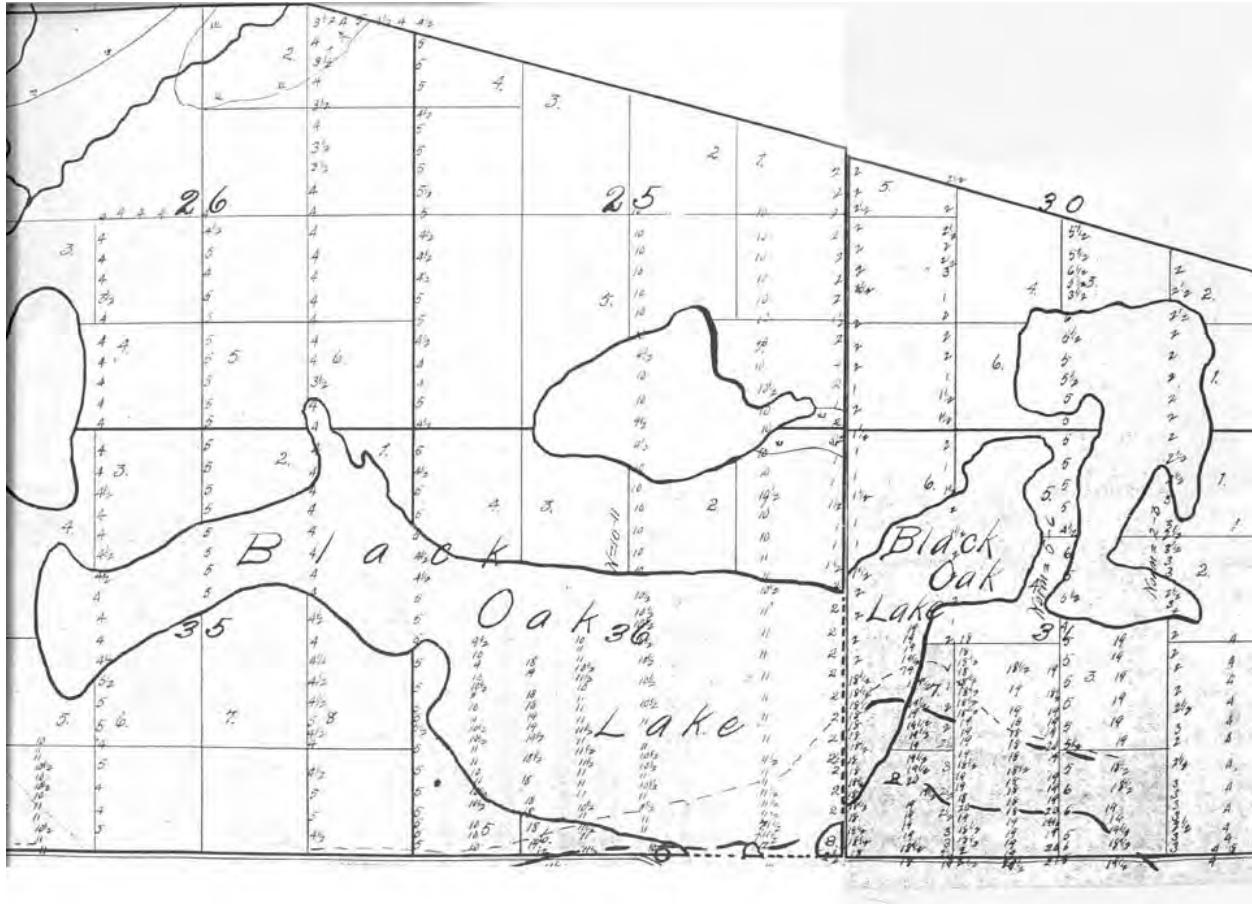


Figure 31. Frederick Carpenter commissioned a magnetic dip-needle survey of the Black Oak Lake area around 1911 in search of iron deposits (unpublished from the USGS office in Middleton, WI)

An entrepreneur named Frederick Carpenter undertook a mineral exploration survey in Vilas County during the years 1911-14, and his survey covered the Black Oak Lake area (Fig 31). Carpenter's surveyors made magnetic measurements every 100' along north-south trending lines spaced about 1000' apart. Anomalously high readings in the vicinity of George St. Clair's resort led Carpenter to close a deal with St. Clair which would allow Carpenter to open an iron mine on Black Oak Lake in exchange for a portion of the profits. It is doubtful that Carpenter ever drilled the St. Clair property, and the mine never advanced beyond the fantasy stage.

Around the same time that Carpenter was planning mineral exploitation on Black Oak Lake, Emil Wiese (1875-1950) began the earliest known environmental monitoring on the lake. By 1909, Wiese (who built the house currently owned by John and Delores Caruso) had begun to make observations on fish populations as well as recommendations to the state of Wisconsin on fish management. Wiese also began collecting "ice-out" data indicating the annual date that the ice melts on Black Oak Lake (Fig 32). His data collection began in 1909 and continues through to the present making this one of the longest-lived environmental data sets in northern Wisconsin. Wiese handed over the data-collecting duties to Joe Handlos (1891-1972) in 1922, who handed over the duties to Jim Lowenstine (1923-1996) in 1966. Walt Bates currently monitors the ice-out dates.

DATE ICE LEFT BLACK OAK LAKE					
MAY 10, 1909	↑	MAY 10, 1947	↑	APR 23, 1985	↑
APR 1, 1910	W	APR 23, 1948		APR 14, 1986	
APR 24, 1911	S	APR 23, 1949		APR 13, 1987	
APR 28, 1912	S	MAY 16, 1950		APR 19, 1988	W
APR 29, 1913	W	MAY 2, 1951		MAY 4, 1989	N
APR 26, 1914	-	APR 27, 1952		APR 22, 1990	-
APR 20, 1915	W	APR 29, 1953	S	APR 23, 1991	T
APR 27, 1916		APR 27, 1954	O	MAY 1, 1992	S
APR 30, 1917	L	APR 19, 1955	L	MAY 6, 1993	N
MAY 1, 1918	I	MAY 7, 1956	D	APR 24, 1994	W
APR 29, 1919	W	APR 23, 1957	N	APR 30, 1995	LOWEN
APR 30, 1920	W	APR 23, 1958	A	MAY 17, 1996	LOWEN
APR 26, 1921	↓	APR 26, 1959	I	MAY 4, 1997	↑ LOWEN
APR 23, 1922	↑	APR 24, 1960		APR 11, 1998	
APR 29, 1923		MAY 5, 1961		APR 14, 1999	
APR 24, 1924		APR 29, 1962		APR 16, 2000	
APR 28, 1925		APR 17, 1963		APR 23, 2001	
APR 29, 1926		APR 25, 1964		APR 23, 2002	
APR 26, 1927		MAY 3, 1965	↓	APR 27, 2003	
APR 20, 1928		MAY 5, 1966	↑	APR 25, 2004	
APR 28, 1929		APR 20, 1967		APR 17, 2005	
APR 28, 1930		APR 12, 1968		APR 17, 2006	BATES
APR 20, 1931	S	APR 22, 1969	W		
APR 24, 1932	LOS	APR 28, 1970	N		
APR 28, 1933		APR 28, 1971	I		
MAY 3, 1934	AND	MAY 10, 1972	T		
APR 27, 1935	N	APR 19, 1973	S		
MAY 7, 1936	A	APR 29, 1974	N		
MAY 4, 1937	H	MAY 5, 1975	N		
APR 15, 1938		APR 18, 1976	LOWEN		
MAY 3, 1939		APR 19, 1977	LOWEN		
MAY 6, 1940		MAY 3, 1978	L		
APR 17, 1941		MAY 9, 1979			
APR 22, 1942		APR 27, 1980	N		
MAY 4, 1943		APR 14, 1981	J		
APR 30, 1944		MAY 4, 1982	J		
MAR 27, 1945		MAY 4, 1983	↓		
APR 15, 1946	↓	APR 25, 1984	↓		

Figure 32. Emil Wiese was the first lake resident to begin recording ice-out data on Black Oak Lake in 1909. Wiese also made observations on fish populations in the lake (BOLROA).



Figure 33. By 1906 George St. Clair (the only man in the photo) had taken over Mary Mather's camp on Black Oak Lake, and he began successfully marketing his Black Oak Resort to out-of-state summer tourists. George's wife Nellie stands to the left of George. Photo ca. 1920 (LOLHS).



Figure 34. St. Clair's Black Oak Resort boasted a variety of lakefront cabins by the 1920s (Mark Siegworth).

There were two commercial resorts on Black Oak Lake. H.C. and Trudy Razell operated a small group of rental cabins on the southwest shore called the Pine Terrace cabins. The Razells lived at the cabins year round, and their guests commonly returned to the cabins year after year. The resort operated between the late 1930s and the early 1970s, and several of the cabins still stand on Grace and Maury White's property.

George St. Clair operated the more famous of the two resorts (Figs 33-36). His Black Oak Resort sat on 92 acres located on the southeast shore of Black Oak Lake. St. Clair began marketing his resort in 1906, and the collection of resort buildings grew through the years. Advertisements through time indicate that St. Clair's capacity for guests grew from 25 in 1910 to 40 in 1924 to 50 in 1941. St. Clair operated the resort until his death in 1964, but the resort remained in the family until 1974 and continued to operate through 1974. At the time the St. Clair family sold the resort, current owner Ed Hook recalls that there were 16 cabins in a wide variety of styles and materials including the main lodge, a caretakers residence, a tennis court, a minnow trough, and a three-car garage.

St. Clair, born in Faribault, MN in 1873, trained as a chef before opening his resort. A 1924 biography of St. Clair describes the facilities at the resort including an electric plant, a water plant, a refrigeration plant, an athletic field, a moving picture stadium, and a diving pavilion located 200' from the shore (Jones, McVean, et al., 1924). At that time, St. Clair offered 10 cabins and a main lodge (46' x 50') which boasted two dining rooms, a reception room, and an office (all on the first floor) and sleeping rooms on the second floor. The big weekly summer event was a Sunday evening bonfire and meal which commonly attracted 200 guests.

By the 1950s the resort had begun to decay, and its popularity had fallen-off, although it continued to attract summer visitors until the St. Clair family sold the resort. Today, a private house stands on the resort site (Barbara and Ed Hook), and only a few relics remain including remnants of the tennis court, the minnow trough, and the chimney from the old lodge which was incorporated into a contemporary house.

The public beach sits adjacent to and southwest of the site of the Black Oak Resort (Fig 37,38). That beach has been popular for many years with both swimmers and boaters. The beach is also the site of an annual New Year's tradition in which area residents "plunge" through the ice into the freezing waters of Black Oak Lake (Fig 39). Another longstanding tradition is the annual regatta parade on the Fourth of July where lake residents costume their boats along a particular theme and then motor around the lake (Fig 40).



Figure 35. St Clair's resort also thrived during the 1940s and remained in business into the 1960s (LOLHS).



Figure 36. Today, the spaces between the trees give an idea where St. Clair's cabins used to sit (Paul McLeod).



Figure 37. The bathing beach associated with the Black Oak Resort, ca. 1950s (LOLHS).



Figure 38. The bathing beach on Black Oak Lake continues to be popular, 2003 (Paul McLeod).



Figure 39. Annual “plunge” into Black Oak Lake at the public beach, January 1, 2004 (Paul McLeod).



Fig 40. Entrant in the annual Black Oak Lake regatta, July 4, 2003 (Paul McLeod).

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Appendix E

Fisheries Summary

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Black Oak Lake Fisheries Summary

Prepared by White Water Associates, Inc.

Black Oak Lake has a diverse fish community including walleye, largemouth bass, smallmouth bass, brown trout, lake trout, cisco, northern pike, bluegill, pumpkinseed, yellow perch, rock bass, white sucker, bluntnose minnow, and black bullhead. Like most lakes, the natural fish community has been augmented by stocking. Available stocking records (included in this Appendix) for Black Oak Lake extend back to 1951. Introduced fish species includes lake trout, brown trout, rainbow trout, brook trout, coho salmon, splake, walleye, largemouth bass, smallmouth bass, bluegills, yellow perch, and black crappie. Many of these species are not native to the lake. Walleye have been the most aggressively managed fish in Black Oak Lake. The primary recruitment source for this fish is from stocking and recent surveys indicate that there is a fairly high density of large adult fish. The high density of this piscivorous fish has a significant effect on other fish species in the lake, through both direct predation and through competition for food.

Black Oak Lake is one of two lakes in Wisconsin (nearby Trout Lake is the other) that harbors inland populations of self-sustaining lake trout (Piller *et al.* 2005)¹. These two populations represent the only two extant populations of lake trout indigenous to the Upper Mississippi River Basin. Genetic testing has shown the Black Oak Lake population to be genetically distinct from all others. Thus, the Black Oak Lake's population of lake trout represents an absolutely unique part of the world's biodiversity.

This genetic testing lake trout from Black Oak Lake (see Piller *et al.* 2005) indicates that the strain has remained pure in spite of continued introduction of non-native lake trout strains. The management implications of these findings are significant. The genetically distinct population of lake trout in Black Oak Lake should be given a high level of protection (Piller *et al.* 2005) and a strong effort should be undertaken to guard against additional human-caused impacts (over-fishing, habitat loss, and genetic degradation by way of lake trout stocking).

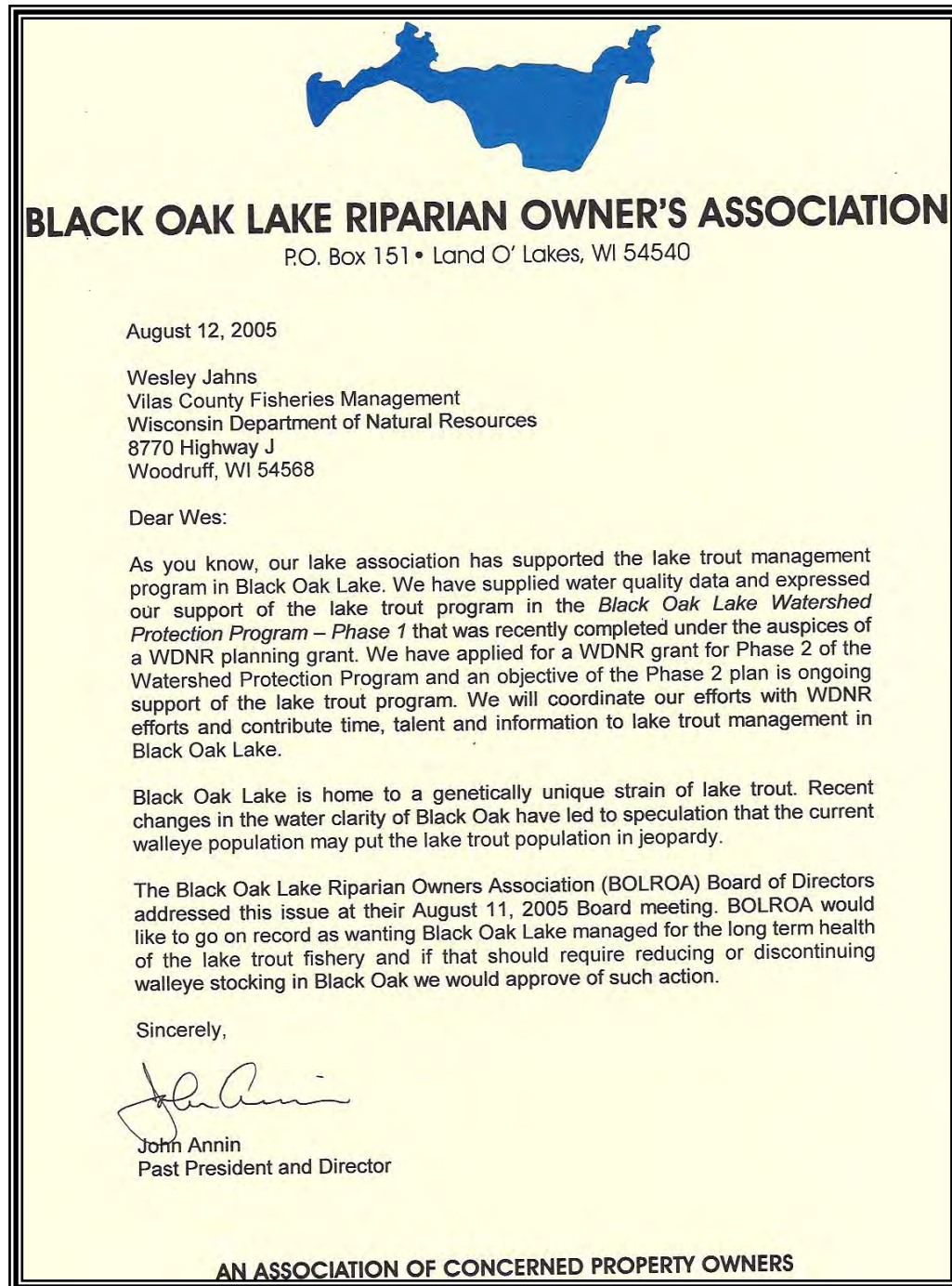
In an effort to safeguard the unique lake trout of Black Oak Lake the WDNR netted fish in the fall of 2005 and collected gametes (eggs and milt) prior to releasing the fish. The eggs were fertilized and raised to fry in the hatchery. Fry were then planted in Big Carr Lake (Oneida County), Long Lake (Vilas County), and Lucerne Lake (Forest County).

Black Oak Lake's lake trout population has received management attention through management effort directed specifically at Black Oak Lake and through statewide lake trout management planning. Population estimates for lake trout in Black Oak Lake are uncertain (estimates put the population at under 1,000 individuals). Recaptured marked individuals demonstrated very slow growth rates. There is some concern by the WDNR that the increasing walleye populations (especially those fish over 20 inches) will significantly compete with lake trout for forage (primarily ciscos) and will directly consume juvenile lake trout. A 2003 Fisheries Rule Development Proposal called for an increased size limit on lake trout in Black Oak Lake in order to protect a greater proportion of the population from harvest. The 2002 Lake Trout Management Report for Black Oak Lake (included in this appendix) states that, "Preservation of this unique lake trout resource should be the top management priority for Black Oak

¹ Available via the world-wide-web at: http://www.selu.edu/Academics/Faculty/kpiller/pdfs/Piller_et_al_2005.pdf

Lake. Walleye stocking may need to be re-evaluated should the lake trout population begin to decline.”

The Preservation Foundation has been keenly interested in lake trout management on Black Oak Lake. The organization articulated its position in a letter (8/12/05) to Wes Jahns (WDNR Fisheries). The letter was reviewed at the August 11, 2005 meeting of the Preservation Foundation Board of Directors the Board voted 10-0 to support this position. It is reprinted below.



As of late fall 2006, e-mail correspondence of WDNR Fish Biologist Stephen Gilbert stated the goal of needing to balance the lake trout and walleye fisheries with the available forage (ciscoes) in Black Oak Lake. He stated that the best way to do this is with fishing regulations and controlling walleye stocking. The WDNR goal is to maintain the Lake Trout adult numbers at 0.5 or better per acre and keep the adult walleye numbers more in the 1.5 per acre range. By this approach, the WDNR hopes to maintain the trout fishery, provide a trophy walleye fishery, and keep the cisco population healthy. WDNR and Great Lakes Indian Fish & Wildlife Commission conduct periodic surveys to monitor walleye. This monitoring helps the WDNR determine status of the fishery and decide walleye stocking levels and/or regulations.

COUNTY: VILAS | WATERBODY NAME: BLACK OAK L | REPORT CREATED: APR 12, 2004 - 09:00 AM

	YEAR	SPECIES	STRAIN	AGE CLASS	AVG LENGTH (INCHES)	NUMBER FISH STOCKED	LEGAL DESC & LOCAL
1	1972	LAKE TROUT	UNSPECIFIED	YEARLING	5.0	17,120	T33N R9E S35 -
2	1973	LAKE TROUT	UNSPECIFIED	YEARLING	5.0	25,349	T33N R9E S35 -
3	1974	LAKE TROUT	UNSPECIFIED	YEARLING	7.0	12,500	T33N R9E S35 -
4	1977	LAKE TROUT	UNSPECIFIED	FINGERLING	3.0	70,000	T33N R9E S35 -
5	1978	LAKE TROUT	UNSPECIFIED	FINGERLING	2.0	80,000	T33N R9E S35 -
6	1979	LAKE TROUT	UNSPECIFIED	FINGERLING	4.0	25,000	T33N R9E S35 -
7	1980	LAKE TROUT	UNSPECIFIED	FINGERLING	4.0	15,000	T33N R9E S35 -
8	1980	WALLEYE	UNSPECIFIED	FINGERLING	2.0	29,550	T33N R9E S35 -
9	1981	WALLEYE	UNSPECIFIED	FINGERLING	2.0	15,500	T33N R9E S35 -
10	1981	WALLEYE	UNSPECIFIED	FINGERLING	3.0	16,500	T33N R9E S35 -
11	1982	WALLEYE	UNSPECIFIED	FINGERLING	1.0	30,876	T33N R9E S35 -
12	1984	WALLEYE	UNSPECIFIED	FINGERLING	2.0	27,990	T33N R9E S35 -
13	1986	WALLEYE	UNSPECIFIED	FINGERLING	2.0	28,000	T33N R9E S35 -
14	1987	WALLEYE	UNSPECIFIED	FINGERLING	2.0	75,000	T33N R9E S35 -
15	1988	BROWN TROUT	UNSPECIFIED	ADULT	15.0	164	T33N R9E S35 -
16	1988	WALLEYE	UNSPECIFIED	FINGERLING	2.0	25,000	T33N R9E S35 -
17	1989	BROWN TROUT	UNSPECIFIED	YEARLING	9.0	3,200	T33N R9E S35 -
18	1989	WALLEYE	UNSPECIFIED	FINGERLING	3.0	12,054	T33N R9E S35 -
19	1989	WALLEYE	UNSPECIFIED	FINGERLING	6.0	1,826	T33N R9E S35 -
20	1989	WALLEYE	UNSPECIFIED	FINGERLING	7.0	583	T33N R9E S35 -
21	1989	WALLEYE	UNSPECIFIED	FINGERLING	8.0	765	T33N R9E S35 -
22	1990	BROWN TROUT	UNSPECIFIED	FINGERLING	6.0	7,550	T33N R9E S35 -
23	1990	BROWN TROUT	UNSPECIFIED	FINGERLING	5.0	2,450	T33N R9E S35 -
24	1990	LARGEMOUTH BASS	UNSPECIFIED	FINGERLING	3.0	2,230	T33N R9E S35 -
25	1990	WALLEYE	UNSPECIFIED	FINGERLING	7.0	2,505	T33N R9E S35 -
26	1991	BROWN TROUT	UNSPECIFIED	FINGERLING	6.0	10,000	T33N R9E S35 -
27	1991	WALLEYE	UNSPECIFIED	FINGERLING	5.0	5,400	T33N R9E S35 -
28	1992	BROWN TROUT	UNSPECIFIED	FINGERLING	6.0	10,000	T33N R9E S35 -
29	1992	WALLEYE	UNSPECIFIED	FINGERLING	4.0	5,500	T33N R9E S35 -

30	1993	BROWN TROUT	UNSPECIFIED	FINGERLING	6.0	10,000	T33N R9E S35 -
31	1994	BROWN TROUT	UNSPECIFIED	FINGERLING	6.4	10,000	T33N R9E S35 -
32	1994	WALLEYE	UNSPECIFIED	FINGERLING	3.0	14,700	T33N R9E S35 -
33	1995	BROWN TROUT	UNSPECIFIED	FINGERLING	5.8	11,900	T33N R9E S35 -
34	1995	WALLEYE	UNSPECIFIED	FINGERLING	2.8	14,664	T33N R9E S35 -
35	1997	WALLEYE	UNSPECIFIED	LARGE FINGERLING	2.5	716	T33N R9E S35 -
36	1998	BROWN TROUT	ST. CROIX	LARGE FINGERLING	6.2	10,000	T33N R9E S35 -
37	1998	BROWN TROUT	ST. CROIX	YEARLING	7.5	2,400	T33N R9E S35 -
38	1998	BROWN TROUT	ST. CROIX	YEARLING	9.0	2,500	T33N R9E S35 -
39	1998	WALLEYE	UNSPECIFIED	SMALL FINGERLING	1.5	58,000	T33N R9E S35 -
40	2000	BROWN TROUT	ST. CROIX	LARGE FINGERLING	5.9	10,000	T33N R9E S35 -
41	2000	WALLEYE	LAC COURTE OREILLES	SMALL FINGERLING	1.7	29,200	T33N R9E S35 -
42	2002	WALLEYE	MISSISSIPPI HEADWATERS	SMALL FINGERLING	1.5	430	T33N R9E S35 -

PLANTING RECORD

Year	Species	Size	Number
1937	Crappie	Adult	1,500
	Lake Trout	Fry	144,960
1938	Lake Trout	Fry	150,000
	Walleyed Pike	Fry	633,070
1939	W.E. Pike	Fry	600,000
	Perch		
	Lake Trout		150,000
1940	L.M. Bass	Fry	5,000
	W.e. pike	Fry	500,000
1940	Lake Trout	#2 Fry	2,500
1940	L.M. Bass	Fry	5,000
1941	Lake Trout	Any	126,000
1942	Lake Trout	Fry	100,000
1940	Lake Trout	Fry	2,500
1940	Lake Trout	Fry	122,500
1944	S.M. Bass	Fry	8,625
1946	Lake Trout	Fry	240,000
	5 m Bass	5 m Fry	50 F

A

50

Wisconsin Conservation Department

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72. 5

Year	Species	Size	Number
1933	LAKE TROUT	FRY	182,000
1933	WALLEYED PIKE	FRY	515,750
1933	BLACK BASS	FGLS.	79
1934	LAKE TROUT		50,000
1935	WALLEYED PIKE	FRY	130,320
1935	BLACK BASS	FGLS.	1,200
1935	LAKE TROUT	FRY	228,330
1935	BLUEGILLS, BASS, PERCH	YRLS.	850
1935	BASS	ADULT	9
1936	PERCH	YRLS.	360
1936	BLUEGILLS	YRLS.	120
1936	BASS	ADULT	90
1937	CRAPPIE	ADULT	1,500
1937	LAKE TROUT	FRY	134,960
1938	LAKE TROUT	FGLS.	150,000
1938	WALLEYED PIKE	FRY	633,070
1939	LAKE TROUT	FRY	126,000
1939	LARGE MOUTH BLACK BASS	FRY	5,000
1939	WALLEYED PIKE	FRY	600,000
1940	LAKE TROUT	FGLS.	5,000
1940	LAKE TROUT	FRY	122,500
1940	LARGE MOUTH BLACK BASS	FRY	5,000
1940	WALLEYED PIKE	FRY	500,000

Wisconsin Conservation Department

Form F1-36

Landing _____
Cooperator _____
Address _____ Tel. _____
Boats _____ Motor _____
Other resorts (name) _____
Housekeeping cabin groups (name) _____
MOST ALL SUMMER PEOPLE
Remarks: _____

N

W



22

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PLANTING RECORD

[illegible]

Wisconsin Conservation Department

Form F1-85

Landing -----
Cooperator -----
Address ----- Tel. -----
Boats ----- Motor -----
Other resorts (name) -----

Housekeeping cabin groups (name) -----

Remarks: -----

N

W

ss

(This space for mapping by field personnel)

Subj: **Black Oak Lake**
 Date: 12/16/2004 10:27:43 AM Central Standard Time
 From: Wesley.Jahns@dnr.state.wi.us
 To: jonin3027@AOL.com, stu@nnex.net
 Sent from the Internet (Details)

Here are the totals from this falls lake trout sampling. The chart below is the population estimate. This is **not a valid estimate**, but right now its all we have. This estimate was calculated using the marked fish from 2001 and 2002, with 10% annual tag loss figured in as the total marks at large. This time delay(2001-2004), and the fact that both samples were obtained during spawning season with gill nets combine to make the estimate invalid. We hope to get a statistically valid estimate by doing an angling recapture this winter. I can use the 103 marked fish from this falls gillnetting as the total marks at large, and then the total number caught angling in comparison to the number of tagged(recaptured) trout from the angling sample. The number of total trout caught and the number of recaptured fish will determine the accuracy of the estimate. As I said before, the good news is that all indications lead us to believe there are more lake trout than we originally thought.

N= The estimated number of adult lake trout-1080

C.V. is coefficient of variance (32% or less is the cut-off for an acceptable estimate)

95%CI=Confidence Interval (95 out of 100 times the estimate will fall within the range of the upper limit and lower limit(356-1804). As the estimate gets better, the C.V. gets lower, and the spread of the 95%C.I. gets smaller also.

As always, if you have any questions please contact me. Happy Holidays.

Black Oak Lake 2004 Adult PE-2001-2002-2004 gillnet			
M	69	N	1,080
C	107	VAR	136,350
R	6	C.V. (%)	34
		SD	369
M=2001 marks +2002marks		95% CI	724
C= 2004 gillnet sample		Upper Limit	1,804
R=2001&2002 gillnet marks		Lower Limit	356

Notice only three mortalities this year with a significant increase in total number captured.

Total captured=106
 Mortalities = 3
 Total marked = 103
 Min. LT= 20.1 Inches
 Max.LT= 33.7 Inches
 No. Males= 72
 No. Females = 31
 2002 Recaps= 4
 2001 Recaps= 2
 Avg. Lt. = 24.2
 Avg.Lt.Females=24.7
 Avg. Lt.Males = 23.9

Subj: lake trout
Date: 10/27/2004 12:33:57 PM Central Standard Time
From: Wesley.Jahns@dnr.state.wi.us (Jahns, Wesley O)
To: jonin3027@AOL.com (John Annin), stu@nnex.net (Stu Hunt)

Here is a quick summary from our netting on Monday, Oct. 25.

Total trout caught=71—minus two mortalities= a total of 69
Number recaptured with a previous tag=4
Smallest trout 20.1 inches
Largest Trout - 32.6 inches
Number =or > 26 inches = 13

Walleye=2
No other species captured.

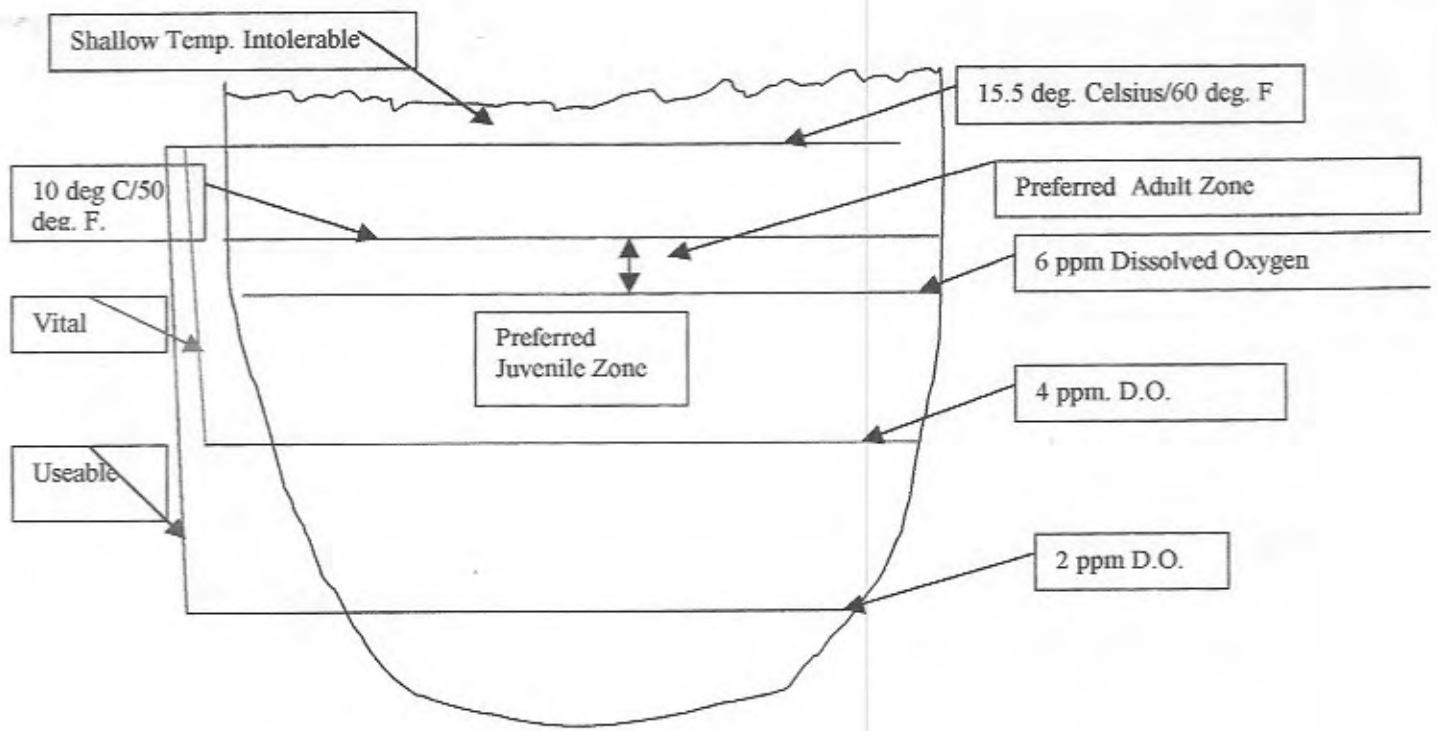
The overall population looks good based on the number of trout caught vs the number of recaptures. We also got more fish over 26 inches in this sample which is good. My major concern now is the lack of fish under 20 inches. As I think you know our plans are to monitor the population every five years at which time we will repeat the sampling with the possibility for taking eggs if needed.

We only got 2qts./ 8 oz of eggs with a target of 4 quarts. We are holding about another 15 females and will hold them until Monday if needed.

It will most likely be at least two weeks before I take a closer look at the data. At that time I will send you an update.

----- Headers -----

Return-Path: <Wesley.Jahns@dnr.state.wi.us>
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Subject: lake trout
Date: Wed, 27 Oct 2004 13:33:37 -0500
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X-MS-TNEF-Correlator:
Thread-Topic: lake trout
Thread-Index: AcS8U3k0A7lk9pq8TvmmtEhSGq7a8g==
From: "Jahns, Wesley O" <Wesley.Jahns@dnr.state.wi.us>
To: "John Annin" <jonin3027@AOL.com>, "Stu Hunt" <stu@nnex.net>
X-AOL-IP: 168.236.1.96
X-AOL-SCOLL-SCORE: 0:0:0
X-AOL-SCOLL-URL_COUNT: 0



Subj: RE: Lake Trout
Date: 10/21/2004 10:42:12 AM Central Standard Time
From: Wesley.Jahns@dnr.state.wi.us (Jahns, Wesley O)
To: jonin3027@AOL.com (John Annin), stu@nnex.net (Stu Hunt)

One other note of interest. We only caught two trout with tags from previous years. One from 2001, and one from 2002. Although its too small of a sample to get a good population estimate it does indicate that our previous estimate most likely erred on the low side, which would be consistent with what we found on Trout Lake. The 2002 estimate on Black Oak ranged from 102-449, with the actual number estimated at 275. The good news is that the actual population would be closer to the 275 estimated in 2002 than it would be to the lower limit of 102.

> —Original Message—

> From: Jahns, Wesley O
> Sent: Thursday, October 21, 2004 11:30 AM
> To: 'John Annin'; 'Stu Hunt'
> Subject: Lake Trout

>
> Things went quite well last night as we caught 37 lake trout, and 13 of them were females. Unfortunately we did not get any eggs. The largest female, 33.7 inches was spent, and all the other females were hard. We intend to hold the fish in the hatchery until Monday and try again to take eggs. I don't think we will be netting again next week, even if we don't get the eggs we need, but I need to discuss that with some other people who will not be available until Monday. Besides the 33 incher we only had one other trout over 26 inches(26.3), and the smallest trout was 20.1 inches. This suggest two things: 1: Not much for recruitment of juvenile trout, and although its a small sample it is still low compared to previous catches. 2: It looks like angling harvest has increased. I will need to analyze the numbers more closely but from memory I think we had more fish over 26 inches in the past. We see this type of length frequency structure in bass populations quite often. When it was a 12 inch limit the number of bass over 12 inches dropped right off, and now that its a 14 inch limit they start to disappear at 13.5 inches.

>
> Total catch:
> Lake Trout=37
> Walleye=6
> Smallmouth=2

> Stu—No cisco's, not a single one.

> Hopefully we will get the eggs we need on Monday. Either way we plan to return the lake trout to the lake on Monday.

----- Headers -----

Return-Path: <Wesley.Jahns@dnr.state.wi.us>
Received: from rly-xb03.mx.aol.com (rly-xb03.mail.aol.com [172.20.64.135]) by air-xb01.mail.aol.com (v101_r1.6) with ESMTP id MAILINXB13-9b4177e6d92d0; Thu, 21 Oct 2004 12:42:12 -0400
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boundary="=_NextPart_001_01C4B78C.E397EFC8"
Subject: RE: Lake Trout
Date: Thu, 21 Oct 2004 11:42:01 -0500
Message-ID: <FE5741C56FE6C341813CF472E0DAB69E05BF8B3C@prodml01.DNR.state.wi.us>
X-MS-Has-Attach:
X-MS-TNEF-Correlator:
Thread-Topic: Lake Trout

Subj: Lake Trout
Date: 5/24/2004 1:27:40 PM Central Daylight Time
From: Wesley.Jahns@dnr.state.wi.us (Jahns, Wesley O)
To: jonin3027@AOL.com (Jon Annin)

File: LT.HabitatZones.doc (22528 bytes)
DL Time (32000 bps): < 1 minute

Jon—We have looked further in our files and do not have a record of the 1999 stocking. Any more information you can get regarding this stock would be greatly appreciated as it could directly effect the conclusions of the walleye stocking survival research project. Do you have a copy of the stocking receipt from the private hatchery, or a copy of the permit issued by the Department?

Here are the temp. oxygen parameters for lake trout and the various habitat zones. See graphic in Attachment for visual depiction.

Adult Lake Trout during summer stratification:

Preferred zone: The volume of the lake that is 10 deg. C., (50 deg. F) or less and has an oxygen concentration of 6 ppm. or more.

Useable habitat: The volume of the lake in which the temperature is either 15.5C, 60 deg. F, or less and the oxygen concentration is 4 ppm or more.

Tolerable: This zone extends down to the depth at which the D.O. level is 2 ppm.

Juvenile Lake Trout: Juvenile lake trout are further restricted within these zones to areas containing 6 ppm oxygen or less by the adults which seek out D.O. values of 6 ppm and higher.

What I would recommend for long term monitoring of the various habitat zones would be annual temperature/oxygen profiles conducted during late summer and taken over the deepest part of the lake. The samples should be taken at approximately the same time and date each year. Maximum thermal stratification will vary somewhat from year to year depending upon ambient air temperatures but will typically occur in late August or early September. Two separate sampling dates approximately two weeks apart will be sufficient. Say perhaps August 25 and September 8. The dates are somewhat arbitrary but I would not go much later than Sept. 8.

Temperature parameters: The most important temperature value is the 15.5 deg. C which delineates the upper boundary in the water column. Determining the water depth at which this temperature occurs will define the upper boundary of useable habitat. The next important temperature value is 10 deg. C which defines the upper limit of the preferred zone for adults.

Dissolved Oxygen parameters: There are three values that need to be determined: 6ppm, 4ppm, and 2ppm. The 6ppm oxygen reading will overlap with the 10 deg.C (or less) reading to determine the preferred zone of adults. The lower depth limit at which 4ppm oxygen occurs will determine the lower limit of the preferred zone for juveniles. The 2ppm oxygen reading will determine the lower limit of the tolerable zone.

Long term temperature/oxygen monitoring should prove valuable in assessing changes in the useable and preferred habitat zones for lake trout. If you have any further questions concerning lake trout management feel free to contact me.

<<LT.Habitat Zones.doc>>

CORRESPONDENCE/MEMORANDUM

State of Wisconsin

DATE: 4/16/2004

FILE REF: [Click here and type file ref.]

TO: Black Oak Lake File

FROM: ^{WJ}Wes Jahns

SUBJECT: Stocking of Black Oak strain lake trout.

Recent genetic testing has shown that the Black Oak lake trout population is unique to the Upper Mississippi River Basin, and may constitute the only pure-ancestry remnants of the Pleistocene Mississippian refugial race of lake trout. Current lake trout management plans call for gill net sampling in two consecutive years on a five-year rotation beginning in 2004.

Goals are to monitor long term population structure, longevity and growth of marked fish, and natural reproduction. Objectives of the plan are to maintain natural reproduction and to introduce the Black Oak strain of lake trout into candidate lakes in hopes of establishing secondary populations of this unique strain. The following is a list of candidate lakes in order of priority as decided upon by the respective County Biologists, the Fisheries Supervisor, and Wes Jahns.

- 1: Big Carr, Oneida County
- 2: Long, Vilas County
- 2: Lucerne, Forest County
- 4: Keyes, Florence County
- 5: Lac Du Lune, Vilas County

Long Lake and Lake Lucerne were ranked evenly at this time but will be re-evaluated following the completion of temperature oxygen profiles in late summer, 2004.

2003 WDNR Fisheries Rule Development Proposal

Title: Lake Trout Regulation Change- 30-inch minimum size limit, one fish bag limit

Location: Black Oak Lake, Vilas County

Author: Wes Jahns, Fisheries Technician— Vilas County

Statement of Problem:

Black Oak Lake is one of two lakes in the state of Wisconsin with a native lake trout population, and is the only lake sustained entirely by natural reproduction. Recent genetic testing has shown that these trout are genetically unique to Black Oak Lake. Historical data concerning the lake trout population is limited, consisting of periodic gill net sampling yielding catch per effort values. In 2002 a mark/recapture population estimate was calculated using the 2001 catch as the marks, and 2002 for the recapture sample. The adult lake trout population estimate was 275, or 0.5/acre. The lower limit of the 95% confidence interval is 102 adults, or 0.2/acre (Table 1).

There is no historical population density data available for inland lake trout populations in Wisconsin, and very little information was found in the scientific literature regarding population densities for lakes in North America. Personal communication with biologists from Ontario, Canada would suggest the Black Oak Lake density of 0.5 adult lake trout per acre is currently at, or slightly below the average of Ontario lakes. Very little age-growth data is available, but lake trout populations in general are characterized as slow growing, long lived (up to 40 years in Trout Lake), with low juvenile recruitment. If the lower limit estimate of 102 adults is accurate, any increased pressure on the population, either by angling, or inter-species competition could be devastating.

Lake trout populations in Ontario Canada have demonstrated an inverse relationship with walleye populations (Evans et al. 1991: Anthropogenic stressors and diagnosis of their effects on lake trout populations in Ontario lakes. Lake Trout Synthesis, Ontario Ministry of Natural Resources, Toronto.). As a result of several successful walleye plants, a major change in the fish community structure has resulted in a trophy walleye fishery. A 1999 survey of the adult walleye population revealed that 71% (1,405 fish) of the population was greater than 20 inches in length (see table 2). The trophy walleye fishery has generated increased angler interest in Black Oak Lake. Increased angler interest for walleye may result in higher incidental lake trout harvest. That as well as possible interspecific competition with walleye has raised concern for the future of this unique fishery.

Recommended Solution:

The current regulation is a 26- inch minimum size limit and daily bag limit of one fish. That regulation protects about 75% of the adult stock. It is recommended that the size limit be increased to 30 inches, with the daily bag limit of one lake trout remaining unchanged. A 30 inch size limit will protect approximately 90% of the population (Table 3). This would effectively eliminate angling harvest on this small population. This will

also provide uniformity with the lake trout regulation in nearby Trout Lake and protect mature fish for many years while providing a trophy fishery.

An alternative regulation would be to close the lake trout fishery entirely. This would be more difficult from an enforcement standpoint and would eliminate the opportunity for fishermen to keep a rare trophy.

A third alternative would be to keep the regulation the same and supplement the natural population through stocking if numbers begin to decline. The consequences of this action would put additional stress on the hatchery system to produce yearling lake trout, and stocking on top of natural reproduction has been shown to be detrimental to, and could actually eliminate recruitment of naturally produced juveniles.

Impact Analysis:

The Black Oak Lake association is in favor of the change and has submitted a letter stating such. Current lake trout harvest is unknown, but believed to be relatively low. This regulation change should not result in a substantial reduction to current lake trout harvest, nor seriously impact local guides or businesses.

The local Conservation Warden was consulted regarding enforcement of the proposed regulation and stated there would be no enforcement problems related to this regulation.

Lake trout management is guided by the Upper Wisconsin Basin Inland Lake Trout Management Plan. Recent sampling information revealed a self-sustaining population that is genetically unique to Black Oak Lake. This information resulted in the submittal and approval of a management project written for Trout Lake and Black Oak Lake for the 2003-2005 fiscal year. Current plans for Black Oak Lake are to monitor population density, size structure, and growth of lake trout over two consecutive years. This monitoring would be repeated on a five-year rotation.

Walleye density will also be monitored in conjunction with the size structure of the lake trout population. The walleye population is primarily stocked fish. While popular and providing a true trophy opportunity, if surveys indicate a decline in the lake trout population, walleye stocking may need to be reduced or eliminated.

Consequences of No Action:

There is a possibility that increased harvest rates, competition with walleye, and low recruitment may result in the loss of this genetically unique fishery. Walleye stocking will need to be evaluated in this light. For the immediate future, angling harvest should be largely eliminated on this unique fishery. Failure to pass the proposed regulation will not accomplish that goal.

Draft Question:

Black Oak Lake Walleye Regulation – Increase the minimum length limit from 26 inches to 30 inches with the daily bag limit of one remaining unchanged.

This genetically unique population is the only naturally sustaining lake trout population in the state of Wisconsin. Recent increases in angling pressure combined with potential competition from the trophy walleye population may threaten the survival of this unique fishery. Raising the legal size limit from 26 inches to 30 inches will protect a majority of the population while providing a trophy fishery.

Do you favor increasing the minimum length limit from 26 inches to 30 inches and maintaining a daily bag limit of one lake trout on Black Oak Lake, Vilas County?

Approvals:

Fisheries Team Leader: _____ Date: _____

Law Enforcement Sup. _____ Date: _____

Regional Fisheries Expert: _____ Date: _____

Regional Director: _____ Date: _____

LAKE TROUT 2002

Subj: Lake Trout
Date: 11/27/2002 12:07:05 PM Central Standard Time
From: Wesley Jahns@dnr.state.wi.us (Jahns, Wesley O)
To: jonin3027@AOL.com (Jon Annin), stu@nnex.net ('Stu Hunt')

Just a quick summary of the totals from the gill netting for this year as compared to last.

	2001	2002
Total Trout	54	40
Avg. Length	23.9	23.7
Min. Length	18.2	15.0
Max. Length	33.8	30.5

Of the 40 trout captured this fall, six contained tags from the 2001 sampling. This yields an adult population estimate of 275 lake trout. Statistically we can determine the accuracy of these estimates. The accuracy is dependent upon the total number of fish marked in year one, the number of fish captured in year two, and the number of recaptures in the year two sample that were marked(tagged) in year one.

For this particular estimate we can say with 95% certainty that the actual population lies somewhere between a low of 102, to a high of 449. Other factors that contribute to the variability of the estimate are tag loss and mortality of fish from year one to year two. With walleye we have the ability to mark and recapture within the same year and eliminate some of the variability allowing for much more accurate estimates. However, due to behavioral factors of lake trout and the relative inaccessibility to sampling we are somewhat limited. This is another reason why we need to monitor the population over a long period of time to more accurately assess its status.

Assuming there are a total of 275 adult lake trout in the lake, and take into consideration that some of these fish may be 30 or 40 years old, it is clear that the population cannot withstand any significant harvest on an annual basis. To further illustrate the point, lets assume the maximum age is 30. If we divide 275 by 30 we get nine, meaning that it would only take nine juvenile trout per year recruiting into the adult population to sustain the 275 total over time. Again, this is without factoring in natural and angling mortality, but I think it shows just how vulnerable a slow growing, low density fishery is.

A total population of 275 calculates out to 0.5 trout per acre. I know you want to ask how this compares to other lakes but unfortunately I can not give you a specific answer. There is just not much information of this type available in the literature due to the problems associated with compiling accurate lake trout estimates. The only other lake in our area that we could possibly compare it to is Trout Lake which appears to be somewhere between 0.4 and 0.6 adults per acre.

I think the lower number of fish captured this year as compared to last is merely the coincidence of getting the net in exactly the right place at the right time. Our current plans are to monitor this fishery every five years to make sure that natural reproduction continues to maintain the population, and to continue to accumulate data on length, sex, longevity, growth, and density. I had expected the results of the genetics testing would be

available by now but I have still not received word regarding the findings. As for growth rates I only have the six recaptures from last year to determine growth during that time span. One of these fish grew from 18.4 inches in 2001 to 19.3 inches in 2002, but four of the other fish only grew one or two tenths of an inch and the sixth fish was shorter in 2002 due to measuring error dealing with live fish. This is much too small of a sample to draw conclusions but it appears that growth rates are going to be very slow, which is similar to observations from Trout Lake.

If you have any further questions feel free to contact me, and hope you have a happy Thanksgiving.

Wes.

----- Headers -----

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From: "Jahns, Wesley O" <Wesley.Jahns@dnr.state.wi.us>
To: 'Jon Annin' <jonin3027@AOL.com>, 'Stu Hunt' <stu@nnex.net>
Subject: Lake Trout
Date: Wed, 27 Nov 2002 12:06:11 -0600
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Subj: Re: Lake Trout
Date: 11/29/2002
To: Wesley.Jahns@dnr.state.wi.us

Hi Wes

Thanks for the lake trout report, very interesting.

I am surprised how small the population is. Does this mean you will close the open season on lake trout in Black Oak in order to protect the population? It would be a shame to lose them.

Please forward the genetic data when you receive it. I would like to see that also.

Best regards, John Annin

Subj: **Lakers**
Date: 12/3/2002 11:00:14 AM Central Standard Time
From: Wesley.Jahns@dnr.state.wi.us (Jahns, Wesley O)
To: jonin3027@AOL.com ('Jon Annin'), stu@nnex.net ('Stu Hunt')

In regards to your concerns about closing all lake trout fishing I do not think we have enough evidence at this point in time to support that. I do however share your concerns about protecting this unique fishery. Although we do not have a lot of information regarding lake trout densities I believe that if the current estimate of 0.5 adults per acre is accurate, that is reflective of what the realistic potential is for the lake to sustain. I want to stress that we cannot simply decide to increase the number of lake trout because the lake itself sets the limit on the number of fish it can support. With the increase in the walleye population, particularly the relatively high density of walleyes over 20 inches, there is an increased demand on the forage base, ie, ciscoes.

Like you I am concerned about possible increases in harvest due to increased angling pressure. Rather than close the fishery at this time I would favor increasing the size limit to 30 inches. The previous three years netting yielded a total of 132 lakers of which nine(7%) were equal to or greater than 30 inches. Legal harvest of lake trout this size would not be detrimental to the population and would provide the opportunity to harvest a trophy. This would also standardize regulations between Trout Lake and Black Oak.

Having stated the above, I will also say that angling pressure could be a real wild card. If in fact angling pressure does increase, hooking mortality and illegal harvest of fish under the size limit are sure to follow. In a worst case scenario if the actual population of adults is closer to 102 rather than 275, angling mortality could pose a realistic threat to the fishery.

In the near future I will discuss these issues with the Vilas County fisheries manager(Steve Gilbert) who has the authority to propose a regulation change. I will keep you informed and as always if you have further questions feel free to contact me.

Stu—if you stop here on Thursday I am upstairs in the old cement block building across the road from the service center off Hwy J. The road is just to the West of the Service Center and goes South toward the hatchery. Take the first right into the parking lot. Use the small door in the center of the building and I am office #3 upstairs.

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From: "Jahns, Wesley O" <Wesley.Jahns@dnr.state.wi.us>
To: 'Jon Annin' <jonin3027@AOL.com>, 'Stu Hunt' <stu@nnex.net>
Subject: Lakers

Subj: genetics
Date: 12/6/2002 11:38:02 AM Central Standard Time
From: Wesley.Jahns@dnr.state.wi.us (Jahns, Wesley O)
To: jonin3027@AOL.com (Jon Annin); stu@nnex.net (Stu Hunt)

I heard back from the geneticist who said he was just about to email me. Not sure when he finished the work but I wish he would have responded sooner. The manuscript will take some time to complete but the bottom line is that both Trout Lake and Black Oak Lake were determined to be pure strains and are very different from each other.

What this means is that we obviously will manage these fisheries to maintain the unique strain and will not stock fish of a different gentic make-up. Budget wise I'm sure you know things are going to be really tight the next couple years but I am going to push to attempt to have a creel census done on the lake in either 2003, or more likely 2004. This will give us an idea on angler harvest and hopefully the ability to determine the effects of angler harvest on the laker population.

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From: "Jahns, Wesley O" <Wesley.Jahns@dnr.state.wi.us>
To: 'Jon Annin' <jonin3027@AOL.com>, 'Stu Hunt' <stu@nnex.net>
Subject: genetics
Date: Fri, 6 Dec 2002 11:38:02 -0600
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Black Oak Lake 2002 Lake Trout Management Report

Introduction:

Black Oak Lake is a 584 acre drainage lake of moderate fertility with a maximum depth of 85 feet. It has slightly alkaline, clear water of high transparency. The diverse fish community includes lake trout, cisco, walleye, northern pike, smallmouth bass, largemouth bass, bluegill, pumpkinseed, and rock bass. Coho salmon, rainbow trout, brook trout, and splake were stocked at various times between 1953 and 1970 with little or no success. Brown trout stocking also occurred as recently as October 2000 with limited success and has subsequently been discontinued.

The walleye population has historically been low density, with minimal, sporadic natural reproduction. Extended growth walleye averaging seven to eight inches long and marked with fin clips were stocked in 1989 and 1990 and assessed for survival. Stocked walleye contributed significantly to the fishery resulting in a 1999 adult population estimate of 3.4/acre. Of even greater significance is a density of 2.4 walleyes per acre over 20 inches long. Fisheries community dynamics are essential for managing lake trout populations. Studies conducted on lake trout lakes in Ontario have shown walleye populations to be detrimental to the sustenance of lake trout populations (David O. Evans, Ontario MNR, personal communication).

Previous lake trout investigations in Black Oak Lake have consisted of periodic gill net sampling to assess stocking, or to determine the status of the population based on catch per effort values. Fall fingerling lake trout of Lake Superior origin have been stocked as recently as 1980 to supplement the naturally reproducing population. Upon approval of the Upper Wisconsin Basin Inland Lake Trout Management Plan (UWBILTMP) in 2000, Black Oak Lake was identified for more intensive study. Objectives were to 1) assess the current lake trout population, 2) rehabilitate the fishery if needed. Since that time, a mark-recapture population estimate has been conducted and the status of the population appears to be stable. Natural reproduction is sustaining the fishery, and recent genetic analysis indicates that the population is a pure distinct strain.

Methods:

Gill Nets: From October 21-23, 2002, three gill nets consisting of 2 1/2 inch stretch mesh, 300 feet long and six feet high were set over the known spawning reef on the north side of the lake (Map attached). Short duration sets were used to minimize mortality. Nets were set approximately one hour prior to sunset, with lifting of the first net commencing approximately one hour after sunset. After processing the first net it was reset and the process continued with the remaining nets. Nets were reset for a minimum of two lifts per net, per night, for a total active fishing time of approximately five hours per net per night. Data was not separated for each lift, but combined for each net resulting in one net night for each of the three nets.

Fish were removed from the net and placed in a tank of fresh water. Processing of the fish took place immediately upon completion of the lift, and stressed fish were allowed to recuperate before being released back into the lake.

Swim Bladders: Lake trout and walleye exhibiting enlarged swim bladders were deflated using an 18 gauge hypodermic needle one and one-half inches long. Upon locating the proper insertion point, the needle, excluding the syringe, was poked through the skin and into the bladder and the air allowed to flow out the open end of the needle. For walleye, the removal of one or two scales at the point of insertion proved beneficial.

Floy Tagging: Model FD-94, 5/8 inch mono Med-T shrink lock floy tags were used to mark individual fish. The tags were inserted approximately one inch posterior of the anterior end of the dorsal fin. The tags were white in color and individually numbered from 235-300.

Genetic Samples: Each lake trout had a piece of the caudal tail approximately 1/2 inch x 1/4 inch removed and placed in a numbered vial containing a preservative and stored for later genetic analysis.

Summary:

Upon approval of the UWBILTMP, an evaluation of the status of the lake trout population in Black Oak Lake was initiated with gill net sampling in 2000. Prior information regarding the lake trout population was minimal and the status of the population was unknown. Gill netting conducted in October 2000 confirmed a viable lake trout population and a project proposal was written for the 2001-2003 biennium. Sampling objectives were to gather CPE, density, length frequency, sex ratio, and age-growth data resulting in the development of a management plan.

CPE: Catch per effort values were: 2002 - 4.4 lake trout per net night, (9) total net nights, 2001- 6.0 (9), 2000- 9.5 (4), 1985- 6.2 (6). Effort expended is not standardized and long term data from Trout Lake shows a decline in CPE values as effort increases. Individual net placement is also crucial and directly affects catch rate values.

Density: A mark-recapture Chapman modification of the Petersen population estimate was conducted using floy tagged fish marked during gill netting in 2001, and recaptured with gill net in 2002. Mortality during the year between samples is unknown, but this is the most accurate indicator of density available. Repeated estimates over a five-year time interval will provide a reliable long-term indicator of relative abundance. The adult lake trout population was estimated to be 275 (0.5/acre). This compares favorably with Trout Lake, (0.4-0.7/acre), and with average densities in Canadian waters, 0.4 – 0.6/acre. (David O. Evans, Ontario MNR personal communication). The lower confidence limit estimate of 102 total adults suggests caution must be exercised in regards to management.

Black Oak Lake Adult Walleye Population Estimate (Sexes Combined)				
M	46	N	275	
C	40	VAR	7,855	
R	6	C.V. (%)	32	
N= Estimated Number		SD	89	
M= 2001 Marks		95% CI	174	
C= 2002 Captures		Upper Limit	449	
R= 2001 Marks in 2002 Capture		Lower Limit	102	

Length Frequency/Size Distribution: A length frequency comparison of the 2000 through 2002 catch is depicted in Figure 1, and a comparison of the 1985 catch is made with the 2002 catch in Figure 2. A total of 40 lake trout were captured in 2002 with an average length of 23.7 inches, ranging in size from 15.0 – 30.5 inches total length. Average length in inches for previous years was 2001 (23.9), 2000 (23.7), and 1985 (22.8). In comparison, the average length of lake trout in Trout Lake has increased from 23.4 inches in 1996, to 25.7 inches in 2002. During this time period the number of lake trout in the sample under 20 inches decreased from 51 in 1996, to zero in 2000 - 2002. In Black Oak Lake the number of lake trout less than 20 inches was, 2000 (6), 2001 (4), and 2002 (5), or 11% of the overall catch. The number of lake trout under 20 inches is a key indicator in monitoring natural reproduction, and subsequently the survival of the population as a whole.

Sex ratios: The ratio of males to females has varied from 2.2:1 in 2001, to 4.0:1 in 2000 and 2002. Female lake trout do not spend as much time at spawning sites as do males and therefore are less vulnerable to capture, and could be underestimated.

Age-Growth Data: Accurate age determinations of individual lake trout in Black Oak and Trout Lake have proven difficult. Overall, scale samples are fairly reliable the first six to eight years but become increasingly "unreadable" with age. Age-growth determinations have been made in Black Oak Lake based upon a very limited sample of yearlings fin clipped prior to stocking and recaptured at a later date. Six year-old trout varied from 18.7-25.0 inches total length.

A total of twelve otolith samples have been collected from netting mortalities but only one of the samples provided a confident age estimate. That fish was 29.3 inches and 10 years old. Two other samples of questionable accuracy were 14.1 inches (7+), and 22.7 inches (9?). The lack of accurate length at age data prevents mortality calculations, and accurate age structure determinations.

Floy tagging will provide long term growth information but will not provide specific length at age data. Of the six trout marked in 2001 and recaptured in 2002, the average length was 24.3 inches, and the average one-year growth was 0.2 inches. This is similar to the average growth of 0.4 inches per year in Trout Lake from 1996-2001.

Gill Net Bi-Catch: The total catch for all species other than lake trout in 2002 was: cisco- 30, walleye-26, burbot- 9, and rock bass-2. Walleye ranged in size from 14.0 – 28.3 inches, with a majority of the fish between 14.0 –16.0 inches. Cisco ranged from 9.0 -15.1 inches with 66% between 12.0 and 14.5 inches.

Genetics: A total of 44 tissue samples were analyzed for Mitochondrial DNA, and Microsatellite DNA (Fst + assignment tests). Black Oak Lake and Trout Lake were both determined to be pure inland populations distinctive from other populations and from each other (Kyle Piller, Wisconsin Department of Natural Resources, personal communication).

Management Recommendations: The two over-riding factors determining the direction of lake trout management in Black Oak Lake are 1) the presence of juvenile lake trout, and 2) the determination that the population represents a pure genetic strain.

Verification of natural reproduction as evidenced by the presence of juvenile trout means this is the only self-sustaining lake trout population in Wisconsin excluding Lake Superior. Stocking hatchery reared fish has proven detrimental to natural reproduction in many waters of Ontario Canada (David O. Evans, Loss of Exploited, Indigenous Populations of Lake Trout, *Salvelinus namaycush*, by Stocking of Non-Native Stocks. C.J.F.A.S.). Catch per effort, length distribution, and the population estimate suggest stable adult densities and natural recruitment. Therefore I recommend the lake not be stocked with lake trout and the population managed as a unique naturally reproducing strain.

The population status needs to be monitored on a regular basis. The two main concerns for the future of the population are the increased walleye density, and a general increase in angler interest in the lake due to increased walleye densities, especially trophy sized fish. Lake trout populations in general do best in low species diversity situations, and have exhibited an adverse relationship to walleye densities. The above average density of large walleye, 2.4/acre > 20 inches, will compete directly with lake trout for available forage, specifically cisco. Adult walleye could also pose a direct threat to lake trout recruitment by direct predation on juvenile lake trout. The second threat to the lake trout population is harvest. Angler harvest could increase due to an increased interest in the trout population, and also indirectly by fishermen targeting trophy walleye. Because of a possible increase in angler harvest I will submit a regulation change to increase the minimum size of lake trout from 26 inches to 30 inches, maintaining the current bag limit of one. This will provide additional protection to mature trout and standardize lake trout regulations with Trout Lake.

Due to the concerns of increased pressure on the lake trout population listed above, I recommend a long term sampling plan using gill nets over two consecutive years on a five year rotation. Trout will be marked with floy tags both years, and the second year of the sampling used as a recapture to calculate a population estimate. At the present time there is only one known spawning reef. This results in a concentration of fish and concern has risen over disrupting the spawning process and possibly negatively affecting natural reproduction. For this reason we feel a five-year rotation is necessary, yet sufficient to monitor the population.

Preservation of this unique lake trout resource should be the top management priority for Black Oak Lake. Walleye stocking may need to be re-evaluated should the lake trout population begin to decline. The UWBLTMP also calls for the introduction of lake trout into new waters to provide additional angling opportunities, and establish subsequent populations that preserve this unique strain. Therefore, I propose using progeny from the Black Oak strain to introduce as yearlings into Long Lake, Vilas County, Keyes Lake, Florence County, and Lake Lucerne, Forest County. All of these lakes contain smelt populations and the stocking of yearling trout at eight per acre at a

minimum weight of 40/pound is recommended. Egg taking will coincide with the two year sampling plan beginning in the fall of 2004 resulting in yearlings being stocked in 2006 and 2007. Gill netting on Black Oak Lake will be limited to three nights with nets being run the same night and not set overnight to reduce mortality. Additional netting will only be conducted to obtain the minimum number of eggs needed to produce the yearlings.

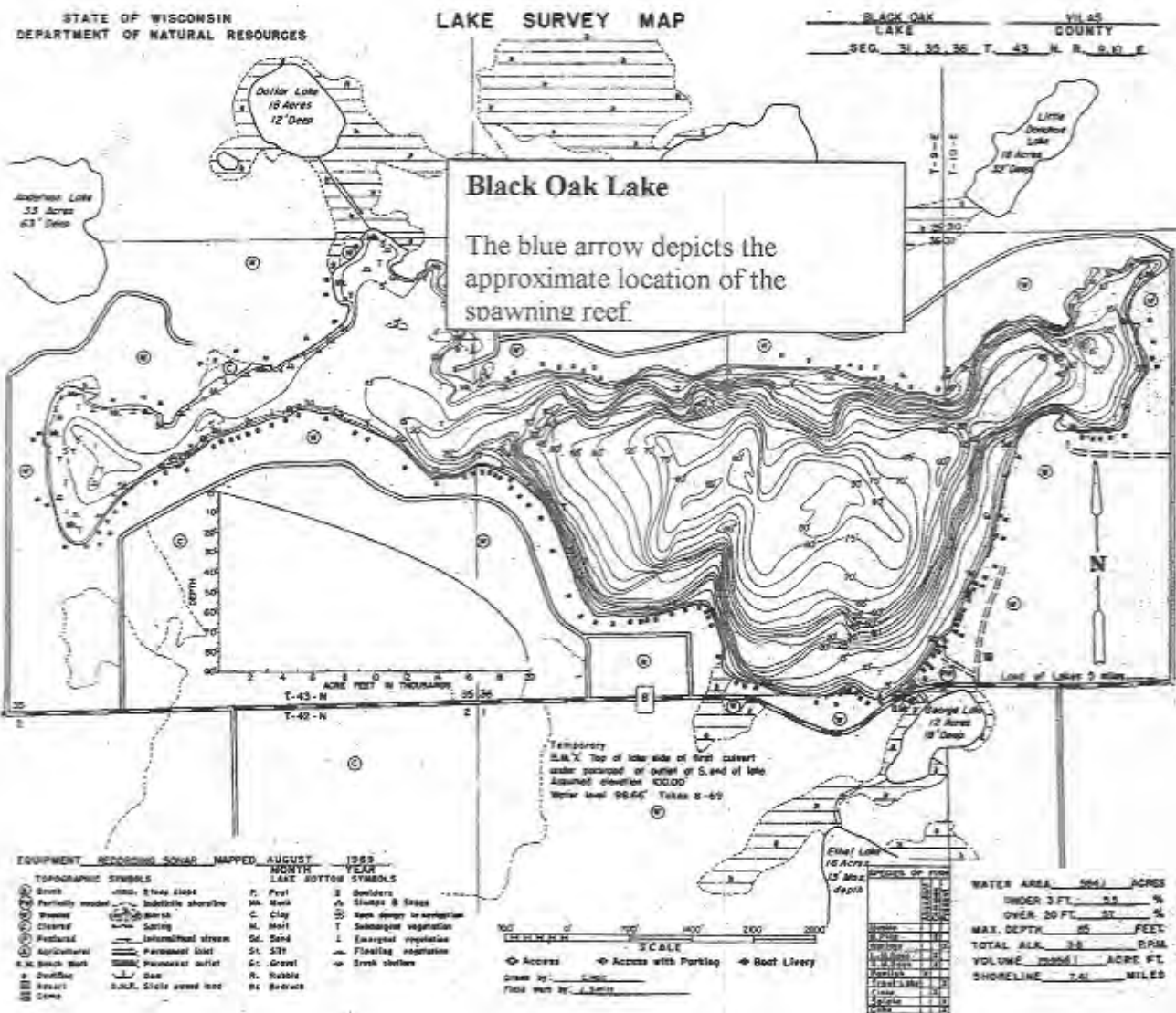
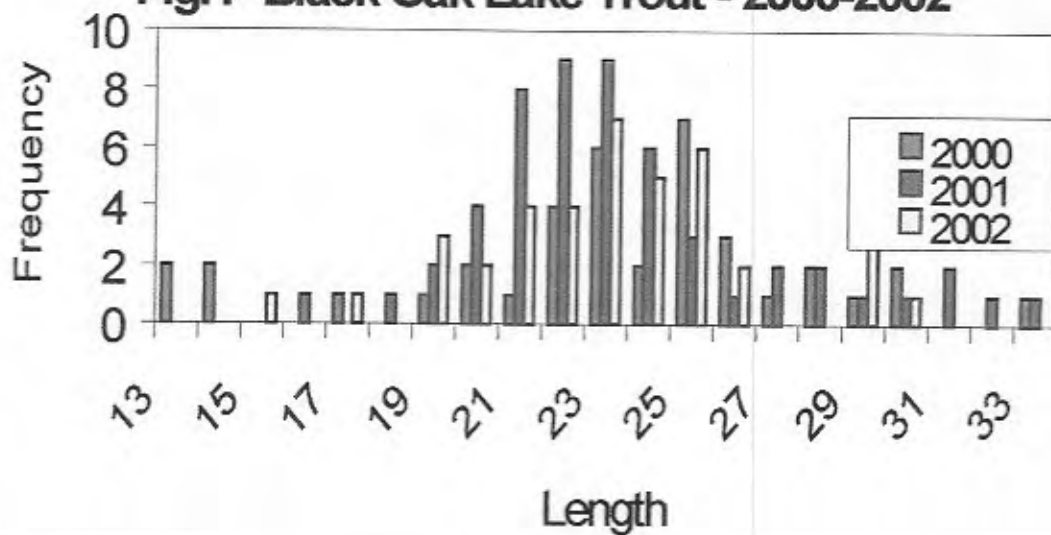
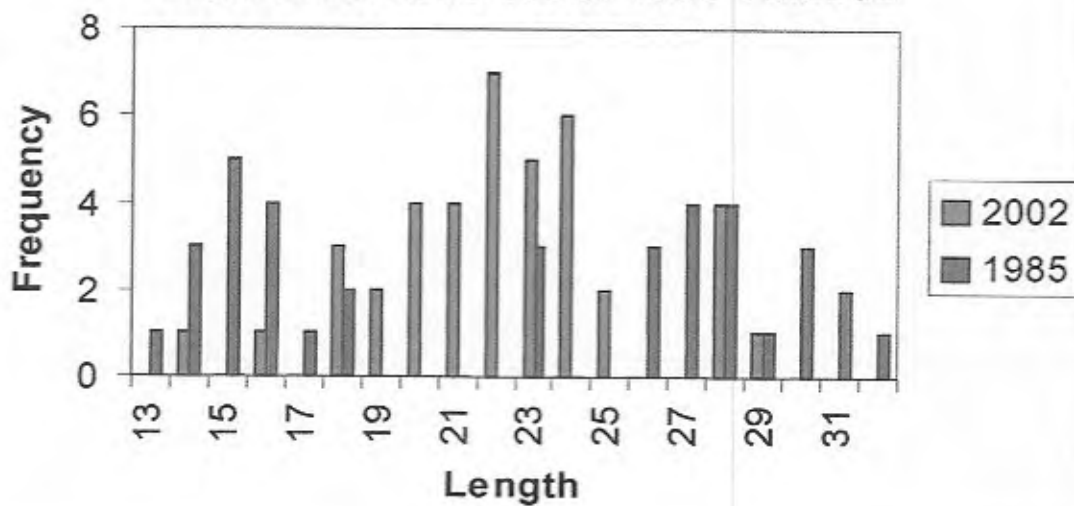


Fig.1- Black Oak Lake Trout - 2000-2002



Black Oak Lake Trout-1985 Vs.2002



BLACK OAK LAKE
LAST TWO PAGES

2001 Lake Trout Management

Trout Lake

Summary:

The two lakes identified in the Upper Wisconsin Basin Inland Lake Trout Management Plan for lake trout sampling in 2001 were Trout Lake and Black Oak Lake. Trout Lake has now been sampled annually since 1996, although no fyke netting or floy tagging occurred in 1998. The total number of trout captured has dropped annually, and quite noticeably the last two seasons, particularly in 2001. The two main spawning areas have been designated Headquarters, and Rocky Reef. The latter site has dropped off dramatically (71%) from 231 trout in 1996, to 66 trout in 2001. The Headquarters site has dropped 37% from 264 in 1996, to 194 lake trout captured in 2001. Historical sampling indicates a peak in spawning near November 1, with water temperatures near 46 degrees F. Sampling efforts are planned around this date, but due to abnormal weather patterns the previous two years, water temperatures have been above the optimum of 46 degrees. The drop in catch rates does not correspond to population estimates conducted at these sites using year one as the mark, and year two as the recapture. During this time population estimates have ranged from a low of $N=1415$ (1997) to a high of $N=1640$ (2000).

Prior to the ice-angling sample collected in March 2002, five years of sampling yielded only two juveniles. Length frequencies continue to point toward an aging population, with no recruitment of sub-adults. Increasing length at age data, albeit minimal, continues to expand upon our knowledge of longevity for individuals within this population. Otoliths removed from a 30.4 inch male were aged at 40 years old. This fish had a RV stocking clip that when referenced to the above age and the stocking history was determined to be either 39 or 41 years old. Unfortunately the two cohorts were given the same clip, and separated by only one year. The 1960 cohort was of Trout Lake origin, the 1962 cohort was of Lake Superior origin. The capture numbers for these two cohorts have been grouped together and were believed to consist primarily of the Trout Lake strain, however no definitive determination can be made. One thing we can be sure of is that this is a long-lived, old age population with little or no recruitment of sub-adults for the previous five years (1996-2001) into that segment of the spawning population currently sampled.

Due to poor recruitment and the success of previous yearling plants, it is vitally important that an agreement has been made to produce yearling trout of the Trout Lake strain. Approximately 100,000 fry were hatched at the Art Oehmcke Hatchery in January 2002, and will be reared to spring fingerlings. In the spring of 2002 approximately 50,000 of the trout will be transferred to the Westfield hatchery where they will be reared to fall fingerling, with the remaining fingerling being stocked in Palette Lake. Approximately

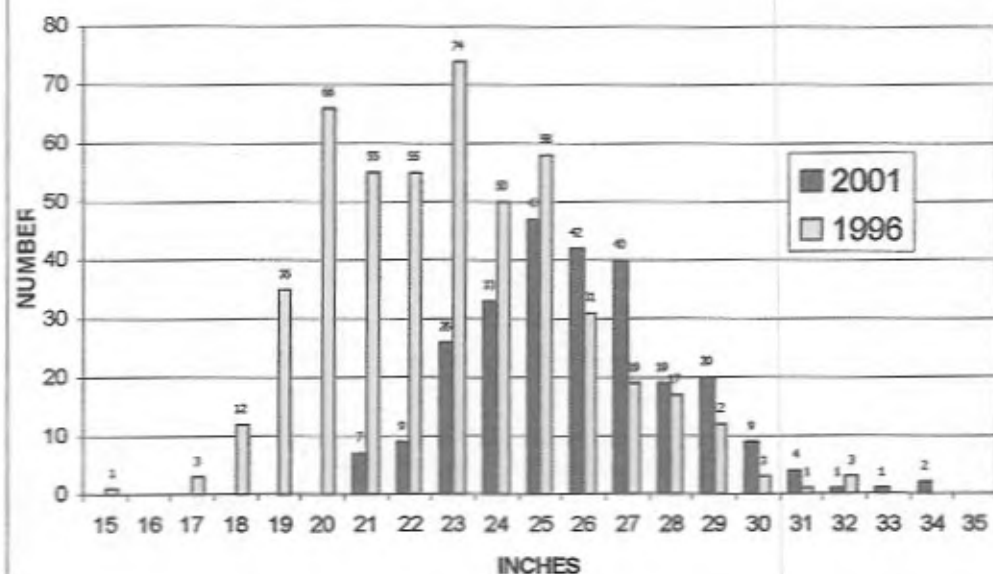
25,000 of the fall fingerlings will be reared to yearlings by the Green Lake co-op pond and stocked in Big Green Lake. In the fall of 2002 approximately 20,000 fingerlings will be transferred back to the Oehmcke hatchery where they will be held and stocked as yearlings in the spring of 2003. Although I continue to believe that high-density spring fingerling stocking may provide necessary recruitment, determination of success is several years away. Fall yearling plants have proven successful in the past. In a 1981 gill net survey the 1970, 1971, and 1972 plants of yearling lake trout comprised 69% of the 228 lake trout captured. The current plan is to produce 20,000 yearlings to be stocked in three consecutive years ending in the spring of 2005. All fish will be fin clipped prior to stocking for future identification. Propagation disease concerns will be re-evaluated at this time and the introduction of lake trout into other surrounding waters will be reconsidered.

On May 7, 2001, 100,000 lake trout fingerling averaging 2.1 inches in length, and weighing 490 per pound were stocked in Trout Lake at the South Trout boat landing. The fish were marked with oxytetracycline by submersing in a 500 ppm bath for six hours. One hundred of the fingerlings were held in the hatchery an additional month allowing for growth to help facilitate the removal and examination of the otoliths. Upon examination the OTC mark was present in all specimens, but the quality of the mark was much poorer than previous years samples requiring increased effort and at times an experienced "eye" to detect the mark.

Sampling Results:

A total of four, four-foot fyke nets were set on October 29, 2001 and fished through November 2, 2001. A total of 260 lake trout were captured in 16 net nights yielding a CPE of 16.2 trout per net night. All fish were transported to the Oehmcke Hatchery where they were measured and examined for fin clips, sex, and prior year floy tags. Untagged fish were given an orange floy tag with numbers 1401-1418 representing Rocky Reef fish, and numbers 1201-1258 designating lake trout captured at the Headquarters site. Capture by site was: Headquarters- 194, and Rocky Reef-66. Composition by sex was 128 males, and 132 females for a ratio of 0.97 males per female. This ratio has dropped annually from a high of 3.5 males/female in 1996. Males ranged in size from 20.0 – 31.3 inches, and females 20.1 – 33.7 inches. Minimum length has increased annually since 1996 (Figure 1), and average length increased annually until 2001 when it leveled off.

**Figure 1. 1996 vs 2001 Trout Lake
Lake Trout Length Frequency**



The chart below shows average length (inches) by year and sex.

Year	Sexes		
	Combined	Males	Females
2001	25.4	25.0	25.7
2000	25.4	25.2	25.7
1999	24.9	24.7	25.2
1997	23.8	23.4	24.8
1996	23.4	23.1	24.3

The percentage of fish marked by fin clip in the 2001 fyke net sample was 73%, which is part of an annual downward trend from a high of 88% in 1996. Shown below is the percent composition of each clip dating from 1996 – 2001. (1998 not sampled).

<u>Clip</u>	<u>1996</u>	<u>1997</u>	<u>1999</u>	<u>2000</u>	<u>2001</u>
AD	12%	14%	14%	13%	15%
LP	7%	3%	6%	7%	4%
LV	22%	24%	21%	18%	17%
RP	21%	15%	20%	17%	16%
RV	25%	29%	26%	24%	26%
None	12%	14%	13%	21%	21%

The percentage of recaptures, fish previously marked with a floy tag is as follows: 2001- 72%, 2000 – 61%, 1999 – 52%, and 1997 – 35%. Homing tendencies, defined as the ratio of fish returning to the same site they were previously captured, was Rocky Reef: 2.1:1, and Headquarters 5.0:1. In 2000, the ratios were Rocky Reef 6.2:1. and Headquarters 3.3:1. Although some individuals have been captured at both spawning sites, the majority of the fish have repeatedly been captured at the same site.

Otolith samples continue to be collected from netting mortalities and aged by Scott Hulse, Bayfield. There were a total of six lake trout mortalities in 2001, including two fish captured by personnel from the University of Wisconsin Trout Lake Field Station. One of these fish was a 30.4 inch male with an RV clip that was aged at 40 years. Age as determined from otolith samples, combined with fin clip stocking data allow for reliable age determination, especially for fish exceeding 20 years of age.

Growth data is calculated from recaptured fish by subtracting the length at first capture from the length at the most recent recapture. A total of 52 trout from the 1996 marks were recaptured, and 58 trout from the 1997 marks. Documented growth is as follows:

	<u>1996-2001</u>		<u>1997-2001</u>	
	<u>Male</u>	<u>Female</u>	<u>Male</u>	<u>Female</u>
Average Growth(Inches)	1.9	1.6	1.8	1.4
Average Length(Inches)	25.9	26.8	24.8	26.5

Tag loss rates were calculated as follows. In 1996 a total of 495 lake trout were captured and floy tagged. The following year 168 of the tagged fish were recaptured and given a second floy tag. During 2001 fall fyke netting, a total of 28 lake trout were identified as having been double tagged for a total of 56 individual tags. Of the 56, a total of 12 tags were missing, yielding a four-year tag loss rate of 21%. This is a minimum estimate derived from a small sample size, so for population estimate calculations tag loss rates were derived from a Lake Superior study (Fabrizio, 1996).

Previous adult spawning population estimates were done using year one of the fyke net catch as the mark, and year two of the fyke net catch as the recapture, or by using multiple year fyke net catches as the mark, and the most recent years catch as the recapture. Estimates ranged from N=1415 in 1997, to N=1640 in 2000. In the fall of 2001 considerable effort was directed toward gill netting prior to peak spawning and a large enough sample was obtained to use the gill net catch as the recapture sample. Several estimates were calculated using different values for the marks.

Estimate 1: M= (388) year 2000 total fyke net catch
C= (22) year 2001 total gill net catch
R= (2) year 2001 gill net recaptures from year 2000 fyke net catch

N= 2982 SD= 1390 CV= 0.46 95%CI= 2725

Estimate 2: M=(797) Total marks 1996-2000 minus 10% annual tag loss
C= (22) year 2001 total gill net catch
R= (7) year 2001 gill net total tagged

N= 2294 SD= 618 CV= 0.27 95%CI= 1210

Estimate 3: M= (1156) total marks 1996-2000-(No Tag Loss)
C= (22) year 2001 total gill net catch
R= (7) year 2001 gill net total tagged

N= 3326 SD= 895 CV= 0.27 95%CI= 1755

Lake Trout angling as a recapture method was conducted on March 4, 2002, and March 28, 2002. A total of 29 lake trout were captured ranging in size from 11.7 – 36.2 inches, and six (21%) were floy tagged. Of the 23 trout 20 inches and longer, 15(65%) were fin clipped compared to 73% fin clips in the 2001 fyke net catch. Otoliths were removed from four juvenile trout less than 16 inches in length, and one of each pair of otoliths were examined for Oxytetracycline marks, and the other otolith was aged. An 11.7 inch trout was thought to have an OTC mark and be of hatchery origin, but the age could not be confirmed.

The following adult spawning population estimate using the ice-angling sample as the recapture sample was calculated using Trout > or = 20 inches.

M= (797)Total tagged fish (1996-2000), minus 10% annual tag loss
C= (23)Total captured during angling
R= (6)Number of tagged fish

N= 2736 SD= 814 CV= 0.30 95%CI= 1596

In October 2000, four adult lake trout were implanted with radio transmitters and released in Trout Lake in hopes of locating new spawning areas. Four additional

transmitters were purchased, and two used transmitters donated by Jeff Roth were implanted on 10/17/2001, and 10/31/2001. Gill netting was conducted the week of October 15, 2001 to capture adult lake trout for transmitter implantation. Three two and one half inch stretch mesh gill nets were set along the East shore of South Trout Lake with one net set directly over the known spawning reef by Allequash Creek, and the other two nets set north along Ben Bendrick Drive. All nets were set perpendicular to shore with the shallow end approximately 20 feet deep, and the deep end in 40 to 60 feet of water. Non floy- tagged trout with no fin clips were targeted for implantation. All unmarked trout captured in the gill nets were marked with an individually numbered bi-colored (yellow/red) floy tag.

On October 17, 2001 five fish were implanted with transmitters. The fish were held overnight in the hatchery, and the trout containing transmitter number 300 died in the tank. The other four fish were taken to the lake and released in good condition. The following week three fish were selected from the trout captured during fyke netting for implantation of the two donated transmitters, and the mortality from the previous week.

The two donated transmitters are frequency 49.154, and 49.918. These two transmitters have an expected life of 470 days. They are programmed to be on 12 hours, off twelve hours for one week, off the entire following week, and then the cycle starts over. All remaining transmitters are programmed to be on for 16 hours, then off for 8 hours. The "200" series transmitters should last through October, 2002, and the "300" series should remain charged until November 2003. The table below lists all of the trout currently implanted with transmitters in Trout Lake, and the activation time for each transmitter.

Frequency	Length	Sex	Clip	Date Tagged	Tag Number	On
49.201	21.4	Male	None	10-17-2001	1120	8 AM
49.221	26.0	Male	None	10-18-2000	Mortality	Noon
49.241	27.8	Female	RP	10-17-2000	No tag	Noon
49.261	24.6	Male	None	10-17-2000	No tag	Noon
49.300	26.8	Female	None	10-31-2001	1202	8 AM
49.321	27.2	Male	None	10-17-2001	1125	8 AM
49.341	26.0	Male	None	10-17-2001	1126	8 AM
49.361	27.8	Male	None	10-17-2001	1124	8 AM
49.154	24.1	Male	None	10-31-2001	1210	Noon
49.918	20.6	Male	None	10-31-2001	1205	Noon

style of tag used (Fabrizio, 1996). The tag-shedding models depicted in the report average approximately 50% tag loss after five years, thus the 10% annual figure used in calculating the population estimate.

The presence of juvenile trout in the ice-angling sample resulted in a length frequency quite different from previous fyke and gill net captures. Of the 29 lake trout caught angling, six (21%) were less than 20 inches in length. In comparison to the 282 lake trout captured during 2001 fall netting, none of the trout were less than 20 inches. The average length and minimum size of fish captured during fall fyke netting has increased annually since 1996, suggesting no recruitment of juvenile fish, yet the ice-angling recapture, although a small sample, showed 21% of the total to be juveniles. Local ice-fishermen also reported catching a number of juvenile lake trout incidental to the whitefish harvest.

Fall fyke net catches have declined annually since 1996, and quite dramatically in 2000, and 2001 prompting concerns of a decreasing population. Contrary to this trend, the most recent population estimate using the ice-angling recapture yielded a higher, more statistically valid estimate. The ice angling recapture sample also provided valuable information concerning juvenile fish, validating the importance of this technique for future use.

Black Oak Lake

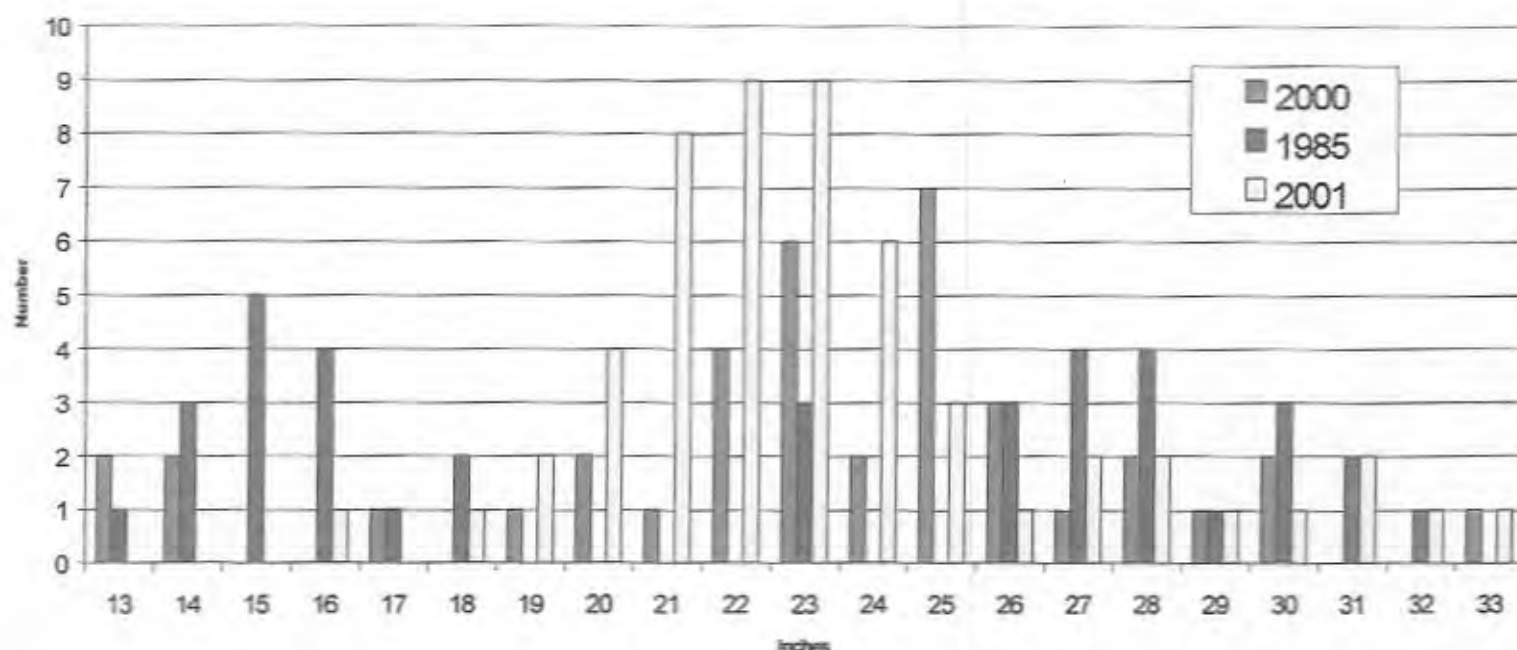
A gill net survey of the lake trout population conducted on October 24-25, 2000, revealed numerous age classes of trout ranging in size from 13.0 inches to 33.5 inches in length, none of which were fin-clipped. The most recent lake trout stocking of fin-clipped fish occurred in 1980, thereby indicating natural recruitment of juveniles. Previous sampling efforts consist primarily of limited gill netting effort, resulting in catch per effort data only. Information pertaining to growth rates, longevity, and population densities are minimal. Therefore, lake trout management in Black Oak Lake has become part of the long term Inland Lake Trout Management Plan approved in 2001.

The current management plan calls for the individual marking of lake trout with floy tags in 2001, and subsequent sampling in 2002 providing a recapture sample for the calculation of a population estimate. These estimates will be conducted every five years to provide long term monitoring of the population. Plans to supplement the population through stocking were abandoned upon determination of natural reproduction, however long term monitoring is necessary to determine if natural recruitment is sufficient to sustain the fishery. Length at age data for lake trout is difficult to document due to the lack of a reliable aging structure. Otoliths have proven to be fairly accurate and have been gathered from incidental mortalities. Recent age data from Trout Lake indicates individuals may attain forty years of age. Otolith samples have also been taken from Black Oak Lake but for reasons unknown the majority of the samples have been

unreadable. Long term sampling in conjunction with individual marking of lake trout will provide information currently lacking for the parameters listed above.

Three two and one half inch stretch mesh gill nets 300 feet long were set October 22 – October 24, 2001. For comparative purposes I will treat the multiple sets as one set, resulting in nine net lifts. A total of 54 lake trout, 86 cisco, 28 walleye, 13 burbot, one smallmouth bass, and one northern pike were captured. The catch per effort for lake trout was: 2001- 6/lift, 2000 – 9.5/lift, and 1985 – 6.2/lift. The average length was 23.9, 23.7, and 22.8 for the years 2001, 2000, and 1985 respectively. (Length Frequency-Figure 2) Of the 54 lake trout captured, 35 were males, 16 females, and three unknowns. No identifiable stocking clips (1971-1974, 1980) were observed, but lake trout captured in 2000 were given a top caudal clip of which two were identified in 2001 sampling.

**Figure 2. Black Oak Lake Length Frequency
Lake Trout 1985 vs 2000, 2001**



From: Gilbert, Stephen J - DNR
Sent: Friday, November 03, 2006 12:43 PM
To: 'Stu Hunt'
Cc: Jahns, Wesley O - DNR
Subject: RE: Blackoak Lake

Stu,

Sorry I didn't get back to you directly, but I thought that Wes did a good job of explaining what our goals were for Black Lake. We need to balance the Lake Trout and Walleye fisheries with the available forage (ciscoes). The best way to do this on Black Oak is with fishing regulations and controlling walleye stocking.

Our goal is to maintain the Lake Trout adult numbers at 0.5 or better per acre and keep the adult walleye numbers more in the 1.5/acre range. This will hopefully maintain the trout fishery, provide a trophy walleye fishery, and keep the cisco population healthy. The 1999 adult walleye estimate was 3.4/acre. This is almost three times the estimate from 1993 (1.2/acre).

The walleye stocking efforts of the state and lake association are the reason for this increase. We have seen limited natural walleye recruitment over the last 20 years. This year I had planned to switch from stocking small walleye fingerlings (about 2 inches) to extended growth fish (7 inches) to get a better bang for the buck. With the exception of 2002 we have seen very poor survival from small fingerling stocking. This was a priority four stocking and I was asking for 584 fish. Only priority 1 and 2 lakes would have received fish this year due to production limitations. Given this fact and our concerns for the lake trout and ciscoes I removed Black Oak from the stocking quotas for walleye.

We and GLIFWC will continue to conduct annual fall surveys to monitor walleye recruitment. In the summer and of 2007 WDNR will conduct a monitoring survey of Black Oak lake. This will involve small mesh fyke netting and crayfish trapping in August and electrofishing in September. If we are funded, we may be back in the lake in the spring of 2008 for a comprehensive survey of the fishery. The would include a population estimate of the entire walleye population any possibly gill netting for ciscoes. Based on the results from this survey we would evaluate the status of the walleye fishery and decide at that time if we should resume walleye stocking or possibly trying again to get a trophy walleye regulation passed. We will also be conducting a fall survey of the lake trout in two or three years.

Steve

----- Original Message -----

From: Jahns, Wesley O - DNR

To: Stu Hunt

Sent: Monday, September 18, 2006 9:18 AM

Subject: RE: Blackoak Lake

Gilbert and I were netting last week and had some long days in the field so he probably didn't check his emails. Historically Black Oak Lake would have had a low density walleye population, and most likely no walleyes at all until man put them in there. Ciscoes prey on the young walleye thereby limiting the number of young walleye that survive to grow to adulthood. If the cisco population crashes the main food source for the lake trout will disappear. We can't say for sure that the walleye population caused the cisco population to crash, or even that the cisco population has in fact declined because we do not have enough information to prove that, but all indications are that the cisco have declined. If the lakers don't have the cisco to feed on the growth rates will decline. The larger trout will be lucky to just survive. The population then could either disappear, or switch to smaller trout feeding on aquatic insects and an occasional fish. In lakes in Canada and Minnesota where the lake trout do not have a good supply of cisco to feed on and depend mainly on bug life, most of the lake trout reach a maximum size of 18 inches, with an occasional trout that becomes carnivorous growing to a larger size.

From: Stu Hunt [mailto:stu@nnex.net]

Sent: Sunday, September 17, 2006 10:58 AM

To: Jahns, Wesley O - DNR

Subject: Re: Blackoak Lake

Is Gilbert gone on vacation? Wrote to him for the plan and haven't heard anything. Can it be that the cisco's have been eaten by walleyes and trout. What will the trout do with a limited supply of cisco's. Stu

----- Original Message -----

From: Jahns, Wesley O - DNR

To: Stu Hunt

Sent: Wednesday, September 13, 2006 8:14 AM

Subject: RE: Blackoak Lake

Hi Stu-----The last time we gill netted we did not get any ciscoes in the net. I was concerned about predation on the cisco by the large walleye population that was in the lake. Last fall we spent two nights looking for cisco when they should have been up in the shallows spawning and saw very few. In the summer of 2005 I was up there with sonar and did not see hardly anything on the graph for what could have been cisco out in deep water. You will have to check with Gilbert on the walleye stocking but he is either reducing it to maintenance stocking, or eliminating it. If we lose the cisco population the lake trout will be in trouble and preservation of the lake trout population is the highest priority. We will be netting for lake trout in 2008 or 2009 to monitor the population.

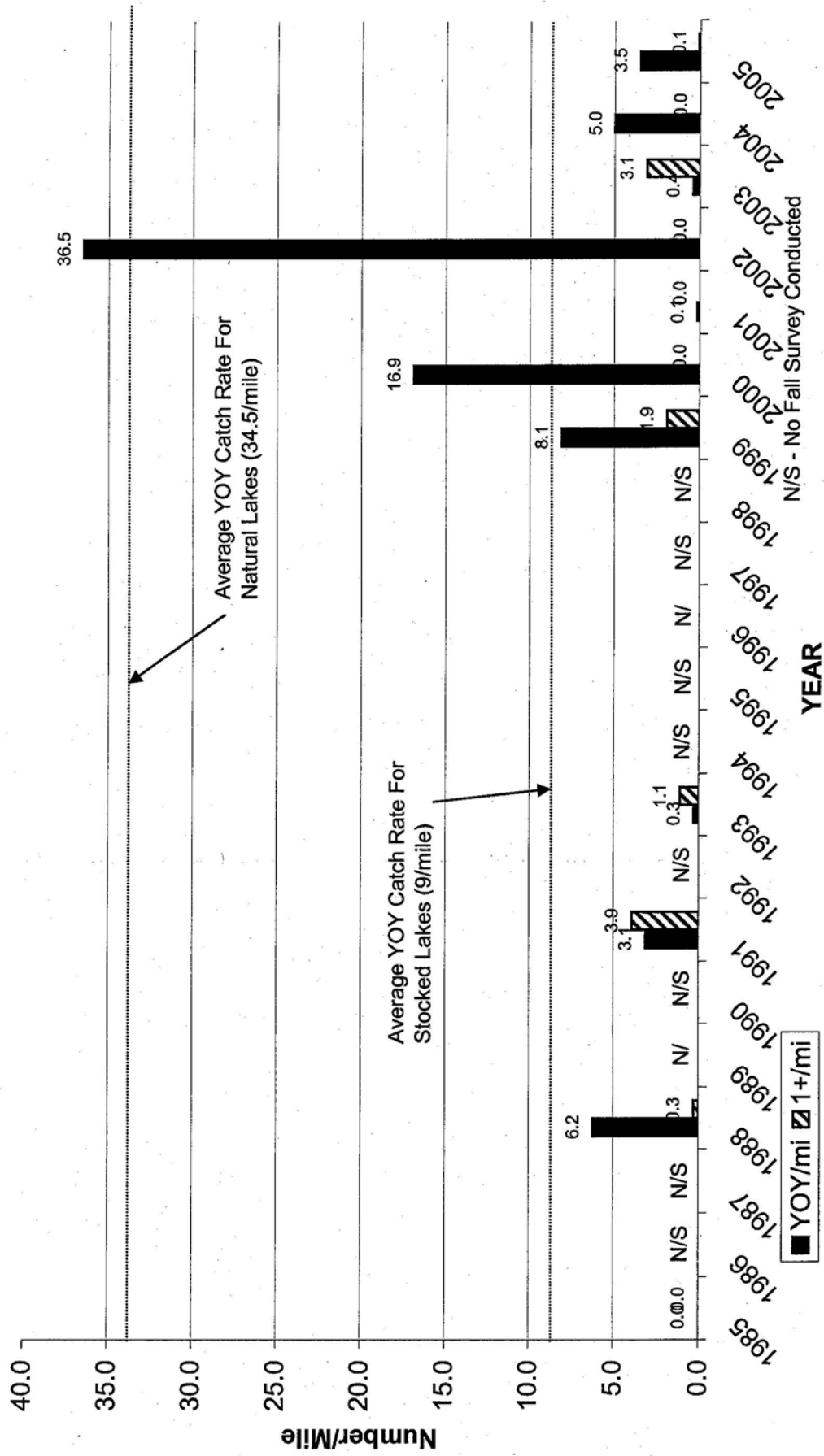
Black Oak Lake Walleye Data

Year	Stocking Fry (x1000)	Small Fingerling Date	Small Fingerling Number	Large Fingerling Date	Large Fingerling Number	Extended Growth Date	Extended Growth Number	Fall Survey Date	YOY/mi	1+/mi	Spring Adult PE Estimate	CI	#/acre Total	Males	Females
1980		25-Jun	29,550												
1981		25-Jun	15,500	08-Jul	16,500										
1982		29-Jun	30,876												
1983															
1984		28-Jun	27,990					16-Oct	0.0	0.0					
1985															
1986		21-Jul	28,000												
1987		16-Jul	25,000												
1988		15-Jul	25,000												
1989				29-Jul	1,000	20-Oct	3,174	26-Sep	6.2	0.3					
1990				05-Aug	14,254	03-Oct	2,505								
1991				26-Sep	5,400			08-Oct	3.1	3.9					
1992				24-Sep	5,500	21-Aug	1,015								
1993								22-Sep	0.3	1.1	689	199.2	1.2	0.6	0.1
1994				04-Aug	2,000										
1995				27-Sep	14,664										
1996															
1997				06-Aug	716										
1998		25-Jun	58,000												
1999															
2000		16-Jun	29,200					21-Sep	8.1	1.9	1,965	373	3.4	1.4	2.6
2001								18-Sep	16.9	0.0					
2002		25-Jun	29,200					01-Oct	0.1	0.0					
2003								16-Sep	36.5	0.0					
2004		18-Jun	29,200					13-Oct	0.4	3.1					
2005								07-Sep	5.0	0.0					
2006								08-Sep	3.5	0.1					
TOTALS	-		327,516		60,034		6,694	Average=	7.3	0.9	1,327	2.3	1.0	1.4	

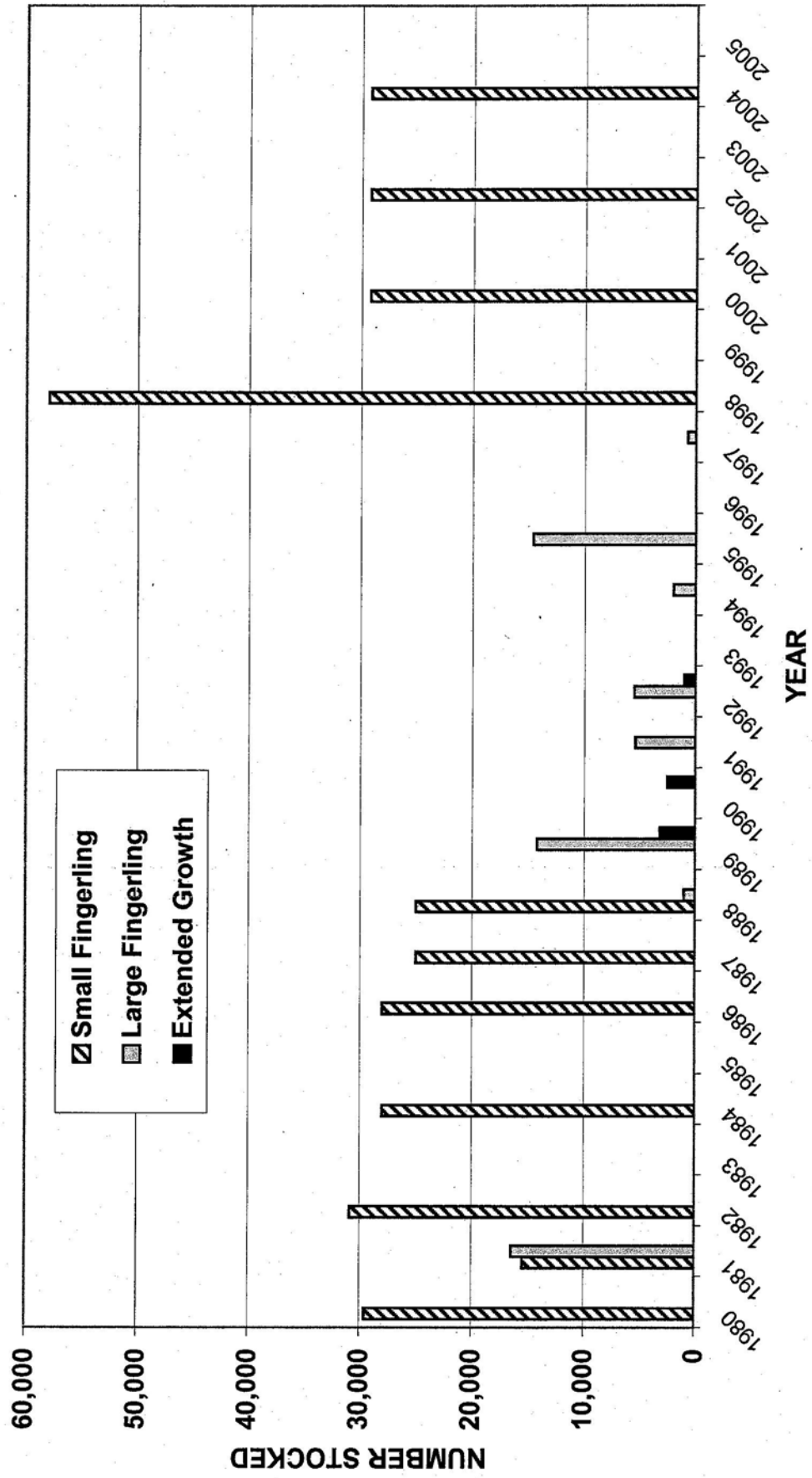
File: stocking and effort Black Oak.xls

Date: 3/20/2006 SJG

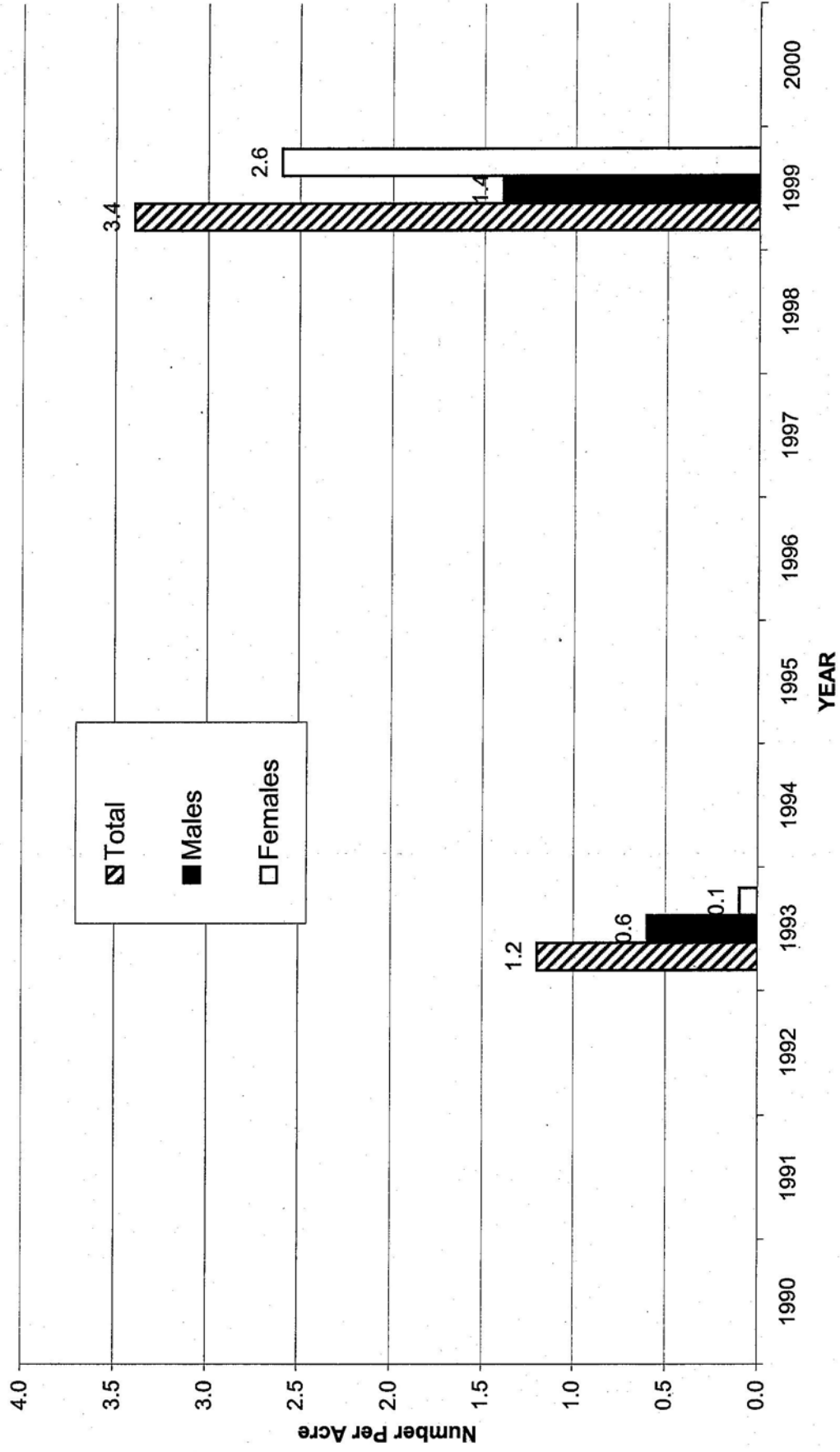
Fall Walleye Recruitment History 1985 to 2005 Black Oak Lake, Vilas County



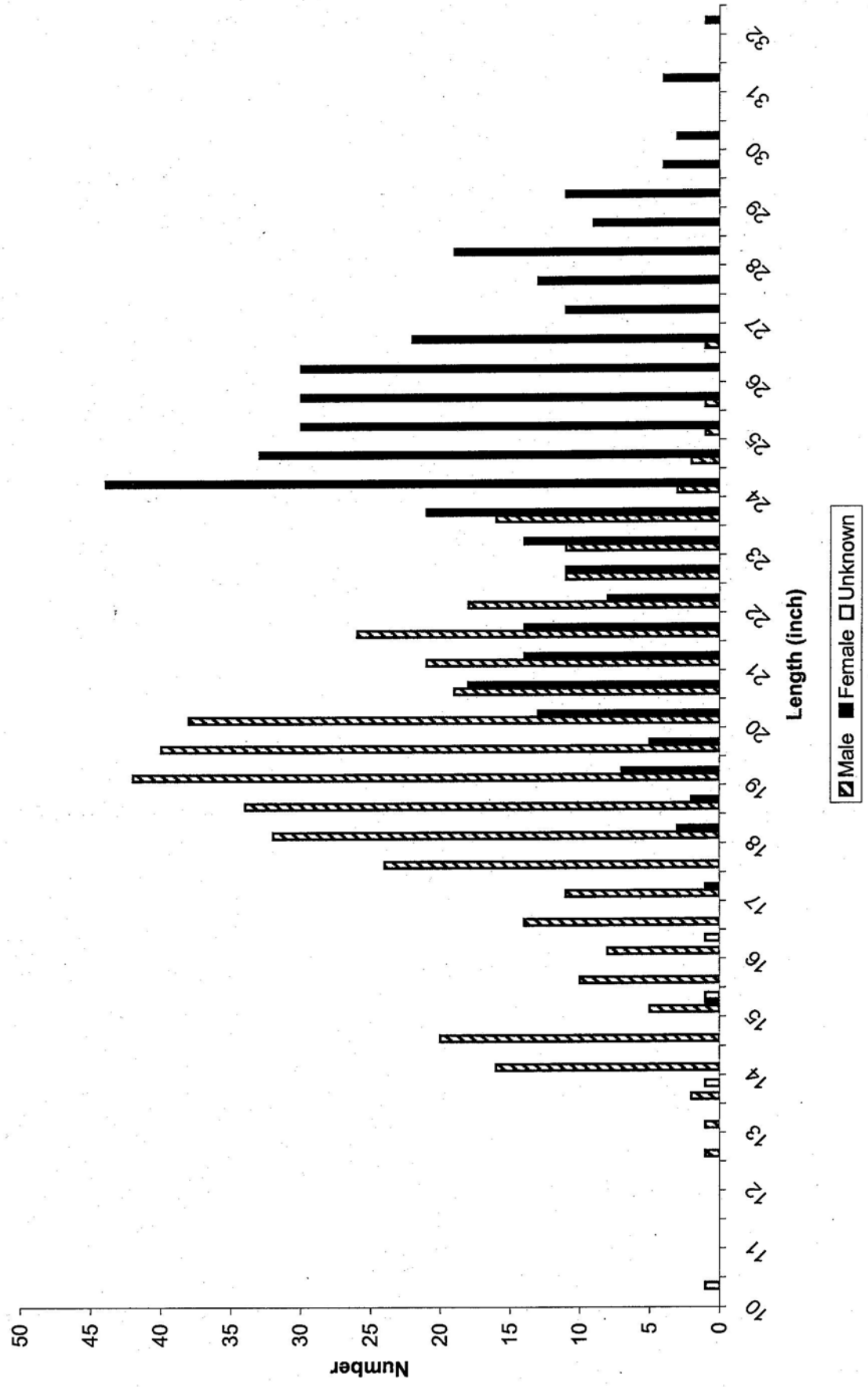
Walleye Stocking Totals 1980 to 2005 Black Oak Lake, Vilas County



Black Oak Lake Adult Walleye Population Estimate History



Walleye Length Frequency Black Oak Lake (Vilas Co.) 1999



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Appendix F

**Water Regulations and Planning
Relevant to Black Oak Lake**

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Review of Water Resource Regulations and Planning Relevant to Black Oak Lake

In this appendix, we provide reviews of documents created to preserve and protect Wisconsin waters, including Black Oak Lake. These reviews were developed from documents created by a variety of sources, including: the Environmental Protection Agency, the Wisconsin Administrative Code, the Wisconsin Department of Natural Resources, the Vilas County Planning and Zoning Department, the Town of Land O' Lakes, the Vilas County Land and Water Conservation Department, and the Vilas County Board.

The first part of this appendix is a review of the federal, state, county and local regulations that influence the water quality of Black Oak Lake. Second is a review of the *Headwaters Basin Integrated Management Plan*. This plan describes issues of concern within the Headwaters Basin (where Black Oak Lake is located), and provides examples of how the WDNR strives to preserve and restore the land and water resources. The third part of this Appendix is a letter sent to the Vilas County Land and Water Conservation Department, providing recommendations to enhance an already well-documented and comprehensive *Vilas County Land & Water Resource Management Plan*.

Regulations and Ordinances that Protect the Water Quality of Black Oak Lake

Federal

The Army Corps of Engineers oversees projects that alter waterways-including discharges to wetlands, and the Environmental Protection Agency (EPA) regulates water quality pollution and drinking water standards. The EPA revised The Clean Water Act in 1972 in order to reduce pollutant discharges into waterways and manage polluted runoff. It has set waste water standards for industries, and for all contaminants in surface waters. The Clean Water Act deemed it unlawful to discharge any pollutant from a point source into navigable waters, unless a permit was obtained. You can view parts of the Clean Water Act at the EPA's website (<http://www.epa.gov/npdes/pubs/cwatxt.txt>).

State

For any given lake in Wisconsin, shoreland protection regulations can be set by the county, town or lake association; however, they must *at least* follow the regulations listed under the State of Wisconsin's Administrative Code, Chapter NR115: Wisconsin's Shoreland Protection Program. The purpose of this Program is to: "establish minimum shoreland zoning standards for ordinances...and to limit the direct and cumulative impacts of shoreland development on water quality; near—shore aquatic, wetland and upland wildlife habitat; and natural scenic beauty" (State of Wisconsin Legislature-a). This document states that a setback of 75 feet from the ordinary high-water mark (OHWM) of any navigable waters is required for all buildings and structures. It also states that the county will be in charge of establishing ordinances that consider the effect of vegetation removal on water quality, including soil erosion, and the flow of effluents, sediments and nutrients. Lastly, it says that a minimum of 35 feet vegetative buffer zone is required from the OHWM (State of Wisconsin Legislature-a).

Changes to the Wisconsin Administrative Code have limited the amount of phosphorus running off into waterbodies. Chapter 151 now restricts the amount of phosphorus farmers can have come off their fields. Moreover, in 2009-2010, Wisconsin legislatures passed laws so that fertilizers with phosphorus would be banned from use on lawns or turfs, and that phosphorus levels in dishwasher detergent were reduced considerably (State of Wisconsin Legislature-b).

The Wisconsin Department of Natural Resources (WDNR) has developed the Wisconsin Pollutant Discharge Elimination System (WPDES) program. This program regulates the discharge of pollutants into waters. Types of permits issued are: individual, general (including ballast water discharge, pesticide pollutant discharge, etc.), storm water and agricultural (WDNR, 2012).

The WDNR also requires permits for specific aquatic plant control techniques. Permits are required for aquatic plant control when: chemicals are used, biological controls are used, and physical

techniques (such as barriers) are used; when wild rice is involved; when plants are mechanically removed, or when plants are removed from an area greater than 30 feet in width along a shoreline (WDNR, 2014).

Personal Watercrafts (PWCs) are restricted to slow, to no-wake speed when within 200 feet of a shoreline, while boats must be at slow, to no-wake speed within 100 feet. These regulations can be more stringent under county or town ordinances (WDNR, 2011).

County

Regulations and ordinances set by Vilas County can be found in the *Vilas County Shoreland and Zoning Ordinance* (2003). This document provides detailed information about zoning and planning near shoreland and wetland areas. The following is a brief summary of some of these regulations that inherently protect the water quality of Black Oak Lake.

Article II discusses general shoreland protection provisions. According to the Ordinance, Shorelands are defined as lands within 1,000 feet from a lake, pond or flowage; and 300 feet from a river or stream (Vilas County, 2003). In general, all structures are required to be 75 feet from the ordinary high-water mark (OHWM) of a navigable waterbody (Vilas Co., 2003).

To prevent erosion, boathouses cannot be constructed if the slope of the land is greater than 20% (Vilas Co., 2003). Similarly, no land disturbances (filling, grading, excavating, creating of impervious areas, etc.) are allowed within 35 feet of the OHWM (Vilas Co., 2003). However, an erosion control plan is required (along with a Shoreland Alteration Permit) for conducting any alterations such as: land disturbance, construction of boat landing or roadway, and/or construction on slopes (Vilas Co., 2003).

Article VIII (Removal of Trees and Shore Cover) states, “Except as set forth in this section, natural shrubbery, trees, and undergrowth shall be preserved as far as practicable on all shoreland properties, and if removed, it shall be replaced with vegetation that is equally effective in meeting the objectives of this Ordinance.” It is also prohibited to remove trees, shrubs or undergrowth within 75 feet of the lake. By keeping this vegetation, soils are less likely to erode and pollutants and contaminants are less likely to enter the water.

Land owners receive mitigation points for the width of their buffer zones. A Primary Active Buffer Zone is 35 feet from the OHWM and earns the property owner three points (Vilas Co., 2003).

Vilas County lakes have been categorized as part of the Vilas County Lakes Classification System. As quoted by the Shoreland Zoning Ordinance, “Each lake in Vilas County greater than 50 acres in surface area was individually evaluated and classified (low, medium, high) based upon its sensitivity to development and the level of existing development along privately-owned shorelines” (Vilas Co., 2003). Further, “Minimum lot size and setback requirements for specified uses were then developed based on the lake’s sensitivity level” (Vilas Co., 2003). Black Oak Lake is classified as having “high” sensitivity and a “low” level of existing development (Vilas Co., 2003, Table 1).

Local

The Town of Land O' Lakes Ordinance #2009-1, *Ordinance Regulating Construction, Subdivision, and Land Use in the Town of Land O' Lakes, Wisconsin*, has established several regulations to protect water resources in the town. Section 6-Minimum Lot Size, states that, “no building shall be constructed on a lot having less than 200 feet of water frontage and less than 60,000 square feet of land” (LOL, 2009). Section 7 declares “no boat house shall be built within seventy-five feet of the normal high-water mark...” (LOL, 2009). These regulations are set in place to benefit the water bodies of the town of Land O' Lakes.

Literature Cited

Land O' Lakes. 2009. *Ordinance Regulating Construction, Subdivision, and Land Use in the Town of Land O' Lakes, Wisconsin*. Retrieved 2014.

<<http://townoflandolakes.com/uploads/documents/Subdivision%20and%20Land%20Use.pdf>>

State of Wisconsin Legislature-a. NR 115. Wisc. Admin. Code § 115.01. *Wisconsin's Shoreland Protection Program, Purpose*. Page 145.

State of Wisconsin Legislature-b. NR 151. Wisc. Admin. Code § 151.001-151.32. *Runoff Management*. Pages 399-408.22.

Vilas County Zoning & Planning Department. June, 2003. *Vilas County Shoreland Zoning Ordinance*. Retrieved 2014. <<http://www.vilascountyzoning.com/ordinances.html>>

Wisconsin Department of Natural Resources. 2011. *The Handbook of Wisconsin Boating Laws and Responsibilities*. Boat Ed., Kalkorney, Inc. Dallas, TX. Retrieved 2014.
<<http://dnr.wi.gov/files/PDF/pubs/LE/LE0301.pdf>>

Wisconsin Department of Natural Resources. 2012. *WPDES Permits*. Retrieved 2014.
<<http://dnr.wi.gov/topic/wastewater/permits.html>>

Wisconsin Department of Natural Resources. 2014. *Aquatic Plants*. Retrieved 2014.
<<http://dnr.wi.gov/lakes/plants/>>

Review of *Headwaters Basin Integrated Management Plan* Relevant to Black Oak Lake

The *Headwaters Basin Integrated Management Plan* provides information about the conditions of the land and water resources found in the basin, and addresses the programs that strive to preserve and restore those resources. In this section, we will discuss the programs that provide assistance and protection to the water quality of Wisconsin lakes, including Black Oak Lake.

Of the 15,057 lakes in Wisconsin, 34% are located within the Headwaters Basin. The Basin spans Forest, Florence, Lincoln, Langlade, Oneida and Vilas Counties. There are 29 Outstanding Resource Waters (ORW) located within the Basin. Outstanding Resource Waters support valuable fisheries and wildlife habitats, have good water quality and are not significantly impacted by human activities (WDNR, 2013a). Black Oak Lake is considered an Outstanding Resource Water. There are five lakes within 10 miles of Black Oak Lake are considered as such: Lac Vieux Desert, Partridge Lake, Stormy Lake, North Twin Lake, and South Twin Lake. In contrast, seven waterbodies within 10 miles of Black Oak Lake are listed as Impaired Waters (303(d)): Ballard Lake, Irving Lake, Myrtle Lake, Palmer Lake, Pioneer Lake, Upper Buckatabon Lake and White Birch Lake. These waterbodies are considered impaired because of mercury contamination in fish tissues and high phosphorus values (Myrtle Lake). Nearby Big Portage Lake and Goose (Forest) Lake were previously listed as impaired because of mercury levels, but were delisted in 2010 and 2006, respectively (WDNR, 2013b). Because of Black Oak Lake's outstanding qualities, it is important to maintain that level of water quality and protect the lake from adverse impacts.

The Fisheries Management branch of the WDNR Water Division protects Wisconsin lakes by processing permits required for protecting shorelines, by helping interpret ordinances and regulations, and by providing biological and technical expertise to local units of government. They also help monitor lake levels, assist landowners in learning about lake ecology, process applications for lake management grants, and review licenses and inspections of dams (WDNR et al., 2002).

The Watershed Management branch of the WDNR Water Division, following the standards set by the Federal Clean Water Act, protects Wisconsin surface waters by writing plans for

watersheds, such as: facilities plans, 305 (b) water quality reports to Congress, and aquatic nuisance and exotic species reports. They also create water quality modeling, such as: streams and lakes water quality modeling, contaminated sediment monitoring, and wasteload allocations. The Watershed Program also proposes water quality standards and policies, such as: surface water quality classification and standards, contaminated sediment investigation, total maximum daily loads, and designation of 303 (d) water bodies (WDNR et al., 2002).

The Wastewater branch of the WDNR Water Division, following the standards set by the Federal Clean Water Act, protects Wisconsin surface waters by issuing Wisconsin Pollutant Discharge Elimination System (WDPES) permits, by reviewing industrial and municipal baseline and annual reports, and by providing information to communities about their program and its benefits (WDNR et al., 2002).

The Nonpoint Source Pollution Abatement Program, following the standards set by the Wisconsin Administrative Code, protects Wisconsin surface waters by encouraging landowners to minimize nonpoint pollution sources on their properties, by providing information about the best management practices for both rural and urban areas, and by assisting counties with implementing their land and water resource management plans (WDNR et al., 2002).

The Drinking Water and Groundwater branch of the WDNR Water Division, following the standards set by the federal Safe Drinking Water Act and the Wisconsin Administrative Code protects Wisconsin waters by enforcing standards for wells and pumps, by conducting surveys and inspections of water systems, and by reviewing water quality monitoring reports. They also provide assistance to well owners and the public (WDNR et al., 2002).

The Wildlife Management branch of the WDNR Land Division, following the standards set by the Wisconsin Administrative Code, protects Wisconsin waters by establishing State Wildlife and State Natural Areas, by conducting population and habitat surveys, developing wildlife management plans, monitoring threatened and endangered species, evaluating hunting and trapping regulations, and by educating and encouraging responsible management techniques (WDNR et al., 2002).

The Endangered Resources branch of the WDNR Land Division, following the standards set by the Wisconsin Administrative Code, protects Wisconsin waters by managing the Natural

Heritage Inventory Program (NHI), which is used to determine the existence and location of native plant and animal communities, and of Endangered or Threatened Species of Special Concern, and by providing permits for incidental take of these species (WDNR et al., 2002).

The Wisconsin Bureau of Forestry, following the standards set by the Wisconsin Administrative Code, protects Wisconsin waters by providing technical assistance to county, state and private forest lands. The Bureau helps each county forest by developing a Ten Year Comprehensive Plan, and by assisting with timber sale, reforestation, development of wildlife habitat, and protection of endangered and threatened species. On the state level, the Bureau assists with establishing the best management practices of sustainable forestry, reforestation, and timber harvesting. With private landowners, they help with establishing best management practices of sustainable forestry, help protect endangered and threatened species, and provide assistance with forest disease and insect problems (WDNR et al., 2002).

These programs have been put in place to help preserve, protect and restore the water quality of all Headwater Basin lakes, including Black Oak Lake.

Literature Cited

- Wisconsin Department of Natural Resources, Headwaters Basin Partnership Team and Stakeholders--DRAFT. 2002. *Headwaters State of the Basin Report*. Retrieved 2014. <<http://dnr.wi.gov/water/basin/upwis/>>
- Wisconsin Department of Natural Resources. 2013a. *Outstanding and Exceptional Resource Waters*. Retrieved 2014. <<http://dnr.wi.gov/topic/SurfaceWater/orwerw.html>>
- Wisconsin Department of Natural Resources. 2013b. *Wisconsin's 2012 Impaired Waters List*. Retrieved 2014. <http://dnr.wi.gov/topic/impairedwaters/2012IR_IWLIST.html>

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March 1, 2013

Vilas County Lands and Water Conservation Department
330 Court Street
Eagle River, WI 54521

To whom it may concern:

As ecological consultants, White Water Associates works with lake associations to conduct studies, review data, and create lake management plans. We have helped organizations like *High Fish-Trap Rush Lakes Association*, *Stormy Lake Association*, *Black Oak Lake District*, and *Black Oak Lake Riparian Owners* collect water quality data, fisheries data, and invasive species data, and prepare reports conveying these data. We currently have projects with these associations that are funded by the Wisconsin Department of Natural Resources. One of our tasks in these projects was to review the Vilas County Land & Water Resource Management Plan.¹ The purposes of that review are to (1) determine where our lake management efforts integrate with the county plan and (2) provide input to the county for how future iterations of the plan might better address water resource issues. It is with those purposes in mind that we submit this summary of recommendations for your consideration to further improve an already comprehensive plan.

Organization

I first recommend reorganizing the Table of Contents. For example, under Land Resources/Land Use, the sub-categories (Agriculture, Forestry, etc.) are not listed in the Table of Contents; however, that is not the case with Surface Water Resources. In the Table of Contents, after Surface Water Resources, most of the sub-categories are listed, but not all. Sections missing are: River Drainage System, Wetlands, Lakes and Streams, and Lake Classification. Instead, it may be beneficial to create two major categories: Land Resources and Water Resource and list each sub-category thereafter. This would then be reflected in the Table of Contents.

In the Water Resources section, I recommend discussing the major water types first: Basins and Watersheds, Groundwater, and Surface Waters (including River Drainage System, Lakes and Streams, and Wetlands). After these sections (and their corresponding sub-sections), I would then address Impaired Waters-303(d) Waters, and Outstanding/Exceptional Resource Waters since these subjects reflect a combination of lakes, rivers and wetlands.

¹ The Vilas County Land & Water Resource Management Plan used for this review was found at <http://www.ncwrpc.org/vilas/lwrmp.html>.

Lastly, I propose that Invasive Species becomes a new major category, placed after the Land and Water Resources sections. Since invasive species do not fall specifically under just one of these major categories, it merits a section of its own.

Content

Within the River Drainage System section, if there are any rivers associated with the Northern Rivers initiative (NRI), here would be a good place to inform the reader about NRI, and list the rivers involved.

If there are any streams classified as “trout streams,” the Lakes and Streams section would be a good place to list the names of these streams, list how many miles of streams there are, and how a stream becomes classified.

The Lakes and Streams section could also benefit from providing statistics about what lake classifications are most common in Vilas County. Listing the number of lakes that are seepage, drainage and spring would be a nice addition to this section.

The Impaired Waters section is already very thorough; however, a sentence or two describing the priority level of clean-up on these waters would be educational.

It would be informative for readers to provide information about soil associations in Vilas County. It may also be beneficial to create a table and/or a map listing each soil association and showing where in the county they are located.

Lastly, in the Wetlands section, I recommend stating the acres of wetlands in the county, and refer to the Clean Water Act (Section 404) in regard to wetland protection.

I was very impressed with the detail you have incorporated in this plan. It is thorough and comprehensive. I am sure it serves the residents of Vilas County well. If you have questions or comments regarding my recommendations, please contact me at the phone number given above.

Sincerely,

Caitlin Clarke
Biologist

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Appendix G

Qualitative Assessment of Littoral Zone and Riparian Area

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Black Oak Lake Qualitative Shoreline Summary

Prepared by White Water Associates, Inc.

A major goal of the Phase III Black Oak Lake study was a photographic and qualitative documentation of the shoreline and near-shore riparian area. The condition of the littoral zone and near shore riparian area was carefully and thoroughly documented in 2008. This assessment will stand as a baseline against which future changes can be measured. In this appendix, we summarize the findings and products of the littoral zone and riparian zone assessment.

A major component of documenting the littoral zone and near shore riparian area was a systematic coverage of the entire shoreline with digital photography. The volunteer team collected a total of 231 photos that capture the state of the shoreline in summer of 2008. This average length of shoreline captured by each photo is approximately 170 feet. Each photo was accompanied by a latitude and longitude position of the photographer. The digital photos have been incorporated into an interactive electronic archive that can be easily accessed for future reference or study. CDROM versions of the electronic archive reside with BOLROA, WDNR, and White Water Associates.

An associated product of the photographic documentation was the qualitative assessment of each of the 231 shoreline segments that were depicted in the photographs. At the time the photograph was taken, the BOLROA volunteer team did a rapid qualitative assessment of shoreline condition. This information has also been integrated into the electronic archive for future reference.

In the remainder of this appendix, we summarize the qualitative data collected during the 2008 assessment. This data will be a useful tool in identifying and planning restoration projects in the Black Oak Lake riparian area and for monitoring long-term change.

Black Oak Lake Shoreline – Development		
Type	Number of records	% records
house	145	63%
shed	11	5%
garage	5	2%
gravel drive	1	0.4%
paved drive	3	1%
lawn	31	13%
other	0	0%

For 76 segments no development was noted (33% of the segments).

Black Oak Lake Shoreline – Structures		
Type	Number of records	% records
dock	126	55%
breakwater	4	2%
stormwall	4	2%
boathouse	47	20%
rip-rap	20	9%
other	8	3%

For 81 segments no structure was noted (35% of the segments).

Black Oak Lake Shoreline – Access		
Type	Number of records	% records
none	100	43%
unimproved path	76	33%
gravel path	2	1%
chip path	0	0%
paved path	3	1%
boardwalk	13	6%
stairs	64	28%
other	2	1%

For 102 segments no access was noted (44% of the segments).

Black Oak Lake Shoreline – Beach		
Type	Number of records	% records
None	3	1%
natural	228	99%
artificial	1	0%
stable	32	14%
eroding	0	0%
other	0	0%

“Natural beach” is by far the most observed condition on the Black Oak Lake shoreline (99% of segments).

Black Oak Lake Shoreline – Vegetation		
Type	Number of records	% records
upland	147	64%
wetland	6	3%
forested	86	37%
shrub	16	7%
natural openings	0	0%
stream	0	0%
other	4	2%

Black Oak Lake Shoreline – Buffer		
Type	Number of records	% records
buffer None	14	6%
1-3 ft	3	1%
4-10 ft	23	10%
above 10 ft	187	81%
type: herbaceous	28	12%
type: shrubs	186	81%
type: trees	185	80%
type: other	3	1%

There were 44 segments (19%) where shoreline buffer was either not checked or checked with choice other than “above 10 ft”). In other words, 40 segments where the buffer was marked 10 or fewer feet in width (none, 1-3ft, or 4-10 ft) and 4 cases where it was left unmarked.

Black Oak Lake Shoreline – Erosion		
Type	Number of records	% records
none	229	99%
undercut banks/slumping	0	0%
furrows/gullies	0	0%
bare earth	3	1%
other	0	0%

Erosion was not observed along the Black Oak Lake shoreline (99% of segments).

Black Oak Lake Shoreline – Bank Height		
Type	Number of records	% records
none	157	68%
slight (< 2 ft)	56	24%
abrupt (2 ft or greater)	18	8%

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Appendix H

Quantitative Assessment of Littoral Zone and Riparian Area

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Black Oak Lake Quantitative Shoreline Summary

Prepared by White Water Associates, Inc.

We applied the U.S. EPA Lake Assessment Procedure and the Wisconsin Department of Natural Resources Supplemental Lakeshore Assessment in order to quantitatively document the Black Oak Lake littoral zone and near-shore riparian area. We summarize the results in the remainder of this Part. The methodology used and map of sample stations are provided after the data summary.

Average depth of the ten stations was 3.65 feet (range: 2 - 7 feet). No surface film was observed at any of the stations. Table 1 contains the littoral zone bottom substrate data collected from the Black Oak Lake sampling stations. Bedrock and boulders were not observed as bottom substrate in any of the stations. Silt, clay, muck was the most commonly encountered substrate type (eight of ten stations) and sand was the next most common (seven of ten stations). Gravel and woody debris substrate types were each encountered at six of the stations. Gray colored sediment was encountered at nine of ten stations (vegetation covered the sediment at the tenth station making color assessment impossible). No odor was associated with the bottom substrate in any of the ten stations.

Table 1. USEPA Habitat Characterization – Littoral Zone Bottom Substrate										
Station	A	B	C	D	E	F	G	H	I	J
Bedrock	0	0	0	0	0	0	0	0	0	0
Boulders	0	0	0	0	0	0	0	0	0	0
Cobble	0	0	0	0	0	0	1	2	1	0
Gravel	0	0	0	2	0	3	2	3	3	3
Sand	0	0	0	3	2	3	4	2	2	3
Silt, Clay, Muck	4	4	4	1	3	2	0	0	1	1
Woody Debris	1	1	0	1	0	0	1	0	1	1
Organic	0	0	4	0	2	0	0	0	0	0
Color	Gray	Gray	Veg.	Gray	Gray	Gray	Gray	Gray	Gray	Gray
Odor	None	None	None	None	None	None	None	None	None	None
Bedrock (>4000mm); Boulders (250-4000mm); Cobble (64-250mm); Gravel (2-64mm); Sand (0.02-2mm); Silt, Clay, or Muck (<0.06mm, not gritty). 0=Absent (0%); 1=Sparse (<10%); 2=Moderate (10-40%); 3=Heavy (40-75%); 4=Very Heavy (>75%)										

Table 2 presents the observations made on aquatic macrophytes in the littoral zone. Submergent macrophytes were observed at nine of ten stations. Emergent macrophytes were not observed at any of the ten stations. Five of the ten stations had floating macrophytes present. Total macrophyte cover was “absent” at three stations, “sparse” at three stations, or “moderate” at three stations. “Very heavy” total macrophyte cover was observed at one station. Macrophytes extended lakeward from the stations in eight of ten stations.

Table 2. USEPA Habitat Characterization – Littoral Zone Aquatic Macrophytes										
Station	A	B	C	D	E	F	G	H	I	J
Submergent	1	1	4	1	0	2	1	2	2	2
Emergent	0	0	0	0	0	0	0	0	0	0
Floating	1	1	4	1	0	0	0	0	0	1
Total Aquatic Macrophyte Cover	1	1	4	1	0	2	0	0	2	2
Do macrophytes extend lakeward from plot?	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	Yes
0=Absent (0%); 1=Sparse (<10%); 2=Moderate (10-40%); 3=Heavy (40-75%); 4=Very Heavy (>75%)										

Littoral zone fish cover observations are presented in Table 3. Aquatic and/or inundated herbaceous vegetation was observed at seven of ten stations, but was typically sparse (less than 10% cover). Woody debris and snags greater than 0.3 meters in diameter were observed at seven of the ten stations and had sparse or moderate coverage. Woody brush/woody debris less than 0.3 meters in diameter was found at three of the ten stations. Inundated live trees (greater than 0.3 meters in diameter) were not observed at any station. Overhanging vegetation within one meter of the surface was observed at one station. Ledges or sharp drop-offs were observed at one station and boulders were not observed at any of the ten stations. Finally, human structures (such as docks) were not observed as fish cover at any of the stations.

Table 3. USEPA Habitat Characterization – Littoral Zone Fish Cover										
Station	A	B	C	D	E	F	G	H	I	J
Aquatic & Inundated Herbaceous Cover	1	1	4	2	0	0	0	1	1	2
Woody Debris/Snags >0.3 m dia.	1	1	0	0	2	2	1	0	1	1
Woody Brush/ Woody Debris <0.3 m dia.	1	0	0	0	0	2	1	0	0	0
Inundated Live Trees >0.3 m dia.	0	0	0	0	0	0	0	0	0	0
Overhanging veg. w/in 1 m of surface	0	0	0	0	1	0	0	0	0	0
Ledges or Sharp Drop-offs	0	0	0	0	2	0	0	0	0	0
Boulders	0	0	0	0	0	0	0	0	0	0
Human Structures (docks, landings, etc.)	0	0	0	0	0	0	0	0	0	0
0=Absent (0%); 1=Sparse (<10%); 2=Moderate (10-40%); 3=Heavy (40-75%); 4=Very Heavy (>75%)										

Table 4 presents observations made on the riparian zone canopy (>5 meters high), understory (0.5 - 5 meters high), and ground cover (<0.5 meters high). Mixed (conifer and deciduous) canopy type was observed in nine of ten stations and deciduous canopy type was observed at one station. The coverage of big trees (>0.3 meters diameter) was moderate to heavy (very heavy at one station) and coverage of small trees (<0.3 meters diameter) was moderate to heavy (very heavy at two stations). Mixed conifer and deciduous understory type was observed at all stations. Coverage of understory woody shrubs and saplings was heavy (three stations), very heavy (three stations), moderate (two stations), or sparse (one station). Tall herbs, grasses, and forbes were present at nine stations with sparse coverage (five stations), heavy coverage (three stations), or very heavy coverage (one station). Ground cover woody shrubs and saplings were observed at all ten stations with coverages of sparse (two stations), moderate (six stations), and heavy (two stations). Understory herbs, grasses, and forbes were observed at all ten stations with coverages of sparse (two stations),

moderate (four stations), or heavy (four stations). Standing water or inundated vegetation was not observed at any station. Barren, bare, dirt, or buildings was observed at two stations (moderate coverage).

Table 4. USEPA Habitat Characterization – Riparian Zone										
Station	A	B	C	D	E	F	G	H	I	J
CANOPY (>5 m high)										
Type	Mix	Mix	Mix	Dec	Mix	Mix	Mix	Mix	Mix	Mix
Big Trees (Trunk >0.3 m dia.	2	1	3	3	3	3	3	2	2	4
Small Trees (Trunk <0.3 m d.	3	3	3	3	4	3	2	2	2	4
UNDERSTORY (0.5 to 5 m high)										
Type	Mix	Mix	Mix	Mix	Mix	Mix	Mix	Mix	Mix	Mix
Woody Shrubs and Saplings	3	4	4	2	4	3	2	2	1	3
Tall Herbs, Grasses, Forbes	3	4	3	1	1	1	0	1	1	3
GROUND COVER (<0.5 m high)										
Woody Shrubs and Saplings	2	3	1	2	3	2	2	1	2	2
Herbs, Grasses and Forbes	3	3	2	3	2	2	1	3	1	2
Standing Water/ Inundated Veg.	0	0	0	0	0	0	0	0	0	0
Barren, Bare Dirt, or Buildings	0	0	0	2	0	0	0	0	2	0
0=Absent (0%); 1=Sparse (<10%); 2=Moderate (10-40%); 3=Heavy (40-75%); 4=Very Heavy (>75%); Mix = Mixed conifer and deciduous; Dec = Deciduous										

Table 5 presents observations recorded on the riparian shoreline substrate zone. Bedrock or boulder substrate was not observed at any of the ten stations. Cobble substrate was observed at seven of the ten stations with sparse or moderate coverage. Gravel substrate was observed at eight of ten stations and ranged from sparse to very heavy coverage. Sand substrate was observed at nine of ten stations and ranged from sparse to very heavy coverage. Silt, clay, or muck substrate was observed at one station and had very heavy coverage at that station. Woody debris was observed at four of ten stations in light or moderate coverage. Organic (leaf pack, detritus) was observed at one station and had heavy coverage. Vegetation was observed at two of the ten stations with sparse or moderate coverage.

Table 5. USEPA Habitat Characterization – Riparian Zone – Shoreline Substrate Zone										
Station	A	B	C	D	E	F	G	H	I	J
Bedrock	0	0	0	0	0	0	0	0	0	0
Boulders	0	0	0	0	0	0	0	0	2	0
Cobble	2	0	0	0	1	1	1	2	1	2
Gravel	3	2	0	0	4	1	4	4	2	2
Sand	2	2	0	4	2	4	2	1	1	3
Silt, Clay, Muck	0	0	4	0	0	0	0	0	0	0
Woody Debris	1	0	1	0	2	2	0	0	0	0
Organic (leaf pack, detritus)	0	0	3	0	0	0	0	0	0	0
Vegetation or other	0	2	1	0	0	0	0	0	0	0
0=Absent (0%); 1=Sparse (<10%); 2=Moderate (10-40%); 3=Heavy (40-75%); 4=Very Heavy (>75%)										

Observations on human influence in the riparian zone are contained in Table 6. Human influence was quite low. Buildings were observed outside of the plot at three of the ten stations. Docks or boats were observed inside the plot at one station and outside the plot at two stations. Lawn was observed outside the plot at one station. All other human influences (commercial development, park facilities, man-made beaches, walls, dikes or revetments, landfill/trash, roads or railroads, powerline, row crops, pasture/range/hayfield, and orchards) were not observed at any of the ten stations.

Table 6. USEPA Habitat Characterization – Riparian Zone – Human Influence Zone										
Station	A	B	C	D	E	F	G	H	I	J
Buildings	0	0	0	P	P	0	0	0	P	0
Commercial	0	0	0	0	0	0	0	0	0	0
Park Facilities/ manmade beach	0	0	0	0	0	0	0	0	0	0
Docks/Boats	0	0	0	C	0	P	0	P	0	0
Walls, dykes, revetments	0	0	0	0	0	0	0	0	0	0
Landfill/Trash	0	0	0	0	0	0	0	0	0	0
Roads or Railroad	0	0	0	0	0	0	0	0	0	0
Powerline	0	0	0	0	0	0	0	0	0	0
Rowcrops	0	0	0	0	0	0	0	0	0	0
Pasture/Range/Hayfield	0	0	0	0	0	0	0	0	0	0
Orchard	0	0	0	0	0	0	0	0	0	0
Lawn	0	0	0	0	0	0	0	0	P	0
0 = Not Present; P = Present outside plot; C = Present within plot										

Table 7 reports the observations made on littoral fish macrohabitat classification. Human disturbance was observed at three of ten stations and was either low (one station) or moderate (two stations). Cover class was recorded as “patchy” at five of ten stations, as “no/little” at four stations and “continuous” at one station. Cover type was recorded as “woody” at three of ten stations, as “vegetation” at six of ten stations, and absent at one station. Dominant substrate was recorded as “sand/gravel” at seven stations and as “mud/muck” at three stations.

Table 7. USEPA Habitat Characterization – Littoral Zone Macrohabitat Classification										
Station	A	B	C	D	E	F	G	H	I	J
Human Disturbance	None	None	None	Mod	None	Mod	None	Low	None	None
Cover Class	Patchy	Patchy	Contin	No/Lit	Patchy	Patchy	No/Lit	No/Lit	No/Lit	Patchy
Cover Type	Woody	Veg	Veg	Veg	Woody	Woody	None	Veg	Veg	Veg
Dominant Substrate	M/M	M/M	M/M	S/G	S/G	S/G	S/G	S/G	S/G	S/G
Mod = Moderate; Contin = Continuous Cover; No/Lit = No or Little Cover; M/M = Mud/Muck; S/G = Sand/Gravel										

Within plot bank features are presented in Table 8. Bank angle was considered “steep” at three stations, “gradual” at six stations, and “flat” at one station. The vertical height from waterline to the high water mark was 0.3 meters at all stations. The horizontal distance from waterline to the high water mark averaged 1.8 meters (range was 1 to 3 meters).

Table 8. USEPA Habitat Characterization – Within Plot Bank Features										
Station	A	B	C	D	E	F	G	H	I	J
Angle	Grad	Flat	Grad	Grad	Steep	Grad	Steep	Grad	Steep	Grad
Vertical Height (m) from water line to HWM	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Horizontal Distance (m) to HWM	1	1	2.5	2	1.5	2	3	2	1.5	2
HWM = High Water Mark; Flat = <5 degrees; Grad = Gradual (5-30 degrees); Steep (30-75 degrees)										

None of the target invasive species were observed in the littoral plot or the shoreline/riparian plot (see Table 9).

Table 9. USEPA Habitat Characterization – Invasive Plant Species										
Station	A	B	C	D	E	F	G	H	I	J
Target Invasive Species in Littoral Plot	None	None	None	None	None	None	None	None	None	None
Target Invasive Species in Shore-line/Riparian Plot	None	None	None	None	None	None	None	None	None	None
Target Invasive Species include: Zebra or Quagga Mussel, Eurasian Watermilfoil, Hydrilla, Curly Pondweed, African Waterweed, Brazilian Waterweed, European Water Chestnut, Water Hyacinth, Parrot Feather, Yellow Floating Heart, Giant Salvinia, Purple Loosestrife, Knotweed (Giant or Japanese), Hairy Willow Herb, Flowering Rush										

The Wisconsin Department of Natural Resources Supplemental Methodology observations are presented in Tables 10 and 11. A photo was taken of each of the ten stations and these ten photos are contained in Appendix G. Table 10 shows a total of 267 pieces of small woody material (>5cm diameter) was counted all ten littoral zone transects (average of 26.7 pieces per station). A total of 46 pieces of large woody material was tabulated in the same ten transects (4.6 pieces per station on average). None of the five target invasive species (Japanese stiltgrass, reed canary grass, Phragmites, cattails, or yellow iris) were observed at any of the ten stations.

Table 10. WDNR Supplemental Methodology to USEPA Habitat Characterization – Wood and Invasive Plant Species										
Station	A	B	C	D	E	F	G	H	I	J
Wood: >5cm diameter	90	52	7	18	60	14	5	0	10	11
Wood: >10cm diameter	12	4	0	0	14	5	1	0	5	5
Invasive: Japanese stiltgrass	No	No	No	No	No	No	No	No	No	No
Invasive: Reed canary grass	No	No	No	No	No	No	No	No	No	No
Invasive: Phragmites	No	No	No	No	No	No	No	No	No	No
Invasive: Cattails	No	No	No	No	No	No	No	No	No	No
Invasive: Yellow Iris	No	No	No	No	No	No	No	No	No	No

Table 11 tabulates that seawalls, riprap, artificial beach, and pavement were not observed in either the riparian plot or the upland plot at any of the ten stations. Lawn was observed in the upland plot at one station. Residences were observed in the upland plot of three of the ten stations. Boat lifts were observed in the riparian plot of two stations and docks were observed in the riparian plot of two stations. The WNDR protocol called for counting the number of piers between each of the ten stations (this amounts to a count of the total number of piers on Black Oak Lake. Table 18 gives the counts for each of the ten intervals. A total of 122 piers were counted on the entire perimeter of Black Oak Lake.

Table 11. WNDR Supplemental Methodology to USEPA Habitat Characterization – Landcover, Human Development, and Piers										
Station	A	B	C	D	E	F	G	H	I	J
LANDCOVER (if 1 number is given it's for riparian plot; if 2 numbers given, the 1 st is for riparian plot & 2 nd for upland plot) Key: 0 (0-1%), 1 (>1-10%), 2 (>10-40%), 3 (>40-75%), 4 (>75%)										
Seawall	0	0	0	0	0	0	0	0	0	0
RipRap	0	0	0	0	0	0	0	0	0	0
Artificial beach	0	0	0	0	0	0	0	0	0	0
Lawn	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/4	0/0
Pavement	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
HUMAN DEVELOPMENT (1 number given for riparian plot; if 2 numbers, 1 st for riparian plot & 2 nd for upland plot)										
Residences	0/0	0/0	0/0	0/1	0/0	0/1	0/0	0/0	0/1	0/0
Commercial buildings	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
Structures (sheds/boat houses)	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
Boat lifts	0	0	0	0	0	1	0	1	0	0
Swim rafts	0	0	0	0	0	0	0	0	0	0
Docks	0	0	0	1	0	0	1	0	0	0
NUMBER OF PIERS BETWEEN STATIONS										
From:	A-B	B-C	C-D	D-E	E-F	F-G	G-H	H-I	I-J	J-A
Count	6	10	18	15	23	25	8	0	7	10

The U.S.EPA protocol called for a composite sample of aquatic benthic macroinvertebrates, combining net sweeps from each station into one sample. Table 12 provides the identified invertebrate taxa and counts of individuals by taxa for the composite sample. A total of twelve taxa and 192 individual organisms were identified.

Table 12. Composite Benthic Macroinvertebrate Sample from Black Oak Lake			
Taxon	Count	Taxon	Count
Annelida:Oligochaeta (aquatic worm)	2	Zygoptera (damselflies): Coenagrionidae	6
Crustacea: Amphipoda (freshwater shrimp, scuds)	75	Trichoptera (caddisflies): Limnephilidae	2
Crustacea: Decapoda (crayfish)	1	Diptera (true flies): Ceratopogonidae	32
Crustacea: Isopoda (isopods)	26	Diptera (true flies): Chironomidae (midges)	9
Ephemeroptera (mayflies): Baetidae	21	Gastropoda (snails): Physidae	2
Anisoptera (dragonflies): Libellulidae	10	Gastropoda (snails): Planorbidae	6

Finally, the U.S.EPA protocol called for a “fecal indicator” sample at the final sampling station (Station J). In the case of Black Oak Lake, we analyzed the sample collected at Station J for *Escherichia coli* (*E. coli*). One sample and one duplicate were collected. The *E. coli* analysis resulted in values of 1 and 0 CFU (“colony forming units”) per 100 milliliters of sample. To place this value in context, the U.S.EPA recommends a water quality advisory (for swimming) when levels of the indicator bacterium *E. coli*, exceeds a limit is 235 CFU in 100 milliliters of water.

5.0 LITTORAL AND SHORELINE ACTIVITIES

To better understand the character of near-shore habitats and conditions, the Lakes Survey team will travel to 10 evenly spaced physical habitat ("P-Hab") stations around the lake and document conditions and characteristics observed within a defined plot area. The full array of measurements and sampling described in this chapter include:

- measures or observations of littoral and riparian physical habitat structure at 10 P-Hab stations;
- observations of invasive plants and macroinvertebrates;
- sampling of benthic macroinvertebrates at each of the 10 stations and composited as a single sample; and
- collection of water sample at the last P-Hab station for fecal indicator (Enterococci) analysis.

It should be noted that for lakes with a surface area of greater than 5,000 ha (defined as Large Lakes) the Lakes Survey team will not be required to travel to the P-Hab stations and perform physical habitat assessments or benthic macroinvertebrate sampling due to the increased level of effort required to complete such large areas. Additionally, such lakes will require modified procedures for collecting the fecal indicator (see Section 5.3).

5.1 Physical Habitat Assessment

5.1.1 Summary of Method

Figure 2-2 displays the placement and distribution of P-Hab stations around the lake. The plot at each station measures 25 m by 15 m and include portions of the riparian zone (shoreline and uplands) and the littoral zone. Figure 5-1 displays the plot dimensions of a P-Hab station used in the Lakes Survey.

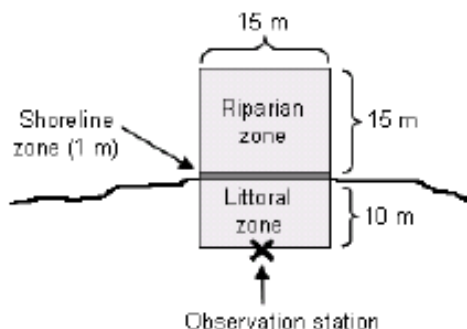


Figure 5-1. Dimensions and layout of a P-Hab station.

The approximate locations of the 10 stations are determined prior to the sampling visit and marked on the Lake Outline Sketch to be attached to the Lake Verification Form, Side 2 (Figure 3-2b). Once on the water, the Lakes Survey field team travels to a station and establishes the dimensions of the survey plot. The survey begins by estimating an observation

location 10 m (perpendicular) from the shoreline. This spot may be marked with a buoy and is the vantage point from which the team records riparian observations, and is also the point that separates the open water from the rectangular littoral plot. The remaining dimensions of the plot are visually estimated.

The riparian portion of the plot extends 15 m into the upland (beginning at the shoreline) and 15m along the lakeshore (15 m is about 3 standard canoe lengths). In this zone the team records information about the vegetation type and the height and areal coverage of trees, shrubs, and grasses. Observing the shoreline, they record information about shoreline substrate (e.g., gravel, sand), the high-water mark, and bank slope. Anthropogenic activities and other features (e.g., buildings, land use, docks) will also be noted.

The littoral region of the lake is that portion of the shoreward profile susceptible to the habitation of autotrophic plants, and includes the region of fluctuating water level between the high and low water marks (Ruttner 1969). The littoral portion of the plot measures 10 m distance from buoy to shoreline and 15 m across (7.5 m on either side of the boat). At the shore station 10 m offshore, the field team measures the water depth. They note any surface film or algae growth in the zone and probe the sediments to determine the type (e.g., gravel, sand) and areal cover of each bottom substrate type. In addition they estimate the areal cover of macrophytes and habitat/cover within the littoral plots using a simple coding system. All these observations are recorded on Side 1 of the Physical Habitat Characterization Form (Figure 5-2a). Physical habitat comments are recorded on the bottom half of Side 2 of the form (Figure 5-2b).

5.1.2 Equipment and Supplies

Table 5-1 provides the equipment and supplies needed for field operations to locate the P-Hab stations and conduct the physical habitat assessment. Field teams are to record the physical habitat observations on the Physical Habitat Characterization Form, as seen in Figure 5-2 (a) and (b).

Table 5-1. Equipment and supplies list for Physical Habitat Assessment.

Item	Quantity
Physical Habitat Assessment	
Sonar	1
GPS unit with manual, reference card, extra battery pack	1
Anchor with 50-m line	1
Float to attach to anchor	1
Surveyor's tape	1 roll
Lake Verification Form	1
Physical Habitat Characterization Forms	10
Field notebook	1
Quick reference field operations handbook	1
PVC sounding rod, 3-m length, marked in 0.1 m increments	1
Buoy for marking observation point	1

5.1.3 Locating the Physical Habitat Stations and Defining the Shoreline Boundary

A Lake Outline Sketch from a 1:100,000 topographic map should be recorded on Side 2 of the Lake Verification Form (Figure 3-2a). (Alternatively, a photocopy of the lake may be made and attached to the form, as long as the top of the copy has a continuous strip of tape going across it; if there are gaps it will catch in the scanner). A random starting point (i.e., Station A) on the lake outline should then be assigned prior to beginning sampling activities (e.g., in the office before beginning field work). Any reasonable method may be used to randomly select the starting point (e.g. tossing a coin on the map, place a compass on the map in the center of the lake and find due north). It is important that the remaining nine stations be located at equal distances around the lake going in a clockwise direction (see Figure 2-2). This can be done using a string to trace the perimeter of the lake, which can then be straightened and marked in equal intervals, or by using a planimeter wheel to measure the perimeter and dividing by 10. Coordinates entered as GPS waypoints greatly facilitate correctly locating P-Hab stations by boat in the field, especially on large lakes.

Starting at the nearest boat access point, proceed by boat around the lake near the shore, observing bank, shoreline, emergent, and subsurface characteristics. Using the Lake Outline Sketch and a topographic map or GPS unit, locate and stop at each of the 10 P-Hab stations. Position the boat at a distance of 10 m (~30 ft, offshore), anchor if necessary, and make the semi-quantitative measurements on the Physical Habitat Characterization Form, (Figure 5-2a and b). A separate Physical Habitat Characterization Form will be completed for each station. Make every reasonable attempt to record physical habitat observations and measurements for all 10 P-Hab stations. Where this is impossible, record a "K" flag in each field to clearly indicate on the form that no observations could be made at that particular station.

PHYSICAL HABITAT CHARACTERIZATION - LAKES

SITE ID: NLA06608 - 9999 DATE: 05/01/2007

STATION: ☒ A ☐ B ☐ C ☐ D ☐ E ☐ F ☐ G ☐ H ☐ I ☐ J DEPTH AT STATION (to nearest 0.1 m) 2.0 m LAT 33.07900

IF STATION WAS RELOCATED, INDICATE HERE: ☐ DROPPED: ☐ LONG 096.94020

NEW STATION (N, S, etc.): IS IT AN ISLAND? ☐ UNABLE TO SAMPLE: ☐

LITTORAL ZONE

Surface Area: ☒ None ☐ None ☐ Algal Bed ☐ Clay ☐ Other

1 = Algal Bed (100%) 2 = Sparse (10-99%) 3 = Moderate (10-49%) 4 = Dense (50-99%)

BOTTOM SUBSTRATE Flag

Bedrock (>400mm, larger than 4 cm) 0 1 2 3 4

Bedrock (150-400mm, smaller than 4 cm) 0 1 2 3 4

Silt/clay (64-250mm, terminal ball-breakable) 0 1 2 3 4

Gravel (2-64mm, only if in terminal ball size) 0 1 2 3 4

Sand (0.06-2mm, gritty between fingers) 0 1 2 3 4

Silt, Clay, or Muck (<0.06mm, not gritty) 0 1 2 3 4

Woody Debris 0 1 2 3 4

Color: ☒ Green ☐ Blue ☐ Grey ☐ Red ☐ Other

Other: ☒ None ☐ H₂O ☐ Amino ☐ CO₂ ☐ Chemical ☐ Other

AQUATIC MACROPHYTES Flag

Submerged 0 1 2 3 4

Emergent 0 1 2 3 4

Floating 0 1 2 3 4

Total Aquatic Macrophyte Cover: 0 1 2 3 4

Do macrophytes extend lakeward? ☐ Yes ☒ No

FISH COVER Flag

Aquatic and Inland Forest/Grass Veg. 0 1 2 3 4

Woody Debris/Grass > 0.3 m dia. 0 1 2 3 4

Woody Debris/Grass < 0.3 m dia. (all or dead) 0 1 2 3 4

Inland Forest Line Trees < 0.3 m dia. 0 1 2 3 4

Overhanging Veg. within 1 m of Surface 0 1 2 3 4

Ledges or Sharp Dropoffs 0 1 2 3 4

Buildings 0 1 2 3 4

Human Structures: Docks, Landings, etc. 0 1 2 3 4

RIPARIAN ZONE

1 = Absent (0%) 2 = Sparse (10-29%) 3 = Moderate (30-49%) 4 = Dense (50-99%)

CANOPY (>5 m high) Flag

Deciduous ☐ Broad ☒ None ☐ Coniferous

Big Trees (Trunk > 2 m dbh) 0 1 2 3 4

Small Trees (Trunk < 2 m dbh) 0 1 2 3 4

UNDERSTORY (0.5 to 5 m high) Flag

Deciduous ☐ Broad ☒ None ☐ Coniferous

Woody Shrubs & Saplings 0 1 2 3 4

Tall Herbs, Grasses, & Forbs 0 1 2 3 4

GROUND COVER (<0.5 m high) Flag

Woody Shrubs & Saplings 0 1 2 3 4

Herbs, Grasses and Forbs 0 1 2 3 4

Standing Water or Inundated Vegetation 0 1 2 3 4

Barns, Bare Docks or Buildings 0 1 2 3 4

SHORELINE SUBSTRATE ZONE Flag

Bedrock (>400mm, larger than 4 cm) 0 1 2 3 4

Bedrock (150-400mm, smaller than 4 cm) 0 1 2 3 4

Silt/clay (64-250mm, terminal ball-breakable) 0 1 2 3 4

Gravel (2-64mm, only if in terminal ball size) 0 1 2 3 4

Sand (0.06-2mm, gritty between fingers) 0 1 2 3 4

Silt, Clay, or Muck (<0.06mm, not gritty) 0 1 2 3 4

Woody Debris 0 1 2 3 4

Vegetation or other 0 1 2 3 4

HUMAN INFLUENCE Flag

0 = Not Present P = Present outside plot C = Present within plot

Buildings 0 P C

Commercial 0 P C

Park Facilities 0 P C

Deciduous 0 P C

Woods, Grass, or Inundated 0 P C

Landfill/Trash 0 P C

Scrub or Pasture 0 P C

Row Crops 0 P C

Pasture/Grassland Field 0 P C

Orchard 0 P C

Lawn 0 P C

Human Influence Zones

Flag codes: 0 = Not present or no measurement; 1 = 2 = Sparse measurement or measurement; 3 = 4 = Moderate measurement; 5 = 6 = Dense measurement; 7 = 8 = Very dense measurement; 9 = 10 = Extreme measurement.

2007 Physical Habitat Characterization Form - Lakes 01/05/2007

Draft

Figure 5-2(a). Physical Habitat Characterization Form, Side 1.

PHYSICAL HABITAT CHARACTERIZATION - LAKES (continued)																											
SITE ID: <u>NLA0608 - 9999</u>			DATE: <u>05/01/2007</u>																								
LITTORAL FISH MICROHABITAT CLASSIFICATION			BANK FEATURES (within plot)																								
Human Disturbance	☐ None ☒ Low ☐ Moderate ☐ High		Angle (see figure below)	☒ Flat (<5°) ☐ Gravelly (5-30°)																							
Cover Class	☐ No/Little Cover ☒ Patchy Cover ☐ Continuous Cover			☐ Steep (30-75°) ☐ Near vertical/undercut (>75°)																							
Cover Type (mark all that apply)	☐ Artificial ☐ Boulders ☐ Fill ☐ Woody ☒ Vegetation ☐ None		Vertical height from waterline to high water mark:		<u>0.5</u> (m)																						
Dominant Substrate	☐ Mud/Muck ☒ Sand/Gravel ☐ Cobble/Boulder ☐ Bedrock		Horizontal distance from waterline to high water mark:		<u>10.0</u> (m)																						
INVASIVE PLANTS AND INVERTEBRATES																											
Littoral Plot			Shoreline/Riparian Plot																								
SPECIES	Mark if observed	FLAG	SPECIES	Mark if observed	FLAG																						
NONE OBSERVED	☒		NONE OBSERVED	☐																							
Zebra or Quagga Mussel	☐		Purple loosestrife	☒																							
Eurasian watermilfoil	☐		Knotweeds	☐																							
Hydrilla	☐		Hairy willow herb	☐																							
Curly pondweed	☐		Flowering rush	☐																							
African waterweed	☐			☐																							
European water chestnut	☐			☐																							
Water hyacinth	☐			☐																							
Parrot feather	☐			☐																							
Yellow floating heart	☐			☐																							
Giant salvinia	☐			☐																							
	☐			☐																							
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 10%;">Flag</th> <th style="width: 90%;">Comments</th> </tr> </thead> <tbody> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> </tbody> </table>						Flag	Comments																				
Flag	Comments																										
			Bank Angle Classes																								
Flag codes: N = No measurement or observation made; U = Suspect measurement or observation; F1, F2, etc. = misc. flags assigned by field crew. Explain all flags in comment section.																											
2007 Physical Habitat Characterization Form - Lakes 03/28/2007																											

Figure 5-2(b). Physical Habitat Characterization Form, Side 2.

5.1.3.1 Shoreline Adjustments

Once in the field, the field team might run into conditions or problems that will require modifications to the shoreline and/or station location(s) as drawn on the Lake Outline Sketch. If this occurs, the field team makes the corrections and adjustments on the Lake Verification Form and the Physical Habitat Characterization Form and notes reasons on the comments section of the form. The general guidelines for locating or modifying the location of the littoral and shoreline stations are summarized in Table 5-2.

Table 5-2. General guidelines for locating or modifying the location of littoral and shoreline stations.

At Each Physical Habitat (P-Hab) Sampling Station:

1. Locate station using maps, aerial photos, or GPS units.
2. Define shore as either the current waterline OR the boundary between open water and the edge of dense vegetation (terrestrial, wetland, or emergent vegetation) or extensive very shallow water. (Shoreline defined by limit for navigating sample boat.)
3. If the shoreline observed in the field differs from the mapped shoreline, enter a comment on the Physical Habitat Characterization Form (Side 2) stating the apparent reason (e.g., drought, flooding, dredging). Mark "Station Relocated" on side 1.
4. If a P-Hab station is lost because of shoreline changes, position one or more new stations at approximately equal intervals. Mark "Station Relocated" at the top of the Physical Habitat Characterization Form.
5. If a station is eliminated, enter "K" flags on the Physical Habitat Characterization Form to indicate no observations, mark the "Station Dropped" box.
7. If the shoreline observed in the field differs radically from the Lake Outline Sketch and you are sure you are at the correct lake, draw a new map on the same page as the original lake. Use a string to measure the new outline, divide it into 10 equal parts, and lay out the 10 station locations.
8. At each of the 10 P-Hab stations, position the boat at an observation point 10 m from shore. Drop buoy at observation point, or maintain position while anchored.
9. Limit shoreline and riparian observations to an area 15 m (50 ft) wide by 15 m (50 ft) inland from shore, and littoral observations to an area 15 m wide (50 ft) by 10 m (30 ft) from shore to the boat.
10. Record littoral and riparian characteristics on side 1 of the Physical Habitat Characterization Form. Record any observed invasive plants and invertebrates, as well as any additional comments on side 2 of the Physical Habitat Characterization Form.

The shoreline is defined as the interface between "lake-like" conditions and riparian or wetland conditions. In most cases the shoreline will be easily identified as the current waterline. In some instances, however, the shoreline might not be obvious. Listed below are some general situations and rules that should be applied.

- If there has been a big drop in lake level due to drought, dam repair, or other reasons, shallow areas may be exposed that are usually covered with water. In this case, consider the current waterline as shoreline for the purposes of this survey, not the normal waterline.
- If there are extensive very shallow areas, or shoal-type areas, consider the shoreline to be the boundary between the shallow area and deeper open water, as defined by ease of access by small sampling boat.

- If access to the true shoreline is prevented by an area of dense aquatic or terrestrial vegetation, consider the shoreline to be the boundary between the vegetation and deeper open water. Again define the operational shoreline by ease of access by small sampling boat.

All adjustments to the shoreline based on field observations should be drawn directly on the Lake Outline Sketch and noted in the comments section of the Physical Habitat Characterization Form. If the Lake Outline Sketch does not in any way match the lake shoreline, the field team will need to draw a new sketch map approximating the shoreline, and establish the 10 P-Hab stations. A quick way to locate 10 evenly-spaced P-Hab stations is to: (a) lay a piece of string on the lake perimeter, (b) pick up the string, measure it, and mark out 10 equal parts, and (c) lay the string back on the perimeter and use the marks to locate the 10 sites on the map.

5.1.3.2 Relocating, Adding, and Eliminating Stations

The goal of the physical habitat survey is to characterize the lakeshore based on observations of conditions at 10 evenly spaced P-Hab sites around the lake. Adjustments to station locations might be needed if the field team runs into unusual conditions or problems. Below are some rules concerning modifications to the station location(s).

Actual shoreline is different than appears on the map

- If only a small portion of the shoreline differs and it does not affect, or only slightly affects, a P-Hab site location, sketch the lake shoreline on the Lake Outline Sketch and reposition the station (if needed).
- If the difference causes a contraction of the shoreline and a P-Hab station location is lost, the field team should sketch the lake shoreline on the Lake Outline Sketch and make a decision to (a) keep the station, relocate it on the revised shoreline map and adjust some or all other stations in order to keep stations evenly spaced around the lake (i.e., keep 10 stations), or (b) eliminate the station altogether (i.e., reduce the number of stations).
- If the difference causes an expansion of the shoreline the team should sketch the lake shoreline on the Lake Outline Sketch and make a decision to (a) add one or more stations, mark them on the revised shoreline map and adjust some or all other stations if needed so they are evenly spaced around the lake (i.e., designate more than 10 stations), or (b) adjust the stations so they are evenly spaced around the lake (i.e., keep 10 stations). On larger lakes the field team should try to maintain the goal of 10 stations.

P-Hab Station is inaccessible

- If a P-Hab station is inaccessible the field team must make a decision to (a) relocate the station and adjust some or all other stations so they are evenly spaced around the lake (i.e., keep 10 stations), or (b) eliminate the station altogether (i.e., reduce the number of stations). The size of the lake will help drive this decision. On larger lakes the field team should try to maintain the goal of 10 stations.

5.1.3.3 Identifying Relocated and New Stations on the Form

The field team should use the following notations when recording station location modifications.

- If a station is relocated, note the new location on the Lake Outline Sketch and check the appropriate original station letter (e.g., "C") on that form. The team also must check the box for the station letter on the Physical Habitat Characterization Form and check the box for "Station Relocated".
- If a station is lost and cannot be replaced, cross out the original station location on the pre-printed Lake Outline Sketch and check the box for "Station Dropped" on the Physical Habitat Characterization form, fill in each of the data boxes with "K" to indicate that no observations were made at the designated station, and note the reason in the comments.
- If one or more stations are added, check the nearest station locations on the Lake Outline Sketch, and fill in the box for "New Station" on a blank Physical Habitat Characterization Form.

5.1.4 Physical Habitat Characterization Form and Instructions

At each P-Hab station, make observations and measurements of the shoreline from the boat which is 10 m offshore (estimated by eye). It is important to stay 10 m from shore and to limit bank and shoreline observations at each station to the area that is within the defined plot dimensions. The littoral and riparian observation plots have fixed dimensions (Figure 5-1) that are estimated by eye. Littoral measurements pertain to the water and lake bottom in the 10 m (30 ft) distance between the boat and the shoreline and extending 15 m (50 ft) along the shore. Riparian observations at each station pertain to the adjacent land or wetland area that is 15 m wide and extends 15 m back onto land. The bank angle and shoreline substrate observations refer to a narrower shoreline zone that extends 1 m landward from the present waterline.

The shoreline boundary is defined as the approximate interface between "lake-like" conditions and riparian or wetland conditions. In cases where the lake shoreline is not obvious (e.g., where there is evidence of large seasonal change in lake level) define the shoreline as the current waterline. In cases where the lake shoreline is not visible, define the lake shoreline as the approximate boundary between open water and swamp or marsh conditions into which your boat could not easily move.

Use the rating system based on areal coverage in evaluations of riparian vegetation, shoreline substrate, littoral bottom substrate, fish cover, and aquatic macrophytes. The five entry choices range from 0 (absent) to 4 (>75% cover) and are defined in Table 5-3, which lists steps required to complete the Physical Habitat Characterization Form (Figures 5-2a and b). The second page of the form has space for comments. When estimating cover or substrate type, mixtures of more than one class might all be given sparse (1), moderate (2), or heavy (3) rankings. One dominant class with no clear subdominant class might be ranked very heavy (4) with all the remaining classes either sparse (1) or absent (0). Two dominant classes with more than 40 percent cover can both be ranked 3.

Table 5-3. Completing the physical habitat characterization form.

General	1. Fill in a Physical Habitat Characterization Form at each of the 10 P-Hab stations, clearly indicating station from which the observations have been made. 2. Survey plot dimensions: • Riparian Vegetation – 15 m along shoreline and 15 m back onto land. • Shoreline Substrate and Bank Angle – 15 m along shore and 1 m back. • Littoral (in lake) – 15 m along shoreline and 1 m out into lake 3. Use semi-quantitative ranking for vegetation, substrate, aquatic macrophytes & fish cover: • Very heavy (greater than 75% coverage) = 4 • Heavy (40 to 75% coverage) = 3 • Moderate (10 to 40% coverage) = 2 • Sparse (present, but less than 10% coverage) = 1 • Absent = 0
Littoral Habitat	1. Measure lake depth 10 m from shore at each P-Hab station, noting new location if the point has to be relocated for some reason. 2. Note the presence or absence of water surface scums, algal mats, or oil slicks. 3. Determine the lake bottom substrate visible from the boat. If the bottom is not visible, attempt to collect a sample or characterize by remote sensing with a sounding tube (e.g., PVC tubing). 4. Rank the littoral substrate sediment particle size, making multiple probes if the bottom is not visible. If the bottom is covered with logs, sticks, or other organic debris, choose "woody debris." If the substrate is concealed and remote sampling is not possible, use "Not observed" flag (K). 5. Note sediment color and odor if a sample can be seen or collected. 6. Estimate the areal coverage of the three individual aquatic macrophyte types and the areal coverage of all three types combined: submerged, emergent, and floating within the 10 x 15 m plot between the boat and shoreline. If you cannot see or probe the bottom, move closer to shore and note your new location with a Flag in the "Bottom Substrate" section. 7. Record fish habitat cover observed from the shore to the boat and 15 m along shore. 8. Record fish habitat macrohabitat classification for the general vicinity visible from the sampling station 10 m by 15 m littoral area. 9. Record invasive plant or invertebrate species observed.
Riparian Habitat	1. Divide shoreline vegetation into 3 categories: • Greater than 5 m high = canopy layer • 0.5 to 5 m high = understory layer • Less than 0.5 m high = ground cover layer <i>(Grasses or woody shrubs and tree branches can occur in >1 layer. The ground cover layer may be vegetation, water, barren ground, or duff.)</i> 2. Record the type of vegetation in the two tallest shoreline vegetation layers (canopy & understory) as none, deciduous, coniferous, broadleaf evergreen, or mixed. Define mixed as a segment where at least 10% of the areal coverage is made up of the alternate vegetation type. 3. Estimate the areal cover of the shoreline vegetation, recording the % of each coverage type within 3 vegetation classes (canopy, understory, and ground cover): 4. Rate the shoreline substrate 1 m into the riparian plot for areal coverage in particle size classes shown on the Physical Habitat Characterization Form. 5. Describe the angle of the shoreline bank back 1 m from the edge of the water 6. Estimate the vertical and horizontal distances between the present lake level and the high water line. 7. Record presence of each human influence type 8. Record invasive plant or invertebrate species observed.

On the human influence entry fields, mark "C" if present within the shoreline or littoral plot. Record a "P" if visible but adjacent or behind (outside) the plot, or "0" for absence of listed features. "Adjacent" is defined as found within a hypothetical plot of equal size to the right or left of the sampling plot. If, for some reason, you cannot make measurements at a station, record a "K" flag in all data fields for that station. This entry is very important, as there is no other way of determining whether your intent is to record the absence of features or to denote a missed station.

For any particular measurement variable, if no effort is made to collect data, or if you make an effort but for some reason are unable to obtain data, enter a "K" flag in the flag field. Explain on the Physical Habitat Characterization Form, Side 2 (Figure 5-2b) in the section designed for comments why data could not be obtained. If you collect data for a variable but have reason to believe it is suspect (or it was collected using a nonstandard protocol), enter a "U" flag in the flag field. In the comments section, explain why you think it is suspect (or describe what nonstandard procedure was used and why). If there is unusual or otherwise relevant information critical to interpreting data entered on the form, enter sequential flags (F1, F2, F3, etc.), and explain these flags in the comments section. Numbered "F" flags pertain to the front and back side of each individual form.

5.1.5 Littoral Zone Habitat Characterization

Lake depth at the observation point 10 m (30 feet) offshore in each littoral station is taken using the sonar, calibrated Secchi disk line, or the marked PVC sounding rod. Record the presence or absence of water surface scums, algal mats, or oil slicks. All measurements or observations in the following categories are recorded on the Physical Habitat Characterization Form (Figure 5-2a).

5.1.5.1 Bottom Substrate

To characterize littoral bottom substrate, restrict observations to the substrate you can detect from the boat. If you can't see the bottom, examine sediment indirectly using a long tube (e.g., the 3-m PVC sounding rod). Probe the bottom beneath the boat with the sounding rod (you may have to move closer to shore if too deep to use rod). Soft sediment can be brought to the surface for examination. Hard sediments can be "felt" with the sounding rod. Sandy substrate can be "felt" or "heard" by twisting the sounding rod and detecting grittiness. If you had to move into shallow water to use sounding rod to observe sediment characteristics, flag the observation and record (on the Physical Habitat Characterization Form comments section) the depth where you observed the sediment. Rate the cover of substrate sediment particle sizes that have very heavy, heavy, moderate, sparse, and absent areal coverage. Base these ratings on visual observations and judgments using the size classes defined on the form. If the bottom is covered with logs, sticks, or other organic debris, choose "woody debris." If the substrate is obscured by vegetation and you cannot obtain a PVC sounding rod sample, enter a "K" flag to denote "no observation made", and explain reason in comment field on back of form. However, probing with the sediment tube usually makes it possible to determine if the sediment is soft (therefore either Sand or Silt/Clay/Muck).

Sediment color and odor are subjective observations to be noted on the form, whenever possible. Select "None" or "Other" if sediment color does not match one of the categories. For sediment odor, the choices are "H₂S" (sulfurous, rotten egg), "Anoxic" (sewage odor), "Chemical" (strong odor like turpentine, paint, etc.), "Oil", or "Other" (including musty, no odor,

organic, and fishy odors). If "Other" is indicated, explain the observation on the comment form.

5.1.5.2 Aquatic Macrophytes

To characterize aquatic macrophytes, separately estimate the areal coverage (as defined in Table 5-3) within the lake area between your boat and the shoreline for each of the three aquatic macrophyte types:

- submerged,
- emergent (has erect portions above the water surface), and
- floating (either rooted or non-rooted vegetation)

Count any plant as being in only one of these types. Then estimate the coverage of all combined types of aquatic macrophytes in the same area. You may have to probe the bottom with the PVC sounding tube or your anchor if the water is turbid. Indicate ("yes" or "no") if the aquatic macrophytes extend further out into the lake than the area included in your observation area (i.e., more than 10 m [or 30 ft] from shore).

5.1.5.3 Fish Habitat Cover

Evaluate the areal cover of the listed types of fish habitat and cover features that are in the water and shoreline within the 10 x 15 m littoral portion of the field of vision at each P-Hab station (Table 5-3). Select a rating of 0 (absent) to 4 (>75% cover) based on the abundance of the various fish cover types (Table 5-3). These features are within or partially within the water and conceal fish from aquatic and terrestrial predators such as larger fish, otters, kingfishers, and ospreys.

- Aquatic and Inundated Herbaceous Vegetation -- submerged, floating, or emergent live aquatic or non-woody herbaceous plants
- Woody Debris/Snags -- inundated or partially inundated dead trees, branches, or rootwads with diameter >0.3 m (1 ft)
- Woody brush/woody debris -- inundated dead or living woody vegetation <0.3 m diameter.
- Inundated Live Trees -- inundated portions of trees >0.3 m in diameter
- Overhanging Vegetation -- <1 m from the water surface (do not include higher overhanging vegetation, which might provide perches for birds such as kingfishers)
- Ledges or Sharp Dropoffs -- overhanging banks, submerged rock shelves, and steep sloping rock walls
- Boulders -- >basketball size
- Human Structures -- docks, barges, houseboats, swimming platforms, tires, car bodies, and habitat enhancement structures (e.g., log rafts)

5.1.5.4 Littoral Fish General Macrohabitat Habitat Classification

At each physical habitat station, classify the general category of fish macrohabitat in the general vicinity of the sampling station. The hierarchical classification system defined in Table 5-4 consists of four levels. The first classification level refers to disturbance: is there major human influence in the littoral zone (not the shore) or is this area in a more or less natural state (including largely recovered areas)? The second level refers to the presence of cover: is there

cover for fish or open water or a mixture of the two? The third level defines the kind of cover: human influence includes "structures" (e.g., docks, boats, floating platforms) and "fill" (e.g., revetment boulders, trash); natural areas include in-lake vegetation, boulders, or woody materials or a mixture. The fourth level describes substrate. Check the appropriate box for each category on the Physical Habitat Characterization Form, Side 2 (Figure 5-2b).

Table 5-4. Littoral macrohabitat characteristics.

Littoral Fish Macrohabitat Classification	Classify the habitat for fish into the following categories for each respective level:
	1st level (in-lake disturbance) High, Med, or Low 2nd level (in-lake cover) Cover (major fish cover), <u>O</u>pen, or <u>M</u>ixed (patchy). 3rd level (cover type) Artificial Structure (docks, boats), Fill (revetment, boulders, etc.), Vegetated, Woody, Boulders, Mixed (a combination), or None. 4th level (dominant substrate) Mud/Muck, Sand/gravel, Cobble/Boulder, or Bedrock.

5.1.6 Riparian Zone Habitat Characterization

The riparian habitat characterization includes riparian vegetation cover, shoreline substrate, bank features, and human influences. Record all measures or observations for these categories on the Physical Habitat Characterization Form (Figures 5-2a with comments on 5-2b).

5.1.6.1 Riparian Vegetation Cover

To characterize riparian vegetation, observe the visible area from the shoreline back a distance of 15 m (50 ft) from the shore. If the high water mark is more than 15 m away from shore, the riparian plot includes parts of the shore that are sometimes inundated. On the other hand, if the "shoreline" boundary (defined as the approximate interface between "lake-like" conditions and riparian or wetland conditions) is an inundated wetland, then this area includes the wetland vegetation, or aquatic macrophytes. Conceptually divide the shoreline vegetation into three layers:

- Canopy (>5 m high)
- Understory Layer (0.5 to 5 m high)
- Ground Cover Layer (<0.5 m high)

Note that several vegetation types (e.g., grasses or woody shrubs) can potentially occur in more than one layer. Similarly note that some things other than vegetation are possible entries for the "Ground Cover" layer (e.g., water or barren ground), as indicated in Table 5-3. Before estimating the areal coverage of the vegetation layers, record the type of vegetation in each of the two taller layers (Canopy and Understory).

- deciduous,
- broadleaf evergreen,
- coniferous (needle-leaved, usually evergreen),

- mixed, or
- none

Consider the layer "Mixed" if >10% of the areal coverage is made up of the alternate vegetation type.

5.1.6.2 Shoreline Substrate

Rank, by areal coverage (very heavy, heavy, moderate, sparse, and absent) particle size classes of the substrate that are visible in the 1-m wide (terrestrial) strip nearest to the lake shoreline. These size estimates are made by eye from the boat, using the size classes and cover class ratings defined on Side 1 of the Physical Habitat Characterization Form (Figure 5-2a). If the inorganic substrate is obscured by vegetation, choose "Vegetation or Other"; if there is another type (e.g., organic flotsam), record its coverage rank in the "Vegetation or Other" category and then identify the category in the comments section.

5.1.6.3 Human Influences

Select "C" for any and all of the human activities and influences that you observe within the defined lake and riparian observation areas. If present (15 x 15 m areas to left and right) adjacent to the plot or within your field of vision behind (outside) the defined observation area, choose "P." Select "0" if human activity is not present in either lake or riparian areas.

5.1.6.4 Bank Type and Evidence of Lake Level Changes

Choose the bank angle description that best reflects the current shoreline that is dominant within your field of vision and 1 m into the riparian plot: Near vertical/undercut (>75 degrees, steep (>30 to 75 degrees; need hands to climb up), gradual, (5 to 30 degrees; can walk up), or flat (< 5 degrees). Estimate the vertical difference between the present level and the high water line (using survey pole and level or visual estimation); similarly, estimate the horizontal distance up the bank between current lake level and evidence of higher level (usually done using a laser range finder).

5.1.7 Invasive Plants and Invertebrates

Record if any invasive plant and invertebrate species listed in Table 5-5 have been observed within the habitat plot. Check the boxes on the side 2 of the Physical Habitat Characterization Form (Figure 5-2b) for any species observed within either the littoral or shoreline/riparian plots.

Table 5-5. Invasive plants and invertebrates.

Littoral Species	• Zebra (or Quagga) mussel • Eurasian watermilfoil • Hydrilla • Curly pondweed • African waterweed	• European waterchestnut • Water hyacinth • Parrot feather • Yellow floating heart • Giant salvinia
Shoreline/Riparian Species	• Purple loosestrife • Knotweed	• Hairy willow herb • Flowering rush

5.2 Benthic Macroinvertebrate Sampling

5.2.1 Summary of Method

Benthos are collected using a semi-quantitative sampling of multiple habitats in the littoral zone of lakes using a D-frame dip net (Figure 5-3). Sample collection is stratified on the following three specific habitat types: rocky/cobble/large woody debris; macrophyte beds; and organic fine muds or sand.



Figure 5-3: D-frame net used for collecting benthic macroinvertebrates.

5.2.2 Equipment and Supplies

Table 5-6 provides the equipment and supplies needed for field operations to collect benthic macroinvertebrates. Field teams are to record the benthic macroinvertebrate sampling data on the Lake Shoreline Sample Collection Form, Side 1 (Figure 5-5a).

Table 5-6: Equipment and supplies list for benthic macroinvertebrate collection.

Item	Quantity
Benthic Macroinvertebrate	
Modified kick net (D-frame with 500 μ m mesh) and 4-ft handle	1
Spare net(s) and/or spare bucket assembly for end of net	
Buckets, plastic, 8- to 10-qt capacity	2
Sieve-bucket or soil sieve with 500 μ m mesh openings (U.S. std No. 35)	1
Watchmakers' forceps	2 pr.
Wash bottle, 1-L capacity labeled "LAKE WATER"	1
Small spatula, spoon, or scoop to transfer sample	1
Funnel, with large bore spout (optional)	1
Sample jars, HDPE plastic with leakproof steam caps, 500-mL and 1-L capacity, suitable for use with ethanol	4 to 6 each sample
95% ethanol, in a properly labeled container	2 gal
Rubber gloves	2 pr.

Table 5-6. Equipment and supplies list for benthic macroinvertebrate collection.

Cooler (with suitable absorbent material) for transporting ethanol and samples	1
Benthic sample labels, with preprinted sample numbers	2
Benthic sample labels without preprinted sample numbers	4
Internal benthic sample labels on waterproof paper	6
Lake Shoreline Sample Collection Form	1
Soft (#2) lead pencils	
Fine-tip indelible markers	
Clear tape strips	1 pkg.
Plastic electrical tape	4 rolls
Scissors	1
Pocket-sized field notebook (optional)	1
Field operations and methods manual	1 copy

5.2.3 Sampling Procedure

5.2.3.1 Site Selection and Sample Collection

The process for selecting the p-Hab stations is described in the Physical Habitat Assessment Section 5.1. All benthic samples should be collected from the dominant habitat type within the 10 m x 15 m littoral zone component of each of the 10 P-Hab stations (Figure 5-4). The sampling process is described in Table 5-7.

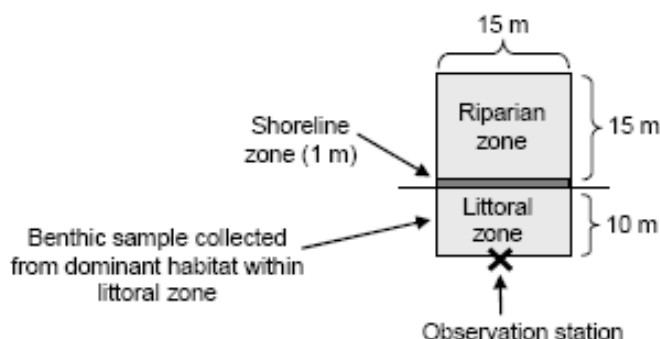


Figure 5-4. Benthic and habitat sampling station diagram.

5.2.3.2 Sample Processing in the Field

Use a 500 μ m mesh sieve bucket placed inside a larger bucket full of lake water while sampling to carry the composite sample as you travel around the lake. Once the composite sample from the collections from the 10 stations is sieved and reduced in volume, store in a 1-liter jar and preserve with 95% ethanol. Multiple jars may be required if detritus is heavy (Table

5-8). If more than one jar is used for a composite sample, use the "extra jar" label provided; record the SAME sample ID number on this "extra jar" label. The sample ID number is also recorded with a lead pencil (No. 2) on a waterproof label that is placed inside each jar. If a sample requires more than one jar, make sure the correct number of jars for the sample is recorded on the Sample Collection Form. Record information for each composite sample on the Lake Shoreline Sample Collection Form as shown in Figure 5-5(a).

Check to be sure that the pre-numbered adhesive label is on the jar and covered with clear tape. Place the samples in a cooler or other secure container for transporting and/or shipping the laboratory (see Appendix C).

Table 5-7. Procedure for benthic macroinvertebrate sampling

1. After locating the sample site according to procedures described in the physical habitat section, identify the dominant habitat type within the plot:
 - Rocky/cobble/large woody debris;
 - Shorezone vegetation and/or submerged aquatic vegetation;
 - or organic fine muds or sand.
2. After identifying the dominant habitat type, use the D-frame dip net (equipped with 500 μ m mesh) to sweep through 1 linear meter of the dominant habitat type at a single location within the 10m x 15m littoral zone sampling area, making sure to disturb the substrate enough to dislodge organisms.
 - If the dominant habitat is rocky/cobble/large woody debris it may be necessary to exit the boat and disturb the substrate (e.g., overturn rocks, logs) using your feet while sweeping the net through the disturbed area.
 - Because a dip-net is being used for sampling, the maximum depth for sampling will be approximately 0.5 m (the length of the dip-net staff); therefore, in cases in which the depth of the lake quickly drops off it may be necessary to sample in the nearest several meters to the shore.
3. After completing the 1-meter sweep, remove all organisms and debris from net and place them in a bucket following sample processing procedures described in the following section.
4. Proceed to the next sampling station and repeat steps 1-5. The organisms and detritus collected at each station on the lake should be combined in a single bucket to create a single composite sample for the lake. After sampling at all 10 stations is completed, process the composite sample in the bucket according to procedures described in the following section.

Revised by (date)

LAKE SHORELINE SAMPLE COLLECTION FORM

SITE ID: NLA05608- 9999

DATE: 05/01/2007

BENTHOS

Sample ID	Sample Type	No. of Jars	Flag	Comment																			
9999009	P	2																					
STATION				A		B		C		D		E		F		G		H		I		J	
SUBSTRATE Rocky/Cobble/ Woody debris Microphyte beds Organic/Flne muds Other: Note in Comments	COLL	Sub	Coll	Sub	Coll	Sub	Coll	Sub	Coll	Sub	Coll	Sub	Coll	Sub	Coll	Sub	Coll	Sub	Coll	Sub	Coll	Sub	Coll
	Boat	☐ R	☐ B	☐ R	☐ B	☐ R	☐ B	☐ R	☐ B	☐ R	☐ B	☐ R	☐ B	☐ R	☐ B	☐ R	☐ B	☐ R	☐ B	☐ R	☐ B	☐ R	☐ B
	Wading	☐ M	☐ W	☐ M	☐ W	☐ M	☐ W	☐ M	☐ W	☐ M	☐ W	☐ M	☐ W	☐ M	☐ W	☐ M	☐ W	☐ M	☐ W	☐ M	☐ W	☐ M	☐ W
		☐ F	☐ F	☐ M	☐ F	☐ M	☐ F	☐ M	☐ F	☐ M	☐ F	☐ M	☐ F	☐ M	☐ F	☐ M	☐ F	☐ M	☐ F	☐ M	☐ F	☐ M	☐ F
		☐ D	☐ D	☐ D	☐ D	☐ D	☐ D	☐ D	☐ D	☐ D	☐ D	☐ D	☐ D	☐ D	☐ D	☐ D	☐ D	☐ D	☐ D	☐ D	☐ D	☐ D	☐ D
FLAG												K		F1						F2			

* Sample Types: P = Primary, D = Field duplicate

Flag	Comment
K	COULD NOT COLLECT SAMPLE - TOO DEEP (>3 m)
F1	SAMPLE COLLECTED FROM BENT - UNSAFE TO WADE (DEEP MUCK)
F2	OTHER - INUNDATED GRASS AND HERBACEOUS TERRESTRIAL VEGETATION

figure 5-5a. Lake Shoreline Sample Collection Form, Side 1.

LAKE SHORELINE SAMPLE COLLECTION FORM (cont.)

SITE ID: NLA06608- 9999

DATE: 05/01/2007

Revised by
5/10/07

ENTEROCOCCI (Target Volume = 250 mL)

Sample ID	Sample Type *	Time Collected (hh:mm)	Depth Collected (m)	Sample Volume (mL)	Filt. Start Time (hh:mm)	Volume Filtered (Target = 50 mL) **				Filt. End Time (hh:mm)	Time Frozen (hh:mm)	Flag
						FIL. 1	FIL. 2	FIL. 3	FIL. 4			
500020	P	1630	0.3	250	1800	50	50	50	50	1845	1900	F3

* Sample Types: P = Primary, D = Field duplicate; F = Filter blank (Enterococci sample only). Filter blank is collected at void where field duplicate sample is NOT taken.
** If <25 mL of buffer solution was used to rinse filter, indicate with a 2 flag and note in comment section which filter(s) were affected along with the appropriate volume(s) of buffer solution used.

Flag	Comment
F3	15 mL of buffer solution was used on Filter 3, 20 mL on Filter 4.

Flag codes: K = No measurement or observation made; B = Suspect measurement or observation; F1, F2, etc., = misc. flags assigned by field crew. Explain all flags in comments section.

2007 Lake Shoreline Sample Coll. 03/10/2007

Figure 5-5b. Lake Shoreline Sample Collection Form, Side 2.

Table 5-8. Procedure for preparing composite samples for benthic macroinvertebrates

1. Pour the entire contents of the bucket through a sieve (or into a sieve bucket) with 500 µm mesh size. Remove any large objects and wash off any clinging organisms back into the sieve before discarding.
 2. Using a wash bottle filled with lake water, rinse all the organisms from the bucket into the sieve. This is the composite sample for the lake.
 3. Estimate the total volume of the sample in the sieve and determine how large a jar will be needed for the sample (500-mL or 1-L) and how many jars will be required.
 4. Fill in a sample label with the Lake ID and date of collection. Attach the completed label to the jar and cover it with a strip of clear tape. Record the sample ID number for the composite sample on the Sample Collection Form. For each composite sample, make sure the number on the form matches the number on the label.
 5. Wash the contents of the sieve to one side by gently agitating the sieve in the water. Wash the sample into a jar using as little water from the wash bottle as possible. Use a large-bore funnel if necessary. If the jar is too full pour off some water through the sieve until the jar is not more than $\frac{1}{2}$ full, or use a second jar if a larger one is not available. Carefully examine the sieve for any remaining organisms and use watchmakers' forceps to place them into the sample jar.
 - If a second jar is needed, fill in a sample label that does not have a pre-printed ID number on it. Record the ID number from the pre-printed label prepared in Step 4 in the "SAMPLE ID" field of the label. Attach the label to the second jar and cover it with a strip of clear tape. Record the number of jars required for the sample on the Sample Collection Form. **Make sure the number you record matches the actual number of jars used.** Write "Jar N of X" on each sample label using a waterproof marker ("N" is the individual jar number, and "X" is the total number of jars for the sample).
 6. Place a waterproof label inside each jar with the following information written with a number 2 lead pencil:

• Lake ID • Type of sampler and mesh size used • Name of lake • Date of collection	• Collectors initials • Number of stations sampled • Jar N of X
---	---
 7. Completely fill the jar with 95% ethanol (no headspace). It is very important that sufficient ethanol be used, or the organisms will not be properly preserved. Existing water in the jar should not dilute the concentration of ethanol below 70%.
 - NOTE: Prepared composite samples can be transported back to the vehicle before adding ethanol if necessary. In this case, fill the jar with lake water, which is then drained using the net (or sieve) across the opening to prevent loss of organisms, and replaced with ethanol at the vehicle.
 8. Replace the cap on each jar. Slowly tip the jar to a horizontal position, then gently rotate the jar to mix the preservative. Do not invert or shake the jar. After mixing, seal each jar with plastic tape.
- Store labeled composite samples in a container with absorbent material that is suitable for use with 70% ethanol until transport or shipment to the laboratory.

5.3 Fecal Indicator (Enterococci)

5.3.1 Summary of Method

Field teams are to collect a water sample within the littoral zone of the final habitat station (station J) where the water is about waist deep (1 meter). Teams are to use a pre-sterilized, 250 ml bottle and collect the sample at about 0.3 meter (12 inches) below the water. Following collection, samples are placed in coolers and maintained on ice prior to filtration of four 50 mL volumes. Samples must be filtered within 8 hours of collection. For "large lakes" (greater than 5,000 ha) the sample is to be collected from the launch site at the end of the day.

5.3.2 Equipment and Supplies

Table 5-9 provides the equipment and supplies needed for field operations to collect the fecal indicator sample. The Lake Shoreline Sample Collection Form (Figure 5-5b) is used to record and document the fecal indicator sample.

Table 5-9. Equipment and supplies list for fecal indicator sampling

Item	Quantity
Fecal Indicator	
surgical gloves (non-powdered)	
pre-sterilized, 250 ml sample bottle	
Lake Shoreline Sample Collection Form	1
Fecal Indicator sample labels	4 vial labels and 1 bag label
Wet ice	
cooler	1

5.3.3 Sampling Procedure

Table 5-10. Procedure for Fecal Indicator (Enterococci) sample collection.

Collect the Enterococci Sample

1. Put on surgical gloves (non-powdered).
2. Transfer sodium thiosulfate tablet from the pre-sterilized, 250 ml sample bottle to a sterile screw-cap 50-mL PP tube.
3. Approach 1 m deep sampling location slowly from downstream or downwind.
4. Lower the un-capped, inverted 250 ml sample bottle to a depth of 0.3 meter below the water surface, avoiding surface scum, vegetation, and substrates. Point the mouth of the container away from the body or boat. Right the bottle and raise it through the water column, allowing bottle to fill completely.
5. After removing the container from the water, discard a small portion of the sample to allow for proper mixing before analyses.
6. Add the sodium thiosulfate tablet, cap, and shake bottle 25 times.
7. Store the sample in a cooler on ice to chill (not freeze). Chill for at least 15 minutes and do not hold samples longer than 8 hours before filtration.

Wisconsin Department of Natural Resources
Supplemental Lakeshore Habitat Assessment
Methodology for the USEPA National Lake Assessment

WISCONSIN DEPARTMENT OF NATURAL RESOURCES
101 S. WEBSTER, PO BOX 7921
MADISON, WI 53707-7921

Method Summary:

In an effort to develop a lakeshore habitat assessment tool for the Wisconsin DNR, the following enhancements were created to supplement the USEPA National Lake Assessment physical habitat protocol. The surveys were conducted on expanded 45-meter plots based on the ten USEPA habitat plots described in section 5.0 of the Field Operations Manual (USEPA 2007). The supplemental method collected additional data on fish habitat, invasive species specific to Wisconsin, and better quantified human development impacts on lake shores. It also provided more detail on the aquatic plant composition in the near shore, littoral zone.

Purpose:

1. Collect preliminary data and test field methods to develop a lakeshore habitat assessment tool to be used by WDNR staff, consultants, or citizen volunteers in the future to characterize a lake's shoreland quality and degree of human influence.
2. Quantify the amount of woody debris in near-shore 45 m transects.
3. Document the presence of invasive species of particular concern in Wisconsin.
4. Quantify ranges of human disturbance both in the shoreland and littoral zone plots, specifically addressing shoreline modifications, paved surfaces, buildings, lawns, residences, buildings, piers, boat lifts, and swim rafts.
5. Identify aquatic plant species and relative quantities to characterize the littoral zone plant community.

Requirements:

1. Survey was completed on the same day that the lake was visited for the USEPA NLA.
2. Survey sites physically coincided with the ten randomly selected, near-shore USEPA NLA habitat plots.
3. Survey was conducted by wading or from a boat.

Equipment and Supplies:

In addition to the equipment and supplies listed in Table 5-1 of the field manual, the following equipment and supplies were needed to conduct the supplemental method:

- Two garden rake heads welded together onto an extension rod (1)
- WDNR Supplemental Methodology data sheets (10)
- Ziploc bags for collecting unknown aquatic plants (1 box)
- Waterproof paper ID tags for labeling unknown aquatic plants (50)
- *Through the Looking Glass* plant identification manual (1)
- Waders for the woody debris transects

Method:

The sampling plots used in this supplemental protocol extended for 45 meters along the shore, 10 meters lakeward, and were centered on the USEPA National Lake Assessment stations. On shore they were divided into two zones: the riparian plot within 15 meters of the water and the zone farther than 15 meters from the water, referred to as the upland plot.

1. **Woody Debris:** In 0.5 meter water depth, we walked the entire 45 meter shoreline and counted the number of small (5-10 cm) and large (> 10 cm) pieces of woody debris crossed. In clear water we sometimes conducted the survey by driving the boat slowly and counting logs crossed off the bow. In murky water, we attempted to feel the bottom substrate with a paddle to count logs.
2. **Invasive Species:** At each station we noted the presence of Japanese stiltgrass (*Microstegium vimineum*), reed canary grass (*Phalaris arundinacea*), phragmites (*Phragmites australis*), hybrid cattail (*Typha spp.*) and yellow iris (*Iris pseudacorus*) within the riparian plot.
3. **Human Development:** At each station we determined the most appropriate percent categories (0 = 0-1%, 1 = 1-10%, 2 = 10-40%, 3 = 40-75%, 4 = >75%) within the riparian and upland plots for a variety of human development parameters. For development that only applied to the shoreline, such as a seawall, the rating was applied only to the immediate shoreline. For example, a '4' rating for seawall indicated that greater than 75% of the shoreline was seawall. The variables were as follows:
 - a. Seawall: concrete or paved protective structures to prevent shoreline erosion
 - b. Riprap: loose stones or boulders placed artificially prevent shoreline erosion
 - c. Artificial beach: included both imported sand and zones cleared of natural vegetation to create a beach
 - d. Lawn: stretch of open, mown, grass-covered land
 - e. Pavement: any impervious ground cover, including driveways, roads, and impermeable patios

In addition, we counted the number of human development features present in the riparian and upland plots. The variables were as follows:

- a. Residences: private homes
 - b. Commercial buildings: included restaurants, businesses, yacht clubs, etc.
 - c. Structures: any non-resident, non-commercial buildings, such as sheds, garages, or boat houses.
 - d. Boat lifts: included jet skis and sail boats
 - e. Swim rafts: only if present within the 10 m littoral zone plot
 - f. Docks: counted individual piers, flagging multi-boat docks (e.g. marina)
4. On smaller lakes or lakes not completely developed, we recorded the number of piers between stations. We also noted any land use information between stations to help when

evaluating the full NLA Lake Assessment form, such as the presence of a golf course, marina, or causeway.

5. Aquatic Plant Surveys:

- a. Within each of the ten USEPA littoral plots, we sampled the aquatic plant community with a rake at 2 meters, 5 meters, and 8 meters from the shoreline. Using a welded, double-headed rake on a pole, we first collected the station depth. We then rotated the rake two full circles before lifting it from the lake bottom.
- b. Sifting through the plants, we identified each unique plant present on the rake down to the species level if possible. We also rated the plant density on a relative scale of 1 to 3, where 1 indicated the presence of a singular plant fragment and a 3 meant the rake was overflowing with a specific species.
- c. Last, we collected any unidentifiable specimens in Ziploc bags and included a waterproof tag with the lake name, NLA ID, date, station ID, and the temporary name used. These specimens were later identified using the *Through the Looking Glass* book or referring to an aquatic plant expert.

Works Cited:

Borman, S., R. Korth, and J. Temte. 1997. *Through the looking glass ... A field guide to aquatic plants*. Wisconsin Lake Partnership, Stevens Point, WI. 248 pgs

USEPA. 2007. *Survey of the Nation's Lakes. Field Operations Manual*. EPA 841-B-07-004. U.S. Environmental Protection Agency, Washington, DC.

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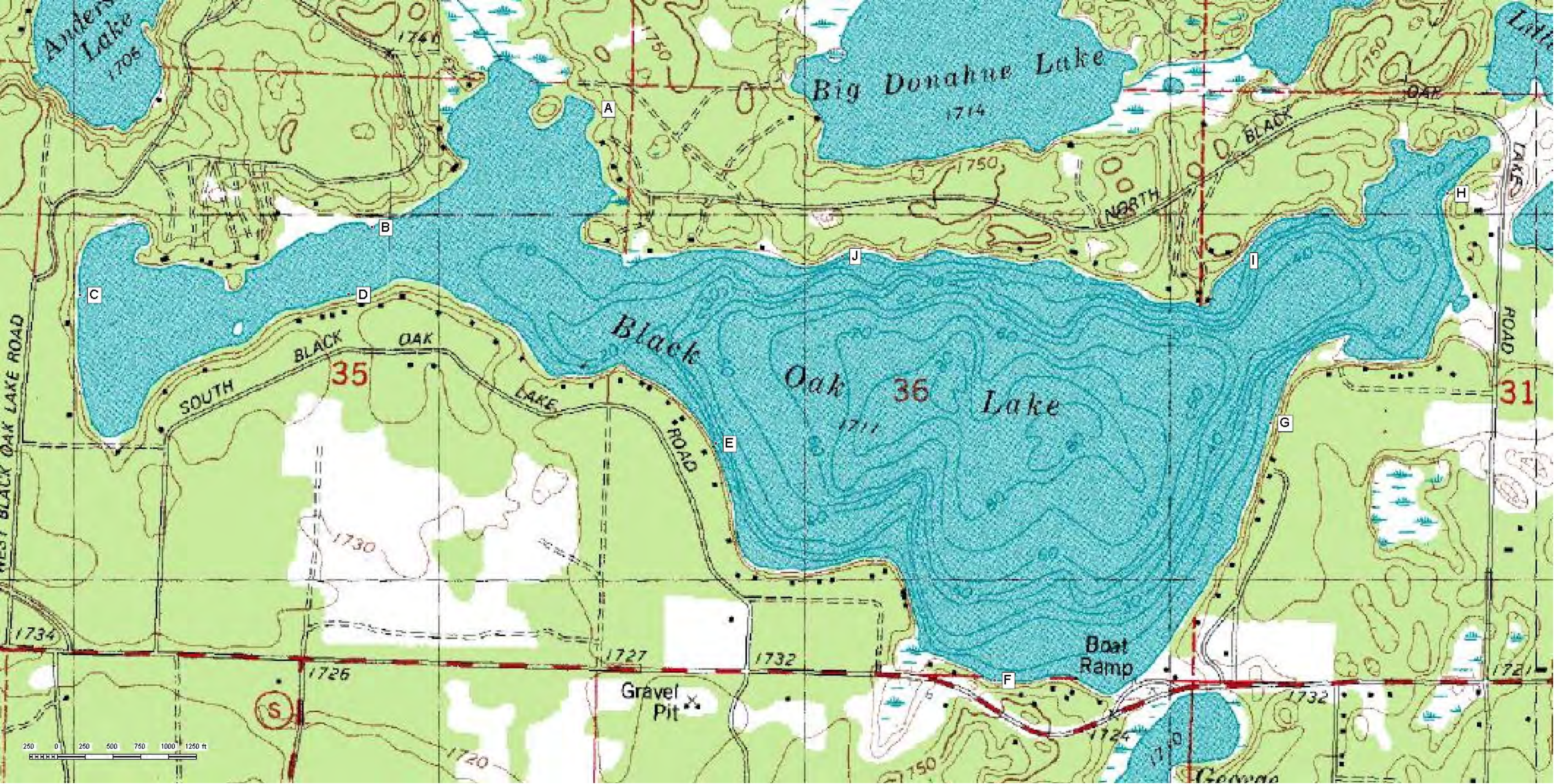
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			Piers
SHORELINE NOTES	A and B		
	B and C		
	C and D		
	D and E		
	E and F		
	F and G		
	G and H		
	H and I		
	I and J		
	J and A		

Site ID		Shore distance (m)		Depth (ft)																	
A	2																				
	5																				
	8																				
B	2																				
	5																				
	8																				
C	2																				
	5																				
	8																				
D	2																				
	5																				
	8																				
E	2																				
	5																				
	8																				
F	2																				
	5																				
	8																				
G	2																				
	5																				
	8																				
H	2																				
	5																				
	8																				
I	2																				
	5																				
	8																				
J	2																				
	5																				
	8																				
K	2																				
	5																				
	8																				
L	2																				
	5																				
	8																				

Numbers refer to rake fullness, ranging from 1 (just one specimen) to 3 (filling the entire rake), or V, a visual find within 2 m of the rake throw.



Black Oak Lake Sampling Points, September 2008				
Label	Latitude (d m.m)	Longitude (d m.m)	Latitude (d.d)	Longitude (d.d)
A	46 10.16376	-89 19.58082	46.169396	-88.673653
B	46 9.97902	-89 20.046	46.166317	-88.6659
C	46 9.8667	-89 20.66124	46.164445	-88.655646
D	46 9.87888	-89 20.0904	46.164648	-88.66516
E	46 9.67494	-89 19.30254	46.161249	-88.678291
F	46 9.33768	-89 18.69534	46.155628	-88.688411
G	46 9.72882	-89 18.12612	46.162147	-88.697898
H	46 10.0752	-89 17.76468	46.16792	-88.703922
I	46 9.96786	-89 18.19578	46.166131	-88.696737
J	46 9.95712	-89 19.0455	46.165952	-88.682575



Appendix I

Study Site Photos for Quantitative Assessment

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Station A

USEPA & WDNR
Physical Habitat
Assessment)
Photograph taken
9/19/08



Station B

USEPA & WDNR
Physical Habitat
Assessment)
Photograph taken
9/19/08



Station C

USEPA & WDNR
Physical Habitat
Assessment)
Photograph taken
9/19/08



Station D

USEPA & WDNR
Physical Habitat
Assessment)
Photograph taken
9/19/08



Station E

USEPA & WDNR
Physical Habitat
Assessment)
Photograph taken
9/19/08



Station F

USEPA & WDNR
Physical Habitat
Assessment)
Photograph taken
9/19/08



Station G

USEPA & WDNR
Physical Habitat
Assessment)
Photograph taken
9/19/08



Station H

USEPA & WDNR
Physical Habitat
Assessment)
Photograph taken
9/19/08



Station I

USEPA & WDNR
Physical Habitat
Assessment)
Photograph taken
9/19/08



Station J

USEPA & WDNR
Physical Habitat
Assessment)
Photograph taken
9/19/08

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Appendix J

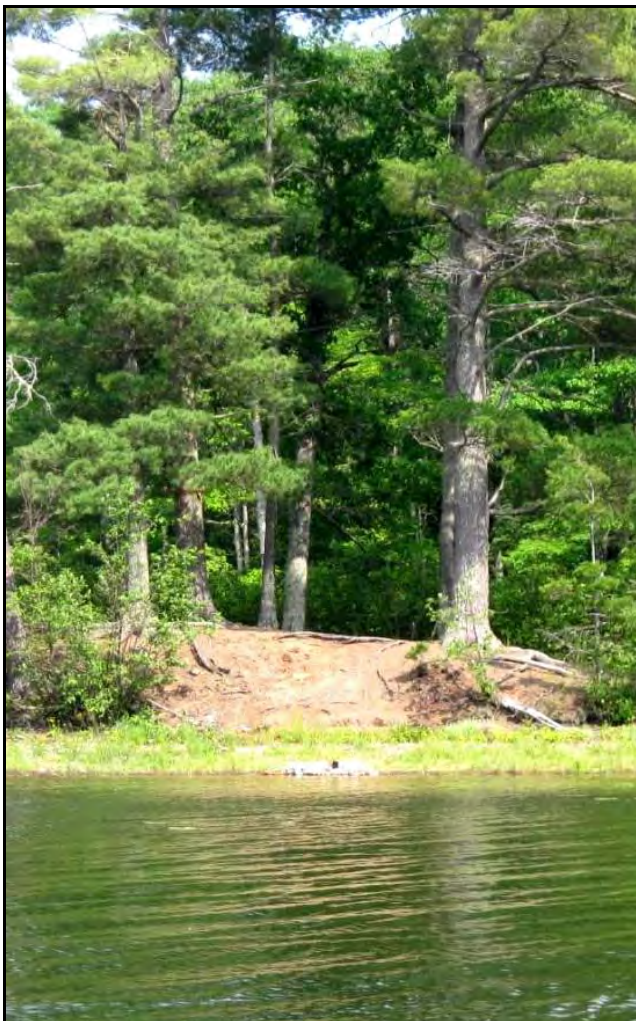
Phase 4 Report
(Shoreland Restoration)

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Black Oak Lake Watershed Protection Program (Phase 4): Protection & Restoration of Riparian Shorelines

The Black Oak Lake Preservation Foundation



Date: June 2012

Cite as document as:

Premo, Dean, and Barbara Gajewski.
2012. Black Oak Lake Watershed
Protection Program: Protection &
Restoration of Riparian Shorelines.
(Report for Phase 4, WDNR Lake
Planning Grant). White Water
Associates, Inc.

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Black Oak Lake Watershed Protection Program (Phase 4): Protection & Restoration of Riparian Shorelines

Report for a WDNR Lake Planning Grant (Phase 4)

Submitted to:

Wisconsin Department of Natural Resources
Attention: Kevin Gauthier
107 Sutliff Avenue
Rhineland, WI 54501
Phone: (715) 365-8937

This document is a product of a WDNR Lake Planning Grant awarded to:

The Black Oak Lake Preservation Foundation
Contact: Tom Allman
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Prepared and Submitted by:

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Literature Cited

APPENDICES

Appendix 1 – EcoGrid Ground Reinforcement

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Introduction

The Black Oak Lake Watershed Protection Program is an ongoing endeavor composed of annual phases that progress toward the overall vision. The Black Oak Lake Preservation Foundation (formerly, Black Oak Lake Riparian Owners Association) is the lead organization in this long-range effort. White Water Associates, Inc. has been the organization's consultant throughout the history of the program.

In Phase 3 of the program, we conducted a qualitative, quantitative, and photographic documentation of the condition of the littoral and riparian zones of Black Oak Lake. This information led directly to Phase 4 that seeks to prevent establishment of Aquatic Invasive Species (AIS) in Black Oak Lake through protection and restoration of littoral zone and riparian habitat and monitoring of boat/trailer traffic at Black Oak Lake through the Clean Boats, Clean Waters Program. In Phase 4, data were analyzed and areas selected for potential "demonstration restoration projects." A restoration plan was prepared for each site. This report presents these activities and becomes part of the overall adaptive management plan for the Black Oak Lake Watershed Protection Program. It is a required report to the Wisconsin Department of Natural Resources (WDNR) Lake Planning Grants Program. A planning grant funded for this project.

Project participants continue to embrace the concept of "adaptive management" in their approach to the Black Oak Lake Watershed Protection Program. Simply stated, adaptive management uses findings from planned monitoring activities to inform future management actions and periodic refinement of the plan. An adaptive management plan accommodates new findings by integrating this information into successive iterations of the comprehensive plan (Walters 1986). The plan is therefore a dynamic entity, successively evolving and improving to fit the needs of the Black Oak Lake watershed. A central premise of adaptive management is that scientific knowledge about natural ecosystems is uncertain and therefore a practical management plan allows for ongoing adjustments in management designed to "adapt" to changing conditions and new information or understanding. Monitoring the outcomes of plan implementation is essential to the process of adaptive management.

Besides this introductory chapter, this report contains three additional chapters. Chapter 2 describes the background and study area. Chapter 3 lays out the methods we followed in carrying out this project. Chapter 4 presents and discusses the results of Phase 4.

Background

Black Oak Lake is a 584 acre lake located near the town of Land O'Lakes in northern Vilas County, Wisconsin. It is a deep lake (more than 80 feet in places) and has a high diversity of aquatic habitats (from shallow to deep water). Black Oak Lake can be best described as a "Groundwater Drainage Lake" although the outflow stream has been dry for many years. It is an oligotrophic lake. Its outflow stream is small. There is a public park with swimming beach, picnic area, and boat landing. Black Oak Lake is an important resource used by the public. In recent years its water levels have dropped fairly dramatically, affecting littoral zone elements in the lake and providing some open habitat for colonizing plant species.

The Black Oak Lake landscape has several lakes including Anderson Lake, Dollar Lake, Big Donahue Lake, Little Donahue Lake, Little Bateau Lake, Big Bateau Lake, Spring Lake, Lake Elaine (formerly Lonewood Lake), and George Lake. This complex of aquatic habitats forms an abundance of riparian habitats for birds, mammals, amphibians, reptiles, and invertebrates that require this kind of habitat.

The land matrix of this complex of lakes is largely forested, with some prime examples of northern hardwoods forest stands. Large tracts of undeveloped land exist offering high quality habitat for many terrestrial organisms and very stable surroundings that are protective of the lake environment. The Conserve School property of 1200 acres is included in the watershed. Immediately adjacent to the north of the watershed is the Sylvania Recreation Area – a wilderness area in Michigan's Upper Peninsula.

Black Oak Lake has a remarkable aquatic biota that to our knowledge does not currently include aquatic invasive plant species. In many parts of the lake, the riparian area is naturally forested. In other areas of shoreline, development has altered the riparian area (in some cases, dramatically so). There are occurrences of invasive terrestrial plant species in the Black Oak Lake riparian area.

The project phases that have preceded Phase 4 provided the baseline understanding necessary to proceed with restoration planning. Black Oak Lake has a shoreline of nearly 7½ miles and comprised of 173 ownership parcels. Large stretches of shoreline on the north shore are undeveloped. The Black Oak Lake Preservation Foundation is particularly focused on this project since impacts to lake ecosystems typically emanate from development and degradation of the riparian area. According to the U.S.EPA's 2007

National Lakes Assessment, poor lakeshore habitat (riparian vegetation) is the number one stressor of lake ecosystems. Poor littoral zone habitat is number two. The study further indicates that lakes with poor lakeshore habitat are three times more likely to exhibit poor biological condition as measured by the planktonic community (food web). By managing for healthy and naturally functioning lakeshores (littoral & riparian zones), we can make a difference in the lake's ecological health.

Restoring riparian areas that involve private property is certainly a sensitive undertaking, one that is best accomplished through a process that includes education and orientation of the landowners and other stakeholders. We believe that a few carefully selected sites, once successfully restored, will serve to demonstrate the ecological advantages and natural beauty of native plantings and allow a conversation among Black Oak Lake residents regarding the value of a healthy riparian area to the health of Black Oak Lake.

The Black Oak Lake Preservation Foundation takes a long range perspective on instituting restoration in the riparian area of Black Oak Lake. This perspective includes the importance of engaging future generations of lake property owners by providing good examples of intact and restored riparian area. Crucial junctures in the stewardship and lake health occur as family properties are conveyed to children and grandchildren and other private properties sold to people who are new to lake ownership. These are points in time when decisions about the property are made that have direct influence on lake quality. It is the Preservation Foundation's hope that the preponderance of these decisions favors the ongoing quality of Black Oak Lake. Through good examples of stewardship, including high quality and attractive restoration projects, and other education opportunities, both long-time residents of Black Oak Lake and newcomers will be exposed to good stewardship practices with regard to the riparian area.

Methods

The overarching goal of the Phase 4 project is to prevent the establishment of AIS in Black Oak Lake. We followed two principal approaches to achieve this goal: (1) we selected and planned demonstration projects for planning protection/restoration actions and (2) we continued the monitoring of watercraft traffic into Black Oak Lake through the Clean Boats, Clean Waters Program. Six objectives supported our goal: (1) review and analyze the photographic, qualitative, and quantitative data collected during Phase 3 on the littoral zone and riparian area conditions of Black Oak Lake; (2) select candidate demonstration protection/restoration projects; (3) create a protection/restoration plan for each demonstration area; (4) integrate the Phase 4 demonstration plans into an updated Black Oak Lake adaptive management plan; (5) continue with the Black Oak Lake “Clean Boats, Clean Waters Program,” and (6) manage and administer the Phase 4 Project. This Chapter describes the methods we followed to accomplish these objectives.

Part 1 — Shoreland Restoration Plans

Phase 3 of the Black Oak Lake Stewardship Program created an Image-Based Waterfront Archive using lake association volunteers to collect a large data set that characterized the riparian and littoral zones of Black Oak Lake. This archive documented 2008 shoreline conditions for the purpose of verifying extent and origin of future human-caused changes or natural changes. To allow efficient data storage and retrieval, we created a web-based product to interface with and access photos and data. Topographic maps and aerial photos are part of the database as well. The data archive can be accessed, navigated, and reviewed from CD-ROM.

White Water staff reviewed the entire data set (including photographs) along with aerial photography and topographic information in order to select areas where some degradation exists and might be improved by rehabilitation actions.

Phase 3 of the Black Oak Lake Stewardship Program also produced a Quantitative Assessment of Littoral and Riparian area of Black Oak Lake using two methodologies –

one published by the US-EPA and the other by the WDNR. These focused on littoral zone and shoreline activities of Black Oak Lake. To characterize the near-shore habitats and conditions (both littoral zone and riparian area), the survey team established and evaluated ten evenly spaced “physical habitat” stations around the lake. These data were also reviewed for our selection of sites on Black Oak Lake.

White Water consultant, Barbara Gajewski, and Preservation Foundation board member Walt Bates conducted a field reconnaissance in late summer 2011 to review possible sites. After the initial field reconnaissance, Barbara Gajewski visited the sites with Mariquita (Quita) Sheehan (Vilas County Lake Conservation Specialist) to review possible actions and suitable plant species for use in restoration. Finally, a field trip that included Gajewski and Dean Premo (White Water) and several members of the Preservation Foundation Board (Walt Bates, John Annin, Bob Pierce, and Tom Allman) was conducted in October 2011 to view and discuss candidate sites. After the October field trip, Gajewski drafted restoration plans and corresponded with affected landowners.

Four sites were selected including: a portion of the island, a section of the Lowenstein property, the Pierce property and the Kegel property. An important theme incorporated in the restoration plans is the creation of a natural buffer zone of native vegetation along the shoreline. Shoreland buffers mitigate surface runoff that can cause erosion and deliver unwanted nutrients to the lake. Also shoreland buffers create critical habitat for species of birds, amphibians and insects that require natural shorelands and the related habitat for their existence.

Part 2 — Clean Boats / Clean Waters

As previously stated, the overarching goal of the Phase 4 project is to prevent the establishment of AIS in Black Oak Lake. Part 1 of the methodology has presented an approach to protecting and restoring sites on Black Oak Lake so that they provide a “natural armor” - that is, a healthy habitat with diverse native biota in both riparian and littoral zone areas that prevents establishment of AIS if/when they are accidentally introduced. The second, and equally important, approach to prevent establishment of AIS in Black Oak Lake is to minimize the opportunities for introduction of AIS propagules on recreational watercraft through the Clean Boats, Clean Waters Program. Since 2004, watercraft inspection has been a significant part of Wisconsin’s AIS prevention efforts. Research has shown that inspections play an important role in helping contain AIS to already affected water bodies, preventing the spread of invasive species to new waters.

Black Oak Lake has participated in the Clean Boats, Clean Waters Program since 2008. The WDNR and University of Wisconsin Extension (UWEX) have developed a well-defined protocol for carrying out this program. In 2011 BOLROA carried out the CBCW program and submitted data collected by boat landing monitors to the SWIMS database.

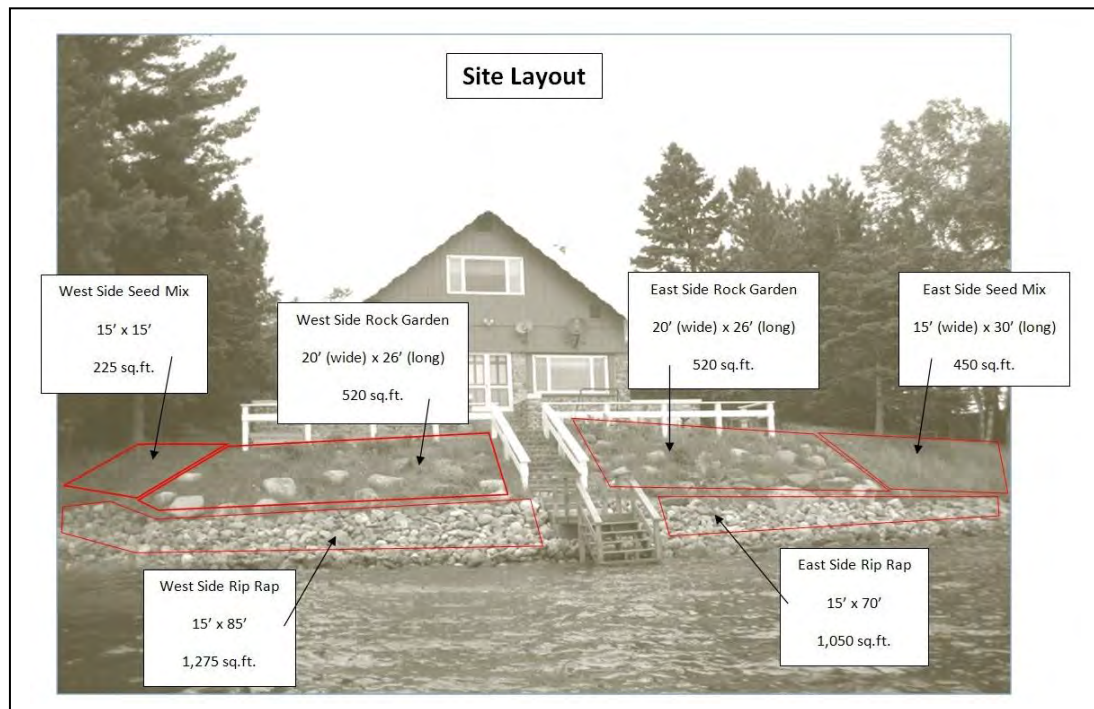
The Black Oak Lake CBCW monitor worked Saturdays and Sundays, two shifts each day, 6:00-10:00 AM, and 3:00-7:00 PM. The boat landing was staffed April through September. The monitor's duties were to greet each person that arrived to launch a boat, and briefly explain the CBCW program, and the laws regarding AIS. The monitor would inspect the boat, fishing gear, trailer, and tow vehicle, for any AIS and gather and record information on DNR forms.

Results and Discussion

In this Chapter, restoration plans are described for the four sites identified in Phase 4. The general format is to present the plan using site photographs and captions to describe the recommended actions. Several photos of each site are provided for plan description and documentation of conditions as they existed in 2011. In each plan, a table provides details regarding recommended plant materials. Each plan concludes with a summary of estimated restoration costs.

Part 1. Conserve School Lowenstein Lakefront Restoration

An area of older development on Black Oak Lake exists on Conserve School property. This is known as the Lowenstein property. Long ago the riparian area was modified by placing rock rip-rap and converting natural shoreline vegetation to a lawn. The restoration plan for this site is considered in this subsection.





General Site Plan

- Plant native vegetation into current rock gardens.
- Planting arrangement will mimic a more native arrangement and less formal.
- Remove cultivated shrubs.
- Removal of marsh thistle below the OHWM across all shoreland area, by cutting base of plant off – soil disturbance is permitted
- Deer prevention program required (Fencing and spraying)



Use of native shrubs appropriate to live stake into the current rip rap. OHWM will determine the extent of this planting. If planting occurs below the OHWM a WDNR permit may be required. (Allow minimum of 60 days to obtain permit.)



Option 1: Plant directly into the hillside. Mulch bare areas.

Option 2: Seed hillside with native seed mix. Cover seeded area with a non-woven erosion control blanket.



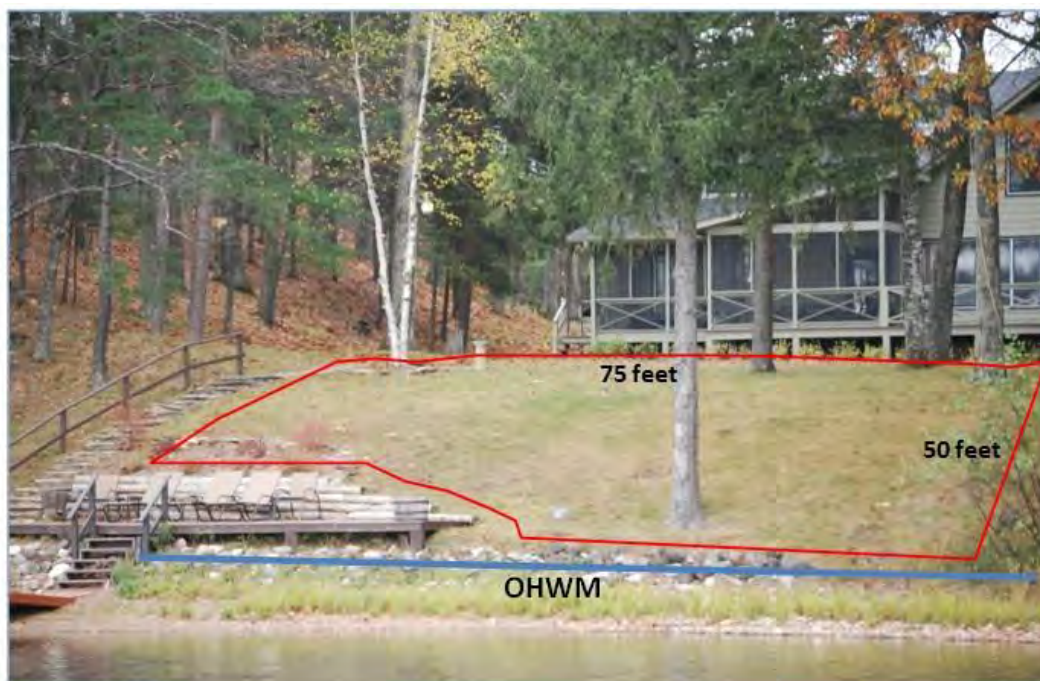


Potential Plants for Restoration						
	Latin Name	Common	Characteristics	Herbarium Link	Bloom	Color
Shrubs	<i>Aronia melanocarpa</i>	Black Chokeberry	flowers are white to pink	Black Chokeberry	June	
	<i>Comptonia peregrina</i>	Sweet-fern	2 - 3' tall, great scent, likes more sterile soils	Sweetfern	June-July	
	<i>Corylus cornuta</i>	Beaked Hazelnut	up to 10' tall, decorative fruit, good wildlife shrub	Beaked Hazelnut	June	
	<i>Diervilla lonicera</i>	Northern Bush Honeysuckle	1-3' tall, flowers are yellow to red, good fall color	Northern Bush Honeysuckle	June-July	
	<i>Rosa blanda</i>	Smooth Rose	3'-4' tall, white to pink flowers	Smooth rose	June-July	
	<i>Viburnum rafinesquianum</i>	Downy arrow-wood	6'-12' tall, great fall colors, blue berries	Downy arrow-wood	June	
Forbes	<i>Achillea millefolium</i>	Yarrow	8"-40" tall, flat-topped inflorescence of small white flowers	Yarrow	July-August	Multiple
	<i>Anaphilis margaritacea</i>	Pearly Everlasting	1'-3' tall, flowers are white with yellowish disk in the middle	Pearlyeverlasting	July-August	
	<i>Asclepias syriaca</i>	Common milkweed	3'-6' tall, pink to cream flower monarch butterfly food	Common milkweed	June-August	
	<i>Epilobum angustifolium</i>	Fireweed	2'-6' tall, pink to purple flowers,	Fireweed	June-Sept.	
	<i>Euthamia graminifolia</i>	Grass-leaved Goldenrod	1'-4' tall, flat-topped yellow clusters	Grass-leaved goldenrod	July-October	
	<i>Liatris aspera</i>	Rough blazing star	1'-3' tall, pink flowers late summer - fall	Rough blazing star	August-October	
	<i>Lupinus perennis</i>	Wild lupine	8"-24" tall, blue to white flowers, early summer	Wild lupine	May-June	
	<i>Monarda fistulosa</i>	Wild Bergamot	2'-4' tall, pale purple to pink flowers	Wild Bergamot	July-October	
	<i>Rudbeckia hirta</i>	Black-eyed Susan	1'-3' tall, yellow/brown flowers	Black-eyed susan	June-October	
	<i>Solidago canadensis</i>	Canada goldenrod	1'-3' tall, colonial plant with yellow flowers	Canada goldenrod	July-October	
	<i>Solidago nemoralis</i>	Old Field goldenrod	1' to 1.5' tall, yellow flowers, grey stems	Old Field Goldenrod	July-October	
Grasses	<i>Danthonia spicata</i>	Poverty oat grass	grows 1-2'	Poverty oats	June	
	<i>Oryzopsis asperifolia</i>	Rough-leaved rice cut-grass	1'-2' tall, evergreen bunchgrass	Rough-leaved rice cut-grass	-	

Approximate Cost of Materials for Restoration for Conserve School Site			
Description	Quantity	Price/Unit	Cost
Seed Mix Areas			
West and east shore seed mix (Agrecol Savanna/Woodland Edge) 675 sq.ft.	1 bag (covers 1000 sq.ft.)	95.00	95.00
Seed Shipping	1	15.00	15.00
Excelsior non woven mats	1 roll (720 sq.ft.)	1.20	864.00
Biodegradable stakes	1 box (1000) stakes	120.00	120.00
TOTAL COST			1,094.00
West & East Side Rock Garden Areas			
Native forbs 2.5" container (Hansen's Garden Village)	434	2.45	1063.30
Native grasses 2.5" container (Hansen's Garden Village)	190	2.45	465.50
Shrubs (Hansen's Garden Village)	10	17.50	175.00
Mulch 400 sq.ft.	Bulk scrap from tree service company		50.00
TOTAL COST			1,753.80
West & East Side Rip Rap Areas			
Live Stakes (Students can collect)			
Root stimulator	1 container	20.00	20.00
Deer Fencing (Seed mix and rock garden areas only)			
Fencing (264 linear feet)	3 rolls	110.00	330.00
Stakes (8' spacing)	35	6.50	227.50
Zip ties	2 packages	10.00	20.00
TOTAL COST			577.50
GRAND TOTAL COST			\$3,425
<i>Note: Costs do not include tax and labor (labor assumed as Conserve School students).</i>			

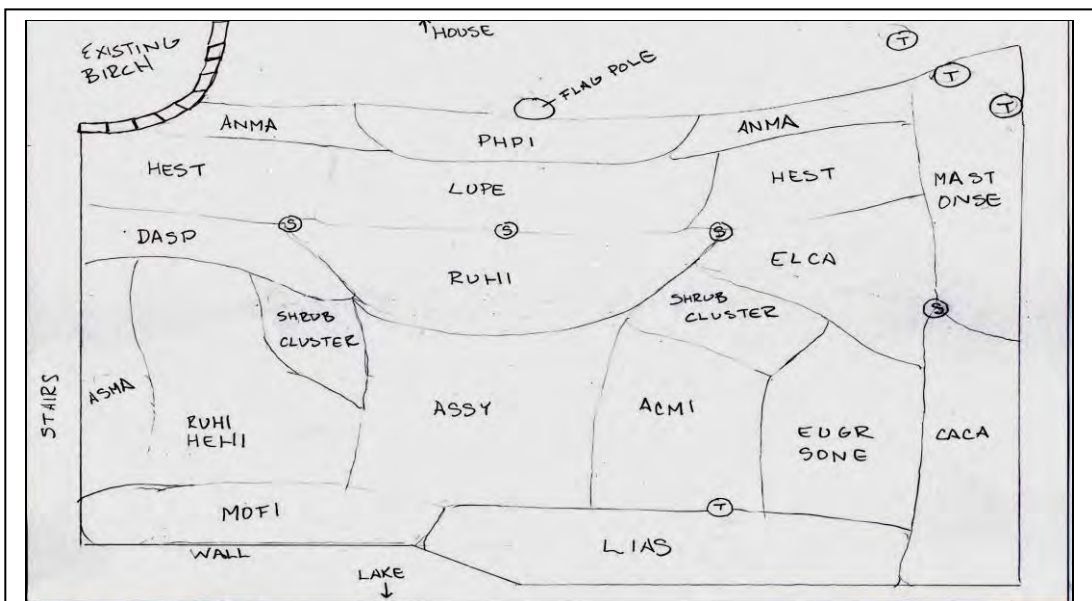
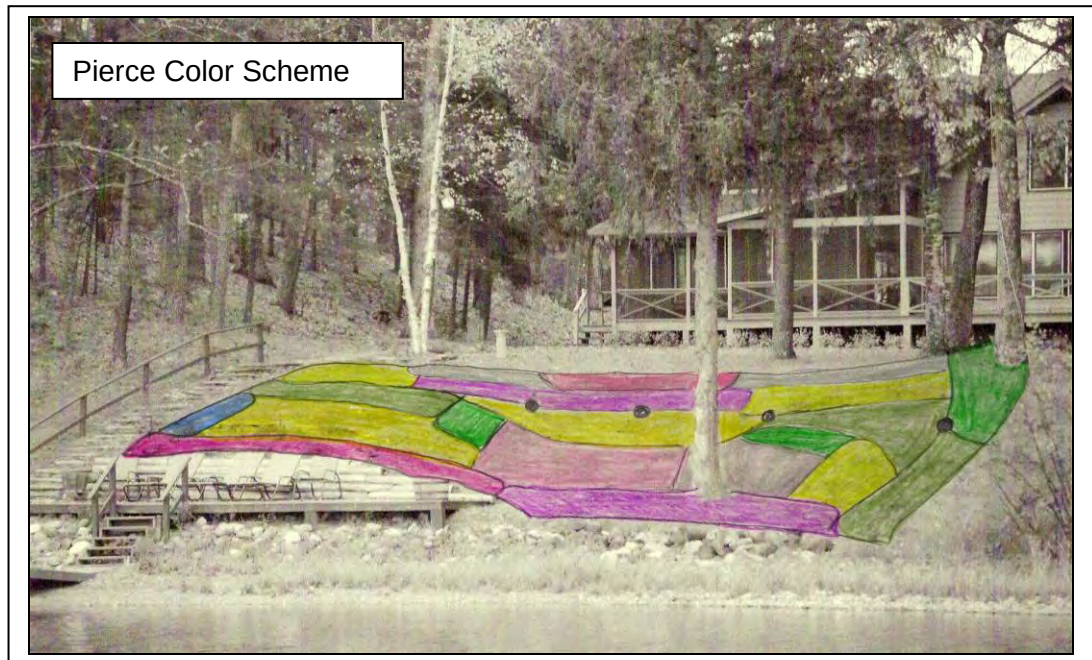
Part 2. Pierce Lakefront Restoration

On the east end of Black Oak Lake is a property owned by the Pierce family. The near shore riparian area on this property is the subject of this restoration plan that seeks to return native vegetation to the site.



General Site Plan

- Mulch around established trees in front (lake side) of the house as necessary.
- Plant native vegetation into current lawn, minimizing erosion and allowing current seed bank to emerge. Mulch as necessary.
 - Approximately 3750 square feet of planting area with forbs, shrubs, grasses and trees (trees via natural colonization).
- Planting scheme will emphasize accent and color. Paying attention to placement, organization and height.
- Removal of marsh thistle below the OHWM across all shoreland area, by cutting base of plant off – soil disturbance is permitted
- Deer prevention program required (fencing and spraying)



Example of Plant Selection for Pierce Site (subject to change based on owner preference and plant availability. Plant abbreviation key described on plant table)



Additional Site Restoration

- Discontinue removal of leaves along hill side area to promote natural duff layer and minimize soil movement.
- Monitor re-colonization of native vegetation; possibly reseed area with an appropriate native seed mix.
- Future potential for a spring ephemeral site, once an adequate duff layer has been achieved.



Additional Site Restoration

- Remove non-native shrubs.
- Remove flagstone edging and grade into slope.
- Plant with native vegetation.
- Mulch area to minimize erosion.



Potential Plants for Restoration					
Latin Name	Common	Characteristics	Herbarium Link	Bloom	Color

Shrubs	<i>Comptonia peregrina</i>	Sweet-fern COPE	2 - 3' tall, great scent, likes more sterile soils	Sweetfern		
	<i>Cornus stolonifera</i> (C. sericea)	Red Osier Dogwood COST	3'-10' tall, white flowers, good fall and spring color	Red osier dogwood	June	
	<i>Diervilla lonicera</i>	Northern Bush Honeysuckle DILO	1-3' tall, flowers are yellow to red, good fall color	Northern Bush Honeysuckle	June-July	
	<i>Rosa blanda</i>	Smooth Rose ROBL	3'-4' tall, white to pink flowers	Smooth rose	June-July	
	<i>Rosa palustris</i>	Swamp Rose ROPA	3 - 7' tall, pink flowers, red hips	Swamp rose	June	
	<i>Spiraea alba</i>	White meadow sweet SPAL	grows 3-4' tall, flowers are white	White meadow sweet	June	

Forbes	<i>Achillea millefolium</i>	Yarrow ACMI	8"-40" tall, flat-topped inflorescence of small white flowers	Yarrow	August	Multiple
	<i>Anaphilis margaritacea</i>	Pearly Everlasting ANMA	1'-3' tall, flowers are white with yellowish disk in the middle	Pearlyeverlasting	August	
	<i>Asclepias syriaca</i>	Common milkweed ASSY	3'-6' tall, pink to cream flower monarch butterfly food	Common milkweed	June	
	<i>Aster macrophyllus</i>	Big leaved aster ASMA	1'-3' tall, pale blue flowers	Big-leaved aster	July-October	
	<i>Euthamia graminifolia</i>	Grass-leaved Goldenrod EUGR	1'-4' tall, flat-topped yellow clusters	Grass-leaved goldenrod	July-October	
	<i>Fragaria virginiana</i>	Wild Strawberry FRVI	4"-6" tall, white flowers	Wild strawberry	June	
	<i>Gaultheria procumbens</i>	Wintergreen GAPR	4"-8" tall, white flowers, red berries	Wintergreen	April-May	
	<i>Helianthus hirsutus</i>	Rough sunflower HEHI	2'-4' tall, large bright yellow flowers	Rough sunflower	August-Sept	
	<i>Helianthus strumosus</i>	Woodland sunflower HEST	2"-6" tall, woodland edges	Woodland sunflower	August	
	<i>Liatris aspera</i>	Rough blazing star LIAS	1'-3' tall, pink flowers late summer - fall	Rough blazing star	August	
	<i>Lupinus perennis</i>	Wild lupine LUPE	8"-24" tall, blue to white flowers, early summer	Wild lupine	June	
	<i>Monarda fistulosa</i>	Wild Bergamot MOFI	2'-4' tall, pale purple to pink flowers	Wild Bergamot	June	
	<i>Phlox pilosa</i>	Prairie phlox PHPI	8'-15' tall, bright pink	Prairie phlox	July	

	<i>Rudbeckia hirta</i>	Black-eyed Susan RUHI	1'-3' tall, yellow/brown flowers	Black-eyed susan	July-August	
	<i>Solidago nemoralis</i>	Old Field goldenrod SONE	1' to 1.5' tall, yellow flowers, grey stems	Old Field Goldenrod	July-August	
	<i>Tradescantia ohiensis</i>	Ohio spiderwort TROH	2'-3' tall	Ohio spiderwort	July-August	
	<i>Verbena stricta</i>	Hoary vervain VEST	2'-4' tall, tall purple flowers	Hoary vervain	August	

Grasses	<i>Calamagrostis canadensis</i>	Blue-joint grass CACA	grows 2'-3'	Blue Joint Grass	June	
	<i>Danthonia spicata</i>	Poverty oat grass DASP	grows 1'-2'	Poverty oats	June	
	<i>Oryzopsis asperfolia</i>	Rough-leaved rice cut-grass ORAS	1'-2' tall, evergreen bunchgrass	Rough-leaved rice cut-grass		
	<i>Bouteloua curtipendula</i>	Side oats grama BOCU	2'-3' tall	Side oats grama	June	
	<i>Elymus canadensis</i>	Wild rye ELCA		Wild rye		
	<i>Carex brevior</i>	Plains oval sedge CABR		Plains oval sedge		

Ferns	<i>Matteuccia struthiopteris</i>	Ostrich Fern MAST	2'-3' tall, Vaselike shape, fertile fronds overwinter	Ostrich Fern		
	<i>Onoclea sensibilis</i>	Sensitive fern ONSE	1'-2' tall, good texture,	Sensitive fern		

Approximate Cost of Materials for Restoration for the Pierce Site			
Description	Quantity	Price/Unit	Cost
Planting Area Approximately 3375 sq.ft. Forbs/Grasses planting area approximately 3205 sq. ft. Shrub planting area approximately 170 sq.ft. Plant spacing every 6-10 inches			
Native forbs/grasses 2.5" containers	2,500	2.45	6,125
Shrubs (bare root shrubs; require early spring installation)	25	9.00	225
Chipper mulch for erosion areas (from tree service company)	Bulk scrap		100.00
TOTAL COST			6,450.00
Deer Fencing			
Fencing (250 linear feet)	3 rolls	110	330
Stakes (8' spacing)	35	6.5	227.5
Zip ties	2 packages	10	20
TOTAL COST			577.50
GRAND TOTAL COST			\$7,028
<i>Note: Costs do not include tax, labor, and mobilization (acquiring and delivering supplies).</i>			

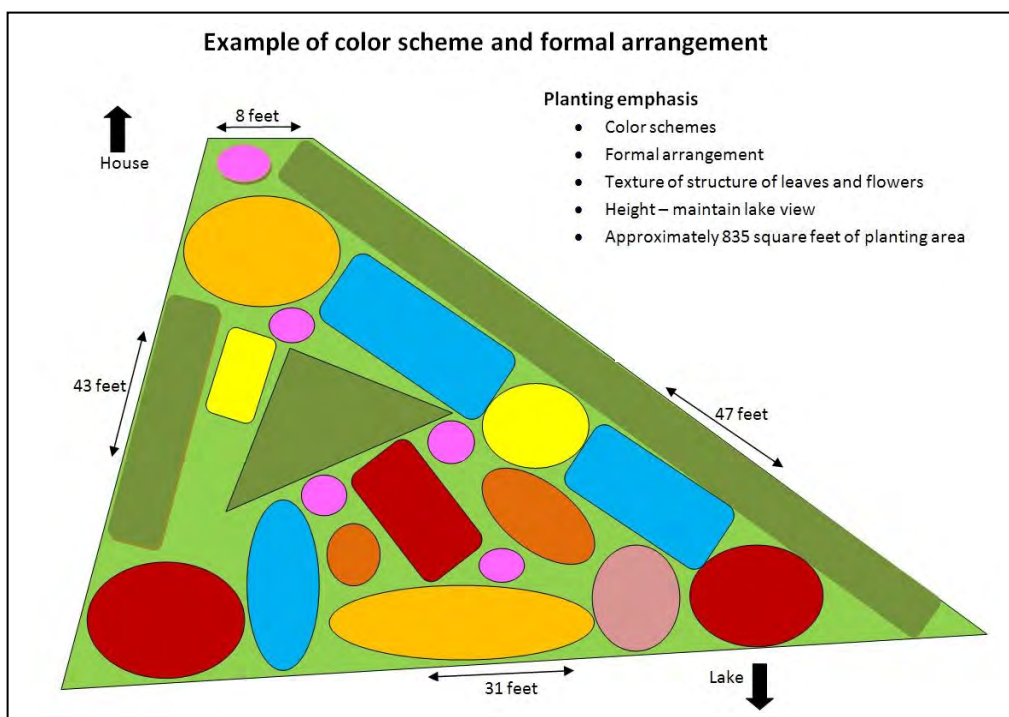
Part 3. Kegel Lakefront Restoration

On the south-central shore of Black Oak Lake is a property owned by the Kegel family. The near shore riparian area on this property is the subject of this restoration plan that seeks to return native vegetation to the site.



General Site Plan

- Dimensions: 8' x 47' x 31' x 43'
- Plant native vegetation directly into hillside. Emphasis will be on accent and color. Paying attention to placement, organization and height to protect view of lake.
- Plant spacing: As appropriate for number of plants purchased
- Remove invasive honeysuckle from site.
- Removal of Marsh Thistle below the OHWM across all shoreland area by cutting base of plant off – soil disturbance is permitted
- Deer prevention program is required. (Fencing and spraying)



Additional Site Restoration

- Use of native shrubs to accent the established flower bed, paying attention to shape and height of shrubs to protect lake view.
- Monitor the presence of “snow on the mountain;” decide if removal efforts are necessary.



Additional Restoration Effort

Use of a down spout off of the gutters that will divert water away from the edge of the house into a French drain that will run under lawn area towards a wooded area down slope.

Approximate Cost of Materials for Restoration for the Kegel Site			
Description	Quantity	Price/Unit	Cost
Planting Area Approximately 835 sq.ft. Forbs/Grasses planting area approximately 627 sq. ft. Shrub planting area approximately 125 sq.ft. Plant spacing every 6-10 inches			
Native forbs/grasses 2.5" containers	1570	2.45	3846.5
Shrubs	28	17.5	490
Trees	3	65	195
Mulch	16 bags	2.75	44
TOTAL COST			4575.50
Deer Fencing			
Fencing (130 linear feet)	2 rolls	110	220
Stakes (8' spacing)	20	6.5	130
Zip ties	2 packages	10	20
TOTAL COST			370
GRAND TOTAL COST			\$4,946
<i>Note: Costs do not include tax, labor, and mobilization (acquiring and delivering supplies).</i>			

Part 4. Island Erosion Restoration

On the west end of Black Oak Lake is a small island used by the public. The much-used approach to this island is devoid of plant material and is eroding onto the shore and into the lake. Below, we provide options for minimizing erosion and providing some public education. The "EcoGrid" brochure referenced below is contained in Appendix 1.



Minimize erosion in high traffic area

Option 1:

- Install a stair case that would funnel foot use into a single use area. (Note: need to stay above the OHWM.)

Option 2:

- Install an ecogrid-like system to minimize erosion while being able to maintain foot traffic. ([EcoGridBrochureWebv3.pdf](#))

In the case of either option, install a small educational sign about reasons to minimize shoreland erosion.

We estimate that the approximate cost of Option 2 (ecogrid) would be \$7,000.

Literature Cited

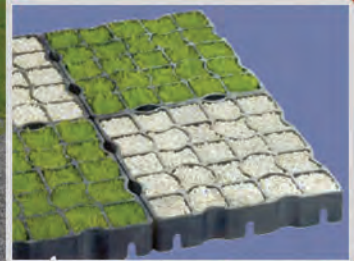
Walters, C. 1986. Objectives, constraints, and problem bounding. In W.M. Getz, ed., Adaptive Management of Renewable Resources. Macmillan Publishing Company. New York. p. 13+.

EcoGrid Ground Reinforcement



The Ultimate Ground Reinforcement

Improve water drainage and stop erosion.
The environmental alternative to paving.



EcoGrid/EcoRaster is a tough, durable, interlocking grid system designed to provide turf protection, ground reinforcement, and erosion control. Manufactured from 100% recycled plastics and providing superior water drainage, this revolutionary system provides an economical and environmentally sustainable alternative to asphalt or paving.

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- Quick and easy to install
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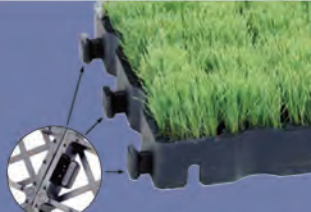


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Technical Specifications



Grid Area	33 x 33 cm (13 x 13 inches)				
Wall Thickness	5 mm (0.2 inches)	4 mm (0.16 inches)	3.6 mm (0.14 inches)	5 mm (0.2 inches)	2.5 mm (0.10 inches)
Wall Depth	30 mm (1.2 inches)		40 mm (2.0 inches)	50 mm (2.0 inches)	
Sheet Size	12 pieces = 1.33 m ² (14.32 ft ²)				
Weight per m ² (ft ²)	6.93 kg (1.42 lbs)	5.175 kg (1.06 lbs)	5.22 kg (1.07 lbs)	10.917 kg (2.24 lbs)	6.84 kg (1.4 lbs)
Carrying load per m ²	up to 150 tonnes	up to 120 tonnes	up to 120 tonnes	up to 350 tonnes	up to 120 tonnes
Material	100 % recycling material PE (polyethylene)				
Dimensional stability	Temperature Range -50°C to 90°C				
Dimensional change	0.5% (with standard temperature +20°C to 80°C)				
Humidity Absorption	0.01%				
Chemical Resistance	Resistant to acids, alkalis, alcohol, oil and petrol (de-icing salt, ammonia, acid rain etc.)				
Estimated Install Time	100 m ² (1076 ft ²) per person per hour (dependent on ground preparation)				
Suggested Use	Technical Applications (machine rooms), Green Roofs	Low to moderate vehicle traffic, Paths, Paddocks, Green Spaces, Stables	Moderate vehicle traffic, Outdoor Arenas, Paths, Helipads, Green Spaces	Moderate to heavy vehicle traffic, Military, Parking Lots, Roadways	Reduced Load Capacity Slope Stabilization, Golf Course Paths



The patented safety interlocking system sets a new standard.

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EcoGrid/EcoRaster can be filled with wide range of materials including grass seed and gravel.

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Choose the appropriate EcoGrid/EcoRaster type for the application. Not sure which one to use? Ask us ... we're always happy to help.

Blinding/Leveling Layer
To level any possible unevenness in the base layer and provide a rooting zone if planting grass.

Base Layer
To ensure optimum drainage, install a layer of crushed rock. Depth and size of rock is dependent on application.



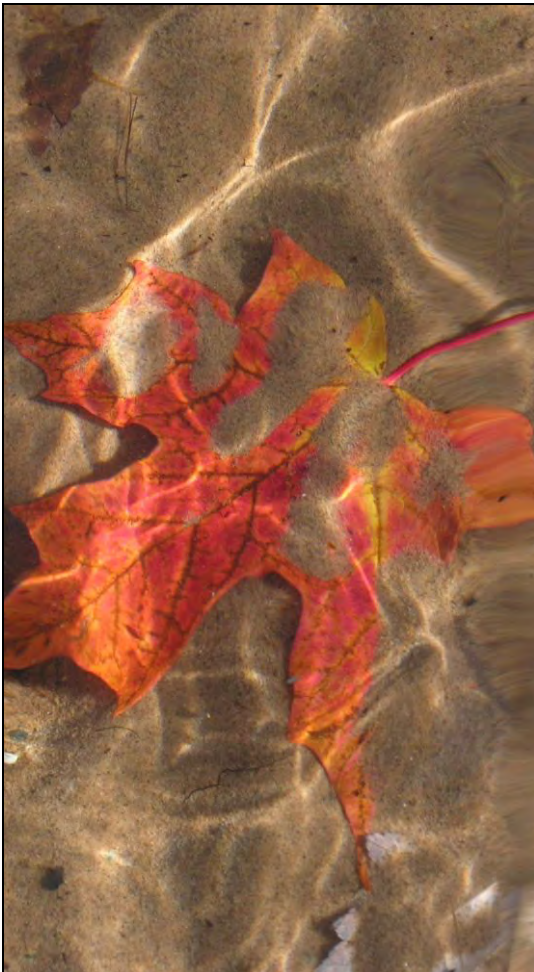
Appendix K

Phase 5 Report

(Water Quality and Lake Stage Monitoring)

Black Oak Lake Watershed Protection Program (Phase 5): Planning & Implementation of Long-term Water Quality & Stage Monitoring

The Black Oak Lake Preservation Foundation



Date: April 2013

Cite as document as:

Premo, Dean, and Barbara Gajewski.
2013. Black Oak Lake Watershed
Protection Program: Planning and
Implementation of Long-term Water
Quality and Stage Monitoring. (Report
for Phase 5, WDNR Lake Planning
Grant). White Water Associates, Inc.

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Black Oak Lake Watershed Protection Program (Phase 5): Planning & Implementation of Long-term Water Quality & Stage Monitoring

Report for a WDNR Lake Planning Grant (Phase 5)

Submitted to:

Wisconsin Department of Natural Resources
Attention: Kevin Gauthier
107 Sutliff Avenue
Rhinelander, WI 54501
Phone: (715) 365-8937

This document is a product of a WDNR Lake Planning Grant awarded to:

The Black Oak Lake Preservation Foundation
Contact: Tom Allman
5894 South Black Oak Lake Road
Land O' Lakes, Wisconsin. 54540
Cell Phone: 715-891-7563; E-mail: tomimi@nnex.net

Prepared and Submitted by:

White Water Associates, Inc.
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Introduction

The Black Oak Lake Watershed Protection Program is an ongoing endeavor composed of annual phases that progress toward the overall vision. The Black Oak Lake Preservation Foundation (formerly, Black Oak Lake Riparian Owners Association) is the lead organization in this long-range effort. White Water Associates, Inc. has been the organization's consultant throughout the history of the program.

Five project phases have been undertaken over the course of the Watershed Protection Program. Phase 5 sought to plan for long-term water quality and stage monitoring at Black Oak Lake and (in concert with Phase 4) continue the ongoing Clean Boats, Clean Waters effort. This report presents these activities and becomes part of the overall adaptive management plan for the Black Oak Lake Watershed Protection Program. It is a required report to the Wisconsin Department of Natural Resources (WDNR) Lake Planning Grants Program. A planning grant partially funded this project.

Project participants continue to embrace the concept of “adaptive management” in their approach to the Black Oak Lake Watershed Protection Program. Simply stated, adaptive management uses findings from planned monitoring activities to inform future management actions and periodic refinement of the plan. An adaptive management plan accommodates new findings by integrating this information into successive iterations of the comprehensive plan (Walters 1986). The plan is therefore a dynamic entity, successively evolving and improving to fit the needs of the Black Oak Lake watershed. A central premise of adaptive management is that scientific knowledge about natural ecosystems is uncertain and therefore a practical management plan allows for ongoing adjustments in management designed to “adapt” to changing conditions and new information or understanding. Monitoring the outcomes of plan implementation is essential to the process of adaptive management.

Besides this introductory chapter, this report contains three additional chapters. Chapter 2 describes the background and study area. Chapter 3 lays out the methods we followed in carrying out this project. Chapter 4 presents and discusses the results of Phase 5

Background

Black Oak Lake is a 584 acre lake located near the town of Land O'Lakes in northern Vilas County, Wisconsin. It is a deep lake (more than 80 feet in places) and has a high diversity of aquatic habitats (from shallow to deep water). Black Oak Lake can be best described as a "Groundwater Drainage Lake" although the outflow stream has been dry for many years. It is an oligotrophic lake. Its outflow stream is small. Black Oak Lake has remarkable water quality and associated native biotic community. There is a public park with swimming beach, picnic area, and boat landing. Black Oak Lake is an important resource used by the public.

Phases 1 and 2 assembled existing water quality information on Black Oak Lake and Phase 5 has conducted further analysis of this data as well as more recently collected data. This analysis and consultation with Wisconsin water quality professionals has helped the development of a water quality monitoring program that informs The Black Oak Lake Preservation Foundation members and other stakeholders about the status of Black Oak Lake water quality. It will help reveal trends in water quality measures such as water transparency.

The recent years of draught conditions in northern Wisconsin have resulted in low lake levels in Black Oak Lake. Since widely varying lake level represents a possible stressor on the Black Oak Lake ecosystem, it is important to document the extent of this variation. Measurements of Black Oak Lake water levels have taken place since 2001. In fact, this kind of stage height monitoring is rarely done for lakes and generally prevents us from determining how current lake levels compare to historic values and whether the current drought and coincident low lake levels is having an unusual duration. Phase 5 has endeavored to establish an accurate, repeatable, and standardized approach to lake level monitoring in Black Oak Lake.

Methods

There were three principal goals of the Phase 5 project: (1) institute a system that detects changes in water quality, (2) establish a scientifically acceptable method for monitoring lake stage height (lake level), and (3) prevent establishment of AIS. The approaches we used to accomplish these goals are described in this chapter.

Part 1 — Long-range Water Quality Monitoring

Our approach with long-range water quality monitoring was to review and analyze historical water quality data available for Black Oak Lake to see if long-term trends were evident. We consulted with Wisconsin-based limnology professionals regarding Black Oak Lake water quality issues to glean other ideas about approaching long-range monitoring. Members of the Black Oak Lake Preservation Foundation have consulted with Tim Kratz (former Trout Lake Director) and Susan Knight (Trout Lake Research Scientist). We also consulted with Tim Asplund (WDNR) and Kevin Gauthier (WDNR).

The Citizen Volunteer Water Quality Monitoring Program was ongoing throughout Phase 5. In addition, White Water Associates collected a mid-summer 2011 water quality sampling to evaluate additional water quality parameters.

One outcome of our data review, analysis, and discussion with other scientists was the preparation of a water quality sampling plan for Black Oak Lake that will monitor for changes in water quality. Black Oak Lake Preservation Foundation Board members asked that water quality plan allow the determination of a Black Oak Lake water quality “report card” on an periodic basis. This will help identify areas of quality or concern for Black Oak Lake stakeholders. In order to “grade” the lake, we consider attributes on which to base such an evaluation.

Part 2 — Long-term Stage Monitoring

In the process of establishing a scientifically acceptable method for monitoring Black Oak Lake stage height (lake level), we consulted Preservation Foundation Board member Walt Bates regarding the lake stage monitoring that he has conducted for several years on Black Oak Lake. He has begun an important long-term record of lake level. We also consulted with Tim Asplund (WDNR) regarding lake stage monitoring protocols for Wisconsin, training for lake stage monitors, and disposition of lake stage data. In addition, we consulted with the U.S. Geological Survey (USGS) for advice on protocols for lake stage monitoring. Early on, we spoke with Dr. Carl Watras (University of Wisconsin, Center for Limnology, Trout Lake Station) regarding a program of lake level monitoring in which he was involved (now being managed by the North Lakeland Discovery Center).

Part 3 — Clean Boats / Clean Waters

Phases 4 and 5 shared the goal of preventing establishment of AIS in Black Oak Lake. Phase 5 included (in part) volunteer monitoring of watercraft traffic into Black Oak Lake through the Clean Boats, Clean Waters Program. This monitoring serves to minimize the opportunities for introduction of AIS propagules on recreational watercraft. Since 2004, watercraft inspection has been a significant part of Wisconsin's AIS prevention efforts. Black Oak Lake has participated in the Clean Boats, Clean Waters Program since 2008. The WDNR and University of Wisconsin Extension (UWEX) have developed a well-defined protocol for carrying out this program. In 2011 BOLROA carried out the CBCW program and submitted data collected by boat landing monitors to the SWIMS database.

Part 4 — Education

As part of the Phase 5 project, we had numerous direct interactions and correspondences with Preservation Foundation board members that, in part were educational in nature. Aspects of these discussions were presented on the foundation website. The Phase 5 report and the adaptive management plan that houses it are educational documents intended for Black Oak Lake stakeholders to become more knowledgeable about the Black Oak Lake ecosystem and watershed.

Results and Discussion

In this Chapter, we describe the results of the Phase 5 effort under two corresponding parts: (1) long-range water quality monitoring and (2) long-term stage monitoring.

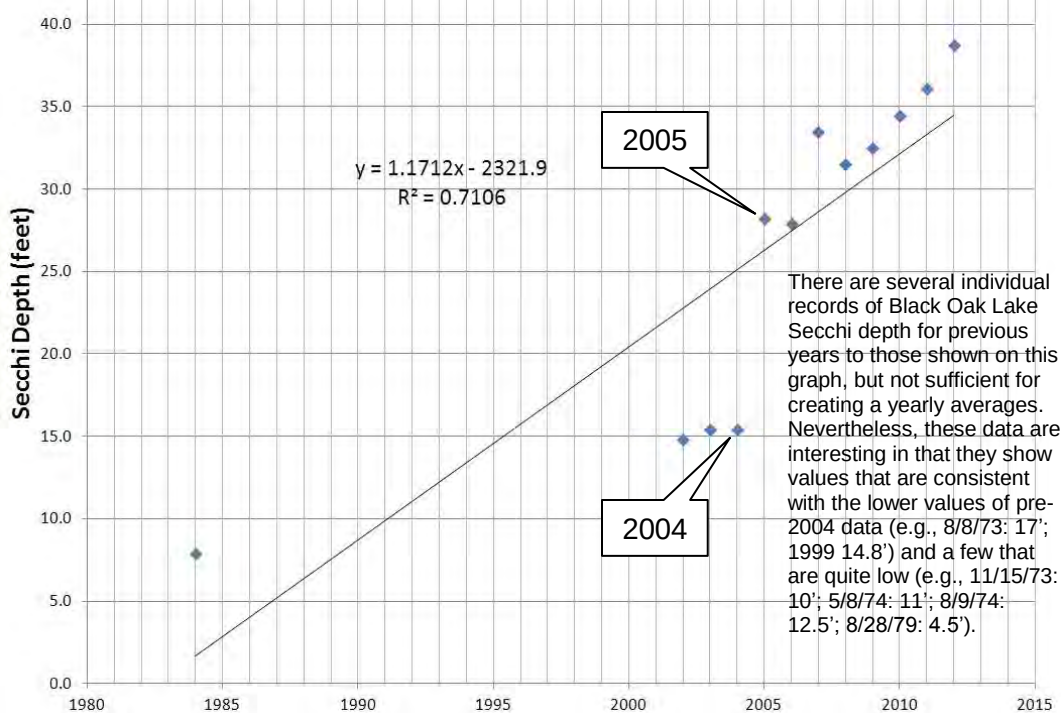
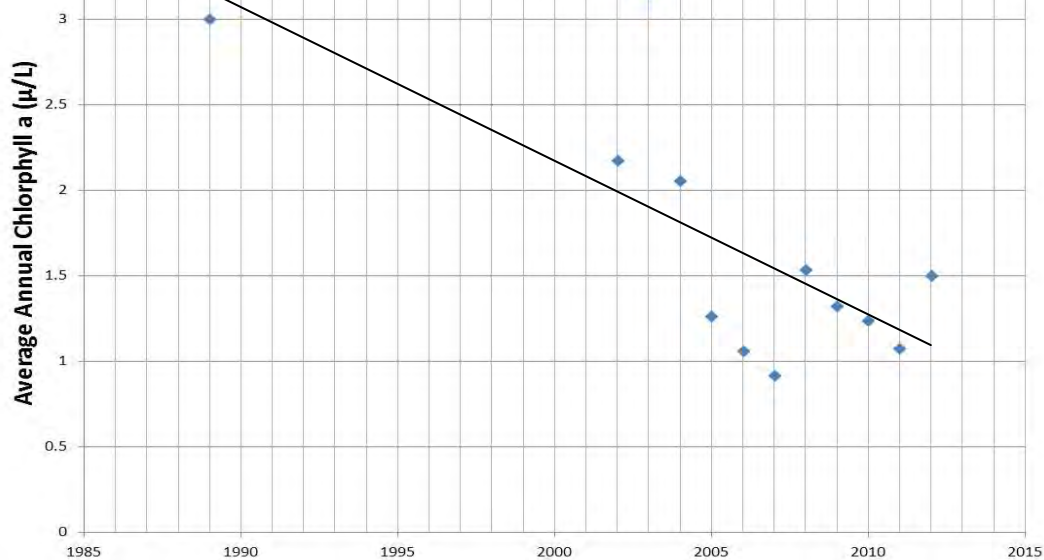
Part 1. Long-range Water Quality Monitoring

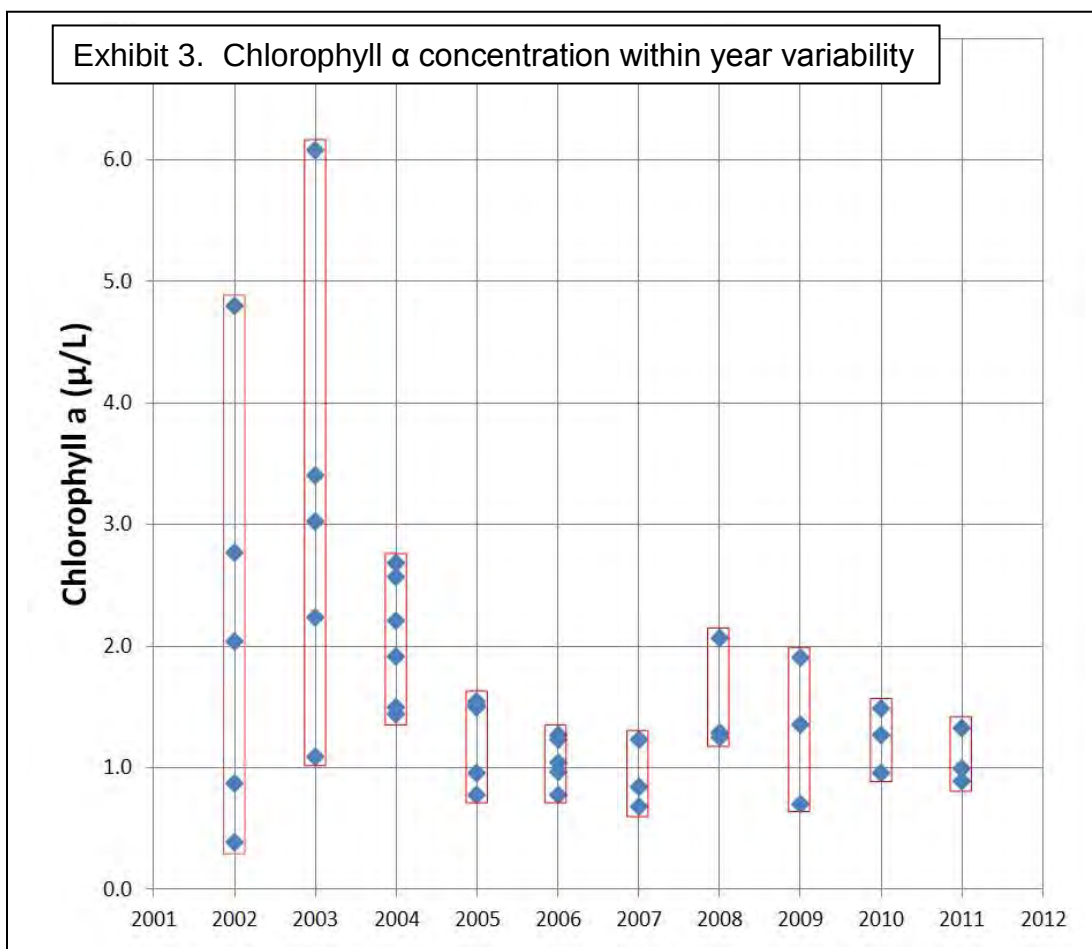
The adaptive management plan for Black Oak Lake summarizes and interprets water quality data collected in Black Oak Lake from two sources: (1) Conserve School classes from 2000 through 2002 and (2) WDNR Self-Help Monitoring Program data from 2002 through 2006. In this Phase 5 report, we update the data analysis (including more recently obtained data) and focus on measures of trophic status (specifically, Secchi depth, phosphorus concentration, and chlorophyll α concentration).

As has been previously documented, a dramatic increase was observed in Black Oak Lake water clarity beginning in 2005. Secchi depths went from an annual average of around 15 feet to an annual average of about 28 feet in 2005 and 2006 (Exhibit 1). Since 2007, average Secchi depth readings in Black Oak Lake have not been less than 31 feet (and most are higher). Black Oak Lake has long been known for its high water clarity, but this increase was noteworthy.

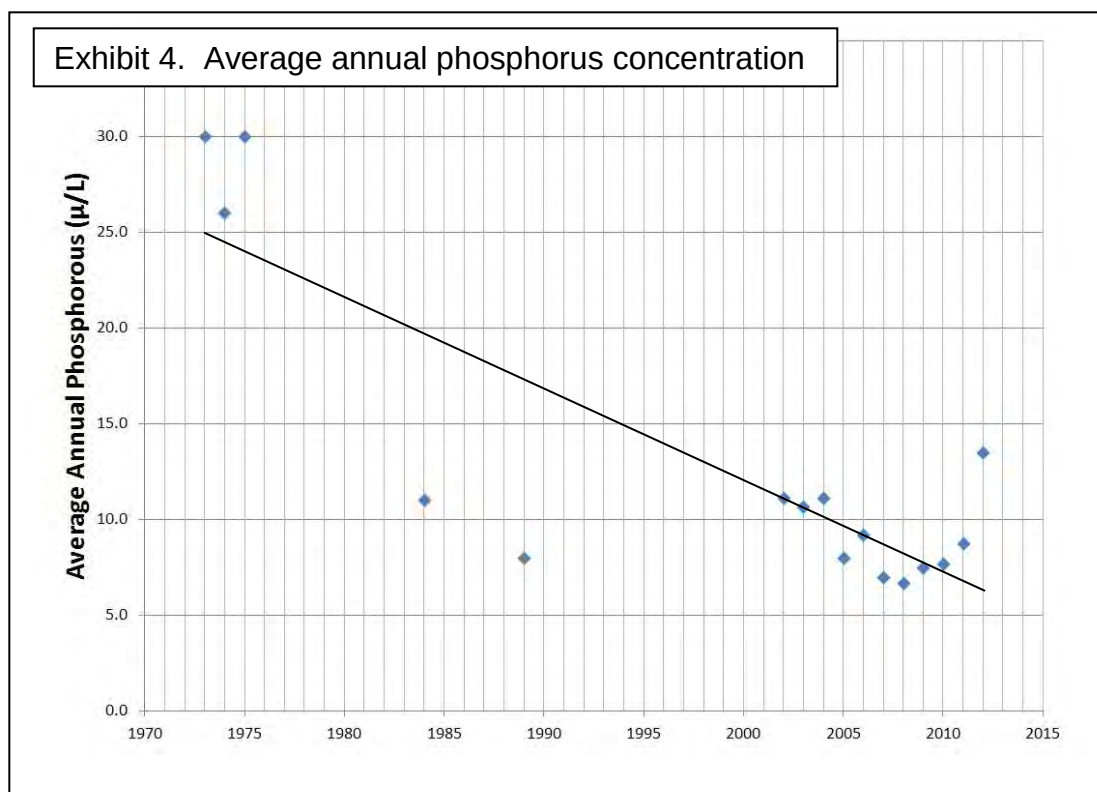
The reasons for this greater than doubling of water transparency are generally unknown. One might guess that the presence of some sort of filtering organism such as the AIS zebra mussel would be behind the phenomenon, but in fact zebra mussel are not present in Black Oak Lake (in fact, lake's calcium concentration is sufficiently low so as to be unsuitable for zebra mussels). Small changes in chlorophyll α concentration may lead to more noticeable changes in an already clear lake. In fact, average chlorophyll α concentration in Black Oak Lake was lower beginning in 2005 (coincident with the high Secchi transparency). This is graphically displayed in Exhibit 2. For a few years, chlorophyll α concentration was measured at several times during the ice free season. When these data are examined graphically (Exhibit 3) the variability of chlorophyll α concentration was higher in 2002 and 2003 (varying about 5 μL over the course of each of those years. Starting in 2004, however, the variability of chlorophyll α varied less than 1.5 μL (and often less than 1.0 μL) over the course of any given year. More dramatic algal "blooms" apparently took place in 2002 and 2003, but less so since then.

Exhibit 1. Average annual Secchi depth (in feet)

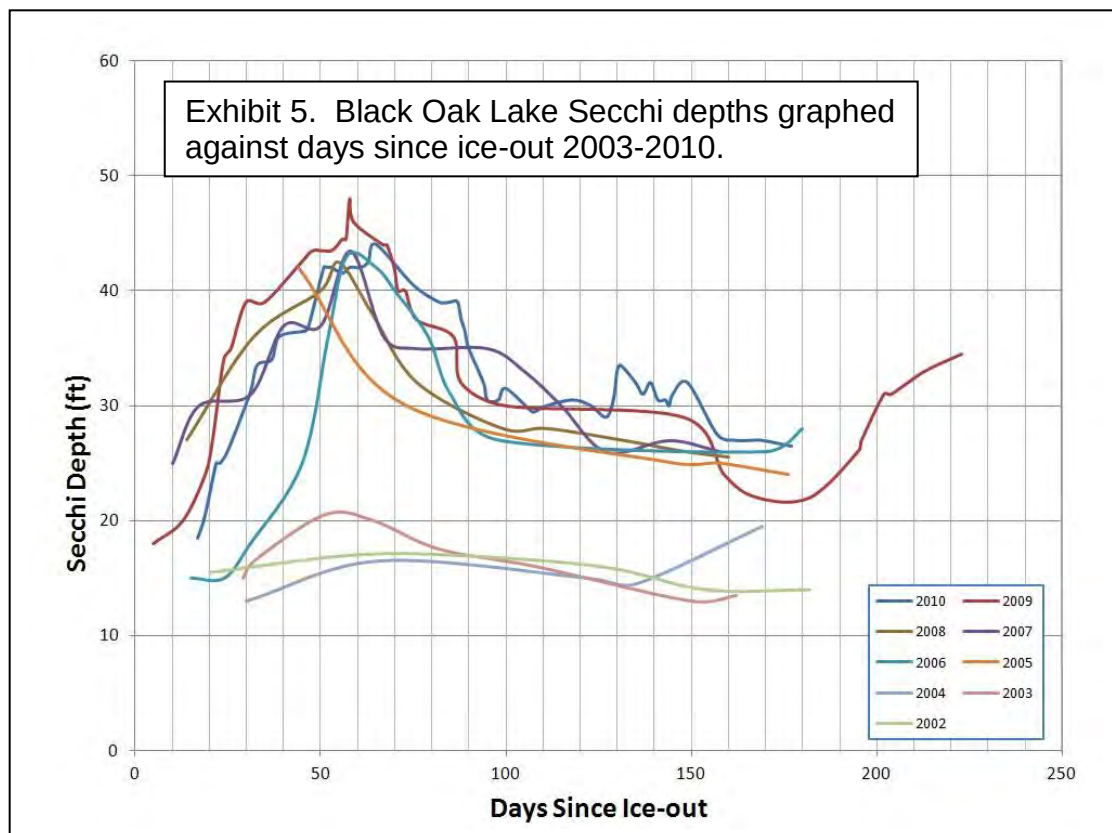
Exhibit 2. Average annual Chlorophyll α 



Chlorophyll α and water transparency are often related to concentration of the nutrient phosphorus. The annual average concentration of phosphorus measured in Black Oak Lake over the past 39 years is shown in Exhibit 4. Values in 1973, 1974, and 1975 were more than twice what has been observed since 1984. This could be a real phenomenon or perhaps a different laboratory or field sampling methodology. In the last 28 years (since 1984) the average phosphorous concentration has remained between 6 and 11 μ/L . The single phosphorus value for 2012 was 14 μ/L . The average annual phosphorus concentrations were about 11 μ/L in 2002, 2003, and 2004. In the first year of the high water transparency the average annual phosphorus concentration was 8 μ/L .



Dr. Susan Knight, WDNR and UW Research Scientist and Aquatic Biologist at the University of Wisconsin Center for Limnology Trout Lake Station, has had a long time interest in Black Oak Lake. Dr. Knight examined Secchi depth data to document and understand the increased water clarity phenomenon. She prepared and interpreted the graphs displayed in Exhibit 5. This multi-year set of graphs shows the large increases (more than doubling) of Black Oak Lake's Secchi depths starting in 2005. Dr. Knight notes that the intra-summer changes of Secchi depth are of scientific interest in the Exhibit 5 graphs of annual Secchi depth (Knight, 2012, unpublished). The worst clarity is right after ice-out. Clarity continues to increase and eventually more than doubles the initial reading. Peak clarity is reached at about 55 days after ice-out. Over the next 40 or so days it drops back to about half way between the two values and stays there until fall. Also of interest is how tightly the Secchi peaks cluster at that 55 days since ice-out point, especially considering that the actual calendar ice-out date varied by more than a month over the six years covered by these graphs. This would indicate that a lake's biotic year is far more affected by ice-out than by sun angle. Indeed, many significant things happen at ice-out such as the first infusion of fresh oxygen, spring turnover, first solar illumination, first wind mixing, first rainfall turbulence, and more.



Dr. Knight interprets the seasonal variability in Secchi depths by describing the trophic interactions between algae and zooplankton (nearly microscopic organisms that eat single-celled algae). In the early spring, right after ice-out, lake turnover brings up nutrients from the bottom and this spurs algal growth in the lake. Zooplankton benefit from the increasing numbers of algae and consume more and more. Consequently the numbers of zooplankton also go up as they reproduce and prosper from the rich food source. As more algae are eaten the water clarity increases. When the zooplankton numbers are at their peak and they are eating the most algae, Secchi readings will also be at their peak. This is known as the “clear water phase.” As the graphs in Exhibit 5 show, this peak clarity seems to happen in Black Oak Lake data about 55 days after ice-out. After this, the algae numbers will start to fall, and the zooplankton numbers will also fall. The interactions between algae, zooplankton, nutrients and fish become more complicated as the summer moves on and thus a more intermediate water clarity results.

By any standard, the water clarity of Black Oak Lake would be considered an indicator of excellent lake water quality. Recent measures of phosphorus and chlorophyll α reinforce this conclusion. Like any ecosystem, Black Oak Lake is complex and an absolute

determination of cause for the increased water clarity in 2005 and thereafter remains elusive. Has it reached a new equilibrium or will it continue to change? This can only be learned through the efforts of devoted lake stewards and their ongoing lake monitoring.

Future sampling should continue with the frequent Secchi depth measures (weekly would be good). For a period of five years, Chlorophyll α and phosphorus should be measured close to the time of ice-out, at 55 days after ice out and at 130 days after ice-out. Dissolved oxygen/temperature profiles should be done as time permits, but at least monthly. Stage height measurements should be taken in spring and fall. Sampling efforts are coordinated by Walter Bates. These parameters and sampling frequency are outlined in the bulleted list below:

- Secchi depth – weekly during ice-free season;
- Chlorophyll α – three times: ice-out, 55 days after ice-out, 130 days after ice-out;
- Phosphorus – three times: ice-out, 55 days after ice-out, 130 days after ice-out;
- Dissolved oxygen/temperature profiles - at least monthly during ice free season;
- Stage height (lake level) – Twice per year: early spring and late fall.

Water quality data should be input into the SWIMS database from which it should be periodically accessed for analysis. Once per year the water quality data should be compared to values to previous years to see if unexpected changes have become evident. This data review should be conducted by a committee of the Black Oak Lake Preservation Foundation. Past foundation president, Tom Allman, recommends that two people from each current board (one senior board member and one freshman member) form this committee and complete the annual review with needed assistance from a professional consultant. As future understanding or observations dictate, additional parameters can be added to the monitoring plan. A Phase 6 project will be proposed in 2013 and will incorporate these new water quality sampling recommendations.

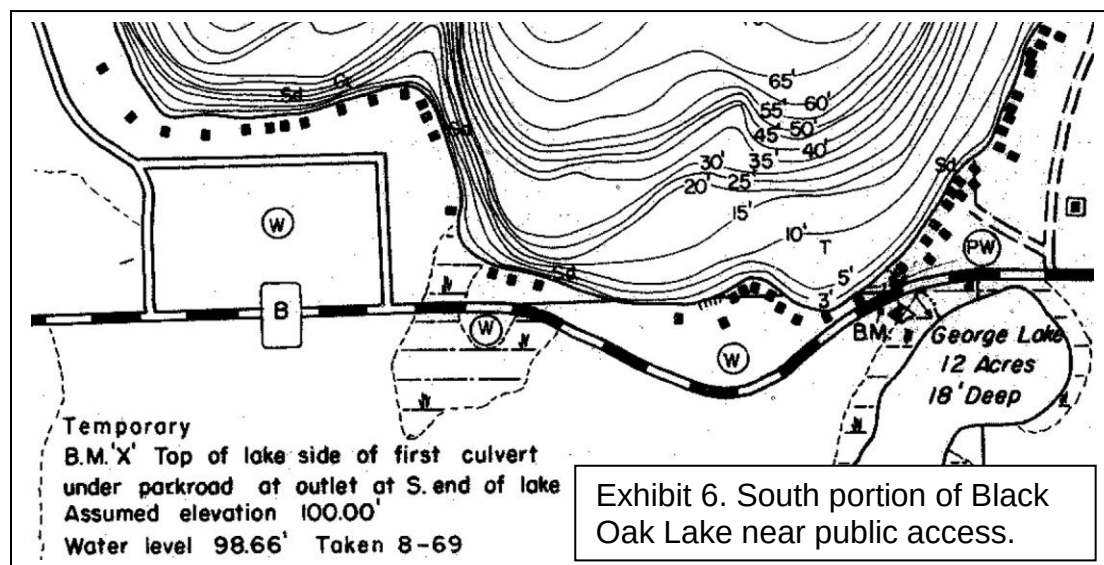
In addition to the ongoing water monitoring, members of the Foundation Board and their consultant are considering additional studies to help understand the trophic status and dynamic nature of the Black Oak Lake ecosystem. These possible studies include:

- Analysis of a 2011 point-intercept aquatic plant survey and comparison to the previous survey to determine changes in composition, density, and distribution of the aquatic Macrophytes in Black Oak Lake;
- Analysis of sediment core sample taken in Black Oak Lake in July 2012;
- Algae and zooplankton studies to understand these communities, their trophic interactions, and influence on water clarity.

Foundation board member, Bob Pierce has expressed an interest in developing a Black Oak Lake “report card” that would reflect the health status of the lake. One of the actions anticipated in the 2012 iteration of the Black Oak Lake Adaptive Management Plan is to develop such an evaluation process based on lake monitoring data. Also involved in this process is to establish standards for what constitutes various ratings (in other words, the grading scale). For example, what Secchi transparency value would be considered as the ideal? Perhaps a more integrated evaluation of parameters that results in a rating of the lake as oligotrophic or mesotrophic would be preferred. The board committee should consider these and other topics. Good candidate factors to consider when evaluating the lake include: clarity, phosphorous, chlorophyll α , temperature, dissolved oxygen, water level, aquatic plant community, presence of AIS, and the fish community.

Part 2. Long-term Stage Monitoring

In August of 1969, the WDNR created a “Lake Survey Map” for Black Oak Lake. This included the lakes bathymetric contours and water level. At that time a benchmark was established as an “X” on the top of the lake side of the first culvert under the park access road at the south end of the lake. This is labeled in Exhibit 6. The benchmark was assumed to be 100.00 feet in elevation. A water level obtained at that time was 98.66 feet. That culvert still exists on Black Oak Lake although it, and the road that travels over it, are old and replacement in the near future is likely.



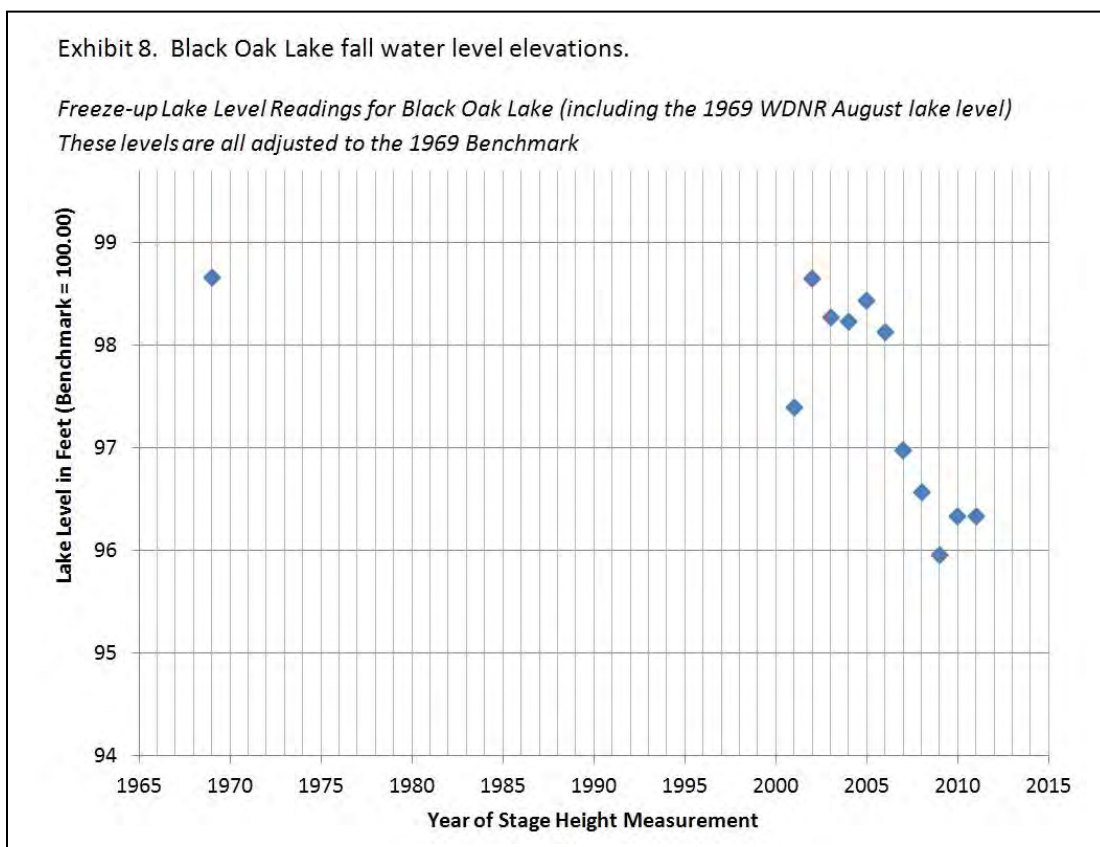
Black Oak Lake water level has been accurately recorded since early spring of 2001, by lake volunteer Walt Bates. On flat calm water, Mr. Bates measures vertical height from a submerged concrete block that exists in front of his property near the west end of North Black Oak Lake Road (this is one mile northwest from the bench mark described in the previous paragraph and within a line-of-sight from the benchmark). Actually, two blocks of concrete are used in the determination of lake level. One is a very large block whose surface is approximately seven feet underwater. The second is a smaller block located in shallower water. The shallower block is more convenient to measure stage height from and the larger block is used to document the stability of the shallower block. From 2001 to 2010 the relative measurements of these two concrete blocks remained unchanged. Low water in winter of 2010 caused ice to break up the shallow concrete piece. A new one was installed in slightly deeper water. The deeper water concrete block was used to standardize the new shallow block's elevation measurement. In the years since the new block was installed, its position relative to the deeper block has remained stable.

On August 22, 2011 (a very calm, windless day), Mr. Bates and an assistant used a transit to determine that the top of the culvert (the 1969 benchmark for lake level) was 3.27 feet above Black Oak Lake water surface (in other words the lake level was at 96.73 feet (relative to the BM). Mr. Bates next took the measurement from the top of the large concrete block to the water surface. Using the survey technique of "water level transfer" it was possible to establish that the vertical distance from the top of the large concrete block to the top of the culvert benchmark (=100.00 feet) was 130.25 inches (=10.85 feet). Relative to the 100.00 BM, the elevation of the top of the large concrete block is 89.15 feet. Using this datum we are able to report the entire history of Black Oak Lake level at the same scale and relative to the original bathymetric map of the lake in 1969 when the benchmark was established. These data are presented in Exhibit 7. Exhibit 8 displays the water level elevations for the fall measures. Over the course of these records, fall water level readings have ranged from a high of 98.66 feet (in 1969 and 2004) to 95.96 feet (in 2009). This is a 2.7 foot (32.4 inch) range.

Exhibit 7. Black Oak Lake water level elevations (in feet) relative to the 1969 benchmark established by the WDNR.

Note: measures are made at the time of ice out in spring and freeze-up in fall. The 1969 bathymetric survey was conducted in August.

Year	Ice-Out	Freeze-Up
1969 (August)		98.66
2001	97.60	97.40
2002	97.81	98.65
2003	98.77	98.27
2004	98.65	98.23
2005	98.19	98.44
2006	98.69	98.12
2007	98.17	96.98
2008	97.15	96.56
2009	96.62	95.96
2010	95.77	96.33
2011	96.87	96.33
2012	96.48	



As part of the Phase 5 effort, we have been in contact with Tim Asplund (WDNR) and Paul Juckem (USGS) regarding the status of the Wisconsin lake level monitoring program. This program is in its early stages. They are currently developing the portion of the program called "train the trainers" which gets a core group of people trained locally who can work with lake associations to create a lake level monitoring program that the lake association will follow and enter lake level data into the SWIMS database. Since Black Oak Lake has several years of monitoring and has tied the lake level elevation data to the 1969 benchmark, the advice we glean from the WDNR at this time is to continue with the Black Oak Lake protocol and enter the data into SWIMS as it becomes available. Black Oak Lake stewards will remain informed regarding the status of the WDNR-UWEX Lakes train the trainer program.

Literature Cited

Knight, Susan. 2012. Unpublished analysis.

Walters, C. 1986. Objectives, constraints, and problem bounding. In W.M. Getz, ed., Adaptive Management of Renewable Resources. Macmillan Publishing Company. New York. p. 13+.

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Appendix L

Black Oak Lake Sediment Core

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RESULTS OF SEDIMENT CORE TAKEN FROM BLACK OAK LAKE, VILAS COUNTY, WISCONSIN

*Paul Garrison Wisconsin Department of Natural Resources
December 2012*

Aquatic organisms are good indicators of a lake's water quality because they are in direct contact with the water and are strongly affected by the chemical composition of their surroundings. Most indicator groups grow rapidly and are short lived so the community composition responds rapidly to changing environmental conditions. One of the most useful organisms for paleolimnological analysis are diatoms. These are a type of algae which possess siliceous cell walls, which enables them to be highly resistant to degradation and are usually abundant, diverse, and well-preserved in sediments. They are especially useful, as they are ecologically diverse. Diatom species have unique features as shown in Figure 1, which enable them to be readily identified. Certain taxa are usually found under nutrient poor conditions while others are more common under elevated nutrient levels. Some species float in the open water areas while others grow attached to objects such as aquatic plants or the lake bottom.

By determining changes in the diatom community it is possible to determine water quality changes that have occurred in the lake. The diatom community provides information about changes in nutrient concentrations, water clarity, and pH conditions as well as alterations in the aquatic plant (macrophyte) community.



Figure 1. Photomicrograph of the diatoms commonly found in the Black Oak Lake sediment core. The diatom in the bottom left (*Aulacoseira subarctica*) is a filamentous diatom common in low nutrient waters. The circular shaped diatoms in the upper right (*Discotella stelligera*) is also common in low nutrient waters.

On 18 July 2012 a sediment core was collected near the deep area of Black Oak Lake (N46° 09.75' W89° 18.69') using a gravity corer. The water depth was 81 feet. The length of the core was 54 cm. It is assumed that the upper sample represents present day conditions while the deeper sample is indicative of water quality conditions at least 100 years ago. The upper 30 cm was dark brown in color while the portion below 30 cm was light brown in color. The diatom community was analyzed from a section representing the top 2 cm and a section from 48-50 cm .

Results

In Black Oak Lake, historically the major component of the diatom community are those species that float in the open water of the lake. The major taxa of these planktonic diatoms in the bottom sample were the chain forming diatom *Aulacoseira subarctica* and *Discotella stelligera* (Figure 2). These diatoms are common in lakes throughout the Upper Midwest with low nutrient levels.

There are similar amounts of planktonic diatoms in the top and bottom of the core indicating there has not been a significant change in the lake's ecology. There has been a subtle change in the floristic composition of the diatom community between the time the bottom sample was deposited and the present time. There has been a decline in *A. subarctica* and an increase in *Cyclotella* spp. (includes *Discotella*) (Figure 2). There was a decline in *D. stelligera* and an increase in *Cyclotella bodanica* var. *lemanica*. The first taxa is generally more common in lakes with lower phosphorus concentrations and the latter taxa is more common in waters with slightly higher phosphorus levels.

In the top sample there is an increase in *Asterionella formosa* (Figure 2). This species is one of the first diatoms to increase as a result of nutrient enrichment following human disturbances. Recent studies have shown that this diatom may respond more to an increase in nitrogen and not necessarily to an increase in phosphorus.

The percentage of planktonic diatoms was similar in the top and bottom sample (Figure 2). In many northern WI lakes with shoreline development, there is an increase in the diatom species that grow attached to substrates such as submerged aquatic vegetation (SAV). Dr. Susan Borman recently conducted a study in lakes in the northwestern part of WI where she compared the SAV community in the 1930s with the present day community. She found that lakes with cottages have more plants and the species have shifted to those that are larger and grow closer to the lake's surface. The diatom community indicates that in Black Oak Lake there has not been a large increase in SAV. There may be some local areas where this has changed in recent decades but it is not evident in the sediment core.

Diatom assemblages historically have been used as indicators of nutrient changes in a qualitative way. In recent years, ecologically relevant statistical methods have been developed to infer environmental conditions from diatom assemblages. These methods are based on multivariate ordination and weighted averaging regression and calibration. Ecological preferences of diatom species are determined by relating modern limnological variables to surface sediment diatom assemblages. The species-environment relationships are then used to infer environmental conditions from fossil diatom assemblages found in the sediment core.

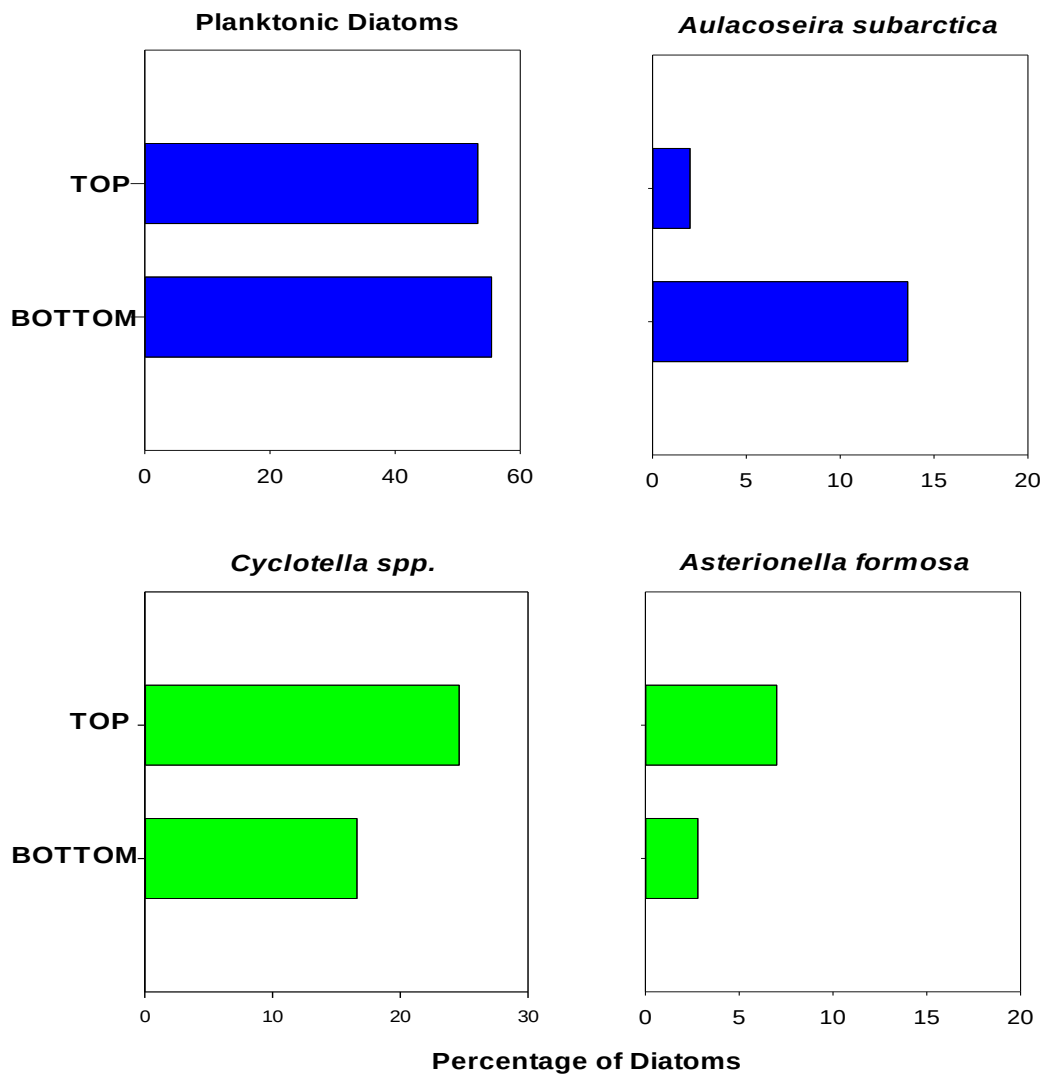


Figure 2. Changes in the abundance of important diatoms found at the top and bottom of the Black Oak Lake sediment core. The dominant diatoms were planktonic diatoms which float in the open water. The decline in *A. subarctica* and increase in *A. formosa* indicates a slight increase in nutrients.

Such a model was applied to the diatom community in the core from Black Oak Lake. The model indicates there has been a small increase in phosphorus of around $2\text{--}3\ \mu\text{g L}^{-1}$. The model predicted a present day summer mean phosphorus concentration of $9\ \mu\text{g L}^{-1}$ but the measured concentration for the last 3 years is $6\text{--}7\ \mu\text{g L}^{-1}$. The model over estimates the present day concentration because most of the lakes used in the calibration dataset have phosphorus concentrations that are higher than those found in Black Oak Lake. The model predicts the pre-settlement phosphorus concentration of $6\text{--}7\ \mu\text{g L}^{-1}$. It is likely that the historical concentration is $4\text{--}5\ \mu\text{g L}^{-1}$.

In summary, the sediment core indicates that there have only been subtle changes in the lake over the last 100 years. Nutrient levels have only increased a small amount. Unlike many northern lakes with shoreline development there has not been a significant increase in

submerged aquatic vegetation. The floristic changes in the diatom community as well as the modeling indicate there has been a small increase in the nutrient concentrations. Phosphorus levels have probably increased 2-3 $\mu\text{g L}^{-1}$.

Although the increase in nutrients is relatively small, it does indicate that shoreline development is having some adverse effect on the nutrient levels in the lake. While the greatest impact of shoreline development is the alteration of habitat on the shoreline as well as in the shallow water area of the lake, some increased nutrients are added to the lake. It is easier to reduce this input now than wait until it becomes a problem and then try to fix it.

BLACK OAK LAKE
Vilas County

Top (0-2 cm)

TAXA	COUNT TOTAL	
	Number	Prop.
<i>Achnanthes curtissima</i> Carter	2	0.004
<i>Achnanthes</i> sp. 1	6	0.012
<i>Achnantheidium altergracillima</i> (Lange-Bertalot) Round et	16	0.032
<i>Achnantheidium exiguum</i> (Grunow) Czarnecki	1	0.002
<i>Achnantheidium eutrophilum</i> (Lange-Bertalot in Lange-	2	0.004
<i>Achnantheidium minutissimum</i> (Kützing) Czarnecki	7	0.014
<i>Adlafia minuscula</i> (Grunow) Lange-Bertalot	1	0.002
<i>Asterionella formosa</i> Hassal	35	0.070
<i>Aulacoseira subarctica</i> (Müller) Haworth	10	0.020
<i>Brachysira microcephala</i> (Grunow) Compère	2	0.004
<i>Cavinula pseudoscutiformis</i>	1	0.002
<i>Cyclotella bodanica</i> var. <i>lemanica</i> Müller	48	0.096
<i>Cyclotella comensis</i> Grunow et Van Heurck	13	0.026
<i>Cyclotella delicatula</i> Hustedt	1	0.002
<i>Cyclotella michiganiana</i> Skvortzow	2	0.004
<i>Cyclotella</i> sp. 1	3	0.006
<i>Cymboppleura subcuspidata</i> (Krammer) Krammer	2	0.004
<i>Discotella pseudostelligera</i> (Hustedt) Houk et Klee	9	0.018
<i>Discotella stelligera</i> (Hustedt) Houk et Klee	47	0.094
<i>Encyonema mesianum</i> (Cholnoky) Mann in Round, Craw-	1	0.002
<i>Encyonopsis subminuta</i> Krammer & Reichardt	4	0.008
<i>Fragilaria</i> (GV) 12-13/10 u central area	8	0.016
<i>Fragilaria crotonensis</i> Kitton	10	0.020
<i>Fragilaria crotonensis</i> var. <i>oregona</i> Sovereign	48	0.096
<i>Gomphonema gracile</i> Ehrenberg emend Van Heurck	1	0.002
<i>Gomphonema pumilum</i> (Grunow) Reichardt et Lange-		
Bertalot	2	0.004
<i>Karayevia clevei</i> (Grunow) Bukhtiyarova	5	0.010
<i>Mayamaea permitis</i> (Hustedt) Bruder et Medlin	2	0.004
<i>Navicula cryptocephala</i> Kützing	2	0.004
<i>Navicula cryptotenella</i> Lange-Bertalot ex Krammer et	2	0.004
<i>Navicula harderii</i> Hustedt	2	0.004
<i>Navicula lanceolata</i> (Agardh) Ehrenberg	1	0.002
<i>Navicula minima</i> Grunow in Van Heurck	2	0.004
<i>Navicula radiosa</i> Kützing	2	0.004
<i>Navicula schmassmanni</i> Hustedt	4	0.008
<i>Navicula</i> sp. 1 ?	2	0.004
<i>Navicula</i> spp.	4	0.008
<i>Navicula subminuscula</i> Manguin	5	0.010

BLACK OAK LAKE
Vilas County

Top (0-2 cm)

	COUNT TOTAL	
	Number	Prop.
TAXA		
<i>Nitzschia acicularis</i> (Kützing) Smith	4	0.008
<i>Nitzschia lacuum</i> Lange-Bertalot	1	0.002
<i>Nitzschia palea</i> (Kützing) Smith	2	0.004
<i>Nitzschia palea</i> var. <i>debilis</i> (Kützing) Grunow	2	0.004
<i>Nitzschia tropica</i> Hustedt	8	0.016
<i>Planothidium frequentissimum</i> (Lange-Bertalot) Lange-	2	0.004
<i>Platessa conspicua</i> (Mayer) Lange-Bertalot	4	0.008
<i>Pseudostaurosira brevistriata</i> (Grunow) Williams et Round	4	0.008
<i>Pseudostaurosira trainorii</i> Morales	4	0.008
<i>Sellaphora pupula</i> (Kützing) Mereschkowsky	1	0.002
<i>Stauroneis</i> spp.	1	0.002
<i>Staurosira construens</i> Ehrenberg	9	0.018
<i>Staurosira construens</i> var. <i>venter</i> (Ehrenberg) Hamilton	8	0.016
<i>Staurosirella pinnata</i> (Ehrenberg) Williams et Round	13	0.026
<i>Staurosirella pinnata</i> var. <i>intercedens</i> (Grunow) Hamilton	8	0.016
<i>Staurosirella pinnata</i> var. <i>lancettula</i> (Schumann) Siver et	2	0.004
<i>Stephanodiscus alpinus</i> Hustedt	10	0.020
<i>Stephanodiscus medius</i> Håkansson	1	0.002
<i>Stephanodiscus minutulus</i> (Kützing) Cleve et Möller	7	0.014
<i>Synedra acus</i> var. <i>angustissima</i> (Grunow) Van Heurck	9	0.018
<i>Synedra delicatissima</i> Smith	26	0.052
<i>Synedra famelica</i> Kützing	4	0.008
<i>Synedra rumpens</i> var. <i>familiaris</i> (Kützing) Hustedt	3	0.006
<i>Synedra</i> sp.	1	0.002
<i>Tabellaria flocculosa</i> (strain III) sensu Koppen	5	0.010
<i>Tabellaria flocculosa</i> (strain IIIp) sensu Koppen	23	0.046
<i>Tabellaria</i> spp.	4	0.008
unknown pennate	19	0.038
TOTAL	500	1.000

BLACK OAK LAKE
Vilas County

Bottom (48-50 cm)

TAXA	COUNT TOTAL	
	Number	Prop.
<i>Achnanthes biasolettiana</i> (Kützing) Grunow	2	0.004
<i>Achnanthes subatomoides</i> (Hustedt) Lange-Bertalot et Archibald	5	0.010
<i>Achnantheidium altergracillima</i> (Lange-Bertalot) Round et Bukhtiyarova	3	0.006
<i>Achnantheidium exiguum</i> (Grunow) Czarnecki	1	0.002
<i>Achnantheidium minutissimum</i> (Kützing) Czarnecki	7	0.014
<i>Achnantheidium</i> sp. 1 ?	2	0.004
<i>Achnantheidium</i> spp	5	0.010
<i>Adlafia bryophila</i> (Petersen) Lange-Bertalot	2	0.004
<i>Adlafia minuscula</i> (Grunow) Lange-Bertalot	2	0.004
<i>Amphora veneta</i> Kützing	4	0.008
<i>Asterionella formosa</i> Hassal	14	0.028
<i>Asterionella ralfsii</i> var. <i>americana</i> Körner	1	0.002
<i>Aulacoseira italica</i> (Ehrenberg) Simonsen	3	0.006
<i>Aulacoseira</i> sp. 1?	2	0.004
<i>Aulacoseira subarctica</i> (Müller) Haworth	66	0.132
<i>Cocconeis pseudolineata</i> (Geitler) Lange-Bertalot	1	0.002
<i>Cocconeis pseudothumensis</i> Reichardt	2	0.004
<i>Cyclotella bodanica</i> var. <i>lemanica</i> Müller	5	0.010
<i>Cyclotella michiganiana</i> Skvortzow	2	0.004
<i>Discotella glomerata</i> (Hustedt) Houk et Klee	1	0.002
<i>Discotella stelligera</i> (Hustedt) Houk et Klee	75	0.150
<i>Encyonema minutum</i> (Hilse) Mann	3	0.006
<i>Encyonema</i> spp.	2	0.004
<i>Encyonopsis cesatii</i> (Rabenhorst) Krammer	2	0.004
<i>Encyonopsis subminuta</i> Krammer & Reichardt	1	0.002
<i>Eucocconeis flexella</i> (Kützing) Cleve	1	0.002
<i>Eunotia</i> spp.	1	0.002
<i>Fragilaria capucina</i> var. <i>mesolepta</i> Rabenhorst	6	0.012
<i>Fragilaria crotonensis</i> Kitton	43	0.086
<i>Fragilaria crotonensis</i> var. <i>oregona</i> Sovereign	14	0.028
<i>Fragilaria radians</i> (Kützing) Williams et Round	3	0.006
<i>Fragilaria tenera</i> (Smith) Lange-Bertalot	1	0.002
<i>Gomphonema auritum</i> Braun ex Kützing	1	0.002
<i>Gomphonema gracile</i> Ehrenberg emend Van Heurck	2	0.004
<i>Gomphonema parallelistriatum</i> Lange-Bertalot et Reichardt in Lange-Bertalot	1	0.002
<i>Gomphonema parvulus</i> (Lange-Bertalot et Reichardt) Lange-Bertalot et Reichardt	2	0.004
<i>Gomphonema pumilum</i> (Grunow) Reichardt et Lange-Bertalot	2	0.004
<i>Gomphonema</i> spp.	2	0.004

BLACK OAK LAKE
Vilas County

Bottom (48-50 cm)

COUNT TOTAL

TAXA	Number	Prop.
<i>Gomphonema truncatum</i> Ehrenberg	1	0.002
<i>Hantzschia amphioxys</i> (Ehrenberg) Grunow	2	0.004
<i>Karayevia clevei</i> (Grunow) Bukhtiyarova	3	0.006
<i>Karayevia suchlandtii</i> (Hustedt) Bukhtiyarova	1	0.002
<i>Navicula cryptotenella</i> Lange-Bertalot ex Krammer et Lange-	2	0.004
<i>Navicula menisculus</i> Schumann	2	0.004
<i>Navicula pseudoventralis</i> Hustedt	1	0.002
<i>Navicula radiosa</i> Kützing	3	0.006
<i>Navicula</i> spp.	7	0.014
<i>Navicula vitabunda</i> Hustedt	2	0.004
<i>Neidium</i> spp.	1	0.002
<i>Nitzschia acicularis</i> (Kützing) Smith	1	0.002
<i>Nitzschia acidoclinata</i> Lange-Bertalot	1	0.002
<i>Nitzschia inconspicua</i> Grunow	1	0.002
<i>Nitzschia lacuum</i> Lange-Bertalot	2	0.004
<i>Nitzschia linearis</i> (Agardh ex Smith) Smith	4	0.008
<i>Nitzschia palea</i> (Kützing) Smith	1	0.002
<i>Nitzschia pura</i> Hustedt	1	0.002
<i>Psammothidium didymum</i> (Hustedt) Bukhtiyarova et Round	4	0.008
<i>Sellaphora pupula</i> (Kützing) Mereschkowsky	4	0.008
<i>Sellaphora rugula</i> (Hohn & Hellerman) Potapova & Ponader	1	0.002
<i>Staurosira construens</i> var. <i>binodis</i> (Ehrenberg) Hamilton	2	0.004
<i>Staurosira construens</i> var. <i>venter</i> (Ehrenberg) Hamilton	5	0.010
<i>Staurosirella leptostauron</i> var. <i>dubia</i> (Grunow) Edlund	2	0.004
<i>Staurosirella pinnata</i> (Ehrenberg) Williams et Round	27	0.054
<i>Staurosirella pinnata</i> var. <i>lancettula</i> (Schumann) Siver et	13	0.026
<i>Synedra cyclopum</i> Brutschy	2	0.004
<i>Synedra delicatissima</i> Smith	24	0.048
<i>Synedra famelica</i> Kützing	45	0.090
<i>Synedra</i> sp.	2	0.004
<i>Tabellaria flocculosa</i> (strain III) sensu Koppen	13	0.026
<i>Tabellaria flocculosa</i> (strain IIIp) sensu Koppen	12	0.024
<i>Tabellaria flocculosa</i> var. <i>linearis</i> Koppen	1	0.002
<i>Tabellaria</i> spp.	1	0.002
unknown pennate	14	0.028
TOTAL	500	1.000

ADDENDUM TO SEDIMENT CORE RESULTS TAKEN FROM BLACK OAK LAKE, VILAS COUNTY, WISCONSIN

Paul Garrison Wisconsin Department of Natural Resources

June 2014

This report summarizes examination of the zooplankton fossils found in the sediment core collected 18 July 2012. This sediment core was collected in the deep area of the lake. The top and bottom samples were kept from this core which was 54 cm in length. Fossils from many zooplankton types are not preserved in the sediments. Only those belonging to the Cladocera group are typically preserved. This group is useful as indicators of changes in food web dynamics and the general extent of submerged aquatic plants (SAV). The samples were cleaned with 10% potassium hydroxide and a portion of the cleaned sample was mounted onto coverslips using stained polyvinyl lactophenol. Most of 2 coverslips for each sample was examined at 200X and recognizable fossils were recorded.

The main purpose of looking at the zooplankton was to determine if there has been a change in the *Daphnia* population, specially large bodied Daphnids. These taxa feed on algae and the larger the Daphnids, the more algae they eat and this results in greater water clarity. These large Daphnids are also a preferred food resource for some fishes.

Only a few *Daphnia* were found in the sediment samples. Only one post abdominal claw was found in the bottom sample but 7 were found in the top sample. The species present in the top sample were of the larger *Daphnia pulex* type. It is likely that at the present time the *Daphnia* are eating enough algae to increase water clarity more than they were historically. However the numbers are small so that they are not having a large impact.

The biggest difference in the Cladoceran community between the top and bottom samples was that in the top sample there was an increase in taxa found in the littoral area, specifically those that are associated with submerged aquatic plants (Figure 1). This indicates that at the present time there is more SAV compared with historical times. This is in contrast to the diatom analysis which did not find a change in the SAV community. This discrepancy may indicate that the additional plants at the present time are of smaller stature than often occurs with the SAV community that often accompanies shoreland development. The increased SAV may also indicate an increase in water clarity which allows plants to grow to deeper depths and thus the areal coverage of plants is greater at the present compared with historical times.

In summary the Cladoceran zooplankton community indicates that at the present time the submerged aquatic vegetation community is larger than it was historically. This is in contrast to the findings from the diatom analysis and may indicate a more extensive coverage of plants with smaller stature. In many lakes in northern and central Wisconsin with shoreland development there has been a change in the plant community from small species to those that are much larger and grow higher in the water column. This probably has not happened in Black Oak Lake. The Cladoceran fossils indicate a relatively small increase in large bodied Daphnids which may have resulted in increased water clarity at the present time.

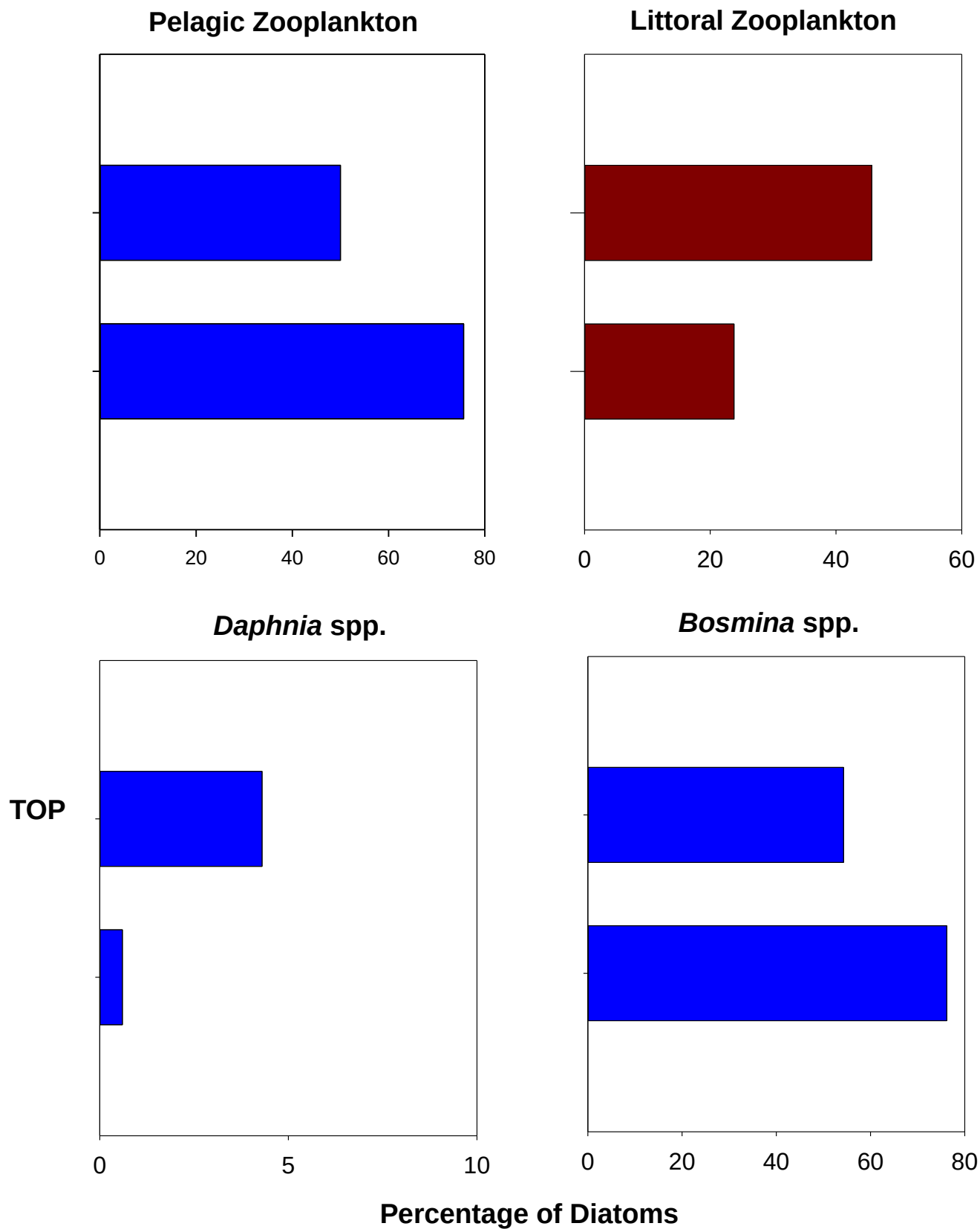


Figure 1. Changes in the abundance of the zooplanktonic Cladocerans found at the top and bottom of the Black Oak Lake sediment core. The increase in littoral zooplankton in the top sample indicates an increase in the submerged aquatic vegetation community.

Appendix M

Groundwater Study

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Black Oak Lake Groundwater Study



This document is a product of a WDNR Lake Management Planning Grant awarded to:

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Date: June 2014

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Introduction

As part of Phase 6 of the Black Oak Lake Watershed Stewardship Program, volunteer lake steward Walt Bates conducted a study of groundwater inflow and outflow from Black Oak Lake. The main tool of this study was a piezometer, actually several piezometers that Walt fabricated from common hardware store materials (steel conduit, carriage bolts, clear vinyl tubing, electrical tape, and a tape measure/ruler). A piezometer measures the pressure (either negative or positive) of groundwater at a specific point. Walt deployed piezometers at many places around the shoreline of Black Oak Lake to detect areas where ground water was flowing into the lake (a positive pressure) and areas where it was seeping out of the lake (a negative pressure). In this report, Walt documents the methods he used and reports the results. He concludes with his summation of the findings.

Methods

I cut several pieces of 1/2" steel conduit pipe ranging from 5 feet to 10 feet long. At a deployment site, I would insert a 3/8" diameter carriage head bolt that fit loosely into the end of the pipe and drive it 2 to 3 feet into the lake bottom with a sledge hammer in water depth of about 18 inches. The bolt head would keep the pipe from clogging with substrate as it was driven into the lake bottom and would allow water to more easily flow into the pipe. My next step was to fill the pipe to the brim with water from a water bottle. Next, I would cut a piece of 1/2" clear vinyl tubing about the length of the pipe. Using electrical tape, I would tape one end of the tube to the outside of the pipe near the lake bottom. I would then suck water from the other end of the vinyl tube until it was full and quickly insert that end into the top of the pipe, shoving it down to well below the lake water level. I would then tape the tube into place leaving a loop in it above the top of the pipe. There would usually be a short slug of air in the loop. I had a 5 foot piece of thin (1/8") plastic tubing and would then insert one end of that thinner tube into the underwater end of the larger vinyl tube where it was taped to the side of the pipe underwater. I would then blow a short puff of air into the thin tube to get about one foot of air trapped in the top of the loop in the larger vinyl tubing. It could take several days for the water columns to stabilize depending upon how porous the substrate was. An early tip off as to what to expect on that was

obtained by watching the water level in the pipe after filling it from the water bottle. If the water level remained near the top of the pipe you knew you were into relatively non-porous substrate and that it would be a while before the water levels would stabilize. For photographs of one of the installations see Figures 1 and 2 (below).

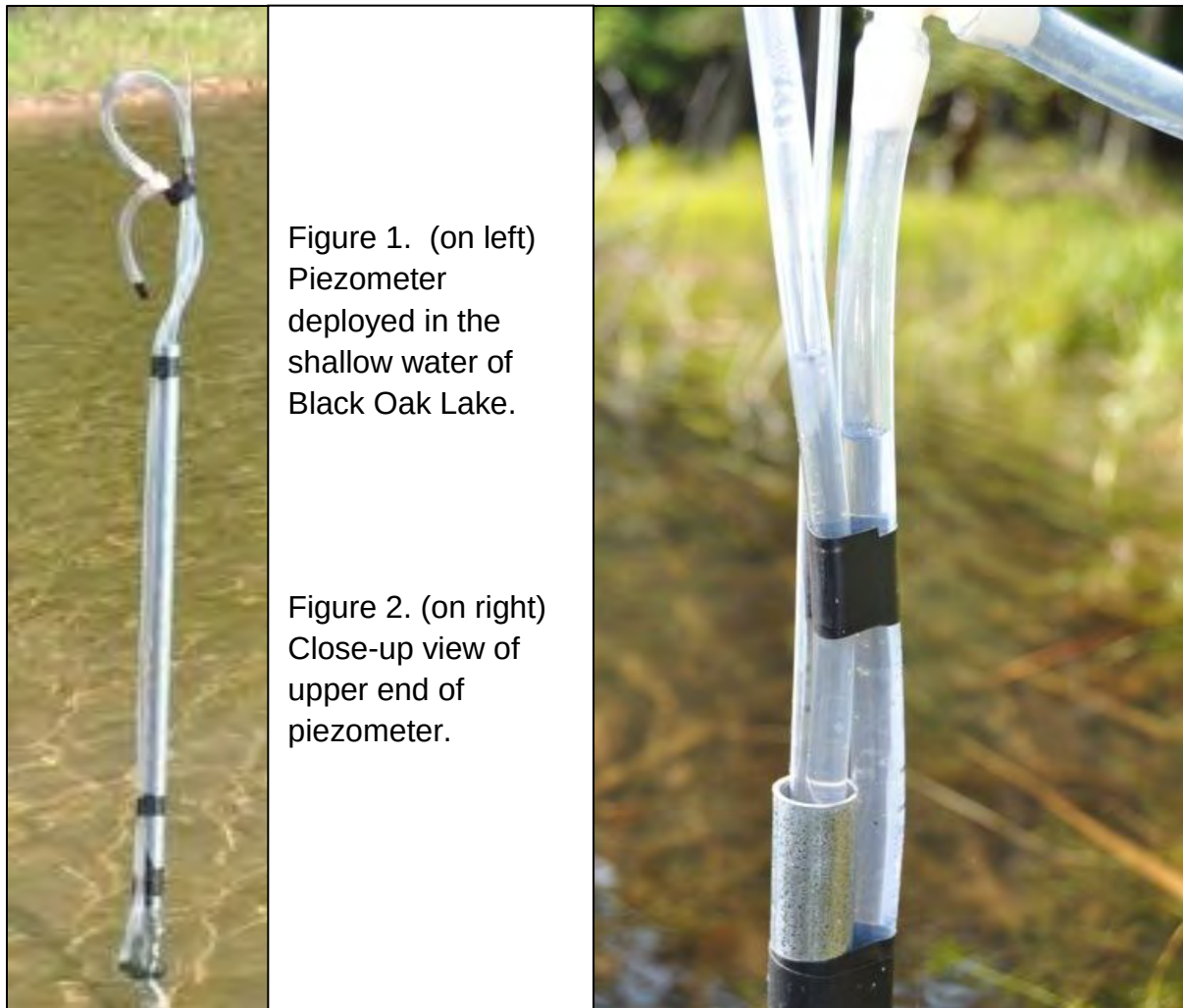


Figure 1. (on left)
Piezometer
deployed in the
shallow water of
Black Oak Lake.

Figure 2. (on right)
Close-up view of
upper end of
piezometer.

I conducted the work in summer 2013. Initially, I placed 42 piezometers at about a 1,000' spacing. Black Oak has just over 40,000 feet of frontage so this distribution fairly evenly covered the entire lake shore. Wherever one piezometer showed a significant pressure difference, I followed up by placing more piezometers closer to it to better define the groundwater flow of that area. I defined “significant pressure difference” as 1 inch or more between the two water column heights. In the end, I measured a total of 53 sites. Using a global positioning unit (GPS), I recorded latitude and longitude coordinates at each site so the study could be repeated.

The water level in any given piezometer did not immediately stabilize. Depending on the substrate, it might take several days for the water level to come to this point. I would visit these sites over a period of time, observing the measurements until they stabilized. This final measurement would be recorded and is reported in this document for all of the stations.

Results

The piezometers I deployed measured the difference in water pressure at the lake bottom. A higher (positive) pressure below the bottom implies water flow into the lake at that site. Conversely a lower (negative) pressure indicates that lake water is flowing into the substrate and entering the ground water. The amount of flow is roughly proportional to the pressure difference and the porosity of the underlying substrate. In Figure 3 (below), the column of water in the tube coming out of the pipe that's driven about three feet into the bottom is about 1" higher than that in the tube open to lake water showing water flow up into the lake at this site.

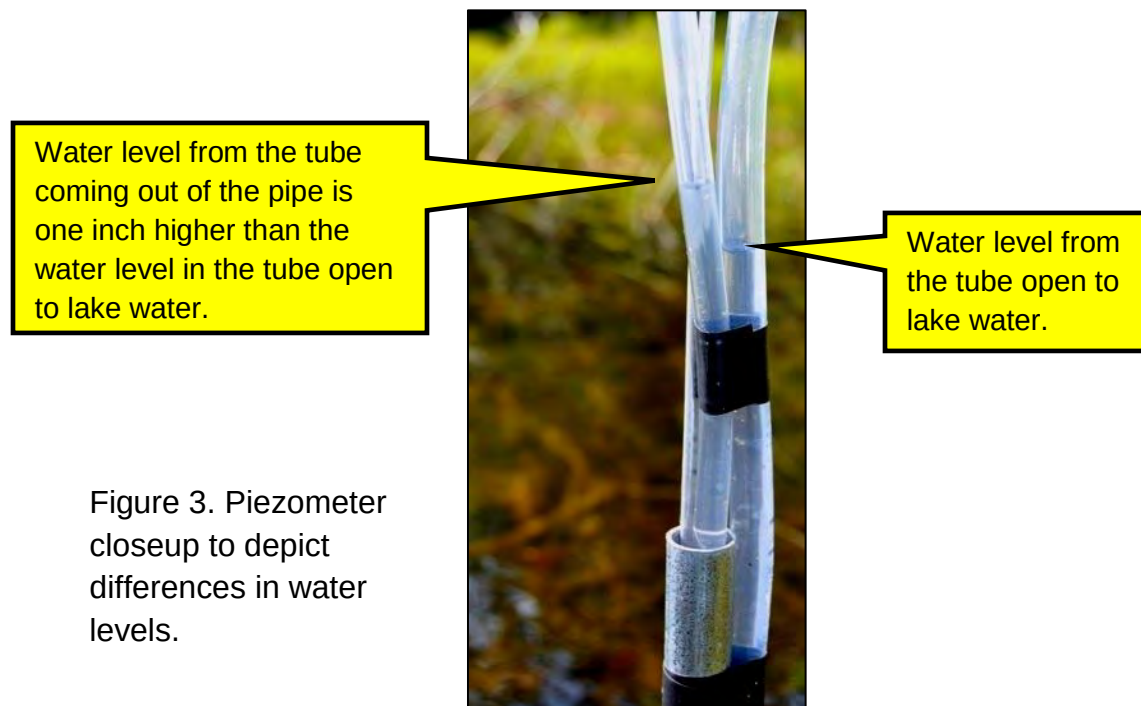


Table 1 provides the results from the piezometers on Black Oak Lake in summer 2013. There were 53 sites and for each is a reference number. These numbers are in clockwise order starting at the public beach and have no relation to the Black Oak Lake property number as exists in the

directory. Table 1 also provides the latitude and longitude for each site and the nearest property owners' names. The final piezometer results are provided in inches. Final readings greater than one inch, either negative or positive, are indicated as large inflow or large outflow, respectively. Note that there are areas of significant inflow centering on Flemma, Senechalle, Annin, and northeastern Barber's Bay. These results are graphically summarized in a map created by Susan Knight (see Figure 4).

Table 1. Black Oak Lake Piezometer Study Final Readings.			
<i>Final measures are given in inches, with positive numbers indicating groundwater inflow into the lake and negative numbers indicating flow out of lake water out of the lake and into the groundwater. A zero indicates no flow in either direction. Flows in either direction that are greater than 1 inch are designated "large" and labeled as such on the table.</i>			
Reference Number	Latitude / Longitude	Name Reference	Final Measure (inches)
1	N46 09.341 W089 18.442	Public Beach South Side	0.1
2	N46 09.356 W089 18.566	Clarke	-0.5
3	N46 09.357 W089 18.728	Tremberth	0
4	N46 09.392 W089 18.840	Trochlell	-0.6
5	N46 09.462 W089 18.862	Eaton	0
6	N46 09.522 W089 18.935	J. Bates	0
7	N46 09.498 W089 19.069	Spinner	0
8	N46 09.536 W089 19.242	Hunt	-0.5
9	N46 09.689 W089 19.310	Tryczak	0
10	N46 09.792 W089 19.457	Lommen	-0.5
11	N46 09.775 W089 19.640	Cuttell / MacDonald	0
12	N46 09.847 W089 19.712	Loader	Large Inflow: 4.5
13	N46 09.851 W089 19.762	Von estorff	Large Outflow: -6.5
14	N46 09.880 W089 19.837	Flemma	Large Outflow: -1.2
15	N46 09.885 W089 19.867	Hinze	Large Inflow: 3.0
16	N46 09.901 W089 19.904	Allman	Large Outflow: -7.0
17	N46 09.911 W089 19.964	Gilling	0
18	N46 09.900 W089 20.026	Cheryl Mitchell	Large Outflow: -1.4
19	N46 09.844 W089 20.265	Hostetler	0.2
20	N46 09.795 W089 20.394	Beers	-0.6
21	N46 09.692 W089 20.580	Kujawa	0
22	N46 09.868 W089 20.621	McAdams	0
23	N46 09.904 W089 20.474	Lauer	-0.1
24	N46 09.955 W089 20.143	Shely	-0.6

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Reference Number	Latitude / Longitude	Name Reference	Final Measure (inches)
25	N46 09.988 W089 20.023	Felton	Large Outflow: -5.0
26	N46 10.036 W089 19.908	Senechalle	Large Outflow: -10.0
27	N46 10.057 W089 19.858	Woltman	Large Outflow: -8.0
28	N46 10.093 W089 19.841	Hattenhauer	Large Outflow: -12.0
29	N46 10.202 W089 19.766	Osprey Nest	0
30	N46 10.154 W089 19.619	Mackevicius	0.1
31	N46 10.042 W089 19.557	Collar	-0.4
32	N46 10.032 W089 19.551	Annin/Collar	Large Outflow: -4.6
33	N46 10.019 W089 19.586	Annin mid north shore	Large Outflow: -3.0
34	N46 09.977 W089 19.618	Annin westernmost point	0.6
35	N46 09.930 W089 19.479	Annin south end of swale	0
36	N46 09.954 W089 19.347	W. Bates	0
37	N46 09.964 W089 19.018	200' West of Rope Swing	0.1
38	N46 09.957 W089 18.765	LaChance/Crown	0
39	N46 09.946 W089 18.583	Nagel	0
40	N46 09.925 W089 18.447	Steiner/Conserve	0.1
41	N46 09.927 W089 18.247	Conserve Boathouse	0
42	N46 10.041 W089 18.027	Bay NE of Conserve Boathouse	0.2
43	N46 10.086 W089 17.920	Bay NW of Conserve Log Head	Large Inflow: 1.9
44	N46 10.130 W089 17.861	Conserve Log Head	Large Inflow: 1.9
45	N46 10.148 W089 17.764	Far East End /Conserve Log Head	Large Inflow: 1.8
46	N46 10.156 W089 17.685	Far East End	0.2
47	N46 09.919 W089 17.763	Vineyard's Boathouse Bay	0
48	N46 09.846 W089 17.813	Caruso	0.4
49	N46 09.858 W089 17.955	Erickson	0
50	N46 09.680 W089 18.150	F. Hill	0
51	N46 09.575 W089 18.194	Hoffman	0.9
52	N46 09.480 W089 18.266	Hook	0
53	N46 09.370 W089 18.381	Public Beach North Side	-0.1

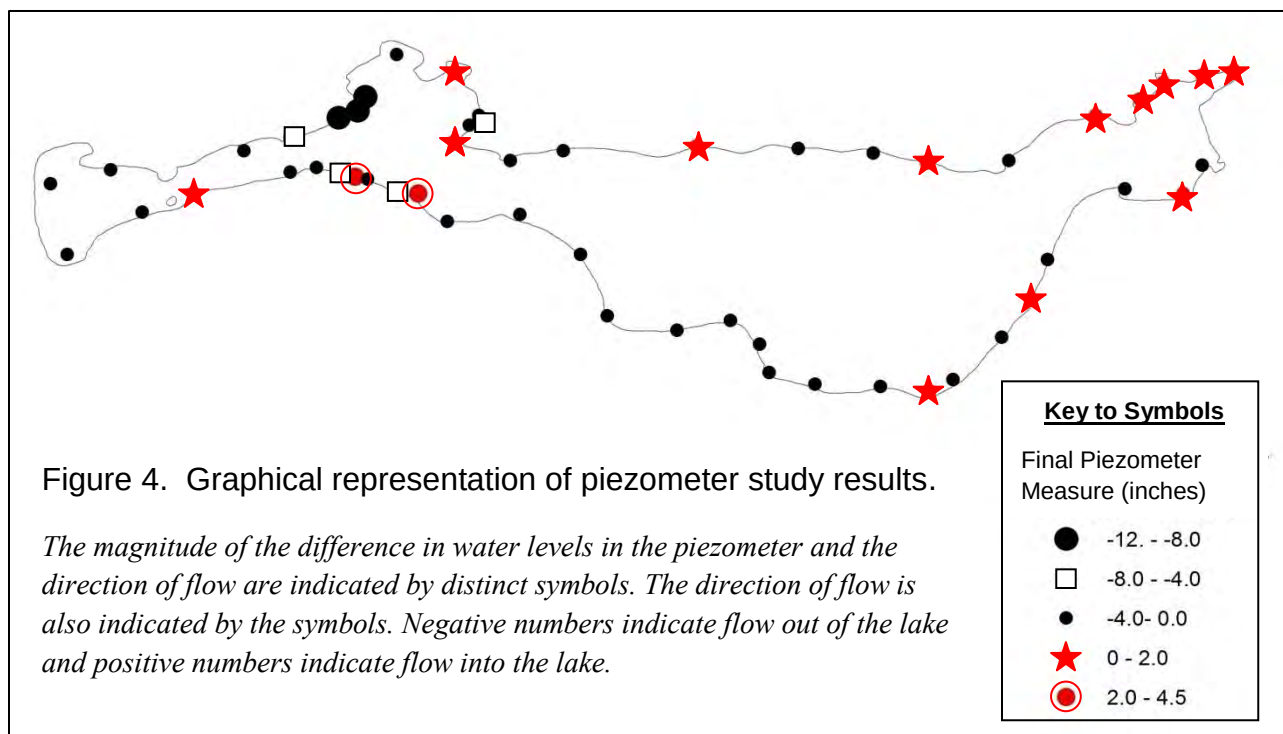


Figure 5 displays the Black Oak Lake properties and property numbers. Table 2 provides the landowner surname and property number.

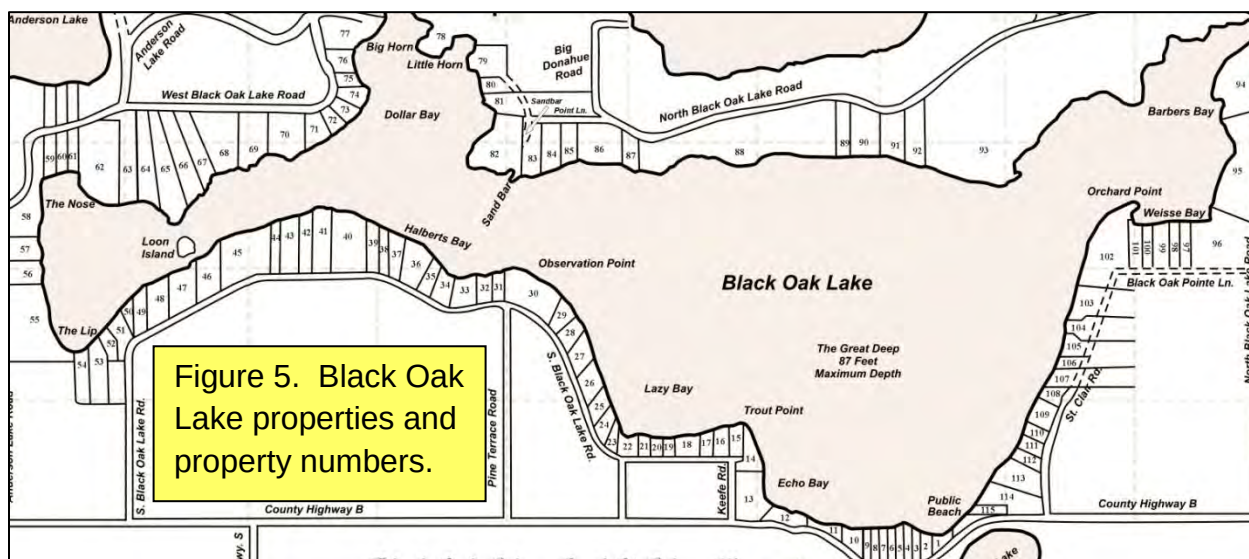


Table 2. Property numbers and associated surnames for Black Oak Lake properties.

Surname	Number	Surname	Number	Surname	Number
Hesselman	1	Allman	40	Mackevicius	79
Berg, Duff	2	Gilling	41	Klomhaus	80
Vieth	3	Mitchell	42	Collar, Welsh	81
Madigan	4	Meyer, D	43	Annin	82
Sundberg	5	Horton	44	Lang	83
Clarke	6	Shely	45	Beedie	84
Clarke, Trenary	7	Hostetler	46	Bates, W	85
Kurkamp	8	Peterson, W	47	Meyer, D	86
Fleming, J	9	Beers	48	Morrison	87
Barnum	10	Peterson, B	49	Washburn	88
Tremberth	11	Strawn	50	LaChance	89
Trochlell	12	Krans	51	Frawley	90
Binder	13	Warner	52	Nagel	91
Eaton	14	AJ Lodge	53	Steiner	92
Bates, J	15	Kujawa	54	Conserve Schl	93
Knaak	16	Kuhlman	55	Pierce	94
Walsh	17	Torres	56	Vineyard	95
Arpke	18	Heiniger	57	Caruso	96
Spinner	19	McAdams	58	Klieve	97
Knecht	20	Adams	59	Basten	98
Morris	21	Broyles	60	Smith	99
Aikins	22	Evans	61	Berg	100
Kegel	23	Lauer	62	Erickson	101
Hunt	24	Hall	63	Hofmann	102
Thomas	25	Zweber	64	Hill, F & K	103
Lippert	26	Becker, E	65	Surpless, J	104
Whipp	27	Becker, G	66	Ferry	105
O'Sullivan	28	Howard	67	Hill, R	106
Kistler	29	Zane	68	Fleming, B	107
Lommen	30	Tracy	69	Hoffman	108
Tracy	31	Crass	70	Olk	109
Hoeft	32	Felton	71	Surpless, F	110
Somers	33	Samp	72	Gelb	111
MacDonald	34	Senechalle	73	Hook	112
Shely	35	Woltman	74	Anderson	113
Loader	36	Hattenhauer	75	Foreman	114
von Estorff, MacDonald, Frenzen	37	Legat	76	Maciulis	115
Flemma	38	Cupi	77		
Hinze	39	Conserve Schl	78		

I provide a few observations about the piezometer data in the following bullets:

- Note how there is no flow at Cuttell/MacDonald, then an inflow of 4 1/2" at Loader reversing to a minus 6 1/2" at von Estorff. (I did find a few examples of big changes in short distances). Then it goes positive again at Hinze and then to a 7" outflow at Allman. Not until Hostetler does it settle near zero.
- By far the largest area of outflow is from Felton to Hattenhauer finally zeroing out near the Osprey nest. The negative numbers are large and the area affected is wide.
- A smaller area of outflow is along the north side of Annin's peninsula.
- The only area of significant inflow is along the northeast shore of Barber's Bay.

There seems to be no relation between a piezometer reading and the adjacent shoreline profile. Note that in front of flat swales where you might think that there would be strong flow one way or the other (Trochlell, McAdams, Osprey Nest, Public Beach) there was no flow either way. And in front of most hilly shorelines there was either significant outflow or no flow. During Dr. Susan Knight's AIS survey visit in early October she commented on some of these piezometer readings. She said that flow depends more on the type of glacial deposit underlying any given part of the lake. A firm clay will not have the flow that areas of porous gravel have. These are known as glacial eskers and kames. Former geology teacher at Conserve School, Paul McLeod, has also reviewed this data and agrees saying, "I think Susan is probably right about the underlying glacial sediments. You can wander to any of the gravel pits and road-cuts in the area and see that in some places the sediments are highly porous and permeable, while in other places the clays make the sediments impermeable or at least low permeability so there's no reason to think that you wouldn't have the same variability beneath Black Oak Lake". And if you are really interested in this you can convert the differential column heights to pounds per square inch (psi) using the relationship that one inch of water depth exerts 0.036 psi. This means that the negative 12" reading near Hattenhauer equates to just under one half of a psi and that's a lot of pressure forcing outflow. To test this I took a plastic sheet about 2' x 3' to that area and laid it on the bottom in about two feet of water. Sure enough, it stuck to the bottom.

In summary, without considering precipitation, the lake seems to be losing more water than it is gaining. I guess this should be expected considering the relatively high elevation (1,711' above sea level and 1,108' above Lake Superior) of Black Oak Lake. The "Subcontinental Divide" runs along Black Oak's north shore meaning that we drain to the south while Big Donahue flows to the north. There is little area around us that has significantly higher elevation and water table than the height of the lake. According to DNR's Topo maps Black Oak's "drainage basin" is 3 square miles (including the 1 square mile of lake surface). This is a very small ratio as many southern Wisconsin lakes receive drainage from an area over 100 times the size of the lake. Lakes both to our east and west are lower than we are (the Cisco Chain is over 60 feet lower). The upside is that this is very good for water clarity.