Whitefish Lake Watershed Management Plan

June 2009

Prepared for the Whitefish Lake Conservation Organization and the Wisconsin Department of Natural Resources

Eric Olson • Center for Land Use Education • University of Wisconsin - Extension

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Executive Summary

Whitefish Lake in Douglas County, Wisconsin is a remarkable water resource situated in a unique region. This plan reviews the research and reporting recently completed on the lake's water quality, ecology and socioeconomic situation to synthesize a strategic framework for lake improvement and protection. Whitefish Lake is a large, deep, oligotrophic lake with a small watershed and a rich ecology of plants and animals. Lakeshore owners and visitors hold the lake in high regard, and many people have already taken steps to proactively ensure its long-term health. Owing to the lake's current excellent water quality, much of what needs to happen on the lake's behalf is defensive in nature. The overarching goal for this plan is to maintain and protect the present conditions at Whitefish Lake, including its admirable water quality, unique biodiversity and essential ecological functions. Core strategies for reaching this goal include continuing lake monitoring, preventing aquatic invasive species and limiting unnecessary changes to the lake's watershed. Ongoing efforts to build institutional strength and resilience among stakeholders will aid in reaching the goal, as will an increasing level of awareness and understanding about the lake's ecology and the threats it faces.

Acknowledgments

This document is the culmination of many years' work by a tremendous collection of people and institutions. Fred and Sandy Anderson deserve special praise for their patience and insights into the lake, as well as their generous hospitality. The entire Whitefish Lake project would not have happened without their drive and passion. Ted Griggs provided motivation and skilled editing advice. John Haack, Basin Educator for the St. Croix River, shared his knowledge and wisdom on many occasions. Eleanor Baldwin and Lue Paddock were also generous with their hospitality. Paddocks shared their collection of older photos of the lake, some of which appear in this report.

This project drew on the insights and ideas of a task force that met several times to review and discuss the science developed over the last five years, including:

Ellie Connolly	Herb Udeen	Frank Koshere
Sandy Anderson	Christine Ostern	Amy Eliot
Fred Anderson	Kinnie Smith	Ted Griggs
Jan Jensen	Steve Balcsik	Dave Van Ells
Lance Burns	Scott Toshner	

Several people provided review and editorial assistance in completing the plan, including Fred and Sandy Anderson, Ted Griggs, John Haack, Dale Robertson (USGS), Pamela and Scott Toshner (WI DNR), Paul Garrison (WI DNR) and Susan Borman. The 2009 WILCO Board of Directors also reviewed the draft plan. Thanks goes to the dozens of WILCO members who remain dedicated to Whitefish Lake and take action to protect it for future generations.

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I. Introduction

The clear waters of Whitefish Lake instill admiration and wonder. For people interested in maintaining the lake's qualities, this admiration and wonder generates a series of ecological questions: Has Whitefish Lake always been this clear? How does it retain its water clarity? What is the relationship in Whitefish Lake between phosphorus, algae, insects, leafy plants and fish? What impacts do humans have on the lake? How might these impacts harm the lake? What other threats confront the lake? And what can be done today to ensure that Whitefish Lake generates the same sense of wonder and admiration for future generations?

These same questions may be asked at any of the world's deep, clear water (*oligotrophic*) lakes. From Quebec to Alaska, recent glaciers have left behind hundreds of similar lakes, with piney shores and diverse cold-water fisheries. But Whitefish Lake stands apart in several ways: at nearly 850 acres, it is fairly large; it is within a three-hour drive of millions of Americans; its shoreland supports about 100 homes and cabins, some of which have been in the same family for several generations; it is the basis for a citizen group, the Whitefish Lake Conservation Organization, that has diligently worked to better understand and protect the lake; and finally, Whitefish Lake is in Wisconsin, where the public has long been involved in managing water resources for the benefit of all. Whitefish Lake is so uncommon among Wisconsin's thousands of lakes that ecologists, biologists and other lake scientists have spent the past several years gathering and analyzing data to help ensure Whitefish Lake's future health. This report provides a tentative answer to the question, "How can we preserve the lake's outstanding qualities?" The plan is a starting point for organizing actions and decisions in a way that maximizes the resilience of the lake and its ecology.

This plan is arranged into three major sections. The first section discusses Whitefish Lake's current situation, including recent trends identified through lake research. The second section provides ideas for lake management planning that are based on our best understanding of healthy ecosystems. Finally, the plan summarizes key strategies, goals and objectives required to ensure that Whitefish Lake remains healthy and retains the characteristics that make it so unique.

Figure 1. Whitefish lakeshore beach at Blueberry Hill circa 1944

II. Three Contexts of Lake and Watershed Planning

Whitefish Lake and its watershed are prominent landscape features embedded in three highly interrelated contexts. The *ecological context* is the system of energy, nutrients, and habitats that are the basis for living systems. The *socioeconomic context* is the realm of individuals and households with a stake in the lake's present and future. The *institutional context* is the system of organized groups of people that can impact the lake, mostly governmental organizations but also non-governmental groups, such as the Whitefish Lake Conservation Organization. These three contexts combine to set the stage for nearly all activities that occur in and around the lake.

A. Ecological Context

The ecological context of Whitefish Lake is a fascinating system that combines climate, geology, and biology into a series of cycles that transfer nutrients and energy across space and among living organisms. Though they appear to be relatively stable to humans, these cycles are subject to radical and transformative changes at the geological time scale. To understand the potential for change, one need only imagine what the Whitefish Lake watershed looked like 14,000 years ago, when it was entirely covered by a massive glacier. One huge chunk of ice, broken off and embedded into the glacier's mineral deposits, would later melt and form the deep basin that resulted in Whitefish Lake. But for thousands of years as the glaciers melted, the area was covered by meltwater and precipitation.

At one point, the waters of Glacial Lake Grantsburg flooded the region and connected the Whitefish Lake area to both the Mississippi drainage via the St. Croix and the Great Lakes. In a relatively short amount of time, the most recent Midwest glaciers receded and the region became warmer and drier. As ice dams broke up and the water drained, a system of lakes, wetlands and interconnected rivers formed atop the glacial sediments. Relatively recently, Whitefish Lake was "cut off" from the surrounding surface waters of the St. Croix and Totagatic. During the post-glacial period, a complex array of species came into the lake and the surrounding lands, adding life to what had been only sand, rock, and water.

1. Components of the Whitefish Lake Ecosystem

Whitefish Lake is large enough and deep enough to have several distinct habitats. The lake is set in a larger eco-region, the Northwest Sand Plains, a globally rare system of plants, animals, soils and climate. The physical features of the lake and its watershed are described first, as they form the basis for the plant and animal life that make up the ecology of Whitefish Lake.

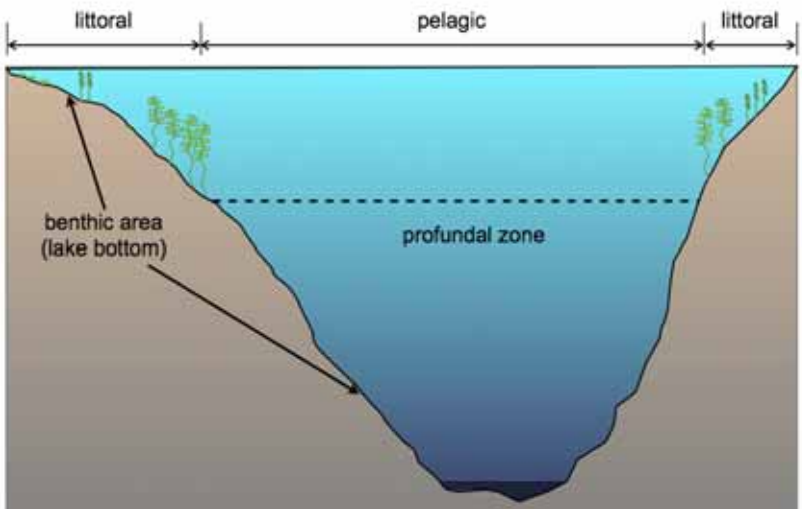


Figure 2. Ecological components of a lake

The lake is divided into distinct habitats based on the proximity to shore and the proximity to the lake's bottom surface (the *benthic* area; see figure 2 above). The near-shore area is where the water is shallow enough to allow a large amount of sunlight to reach the benthic area, which in turn supports rooted plants (*macrophytes*). Lake ecologists refer to this as the *littoral zone*. The benthic areas in deeper parts of the lake do not support plants, but there are a number of important organisms (*detritivores*) that live there by feeding off of the plant and animal matter that annually sinks to the lake's bottom. This deep, permanently dark area is known as the *profundal zone*. Then there is the deeper area away from the shores, referred to as the *pelagic zone*. This area hosts an array of suspended algae, as well as organisms that feed on algae.

Beyond the shoreline is the riparian land circling the lake as well as the upland watershed of Whitefish Lake. There are several small wetland areas that occasionally drain surface water into the lake and into Lake Deborah, to the southeast, which receives runoff from Whitefish in high-water years. The surface land immediately surrounding the lake drains snowmelt and rainwater into the lake. The topography of this surface watershed and the surrounding landscape is irregular and hilly. Numerous small depressions, ice ridges, and very sandy soils allow water in the area to quickly infiltrate into the groundwater. As a result, the Whitefish Lake surface watershed is very small considering the size of the lake.

The ground-watershed extends beyond the surface watershed to the east and west of the lake. In this area, the annual snow and rainfall moves downward through the sandy soil and then flows slowly underground before entering Whitefish Lake through its porous benthic surface in the near shore area. Groundwater also leaves the lake through the lake bottom, moving back into the groundwater to the north and south of the lake to eventually resurface as part of either the St. Croix or Totogatic Rivers.

2. Lake Water Quality

The highly porous nature of Whitefish Lake's sandy ground and surface watersheds results in lake water characteristics that are similar to rainwater and snowmelt. This is in contrast to lakes with less porous soils and more impervious surfaces in their watershed, where runoff water coming into the lake often travels a longer distance and brings with it more sediments and nutrients from the surrounding landscape. Whitefish Lake is also distinct from other lakes that have phosphorus-rich groundwater and mineral deposits that make even the groundwater upwellings beneath the lake surface a significant source of additional nutrients. Actual phosphorus levels measured at Whitefish Lake are shown in table 1 below (Robertson, Rose, & Juckem, 2009).

Table 1. Phosphorus concentrations in water samples from a range of sources at Whitefish Lake

Typical phosphorus concentration in…	
…late summer rain at Whitefish Lake:	0.030 mg/L
…snow at Whitefish Lake:	0.005 mg/L
…median precipitation concentration:	0.016 mg/L
…groundwater near Whitefish Lake:	0.012 mg/L
…surface water sample from Whitefish Lake:	0.008 mg/L
…a lake classified as mesotrophic:	0.012 to 0.024 mg/L

Noting the lake's clarity and depth, we might theorize that the sandy landscape is the primary reason for those conditions. It is up to scientists to test this theory with a series of measurements: the movements of ground and surface water; the evaporation of lake water; and the interactions between water-born chemicals and plants and animals in the lake. Synthesizing these data, they can then draw a firm conclusion about the causal factors that result in Whitefish Lake's remarkable water quality. This process and all that it entails made up the bulk of the data collection and research that went into this project.

a. Methods of Measuring Water Quality

The quickest way of measuring water quality is though our senses. We see that the lake is clear most days, but we note that in the spring and fall, it is less clear, as the different layers of the lake mix, allowing nutrients and particles from the bottom to rise to the surface. We can also detect different smells and tastes in the water. We standardize the visual process by lowering a *Secchi disc* into the lake and measuring the depth at which the disc can no longer be seen. By this measure, Whitefish Lake is among the clearest in the state.

Table 2. Secchi disc measurements of water clarity

Typical summer Secchi disc measurements in…	
…Crater Lake, Oregon:	120 feet
…Lake Superior:	60 feet
…Elkhart Lake, Sheboygan County:	9-13 feet
…Lake Owen, Bayfield County:	20-25 feet
…Whitefish Lake, Douglas County:	21-30 feet

The visual appearance of the water is a *lagging indicator*—what we see is the consequence of chemical and energy interactions in the lake. We lose sight of the Secchi disc because algae and other small organisms block our view of it. The density of these organisms largely determines how far down we can see in the water. We estimate the density of these organisms by isolating them from a water sample and measuring their volume. On Whitefish Lake, scientists and volunteers use a measure of chlorophyll in a lake sample to estimate the amount of algae in the lake.

We can also measure the concentration of nutrients that algae use to get a sense of how much algae to expect. To help make this measurement, volunteers and scientists collected and submitted Whitefish Lake water samples to a lab where scientists measured the concentration of phosphorus, the key nutrient that limits algal growth in the lake.

We can think of these three related dimensions as parts of an equation where a particular level of phosphorus should yield a certain concentration of algae (measured by the concentration of chlorophyll) that, in turn, should result in a specific measure of water clarity. Adding more phosphorus would yield more algae and chlorophyll, which would reduce water clarity. Taking phosphorus away decreases algal growth and increases clarity.

There are other variables at work that may be harder to measure, such as the concentration of suspended microscopic particles or the actual color of the water itself. Some lakes, for example, have tannins from forest leaves and wetlands dissolved into their water, resulting in a brownish color that reduces measurable Secchi depth. Ideally, one would measure these aspects of the lake multiple times over a series of summers to see how well this basic ecological equation describes the lake's actual qualities.

b. Status and Trends

At Whitefish Lake there are ten years of Secchi depth, chlorophyll, and phosphorus data and several sample points within each year. The United States Geological Survey (USGS) study at Whitefish Lake compiled these data to develop a trophic state index (TSI) trend for Whitefish Lake. Lake scientists use this index to compare different lakes and track productivity over time. Interpretation of this index for Whitefish Lake is complicated by the fact that many samples of lake chemistry (phosphorus and chlorophyll) were pure enough to be below the concentration that laboratories are capable of measuring. Nevertheless, the USGS scientist drew a handful of important results from this initial analysis:

- The relationships among recent measurements of phosphorus, algae, and water quality in Whitefish Lake are similar to what would be expected based on other studies and models. As a result, water clarity (measured by

Secchi disc depth) provides a fairly good estimation of overall water quality.

- There is a slight upward trend in phosphorus and chlorophyll concentration, and fewer samples are yielding chemical concentrations that fall below detection limits. In addition, 2005 and 2006 yielded water clarity measurements that, while still good, are worse than historic measurements. Most recently water quality indicators have improved and Secchi measurements have been among the best recorded (Robertson, Rose, & Juckem, 2009).

The upward trend in chemical concentrations in the lake coincided with a period of high water levels in the lake (2002), which led the USGS scientists to wonder what role precipitation and changing water levels might play in changing lake chemistry and water quality. Could higher water levels add to the lake's phosphorus levels through the incorporation of near-shore organic materials into the lake? Could higher volumes of runoff in wet years be delivering larger loads of sediment and nutrients to the lake? Could more phosphorus enter the lake with the increased amount of rain? Answering such questions involves creating a "budget" of water volume and nutrients coming into and leaving the lake. This required the USGS and volunteers around the lake to collect highly detailed data on precipitation, evaporation and groundwater flow.

Developing a water budget for Whitefish Lake is complicated by the fact that much of the water coming into and leaving the lake does so below the water surface, as groundwater moves across the benthic area separating waterlogged sand and open water. Many lakes, in contrast, are fed and drained by streams that can be more easily observed and measured to better understand the water budget. To estimate the water budget for Whitefish Lake, the USGS needed to measure the amount of precipitation coming into the lake, estimate the amount of water leaving from evaporation, develop groundwater models for thelake, and record even the slightest changes in lake water levels (or *lake stage*). From these figures, the USGS was able to deduce the volumes of groundwater inflow and outflow necessary for the observed lake level to be maintained.

The USGS constructed a water budget in the Whitefish Lake watershed for 2005 and 2006. The water inputs for those years totaled 3,880 and 3,400 acre-feet, while the amount leaving the lake was about 4,180 acre-feet in 2005 and 4,360 in 2006. The "budget deficit" in each of the two years resulted in the declining water levels over that period. Water coming into the lake is roughly half from groundwater and half from precipitation. In dry years, the precipitation component is a slightly smaller share. About 60% of the water leaving the lake does so as outflow into the groundwater system; the balance evaporates into the air. The evaporative component increases in years with warmer, windier, and sunnier summers.

The USGS used similar methods to estimate a phosphorus budget for the lake, but in addition to phosphorus associated with groundwater, precipitation and runoff, they needed to account for dry organic material that blows into the lake. Dry precipitation includes pollen, a particularly phosphorus-rich substance, as well as leaves, needles and small soil particles blown into the lake. The USGS, with the help of local volunteers, collected and sent precipitation, *dryfall* (samples of pollen, soil particles and plant debris), and groundwater samples to labs in order to measure the phosphorus mass associated with each component of the phosphorus budget. The USGS maintained an electronic log of precipitation events.

The USGS used their estimates of groundwater inflow and the concentration of phosphorus in that water to estimate the amount of phosphorus coming from the overall groundwatershed. They used the precipitation samples to estimate the nutrients coming into the lake as dry fall and as a component of snow and rain. They compared this amount to the actual nutrient concentrations in the lake and found that these two sources accounted for 84% of the resulting lake phosphorus levels (Robertson, Rose, & Juckem, 2009). There are two additional sources of phosphorus, which are more difficult to measure: surface runoff (carrying sediments to the lake) and nutrient-rich effluent plumes from septic systems. The sandy soils around the lake result in very small amounts of surface runoff. These same soils help keep septic systems from becoming backed-up pools of standing water, but they do little to bind nutrients, such as phosphorus. Using the number of homes on the lake and the ranges of occupancy associated with the homes, the USGS estimates that 15% of the phosphorus coming into the lake is from septic systems and 1% is coming from surface runoff.

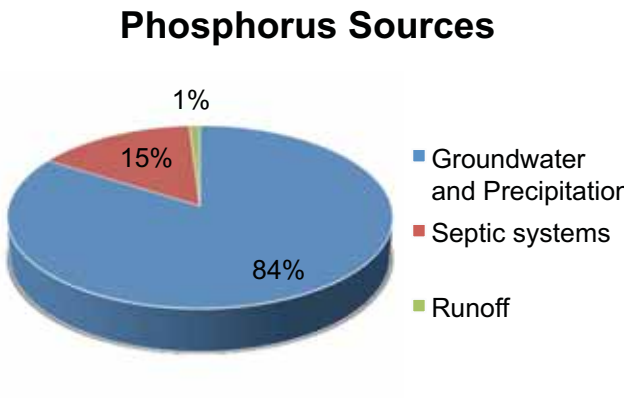


Figure 3. Sources of phosphorus at Whitefish Lake

The total nutrient budget estimated for Whitefish Lake was 238 pounds of phosphorus in 2005 and 225 pounds in 2006. Considering the volume of water in the lake, this is a remarkably small amount of nutrients, and it helps explain some of the lake's remarkable characteristics. Simply stated, this very low level of phosphorus limits plant and algae growth in the lake and results in clear water. The USGS findings also show that the lake is more sensitive to changes in nutrient loadings than a lake with a larger overall phosphorus budget. For example, a 20-pound increase on a lake with a total phosphorus budget of about 1000 pounds (such as 977-acre Little St. Germain Lake in Vilas County) would

translate to a 2% increase, but a similar change to Whitefish Lake represents almost a 20% increase. At Whitefish Lake, because the phosphorus budget is so small to begin with, each incremental addition of phosphorus has a larger relative effect.

c. Future Considerations

The USGS study also used computer modeling to examine the potential impact of increases and decreases of phosphorus in the lake. Because so much of the nutrient budget is from groundwater and precipitation, there are not many ways to reduce the phosphorus coming into the lake. One hypothetical example would be to replace, over time, septic systems with holding tanks. This would eventually eliminate the nutrient loading attributed to septic system plumes. In contrast, it is easy to imagine ways to increase phosphorus loading. For example, the level of development around the lake could increase dramatically, resulting in more septic loading as well as surface runoff.

The USGS's forecasting models found that the lake will likely respond with higher levels of productivity if nutrients are added, and lower levels if they are withheld. For example, Whitefish Lake's phosphorus levels could be reduced by nearly 10% by eliminating septic plumes. Alternatively, the levels would likely increase by over 10% if the watershed were to become more dense with housing that subsequently generated more surface runoff to the lake. As noted earlier, the changes in phosphorus loading would result in changes in the amount of algae and clarity levels in the lake, though the model suggests that improvements in quality would be minimal because of the present lack of sources of phosphorus; however, degradation in quality could be significant if major changes take place in the watershed.

Table 3. USGS water quality forecasting scenarios for Whitefish Lake

Scenario	Change in Phosphorus	Change in chlorophyll	Change in clarity (Secchi depth)
Elimination of septic plumes	- 35 lbs/year	- 0.22 ug/L	+ 3.1 feet
Doubling of septic plumes	+ 37 lbs/year	+ 0.23 ug/L	- 2.9 feet
Intense buildout of 25% of watershed	+ 51 lbs/year	+ 0.31 ug/L	- 3.4 feet

3. Lake Ecology

While a 10% increase in phosphorus may not seem alarming, there is a more potent problem potentially growing at the bottom of the lake. The ecology of a clear-water lake such as Whitefish functions as a "sink" for phosphorus. Evidence of this can be found in the different water samples analyzed as part of this study (shown earlier in table 1). The total phosphorus concentration found in the Whitefish Lake water samples (typically 0.008 mg/L) is lower than both the

concentration of groundwater (0.012 mg/L) and precipitation (0.016 mg/L) that feeds water into the lake. Since the groundwater and precipitation have been coming into the lake for thousands of years, we know that the lake is constantly working to remove phosphorus. The question is, "How?"

The answer is simple and elegant. The living organisms in the lake (algae, plants, bacteria, fish, etc.) are continuously using the available phosphorus to fuel their growth and remove it from the water when they do so. But this alone does not explain why the nutrient concentrations are lower in the lake than the concentrations coming into the lake. We know this because the water samples from the lake include the phosphorus that is in the algae suspended in the water (lake scientists refer to this as *total phosphorus*, or *TP*). It is the continual mortality of these organisms that reduces the amount of total phosphorus. As they die, algae and other organisms settle out of the water to the bottom of the lake. There they are decomposed by bacteria and small organisms, and buried by a steady shower of more recently deceased organisms sinking down into the dark profundal zone (see figure 4 below). The primary destination for the lake's annual incoming load of phosphorus is deposition as dead or dying organic matter on the lake bottom. As layers upon layers of dead organisms accumulate there, they are effectively sequestering phosphorus out of the lake.

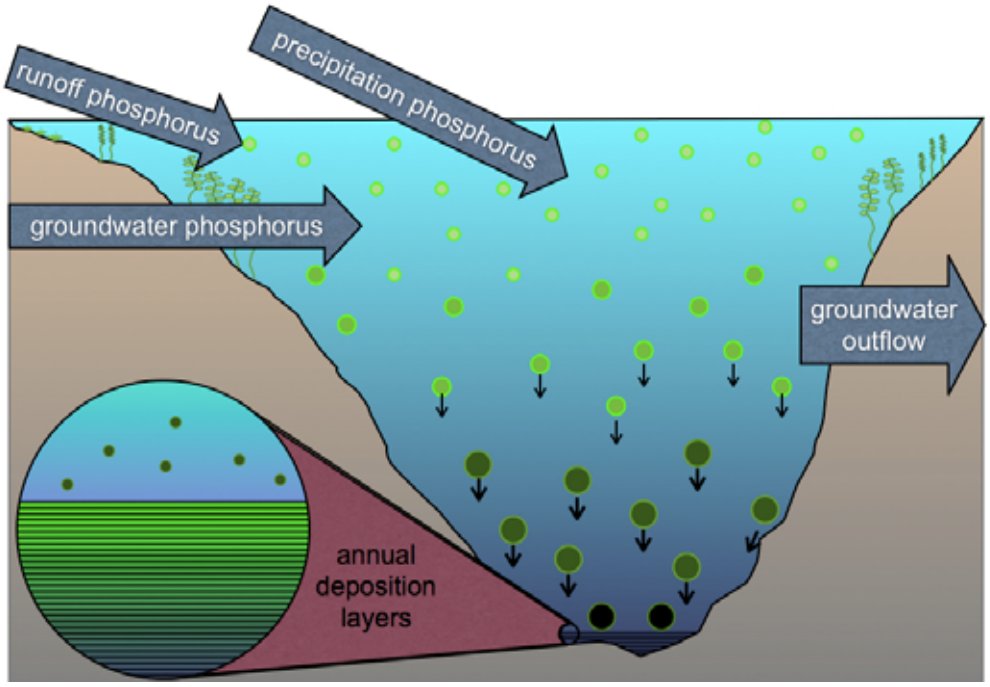


Figure 4. Diagram of phosphorus input and destiny

There are specific organisms, called detritivores, which live off of this dead organic matter and typically consume oxygen in the process. These organisms receive a fresh supply of oxygen twice a year when the lake water mixes during fall and spring turnover. However, because there are no plants at the dark lake bottom, the respiring detritivores and decomposing organic matter eventually

deplete the amount of oxygen over the course of a summer, resulting in their own death or forcing them to migrate upward away from the lake's very bottom. The USGS review of lake data found that the bottom oxygen depletes by mid-July in both basins. The lake bottom becomes *anoxic*, or devoid of oxygen, and only specific types of bacteria can continue to break down the organic matter in such

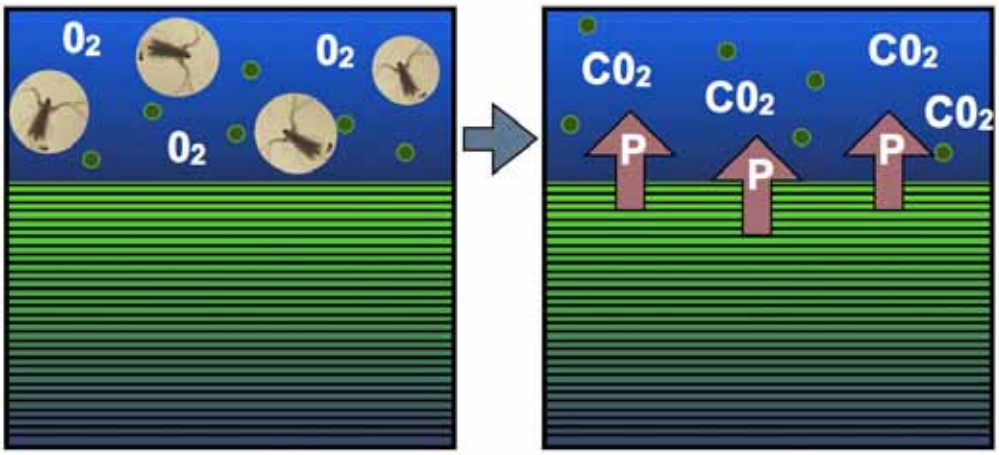


Figure 5. Phosphorus release from bottom sediments resulting from respiration and oxygen depletion

an environment. The zone of oxygen depletion typically begins at the very bottom of the lake and then expands upward, bringing in more of the lake bottom surface as it grows. The USGS found that this anoxic zone expands to within 36 feet of the surface in the north basin and within 60 feet of the south basin's surface.

During the late-summer period when oxygen is depleted at the lake's bottom, a chemical reaction occurs in the deposited organic matter that emits phosphorus back into the water (see figure 5). With no sunlight, algae plants cannot utilize nutrients; therefore this emitted phosphorus accumulates in the cold water at the

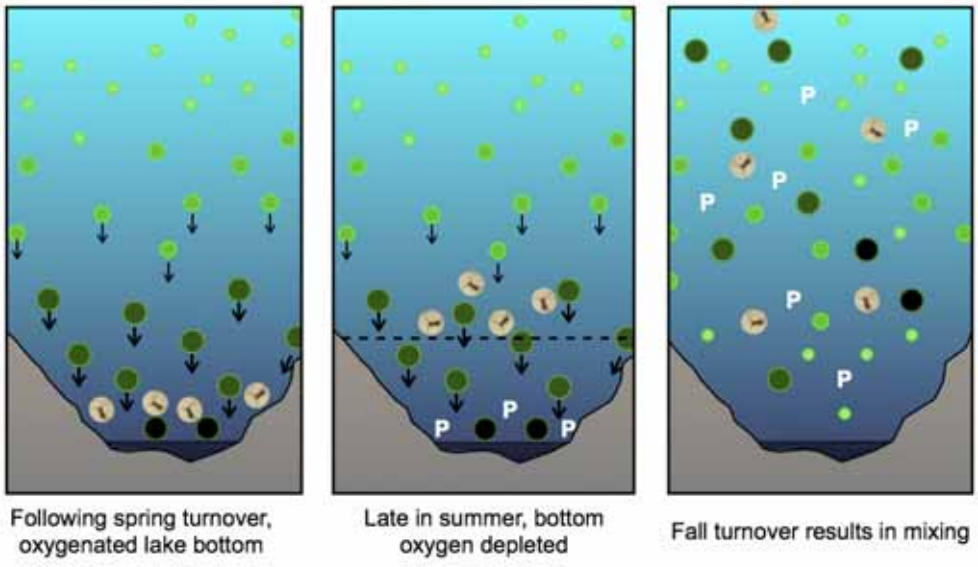


Figure 6. Accumulation and distribution of internal phosphorus during summer and fall

bottom of the lake until it is redistributed back into the entire lake at spring and fall turnover (figure 6).

Lake scientists refer to this nutrient source as *internal loading*. The internal loading process is common in lakes worldwide but is oftentimes most potent in lakes subject to significant increases in organic material. For example, many lakes have historically been used as dumping waters for untreated sanitary waste. It is only over time that the lake's natural capacity to seasonally sequester this organic material and the associated phosphorus is overcome.

When the total anoxic region grows and the amount of internal loading begins to increase, the lake itself can represent a growing source of phosphorus being added to the lake's annual nutrient budget. At the same time, a smaller and smaller portion of phosphorus is being permanently sequestered at the lake's bottom. This phenomenon can become self-perpetuating, as each year's growing deposit of dead organic matter more quickly consumes the bottom oxygen. This results in a slightly larger oxygen-free zone and slightly more phosphorus being released as fuel for next year's growth, resulting in still greater volumes of decomposing organic matter. The result is a potential acceleration of declining lake quality, referred to as *eutrophication*.

The USGS study looked at the timing of oxygen depletion and compared it to measurements taken in 1974. They concluded that there has been no acceleration of oxygen depletion, but they also noted that there must be additional data gathered in order to determine if a trend exists. The DNR's study of bottom sediments, discussed in more detail below, found evidence that since 1985 the zone of oxygen depletion in the south basin of Whitefish Lake has been increasing (Garrison, 2006). The author notes that this is a typical sign of increasing eutrophication.

To prevent the internal loading feedback loop from growing, it is important to maintain Whitefish Lake's ecological functions and limit additional organic matter from settling to the lake bottom. For thousands of years, the plants, animals and other organisms in the lake have maintained the lake's clear water characteristics through their own biological processes. The unique aspects of the lake have also fostered plant and animal diversity, as well as species that are rare in Wisconsin. Abnormal fish mortality, the loss of rooted aquatic plants, or increases in the productivity of algae in the lake would lead to a greater mass of organic material raining to the lake bottom. Over time, this would increase oxygen depletion and fuel the growth of internal nutrient loading. The future of the lake's water quality is tightly bound to the health and resilience of its living ecosystems. The following section discusses the lake's ecology to foster a better appreciation of this relationship.

a. Nutrients, Energy, and Productivity

This plan has already covered the role of phosphorus as a key nutrient driving plant productivity. The amount of plant growth is also a function of temperature and sunlight, factors that vary over the course of the year but are assumed to be relatively stable over the long course of time. Many types of plants, from single-celled algae to large rooted plants, are the basis of the Whitefish Lake food web. Their level of productivity affects the entire lake in ways seen and unseen.

b. Plankton

Whitefish Lake is teeming with microscopic organisms that quickly and continuously absorb nutrients and sunlight. The smallest algae live in a continual struggle against gravity to remain near the lake surface where sunlight is most plentiful. When they fail to absorb enough light they sink towards the lake bottom, and are either consumed along the way by other organisms or settle as part of the organic debris at the lake's bottom.

The types of plankton found in a lake serve as biological indicators of lake health. Some microscopic algae (*phytoplankton*) thrive in clear-water, oxygen- rich lakes, while others are more common in productive lakes. The layering of algal remains at the lake's bottom provides a chronological record of the lake-- a history not only of the algae species but also of the lake's water quality.

The Wisconsin DNR conducts research on lake histories using sediment samples drawn from lake bottoms. DNR scientists collected samples from each of Whitefish Lake's basins and analyzed the resulting layers as part of this project. The results show that the lake has been remarkably stable over the last 200 years. The *sedimentation rate* (the rate at which plankton and other materials settle at the lake's bottom) had declined for much of this time, increasing only in the period from about 1980 to present, returning to rates just above their long-term historic highs (Garrison, 2006). Even at the more recent elevated levels, the rate of sedimentation in Whitefish Lake is among the lowest of all lakes examined by the DNR.

When the sediment was analyzed for trends in the type of plankton found, the DNR found a distinct trend: periphytons (the algae that piggybacks on macrophytes) are becoming more common. This is consistent with other evidence in the sediment record suggesting rooted aquatic plants becoming increasingly common beginning about 1960. Other trends in the macrophyte community are discussed in the next section.

In addition to algae, Whitefish Lake hosts a diverse community of *zooplankton* (small invertebrates). These organisms feed on algae or their fellow zooplankton. Different lakes will be more hospitable to different zooplankton communities, depending on the types and amount of algae available as well as the amount of dissolved oxygen and other lake chemical characteristics. A research team from the University of Wisconsin – Stevens Point (UWSP) analyzed samples of the

zooplankton and found that the species in Whitefish Lake are generally consistent with a low-nutrient, oligotrophic lake (Hartleb & Spude, 2007). With samples taken on a bi-weekly basis, the UWSP zooplankton study also demonstrated the dynamic nature of this part of the lake's ecosystem. The relative populations of zooplankton species were different at each sampling period, as some species were becoming less common and others more so with the passing of the season.

UWSP researchers also compared their findings to a similar project from the 1970s and found several species of zooplankton that were new to Whitefish Lake. A fishery study, discussed below, also found new species, in particular spiny water flea, an aquatic invasive species that has disrupted food webs in other lakes. The population of spiny water flea appears to be kept in check in Whitefish Lake by the robust cisco fish population, but its occurrence highlights the need to continue tracking zooplankton at Whitefish Lake and to be more vigilant with respect to aquatic invasive species prevention.

c. Aquatic plants

Whitefish Lake's clear water and sand bottom support a unique community of rooted plants. Susan Borman, a researcher specializing in aquatic plant identification, thoroughly documented these plants as another part of the Whitefish Lake studies. Dr. Borman compared her findings with a plant inventory conducted in the 1930s at Whitefish Lake. The present-day inventory and historical comparisons allowed her to analyze the potential impacts of development and changing lake conditions on the aquatic plant community.

Like algae, aquatic macrophytes play an important role in using nutrients in Whitefish Lake to translate sunlight into energy. These plants have additional ecological roles: they provide important habitat for lake organisms, such as fish and aquatic insects. They also trap and hold fine sediments with their roots, which moderates the effects of wave action near the shoreline. Because they are typically rooted in soil, macrophytes can only be found in the portion of the lake with adequate sunlight reaching the lake bottom. This is primarily near shore, but the plants also grow on and near several shallow sand reefs. In Whitefish Lake's clear waters, aquatic macrophytes are found in locations as deep as 30 feet.

Photo from Borman and Berg, 2008

Figure 7. Isoetids (quillworts) at Whitefish Lake

Researchers in the plant study located and identified all but two plant species that were initially inventoried in the 1930s study. They also found 21 species that were not included in the initial macrophyte survey. The community of plants has also changed, from one primarily dominated by small submersed plants (*isoetids;* see figure 7) to one that is increasingly dominated by

larger, leafier submersed plants (*elodeids*) (Borman & Berg, 2008). The loss of the smaller isoetids is common in lakes that are becoming more nutrient rich, as is the growth of elodeids. The plant inventory did not find any invasive aquatic plant species. It did, however, reveal that Whitefish Lake is home to three species that are rare in Wisconsin: small purple bladderwort (*Utricularia resupinata*) and water-thread pondweed (*Potamogeton diversifolius*), both of which are *State Species of Special Concern*, and redhead pondweed (*Potamogeton perfoliatus*), a species recognized as *State Imperiled.*

The plant survey also examined the location of certain plants to see what role shoreland development may be having in affecting the aquatic plant community in Whitefish Lake. Emergent species (spikerush and bulrush) were only present at sites that did not have significant shoreland modification (greater than 50% of natural shoreline disturbed). High disturbance sites were found more likely to be dominated by the larger, leafier elodeids than the diminutive isoetids (Borman & Berg, 2008). Three beds of the partially emergent water lobelia (*Lobelia dortmanna*) were also mapped, and they always coincided with minimally disturbed shorelines. Many of these emergent plant beds were included in the official designations of the Whitefish Lake Sensitive Area Study, but several small beds near the western shore were not.

The plant analysis revealed a lake that is rich in diversity and home to unique species. The lake's plants play a critical role in providing fish habitat and are a food source for a wide range of organisms, from fish to waterfowl. Their presence contributes to the outstanding beauty of the lake. They help maintain water clarity in the short-term by retaining small soil particles and organic debris that would otherwise be regularly suspended by wave action and motorboats. Keeping this plant community vibrant is a major objective for protecting the overall health of the lake.

d.Littoral Fishery

The clear waters and diverse plants of Whitefish Lake support a robust community of shallow water fish that spend much of their life in the littoral zone near the shore. This fishery has been the subject of several recent data collections and, until recently, was a prominent focus of human intervention in the lake's ecosystem through stocking programs. The Wisconsin DNR and its predecessor agencies have allocated significant resources to the lake's fishery. More recently, there has been co-management with the Native American tribes in the region who retain treaty rights to gather fish at Whitefish Lake.

One can identify several major periods in the lake's fishery through fish stocking records and prior lake studies. The records show that stocking began in the 1930s, though anecdotes indicate that a less formal process of fish stocking by seasonal residents may have proceeded this period. In 1934, over 150,000 walleye were placed in the lake to begin its official stocking history (Riordan & Manz, 2008). Until 1950, walleye and largemouth bass were the only species officially stocked

at Whitefish. 1950 and 1952 saw almost a quarter million northern pike placed in the lake. Beginning in 1958, the state discontinued stocking of any fish other than salmonids (discussed below in the section on pelagic fisheries) and no littoral fish were stocked until 1978. The DNR began a program of regularly stocking walleye in that year. By 1993, the DNR determined that after 25 years of augmenting the walleye population, the species was sufficiently self-sustaining through natural reproduction in the lake (Riordan & Manz, 2008).

In 2004-2005, the Wisconsin DNR surveyed the lake's riparian fish population using electroshocking and fyke nets. DNR staff followed standardized procedures to create comparisons between fisheries in Whitefish Lake and other lakes, as well as comparisons within Whitefish over time. They found that the lake is still supporting a self-sustaining warm and cool water fishery at a population density consistent with what one would expect in a low-productivity, oligotrophic lake (Riordan & Manz, 2008). No aquatic invasive species were discovered in their inventory.

The DNR's fishery study focused on learning more about walleye, in part because this species is important for the treaty lakes in the ceded territory. The researchers found that the walleye fishery is robust and self-sustaining, with a density and size structure similar to other oligotrophic lakes. They also found that the northern pike population is still self-sustaining, but with a much lower density of fish and an occasional "trophy" speciman. The large and smallmouth bass fishery was not adequately surveyed, along with the rest of the panfish community, as the lake's sandy substrate and sharp drop-offs allow the fish to elude electroshocking. The fyke net results indicated that sunfish and bass are common in the lake and that the size of bass is favorable for anglers, while the lake's perch population is dominated by younger fish, with few large adults (Riordan & Manz, 2008).

e. Pelagic Fishery

Whitefish Lake's clear, cold waters support a diverse, open water (*pelagic*) fishery, made up of cisco, trout and yellow perch. These fish thrive in the colder, oxygen-rich water found deep in the lake. Beginning in the 1950s, the State of Wisconsin took advantage of the lake's unique characteristics to augment its recreational fishery. From 1958 to 1977, only salmonid species were added to the lake through government stocking efforts-- predominantly brook, brown, and rainbow trout, but also Kamloop trout and coho salmon (Riordan & Manz, 2008). From 1978 through the present day, trout stocking was limited to two species (brown and rainbow trout) and done on a more episodic basis, rather than annually

The DNR retained Thomas Hrabik, of the University of Minnesota-Duluth (UMD), to study this aspect of the Whitefish Lake fishery. The UMD researchers have studied the pelagic fishery on numerous large lakes, including Lake Superior. Their technique combines open-water gill netting (to establish size and

species composition) with a whole-lake hydroacoustic survey (to record the location, depth and densities of fish populations.)

The UMD results show that yellow perch and cisco are the dominant pelagic species in the lake and that each occupies a distinct region of the lake. Perch were found above 33 feet of water, and cisco were living in areas below 33 feet. The hydroacoustic survey provided an estimate of the total number of pelagic fish (just over 89,000) and a breakdown by species: 11,000 (+/- 7,900) cisco and 78,000 (+/-25,000) yellow perch (Hrabik, 2006). The netted cisco ranged in size from 87 to 406 mm (3.4 – 16.0 inches), while the yellow perch were much smaller, ranging from 86 to 100 mm (3.4 – 4 inches), with numerous perch observed acoustically that were too small to be trapped in the net.

The total biomass of these pelagic species was within the range found on other oligotrophic lakes. The UMD researchers noted that some of the cisco caught in the net and detected by the hydroacoustic survey were remarkably large, suggesting a healthy range of sizes and ages. The cisco and yellow perch play an important role in the lake's ecology. They subsist largely on the zooplankton found in the deeper parts of the lake, and if they are effectively limiting the number of zooplankton, they could be indirectly affecting the population of algae.

In addition, the pelagic study estimated the total biomass of pelagic fish to be just over 5,000 pounds. Disease and other threats, including viral hemorrhagic septicemia (VHS), could quickly decimate this population, adding a large amount of biological material to the lake bottom for decomposition. Additionally, the cisco population, which constitutes nearly three-quarters of the pelagic biomass, is dependent upon an oxygen-rich cold water found in deep water. Oxygen depletion at the lake's bottom shrinks this zone from below during the late summer and effectively limits the size of the cisco's habitat. If shrunk too far, the habitat could be lost altogether, resulting in the disappearance of cisco from the lake. This has already occurred in many Midwestern lakes that once were home to this species.

f. Future Considerations

Whitefish Lake's ecology is a complex, interconnected network that moves nutrients and energy from primary producers (algae and plants) to zooplankton, fish that eat plankton (yellow perch, cisco and minnows) and finally to game fish like bass, northern pike, walleye and trout. Along the way, loons, eagles, ospreys and the lucky angler take a few. The remaining fish eventually die and sink to the lake bottom, where they are decomposed by detritivores and partially buried by the rain of dead and dying plankton.

The presence of oxygen in the deep part of the lake during most of the year ensures that a large portion of the bottom organic matter does not emit phosphorus back into the lake during seasonal turnover. This oxygen is also critical for the continuing existence of cisco and other deep, coldwater species, such as brown trout. Should the lake bottom ever become overwhelmed with

organic material and increasingly depleted of oxygen, an undesirable feedback loop could grow, which would noticeably accelerate the eutrophication of the lake.

Closer to shore, rooted aquatic plants are providing important habitat for small and young fish, as well as adding to the overall biodiversity of the lake. Their roots and leaves can help capture fine sediment that might otherwise be regularly re-suspended by wave action and motorboats. Many of the lake's more unique plants such as the small isoetids and emergent rushes begin to disappear as shoreline development increases. Their continuing existence at Whitefish Lake is an important indicator of lake health.

The relatively oxygen-rich lake bottom and the diverse plant community are both vital to the continued well-being of Whitefish Lake. Lake researchers and managers know more about how to lose these unique lake features than they do about restoring them. Losing more oxygen at the lake bottom is an especially troublesome prospect, as it may be difficult to slow down the process once underway. Additional nutrients released during the anoxic period could grow year after year, or at least establish a new equilibrium at a higher level of productivity. Limiting nutrients and organic material coming into the lake is the most effective and least costly means of preventing this undesirable future.

Aquatic invasive species and diseases, including VHS, the lethal fish virus, also pose serious threats to the lake's ecology. While there is no foolproof way to prevent their introduction, every precaution must be taken against these unwelcome species.

4. Riparian Ecology

Whitefish Lake's sandy watershed creates unique conditions for upland plants and wildlife. The acidic, drought-prone soil limits the range of native plants found around the lake and, by extension, shapes the wildlife that live there. The presence of the lake creates a microclimate in the riparian area where groundwater is often available and aquatic insects and upland plants can form interdependencies.

a. Annuals and Perennials

The grasses, broad-leafed annuals, and other short-lived plants near the shore are both ecologically valuable and visually attractive. These plants are critical for many insects that, in turn, are critical for birds, bats and other animals that depend on insects. The root structure of these plants helps hold soil in place and trap nutrients that would otherwise flow towards the lake. The variety of plants adds fine details to the scenic qualities of the near-shore area, and seasonal changes in this community (emergence, blooming, fall color change) provide ongoing reminders of time's passing.

Greg Kessler, a DNR Wildlife Biologist, noted in the DNR's 2004 Sensitive Areas Study of Whitefish Lake that prairie cord grass is growing in the north and

south riparian areas. This species is uncommon in northwest Wisconsin and provides good cover for wildlife (Toshner, 2004).

b. Woody Plants

The soil and water conditions near the lake also impact the type and numbers of shrubs and trees that are found around Whitefish Lake. Jack pine and red pine are particularly suited to the acidic and droughty soils, as are blueberries and other low-growing shrubs. These larger shoreland plants are central to our shared appreciation of scenic beauty around the lake. Like annuals and perennials, trees and shrubs also have ecological functions. Seeds and fruit provide food for a range of wildlife species. Branches and stems provide nesting habitat for birds and mammals. Roots extend deeper into the sandy soils, pulling out nutrients for growth. In summer, they directly intercept rainfall and reduce the potential for surface runoff.

Riparian trees and shrubs may play an even more important role in the drought-prone areas surrounding Whitefish Lake. Because the trees near lakes have more regular access to water, they fare better during extended dry periods; and as a reliable food source, they become relatively more valuable to insects, birds and mammals in the area.

Trees continue to provide important ecological functions after they have died. Standing dead trees often become wildlife habitat. Fallen trees provide cover and food for insects and other detritivores. Dead trees may also fall into the lake, where they become critical habitat for aquatic insects and fish. Young fish in particular rely on fallen underwater woody material as places where they can escape predation from larger fish. Partially submerged trees are important for turtles that rest in the sun, warming their bodies to accelerate their growth while maintaining a quick escape route. These fallen trees can also protect property by breaking waves that may otherwise erode shorelines. In some Canadian lakes, large fallen trees persist for hundreds of years underwater, sustaining many generations of fish and other organisms.

c. Wildlife

The riparian area is a hotspot for wildlife activity at Whitefish Lake. When not covered by ice, the lake provides a reliable source of drinking water to mammals small and large. Insects emerge from the lake as small flies or other adult forms; the balance of their life is spent mating near the shore, after which they become feed for fish and other organisms. For fish-eating birds, such as bald eagles and osprey, trees near the shore are critical perches for resting, feeding and nesting.

The DNR Sensitive Areas Study, completed by Pamela Toshner in 2004, includes the following observations by DNR wildlife biologist Greg Kessler:

- *Annual amphibian surveys are conducted at the public boat landing and at Deborah Lake. These surveys have found a wide variety of amphibians*

including: wood frogs, spring peepers, gray tree frogs (both Eastern and Cope's), American toads, green frogs, mink frog, bull frogs and occasionally leopard frogs. In general, amphibians are more abundant and diverse in Deborah Lake than in the Whitefish Lake itself. This may be attributed to shallow depth, soft fertile sediment, and abundant undisturbed cover in and adjacent to the water in Deborah Lake as opposed to sandy, deeper, less fertile waters in Whitefish.

- *While eagles do not nest immediately on Whitefish lake, they have nested about 1 mile to the east for the past 15 years or more and forage heavily on the Whitefish Lake fish.*

- *Loons are present and thought to be nesting on Whitefish Lake, but no specific surveys have been done to document nesting location or success rates.*

- *A variety of waterfowl uses the lake, with mallards being the primary species* (Toshner, 2004).

d. Future Considerations

The riparian area around Whitefish Lake is fairly healthy, considering the number of homes near the shore. Many homeowners have either protected or restored their riparian plants above and beyond what the DNR and Douglas County regulations require. Several properties that were developed before enactment of state and local minimum standards have deficient buffers, where turf grass and a small number of plants have replaced the native shoreland ecosystem. The health of this ecosystem depends largely on people protecting existing native plants and restoring deficient areas.

There is a surprising absence of fallen wooden material in Whitefish Lake. Anecdotally, much of the larger dead trees that may have been present in the riparian area prior to settlement were removed generations ago during periods of low water level. More recently, people have continued to remove fallen trees for firewood or navigational purposes. The comparatively large amount change in lake levels experienced at Whitefish during dry and wet periods would expose woody material to greater weathering and decay than what would be common in more stable lakes, but it is unknown how long woody material would last at Whitefish Lake since so much of it is already gone.

The Whitefish Lake Sensitive Areas Study notes that the lake and its surrounding lands need to be managed in a holistic manner: “Whitefish Lake and the adjacent wetlands and small lakes should not be viewed as separate entities, but as a whole that is greater than the sum of each component individually. To reduce the quality or quantity of one will negatively impact the other and thereby degrade wildlife habitat” (Toshner, 2004). This holistic approach goes beyond the immediate shoreland and into the surrounding landscape.

5. Watershed Ecology

Beyond the riparian shoreline, the Whitefish Lake watershed includes a wider set of plants, animals and human uses. The watershed sits within a regional ecosystem known as pine barrens, a combination of soils and plants recognized by the Wisconsin DNR and others as globally rare (Wisconsin Department of Natural Resources, 2009). This broader landscape has historically been subject to and dependent upon periodic fires that reset plant succession and maintain an open landscape character similar to savannahs. This is in contrast to much of northern Wisconsin, where a closed forest canopy dominates.

a. Forests

The relatively small watershed area surrounding Whitefish Lake is predominately forested with a mix of hardwood and coniferous tree species. Many of the early settlers at the lake contributed to the portion of conifers by planting pine trees on their land. Birch, oak, aspens, and other deciduous trees naturally reproduce and make up the bulk of the forest resource, though some areas are more greatly populated by jack pine. Forest age and size of trees vary around the lake, and some areas of jack pine appear to be in decline due to overstocking and pine budworm.

The droughty soils and abundance of jack pine create a situation that favors wildfires. Thinning of some forest stands in the watershed to reduce the fuel load available for future fires may be advisable, but aesthetic concerns among landowners and low demand for thinning products in the timber markets create impediments to fuel load management.

b. Barrens/Savannah

The broader region around the watershed is more obviously shaped by natural and purposely-set fires. Southern Douglas County and neighboring Burnett and Washburn Counties have had numerous forest fires in the past 100 years, some of which burned thousands of acres (Wisconsin Department of Natural Resources, 2009). In areas actively managed for barrens ecosystem characteristics, the DNR and Douglas County Forestry use controlled burns to exclude larger trees and favor grasses and smaller shrubs. This landscape is critical for the sharptail grouse, a once common Wisconsin grassland bird that is becoming increasingly rare as grass and shrubland is lost to forest.

Human development in the pine barrens region presents a number of challenges for ecological management of this disturbance-dependent landscape. Homes and other capital investments require fire prevention, even though fires may be needed to sustain the ecosystem. Building sites with landscape trees create fragments within the larger context of grassland and savannah, creating opportunities for non-native species and reducing habitat quality. Tastes and aesthetics may run counter to large-scale forest management practices -- such as clear-cuts and prescribed burns -- limiting the tools available to ecosystem managers.

c. The Constructed Environment

Buildings, roads and land use change represent the major human impacts on the greater Whitefish Lake ecosystems. The majority of buildings in the region have been constructed for residential purposes, and most of those are for seasonal use. There are no commercial establishments on Whitefish Lake, but several are located in the towns of Wascott and Gordon. Solon Springs and Minong are nearby commercial centers.

The homes and cabins around Whitefish Lake are not ecologically benign. Buildings, driveways and patios are typically impervious to rainwater infiltration and generate concentrated stormwater runoff. In heavy storms, runoff from impervious surfaces can reach high volumes and erode the adjacent land. If the erosion takes place close enough to the lake surface, soil and nutrients can run flow into the lake. Combined with other changes to the land around homes and other structures, this runoff often adds significant volumes of nitrogen, phosphorus, and sediment to lakes, with negative consequences for lake water quality.

Residential locations also impact wildlife in a variety of ways. Some species tend to avoid areas with human activities: Bald eagle nesting sites, for example, are not commonly associated with areas that people frequent. Other species find human activities to be attractive, even if our intent is otherwise. Bird feeders bring in a wide range of feathered species but can also draw black bears and other mammals.

Roads have predominantly negative impacts on ecosystems. In addition to creating impervious surface, they divide larger pieces of habitat. Insects and reptiles may find their movements constrained by roads, and vehicle-wildlife collisions are an additional source of direct mortality. The amount and location of roads in the Whitefish Lake watershed have been relatively stable for years. The road network around the lake does not appear to be excessive, though there are numerous un-built town roads platted in the Whitefish Beach subdivision on the lake's eastern shore. These roads only exist on paper today, but their geometric layout and proximity to the lake present a threat to ecosystem health if they are ever built as designed.

d. Future Considerations

The Whitefish Lake watershed and surrounding region are, like the lake itself, relatively rare. The Wisconsin DNR and others consider the region important for ecological restoration and management, particularly the pine barrens areas. Because the pine barrens are globally rare, it is likely that ecosystem management interests in the area will only grow over time (Wisconsin Department of Natural Resources, 2009). Increased residential development is often at odds with ecosystem management for disturbance-dependent communities like pine barrens, since managers depend on prescribed burns and large scale vegetation management to maintain a mosaic of early-succession grasses and shrubs on the

land. Local governments may find themselves looking more closely at the tradeoffs between further residential development and its long-term ecological impact. Nationwide, examples abound of homebuilding in fire-prone regions, a practice that has damaged natural communities and placed human property and life at risk.

The next section of this plan looks more closely at the human dimensions of Whitefish Lake and its surroundings to better understand the motives for development and land use change in the region.

B. Socioeconomic Context

1. History of Settlement in Whitefish Lake Area

Northwest Wisconsin has historically served as a middle landscape, connecting more significant settlement sites to its north at Lake Superior and south nearer the Mississippi. The St. Croix River, passing just north of Whitefish Lake, provided an important route for Native Americans and early European explorers moving between the Mississippi River basin and the Great Lakes. Over time, the modes of transport advanced from canoes to trains to trucks, moving people and goods between the Twin Cities of Minnesota, the Greater Chicago Region and Duluth-Superior. Poor soils and a short growing season constrained farming-based development in the region, and peripheral urban centers (St. Paul, Eau Claire, Duluth) were more effective in developing industrial economies and associated larger populations.

This is not to say that the area surrounding Whitefish Lake has not been developed. The increasing popularity of outdoor recreation and growing leisure time in the 20th Century generated a strong demand for cabins and resorts in the pine barrens region, where desirable clear-water lakes and sandy beaches are found in high numbers. As cabins, tourism and retirement housing grew, the area was transformed from a pathway between points into a destination. Today the region is poised for added development pressures, as the largest demographic bubble in U.S. history -- the postwar Baby Boom -- enters retirement.

a. Tribal Period

The earliest signs of human settlement near Whitefish Lake date to nearly 7,000 years ago. Paleo-Indians left evidence that was discovered by state archeologists in the 1990s, when U.S. Highway 53 was expanded to four lanes. Residents on Whitefish Lake have found spear and arrow points that date to the Paleo-Indian period. Three to five thousand years ago, Native Americans in the area engaged in copper mining, evidence of which has been found near Gordon. Burial mounds dating back 1,000 years in northern Burnett County indicate a Native American society with distinct cultural practices. Known as the Late Woodland culture, they were present at a time when bison, elk and caribou roamed the pine barrens.

The inward migration of Algonquin/Ojibwe people from the east likely displaced the Late Woodland people toward the end of the 17th Century and into the early 1700s. More commonly referred to today as Chippewa, these newer tribes established trade relationships across a broad region and apparently thrived on the natural bounty of rice, fruits and wild game.

Explorer Henry Schoolcraft described in detailed written reports his movements up the St. Croix River in 1832, including a stay at a Native American village near the present location of the St. Croix Flowage Dam, just to the northwest of Whitefish Lake. Schoolcraft's route through the St. Croix headwaters to the Bois Brule River and Lake Superior was by that time a major thoroughfare for traders and Native Americans.

The early1800s were a time of great transformation for tribes in North America. Since the creation of the American Constitution, the U.S. government had expressed a claim on lands east of the Mississippi and north of the Ohio River. Government and elected officials saw this vast landscape-- referred to as the Northwest Territory-- as a region waiting to be settled and developed. Following the War of 1812 and increased settlement in the territory, pressure grew to access rich pine forest resources of the upper Mississippi river basin. Native American tribal leaders and the U.S. government signed treaties in this period to exchange tribal ownership claims for monetary consideration and the right of tribes to continue hunting and gathering on ceded lands. The 1837 treaty included most of the St. Croix basin, including lands around Whitefish Lake. Subsequent years saw area tribes moved by the federal government to reservation lands. The impact of the treaty period and subsequent treatment of Wisconsin tribes on their communities remains a contentious topic. Native Americans today maintain an active role in the management and use of natural resources in Wisconsin's ceded territories.

b. Timber Clearing

Around the time of Wisconsin statehood, timber interests from the east were assessing the forests of Northwest Wisconsin for commercial development. The federal treaties with area tribes resulted in a vast amount of government-owned land. This land was readily transferred to timber companies poised to convert standing trees to barn boards for growing numbers of settlers throughout the Midwest. In a short set of decades, the forests of northwest Wisconsin were harvested and sent downstream.

By the early 1900s, most of the forest was gone and the land was subject to frequent wildfires that would clear the slash and any un-merchantable trees left behind. Timber companies often worked with settlement corporations to market cutover lands to European communities seeking to migrate to the United States. It was not uncommon to give local areas attractive names such as "Cloverland" or "Dairyland" to make them sound more. Settlement of the pine barrens was more difficult than company brochures suggested.

c. Early Settlement

The land around Whitefish Lake, in the Town of Wascott, was not intensively settled immediately after the cutover, due largely to the obviously poor, sandy soils. A 1910 plat map of the area shows large tracts of land held by the Chicago St. Paul Railroad Company (figure 8). The federal government deeded these lands to the companies as an inducement for railway construction through the region. All of the land immediately around Whitefish Lake was divided among less than 20 different owners at that time, and the federal government still held title to hundreds of acres in the area. Around this time, families from outside the region began building modest cabins at Whitefish Lake, then called Bardon Lake. The number of cabins grew slowly through the 1920s, as more people came to appreciate the lake's summertime splendor.

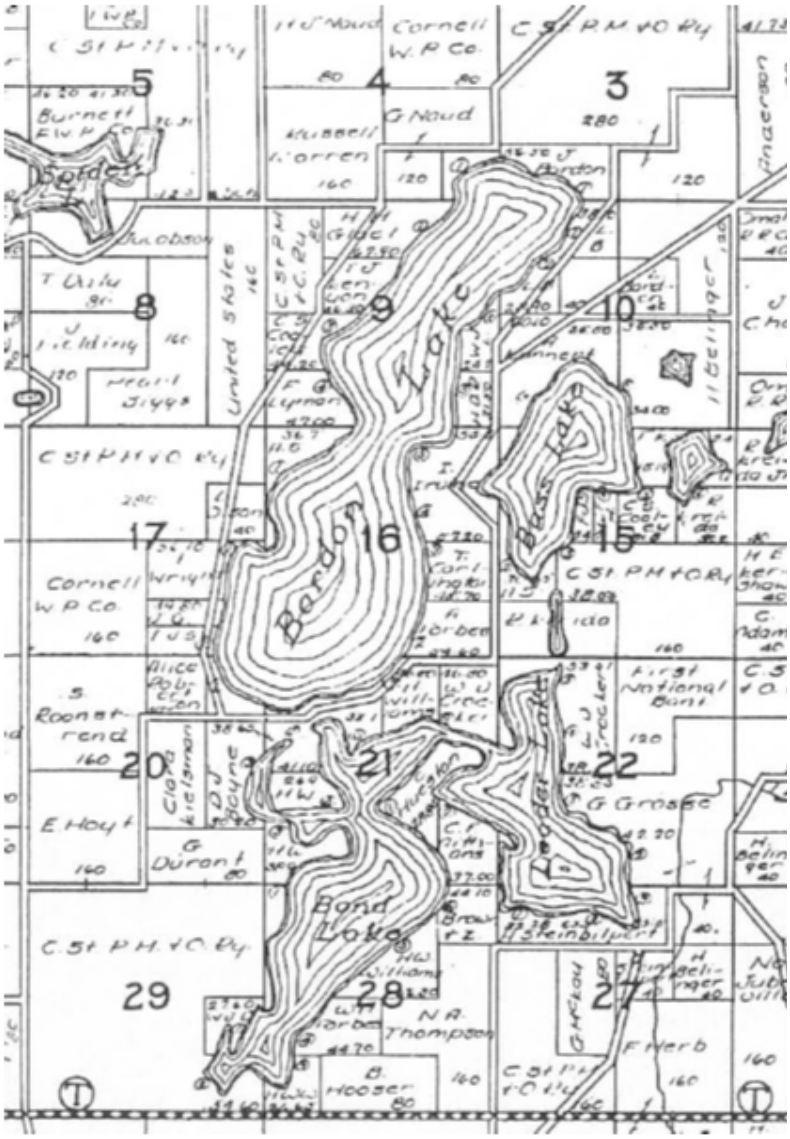
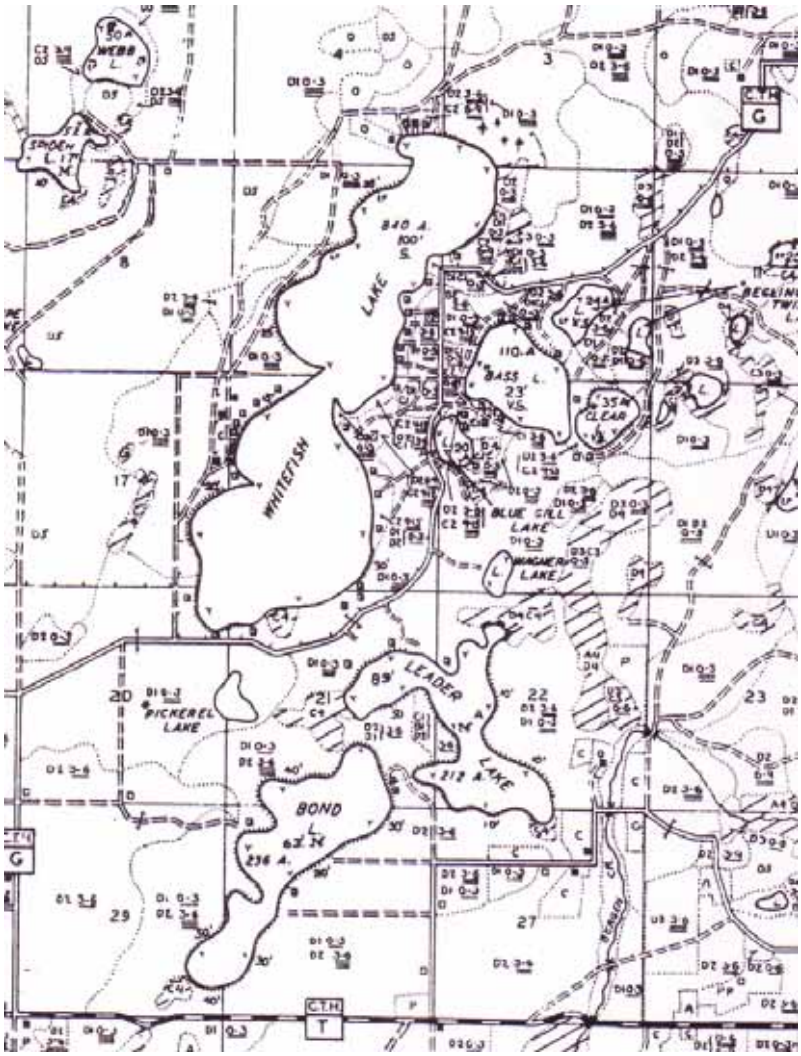


Figure 8. Detail of 1910 plat map showing Bardon Lake



Note: Small hollow squares indicate abandoned settlements

Figure 9. Detail of the Land Economic Inventory for the area surrounding Whitefish Lake circa 1933

By 1933 there were fewer than 30 cabins around the lake, mostly on the eastern side. The U.S. government sponsored land surveys during the Great Depression to assess rural land use issues. The inventory of the entire 36 square mile portion of Wascott surrounding Whitefish Lake contained fewer than 30 farming homesteads at that time, and settlers had already abandoned some of them (figure 9). Large fires west of Whitefish Lake early in the 1930s no doubt left that landscape looking desolate. President Roosevelt's Civilian Conservation Corps established camps nearby in Bayfield and Washburn Counties, and young men planted thousands of pine trees in an effort to restore the forests.

d. Post-war Period

The pace of development increased at Whitefish Lake after World War II, as more families sought lake homes for summer vacations. A small resort operated for a while at the south end of the lake on land that was farmed before the Depression. Over time, the western side of the lake was subdivided into smaller lots and became increasingly developed. By 1967, there were 86 cabins and homes surrounding Whitefish Lake, nearly three times the number found in 1933.

The surrounding pine barrens was increasingly dominated by public land and industrial forests with minimal non-lakeshore home development. One 240 acre parcel was an exception; still held by the railroad companies in 1967, by the early 1980s this tract just west of Whitefish Lake Road was platted into a subdivision containing dozens of smaller non-shoreland lots meant for recreational housing. Today, many of the lots in the Eagle Heights subdivision remain vacant.

2. Patterns of Lakeshore Development

a. Changes Over Time

Early cabins at Whitefish Lake were primitive by modern standards. It was not until 1948 that electric lines were connected to the area. Before that time, people used ice boxes to keep food fresh and hand pumps to provide water. Many of these old cabins still stand; the oldest cabin on the lake is over 100 years old. Newer cabins, built with year-round living in mind, are better insulated and have more in common with typical homes. Newer buildings are also larger, covering a greater portion of their lot with impervious surfaces. There are also numerous garages and other outbuildings associated with each homesite.

The creation and enforcement of statewide shoreland zoning laws in the late 1960s and early 1970s established setback distances from the shore as well as minimum lot sizes. Buildings dating before the shoreland zoning requirements are considered legal non-conforming structures, with limits on their improvement and expansion enforced by county zoning ordinances and state statutes; the impact of these rules and regulations are discussed in following sections on the institutional dimensions of Whitefish Lake.

b. Differences Around the Lake

Because different portions of the lake developed at different times, one can see the changes in development patterns by looking at different portions of the lakeshore. In general, the most challenging sites were not among the first to be developed. Such sites typically had features such as wetlands, shallow water tables and steeper slopes to the lake. Some of these older cabin sites have recently been redeveloped, and the differences around the lake are becoming less obvious over time.

As mentioned above, portions of the western side of the lake have been subdivided into smaller lots that, because of their size, are typically less expensive

and also more constrained with respect to the size of building that the lot can support. A special case is the Whitefish Beach subdivision, with its numerous small, platted parcels; owing to their small size, an owner seeking to build a structure requires numerous contiguous parcels to assemble a site large enough to conform to zoning standards.

3. Human Activities In and Around the Lake

Humans have been an active part of the Whitefish Lake ecosystem for hundreds of years. Native Americans have long harvested fish from the lake for sustenance purposes and no doubt collected berries and wild game in the watershed. Timber interests cleared most timber from the area over 100 years ago. Since then, the predominant human interactions have been through relaxation, housing and recreation.

a. Whitefish Lake as Respite

For many of the first cabin owners around the lake, Whitefish Lake was an idyllic escape from more frantic lives in America's burgeoning industrial centers. Families from the Chicago area, Duluth, the Twin Cities and elsewhere came to the lake during summer to enjoy the clean air, cool waters and scenic wonder of Whitefish Lake. A.J. Powell of Milwaukee described how the north end of the lake was originally populated by a series of cabins built by the Powell, Luse and Gallagher families in the 1920s. The men of the households sought a getaway to hunt and fish with friends; their wives "wanted their cottages close together on the property so that they could visit back and forth easily when at the lake on their own." The highly social nature of early cabin owners would continue throughout the 20th Century, as families and extended families would gather at the lake year after year. In many areas, informal trails still link the cabins of friends and family to maintain the connectedness A.J. Powell described.

Today, Whitefish Lake remains a popular family respite. When asked in a recent survey what the most positive aspects were of owning property at Whitefish Lake, the majority of responses either indicated "beauty of lake and shores" or "peace and quiet" (Olson, Demorest, & Slifka, 2006). When asked what they might want changed about the lake, the most popular response was "nothing". In a series of informal interviews, cabin owners readily noted that it is becoming increasingly difficult to maintain the old family-based social networks, as properties are divided among heirs and people spend shorter amounts of time at the lake. At the same time, there are an increasing number of Whitefish Lake properties being used as full time residences--something that was uncommon in the lake's early years.

b. Whitefish Lake as Home

A recent survey found that roughly one-quarter of the properties at Whitefish Lake are being used as primary residences, and almost 20% of seasonal homeowners anticipate making the lake their full time residence at some point in the future (Olson, Demorest, & Slifka, 2006). People living on the lake are

predominantly retired, and there are only a small number of families with children living fulltime at Whitefish. As residents of the Town of Wascott and Douglas County, people living at Whitefish Lake participate in local government elections and take on other roles in the institutional management of the region.

c. Whitefish Lake as Recreation

The lake provides a range of recreational pursuits enjoyed by cabin owners and visitors. There are two public access points on the lake: the public boat landing, in the southwest corner; and the DNR's Crabb Property, in the southeast corner. The boat landing provides parking and a modest restroom. The Crabb property is hike-in only and provides access to a small sandy beach near the closest point between Whitefish Lake and Lake Deborah. Visitors to the lake fish from boats and ice shanties. Other activities include swimming, boating, snowmobiling, canoeing and SCUBA diving.

Lakeshore owners enjoy a range of activities at the lake. In a recent survey, the most popular activity was swimming, which over one-third of respondents reported doing daily. While the lake's clear waters and sandy bottom make it attractive for swimming, some people noted that the cold waters early in the summer are a barrier. Maintaining the lake's clarity and the absence of invasive exotic plants, such as Eurasian water milfoil, are key to keeping the lake an excellent place to swim.

Leisure boating is popular at Whitefish Lake. There are nearly four watercraft for every property on the lake: over 150 motorboats and more than 200 non-motorized boats, such as sailboats, canoes and kayaks (Olson, Demorest, & Slifka, 2006).

Less popular activities include jet skiing and waterskiing, which 82% and 56% of respondents indicated never participating in, respectively. Motorsports on the lake create some tension among property owners: 41% of respondents reported being annoyed by jet skis either weekly or daily.

Fishing holds a special place among recreational activities, as fishing license sales help fund DNR fish and habitat management. Only a small number of households in the recent survey reported dissatisfaction with the fishery of the lake. A focus group of anglers held in the summer of 2006 found some dissatisfaction with the changing makeup of the fishery, with a smaller portion in panfish and a larger portion in trophy fish like walleye. One participant noted that panfish, easily caught, are a key to getting children interested in fishing.

4. Whitefish Lake and the Local Economy

Whitefish Lake and other lakes in Wascott and Northwest Wisconsin play a key role in the local and regional economy. The lakes are powerful magnets for recreationists. Visitors and residents alike typically bring in money from outside the community to spend on goods and services, generating income and jobs in the

local community. A healthy local economy, in turn, ensures that there are a range of services and retail options for visitors and residences. A.J. Powell, in her recollections of the earliest settlements on the lake, notes that families often hired local residents as caretakers for lake properties. Today, a range of building maintenance and property-related jobs, such as home repair and dock installation, are hired through the local labor market.

Visitors and residences also provide a source of demand for restaurants, taverns, golf courses and other recreation-oriented businesses in the region. The number and diversity of such establishments reflects the health of this demand. These businesses depend in large part on the unique and attractive qualities of Whitefish Lake and other lakes in the area. Maintaining and enhancing these qualities, including lake health, must be a key component of any effort to increase and strengthen the local economy.

5. Political Dimensions of Land in the Whitefish Lake Area

While it may seem rational to protect a valuable natural resource, there are numerous examples in Wisconsin and elsewhere of commercial and residential development damaging the resources drawing people in the first place. Aldo Leopold noted in the 1930s the tension that arises between people who see land as a commodity and those who view it as part of their community. When we view nature as part of our community and treat it with respect, we are more likely to be concerned about the health of the land, lakes and ecosystems. We can then apply Leopold's test to evaluate our projects on the land: "A thing is right when it tends to preserve the health, beauty and stability of nature; it is wrong when it tends otherwise."

Given this maxim, it becomes increasingly difficult to accept many uses of land that tend to fragment landscapes, degrade habitat quality, increase stormwater runoff, introduce invasive non-native species and harm lake species. This ecological perspective does not imply that humans cannot coexist and live in natural areas like Whitefish Lake and the pine barrens; we can, so long as we act with more forethought and respect than we have occasionally displayed in the past.

A special challenge arises in acutely sensitive ecosystems such as oligotrophic lakes and disturbance-dependent landscapes such as the pine barrens. We know that to protect the health of these natural communities, we must reach a limit of intense human land use change, such as development. When property owners in such areas lack influence with decision makers (perhaps because many are seasonal residents), local governments tend to discount the negative impacts of development and more readily approve new projects. Over time, as the area becomes more populated, its residents experience first-hand the negative impacts of development, some of which they have played a role in generating. When property owners begin to call for regulations on further development, decision makers may deride them as selfish and wishing to "pull up the drawbridge behind

them". Yet if development is not curbed at some point, it should be obvious to all that the admirable qualities that make an area special and attractive may be lost.

In the case of Wisconsin lakes, we have more examples of places where development was moderated too late than places where precaution ruled. The cost of undoing ecological damage to lakes is high. In many cases, lakes cannot be restored to desirable characteristics. When decision makers apply Aldo Leopold's land ethic to land use matters, they are more cautious and better recognize the cumulative impacts of development.

C. Institutional Context

The *institutional context* is the system of organized groups of people that can impact the lake -- mostly governmental organizations but also non-governmental groups, such as the Whitefish Lake Conservation Organization. These organizations maintain a system of rules and traditions that direct and guide human activities. Institutions such as the DNR or concepts like the Public Trust Doctrine tend to be stable over time, and their functioning is not wholly dependent on any one individual who may hold a position within an organization. For example, even though a particular judge decides a case involving public waters, that decision often formally enters the larger body of legal precedent and is applied to subsequent cases for decades to come.

1. Federal and State Government

In Wisconsin, the federal and state governments cooperate to support goals and objectives related to environmental and human health. The Wisconsin DNR has a broad range of responsibilities, from fishery management to pollution prevention. Federal agencies have generally respected the broad and integrated program of the DNR and have in many cases delegated national programs to state employees within the DNR. As a result, there is not a highly visible federal presence on many environmental and natural resource issues in Wisconsin, while the state appears to be highly involved.

a. Pubic Trust Doctrine and Clean Water Act

Wisconsin and many other states have adopted a legal principle that assigns ownership of navigable waters to the entire population of the state. Under the Public Trust Doctrine, rivers and lakes are not owned by any individual or a state agency. They are, instead, owned in common. The people of Wisconsin, through their elected government, have placed the care and management of their waters in the hands of the Department of Natural Resources.

The basis for the Public Trust Doctrine is in the Wisconsin State Constitution, which includes the language assigning ownership of waterways to the entire state population. An extensive body of state law, ordinances and codes provide more specific details about the public's interests in water and the government's

obligations as trust manager. These laws are augmented by a continually developing set of court decisions that give still more detail to the ways and means by which the waters of Wisconsin are to be protected. The Wisconsin Legislature recognized in the 1950s and 60s that human activities on land were impacting the health of water resources, and by the late 1960s, they passed and the governor signed new laws to manage shorelands, wetlands and floodplains.

In 1972, the federal Clean Water Act was passed. This law established the goal that waterways in the United States be both fishable and swimmable. Lakes and rivers found to be unhealthy would be placed on a registry for rehabilitation and improvement. In Wisconsin, the DNR had already begun assessing water bodies and has long been given much responsibility for carrying out the Clean Water Act.

b. United States Geological Survey

Well before there was a federal Environmental Protection Agency or Fish and Wildlife Service, the U.S. Geological Survey (USGS) was charged with gathering data and developing the science of the nation's natural resources. USGS's current mission is to provide reliable scientific information to describe and understand the Earth; to minimize loss of life and property from natural disasters; and to manage resources, including water, biological, energy and mineral resources.

The USGS is the nation's largest water, earth, biological science and civilian mapping agency. The Lake Studies Team in the Wisconsin Water Science Center (WI WSC) office in Middleton, Wisconsin has expertise in hydrologic data-collection in lake settings, water and nutrient budget development, source-loading analysis and lake water-quality modeling. From 1998-2001, the USGS cooperatively studied lake water quality at Whitefish Lake with WILCO volunteers. This work helped set the stage for the studies summarized in this report, and the USGS conducted the water and nutrient budget data analysis summarized earlier.

c. The Wisconsin Department of Natural Resources

The Wisconsin Department of Natural Resources (DNR) is the state agency responsible for both environmental protection and wildlife and habitat programs in Wisconsin. The DNR was formed in the late 1960s, when the state's environmental laws were rapidly expanding. The Water Resources Act of 1968 designated the DNR as the lead agency for managing the lakes and rivers of the state and required agency staff to develop an array of new programs aimed at ensuring the protection of waterways and fulfillment of the Public Trust Doctrine. One component of these programs is the state's shoreland zoning program, through which the state requires counties to enact overlay-zoning districts to manage development near water bodies; this program is described in more detail below.

In addition to its regulatory role, the DNR works to promote and enhance recreation in Wisconsin, building on a long history of state support for fish and game management. The DNR supports public access to lakes and rivers to ensure access for fishing and other recreational activities. Fish stocking was undertaken originally to enhance recreation and tourism. It continues today in collaboration with Native American tribes to monitor and manage harvests of fish in the Ceded Territories.

The DNR is also a land management agency, directly responsible for millions of acres of state-owned forestland and wildlife habitat. Through the county forests, Managed Forest Law and numerous smaller programs, the DNR partners with local governments and private landowners to aid land management through advice, financial assistance and public education.

The DNR's many lake-related functions are carried out through collaborative programs within the DNR and with external partners. Lake management grants are a prominent feature of these programs. The grants help pay for research and management activities on Wisconsin lakes. The portion of the state's gasoline tax revenue that derives from motorboat gasoline consumption provides the funding for these competitive grants. Much of the science conducted as part of this management plan was funded by a lake protection grant.

d. Wisconsin Department of Commerce

The Wisconsin Department of Commerce oversees the regulatory framework for buildings in Wisconsin. This includes the state's minimum standards for plumbing, and because septic systems and other private on-site wastewater treatment systems (POWTS) are connected to a building's plumbing, Commerce plays a role in regulating how homes are built in rural areas where municipal wastewater systems are uncommon. The department's administrative code guides local staff, typically in the county zoning office, in the process of approving and recording the locations of septic systems, holding tanks, and other POWTS. Commerce also generates rules concerning the ongoing maintenance and upkeep of septic systems to ensure that failing units or illicit discharges do not impact water resources.

2. County Government

County government is, in many ways, an extension of state government, as much of their work is a matter of carrying out state-mandated programs. Much of a county's work in natural resource management takes place in rural, unincorporated towns. In cases like Douglas County, the population may be concentrated in cities, and proportional representation means that the majority of county board members will represent urban areas, such as the City of Superior. This can be a source of tension when city and rural interests vary, as they can in many natural resource management issues.

a. County and Shoreland Zoning

The Douglas County shoreland zoning ordinance was developed in the early 1970s in response to the 1968 Wisconsin Water Resources Act. In addition to shorelands, floodplains and wetlands, the county regulates all land uses in unincorporated areas through a general zoning ordinance. Permits are required for construction in rural areas. Minimum setbacks must be adhered to with respect to water bodies, neighboring properties, roads and other features. In addition, the zoning ordinance and the subdivision regulations establish minimum lot sizes necessary for new buildings. The Zoning Board of Adjustment provides a forum for landowners who believe that they have a case for variances from the minimum lot size and setback standards.

b. County Forest

Wisconsin's county forest system is a partnership between the DNR and local counties created initially to manage tax forfeit lands in Wisconsin's cutover regions. County-owned forests total nearly 270,000 acres in Douglas County, representing the largest county forest system in Wisconsin. The public's holdings include pine plantations located west and east of Whitefish Lake, as well as lands managed for sharptail grouse in the 4,000-acre Bird Sanctuary, between Gordon and Solon Springs. Commercial timber management in county forests generates revenue that helps fund county and local government. Counties develop fifteen-year management plans with input from county board members, the public and the Wisconsin DNR.

c. County Land and Water Conservation Programs

County Land and Water Conservation departments are an additional local government institution with broad resource management responsibilities. In the past, Douglas County was part of a multi-county collaboration that also served landowners in Bayfield, Ashland and Iron counties. In the late 1990s, the collaboration was dissolved. Douglas County now has a small department of its own. Funding for county conservation programs comes from a partnership between the State Department of Agriculture, Trade and Consumer Protection (DATCP) and county government. Like the county forests, each county is responsible for creating a management plan that is tailored to the needs of local communities. Staff provide technical assistance to farmers and other land owners who manage problems such as erosion, stormwater runoff and native plant restoration. The Land and Water Conservation Department also provides access to cost-share grant programs that give incentives for implementing best management practices that protect water quality and provide wildlife habitat.

3. Town Government

Town government in Wisconsin is largely modeled on the New England ideal of direct involvement and participation in government decision-making. Most towns were formed as six-mile by six-mile municipalities coinciding with survey townships, laid out in the 1800's, as Wisconsin became an American territory. In areas like Wascott, lands were not productive enough to support a dense

population based on farming or commercial trade, so towns were physically larger. Today, the Town of Wascott encompasses 142 square miles in the farthest southeast corner of Douglas County. It is bordered by Washburn County to the south, Town of Dairyland to the west, Bayfield County to the east, and Town of Gordon to the north. The town is responsible for maintaining local roads and providing basic services to residents.

Wascott's land use regulations are carried out by the Douglas County Zoning Department. Zoning and subdivision ordinances limit how land can be used and developed. Zoning ordinances also establish setback distances between buildings as well as setbacks from lakes, rivers, wetlands, roads and other land features. When landowners want to build, they must first contact the county zoning office to ensure that the project complies with use restrictions and setback distances. Landowners wanting to change their land use -- for example, from residential to commercial use -- must refer to the county's zoning ordinance to ensure that the new use is permitted; if not, landowners can request a change in zoning designation (rezone) or an exception to the rule (variance).

Town boards retain some say in whether rezones or variances will be granted by the county. If a town finds that a proposed rezone or variance is inconsistent with the local comprehensive plan, it can veto the request. This veto power does not apply to shoreland zoning provisions. Towns can also note and report violations of zoning to the county, alerting staff to cases that may require enforcement. Violations of the ordinance, such as new structures built without regard to setback requirements, can result in fines, orders for mitigation or abatement measures, such as moving or eliminating structures.

4. Whitefish Lake Conservation Organization

The Whitefish Lake Conservation Organization (WILCO) has been instrumental in this planning project. They have also already begun the tasks necessary to help protect the lake from threats such as invasive species and overdevelopment. WILCO began as Whitefish Lake Property Owners (WILPO), an informal group of cabin and homeowners who engaged in local decision-making and education to fellow members. In the 1990s WILPO went through some major changes: the group was formally incorporated as a non-profit so that donations would be tax-deductable, and the organization was structured to permit it to receive and hold donations of land and easements. The name at that stage was changed to the Whitefish Lake Conservation Organization.

The relationship between WILCO and USGS was initiated in 1998, after the lake association applied for and received a grant for a water quality study. USGS scientists began a four-year project, collecting baseline water quality data to support the analysis discussed earlier. Following the water quality study grant, the lake association received a large lake management grant from the DNR to cost-share shoreland restoration projects around the lake. This program resulted in over 20 properties having some form of native plant restoration. WILCO also started a

boat landing monitoring program to remind visiting boaters to remove all aquatic plants before launching crafts into the lake.

In 2005, Fred and Sandy Anderson were recognized by the Wisconsin Association of Lakes as recipients of their Lake Stewards Award; Sandy has volunteered much time towards making WILCO projects happen and was at the time the President of WILCO, while her husband Fred had worked diligently to ensure that local and state policies were adequately geared towards protecting lake resources. The Andersons, as well as Ted Griggs, the current WILCO President, have completed UW Extension's Lake Leadership Academy. WILCO itself has received recognition by the Wisconsin Association of Lakes as a Lake Steward in the organizational category.

WILCO continues to maintain these projects to carry out their mission of protecting Whitefish Lake. The lake association will likely need to take the lead on many of the more proactive strategies outlined in this plan, since their members and other lakeshore owners have the greatest stake in the lake's future. There are a number of institutions, in addition to those described above, which will be key partners in carrying out the tasks and activities needed to maintain Whitefish Lake's unique qualities.

5. Additional Institutions

There are many additional institutions that interact with and impact the Whitefish Lake watershed in less direct ways than the organizations described above. For example, the West Wisconsin Land Trust (WWLT) has been working with WILCO for nearly 10 years to promote land conservation easements as a method of protecting land from further subdivision and development. WWLT in 2006 partnered with Ted Griggs, a landowner with shoreland and wetlands on the northeast corner of Whitefish Lake, to create such an easement, protecting the 37-acre Griggs property, with 1,300 feet of lake shoreline, in perpetuity. The Douglas County Association of Lakes and Streams (DCALS) is an affiliation of lake and river organizations, as well as a means for property owners on lakes without formal lake associations to get involved in water-protection policy and education. The Friends of the Bird Sanctuary is a non-profit organization that promotes sound ecological management of the pine barrens area north of Whitefish Lake. All of these institutions add opportunities for greater citizen involvement in resource management and governance in the region, but they also call on people to contribute their time, money and attention in order to thrive and function into the future.

III. Strategic Framework for Lake and Watershed Ecosystem Management

This plan is based on an ecosystem management framework that integrates human needs and desires into natural systems. This framework recognizes that humans are a part of nature and that natural systems are dynamic and complex. Because we can never fully understand ecosystems, humans need to take a more tentative and cautionary approach to change and development on the landscape. At the same time, it is often counterproductive to try to eliminate changes in ecosystems, given that these systems developed in a context of ongoing and occasionally dramatic change. The next section expands on these ideas in order to provide a holistic framework for the objectives and actions that follow.

A. Golden Rule of Ecosystem Management

Modern natural resource management developed quickly in the early 1900s as a response to American population growth and resource use. In many parts of the country, unchecked natural resource liquidation created a sickly landscape. Concerns about resource depletion and shortages led to restoration and restocking efforts that could potentially provide a "steady flow" of natural resources such as timber, fish, and game. Only recently have ecologists and managers recognized that the natural world is not a factory that produces a steady flow of resources. Instead, we may be better off anticipating and even embracing natural variations. One set of resource managers put it this way:

> *Natural resource management should strive to identify and retain critical types and ranges of natural variation in ecosystems, while satisfying the combined needs of the ecological, socioeconomic and institutional systems* (Meffe, Nielsen, Knight, & Schenborn, 2002).

This "golden rule" of natural resource management operates at multiple physical scales and conceptual levels. Understanding where Whitefish Lake is located among a range of resources is as important as protecting variation within the lake and its watershed.

1. Types and Ranges of Variation

There are many different types of lakes in Douglas County, Wisconsin and North America. Lakes vary in size, depth, shape, water quality and location within the landscape. Whitefish Lake represents a fairly large, deep, oligotrophic seepage lake with a relatively small watershed. Most Wisconsin lakes are smaller and shallower than Whitefish. There are about 170 inland lakes in Wisconsin that are larger than Whitefish. This places Whitefish in the top one percent in terms of spatial area. Many of these larger lakes are flowages or reservoirs, meaning that they are typically more shallow and nutrient rich, making them warmer and greener in the summer. Among seepage lakes, those fed primarily by groundwater, Whitefish is the 19th largest in the state.

Not all lakes are deep enough and clear enough to support a cold-water fishery. Among the 300-plus Wisconsin lakes larger than 500 acres, Whitefish Lake is one of only two-dozen known to support trout. The lake's self-sustaining pelagic yellow perch and cisco population also make it unique.

Larger lakes can draw heavy visitation levels, development and invasive species. About 25% of Wisconsin lakes as large as Whitefish Lake are infested with Eurasian water milfoil. Many others have zebra mussels. Whitefish Lake has no established populations of aquatic invasive species. Several lakes the size and depth of Whitefish are partially or fully encompassed in National or State Forests, affording the sort of unspoiled, natural shoreline that on Whitefish is only possible thanks to the efforts and foresight of conscientious property owners.

In terms of water clarity, Whitefish Lake has more in common with its large northern neighbor, Lake Superior, where summertime Secchi readings also range between 20 and 40 feet. Most Wisconsin "lakes" with similar water clarity are not lakes, but rather spring-filled abandoned rock quarries.

All of this suggests that Whitefish Lake is unique among Wisconsin's thousands of lakes. In statistical terms, it is an outlier. Its characteristics expand the total range of variation found in Wisconsin, and if its unique qualities diminish over time, then our collection of lakes would become more homogenous. This provides a basis for widespread and deeper concern regarding the lake's future, over and above what might be afforded to a more common body of water.

In addition to this external aspect of variation, Whitefish Lake's ecology draws upon a range of conditions and qualities present within the watershed and the lake itself. The deep, cold pelagic waters, the warmer shallow areas, and the transition between these zones, each provide a unique set of habitat features that support a suite of plant and animal species. The surrounding wetlands and uplands add further to the diversity of the watershed. Maintaining a range of habitat types within and around the lake is part of observing the golden rule described above.

There is also variation over time, or *temporal variation*, present in the Whitefish Lake ecosystem. Daily cycles occur in the movement of fish and wildlife: for example, microscopic zooplankton move up and down the water column, seeking a particular amount of sunlight; and annual cycles of lake turnover, freezing and thawing repeat endlessly. At larger spatial and temporal scales, the ecosystem experiences disturbances and variations that are sometimes so subtle that they can scarcely be detected. Jack pine budworms gradually build in population and then expand rapidly to take advantage of a large number of drought-stressed trees. Forest and grass fires periodically swept through the region over thousands of years, maintaining a more open and savannah-like landscape. Precipitation levels vary, driving lake levels up and down over time. These variations may be more pronounced at a lake like Whitefish Lake, where about one-half of its water budget can typically come from precipitation.

2. Variation and Resiliency

Over the last 100 years, humans have created a remarkable range of systems and practices in order to limit and control natural variation. In some cases, we have sought to control nature to protect our own investments: we prevent and fight forest fires; we build dikes and dams along rivers to limit the effects of seasonal flooding. In other instances, we seek to limit natural changes to preserve parks and other places in a "pristine" condition, without recognizing that natural or human-driven cycles and disturbances can sometimes be the main forces responsible for creating those pristine conditions in the first place. When we enact controls on nature, and invest ourselves financially and psychologically in places seemingly protected from change, we can become dependent on continually reinforcing and strengthening those controls.

Experience has shown us that our best efforts to control nature cannot account for all possibilities. Eventually our controls are thwarted and nature runs its course. Unfortunately, if human-created controls have been in place long enough, the plants and animals may have lost their resiliency to periodic disturbances. The disturbances that overwhelm our control systems also tend to be more severe. Thus, the sandy pine savannahs of southern Douglas County may have gradually built rich topsoil capable of supporting a range of grasses. Fast-moving fires historically refreshed these soils every few years. The same soils may be destroyed by the higher heat of intense forest fires that are more likely on lands overstocked with jack pines and oaks, which prospered in the absence of grass fires. Such fires may leave behind truly barren sands in their wake.

Concerning Whitefish Lake, people may need to relax some of their assumptions about the desirability of strictly controlling natural variation and begin to consider ways in which humans can help maintain variation and build resilience. Already this approach is used in areas like the Douglas County Bird Sanctuary through prescribed burning of grasses and shrubs. Nearer to the lake, protecting variation and enhancing resilience largely translates to preventative actions necessary to keep the lake from becoming artificially homogenized. For example, the range of

plants in the lake could be diminished by invasive aquatic species. And this same diverse plant community is threatened by direct human impacts, such as illegal plant removal, motor boating in designated sensitive areas and driving vehicles on the lakebed during low-water periods. Keeping the existing aquatic plant community diverse, robust and resilient enhances the lake's natural ability to withstand periodic invasions of non-native species.

B. Precautionary Principle

Embracing diversity and enhancing natural resilience are relatively new approaches to natural resource management. Only seventy years ago, the "best practices" of forestry included planting millions of acres of trees in evenly spaced rows containing mostly a single species. We have learned through disease and major fire events that such forests hardly take care of themselves the way that a more natural forest with greater biodiversity does. Other hard-earned lessons from past natural resource management suggest that humans ought to be less cavalier with their actions, as we rarely understand the long-term implications of changes that we introduce. For example, many of the invasive species that we now fight so hard to control were intentionally introduced to meet a human need or desire. Purple loosestrife, a non-native plant that can effectively homogenize wetlands in North America, was until recently promoted as an attractive landscaping plant.

In rare and outstanding ecosystems, such as the pine barrens and Whitefish Lake, a greater degree of precaution and premeditation should prevail when enacting human changes. Too often society permits individuals and groups to do anything they please, limiting them only if and when someone can prove that such actions are likely to cause harm. The precautionary principle turns this approach on its head. It suggests that those favoring or proposing a change ought to demonstrate beforehand that their actions will do no harm. This is similar to the approach we have come to expect in the medical professions, where doctors and nurses are sworn to the Hippocratic oath. Extending this approach to lake and land resources merely shifts the burden of proof, from those protecting natural ecosystems to those looking to introduce new or greater human impacts in those same ecosystems.

An example of how this may be applied can be found in the past, present and future of artificial fish stocking in Whitefish Lake. In the early days of settlement, anglers themselves may have ventured to "stock" the lake with their own preferred species of fish, moving them from one lake to another. State agencies have for over 100 years engaged in fish stocking from hatcheries like the one in the Brule River State Forest. At Whitefish Lake, as discussed earlier, stocking included a wide range of non-native fish, including fish that might never have been expected to exist in this area, such as Coho salmon. Using the precautionary principle approach, state agencies would need to give more explicit attention to the negative consequences that such introductions might bring about. If they

cannot show that their program would in no way harm the lake, they would not be permitted to go forward.

1. Shoreland Development

The precautionary approach to managing change applies to more than just fisheries management. One of the more noticeable human impacts around Whitefish Lake has been the introduction of over 100 structures in the area immediately surrounding the lake, along with associated facilities such as wells, septic systems, piers and landscape plants. Much of this change has involved only minimal consideration of long-term, cumulative impacts, and still today the burden of proof is commonly placed on anyone seeking to limit or prevent a new impact. Embracing the precautionary approach does not imply that no more impacts can be introduced; it simply asks people looking to make changes to show beforehand that their projects will not harm the resilience and diversity of the lake and its watershed ecosystems. This need not entail a major scientific or engineering study, but the degree of change proposed should be related to the extent of evidence required before a new project goes forward.

Take a fisheries proposal as an example: one would not require the same type of analysis for a proposal to rear and release fish into the lake using fish egg and sperm drawn from specimens already in the lake as one might want from a proposal to use species and genetics from distant watersheds. This doesn't prohibit using populations from elsewhere in Wisconsin to stock a lake like Whitefish, but it does mean that before doing so agencies need to show that the possible negative impacts are minimal or non-existent. If negative impacts are likely or expected, then the project ought not go forward.

Around Whitefish Lake there are numerous examples of shoreland development, some of which we know are impacting the lake negatively as demonstrated by the aquatic plant study summarized above. Shoreland zoning helps to reduce most types of land use change that might harm the lake, but there are many aspects of human resource use that are not government regulated and probably never will be. The burden still ought to fall on the person proposing a change. The question that they should be asking of themselves is, "Does this really need to be done, and if it does, can I do it in way that does not harm Whitefish Lake's ecosystem?" A prudent person would not act unless they could strongly answer "yes" to both of those questions.

2. Invasive Species

The need for precaution and prudence is nowhere more evident than at the public boat landing at Whitefish Lake. Here we only expect people to load their boat into the lake if they have already self-inspected to verify that their boat, trailer and vehicle are not harboring invasive species, such as Eurasian water milfoil. WILCO has hired and supervised boat landing monitors to assist landing users and encourage them to be more precautious. We know that it is impossible to ensure that 100% of boats brought in at the landing will be inspected, and it is

likely that at some point a boater will not exercise due prudence and an invasive species will be introduced. Such an event is not a failure of the precautionary approach; rather, it is a failure of people to adhere to it. Staffing the boat landing monitoring effort as much as possible is simply a way to promote greater prudence and place pressure on landing users to exercise necessary precautions.

The arrival in Wisconsin of viral hemorrhagic septicemia (VHS) and its subsequent spread to inland Lake Winnebago from Lake Michigan (through live fish taken from lake to lake), adds a layer of complexity to invasive species control. The precautionary principle implies that anglers moving fish from one lake to another should be required to prove that their particular fish -- whether bait or game fish in a live well -- cannot transmit VHS from one lake to another. Since proving this can be nearly impossible, the DNR asks anglers to not move fish from one lake to another for any reason. The same requirement is placed upon the DNR itself, as its fisheries program now needs to demonstrate that species introduced through their artificial stocking program are not infected with or capable of transmitting VHS and other diseases.

C. Management of Lake Recreation

Fish stocking, live bait use, movements of boats from lake to lake and other in-lake recreational pursuits all entail some degree of risk to the lake's native biodiversity and resilience. Historically, most people have either not considered these risks or deemed them too small to limit their use of the lake. For those visiting the lake, the risk calculation may be skewed to favor action over precaution since Whitefish Lake is only one of perhaps dozens of lakes that they enjoy using. For property owners on the lake, the risk calculation is skewed in the other direction, because they are personally and financially vested in this one particular lake.

This asymmetry concerning recreation in the lake was evidenced in the interviews with shoreland property owners: When asked what they would like changed about the lake, one quarter of respondents mentioned management of the boat landing or behavior of boaters on the lake. The most commonly mentioned activities negatively impacting the residents' enjoyment Whitefish Lake were noise from jet skis and boater disregard for slow-no-wake rules. Some people went so far as to express their desire to see the public landing closed.

As discussed above, Whitefish Lake is a publicly owned resource, an asset not just to property owners on the lake but also to all residents of Wisconsin. Maintaining public access to the lake for recreation and enjoyment is perhaps the primary way to keep the wider public concerned with the lake's future. At the same time, the public may never be as concerned about Whitefish Lake as the subpopulation who live at or own property on the lake. By exercising their greater level of concern about the lake, property owners help to ensure that they, as well

as the public and generations to come, will continue to have a truly unique lake to enjoy. Just as the public expects watershed property owners to exercise precaution when developing and using their land and riparian area, owners expect visiting recreationists to use prudence and self-restraint to prevent harming the lake.

D. Social Considerations for Future Lake Management

People's attitudes towards and perceptions of Whitefish Lake obviously vary. Even among property owners on the lake, there is no single, uniform perspective about the lake's present status or future management. This report is one component of building a shared foundation for understanding the lake and taking actions that protect its long-term future. The ecological perspective used in this plan reflects the best scientific understanding of how the lake maintains its desirable characteristics. What we do with this science -- how we disseminate it and use it as a component of decision-making -- will determine how well we fulfill our obligation to care for and pass on rare and unique natural features like Whitefish Lake.

1. Building Awareness and Understanding

The scientific knowledge concerning Whitefish Lake generated in the last five years is tremendous and can be overwhelming to digest. Yet this knowledge must be shared with all people concerned with the lake's future, including current lake residents; young people in the area; the Town of Wascott; and Douglas County. A broad awareness of Whitefish Lake's unique qualities and healthy ecosystem is needed to ensure that it does not lose the features that make it outstanding. This awareness will not emerge overnight, but will likely be the result of constant reference to the studies summarized in this plan and ongoing data collection and analysis to update and build upon today's knowledge base.

Already there are efforts underway to incorporate more people in the process of studying and managing Whitefish Lake. WILCO has worked with UW Extension and other partners to hold a "field day" to identify the lake's rare aquatic plants. These two parties have also jointly produced a visual field guide to the lake's plants so that anyone can observe and record changes in the lake. Fred and Sandy Anderson, past WILCO board members, continue to participate in DNR Self Help Lake Monitoring, gathering water samples and Secchi disc readings (as well as other lake parameters) on a regular basis. The WILCO newsletter and webpage shares information about the lake and the recently completed studies with a wide range of lake stakeholders. Continuing and expanding these efforts is important to ensure that as many people as possible are versed in the lake's ecology.

2. Cooperation

Knowledge of the lake's needs is a prerequisite to taking steps needed to ensure its future, but by itself it will not be enough. Cooperation across many dimensions will also be needed. Visitors and boat landing users need to cooperate with the

landing monitoring program and the DNR's rules regarding bait and live plant transplant. Neighbors need to cooperate in the management of the riparian areas and shoreland zone. Boaters need to cooperate with each other to enforce norms of good recreational behavior. The town, county and lake residents need to cooperate to detect rule violations and ensure consistency and uniformity in enforcement.

One of our shared social instincts is to take advantage of opportunities to cooperate. While our competitive spirit often drives our individual ambitions, human history is full of examples of people coming together to advance a shared interest. At Whitefish Lake, there is a developing sense that among lake stakeholders, "we are all in this together." Such a cooperative spirit needs nurturing and support, particularly from stakeholders who cannot be heavily involved in the day-to-day activities at and about the lake. As more examples of effective cooperation develop, the community can evolve to take on increasingly greater challenges.

E. Institutional Resilience

How an organization responds to challenges is the main measure of its resilience. Like a natural resource that has been subject to artificial controls on variation and disturbances, an institution can become atrophied and vulnerable if it does not exercise its abilities to address issues and develop cooperative solutions to problems. A resilient institution can withstand surprises and novel difficulties by drawing upon its operating procedures (bylaws, administrative codes, etc.) as well as the diversity of ideas among its members. Where many institutions share an object of concern, as in the case of Whitefish Lake and its watershed, they can use cooperation and networking to help each other build resilience.

1. Networking and Communication

Often there are positions within an institution for people who directly network with other organizations to ensure that each party is kept up-to-speed with the other's activities. Whether informal ambassadors or official designees, the people in networking roles are critical to identifying issues early and fostering opportunities for cooperation. At Whitefish Lake, there have been several periodic meetings of stakeholders from different organizations during the course of creating this management plan. Such a steering committee is worth maintaining in the long run to ensure that the USGS, Douglas County, Town of Wascott, WILCO and others are regularly appraised of updates and programs concerning the lake and its surroundings.

2. Assessing Policies

Already there are a number of policies and regulations impacting Whitefish Lake. It is less common for institutions to critically review those policies to ensure that they are accomplishing what they were intended to do. In addition to sharing ideas

and information, gatherings of organizations with a stake in Whitefish Lake's future can be used to review short and long-term policy effectiveness. Such analysis has been done in the past, leading to modifications of subdivision and zoning rules in Wascott and Douglas County. Institutionalizing a process of shared policy review and assessment is one way to build collective resilience among lake stakeholders.

3. Learning and Experimenting

Organizations can further increase their capabilities and resilience through projects that are specifically designed to foster learning and experimentation. In the business world, this activity is commonly referred to as "research and development", and it is the source of valuable innovations and novel solutions. Governments and non-profits are less inclined to support "radical" learning experiments, but it is becoming more and more accepted for such institutions to test new ideas or modify practices on an experimental basis. It is increasingly common for natural resource management agencies to employ adaptive resource management, an approach that sets up management activities (such as timber harvests or fish stocking events) in a manner similar to scientific experiments, with explicit hypotheses to be tested and a protocol for "treatment" and "control" area necessary to isolate specific factors necessary for healthy ecosystems.

Many lake organizations get involved in a more passive approach to learning through programs like the DNR's Citizen Self Help Lake Monitoring. By engaging citizen volunteers directly in the collection of lake data, the DNR can effectively monitor more lakes than their professional staff allows and generate broader citizen interest in lake water quality issues. Conferences such as the Wisconsin Lakes Convention and the Northwest Wisconsin Lakes Conference provide additional learning opportunities, not just for lakeshore property owners but for government policy-makers as well.

IV. Framework for Future Decisions and Action

Overarching Goal for Whitefish Lake: To maintain and protect the present conditions at Whitefish Lake, including its admirable water quality, unique biodiversity and essential ecological functions.

Discussion: Whitefish Lake's present ecological condition is desirable, unique and resilient, but not immune to new problems. The overarching goal for the lake is defensive in nature, encouraging all who are concerned about the lake to be proactively protective of its current condition. This is different from many lake management plans in Wisconsin that take on a rehabilitation goal to address pressing issues, such as invasive species or rapid eutrophication. In those cases, the presence of a clear and imminent threat to the lake can rally stakeholders to be more engaged in lake management. At Whitefish Lake, with a goal of keeping the lake very much as it is today, the concern may be that some stakeholders adopt a "do nothing" position. Such an approach would work in a static world, but the watershed and its surrounding ecological systems are dynamic, and external threats will continually pose threats to the lake. In short, keeping Whitefish Lake as it is today is not as easy as it may initially sound. The objectives below address several dimensions of this challenge and provide touchstones for stakeholders willing and able to participate in the proactive protection of the lake.

Objective #1: Nutrients and Organic Matter

Limit the amount of nutrients and organic material coming into Whitefish Lake to maintain the excellent oligotrophic lake water and ensure that the zone of oxygen depletion at the lake's bottom does not grow.

Discussion: This plan and the associated research on Whitefish Lake reveals a uniquely oligotrophic lake with an increasingly rare suite of species and ecology. Nutrients and organic matter both increase annual productivity of plankton, but also threaten to increase lake bottom oxygen depletion and accelerate the internal loading of nutrients. While much of the lake's nutrient and organic budget is beyond human control, there are several ways that people can act to limit sediment and nutrient inputs.

Indicators:
Lake water quality as measured by total phosphorus, chlorophyll and clarity: 5 year trends in water quality should maintain within the parameters of an oligotrophic lake (summertime surface samples yield average total phosphorus at or below 0.008 mg/L; summer water clarity Secchi measurements between 20 and 30 feet).

The rate of oxygen depletion during the summer stratification period and resulting size of the oxygen depleted region at the lake's bottom: the rate of oxygen depletion is monitored by repeatedly recording dissolved oxygen profiles at the deep holes weekly during the summer, from the time when stratification begins until fall turnover. Several years' worth of data may be needed to establish trends in the rate of oxygen depletion. The late summer depth of the anoxic zone should be approximately equal to depths established in the USGS study (at or near 36 feet from the surface in the north basin and 60 feet from the surface in the south basin).

The portion of shoreline with above minimum vegetated buffers: 90% of the lake perimeter with above minimum buffers in a 10-year horizon (2020), 99% in a 20-year timeframe. Such buffers would ideally extend from the high water mark 100 feet inward.

Key Implementation Actions:

- Continue monitoring lake water quality characteristics, including: (a) annual DNR-sponsored Citizen Water Quality Monitoring of summer lake water samples, summertime Secchi disk measurements, dates of ice-in and ice-out, and changes in water levels. Citizen monitoring should include records of dissolved oxygen profiles weekly from the onset of stratification to fall turnover; (b) periodically repeating USGS water quality monitoring protocol on a regular basis (every five years); this would entail the same water quality parameters recorded by the USGS in the periods 1998-2001 and 2005-06 (Secchi measurements, near-surface and near-bottom water chemistry and lake profiles).
- Protect existing shoreline buffers and restore buffers in every location available in order to limit any overland runoff coming into the lake.
- Maximize natural plant communities in the shoreland zone and increase the depth of shoreland buffers.
- Eliminate all grass fertilizing and promote alternatives to turf grass in areas where turf does not thrive (sites that are too shady or nutrient-poor for turf grasses).
- Eliminate the use of fertilizer with phosphorus in accordance with state law.
- Begin to modernize septic systems and introduce newer systems that effectively remove phosphorus, particularly where there are older systems in the portion of the watershed where groundwater moves toward the lake.

- Create a volunteer program that permanently protects ecologically sound land management practices on private lands around the lake through conservation agreements (buffers, runoff management, etc.).
- Publicly recognize and reinforce individual and family initiatives to permanently protect sound land use practices.
- Inventory the location and condition of all wetlands in the watershed.

Objective #2: Development and runoff

Carefully manage ongoing development and construction in the Whitefish Lake Watershed in order to limit the amount of impervious surfaces and surface water runoff entering the lake and preserve natural scenic beauty.

Discussion: The Wisconsin DNR partners with local governments to implement shoreland zoning and subdivision regulations designed to minimize the negative impacts of development on water quality. The associated rules and regulations stem from the state's obligations to protect water quality as part of the public trust doctrine. The state's standards are largely uniform throughout Wisconsin, even though lake conditions vary tremendously from one region to another. Many Whitefish Lake stakeholders have recognized that their lake is not a typical Wisconsin lake and have worked with the DNR, Douglas County and the Town of Wascott to develop alternative standards that better manage development in their watershed. The USGS study points out that while the area's sandy soils naturally reduce surface runoff, it is possible for poorly managed development to boost the volume of nutrients and sediments entering the lake. In addition, poorly managed development poses a threat to the unique scenic beauty in the watershed, as trees and natural areas become increasingly replaced by roofs, siding, windows, and decks.

Indicators:
Percentage of the watershed covered by impervious surfaces (roofs, driveways, patios, outbuildings, etc.): Should not exceed 10% for the entire watershed.

Number of structures visible from the lake: should not exceed present-day conditions (approximately 50 in summertime).

Key Actions:
- Promote and facilitate the voluntary establishment of conservation easements to permanently protect land that could otherwise be further divided and developed, keeping wild lands wild.
- Require thorough mapping of existing vegetation in the shoreland buffer zone prior to issuing building permits around the lake (inventory density and location of trees and shrubs, indicate areas of disturbance to ensure adherence to minimal standards).

- Map and enact protections on smaller wetland areas within the Whitefish Lake watershed; provide assistance to landowners in recognizing, protecting, and restoring smaller wetlands.
- Maintain the DNR properties on the lake as minimally developed natural recreation sites and support possible opportunities to expand the Crabb property to permanently protect the shoreline of Lake Deborah from development.
- Initiate a process for modernizing the Whitefish Beach subdivision plat (a collection of dozens of 25' x 50' parcels interspersed by town road right of way on the western side of the lake) to clarify any remaining development potential for the area and provide certainty and simplicity to existing property owners.
- Maintain active lines of communication between state, county and local governments and the local lake association to ensure that no surprises take place with respect to development and land use change. WILCO board executives names and addresses need to be maintained on mailing lists for local government meetings, including county zoning and board of adjustment.

Objective #3: Maintaining Biodiversity

Maintain the full suite of plants and animals found at Whitefish Lake.

Discussion: The biodiversity found within the lake contributes greatly to its ecological health. Rooted aquatic plants in the near-shore area sequester nutrients and help hold sediments in place that might otherwise end up at the lake's bottom. Aquatic invasive species pose a serious and ongoing threat to the health of the lake's plant and fish communities. Humans can also impair plant and animal population by excessively impacting the near-shore area. For example, piers create shaded zones that exclude plants, and riparian homeowners occasionally "clear" aquatic plants from their swimming and lake access points.

Indicators:
Absence of invasive non-native species: zero non-native species discovered in the lake during annual inspections.

Continuing presence of rare and threatened plants: Small purple bladderwort (Utricularia resupinata), water-thread pondweed (Potamogeton diversifolius) and redhead pondweed (Potamogeton perfoliatus) remain present in the lake.

Continuing presence of isoetid plant beds in their present locations: spatial extent of isoetids within 10% variation of extent mapped in 2005.

Continuing presence of a healthy cisco population: Cisco populations periodically re-measured and found within the range of densities expected of oligotrophic lakes.

Key Actions:

- Continued vigilance in preventing and detecting aquatic invasive species through boat landing inspections and in-lake surveillance. Develop partnerships and continue grant applications to support landing inspection staffing.
- Regular monitoring of fishery populations, including pelagic fishery.
- Monitor the presence and health of native plant communities on an annual basis; conduct annual inventories of sensitive areas and unique plant locations. Repeat the lake-wide aquatic plant survey on a regular basis (5-10 years) to better understand normal rates of change.
- Expand the official DNR Sensitive Areas designations to include additional important ecological areas identified in the 2005 aquatic plant study.
- Enforce DNR regulations that limit aquatic plant removal, temporary recreational structures and pier size.
- Educate people about the Sensitive Areas and precautions necessary to protect them (protecting nearby shoreland buffers, limiting recreational motorboating, minimizing disturbances); consider using buoys to mark and protect sensitive areas where boaters commonly traffic (i.e. the channel at the lake's narrows).
- Track the presence of aquatic invasive species in regional lakes and rivers and share this information with property owners and visitors to raise awareness of the ongoing threats such species pose.
- Locate and identify trees that naturally fall into the lake, track their ongoing presence and alert riparian owners of existing rules affecting woody material that falls into public lakes.

Objective #4: Awareness and knowledge

Maintain and increase the awareness and knowledge among all stakeholders and people who value Whitefish Lake's admirable qualities.

Discussion: The people who live around Whitefish Lake universally express interest and concern for the lake's future. Ongoing education and outreach efforts are required to foster a more complete understanding of how the lake maintains its admirable qualities and the nature of the threats it faces. Many groups exist to aid in this effort, but in Wisconsin it often falls on local lake associations to organize and convey knowledge to lake property owners.

Indicators:

WILCO membership: No less than half the property owners around the lake are dues paying members of WILCO; ideally, everyone would be an active member.

WILCO materials: The WILCO newsletter is produced and distributed to all watershed property owners at least twice annually; a WILCO webpage is maintained quarterly with information and updates around the lake.

Participation in WILCO events and programs (Swim and Paddle-a-Thon, Annual Meeting, Sailing Day, Sailing Regatta, Lake Cleanup Day, Shoreline Stewards): Greater involvement with each passing year, with growing interest in assisting with the planning and organization of annual events.

Evidence of proactive steps taken by property owners (new buffers installed or expanded): There should be a record of at least one buffer area being enhanced or expanded with each passing year.

Portion of lake households receiving UW Extension's Lake Tides publication: 100% of mailing addresses around the lake remain subscribed to Lake Tides

Key Actions:

- Organize a "WILCO" owners manual for continuing operation and growth of the organization; manual lists the annual calendar of events and associated tasks, as well as the role and expectations of board members and executives.
- Maintain the existing directory of property owners, noting the arrival of new owners when properties sell and adding them to the WILCO and UWEX Lake Tides mailing lists.
- Continue to organize and produce WILCO events and programs (newsletter and webpage, periodic email updates to members, events including Swim and Paddle-a-Thon, Annual Meeting, Sailing Day, Sailing Regatta, Lake Cleanup and Shoreline Stewards).
- Identify buffer restorations underway each year, highlighting property owners who are proactively working to protect the lake.
- Recognize and reward watershed residents who are protecting the lake in the WILCO newsletter and webpage.
- Develop an "ice angler's guide to Whitefish Lake" explaining the importance of preventing invasive species and diseases to protect the lake's unique pelagic fishery and distribute the guide to wintertime lake users.

Objective #5: A lake ethic

Instill a "lake ethic" at Whitefish Lake in which people treat the lake and their neighbors with the same level of respect and kindness that they themselves would like to be treated with.

Discussion: Beyond knowledge and awareness of the lake's ecosystems, long-term concern for the lake rests on a shared ethic that reduces the tendency to characterize the lake as "separate" from people and their activities. Aldo Leopold

argued over 60 years ago that humans are a part of nature, not apart from it. When we consider lakes and land to be members of our moral community, we are less likely to knowingly treat them in harmful ways.

Indicators:
Recreationists observance of the rules and regulations concerning boat use (slow-no-wake near shore, piers and swimming platforms): there should be zero violations of existing state and local laws regulating recreational boat use.

Property owners display voluntary simplicity with respect to riparian use and structures (minimal piers, respectful treatment of plants in and near the shore): Over time, the shoreline should appear more and more natural. There should be no piers that exceed the limits developed by the DNR. Temporary recreational structures (floating platforms) are not present in designated Sensitive Areas.

The lake is treated with respect that property owners expect from their neighbors: No trash is placed in the lake. Riparian property owners, their guests and the public do not launch fireworks over the lake or each other's property.

Key Actions:
- WILCO continues to organize events that celebrate local lake stewards and champions.
- Develop and distribute a "Visitors Guide to Whitefish Lake" that neatly summarizes the lake's unique ecology and the regulations and norms in place to protect it; provide this guide with visitors at the boat landing and property owners for sharing with visitors and guests.
- Facilitate the enforcement of existing rules and regulation through the Wisconsin DNR safety wardens and through the Town of Wascott. Explore means of enforcing town lake ordinances including no wake times and quiet hours.

A. Short-term Strategic Framework (1-5 years)

In the short-term, institutions concerned with Whitefish Lake need to continue much of what they have been doing and, in some cases, fortify existing practices. Outreach and education concerning Whitefish Lake's ecology are needed to broaden the level of understanding among lake stakeholders. Existing venues such as the WILCO newsletter, web-pages, annual meetings and other lake-related events should be used to remind people of the tremendous knowledge base developed through this planning effort.

Efforts to prevent and detect AIS infestations need to continue and perhaps expand; winter anglers should be included in inspection and outreach programs to ensure that they understand and follow bait rules. WILCO will be a critical institution in both the near and long-term and they may have more than enough on their plate carrying out the actions listed under objective #4 above. Where

possible, WILCO decision-makers should seek out and develop methods for sharing responsibilities with other institutions that are concerned with the lake. For example, the Town of Wascott may be willing to submit and manage a town-wide AIS prevention grant request to the DNR, encompassing not only WILCO's landing monitoring program but also proactive AIS work at neighboring lakes, many of which have too few property owners to create their own full fledged AIS effort.

Lake water quality monitoring needs to continue, as outlined under objective #1 above. WILCO, the Wisconsin DNR, and the USGS should anticipate revisiting USGS-developed water quality parameters by 2015. Several years' worth of oxygen depletion data should be available by that time, permitting lake scientists with additional insight into the lake's condition and developing eutrophication trends. Updated knowledge about the lake will need to be regularly shared with all lake stakeholders and used to support or modify the action items listed in this plan.

All Whitefish Lake stakeholders should take part in efforts to protect undeveloped land in the watershed from further subdivision and development. Already in 2009 there are several possibilities to increase public land holdings and promote voluntary conservation easements: land adjacent to the DNR's Crabb property is presently for-sale and the significant holdings of the Forbes family will likely be changing hands in the near future. The land east of the Crabb property encompasses most of Lake Deborah and would be a valuable addition to the existing public land base. It would also ensure that Lake Deborah remains a totally wild and undeveloped lake. The Forbes property is already developed, but the size of the property would allow greater future development in the absence of a conservation easement. There may also be an opportunity to modernize the Whitefish Beach subdivision as outlined under objective #2.

Some property owners in the watershed may be interested in programs that recognize and reward good lake stewardship. A "stewardship stripes" program could be developed and implemented to visually denote those properties where the owners have gone above and beyond the minimal standards for addressing habitat and water quality issues. Further recognition could be granted to landowners that permanently record their management practices in the form of a conservation agreement that is tied to their property. This would allow help ensure that existing examples of lake stewardship transcend the present-day property owners. Formulating the details of such a program will require additional consultation with lake stakeholders, and this effort could fit in as a "medium-term" strategy if the relevant institutions find that they are doing all they can to carry out the education, outreach, and monitoring tasks needed in the near-term.

B. Medium-term Strategic Framework (6-10 years)

With the passing of time and persistent effort to share the knowledge gained in the past five years, it should become increasingly evident to all in the watershed that

what they do on their land can and does impact the lake. Before 2020, there will likely be a need around the lake to revisit the 2001-2003 shoreland buffer assessment and restoration project. Following the protocol used in that program, WILCO would partner with the DNR and an outside consultant to inventory shoreland buffers and provide advice and cost-share assistance to owners looking to improve their stewardship practices. This should be expanded to address issues related to the amount of impervious surfaces on a property and any runoff management problems.

A repeated effort to assist in buffer restoration and good overall stewardship can also be used to promote voluntary programs such as easements and conservation agreements that make permanent some of the best management practices employed around the lake. In addition, WILCO and other institutions should be continuing many of the short-term strategies listed above (i.e. stakeholder education, lake quality monitoring, AIS prevention, etc.). Changes in available resources (people, time, money) could heavily influence the degree to which institutions can continue and expand present-day efforts. WILCO and others will need to reflect upon any changes and incorporate them regularly into this plan. By 2020, this plan should be fully updated to address such changes and incorporate interim achievements and setbacks.

C. Long-term Strategic Framework (10-100 years)

Planning and management are cyclical activities. In the most basic sense, the strategies outlined in the near and medium-term will need to be regularly revisited by Whitefish Lake stakeholders. Some programs will need to continue on their annual basis, while others may operate on significantly longer cycles. At a minimum, the entire planning framework for the lake should be thoroughly revisited every 10 years.

With determination and persistence on the part of all stakeholders, the most challenging aspects of protecting Whitefish Lake should be addressed between now and 2110. For example, by that time there should no longer be any septic systems still contributing phosphorus into the shallow groundwater that feeds into the lake. All deficient shoreland buffers should be fully restored. Most, if not all, the measurable objectives of this plan should be accomplished within 100 years, if not sooner.

Working backward from 2110, it should be somewhat evident that there needs to be some meaningful accomplishment at the lake in just about each of the next 100 years. These may be minor victories, like the expansion of one *good* shoreland buffer to an *excellent* one, or they could be innovative or revolutionary changes like the installation of septic systems that fully prevent phosphorus from entering the lake.

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