COMMUNITY ASSISTANCE
PLANNING REPORT NO. 324

A LAKE MANAGEMENT PLAN FOR LAKE DENOON

RACINE AND WAUKESHA COUNTIES, WISCONSIN

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

KENOSHA COUNTY
Steve Bostrom
Aloysius Nelson
Robert W. Pitts

RACINE COUNTY
Mike Dawson
James A. Ladwig
Peggy L. Shumway

MILWAUKEE COUNTY
Brian R. Dranzik
William R. Drew, *Treasurer*
Theodore Lipscomb, Sr.

WALWORTH COUNTY
Charles L. Colman, *Chairman*
Nancy Russell
Vacant

OZAUKEE COUNTY
Thomas H. Buestrin
Jennifer Rothstein
Gus W. Wirth, Jr., *Secretary*

WASHINGTON COUNTY
Jeffrey D. Schleif
Daniel S. Schmidt
David L. Stroik

WAUKESHA COUNTY
Michael A. Crowley, *Vice-Chairman*
José M. Delgado
James T. Dwyer

LAKE DENOON ADVANCEMENT ASSOCIATION

Gerry Klamrowski, *President*
Mike Corcoran, *Vice President/Secretary*
Kevin Kubacki, *Board of Directors, Muskego Alderman*

The Lake Denoon Advancement Association would also like to acknowledge the following individuals for their contributions to this plan: Heidi Bunk, Water Resources Management Specialist, Wisconsin Department of Natural Resources; Ben Heussner, Fisheries Biologist, Wisconsin Department of Natural Resources; Tom Zagar, Conservation Coordinator/City Forester, City of Muskego

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION STAFF

Michael G. Hahn, PE, PH .... Executive Director
Kevin J. Muhs .... Deputy Director
Stephen P. Adams .... Public Involvement and Outreach Manager
Christopher T. Hiebert, PE .... Chief Transportation Engineer
Laura L. Herrick, PE, CFM .... Chief Environmental Engineer
Elizabeth A. Larsen, SPHR, SHRM-SCP .... Assistant Director-Administration
Eric D. Lynde .... Chief Special Projects Planner
Benjamin R. McKay, AICP .... Chief Community Assistance Planner
Rob W. Merry, PLS .... Chief Surveyor
David A. Schilling .... Chief Land Use Planner
Dr. Thomas M. Slawski .... Chief Biologist

Special acknowledgment is due to Dale J. Buser PE, PH, Principal Specialist; Dr. Thomas Slawski, Chief Biologist; Beverly Saunders, former Senior Specialist; Zofia Noe, Specialist; Mike Borst, Research Analyst; Anna Cisar, Former Research Analyst; Laura Fields-Sommers, Former Research Analyst; Emma Weiss-Burns, Environmental Planning Technician, for their contribution to the preparation of this report.

COMMUNITY ASSISTANCE PLANNING REPORT
NUMBER 324

A LAKE MANAGEMENT PLAN FOR LAKE DENOON RACINE AND WAUKESHA COUNTIES, WISCONSIN

Prepared by the
Southeastern Wisconsin Regional Planning Commission
W239 N1812 Rockwood Drive
P.O. Box 1607
Waukesha, Wisconsin 53187-1607
www.sewrpc.org

The preparation of this publication was financed in part through a grant from the Wisconsin Department of Natural Resources Lake Planning Grant Program.

December 2017

(This page intentionally left blank)

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF MAPS

LIST OF TABLES

(This page intentionally left blank)

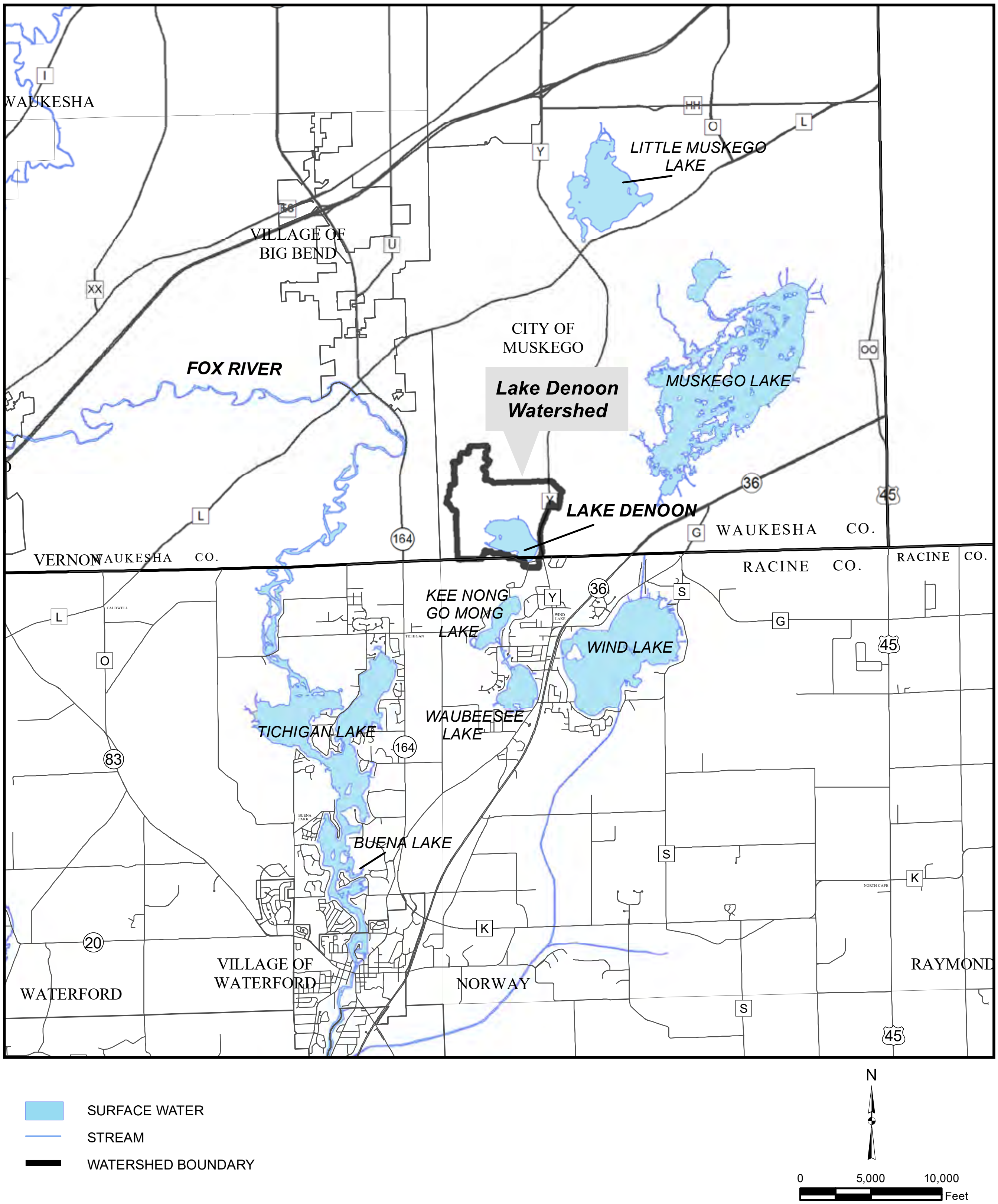
INTRODUCTION 1

Credit: SEWRPC Staff

1.1 PURPOSE OF PLAN

The health of a lake or stream is usually a direct reflection of the use and management of the land within its watershed. Research shows that intervention is often necessary to maintain or improve the conditions of these resources. Lake Denoon, together with its watershed and associated wetlands, is a highly valued natural resource located within U.S. Public Land Survey Sections 31 and 32, Township 5 North, Range 20 East, in the City of Muskego, Waukesha County, and Sections 5 and 6, Township 4 North, Range 20 East, in the Town of Norway, Racine County (see Map 1.1 and "Lake Denoon Characteristics and Assets" section below). The purpose of this plan is to provide a framework that helps stakeholders – the Lake Denoon Advancement Association (LDAA), the City of Muskego, the Town of Norway, members of the public, organizations, and agencies with an interest in the Lake and the natural resources of its watershed – maintain and enhance the quality and integrity of land and water resources within Lake Denoon and its watershed. The plan focuses on protecting existing high-quality resource elements from human impact and preventing future degradation. The plan provides practical recommendations that are appropriate and feasible ways to promote stakeholder goals. Actively following lake management measures can enhance and preserve Lake Denoon's native plant community and water quality while retaining and even enhancing opportunities for safe and enjoyable public and private recreation within the Lake's watershed.

Map 1.1
Location of the Lake Denoon Watershed



Source: SEWRPC

This plan complements other existing plans and reports,[1] programs, and ongoing management actions in the Lake Denoon watershed. It is important to note that the plan relies upon the continuing commitment of government agencies, municipalities, and citizens to diligent lake planning and natural resource protection. Additionally, the plan helps State agencies, local units of government, nongovernmental organizations, businesses, and citizens develop strategies benefiting the natural assets of Lake Denoon. By using the strategies outlined in this plan, the natural environment will be enriched and preserved.

This planning program was funded, in part, by the LDAA, and in part, through a Chapter NR 190 Lake Management Planning Grant awarded to the City of Muskego and administered by the Wisconsin Department of Natural Resources (WDNR). The inventory and aquatic plant management plan elements presented in this report conform to the requirements and standards set forth in the relevant *Wisconsin Administrative Codes*.[2]

1.2 LAKE DENOON CHARACTERISTICS AND ASSETS

Lake Denoon is a 162-acre lake with a maximum water depth of 55 feet (see Map 1.2 for the Lake's bathymetry). Although the Lake's watershed is small, three small, mapped tributaries flow into the Lake. A low dam controls the Lake's elevation under most conditions; however, the outlet stream does not flow during dry weather. The Wisconsin Department of Natural Resources (WDNR) classifies Lake Denoon as a deep seepage lake, meaning that the Lake has no continually flowing inlet and or outlet, only occasionally overflows, and likely stratifies in summer. As a seepage lake, the lake's primary source of water is precipitation and direct runoff from shoreland areas. Groundwater likely enters the Lake in some areas, and the Lake may supply recharge to groundwater in other areas. Table 1.1 further details the hydrologic and morphometric characteristics of the Lake. Chapter 2 provides more details on the importance of these characteristics.

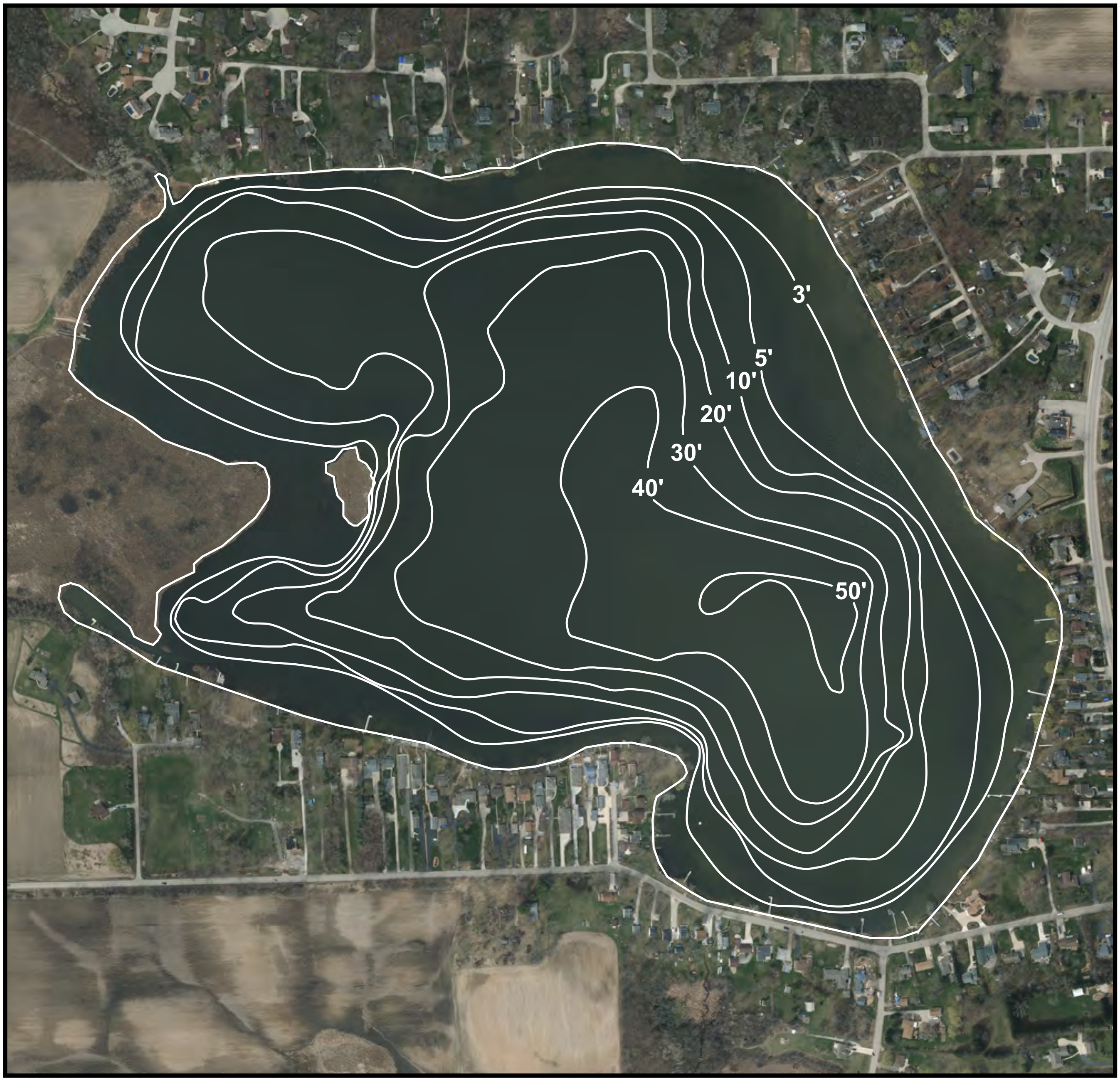
Lake Denoon and its watershed are home to a wide variety of highly valued assets. For example, Lake Denoon supports a variety of recreational opportunities as evidenced by the recreational survey completed by Southeastern Wisconsin Regional Planning Commission (SEWRPC) staff during summer 2013 (see Chapter 2 for more details). This survey shows that Lake users engage in full-body contact uses (such as swimming) as well as high- and low-speed boating and fishing. The Lake enjoys a reputation for good fishing, (especially for northern pike, largemouth bass, and panfish) and supports a wide variety of wildlife. Additionally, the Lake's watershed contains a variety of wetlands, uplands, and woodlands, all of which host unique plant communities. The Lake and its watershed support a variety of resident reptiles, amphibians, fish, mollusks, mammals, birds, insects, and other animal species. Additionally, the Lake and watershed host migratory species (e.g., some species of birds and insects) that inhabit portions of the watershed seasonally or that feed and rest in the area during migration. Some species of plants and animals are locally or regionally rare or uncommon.

---

[1] *Wisconsin Department of Natural Resources Lake Use Report Number FX-23,* Denoon Lake, Waukesha County, Wisconsin, *1969; Wisconsin Conservation Department,* Surface Water Resources of Waukesha County, *1963; SEWRPC Community Assistance Planning Report No. 202,* A Park and Open Space Plan for the City of Muskego, Waukesha County, Wisconsin*, 1992; SEWRPC Planning Report No. 30,* A Regional Water Quality Management Plan for Southeastern Wisconsin–2000, Volume Two, Alternative Plans*, February 1979, as refined by SEWRPC Memorandum Report No. 93,* A Regional Water Quality Management Plan for Southeastern Wisconsin: An Update and Status Report*, March 1995; see also, SEWRPC Community Assistance Planning Report No. 259, 2nd Edition,* A Land and Water Resource Management Plan for Racine County: 2008-2012*, October 2007, and* Waukesha County, Land and Water Resource Management Plan: 2006-2010*, January 2006; Earth Tech, Inc.,* City of Muskego Comprehensive Stormwater Management Plan, Phase 2*, July 1999; SEWRPC Planning Report No. 48,* A Regional Land Use Plan for Southeastern Wisconsin: 2035*, June 2006; see also, SEWRPC Community Assistance Planning Report No. 301*, A Multi-Jurisdictional Comprehensive Plan for Racine County: 2035*, November 2009; and, SEWRPC Community Assistance Planning Report No. 209,* A Development Plan for Waukesha County, Wisconsin*, August 1996, as amended; U.S. Geological Survey Open-File Report No. 2004-1087,* Water-Quality and Lake-Stage Data for Wisconsin Lakes, Water Year 2003*, 2004; U.S. Geological Survey Open-File Report No. 2005-1147,* Water-Quality and Lake-Stage Data for Wisconsin Lakes, Water Year 2004*, 2005.*

[2] *This plan has been prepared pursuant to the standards and requirements set forth in the following chapters of the* Wisconsin Administrative Code*: Chapter NR 1, "Public Access Policy for Waterways;" Chapter NR 40, "Invasive Species Identification, Classification and Control;" Chapter NR 103, "Water Quality Standards for Wetlands;" Chapter NR 107, "Aquatic Plant Management;" and Chapter NR 109, "Aquatic Plants Introduction, Manual Removal and Mechanical Control Regulations."*

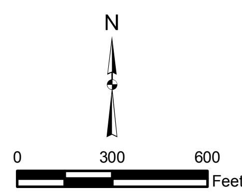
Map 1.2
Bathymetric Map of Lake Denoon



DATE OF PHOTOGRAPHY: APRIL 2015

—20'— WATER DEPTH CONTOUR IN FEET

Source: Wisconsin Department of Natural Resources and SEWRPC



1.3 LAKE PROTECTION PROGRAMS AND GOALS

General lake protection goals and objectives were developed to help maintain and enhance Lake Denoon's many assets. The LDAA and public were consulted to provide input and feedback as an integral part of the planning process. The resultant goals and objectives are listed below:

1. Update existing condition descriptions in the Lake Denoon watershed. This includes identifying and quantifying potential point and nonpoint sources of pollution, nutrient and contaminant inputs, and nutrient and contaminant balances.

2. Identify the extent of existing and potential future water quality problems likely to be experienced in the Lake. This includes assessing the Lake's water quality using physical-chemical monitoring data collected as part of ongoing water quality monitoring programs and estimating future changes.

3. Assess the degree and intensity of recreational water use in and around Lake Denoon.

4. Evaluate the impact of aquatic plants on Lake use and habitat.

5. Formulate appropriate management objectives and actions, public information and education strategies, ordinances, and other possible responses to the identified problems.

Accomplishing these goals will form the basis of a comprehensive lake management plan for the Lake and its watershed consistent with the objectives of Chapter NR 190, *Wisconsin Administrative Code*. The plan is part of an ongoing program of Lake-related management actions being undertaken by the LDAA and the City of Muskego. Implementing the actions recommended herein should serve as an important step toward achieving long-term Lake use/protection objectives.

Table 1.1
Hydrology and Morphometry of Lake Denoon

Parameter	Measurement
Size	
Surface Area of Lake	162 acres
Total Tributary Area[a]	776 acres
Lake Volume	2,940 acre-feet
Residence Time[b]	3.1-4.2 years (avg. 3.6 years)
Shape	
Length of Lake	0.7 mile
Width of Lake	0.4 mile
Length of Shoreline	2.7 miles
Shoreline Development Factor[c]	1.5
General Lake Orientation	NW-SE
Depth	
Maximum Depth	55 feet
Mean Depth	18 feet

[a] *Total tributary area represents land contributing runoff to the lake and specifically excludes the lake surface.*

[b] *Residence time is the average time needed to replace a lake's entire water volume during years of normal precipitation.*

[c] *Shoreline development factor is the ratio of the shoreline length to the circumference of a circular lake of the same area.*

Source: U.S. Geological Survey, Wisconsin Department of Natural Resources, and SEWRPC.

ISSUES AND CONCERNS 2

Credit: SEWRPC Staff

2.1 INTRODUCTION

Despite being a valuable resource, as discussed in Chapter 1 of this report, Lake Denoon is subject to a number of existing and potential future problems and issues of concern. To better define and understand these issues, and to provide for the continued recreational use of the Lake, the Lake Denoon Advancement Association (LDAA) executed an agreement with the Southeastern Wisconsin Regional Planning Commission (SEWRPC) to investigate the causes of community concerns and to develop a comprehensive lake management plan to address those concerns. Table 2.1 lists those issues of concern identified through consultation with the LDAA. This chapter summarizes each issue of concern and presents information relevant to understanding the recommendations provided in Chapter 3 of this report.

Table 2.1
Issues of Concern

	Issues and Concerns
1	Water Quality
2	Water Quantity
3	Aquatic Plant Growth
4	Blue-Green Algae
5	Shoreline Maintenance
6	Recreational Use and Facilities
7	Fish and Wildlife
8	Plan implementation

Source: SEWRPC

2.2 ISSUE 1: WATER QUALITY

Actual and perceived water quality conditions continue to be important issues for the Lake Denoon community. Lake residents have expressed concern that specific pollutants could be entering the Lake from various sources and could be decreasing water quality over time. These sources include phosphorus loading from fertilizer and pesticide runoff from shoreline properties, and fertilizer runoff from agricultural properties within the watershed. Additionally, the concerns about algal blooms (discussed more fully in a subsequent section), reinforces the importance of water quality as an issue of concern given that water quality (more specifically phosphorus levels) greatly influence the tendency of algal blooms to occur throughout the growing season.

As part of the discussion regarding Lake Denoon's water quality, it is important to define what *water quality* means since individuals have varying perceptions and levels of understanding. Water quality is often discussed in terms of visual cues. Algal blooms or cloudy water, for example, can lead an observer to conclude that water in a lake is "unclean". However, to actually *quantify* water quality, lake managers and residents need to collect data and study specific chemical, physical, and biological parameters that influence, or that are indicators of, water quality.

The most commonly used metrics for assessing water quality include: water clarity, water temperature and the concentrations of chloride, phosphorus, chlorophyll-*a*, and dissolved oxygen (see Table 2.2 for further information regarding these parameters). These parameters interact with one another in a variety of ways. For example, nutrients from eroded topsoil and common fertilizers can cause a lake's phosphorus concentrations to increase, its clarity to decrease (due to algal growth in the water column), and chlorophyll-*a* (a measure of algae content) to increase. In addition to water clarity, phosphorus, chlorophyll-*a*, and dissolved oxygen values, a number of other parameters can also help determine the "general health" of a lake. For example, the abundance of the bacteria *Escherichia coli*, commonly known as *E-coli*, is commonly measured to determine if water is safe for swimming, while chloride concentrations are an indicator of overall human-induced pollution entering a lake.[3] To develop a water quality maintenance and improvement program, <u>key water-quality indices must be regularly measured over extended periods of time</u>.[4] This allows lake managers to establish baselines and identify trends.

Lake Denoon's water quality has been monitored for many years, with water quality data records going back to 1966. Major sources of data include the U.S. Geological Survey,[5] and, since 1995, a citizen lake monitor under the auspices of the University of Wisconsin-Extension (UWEX) Citizen Lake Monitoring Network (CLMN). CLMN was formerly known as the Wisconsin Department of Natural Resources (WDNR) Self-Help Monitoring Program. The primary water quality sampling location is situated at the deepest portion of Lake Denoon, as shown on Map 2.1. As part of this lake protection plan, Commission staff reviewed and tabulated all available water quality data.

To develop a water quality maintenance and improvement program, several factors need to be investigated and considered. The basic factors include:

1. **The past and current water quality of the Lake as well as the general characteristics of the Lake itself**—To determine what water quality management efforts are needed to achieve goal, it is important to quantify current conditions, contrast past values, and estimate historical and future water quality. To do this, concentrations of the critical chemical parameters (i.e., phosphorus, water clarity, chlorophyll-*a*, dissolved oxygen), temperature, and potentially other factors, are measured and compared to determine if the water quality has been changing over time, and how the lake changes seasonally. Water quality values from various depths are also contrasted to evaluate in-lake distribution, circulation, and processes. Values that suggest deteriorating conditions can help identify pollutants and issues that should be targeted for management. This information, in combination with general characteristics of the lake (e.g., depth, shape, circulation patterns) can help provide context for understanding water quality data, will help determine the extent of water quality problems, as well as the viable method for water quality management.

2. **A lake's watershed characteristics, including land use and pollutant loadings**—The type and amount of pollutants entering a lake greatly depend on the ways surrounding land (i.e., its watershed) are used. Different land uses produce different kinds of pollutants (Figure 2.1). For example, agricultural land can be a significant contributor of sediment (from soil eroded from cultivated areas and subsequently delivered to lakes by streams) and nutrients (from fertilizers and topsoil washed off fields). For example, tillage can loosen soils promoting erosion while tiles and ditches may hasten runoff and reduce the ability of sediment and nutrients to be captured before they enter

---

[3] *Chloride is used as an indicator of human-induced pollution, because it is usually only present in low concentrations under natural conditions in the Southeastern Wisconsin. Chloride is a "conservative pollutant" meaning that it remains in the environment once released and is not attenuated by natural processes other than dilution. High chloride concentrations may result from road salt or fertilizer application and private onsite wastewater treatment systems that discharge to groundwater, which provides baseflow for streams and lakes.*

[4] *Throughout this report, the use of underlining denotes items having management implications.*

[5] *U.S. Geological Survey Open-File Report No. 2004-1087,* Water-Quality and Lake-Stage Data for Wisconsin Lakes, Water Year 2003*, 2004; U.S. Geological Survey Open-File Report No. 2005-1147,* Water-Quality and Lake-Stage Data for Wisconsin Lakes, Water Year 2004*, 2005.*

Table 2.2
Water Quality Parameter Descriptions, Typical Values, and Regulatory Limits/Guidelines

Parameter	Description	Southeastern Wisconsin Values[a] Median	Southeastern Wisconsin Values[a] Range	Regulatory Limit or Guideline	Lake Denoon Values Median	Lake Denoon Values Range
Chloride (mg/L)	Low concentrations (e.g. < 5 mg/L) naturally occur in lakes due to natural weathering of bedrock and soils. Human activities increase concentrations (e.g., road salts, wastewater, water softener regeneration) and can effect certain plants and animals. Chloride remains in solution once in the environment and **can serve as an excellent indicator of other pollutants.**	16	1-57	Acute toxicity [b,c] 757 Chronic toxicity [b,d] 395	66.5[e]	12.3-66.5
Chlorophyll-*a* (µg/L)	The major photosynthetic "green" pigment in algae. The amount of chlorophyll-*a* present in the water is an indicator of the biomass, or amount of algae, in the water. **Chlorophyll-*a* levels above 10 µg/L generally result in a green coloration of the water** that may be severe enough to impair recreational activities such as swimming or waterskiing and are commonly associated with eutrophic lake conditions	9.9	1.8-706.1	2.6[f]	6.0	2.8-23.3
Dissolved Oxygen (mg/L)	Dissolved oxygen levels are one of the most critical factors affecting the living organisms of a lake ecosystem. Generally, dissolved oxygen levels are higher at the surface of a lake, where there is an interchange between the water and atmosphere, stirring by wind action, and production of oxygen by plant photosynthesis. Dissolved oxygen levels are usually lowest near the bottom of a lake where decomposer organisms and chemical oxidation processes deplete oxygen during the decay process. **A concentration of 5.0 mg/L is considered the minimum level below which many oxygen-consuming organisms, such as fish, become stressed**, while many species of fish are unlikely to survive when dissolved oxygen concentrations drop below 2.0 mg/L.	--	--	≥5.0[f]	--[g]	0-16.3[h]
Growing Season Epilimnetic Total Phosphorus (µg/L)	Phosphorus enters a lake from natural and human-derived sources and is a fundamental building block for plant growth. Excessive phosphorus can lead to nuisance levels of plant growth, unsightly algal blooms, decreased water clarity, and oxygen depletion, all of which can stress or kill fish and other aquatic life**. A concentration of less than 20 µg/L is the concentration considered necessary in a seepage lake such as Lake Denoon** to limit algal and aquatic plant growth to levels consistent with recreational water use objectives. Phosphorus concentration exceeding 30 µg/L are considered to be indicative of eutrophic lake conditions	30	8-720	20[f]	18	5-41
Water Clarity (feet)	Measured with a Secchi disk (a ballasted black-and-white, eight-inch-diameter plate) which is lowered into the water until a depth is reached at which the disk is no longer visible. It can be affected by physical factors, such as suspended particles or water color, and by various biologic factors, including seasonal variations in planktonic algal populations living in a lake. **Measurements less than 5 feet are considered indicative of poor water clarity and eutrophic lake conditions**	4.6	3-12	10.9[i]	7.0	3.4 -16.0
Water Temperature (°F)	Temperature increases above seasonal ranges are dangerous to fish and other aquatic life. Higher temperatures depress dissolved oxygen concentrations. They also serve as an indicator of increases in other pollutants.	--	--	Ambient[f] 35-77 Sub-lethal[f] 49-80 Acute[f] 77-87	48.6	32-85

[a] *Wisconsin Department of Natural Resources Technical Bulletin No. 138,* Limnological Characteristics of Wisconsin Lakes, *Richard A. Lillie and John W. Mason,* 1983.

[b] *Wisconsin Administration Code Chapter NR 105, Surface Water Quality Criteria and Secondary Values for Toxic Substances. July, 2010.*

Table continued on next page.

Table 2.2 (Continued)

[c] *The acute toxicity criterion is the maximum daily concentration of a substance which ensures adequate protection of sensitive species of aquatic life from the acute toxicity of that substance and will adequately protect the designated fish and aquatic life use of the surface water if not exceeded more than once every three years.*

[d] *The chronic toxicity criterion is the maximum four-day concentration of a substance which ensures adequate protection of sensitive species of aquatic life from the chronic toxicity of that substance and will adequately protect the designated fish and aquatic life use of the surface water if not exceeded more than once every three years.*

[e] *This median value is based on year 2014 observations.*

[f] *Wisconsin Administrative Code Chapter NR 102, Water Quality Standards for Wisconsin Surface Waters, November 2010.*

[g] *Oxygen concentrations and temperatures vary with water depth and season. Median values provide little insight to understand lake conditions.*

[h] *Concentration above the upper saturation limit of oxygen in water. Supersaturation is also injurious to fish and other aquatic life.*

[i] *U.S. Environmental Protection Agency,* Ambient Water Quality Criteria Recommendations: Information Supporting the Development of State and Tribal Nutrient Criteria: Lakes and Reservoirs in Nutrient Ecoregion VII, *EPA 822-B-00-009, December 2000.*

Source: Wisconsin Department of Natural Resource, Wisconsin State Legislature, U.S. Environmental Protection Agency, and SEWRPC

waterways. Conversely, conservation tillage, cover crops, and pastured lands can reduce erosion and nutrient delivery. Similarly, urban land uses (e.g., residential, industrial, commercial development) can contribute significant amounts of heavy metals, petroleum products, toxic organic compounds, nutrients, and other substances. For example, oil leaked onto pavement, aromatic compounds in paving materials and sealers, and fertilizers applied to lawns may be transported to a lake by stormwater runoff. The potential for runoff and pollutant transport is influenced by the permeability, degree of cover, and slope (see Map 2.2) of soils. The amount of pollutant actually reaching water bodies may be higher if slopes are steep and ground is bare, paved, or relatively impermeable. Given this connection, it is important to understand past, present and planned future land use within the watershed. Based on these land use conditions, models can estimate the amount of pollution likely entering a lake. This can help identify portions of the watershed that are more likely contributing to water quality deterioration and can therefore help focus pollution reduction strategies and efforts.

3. **The filtering ability of a lake's watershed and shorelines**— A variety of natural or nature-like features can help filter polluted runoff. Features such as wetlands and vegetative buffers,[6] can significantly decrease the amount of pollution entering a lake. Pollutants can either by absorbed and utilized (in the case of nutrients) and/or trapped (such as sediment).

Each of these three factors is discussed in more detail below.

General Lake Characteristics

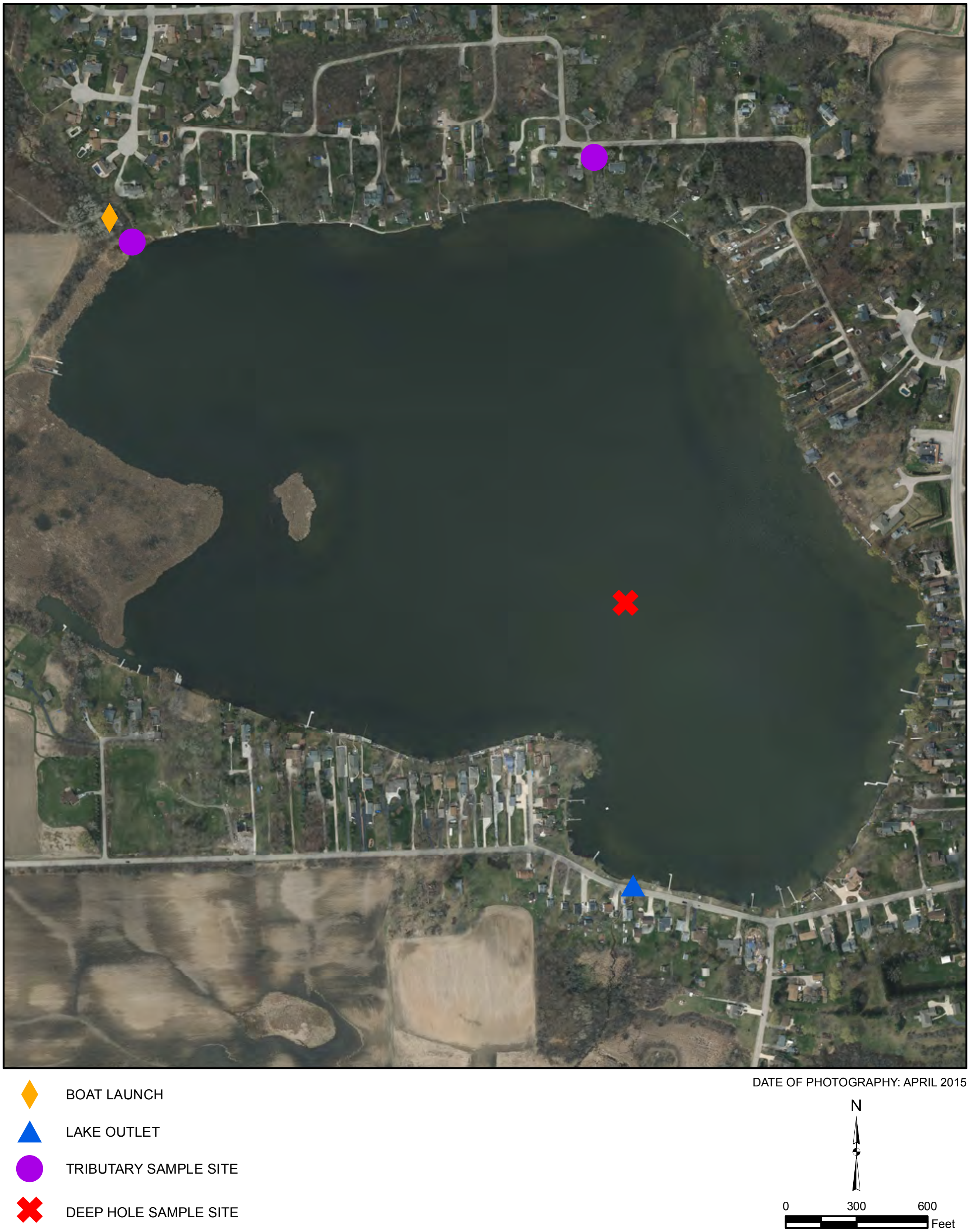
Water quality fluctuates over short- and long-term time periods. Therefore, thorough evaluation of lake water quality relies on periodically monitoring various chemical and physical properties (ideally over protracted time periods). In general, monitoring data is used to determine the level and nature of pollution within a lake, the risks associated with that pollution, the lake's ability to support various fish and recreational uses, as well as the overall health of the lake. When evaluating water quality, it is important to document certain lake characteristics that provide context for evaluation. These lake characteristics include:

1. **A lake's residence time**—Hydraulic residence time refers to the average length of time needed for the lake's natural water sources to completely replace the lake's entire water volume.[7] Residence time helps determine how quickly pollution problems can be resolved. For example, if retention times are short, pollutants are flushed out of the lake fairly quickly. In such cases, management efforts can likely focus on pollutant and nutrient loads contributed to the lake from the watershed.

[6] *Vegetative buffers (e.g., forests, grassed waterways, and manmade vegetative strips) and wetlands have the natural ability to slow runoff. This encourages pollutants to be trapped, stored, and/or consumed before they enter the adjacent lake.*

[7] *The term "flushing rate" is also commonly used to describe the amount of time runoff takes to replace one lake volume. Flushing rate is the mathematic reciprocal of hydraulic residence time. Therefore, while retention time is expressed in years and has units of time, flushing rate is typically expressed as the number of times lake water is completely replaced by runoff in one year, and is therefore a rate (units/time).*

Map 2.1
Location of the Deep Hole Sampling Site, Tributary Sampling Sites, Boat Launch, and Lake Outlet, Lake Denoon



Source: SEWRPC

In contrast, lakes with long retention times tend to accumulate nutrients and pollutants which can eventually become concentrated in bottom sediment. In this case, in addition to preventing external pollution, it is also may be necessary to employ in-lake water quality management efforts.

2. **Whether the lake stratifies and, if it does, when the lake mixes**—Stratification refers to a condition when the temperature difference (and associated density difference) between a lake's surface waters (the *epilimnion*) and the deep waters (the *hypolimnion*) is great enough to form thermal layers that can impede mixing of gases and pollutants between the two layers (see Figure 2.2). If a lake stratifies, oxygen-rich surface waters in contact with the atmosphere do not freely mix with water in deeper portions of the lake. Therefore, the deeper hypolimnetic water cannot exchange gases with the atmosphere. Metabolic processes continue to consume oxygen in the hypolimnion. If oxygen demands are high (such as in an enriched lake), or if the volume of deep isolated hypolimnetic water is small (limiting oxygen storage potential), deep portions of a lake can become extremely low or even completely devoid of oxygen (anoxic) for a period of time. While some lakes remain permanently stratified, stratification in most Wisconsin lakes breaks down at least twice per year (once in spring and once in fall) in response to changing seasons and ambient weather conditions.

   A lake must be relatively deep to stratify. In general, lakes in southeastern Wisconsin less than 15 feet deep are unlikely to stratify, whereas lakes with depths greater than 20 feet are likely to stratify. A lake's propensity to stratify is heavily influenced by the lake's shape, size, and orientation, landscape position, surrounding vegetation, through flow, water sources, and a host of other factors. Depth to the *thermocline* (the transition layer between the epilimnion and hypolimnion, sometimes also called the *metalimnion*) can range from less than 10 feet to well over 20 feet in typical southeastern Wisconsin lakes.

   Most stratifying lakes in the Region become stratified sometime during mid- to late-spring, with a short (usually less than a week) period of whole-lake water circulation and

Figure 2.1
Illustrations of Land Use Affecting Waterbodies

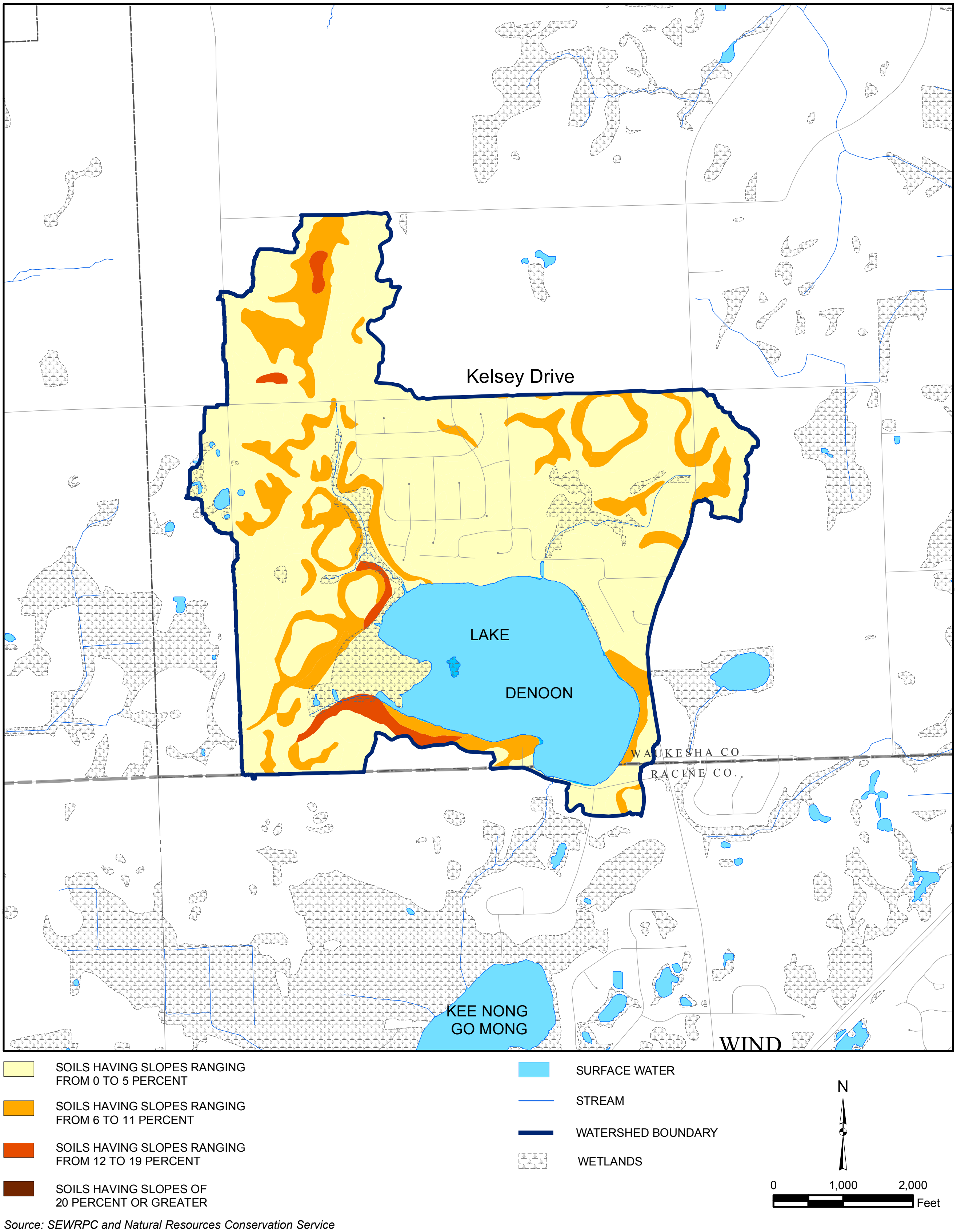
NATURAL STREAM ECOSYSTEM

AGRICULTURAL STREAM ECOSYSTEM

URBAN STREAM ECOSYSTEM

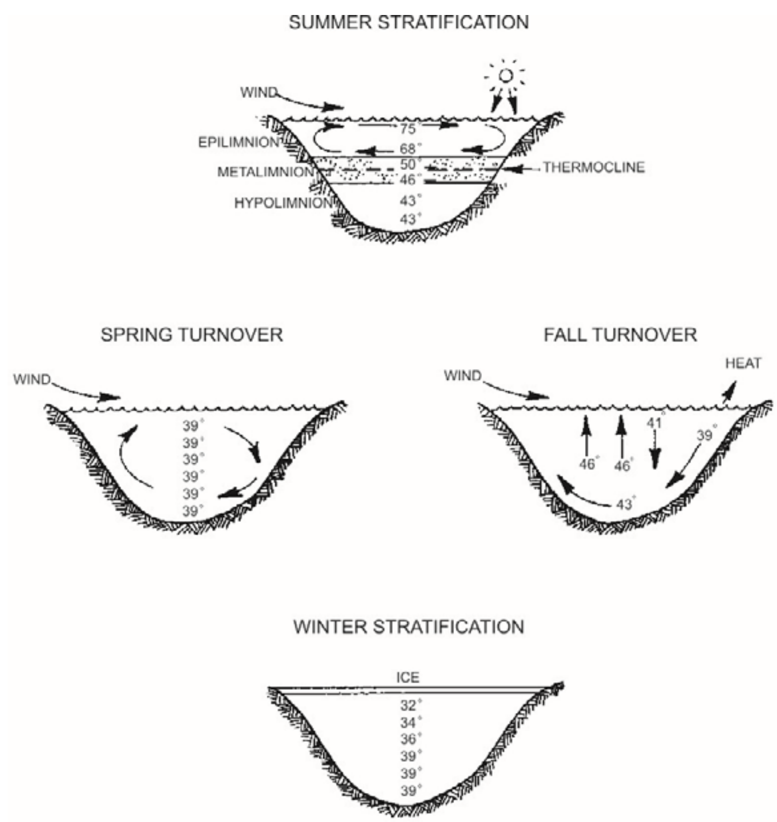
Source: Illustration by Frank Ippolito, www.productionpost.com. *Modified from D.M. Carlisle and others.* The quality of our Nation's waters—Ecological health in the Nation's streams, 1993-2005: U.S. Geological Survey Circular 1391, *120 p.,* pubs.usgs.gov/circ/1391/, *2013, and SEWRPC*

Map 2.2
Slopes Within the Lake Denoon Watershed



Source: SEWRPC and Natural Resources Conservation Service mixing (turnover) that takes place once during spring and once again in the fall (Figure 2.2). At turnover, the lake's temperature is uniform from the surface to the bottom. Lakes that stratify and turn over in the spring and fall are termed "dimictic." Mixing can also occur in response to windy conditions in some lakes. Lakes can also stratify in winter when warmer, warmer, denser water is found in the deeper portions of the lake. It is important to determine if stratification and turnovers occur because nutrients, low-oxygen water, and in some cases pollutants and sediment that have accumulated in the isolated bottom waters can suddenly mix into the entire water column during the turnover period, causing water quality and plant management problems. For example, abundant nutrients from deep portions of a lake can mix into near-surface water which in turn can fuel nuisance-level algae and plant growth.

Figure 2.2
Thermal Stratification of Lakes



Source: University of Wisconsin-Extension and SEWRPC

3. **Whether internal loading is occurring**—*Internal loading* refers to release of phosphorus stored in a lake's bottom sediment under certain water quality conditions associated with stratification. Phosphorus is typically not particularly soluble and often adheres to particles that settle to the lake bottom. When organic detritus and sediment settle to the lake bottom, decomposer bacteria break down organic substances, a process that consumes oxygen. If lake-bottom waters become devoid of oxygen, the activity of certain decomposer bacteria, together with certain geochemical reactions that occur only in the absence of oxygen, can allow phosphorus from plant remains and lake-bottom sediment to dissolve into the water column. This allows phosphorus that is otherwise trapped in deep lake-bottom sediment to be released into lake water. This liberated phosphorus can mix into the water column during the next turnover period fueling plant and algae growth. In most lakes, phosphorus is the nutrient controlling overall plant and algal growth, so additional phosphorus loading can lead to increased plant and algal growth. If this is occurring, a water quality management plan may focus on in-lake phosphorus management efforts in addition to preventing polluted runoff from entering the lake.

4. **The lake's current and past trophic statuses**—Lakes are commonly classified according to their degree of nutrient enrichment, or trophic status. The ability of lakes to support a variety of recreational activities and healthy fish and other aquatic life communities is often correlated with the lake's degree of nutrient enrichment. Three terms are generally used to describe the trophic status of a lake: oligotrophic (nutrient poor), mesotrophic (moderately fertile), and eutrophic (nutrient rich) (see Figure 2.3). Each of these states can happen naturally. Lakes tend to naturally shift to a more nutrient-rich state, a progression sometimes referred to as "aging" (see Figure 2.4). However, if a lake rapidly shifts to a more eutrophic state, human-induced pollution may be responsible for this change. An indicator of severe human pollution is when a lake displays "hyper-eutrophic" nutrient levels, a condition indicating highly enriched water (see Figure 2.5). Hyper-eutrophic conditions do not

commonly occur under natural conditions, and are nearly always related to human pollutant sources.

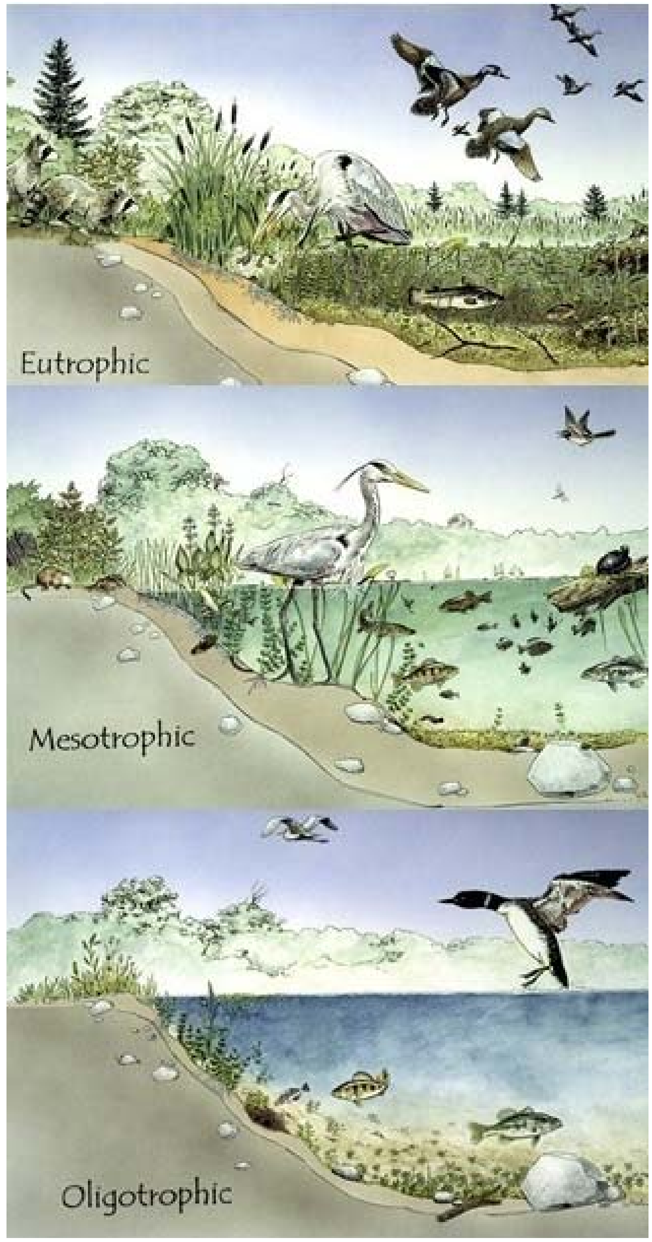
5. **Lake tributary area/type**—Lakes with large tributary streams commonly receive larger sediment and nutrient loads than lakes that are fed primarily by precipitation or groundwater. The type of land use in the watershed greatly effects the pollutant loads carried by tributary streams. Lakes that are fed primarily by tributary streams are labeled drainage lakes.

Lake Type, Water Sources, Outflow, and Hydraulic Residence Time

Lake Denoon is classified as a seepage lake, the most common type of lake found in Wisconsin. Seepage lakes are fed primarily by groundwater, precipitation that falls directly upon the lake's surface and surface runoff from the surrounding watershed. Seepage lakes may or may not have an outlet, but, if an outlet exists, it often does not flow year round. Since seepage lakes depend almost solely upon precipitation and groundwater for their water supply, water elevations in these lakes may fluctuate in response to dry and wet weather more than other lake types. The relatively limited volume of surface water entering seepage lakes typically translates to longer hydraulic residence times.

No large and/or perennial streams enter Lake Denoon. However, two small intermittent tributary streams are mapped, entering the Lake from the northwest and northeast. Another small stream is occasionally mapped entering the Lake from the southwest, through an extensive wetland (Map 2.3). Other, smaller ephemeral tributary streams likely remain unmapped.

Figure 2.3
Illustrations of Trophic States



Source: DH Environmental Consulting, 1995

According to available records, the Lake's present outlet is an artificial ditch dug shortly after settlement. The ditch was reportedly dug to lower Lake Denoon's water elevation to benefit nearby agricultural uses. As recreational use of the Lake increased, lake residents expressed concern over the Lake's water level, and residents constructed an earth and rock dam across the outlet in 1904. Conflict arose regarding higher water levels and an order was issued in 1919 to build a dam across the ditch to maintain the water level in the Lake at a set level. The order noted that the proposed dam elevation was higher than the dry weather water level in the Lake, so some fluctuation of water level was to be expected.[8] A sill was poured in 1949 and was used in conjunction with a single stop log to control the Lake elevation.[9] According to WDNR records, the Lake's water elevation is presently controlled by a small dam located in Racine County on the extreme south end of the Lake upstream of

[8] *Opinions and Decisions of the Railroad Commission, State of Wisconsin, Volume XXIII, May 8 1919 to October 29, 1919,* Application of Harry G. Oakland et.al. for an order fixing maximum and minimum levels of Lake Denoon in Racine and Waukesha Counties*, 1921.*

[9] *Wisconsin Department of Natural Resources Lake Use Report Number FX-23,* Denoon Lake, Waukesha County*, 1969.*

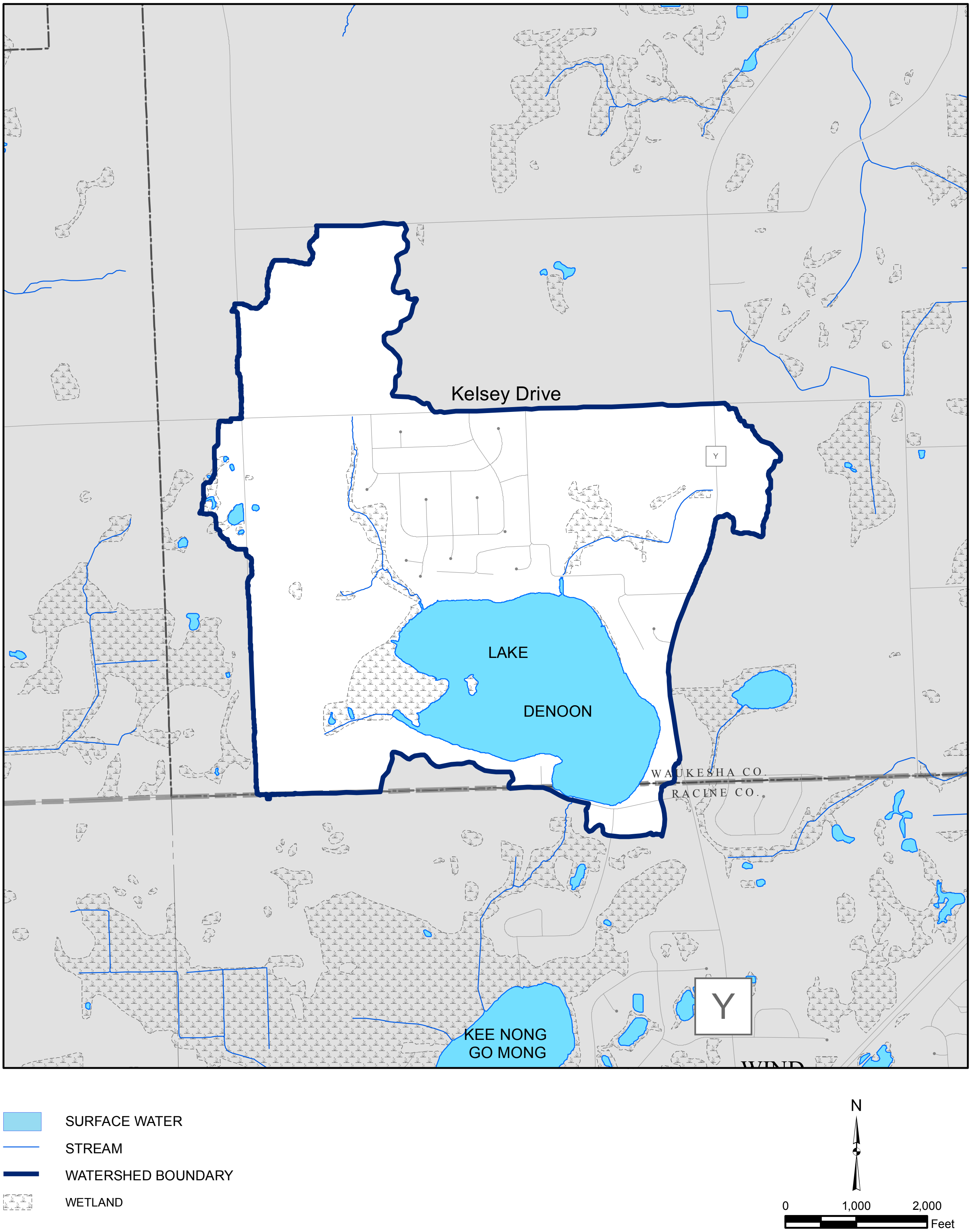
Figure 2.4
Illustrations of Aging Affecting Trophic States

Source: Wisconsin Department of Natural Resources

Figure 2.5
Photograph of a Hyper-Eutrophic Pond

Source: SEWRPC

Map 2.3
Lake Denoon Watershed



Source: SEWRPC

Figure 2.6
Lake Outlet

Facing southwest, north of Denoon Road, Lake in foreground (February 2016)

Facing southwest, south of Denoon Road (February 2016)

Facing northeast, north of Denoon Road, Lake in background, note concrete sill (August 2012)

Facing northeast, north of Denoon Road, Lake in background (August 2007)

Source: City of Muskego, Google Maps, and SEWRPC

Denoon Road that raises water elevations approximately one foot.[10] The spillway is reportedly 30 feet wide. The spillway discharges to an unnamed stream draining to a wetland complex tributary to Long Lake. Long Lake drains to streams that feed the Wind Lake Canal, a fifth order stream discharging to the Fox River just south of Waterford. All referenced documents with information on the Dam may be found in Appendix A.

The actual configuration of the Lake outlet does not correspond with the description on file with the WDNR. As of February 2016, no dam or other lake level control infrastructure were visible upstream of Denoon Road (Figure 2.6). Photographs taken during low water conditions reveal the presence of a low concrete sill near the upstream end of the lake outlet channel. During high water periods, available photographs suggest that the road culvert and possibly portions of the Lake outlet channel immediately upstream and downstream of Denoon Road may be affected by backwater from downstream. The backwatered condition suggests that a point downstream of Denoon Road may control the Lake elevation during higher water periods.

According to City of Muskego staff, the Lake outlet typically flows for about three-quarters of the year, and goes dry during late summer. Nevertheless, water elevations have reportedly been observed rise to

[10] *Information regarding the outlet dam is found on the WDNR's dam information database: dnr.wi.gov/topic/dams/damsearch.html.*

problematic levels during periods of heavy runoff.[11] The culvert under Denoon Road or some unidentified downstream channel condition may not have sufficient capacity to pass flow during periods of heavy runoff. In such a case, the road embankment and culvert or some downstream point may effectively act as a dam and could influence the elevation and extent of floodlands around the entire shoreline of Lake Denoon. Since floodlands are a factor used to judge public and property risks, it is important that they are accurately portrayed and regulated, and careful inspection of the outlet works is recommended in Chapter 3.

Hydraulic Residence Time

Hydraulic residence time (commonly shortened to "residence time) is the number of years required for natural water sources under typical weather conditions to fill the lake one time. Natural water sources include runoff from surrounding areas, precipitation falling directly upon a lake, water entering from tributary streams, and water contributed to a lake by groundwater. It gives a theoretical estimate of the amount of time needed for a lake to refill. Lower hydraulic residence times relate to faster flushing rates. Turnover is the reciprocal of residence time and expresses the number of times a lake's total volume is exchanged per year. Lakes that have high residence times have low turnover rates. For example, a lake with a residence time of 0.5 years has a turnover rate of 2.0, while a lake with a residence time of 5 years has a turnover rate of 0.2.

Based upon typical watershed yield within the Fox River basin, the long-term hydraulic retention time for Lake Denoon ranges from 2.2 to 10 years, averaging 3.6 years. This means that on average, the Lake's entire water volume is replaced by new inflow in about 3.6 years. During periods of heavy precipitation, the instantaneous hydraulic retention time may be much lower, while during drought, the instantaneous hydraulic retention time may be much higher. The average hydraulic retention time for other stratified seepage lakes in Wisconsin is 2.63 years, which means that Lake Denoon has a slower than average flushing rate. The mean watershed to lake surface area ratio for other Wisconsin stratified seepage lakes is nine acres of watershed for each acre of lake surface area. Lakes with similar hydraulic retention times typically have five acres of watershed for each acre of lake surface area, a value similar to Lake Denoon's 4.8 acres of watershed for each acre of water surface.[12] Lake Denoon is deeper than many Wisconsin lakes, a condition that likely contributes to its lower than average flushing rate.

Under natural conditions, lakes with slower flushing rates tend to have lower phosphorus concentrations and better water quality. However, these lakes are more susceptible to pollution accumulation due to the slower flushing rates, making the prevention of external pollutant inflow a consideration of great importance. Most Wisconsin lakes in the slowest (greater than 2 year) hydraulic retention time category have total phosphorus concentrations averaging 0.025 mg/L (25 μg/L),[13] a concentration generally similar to values determined for near surface waters of Lake Denoon.

Water Clarity

Secchi depth, a measure of water clarity or transparency, is often used as an easy to measure and understand water quality indicator. Water transparency can be affected by physical factors such as water color and suspended particles and by various biological factors, including seasonal variations in planktonic algal populations living in the water column. Secchi depth is often greatest during winter months, indicating high water clarity, and lowest during summer months, when biological activity is highest and water clarity is lowest. Secchi depths have been collected at the "deep hole," or deepest area of the Lake. Measurements have been taken at the deep hole since 1991.

As shown in Figure 2.7, average summer Secchi disk measurements were fairly stable with measurements generally in the poor to fair ranges during the period 1991 through 2008. But, starting in 2009, measurements have shown improvement with clarity generally in the fair to good range. It should be noted, however, that the 2014 and 2015 measurements of are based on only a single measurement in those years. Overall, water clarity seems to have remained relatively consistent. This should not be taken as proof of stable Lake conditions and/or lack of a need to pay attention to water quality. Precipitation and runoff patterns vary

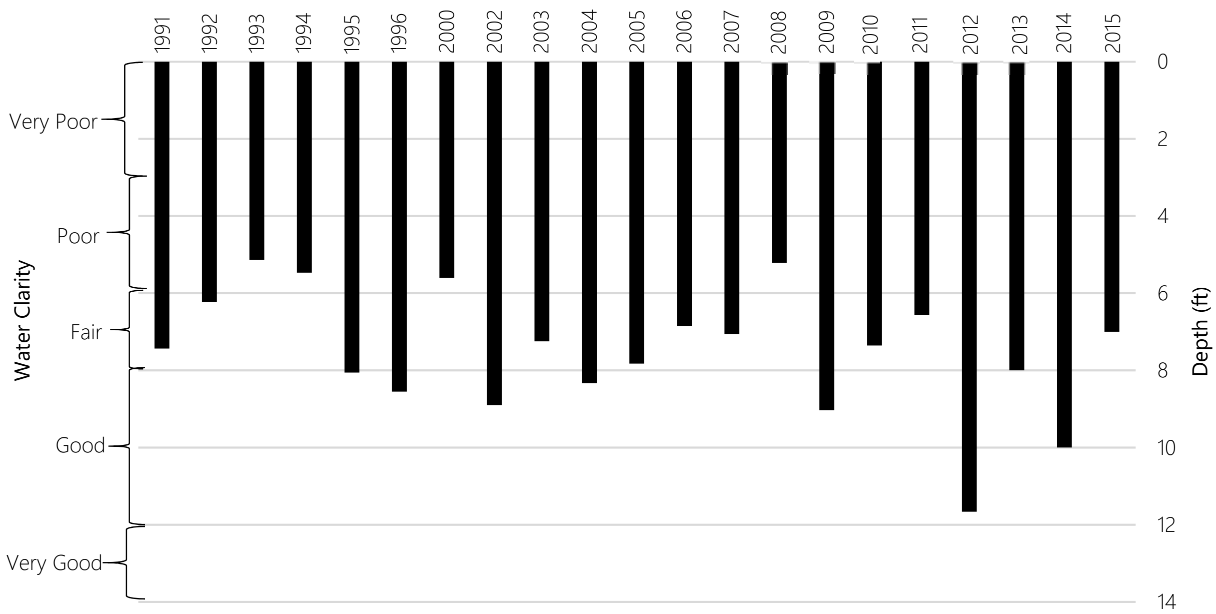
---

[11] *Tom Zagar, Conservation Coordinator/Forester, City of Muskego,* Telephone conversation with Dale Buser, SEWRPC, *January 28, 2016.*

[12] *Wisconsin Department of Natural Resources Technical Bulletin Number 138, op. cit.*

[13] *Ibid.*

Figure 2.7
Average Summer Secchi Disk Measurements for Lake Denoon: 1991-2015



Note: The years 2000, 2002, 2003, 2014, and 2015 are single measurements.

Source: U.S. Geological Survey, City of Muskego, and SEWRPC

each year and can influence water quality. Additionally, the WDNR verified the presence of zebra mussels in Lake Denoon during 2008. Zebra mussels remove particulate matter from the water column and have the tendency to improve water clarity. Although the presence of zebra mussels was confirmed in 2008, they may have been present significantly earlier.

The WDNR has recently began publishing satellite-based water clarity information, a surrogate for Secchi depth measurements. The WDNR website suggests that the most recent satellite-based water clarity values are between 4 and 8 feet, a range of values consistent with Secchi-depth water clarity measured of the past 10 years. Two years of satellite-based water clarity information are now available: 2014 and 2015 (Figure 2.8).

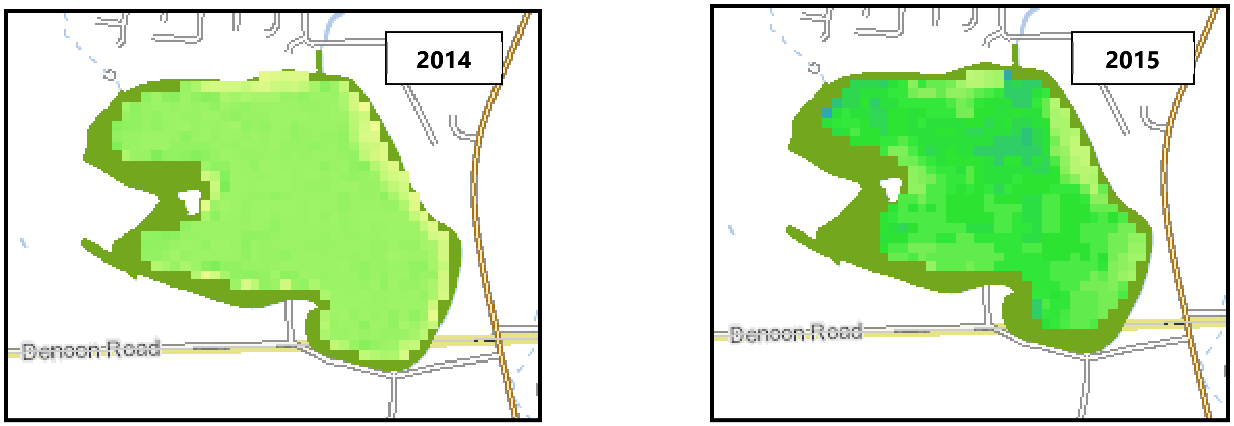
Secchi depth measurements contrast water clarity at a single location in the Lake whereas satellite-derived clarity maps provide clarity information throughout the Lake, allowing differences in water clarity within the Lake on the same day to be studied. The 2014 image suggests that water in Lake Denoon was somewhat clearer in the western near-shore portion of the Lake at that time. The 2015 satellite image shows that the clearest water was found in the same areas as 2014 and also in the main lake basin, especially in the northeastern area. The reason for water clarity differences would require careful consideration of weather, runoff, and other factors, but do provide evidence of considerable variability. Based upon available satellite imagery, Secchi depth readings collected by the City of Muskego generally appear to be measured in a clearer portion of the Lake at the deep hole. Therefore, nearshore water clarity may be noticeably lower than the values recorded at the deep hole site.

Trophic Status

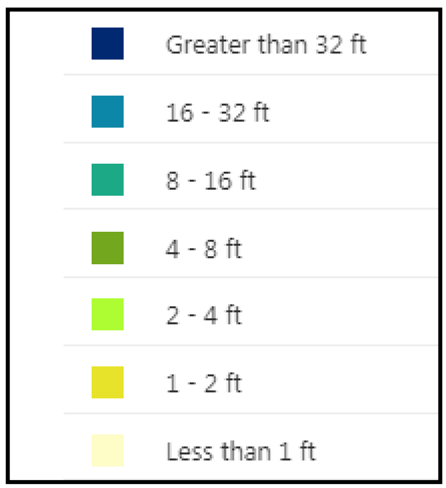
Based on measurements of total phosphorus, chlorophyll-*a*, and water clarity, Lake Denoon appears to be a meso-eutrophic lake with an average TSI over the past five years of 52 (Figure 2.9) which, for a deep seepage lake, is considered transitional between “good” and “fair” lake condition.[14]

[14] *Wisconsin Department of Natural Resources,* Wisconsin 2014 Consolidated Assessment and Listing Methodology (WisCALM), Clean Water Act Section 305(b), 314, and 303(d) Integrated Reporting*, September 2013.*

Figure 2.8
WDNR Satellite-Derived Images of Water Clarity for Lake Denoon: 2013-2015



Average Lake Clarity by Depth:



Source: Wisconsin Department of Natural Resources and SEWRPC

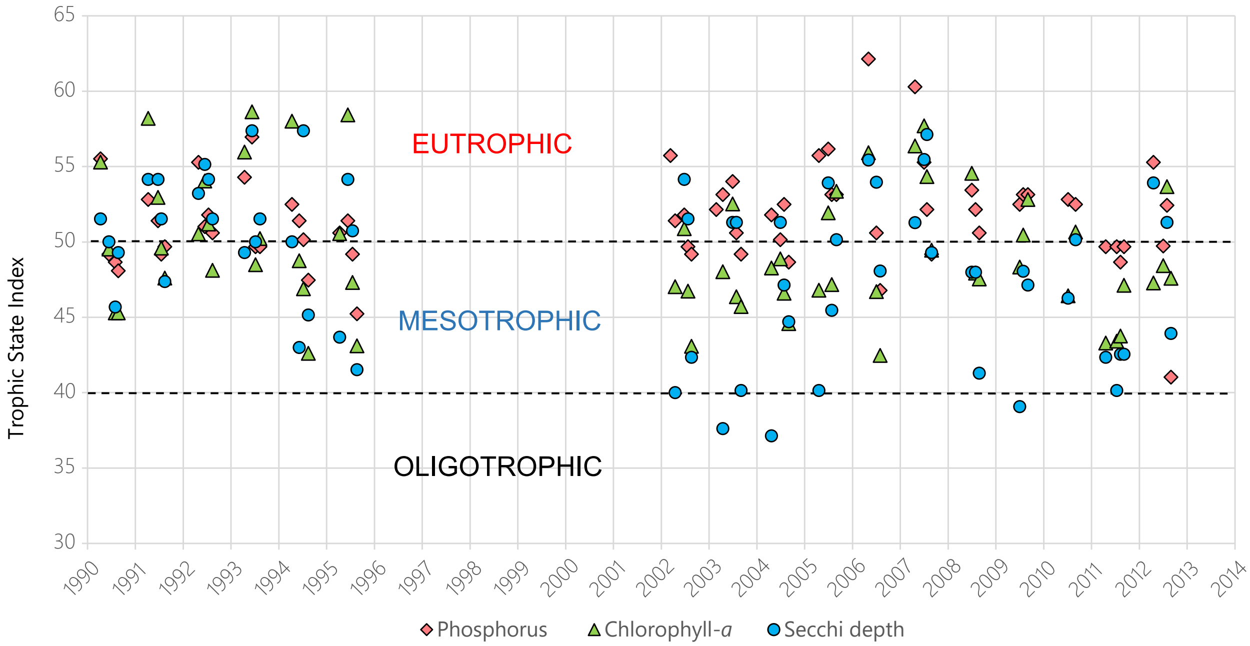
Nutrients

The amount of the nutrient phosphorus limits algal growth in most Wisconsin lakes. However, in some lakes, the amount of nitrogen limits algal growth. Awareness of which nutrient is constraining algal growth can be important when making management decisions. In general, when the ratio of total nitrogen (N) to total phosphorus (P) is 15:1 or greater, available phosphorus limits algal growth. Conversely, when this proportion is less than 10:1, nitrogen concentrations limit plant growth. Ratios between 15:1 and 10:1 are considered transitional.[15] Available data reveal that Lake Denoon is phosphorus limited (Table 2.3). During spring turnover, N/P ratios typically average in the high thirties, and range from as low as 17:1 to as high as 54:1. N/P ratios differ seasonally and by the depth from which samples are drawn while the Lake is stratified.

Because Lake Denoon is phosphorus limited, small additions in lake water phosphorus concentrations can significantly increase algal growth. Increased algal abundance decreases water clarity and increases measured chlorophyll-*a* concentrations. Therefore, all other factors remaining unchanged, increased phosphorus concentrations in Lake Denoon likely translates to more eutrophic conditions. Overall, since 1991, spring nitrogen concentrations in Lake Denoon appear to be decreasing (Figure 2.10) while phosphorus concentrations appear to be slowly rising, with a major shift in the relative proportions of these two substances occurring between 2004 and 2006. Although the data is rather limited, spring

[15] *Wisconsin Department of Natural Resources Technical Bulletin Number 138,* Limnological Characteristics of Wisconsin Lakes, *1983.*

Figure 2.9
Trophic Status Index Measurements for Lake Denoon: 1991-2015



Source: U.S. Geological Survey, City of Muskego, and SEWRPC

turnover N:P ratios (see Figure 2.11) suggest that <u>the Lake may progressively be less phosphorus limited over time, and that the potential for algal blooms may increase</u>.

Table 2.3
Spring N:P Ratios for Lake Denoon: 1991-2014

Date	Total Nitrogen (as N, mg/l)	Total Phosphorus (as P, mg/l)	N:P Ratio
4/23/2014	0.72	0.036	20.1 : 1
4/22/2008	1.05	0.063	16.7 : 1
4/19/2006	0.99	0.035	28.3 : 1
4/20/2005	0.78	0.021	37.1 : 1
4/14/2004	0.99	0.025	36.8 : 1
4/15/2003	0.88	0.020	44.0 : 1
4/10/1996	0.97	0.018	53.9 : 1
4/11/1995	1.10	0.023	47.8 : 1
4/13/1994	1.10	0.029	37.9 : 1
4/27/1993	1.20	0.033	36.4 : 1
4/8/1992	1.30	0.024	54.2 : 1
4/9/1991	1.20	0.034	35.3 : 1

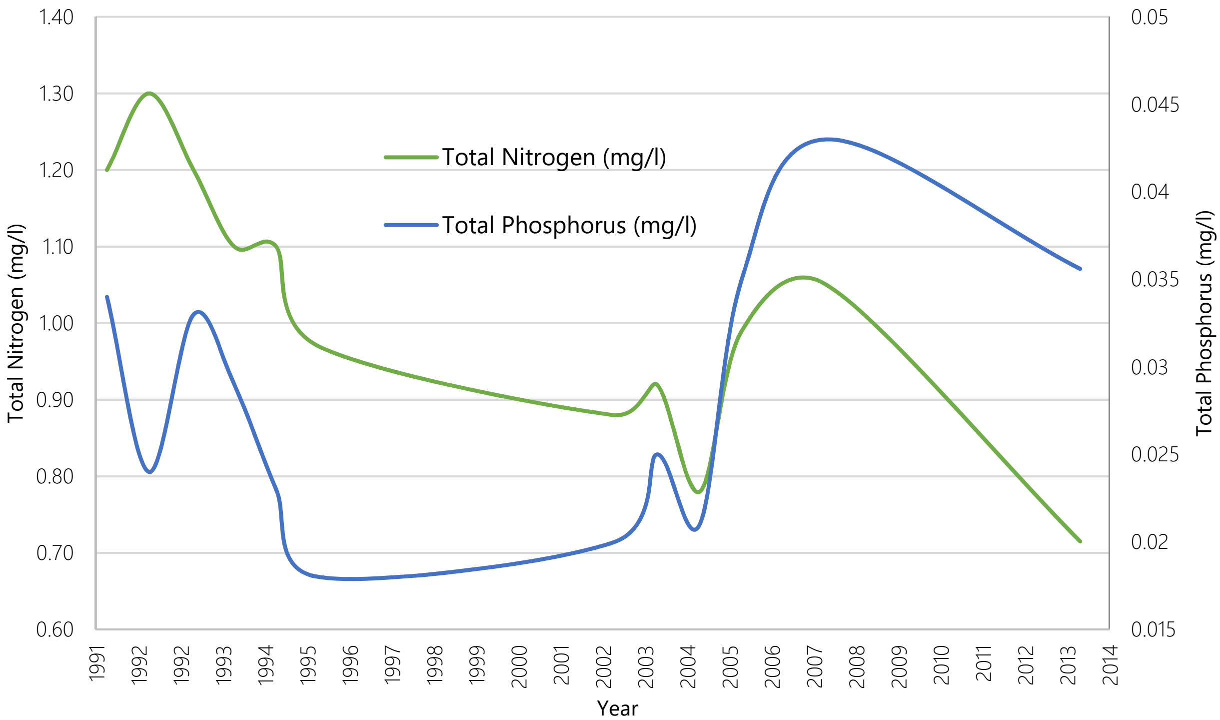
Source: US Geological Survey, Wisconsin Department of Natural Resources, City of Muskego, and SEWRPC

Temperature, Dissolved Oxygen, and Stratification

When a lake is stratified, near-surface water is considerably warmer, supports abundant algae, and contains abundant oxygen. The thermocline is generally found somewhere between 10 and 20 feet below the surface, with the depth varying lake-to-lake, month-to-month, and year-to-year. Water within the thermocline rapidly cools with depth and contains less oxygen than the epilimnion. Below the thermocline, water in the hypolimnion is much colder than water at the lake's surface and may not mix with the epilimnion until fall. Little sunlight penetrates past the thermocline; therefore, the deeper portions of the lake do not host significant photosynthetic activity and hence do not receive oxygen from plants. However, oxygen continues to be consumed by decomposition and other processes in the deeper portions of the lake. As a result, oxygen concentrations in the hypolimnion decline after the lake stratifies and cannot be replenished until the lake fully mixes during its fall turnover.

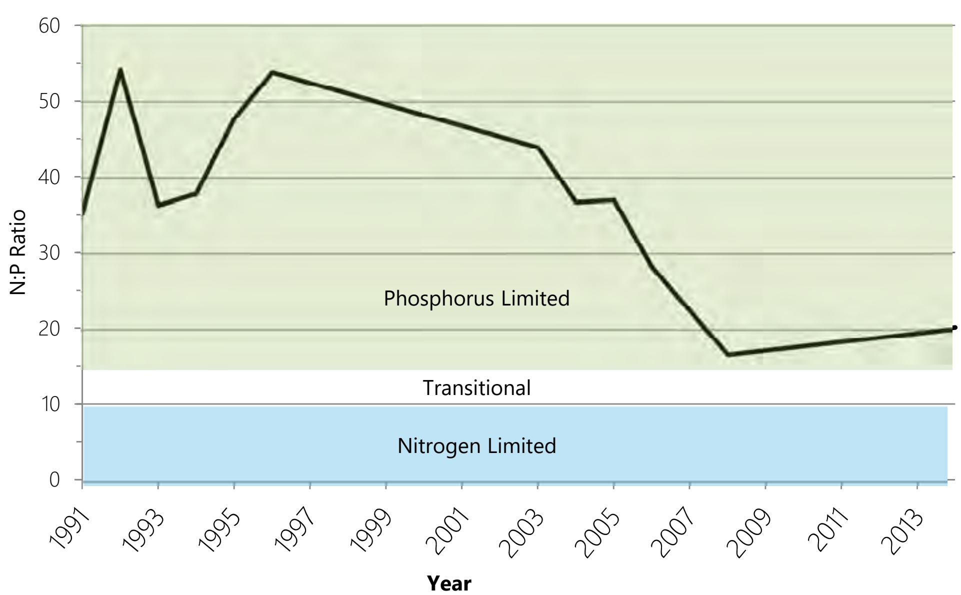
Temperature and oxygen concentration profiles (Figures 2.12 and 2.13) suggest that Lake Denoon stratifies every year and remains stratified throughout the summer. The Lake stratifies remarkably early, as soon as April during some years. The depth to the thermocline varies month-to-month and year-by-year, however, it commonly is found somewhere between 12 and 24 feet of the Lake's surface. Lake Denoon also appears to occasionally weakly stratify in winter under the ice.

Figure 2.10
Spring (Fully Mixed) Nitrogen and Phosphorus Trends, Lake Denoon: 1991-2013



Source: City of Muskego and SEWRPC

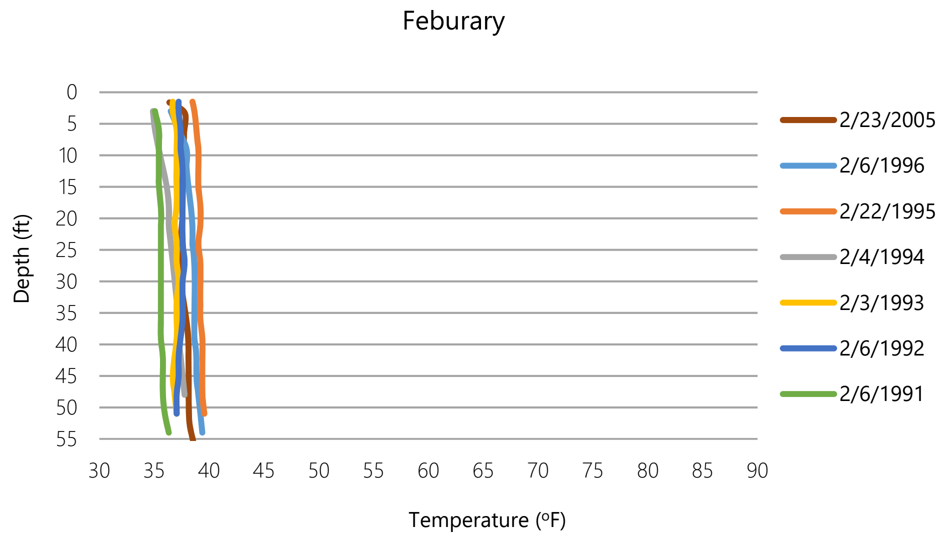
Figure 2.11
Spring (Fully Mixed) Nitrogen to Phosphorus Ratios, Lake Denoon: 1991-2014

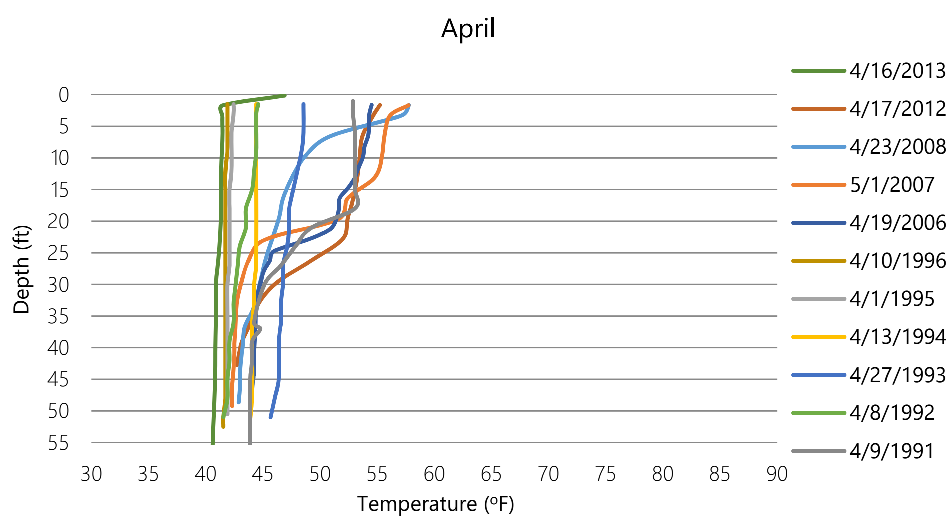


Note: Nitrogen to Phosphorus ratios of 15:1 and greater indicate phosphorus as the limiting nutrient; when N:P ratios are 10:1 or lower, nitrogen is the limiting factor. N:P ratios between 15:1 and 10:1 indicate a transitional stage.

Source: City of Muskego and SEWRPC.

Figure 2.12
Month-by-Month Temperature Profile, Lake Denoon





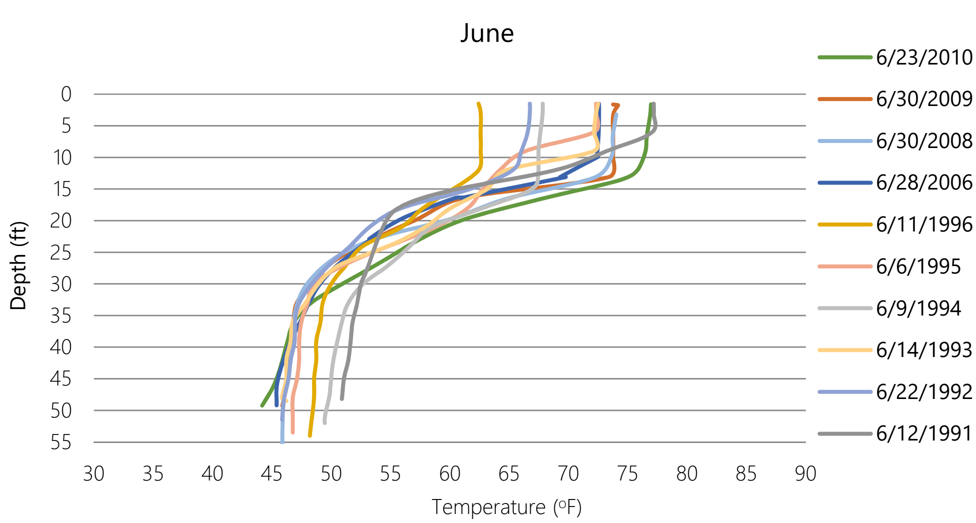
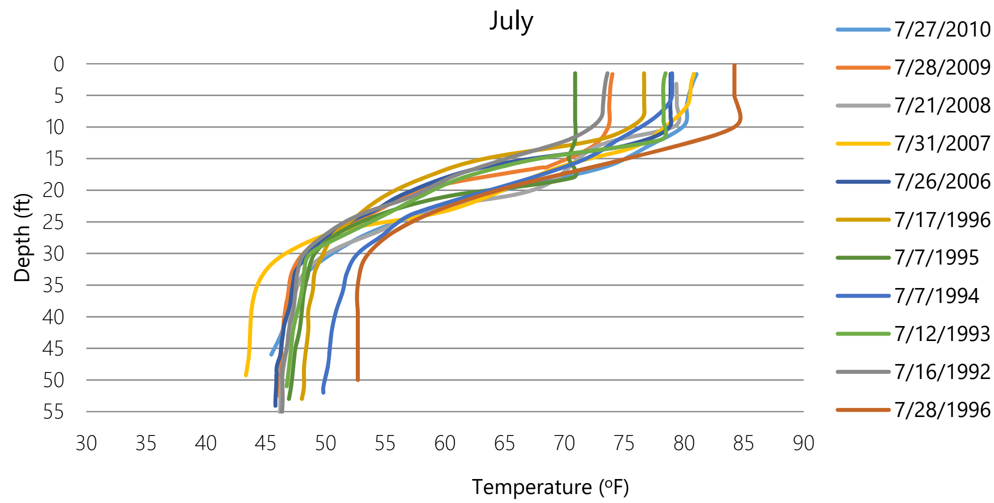
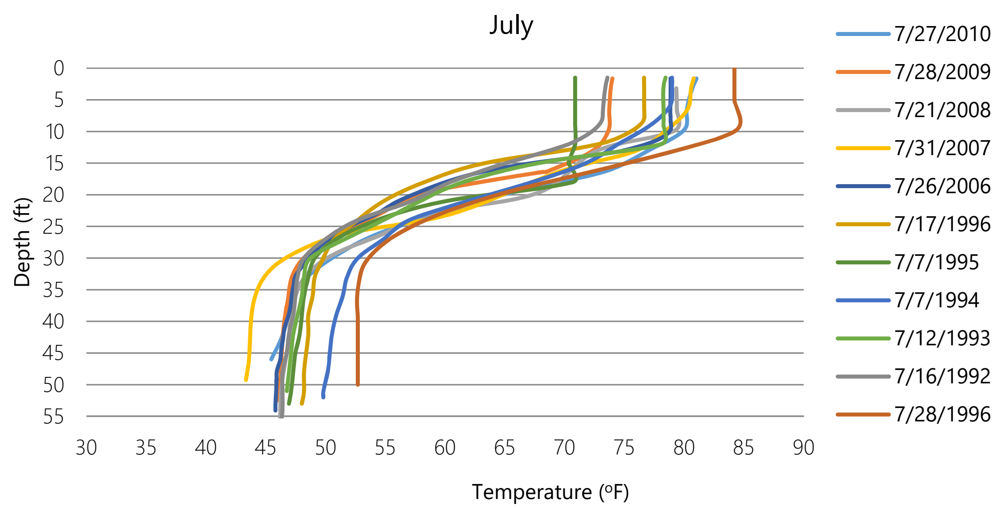


Figure 2.12 (Continued)





Source: City of Muskego and SEWRPC

Based upon the available oxygen profiles, Lake Denoon is usually fully mixed in early spring, with oxygen concentrations capable of supporting aquatic life present at essentially all depths. Interestingly, uncharacteristically low dissolved oxygen concentrations were recorded during a single year (2013), a year that experienced a very cold and long winter. During April 2013, water temperatures were the coldest on record, and only the upper few feet of the Lake contained concentrations of oxygen above the 5.0 mg/L standard set by the WDNR to support warmwater aquatic life.[16] This may be related to a longer than typical ice cover and more severe than typical oxygen depletion under the ice. Severe winter oxygen depletion can cause under-the-ice fill kills. Winter fish kills are not known to be a regularly reoccurring or major problem in Lake Denoon.

During summer, water in Lake Denoon's hypolimnion contains little to no oxygen. Approximately half of Wisconsin lakes containing similar phosphorus concentrations develop anoxia in their hypolimnia during the summer.[17] By early to mid-June, just after the Lake stratifies, the waters below 20 feet contain less than

[16] Wisconsin Administrative Code *Chapter NR 102,* "Water Quality Standards for Wisconsin Surface Waters," *November 2010.*

[17] *Wisconsin Department of Natural Resources Technical Bulletin Number 138, op. cit.*

Figure 2.13
Month-by-Month Dissolved Oxygen Concenteration Profiles, Lake Denoon

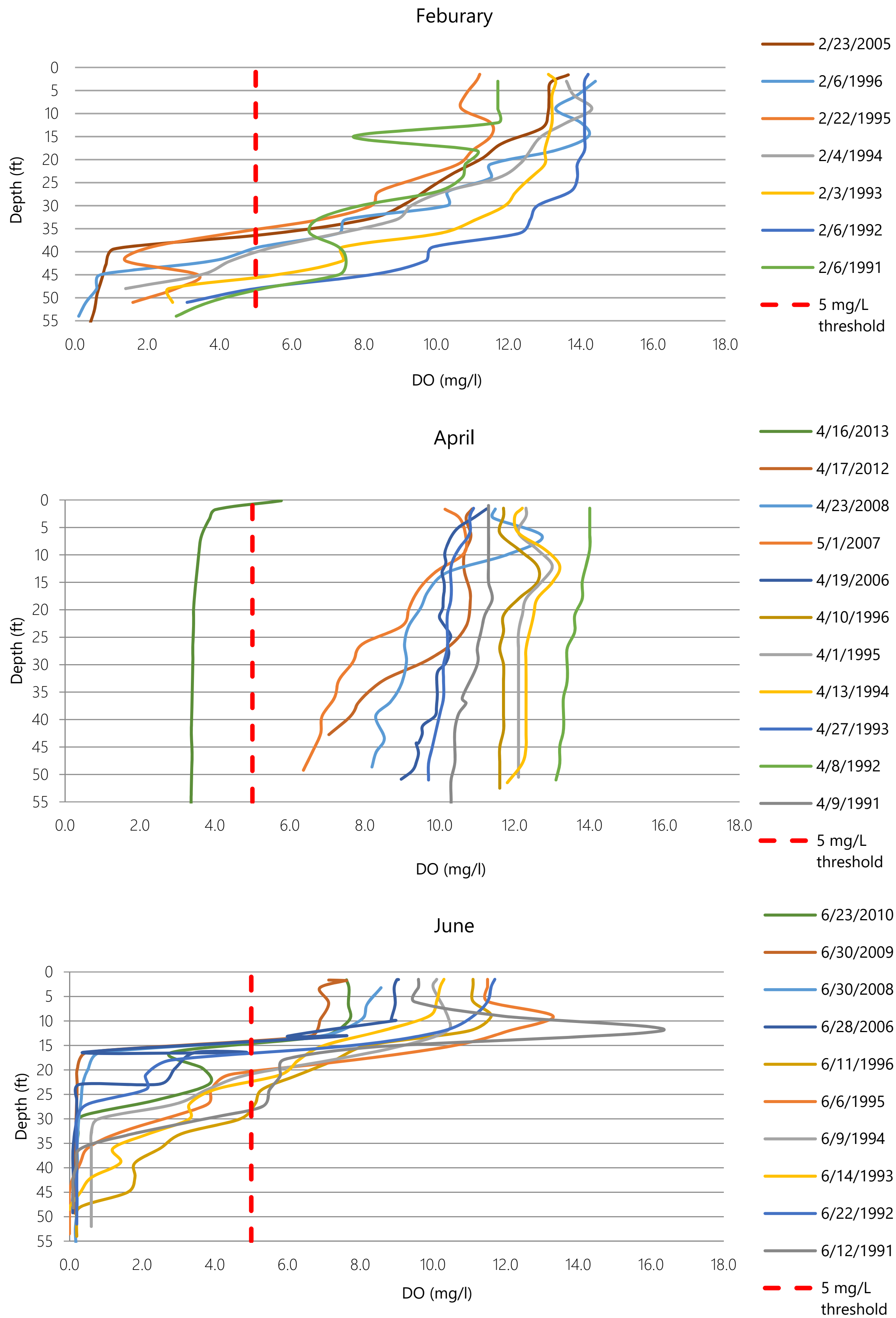
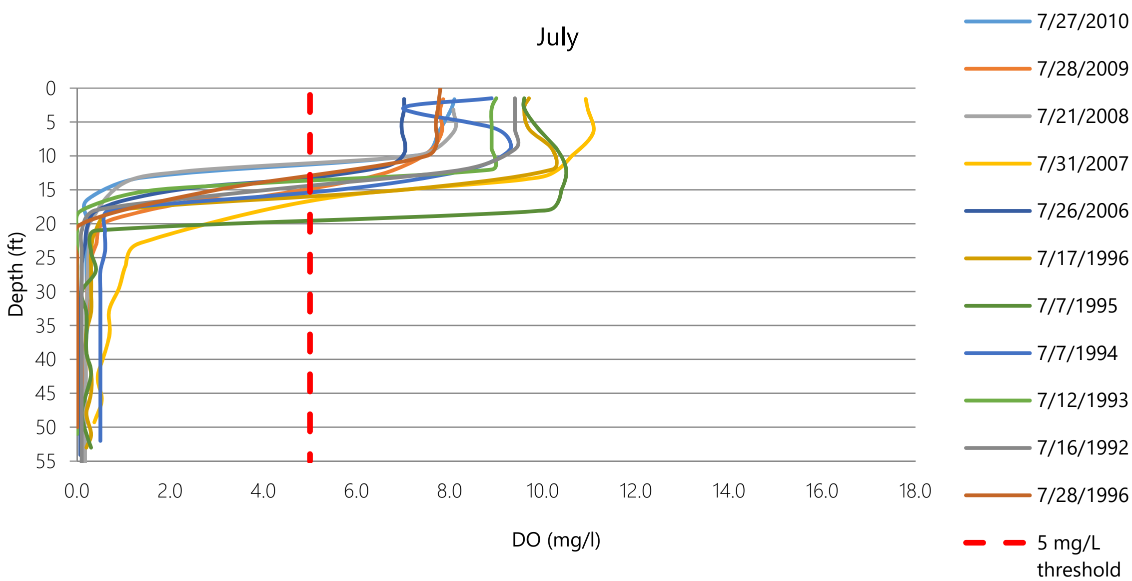
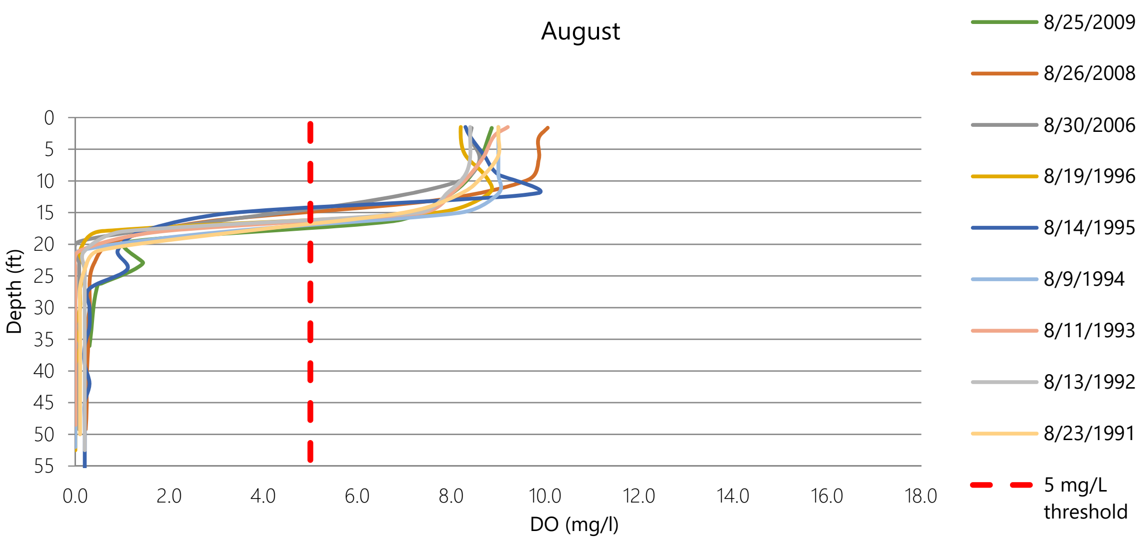


Figure 2.13 (Continued)





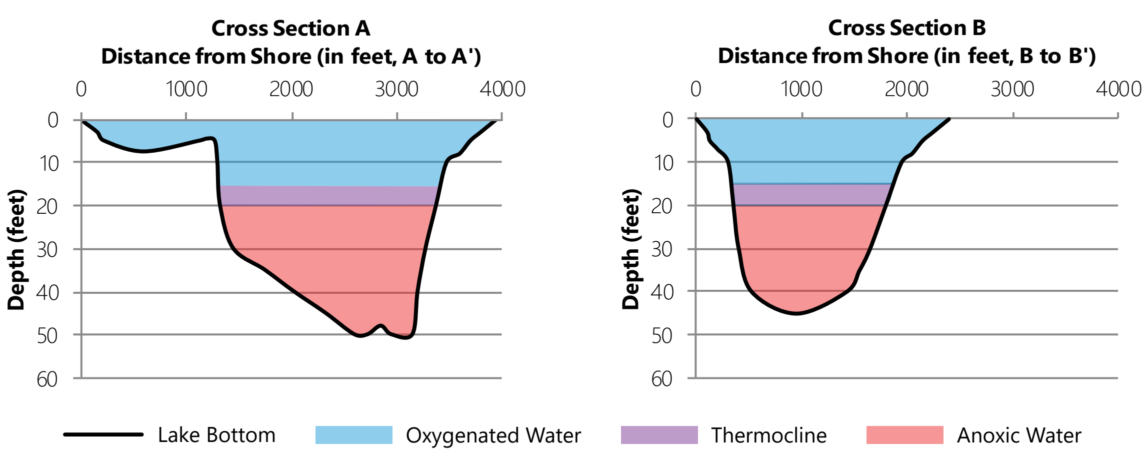
Source: City of Muskego and SEWRPC

5 mg/L of oxygen during most years. The extent of the area with low oxygen is depicted in Figure 2.14. This means that approximately two-thirds of the Lake's total water volume cannot support fish and most other desirable aquatic life during a typical summer (Figure 2.15). Lake Denoon has a broad and relatively deep central basin. During a typical mid to late summer, anoxic waters cover about 70 acres of the Lake's bottom sediment (Figure 2.16). The available data demonstrates that Lake Denoon has developed anoxia in its hypolimnion for at least 49 years

Winter oxygen profiles suggest that the Lake also stratifies in winter. Anoxic water is found near the bottom of the Lake during some cold weather periods. During mid- to late-winter, water found below roughly 40 feet contains less than the 5.0 mg/L standard supportive of the Lake's fish population and desirable aquatic life.

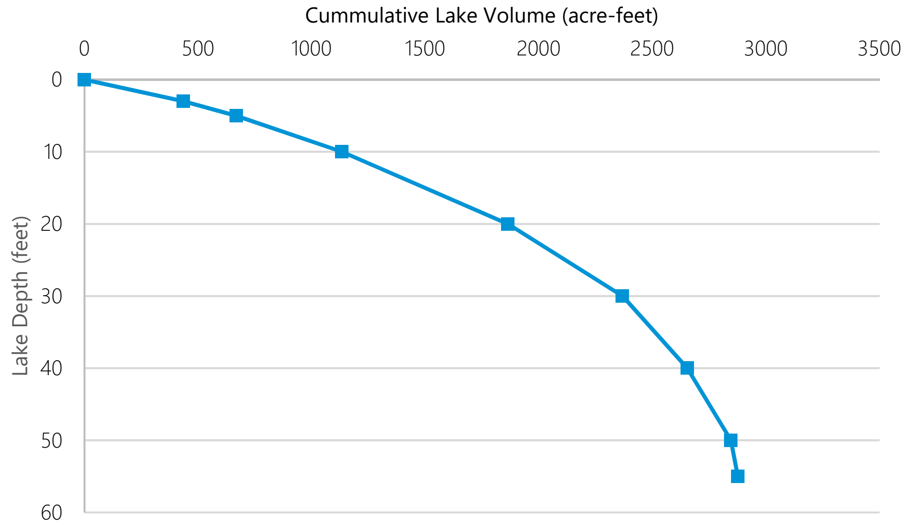
Several other chemical parameters sensitive to low oxygen levels exhibit corresponding increases or decreases, lending further credibility to the hypothesis that oxygen depletion persists for long periods of time in the deeper portions of the Lake. Winter data further suggests that water occupying the deepest portions of the Lake also becomes oxygen depleted under the ice. Although Lake Denoon may always have

Figure 2.14
Typical Midsummer Extent of Anoxic Water Lake Denoon



Source: Wisconsin Department of Natural Resources and SEWRPC

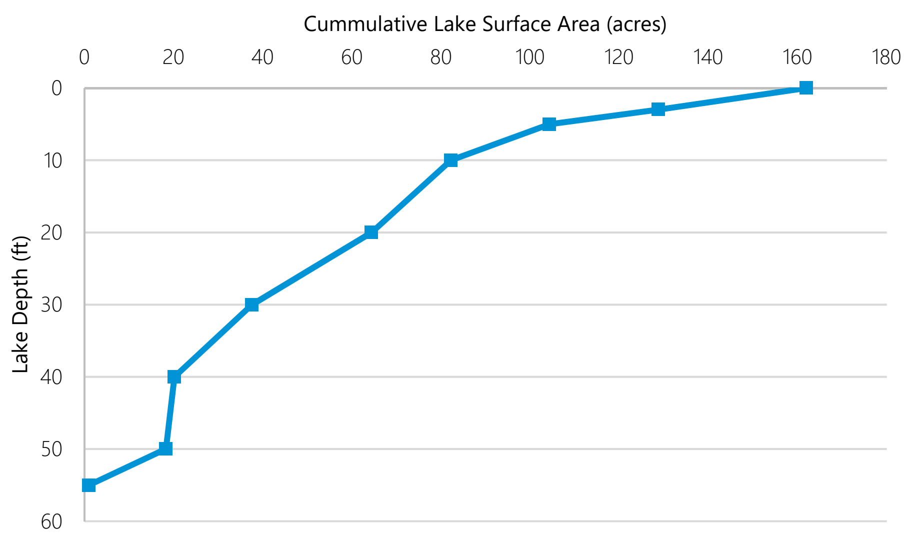
Figure 2.15
Lake Depth Versus Volume, Lake Denoon



Note: This is a cumulative plot of the total volume of the Lake contained in depths less than or equal to depicted values. For example, roughly 1500 acre-feet of the Lake's total volume is contained in the upper 15 feet of the Lake's water column.

Source: WDNR and SEWRPC

Figure 2.16
Lake Depth Versus Surface Area, Lake Denoon



Note: This is a cumulative plot of the total surface area of the Lake with water depths greater than or equal to depicted values. For example, roughly 50 acres of the Lake is deeper than 25 feet.

Source: City of Muskego, Wisconsin Department of Natural Resources, and SEWRPC stratified, it is not possible to conclude if the Lake developed anoxic conditions in its hypolimnion before development of the watershed in agricultural and urban uses. Sediment sampling and analysis can shed light on historical Lake water quality conditions.

Oxygen Saturation

Oxygen saturation relates the concentration of oxygen actually measured in water to a concentration in equilibrium with the atmosphere at a given temperature. Values between 90 and 110 percent saturation are generally considered desirable for aquatic life. Summer oxygen saturation profiles (Figure 2.17) reveal that the near-surface water of Lake Denoon is supersaturated with oxygen during portions of the day,[18] a result of abundant photosynthetic activity, a factor likely related to human-induced nutrient enrichment. Although no information is available for nighttime conditions, many water bodies exhibiting oxygen supersaturation during the day experience low oxygen saturation levels at night, a condition related to respiration and decomposition continuing to occur while photosynthesis is lacking. Such conditions are stressful to aquatic organisms. Oxygen supersaturation far exceeding 110 per cent has been recorded on several occasions during the summer, a condition that may represent time periods unfavorable to the Lake's fish community and potentially other aquatic organisms. Oxygen concentrations have great influence on the Lake's biota and chemistry. For this reason, detailed oxygen concentration profiles should be regularly measured, including profiles collected at night during the summer. More details of this recommendation may be found in Chapter 3.

***Chlorophyll-*a**

Chlorophyll-*a* concentrations above 10 μg/L tend to impair recreational activities due to excessive algae. Chlorophyll-*a* samples have been collected in Lake Denoon since 1991. During that time, summer chlorophyll-*a* concentrations have only occasionally exceeded 10 μg/L (Figure 2.18). It is interesting to note that since about 2005 (see Figure 2.19), the highest chlorophyll-*a* concentrations have coincided with the highest spring overturn phosphorus concentrations. This correlation reinforces other data (such as nitrogen to phosphorus ratios) that Lake Denoon is phosphorus limited, hence, decreased phosphorus concentrations would likely inhibit algal growth.

Phosphorus

When the Lake is fully mixed in the spring, phosphorus concentrations are similar throughout the various depths of the Lake, with phosphorus concentrations averaging 30.7 μg/L (.037 mg/L) over the period of record (Figure 2.20). Phosphorus concentrations vary widely within the Lake when it is stratified; Figure 2.21 plots summer phosphorus concentrations recorded since 1991.[19]

Samples collected near the surface during the growing season commonly have the lowest phosphorus concentrations, averaging 19 μg/L, a value consistent with both the aquatic life impairment threshold and the recreational impairment threshold for deep seepage lakes of 20 μg/L as codified in Chapter NR 102 of *Wisconsin Administrative Code*.[20] Lake Denoon's phosphorus concentrations may occasionally exceed this lower standard since concentrations vary significantly from year-to-year, the average of 19 μg/L represents the average of several years, and the threshold standard is meant to represent an average of three monthly values collected between June 1 and September 15.

Phosphorus concentrations reach their highest values in the deeper waters of Lake Denoon during warm season stratification. Samples drawn from the Lake's hypolimnion during the summer months commonly contain phosphorus concentrations more than ten times higher than near-surface lake water, with values averaging 181 μg/L, and ranging from 67 μg/L to 350 μg/L over the period of available record (Figure 2.21).

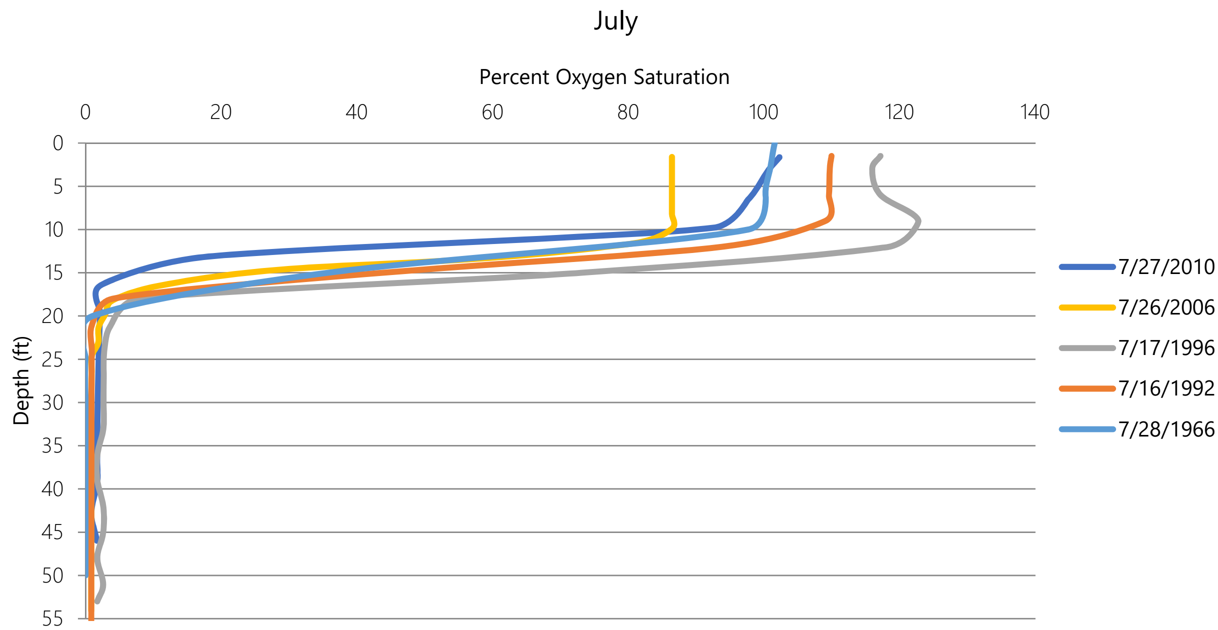
---

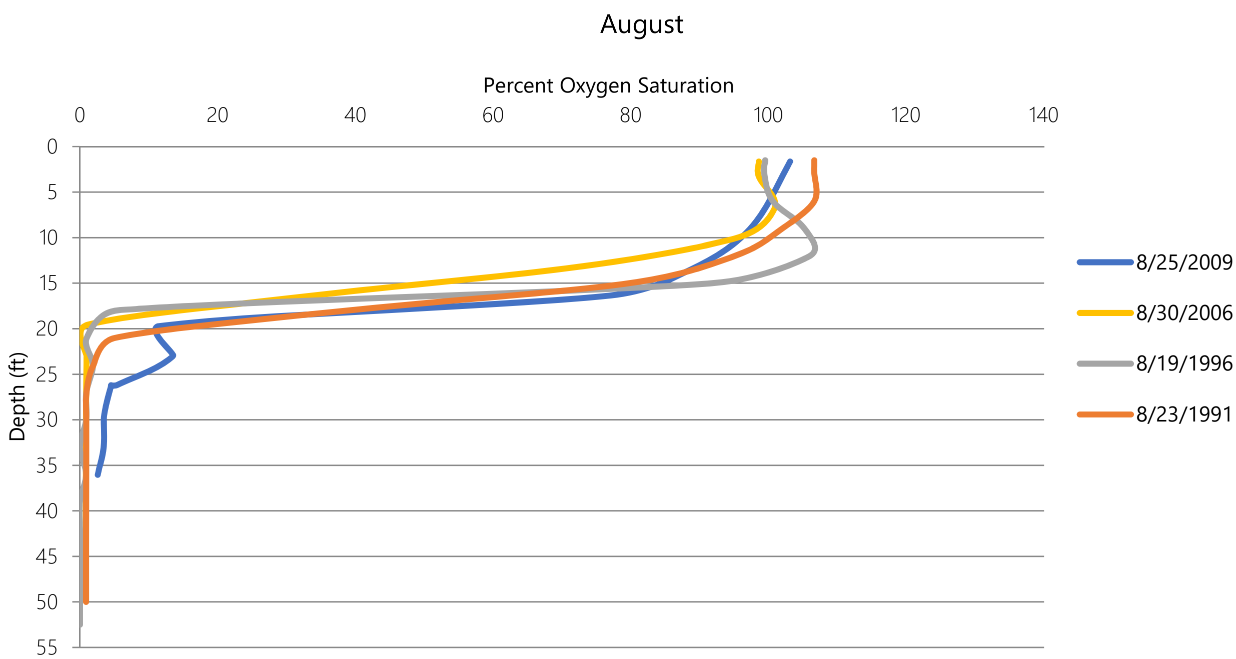
[18] Supersaturation refers to a condition when the amount of dissolved substance exceeds the substance's maximum solubility in the solvent under normal circumstances. Such conditions are typically unstable. Dissolved gas comes out of water as bubbles. Fish exposed to oxygen saturations greater than 115 percent can develop bubbles in their tissues (a condition similar to "the bends" experienced by deepwater divers).

[19] The data set includes one extreme value (120 μg/L) from April 1966 that far exceeds the average. The significance of this value is difficult to estimate as it could represent a typographical or procedural error, or could instead reveal extreme conditions that existed before the implementation of many modern water pollution control practices and regulations prominence. Aside from the 1966 value, spring turnover total phosphorus concentrations range from 16 to 63 μg/L.

[20] *Wisconsin Department of Natural Resources,* Wisconsin 2018 Consolidated Assessment and Listing Methodology (WisCALM), Clean Water Act Section 305(b), 314, and 303(d) Integrated Reporting.

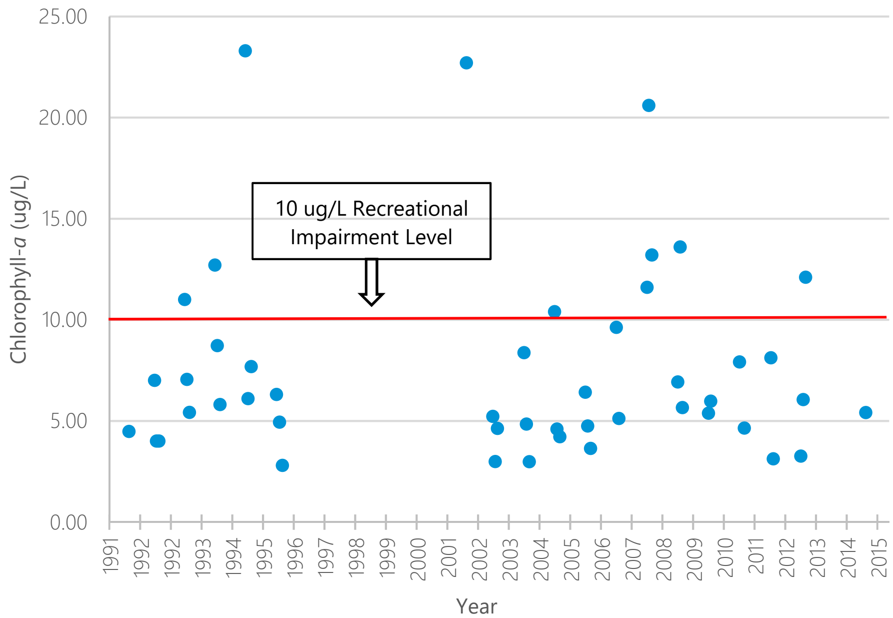
Figure 2.17
Month-by-Month Summer Oxygen Saturation Profiles, Lake Denoon





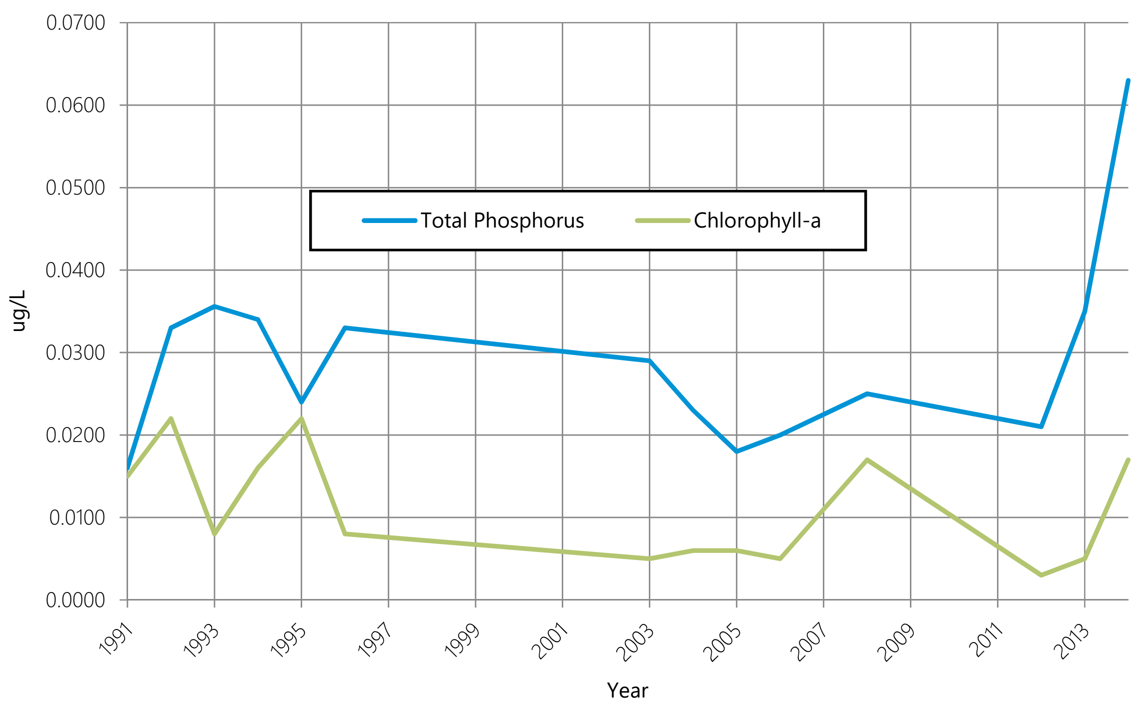
Source: City of Muskego and SEWRPC

Figure 2.18
Summer Chlorophyll-*a* Concentrations Within Lake Denoon: 1991-2015



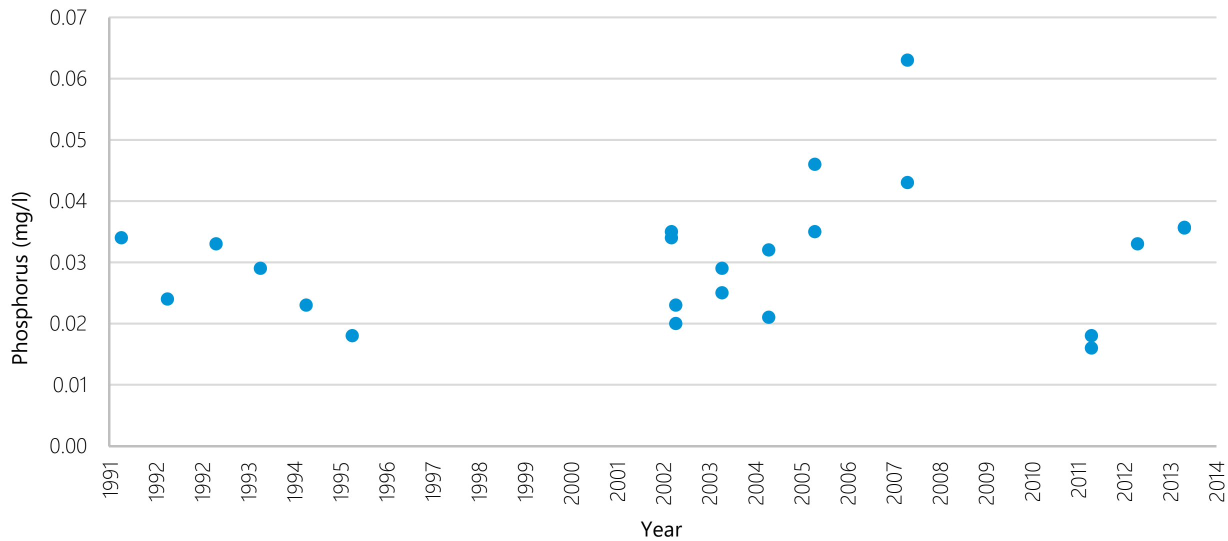
Source: City of Muskego and SEWRPC

Figure 2.19
Spring Overturn Phosphorus and Chlorophyll-*a* in Lake Denoon: 1991-2014



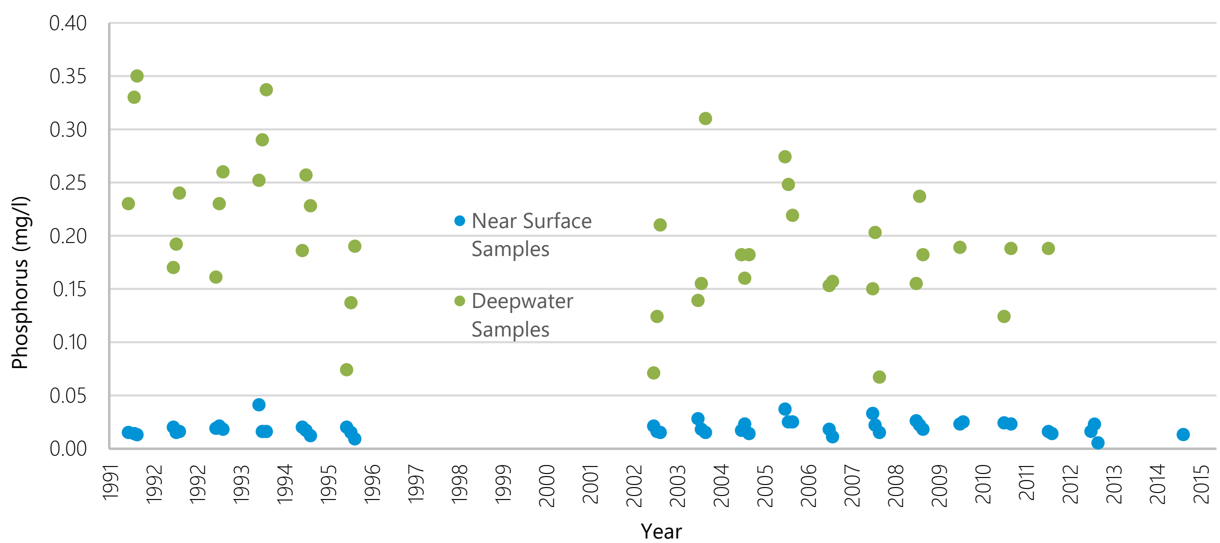
Source: City of Muskego and SEWRPC

Figure 2.20
Spring Turnover Total Phosphorus Concentrations Within Lake Denoon: 1991-2014



Source: U.S. Geological Survey, City of Muskego, and SEWRPC

Figure 2.21
Summer Phosphorus Concentrations Within Lake Denoon: 1991-2015



Source: U.S. Geological Survey, City of Muskego, and SEWRPC

Phosphorus concentrations rapidly increase immediately after the Lake stratifies, commonly reaching their maximum values during July. This is a common occurrence on many lakes since biological productivity and attendant organic loading to deep portions of lakes declines after peaking in late spring. In many years, temperature, dissolved oxygen, and other data suggest that some mixing may occur between the hypolimnion and epilimnion during late summer. Consequently, late summer phosphorus concentrations are occasionally lower than values measured during midsummer.

<u>Phosphorus Sequestration</u>

In areas of mineral-rich calcareous groundwater ("hardwater"), marl is often deposited on the beds of lakes fed by significant groundwater seeps and springs. Marl is composed chiefly of calcium carbonate, clays and silts, and some organic detritus. The formation of marl can co-precipitate dissolved phosphorus, a condition which helps reduce phosphorus concentrations in the water of some lakes. In such instances, co-precipitated phosphorus is deposited as a stable mineral upon the lake bed. Over fifty percent of a lake's external phosphorus loading is typically retained in lake-bottom sediment. The actual amount retained in a lake varies widely with watershed and lake characteristics, but up to ninety percent can be retained in some instances.[21] For example, studies of Lake Nagawicka in Waukesha County have shown that 87 percent of the phosphorus contributed to the Lake is retained in lake-bottom sediment.[22] Maps of Lake Denoon's bottom sediment denote marl deposits along the northeast and southeast shorelines. This suggests that marl formation actively occurs in the Lake, and that phosphorus concentrations may be attenuated by phosphorus co-precipitation.

Marl is commonly formed as a byproduct of growth of certain algae species (e.g., muskgrass), accumulates on plant stems and leaves, and ultimately falls to the lake-bottom as the algae grows and dies. Photosynthesis increases water pH in the immediate vicinity of the plant, enhancing precipitation of calcite. Since enriched lakes generally support more algae, enriched lakes can have a self-reinforcing feedback loop to sequester more phosphorus. However, calcite/phosphorus minerals may become less stable at high pH ranges, potentially reducing the effect of this feedback loop.

Research in Europe has found that although marl lakes are resistant to phosphorus enrichment and eutrophication, the bottom-dwelling species of algae that promote marl production can be sensitive to long-term phosphorus enrichment. Decreased water clarity associated with higher phosphorus concentrations can decrease the depth to which bottom dwelling algae can grow, in turn decreasing the extent of marl-precipitating algae near the lake bottom. Less marl precipitation increases overall dissolved phosphorus in the lake which fosters higher abundance of free-floating algal species. This further decreases water clarity, forming a self-reinforcing loop that eventually breaks down the marl formation process. Some formerly clear European marl lakes that had successfully buffered heavy, long-term external phosphorus loads went through rapid change after the lake's buffering capacity was exceeded and are now eutrophic lakes with low water clarity.[23] This graphically illustrates how <u>the algae-based phosphorus sequestration process is vulnerable to excessive long-term high phosphorus loads, demonstrating the importance of reducing external phosphorus loads to lakes</u>.

Marl formation/phosphorus co-precipitation depends upon continued discharge of mineral-rich groundwater to springs and seeps on the lake bottom. If the supply of groundwater is reduced, the vigor of hardwater algae is reduced, compromising the phosphorus sequestration cycle. Therefore, <u>the Lake's groundwater supply must be protected to ensure that phosphorus sequestration remains active</u>.

In Wisconsin, phosphorus is sequestered in lake-bottom sediment with calcite (as described above) or with iron. Unlike calcium minerals, iron-bound phosphorus is sensitive to the concentration of oxygen in adjacent water. Under low oxygen conditions, iron-bound phosphorus minerals dissolve and release plant-available phosphorus to the water column. This source of phosphorus, an important component of what is commonly referred to as internal loading, can be a significant contributor to the total phosphorus available to algae in lakes, especially in lakes that have fewer sources of external phosphorus during the growing season. For this reason, the presence of anoxic water can profoundly influence the nutrient dynamics of certain lakes.

<u>External Loading</u>

External loading of phosphorus is dependent on activities occurring within the watershed beyond the Lake's shoreline and is discussed more below.

---

[21] *Lijklema L., "Phosphorus accumulation in sediments and internal loading,"* Hydrological Bulletin *20:213, 1986.*

[22] *U.S. Department of the Interior, Geological Survey Scientific Investigations Report 2006-5273,* Water Quality, Hydrology, and Response to Changes in Phosphorus Loading of Nagawicka Lake, a Calcareous Lake in Waukesha County, Wisconsin*, 2006.*

[23] *Wiik, Emma, Helen Bennion, Carl D. Sayer, Thomas A. Davidson, Suzanne McGowan, Ian R. Patmore, and Stewart J. Clarke, "Ecological sensitivity of marl lakes to nutrient enrichment: evidence from Hawes Water, UK",* Freshwater Biology, *Volume 60, Issue 11, November 2015, p. 2226-2247.*

Internal Loading

A 1993 letter from the U. S. Geological Survey (USGS) referenced 1992 water quality monitoring data collected in Lake Denoon and drew a number of conclusions. The USGS reported that overall lake water quality was "good", that the Lake was a "meso-eutrophic" lake, and that oxygen disappeared from the deep waters of the Lake during summer stratification. As a result, moderate amounts of phosphorus were being released from lake-bottom sediments (internal loading). Indeed, 1992 concentrations of total phosphorus in deep waters of Lake Denoon were between 8.5 and 15 times higher than concentrations in shallow portions of the Lake, strongly suggesting that significant internal loading may have been occurring at that time.

As mentioned earlier in this report, lake productivity is controlled by available phosphorus. Phosphorus, under oxygenated conditions, is tightly bound to solids and large amounts of phosphorus are commonly found in lake-bottom sediment. However, when oxygen is absent, geochemical reactions release phosphorus from the bottom sediment into the water column. The amount of sediment exposed to anoxic water is controlled by the shape of the lake basin. Even though two lakes may have equivalent maximum depths, a lake that has broad shallow areas and a small deep hole has less deep water bottom sediment area than an equal depth lake that is uniformly deep. Since sediment exposed to anoxic water can release phosphorus into the water column, lakes with more deep water sediment area are more susceptible to significant phosphorus internal loading. Moderate depth/size stratified lakes are among the most prone to internal phosphorus loading. Such lakes lack large water volumes, and, hence, have comparatively little stored oxygen in the hypolimnion, making them prone to anoxia.

Water chemistry, lake type, and bathymetry information yield strong crosslinking evidence that Lake Denoon supports conditions that favor significant internal phosphorus loading. Waters below about 15 feet contain little to no oxygen during much of the summer, meaning that a large proportion of the lake-bottom is prone to phosphorus dissolution from bottom sediment (Figure 2.14). Over 70 acres of lake-bottom sediment are covered with anoxic water during a typical summer (Figure 2.16) Previous studies report that the lake bottom in deeper portions of the Lake is covered primarily with muck, a fine grained organic-rich sediment. Such sediment commonly contains significant concentrations of phosphorus.

Internal phosphorus mass loading can be estimated using whole lake total phosphorus water concentrations occurring during fully mixed conditions during or shortly after spring turnover and from lake water samples collected from the hypolimnion during the stratified conditions occurring in summer (assuming that little mixing between the epilimnion and hypolimnion occurs after the Lake stratifies). Although values vary significantly between years, internal loading likely contributes on average about 590 pounds of phosphorus to the water column between late spring and midsummer. Since anoxic water covers about 70 acres of the lake-bottom during an average year, each acre of lake-bottom exposed to anoxic water contributes approximately eight and one-half pounds of phosphorus to the water column during a typical late spring and summer day.

During most years, comparatively little internal phosphorus loading appears to occur during late summer. This is consistent with observations in other Midwestern lakes. However, on some occasions, Lake Denoon's hypolimnetic phosphorus concentrations continue to climb through August. The highest late summer phosphorus concentrations documented by the available data set occurred during late August 1991, yielding a warm season internal phosphorus loading of nearly 1,100 pounds.

Assuming that most phosphorus is contributed to the water column during the first 90 days of stratification, a unit area phosphorus flux rate from anoxic bottom sediment can be computed.[24] Lake Denoon's computed unit area phosphorus flux rate is 11 milligrams per square meter per day (roughly one-tenth of a pound per acre per day). This value is near the middle of the range of values determined as part of a State of Michigan lake sediment column study. The Michigan study reports unit-area phosphorus flux rates ranging from 1.6 to 29.5 milligrams per square meter per day.[25] The Lake Denoon value also agrees well with studies completed in Minnesota. Minnesota lakes that were eventually treated to reduce internal phosphorus loading exhibited

---

[24] *Unit area flux rate refers to the mass of a substance moving past a threshold over a set area during a unit of time.*

[25] *Steinman, Alan, Rick Rediske and K. Ramesh Reddy, "The Reduction of Internal Phosphorus Loading Using Alum in Spring Lake, Michigan,"* Journal of Environmental Quality*, 33:2040-2048, 2004.*

unit area phosphorus flux rates ranging from 9.3 to 14.1 milligrams per square meter per day.[26] These comparisons add creditability to the phosphorus flux rates calculated for Lake Denoon and point to the importance of internal loading in the overall nutrient balance of the Lake.

It should be noted that phosphorus released to the hypolimnion is not directly available to most algae growing in the lake since little sunlight penetrates to these depths. Even though the thermocline is a barrier to circulation, it is imperfect and some phosphorus can migrate to shallower areas. For this reason, the highest levels of algal productivity are often found just above the thermocline in lakes with phosphorus internal loading. The highest oxygen supersaturation values are commonly found in Lake Denoon at this depth, suggesting that internal phosphorus loading contributes to abundant algae near the thermocline. Mixing caused by wind and/or seasonal turnover can cause large concentrations of phosphorus from the hypolimnion to suddenly mix with surface water. This can lead to algal blooms.

Spring nutrient concentration trends representing a fully mixed Lake were earlier shown in Figure 2.10. This graph suggests that surface water quality appears to be slowly changing over time, with nitrogen values decreasing and phosphorus concentrations increasing. Since phosphorus is currently the nutrient that is in short supply for algal growth, increasing phosphorus concentration could translate to higher populations of algae, less water clarity, reduced marl sequestration, and an increase in plant detritus delivered to the hypolimnion, all of which could reinforce internal phosphorus loading.

<u>Lake Management Implications and Recommendations</u>

As a seepage lake, Lake Denoon does not receive abundant runoff or stream inflow, limiting the delivery of externally-sourced phosphorus to the Lake. During the growing season, weather conditions can be dry, further reducing the already limited surface water delivery of phosphorus to the Lake. Models and calculations suggest that internal loading may contribute more phosphorus to the Lake than any other source. Also, the Lake appears to be gradually shifting to a lower nitrogen/phosphorus ratio, potentially creating conditions that fuel the growth of algae. <u>These findings make phosphorus internal loading an issue of particular importance</u> for lake management. Phosphorus internal loading is a problem in many lakes. Many approaches have been developed to help mitigate its effects on water quality.

To be truly effective, efforts to reduce phosphorus internal loading must be predicated on or accompanied by efforts that permanently reduce and control external phosphorus loading. If the lake in question receives heavy phosphorus inputs from its watershed or point sources, any improvement in lake health from internal load reduction efforts will be short lived. However, Lake Denoon, a seepage lake with a small watershed and modest external phosphorus loading, is a good candidate for internal load reduction measures. Nevertheless, any activity that helps incrementally reduce external loading will increase the relative success and longevity of internal load control efforts. <u>Efforts to reduce internal loading of phosphorus must not take the place of an aggressive program to identify and minimize external phosphorus loading</u>.

A wide variety of methods have been used in other lakes to attempt to reduce phosphorus internal loading. The applicability of each method is highly dependent on lake-basin morphology, hydrology, water chemistry, cost, and other factors. Some of these methods are listed below along with a judgement of practicality for employment at Lake Denoon.

Dredging

Internal loading depends upon the presence of phosphorus-rich bottom sediment. Dredging physically removes phosphorus rich sediment from the water body in question. Dredging is generally very costly and can negatively affect lake ecology. Furthermore, it is most effective on small, shallow lakes with limited sediment depth. Since Lake Denoon has large areas of deep water, it is impractical from logistical and cost standpoints. <u>Dredging is not recommended for further evaluation</u>.

Chemical Inactivation

Internal phosphorus loading results when low oxygen water destabilizes and dissolves minerals trapped in bottom sediment allowing phosphorus to dissolve into overlying water. Substances can be added to the

---

[26] *Bassett Creek Watershed Management Commission, "*Twin Lake Phosphorus Internal Loading Investigation,*" March, 2011.*

lake to suppress this process. In the Midwest, chemical inactivation generally uses alum (aluminum sulfate), a compound used to clarify drinking water. Alum works in two ways. First, a solid forms immediately upon contact with lake water. The solid captures particles, clears the water, and settles on the lake bottom. The alum forms a layer that is not affected by low oxygen levels, and it therefore isolates the lake bottom from anoxic lake water, hindering phosphorus release from bottom sediment during all seasons. Alum treatments are reasonably priced, can be applied to lakes of essentially all depths and sizes, and have provided long-term improvement in the right application. For this reason, alum treatment is considered a feasible alternative and is discussed in more detail in Chapter 3.

Hypolimnetic Discharge

The goal of hypolimnetic discharge is to reduce the volume and, relatedly, the extent of a lake's anoxic hypolimnion. This is done by modifying the lake's outlet to pull water from deeper areas, decreasing the volume of cool deep water and preserving the volume of warm water in the epilimnion. Although the lake may still develop anoxia in its deepest areas, the volume of the hypolimnion will be reduced. As a result of this, the proportion of the lake's bottom in contact with anoxic water will be reduced, and the flux of phosphorus from bottom sediment will also be reduced. Since Lake Denoon does not have a perennial outlet, hypolimnetic discharge is not feasible for Lake Denoon and is not considered further.

Hypolimnetic Withdrawal and On-Shore Treatment

This process uses standard water treatment processes to remove phosphorus from water drawn from the hypolimnion. The purified water is then returned to the lake. This technique has been used in modest sized lakes, but the long-term success of the technique is not well documented. Lake Denoon's hypolimnion does not have exceedingly high phosphorus concentrations, but the volume is rather large for a lake of its areal extent. Natural treatment processes (e.g., riffles to aerate water, constructed wetlands to settle precipitated phosphorus),can be used to supplant all or some of the wastewater treatment processes On-shore treatment is considered a potentially practical method to reduce phosphorus internal loading, and is described in more detail in Chapter 3.

Aeration/Circulation

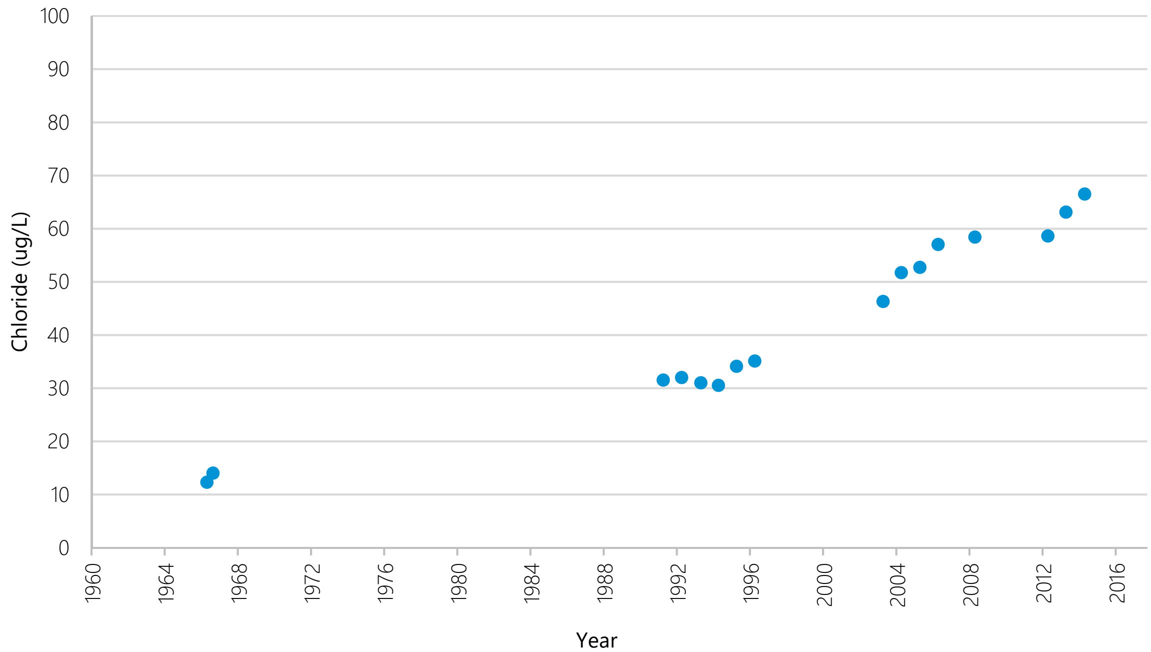
The goal of aeration/circulation is to supplement oxygen levels in the hypolimnion and circulate lake water hindering or preventing thermal stratification. Air is pumped to the lake bottom and is discharged through diffusers that create columns of air bubbles that rise to the surface. On their way to the surface, the air bubbles contribute oxygen to the water and form upwelling currents that mix the lake. Aeration/circulation is feasible, but requires careful design, maintenance, and operation to be effective. Furthermore, if poorly designed or operated, aeration/circulation may not provide sufficient oxygen or mixing to prevent internal loading and phosphorus may be transported to the surface during the growing season. This can increase plant abundance, worsening lake conditions. In addition to this concern, a lake as large as Lake Denoon may require an extensive (and therefore expensive) system to assure success. For these reasons, aeration/circulation for Lake Denoon, is not recommended and is not considered any further in this report.

Chloride

Under natural conditions, surface water in Southeastern Wisconsin contains very low concentrations of chloride. Studies completed in Waukesha County lakes during the early 1900s report three to four mg/L of chloride. Most Wisconsin lakes saw little increase in chloride concentrations until the 1960s, but a rapid increase thereafter. Chloride concentrations in Lake Denoon were first recorded in April 1966, at which time 12.3 mg/L were detected. Figure 2.22 shows that chloride concentrations have consistently increased since that time. The most recent samples (April 2014) contained 66.5 mg/L chloride, a value over 400 percent higher than 1966.

Chloride is considered a conservative pollutant, meaning that natural processes other than evaporation typically do not detain or remove it from water. Humans use chloride bearing materials for a multitude of purposes (e.g., road salt, water softening, industrial processes), and chloride concentrations are normally positively correlated with human-derived pollutant concentrations. Chloride is indicative of a suite of human-sourced and human enriched chemicals. These chemicals include agricultural nutrients and pesticides, pharmaceuticals, petroleum products, and a host of other substances in common use by modern society. For this reason, chloride concentrations are a good indicator of the overall level of human activity/potential

Figure 2.22
Chloride Concentrations Within Lake Denoon: 1966-2015



Source: U.S. Geological Survey, City of Muskego, and SEWRPC

impact and possibly the overall health of a water body. While the concentrations of chloride in Lake Denoon do not exceed current guidelines, rapidly increasing chloride concentrations attest to the fact that Lake Denoon is subject to a great deal of cultural pressure and the Lake has a propensity to accumulate human-introduced substances, a condition that could reduce water quality and overall ecosystem function over time. Management efforts to reduce chloride loading to Lake Denoon and other waterbodies throughout the Region are an important issue of concern. Winter road deicing practices are one issue related to this issue.[27]

Although lake water chloride concentrations are within current guidelines, different species of plants and animals have varying abilities to survive or thrive in saltier environments. For example, reed canary grass, a common invasive species in wetland and riparian settings, is much better adapted to salty water environments.[28] Similarly, Eurasian water milfoil (EWM) can survive levels of industrial and salt pollution that eliminates native aquatic plants.[29] At least a few invasive animal species also are more tolerant of saltier water than native fish species. For example, invasive round goby (*Neogobius melanostomus*), a fish introduced from brackish water areas of Eurasia, grows better in higher salt environments and tolerates concentrations lethal to native fish species.[30] Therefore, high and increasing chloride concentrations may progressively favor unfavorable changes to the flora and fauna of a lake and its watershed.

[27] *Southeastern Wisconsin Regional Planning Commission,* Prospectus for a Road Salt Impact Study for the Southeastern Wisconsin Region*, March 2016 (available online at: www.sewrpc.org/SEWRPCFiles/Publications/prospectus/prospectus-chloride-impact-study.pdf).*

[28] *Prasser, Nick and Joy Zedler, "*Salt Tolerance of Invasive Phalaris arundinacea Exceeds That of Native Carex stricta (Wisconsin)," Ecological Restoration *28(3):238-240, August 2010.*

[29] *Schuyler, A.E., S.B. Andersen, and V.J. Kolaga, "*Plant zonation changes in the tidal portion of the Delaware River." Proceedings of the Academy of Natural Sciences of Philadelphia*. 144:263-266, 1993.*

[30] *Karsiotis, Susanne, Lindsey Pierce, Joshua Brown, and Carol Stepien, "*Salinity tolerance of the invasive round goby: Experimental implications for seawater ballast exchange and spread to North American estuaries," Journal of Great Lakes Research*, Volume 38, Issue 1, pp 121-128, March 2012.*

Available chloride concentration data reflect actual concentrations at set positions during discrete points in time, and are not necessarily representative of the range of values actually present over longer periods or over larger areas. For example, the chloride concentrations found in a tributary stream that drains a large roadway segment will likely have higher concentrations during periods of active de-icing or snow melt than during late summer. Similarly, this tributary will likely have higher chloride concentrations than a similar tributary draining an undeveloped, unpopulated watershed. Therefore, chloride concentrations can vary over time and over short distances. Some streams in Southeastern Wisconsin have been found to contain chloride concentrations far above guideline standards for discrete periods of time but have acceptable concentrations during other periods of time. Episodic high chloride concentrations can dramatically alter the types and numbers of plants and animals living in a stream, even though the "average" concentration appear acceptable.

Chloride concentrations provide an excellent low-cost mechanism to monitor overall human influence on the Lake and can induce change to plant and animal communities. Therefore, it is recommended that chloride concentrations be quantified as part of regular water quality monitoring work and chloride reduction best management practices be implemented. More details are provided in Chapter 3.

Tributary Inflow

As a seepage lake, Lake Denoon does not have perennially flowing tributary streams. However, three intermittently flowing tributaries enter the Lake. The shortest tributary drains wetlands on the west end of the Lake. Upland agricultural areas likely contribute water to this stream. The longest and possibly the largest tributary enters the Lake near the public boat launch site in the northwest corner of the Lake adjacent to Denoon Park. This stream carries runoff from agricultural fields to the north of Kelsey Drive and from the residential development closer to the Lake. Urban and agricultural areas can be a significant contributor of sediment, nutrients, and other pollutants to the Lake. The third tributary is located in the northeast corner of the Lake and drains mostly agricultural and open land. City of Muskego staff retrieved water samples from this stream at the culvert under North Shore Drive, the results of which are included Table 2.4 and Figure 2.23. As can be seen in the figure, total phosphorus concentrations measured in water entering the Lake from the northeast tributary stream exceed State water quality criterion on several sampling dates. This underscores the importance of developing measures that reduce nutrient concentration in runoff from lands contributing to this tributary. Similar data collected from the other tributaries could provide important information for managing nutrient levels in Lake Denoon. If additional sampling occurs, it should include notations on flow, weather, and stream turbidity. More detail regarding suggested sampling methods and criteria are included in Chapter 3.

Table 2.4
Total Phosphorus Concentrations For Lake Denoon Northeast Tributary: 2008-2013

Date	Total Phosphorus (mg/l)
6/30/2008	0.074
8/26/2008	0.047
6/30/2009	0.203
7/28/2009	0.090
8/25/2009	0.050
6/30/2010	0.021
7/27/2010	0.030
7/5/2011	0.236
8/31/2011	0.050
4/17/2012	0.024
4/16/2013	0.062
7/1/2013	0.079

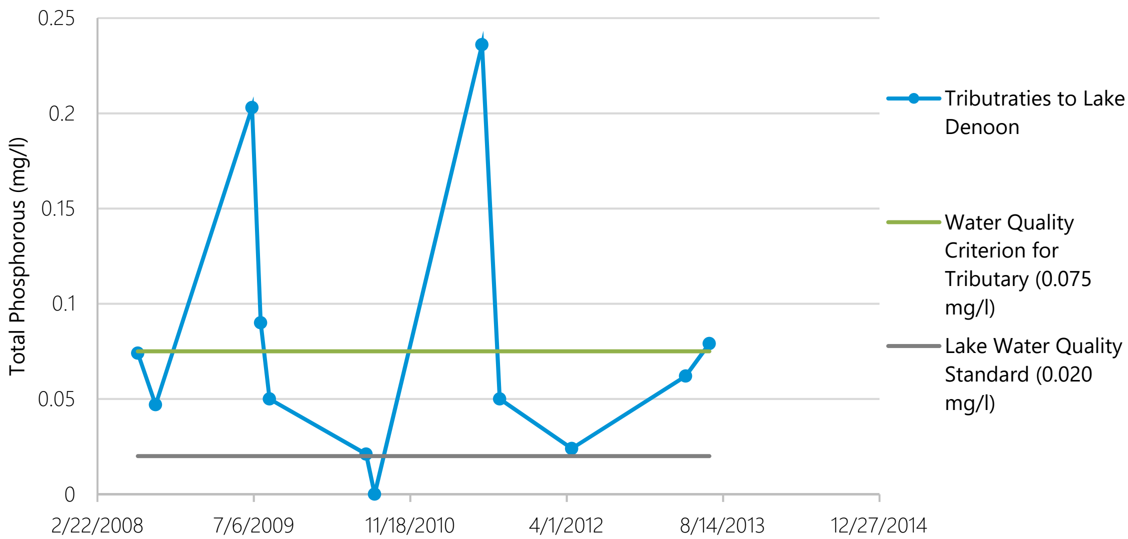
Source: City of Muskego and SEWRPC

A corollary to the subject of tributary and lake nutrient levels is a study conducted in the Lake Wingra watershed in Dane County.[31] Over several years, researchers investigated sources of phosphorus in urban environments. Their findings reveal that, after lawn fertilizers, leaves left on streets in residential areas are the principle source of phosphorus in urban settings. Although the State of Wisconsin has passed legislation prohibiting use of lawn fertilizers containing phosphorus, little has been done in residential communities to address the issue of leaf litter and its role as a major contributor to phosphorus in a lake.

The Lake Wingra study has shown that of the various urban land uses, residential use contributes the greatest percentage of total phosphorus – nearly 60 percent. Furthermore, of the residential land uses, streets and lawns accounted for 65 percent of the total phosphorus loading. Residential streets yielded the largest total phosphorus loading, especially during autumn. During autumn, on average, about 55 percent

[31] *Roger Bannerman, of the USGS, has described the findings of the Lake Wingra study in his presentation entitled* "Urban Phosphorus Loads: Identifying Sources and Evaluating Controls."

Figure 2.23
Total Phosphorus in Lake Denoon Tributaries: 2008-2013



Source: City of Muskego, and SEWRPC

of the total annual residential loading of phosphorus in runoff occurs, and that percentage can be 70 percent or more. Phosphorus loading from streets was shown to be the result of curbside and street-area leaf litter. As vehicle traffic rolls over leaves, the crushed leaf structure accentuates phosphorus leaching during wet weather. Runoff then washes the leaf litter, and especially the released phosphorus from the crushed leaves, into the drainage system and eventually into the Lake.

The Lake Wingra study underscores the importance of effectively managing leaves on residential streets during the fall, significantly reducing this large external phosphorus load. This would be especially important for Lake Denoon in residential areas on the north side of the Lake that are higher in elevation than the shoreland of the Lake and would, thus, drain toward it (Map 2.4).The City of Muskego presently collects leaves each autumn in residential areas of the Lake Denoon watershed within the City limits. However, there is no such program available for those properties on the south side of the Lake that are within the jurisdiction of the Town of Norway. Keeping leaves from collecting on residential streets through prompt leaf collection, and especially the timing of that collection from the streets, is a critical part of reducing phosphorus external loading from residential areas. Leaf may be burned in the Town of Norway if certain conditions are met (e.g., well back from shorelines, not in ditches, permissible hours).

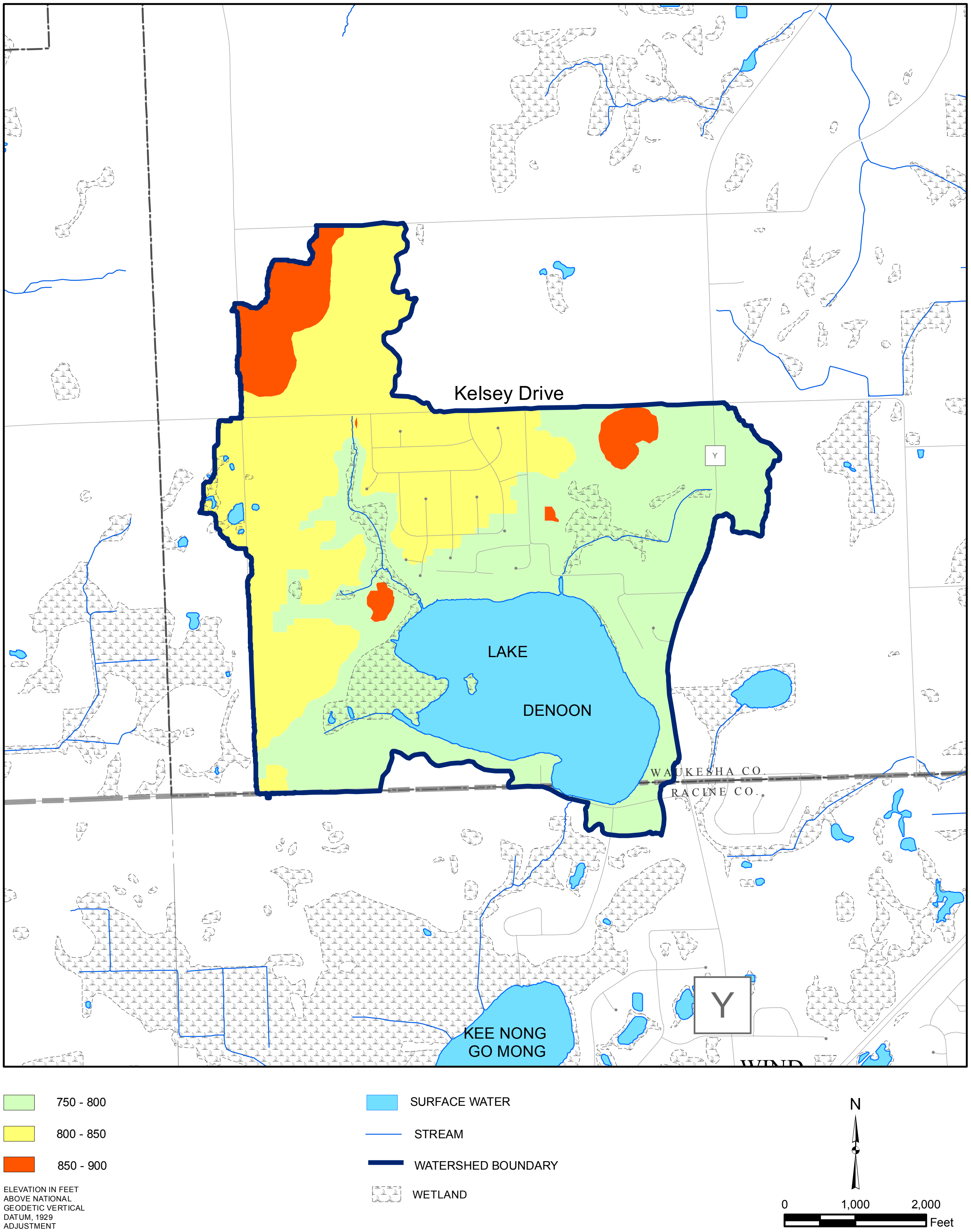
Ultimately, more Lake condition and tributary inflow data will need to be collected to determine to what extent inflow may be impacting Lake Denoon, especially in regard to water quality and aquatic plant growth. However, preventing pollution from entering the Lake would be expected to help maintain or even improve water quality in the long term. Consequently, recommendations related to both monitoring and management are discussed in Chapter 3 of this report, to ensure that the Lake's water quality is maintained and potentially improved.

Watershed Characteristics and Pollutant Loadings

Different land uses contribute different pollutants to a lake. While it is normal for some sediment and nutrients to enter a lake from the surrounding lands (contributing to the natural lake aging process), it becomes an issue of concern when people greatly accelerate soil erosion and introduce anthropogenic pollutants such as heavy metals, fertilizers, and oils.

Given these connections between the practices around a lake and lake water quality, it is important to characterize the area that drains to a lake—its watershed—to determine potential pollution sources and risks to a lake's water quality. Several items need to be examined to complete this characterization, including:

Map 2.4
Topographic and Physiographic Characteristics Within the Lake Denoon Watershed



Source: SEWRPC

1. **The location and extent of a lake's watershed**—Before a watershed can be characterized, the boundaries of the watershed must be carefully identified and located. Watershed delineation involves analyzing land surface elevations surrounding a lake to identify areas where runoff drains toward the lake. This analysis determines whether identified potential pollution sources have a route to enter the Lake. For example, if a nonpoint pollution source is near a lake but outside of the watershed, surface runoff from that source would not reach the lake, and this pollution source would therefore not be a direct threat to the lake's water quality.

2. **Ratio of watershed size to lake surface area**—Lakes with a high watershed area to lake surface area ratios can be more prone to water quality problems. As will be discussed below, the ways that the lands in a lake's watershed are used (e.g., agriculture, residential development, industrial) can greatly influence the types and amounts of pollutants that are carried into a lake by precipitation and runoff events. The greater the amount of land surface draining to the lake, the greater likelihood that pollutants will be washed into the lake. As a rule of thumb, lakes with a watershed to lake surface ratio in excess of 10:1 often experience some type of water quality problems. <u>The Lake Denoon watershed size to lake surface area ratio of 4.8:1 is low, suggesting that external sources of pollution would be less likely to contribute to lake water quality problems than in many lakes in the Region.</u>

3. **The type and location of existing land uses within the watershed**—The extent and location of various land use categories within the watershed can help determine the sources of pollutants reaching a lake. Past, current, and planned land use conditions can be represented within models that use this information to estimate total pollutant loads entering a lake, evaluate the relative contribution of certain land uses or areas, and predict consequences of land use change. Once these loads are determined, it is then possible to determine where to focus management efforts (e.g., if agriculture is the primary source of phosphorus, this may be an effective place to begin nutrient reduction efforts).

4. **The type and location of past land use changes within the watershed**—Knowledge of past land uses and use changes can provide a context for understanding what factors contributed to past issues. This is particularly valuable when contrasted to historical water quality monitoring records or well-documented observations. For example, if long-term lake users or residents have detailed records of years recording algal blooms, heavy aquatic plant growth, or low or high lake levels, these conditions can be assessed in terms of historical land use changes to help ascertain whether something in the watershed changed and caused or contributed to the problem. For example, was turbid water noted after construction of a new subdivision or roadway? Such information can help future planning efforts because it offers insight into how a lake might react to similar situations.

5. **The nature and location of planned land use within the watershed**—In addition to past and current land use in the watershed, it is also possible to estimate future land use changes. Forecasts help determine the areas that may need to be particularly targeted for management efforts in the future, as well as the potential magnitude of future pollution issues.

6. The location of septic systems in the watershed (if applicable)—Private onsite wastewater treatment systems (POWTS), or septic systems, can be a significant source of phosphorus pollution when not properly maintained, and are a source of chloride. Consequently, it is important to investigate where POWTS exist within the watershed.

The Lake Denoon watershed boundary was delineated based on two-foot interval elevation contours developed from a year 2003 digital terrain model. Existing year 2010 land use and planned year 2035 land use within the watershed were quantified by urban and rural categories, and that land use information was used by two separate models to estimate potential pollutant loadings.[32] Pollutant loading characteristics are discussed below.

Summary of Lake Denoon Watershed Characteristics and Water Quality Implications

Lake Denoon's watershed, shown on Map 2.3, is situated within the City of Muskego, Waukesha County, and the Town of Norway in Racine County. The total area that drains to Lake Denoon's outlet is approximately

---

[32] *Wisconsin Lake Model Spreadsheet (WiLMS version 3.0) and the unit area load-based (UAL) models.*

938 acres, or about 1.5 square miles. Lake Denoon's water surface occupies 162 acres of this total. This means that 776 acres of surrounding lands contribute runoff to the Lake. As such, Lake Denoon has a watershed to lake surface ratio of 4.8:1. Such a modest ratio diminishes the likelihood of the Lake experiencing severe water quality issues.

The year 2010 land uses in the area tributary to Lake Denoon (Map 2.5) are comprised of 54.5 percent various rural uses and about 45.5 percent various urban uses (Table 2.5). Currently, agricultural and other open land uses represent the single largest land use in any category – rural or urban – occupying 319 acres (41.1 percent) of the land draining to the Lake. About 7.5 percent of the tributary area is wetland, mostly at the west end of Lake Denoon, as well as a number of smaller areas located primarily in riparian areas along the two tributary streams that enter the north side of the Lake. Woodlands occupy about 5 percent of the watershed, all of which are found to the north of the Lake.

Land use data was used within a unit area load-based model (UAL) to estimate pollutant loadings (sediment, phosphorus, copper, and zinc) which could potentially enter the Lake.[33] <u>These calculations indicate that urban land use is the only significant source of heavy metals</u> (Table 2.6). Limited heavy metal monitoring completed during the 1990s did not identify elevated concentrations of metals typically associated with human/industrial metals. However, urban areas should be targeted if heavy metals are found to be an issue in the future. The planned conversion of agricultural land to urban use may increase copper and zinc runoff load to the Lake by about 30 and 43 percent, respectively. The UAL model also suggests that agricultural land uses contribute about 80 percent of the sediment and about 72 percent of the phosphorus reaching the Lake in surface water runoff. Under planned 2035 conditions, agricultural lands will be converted to urban land use, and the overall mass of sediment and phosphorus delivered to the Lake will decrease by about 15 and 8 percent, respectively. With proactive and aggressive pursuit of runoff water quality measures, sediment and phosphorus loading can be further reduced. <u>Practices to reduce urban loading are discussed in earlier portions of this Chapter (e.g., leaf litter control) and are addressed in more detail in Chapter 3</u>.

Two models were used to estimate lake surface water total phosphorus concentration, both are based on watershed loading.[34] The WiLMS model utilizes land use and hydrology data and predicts a total phosphorus load to the Lake that is approximately 18 percent higher than predicted by the UAL model. The WiLMS model uses several algorithms to predict phosphorus concentrations at spring turnover and shallow water during the summer growing season. All algorithms included in the WiLMS model overestimate current phosphorus concentration to various degrees. This may be related to natural phosphorus sequestration occurring within the Lake as discussed earlier in the section. The algorithms that appear to best fit Lake Denoon's observed total phosphorus concentrations are the Rechow general model for growing season mean and the Vollenweider shallow lake model for spring overturn.

Using 2010 land use, the Rechow model predicts a growing season mean phosphorus concentration of 23 μg/L, which compares favorably to the 19.3 μg/L average determined through laboratory tests. Similarly, the Vollenweider model predicts a spring turnover total phosphorus concentration of 43 μg/L, a value substantially higher than the laboratory average of 30.7 μg/L, but still providing a reasonable predictive tool. To estimate potential future phosphorus concentrations in Lake Denoon, the 2035 planned land uses were applied within the models. According to the models, total phosphorus concentrations collected during spring turnover and the growing season will remain unchanged. It must be noted that these predictions are based solely on watershed conditions, and do not include factors, such as internal loading, which could increase or decrease phosphorus concentrations, or long-term changes in land management and stormwater management which normally would reduce phosphorus concentrations.

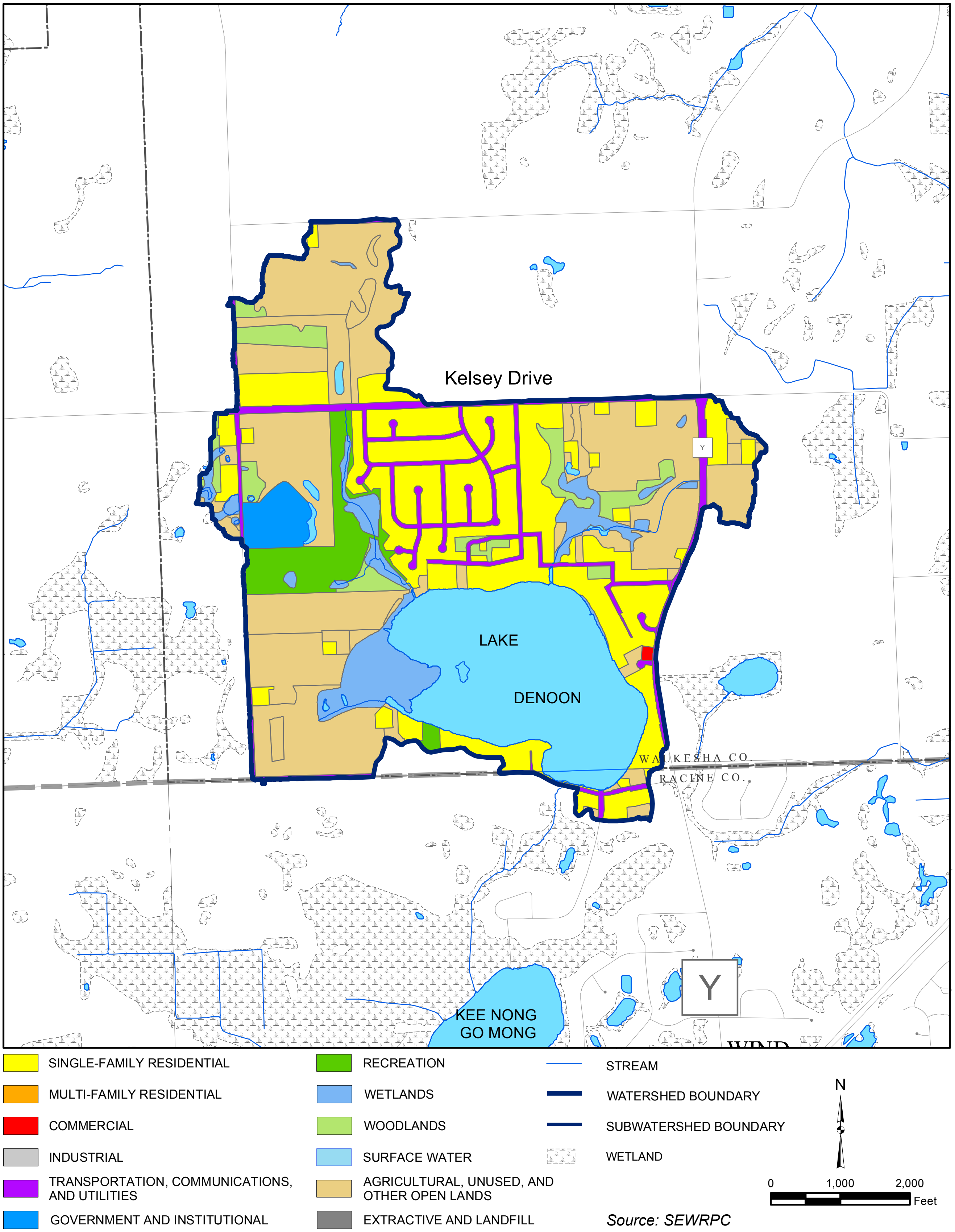
Past land uses in a watershed can, to some degree, be reflected in the amount of historical urban growth in the immediate area, and in the historical changes in populations and number of households. Historical urban growth data for the Lake Denoon watershed is shown on Map 2.6 and represented in Table 2.7. The greatest

---

[33] The calculations for nonpoint source phosphorus, suspended solids, and urban-derived metal inputs to Lake Denoon were estimated using either the Wisconsin Lake Model Spreadsheet (WiLMS version 3.3.18), or the unit area load-based (UAL) model developed for use within the Southeastern Wisconsin Region. These two models operate on the general principal that a given land use will produce a typical mass of pollutants on an annual basis.

[34] Wisconsin Lake Model Spreadsheet (WiLMS version 3.3.18).

Map 2.5
2010 Land Use Within the Lake Denoon Watershed



Source: SEWRPC

Table 2.5
Existing and Planned Land Use Within the Lake Denoon Watershed: 2010 And 2035[a]

Land Use Categories[b]	2010 Acres	2010 Percent of Total Tributary Drainage Area	2035 Acres	2035 Percent of Total Tributary Drainage Area
Urban				
Residential				
Single-Family, Suburban Density	19	2.4	19	2.4
Single-Family, Low Density	127	16.4	185	23.8
Single-Family, Medium Density	87	11.2	87	11.2
Single-Family, High Density	0	0.0	0	0.0
Multi-Family	0	0.0	0	0.0
Commercial	1	0.1	2	0.3
Industrial	0	0.0	0	0.0
Governmental and Institutional	17	2.2	51	6.6
Transportation, Communication, and Utilities	62	8.0	76	9.8
Recreational	40	5.2	38	4.9
Subtotal	353	45.5	458	59.0
Rural				
Agricultural and Other Open Lands	319	41.1	214	27.6
Wetlands	58	7.5	58	7.5
Woodlands	38	4.9	38	4.9
Water	8[c]	1.0	8	1.0
Extractive	0	0.0	0	0.0
Landfill	0	0.0	0	0.0
Subtotal	423	54.5	318	41.0
Total	776	100.0	776	100.0

[a] *As approximated by whole U.S. Public Land Survey one-quarter sections.*

[b] *Off-street parking of more than ten spaces is included with the associated use.*

[c] *Eight acres of open water exist within the upland area draining to Lake Denoon. Lake Denoon occupies an additional 162 acres.*

Source: SEWRPC

increase in land area converted to urban occurred between 1981 and 1990. As can be seen on Maps 2.5 and 2.6, much of the newly urbanized land were new residential developments located immediately north of the Lake along Kelsey Drive. Historical changes in population and households are shown in Table 2.8. The effects of increased population and households can be seen by comparing aerial photographs of the watershed taken in 1970 and 1990, as shown in Figure 2.24. Unfortunately, historical water quality data was not collected in Lake Denoon during this time period (1980-1990), thus, it is not possible to correlate or contrast changes in the Lake's water quality. Nevertheless, it is probably a safe assumption that the urban development occurring in the watershed during and since that time likely has had some impacts on the Lake's water quality.

Planned land use for the Lake Denoon watershed in 2035 is shown on Map 2.7.[35] It is evident that a significant amount of open and agricultural land is planned to be developed, mostly for residential and government and institutional uses. This pattern is more clearly shown on Map 2.8 which delineates portions of the watershed that are planned to be converted from agricultural and open land uses to urban uses between 2010 and 2035. As can be seen by the map, most of the forecast development is single-family residential to the northeast of the Lake and southwest of the intersection of Kelsey Drive and CTH Y. As summarized in Table 2.5, agricultural land uses are anticipated to decrease from about 41 percent of the land area in 2010, to about 28 percent of the land area in 2035. In addition to changing the post-development nature and volume of the pollutants delivered to the Lake in stormwater runoff, construction and grading associated with development pose a transient, although serious, pollution risk. If not properly managed, construction sites can release large pulses of sediment and entrained nutrients into water courses. Dissolved and floating

[35] *See SEWRPC Planning Report No. 48,* A Regional Land Use Plan for Southeastern Wisconsin: 2035*, June 2006.*

Table 2.6
Estimated Annual Pollutant Loadings by Land Use Category Within The Lake Denoon Watershed: 1835, 2010, And 2035

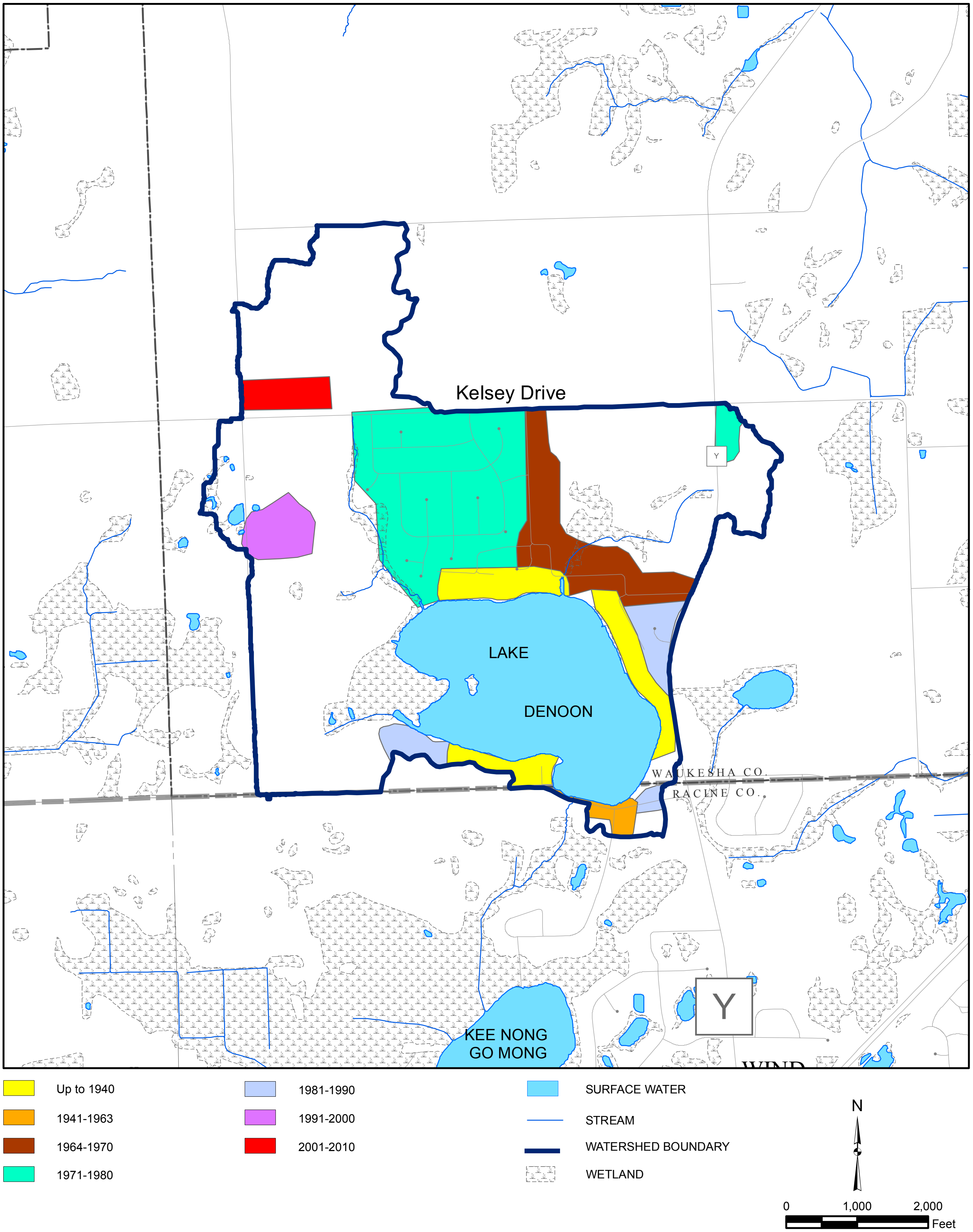
Land Use Category	Pollutant Loads: Circa 1835			
	Sediment (tons)	Phosphorus (pounds)	Copper (pounds)	Zinc (pounds)
Urban				
Residential	--	--	--	--
Commercial	--	--	--	--
Industrial	--	--	--	--
Governmental	--	--	--	--
Transportation	--	--	--	--
Recreational	--	--	--	--
Subtotal	--	--	--	--
Rural				
Agricultural	--	--	--	--
Zetlands	0.11	2.32	--	--
Woodlands	1.31	28.4	--	--
Water	0.75	1.04	--	--
Subtotal	2.17	31.76	--	--
Total	2.17	31.76	0	0

Land Use Category	Pollutant Loads: 2010			
	Sediment (tons)	Phosphorus (pounds)	Copper (pounds)	Zinc (pounds)
Urban				
Residential	7.87	65.04	4.02	28.84
Commercial	0.39	1.20	0.22	1.49
Industrial	--	--	--	--
Governmental	4.34	22.95	1.19	13.6
Transportation	3.36	6.71	14.64	52.46
Recreational	0.48	10.80	0.00	0.00
Subtotal	16.44	106.70	20.07	96.39
Rural				
Agricultural	71.78	274.34	--	--
Wetlands	0.11	2.32	--	--
Woodlands	0.07	1.52	--	--
Water	0.75	1.04	--	--
Subtotal	72.71	279.22	--	--
Total	89.15	385.92	20.07	96.39

Land Use Category	Pollutant Loads: 2035			
	Sediment (tons)	Phosphorus (pounds)	Copper (pounds)	Zinc (pounds)
Urban				
Residential	8.43	76.64	4.02	29.42
Commercial	0.78	2.40	0.44	2.98
Industrial	--	--	--	--
Governmental	13.03	68.85	3.57	40.80
Transportation	4.13	8.25	18.00	64.50
Recreational	0.46	10.26	0.00	0.00
Subtotal	26.83	166.40	26.03	137.70
Rural				
Agricultural	48.15	184.04	--	--
Wetlands	0.11	2.32	--	--
Woodlands	0.07	1.52	--	--
Water	0.75	1.04	--	--
Subtotal	49.08	188.92	--	--
Total	75.91	355.32	26.03	137.70

Source: SEWRPC

Map 2.6
Historical Urban Growth Within the Lake Denoon Watershed: 1860-2010



Source: SEWRPC

pollutants and fine-grained sediment may be delivered to the Lake very quickly, while larger-grained sediment transported near and along the bed of streams may require considerable time to reach the Lake. Consequently, recommendations to mitigate this risk and ensure the continued health of the Lake are included in Chapter 3 of this report.

Finally, nearly the entire Lake Denoon watershed is served by the Town of Norway Sanitary District No. 1 wastewater treatment plant, as shown on Map 2.9. Therefore, management of private onsite waste treatment systems is not an issue of concern for Lake Denoon.

Table 2.7
Historical Urban Growth In the Lake Denoon Watershed

Time Period	Land Developed During Time Period (acres)	Annual Increase in Land in Urban Use (% of watershed land area per year)
Pre-1940	45	--
1940-1963	8	0.04
1964-1970	48	0.9
1971-1980	6	0.08
1981-1985	120	3.1
1986-1990	24	0.6
1991-2000	17	0.2
2001-2010	13	0.2

Source: SEWRPC

How Water Quality is Affected by Watershed and Shoreland Filtering and Storage

Sediment, plant nutrients, and other pollutants can be deposited in a lake from shoreline erosion, aquatic plant death and biomass accumulation, and transport of sediment from the lake's watershed. Sediments can bury natural sand and gravel substrate, degrading fish habitat and causing loss of desirable aquatic organisms. Species such as largemouth bass, bluegill, green sunfish, darters and minnows (e.g., common shiner, sand shiner, and spotfin shiner) depend upon sand and gravel substrates for feeding, nesting, and rearing of juveniles.[36] Loss of water volume and depth associated with sedimentation can limit recreational opportunities, can reduce the number of types of fish and the overall fish population, and can reduce the quality of deep water habitat. Finally, sediment may act as a nutrient reservoir that has the potential to re-enter the water column given the right conditions (e.g., agitation, dissolution under anoxic conditions).

It is important to note, however, that some sedimentation naturally happens as lakes age, (Figure 2.4). Although this process normally occurs naturally over centuries, sedimentation can be accelerated to unnaturally high rates when land use practices in the watershed limit natural attenuation (e.g., filtering provided by streamside vegetation) and instead favor erosion, heavy direct runoff, and artificial pollutant loading.

Since certain land use features and management activities filter or remove pollutants prior to entering a lake system, it is important to evaluate where such features exist within the Lake Denoon watershed. It should be noted that these features can overlap and may provide multiple benefits. Identifying the type and location of such features can help determine if pollutant sources have the potential to directly enter the Lake (without any filtration) or pass through treatment features. Examples of features that help protect a lake's water quality include:

1. **Stormwater detention or retention ponds**—Stormwater management ponds, when properly maintained, can detain water during and after rainfall events, slowing runoff velocity, and allowing many pollutants (e.g., sediments, nutrients, heavy metals) to settle out before reaching downstream water bodies. Since phosphorus is tightly bound to sediment, trapping sediment reduces phosphorus loads passed downstream. Stormwater ponds need to be periodically dredged and may require other maintenance to ensure proper function. Stormwater detention or retention ponds in a lake's watershed help protect or improve lake water quality by significantly reducing sediment and nutrient loads delivered to the lake. Stormwater ponds normally are designed to decrease peak flows by storing water during the heaviest runoff period and releasing stored water at a controlled rate over an extended period of time. Some ponds are designed to infiltrate a portion of the stormwater,

[36] *Despite the potential for sedimentation to adversely affect fish populations, a variety of projects can still be initiated that encourage healthy fish populations. Examples of such projects are described in the "Shoreline Maintenance" and "Fish and Wildlife" sections of this chapter.*

Table 2.8
Population and Households in the Lake Denoon Watershed: 1960-2035

Year	Population	Change from Previous		Households	Change from Previous	
		Number	Percent		Number	Percent
1960	288	--	--	53	--	--
1970	301	13	5	96	43	81
1980	326	25	8	96	0	0
1990	1,129	803	246	343	247	257
2000	1,123	-6	-0.5	352	9	3
2010	1,056	-67	-6	378	26	7
2035	1,241	185	18	417	39	10

Note: Planned 2035 data based on 2000 census data and does not reflect change which may have occurred between 2000 and 2010.

Source: U.S. Bureau of Census and SEWRPC

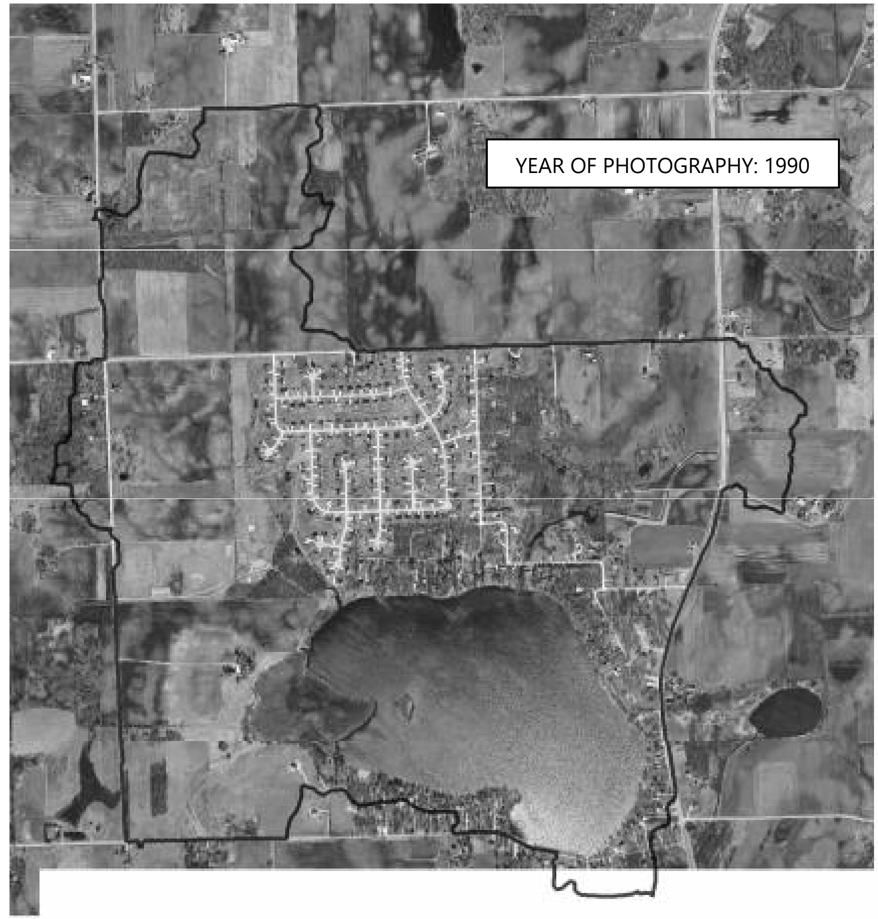
recharging groundwater supplies. On account of this, stormwater management ponds may also help mitigate downstream bed and bank erosion problems, extend the period when intermittent streams actively flow, and contribute to the value of riparian and in-stream habitat. However, they may also increase water temperature, can sometimes attract nuisance species, and can be barriers to aquatic organism migration.

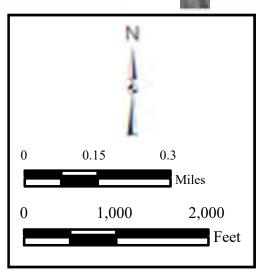
2. **Wetlands**—Wetlands are commonly recognized by the presence of organic and/or wet soils and water-loving plants. Wetlands benefit lake health, particularly when located at or along the lake's shoreline, within floodplain areas, and along the shores of tributary streams. Wetlands slow runoff moving toward the lake reducing flood peaks and allowing sediment and affiliated pollutants to settle in a fashion similar to stormwater management ponds. Additionally, plant life located in wetlands can assimilate and process pollutants such as phosphorus, incorporate them into biomass, thereby detaining or retaining the pollutant from entering the lake. Wetlands have a well-deserved reputation of being "nature's kidneys", filtering pollutants from water. They are provide life-cycle critical habitat for a large number of fish, amphibians, birds, and other animals. Without wetlands, familiar species such as northern pike may not be able to naturally reproduce. Knowing where wetlands are located can help determine if a pollution source is a high risk to downstream waters, since wetlands can detain or retain certain pollutants.

3. **Floodplains**—Floodplains are situated adjacent to water bodies and are inundated during heavy runoff. The portion of floodplains that conveys floodwater is referred to as floodway. Flood fringe areas are located adjacent to and beyond the floodway on either side of a water body. Flood fringe areas temporarily store floodwater, reducing peak flow rates in the floodplain. Water stored in flood fringe lands also helps reduce downstream flood elevations and can reduce stream power reducing erosion and pollutant mobilization/transport. Water stored in flood fringes is relatively still, is commonly spread over large areas, may recharge groundwater supplies, and may be purified by an array of biological, physical, and geochemical processes. Flood fringe areas can act as sediment, nutrient, and pollutant traps, and provide important habitat used by aquatic life for functions such as feeding, refuge, reproduction, and juvenile rearing. Floodplains provide the broadest value in their natural state, but still provide valuable service when developed if compatible open space uses are chosen. Floodplains can be restored along manipulated drainage ways as part of projects that help reduce flooding, improve habitat, and stabilize eroding beds and banks.

4. **Natural terrestrial buffers**—Natural buffers include vegetative features such as woodlands or prairies. When these areas are densely vegetated, they, like wetlands, can slow runoff and incorporate pollutants into biomass. Consequently, when located in areas intercepting runoff flowing toward a lake, buffers can help lower pollutant loads reaching a lake. Moreover, enhancing these features, particularly in areas adjacent to a waterbody, can reduce the amount of pollutants entering that waterbody. Like wetlands, such areas are critical to the life cycle of many herptiles (amphibians and reptiles), mammals, and birds.

Figure 2.24
Historical Aerial Photographs of Lake Denoon: 1970 and 1990

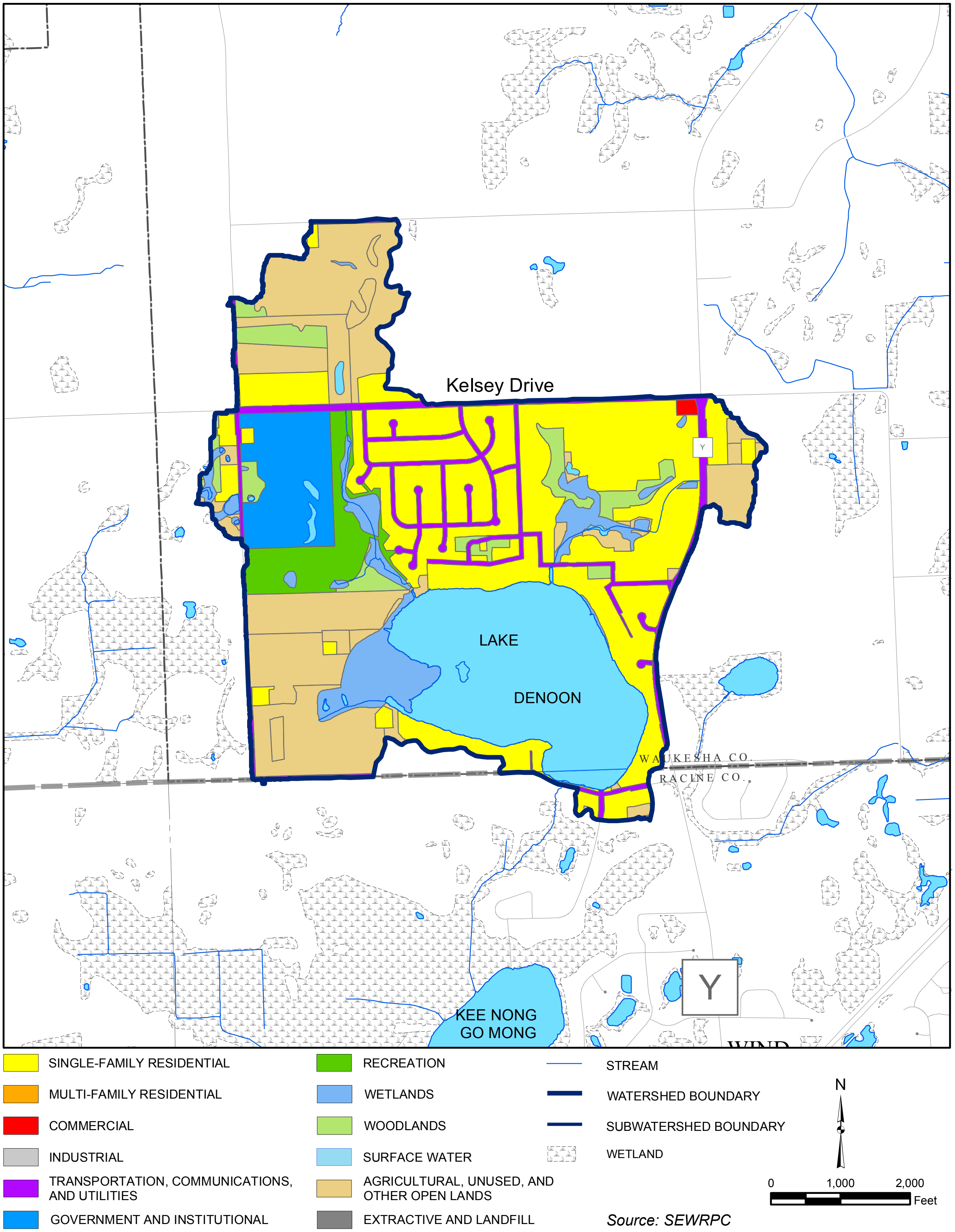




Note: 1970 and 1990 historical aerial photographs unavailable for Racine County.

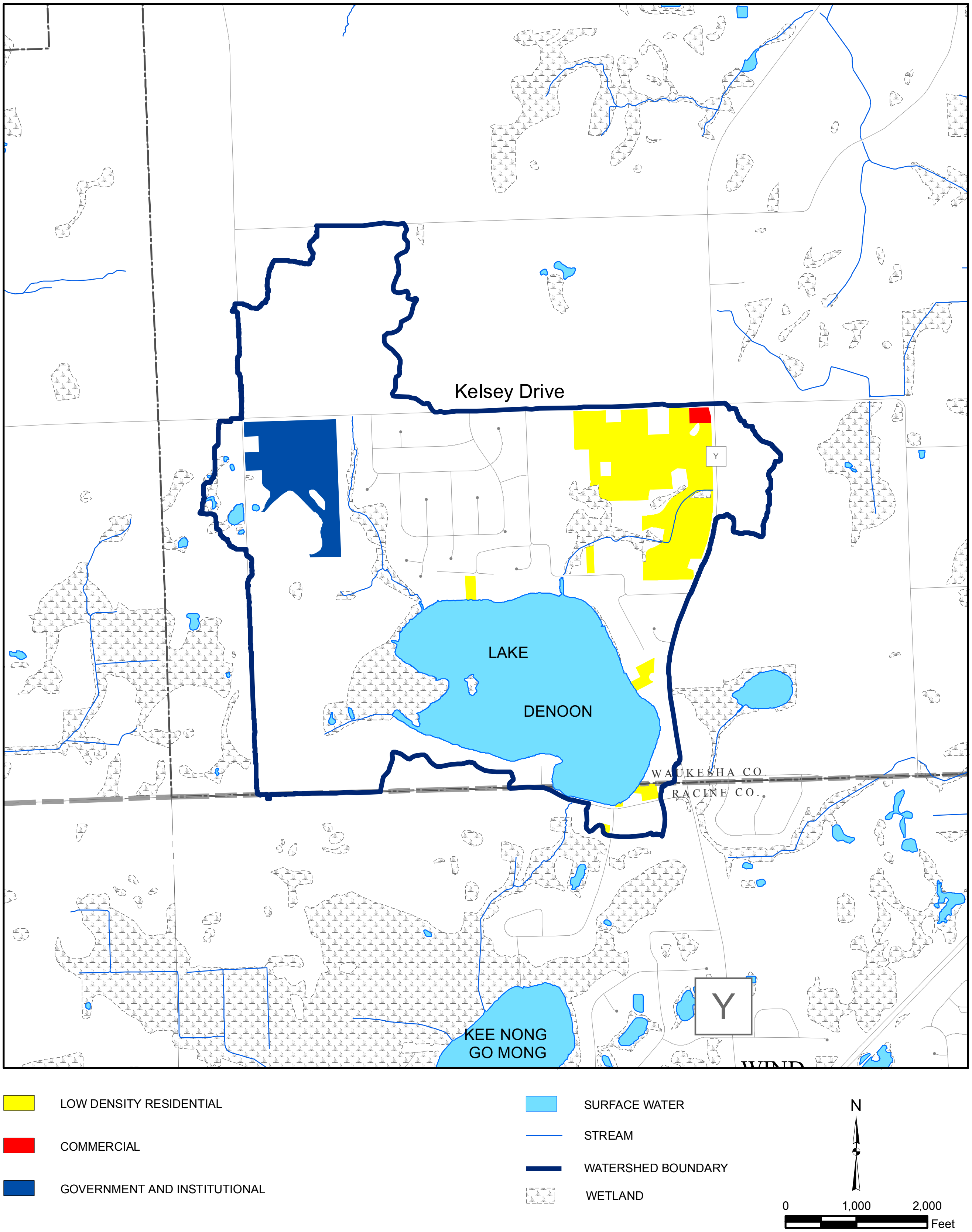
Source: SEWRPC

Map 2.7
2035 Planned Land Use Within the Lake Denoon Watershed



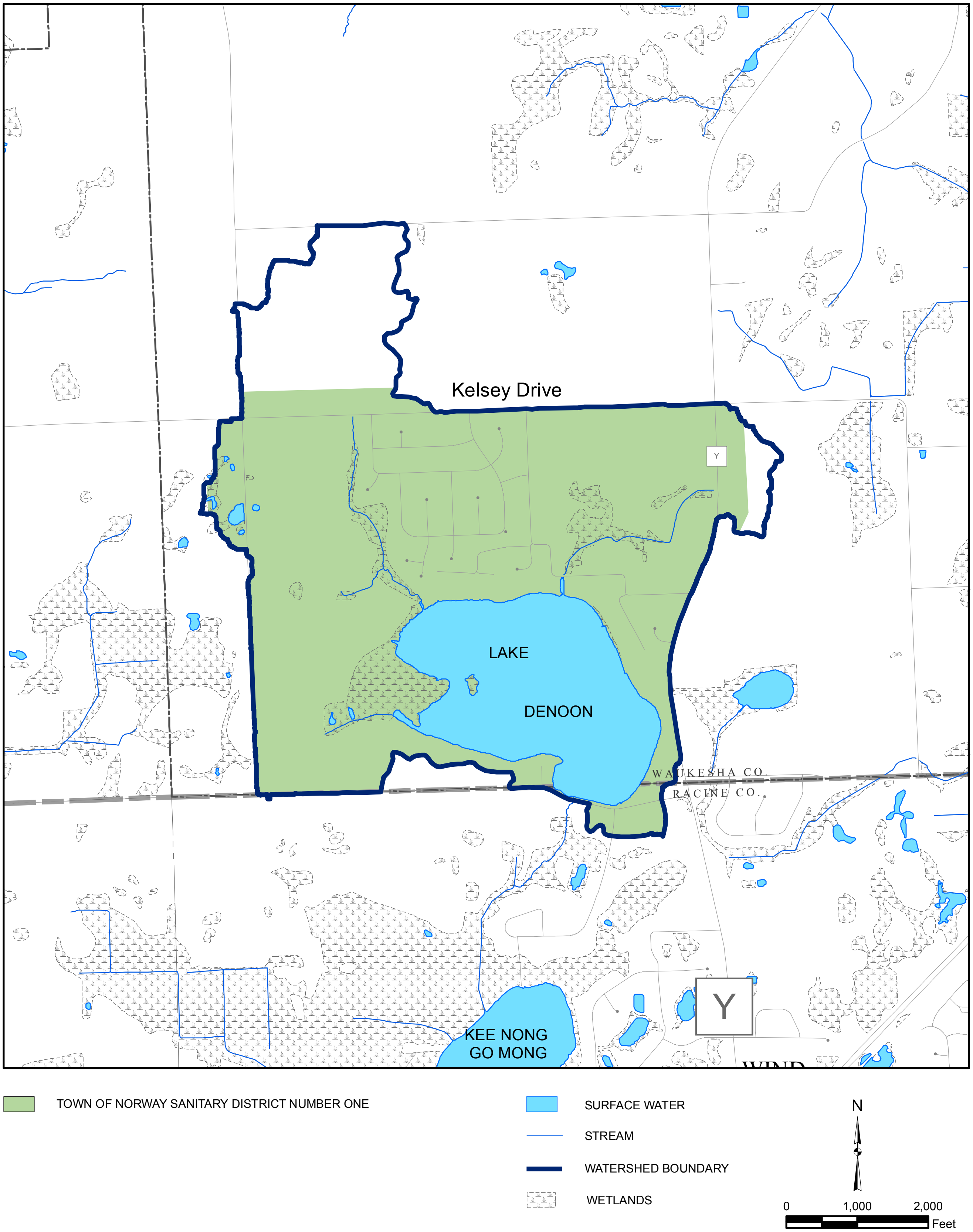
Source: SEWRPC

Map 2.8
2010 Agricultural and Open Lands Converted to Urban Development Under Planned 2035 Land Use Conditions Within the Lake Denoon Watershed



Source: SEWRPC

Map 2.9
Sanitary Sewer Service Area Within the Lake Denoon Watershed



Source: SEWRPC

5. **Artificial buffers (e.g., grassed waterways, vegetative strips)**—Artificial buffers can take a number of forms. A few examples include grassed waterways, vegetative strips, and gardens located along shorelines. Such buffers are generally constructed to intercept runoff shortly before it enters a river or lake. They function in a similar way to natural buffers (i.e., slowing runoff), need to be carefully designed, and should use native plants to promote reliable long-term function. Artificial buffers can enhance lake water quality without significant adverse effects to residential and agricultural land uses. More information regarding artificial buffers and their efficacy is included in Appendix B.

6. **Nearshore Aquatic Vegetative Buffers**—In-lake vegetation (e.g., bulrush, cattails) in shallow nearshore areas can filter and assimilate nutrients and sediments to some degree before runoff reaches the main body of a lake. Nearshore aquatic vegetation also helps protect shorelines from erosion and provides valuable aquatic habitat to a wide range of animals. Consequently, <u>encouraging survival and enhancement of nearshore vegetation can help improve lake water quality</u>.

As noted above, the location, appearance, and function of these features commonly overlaps, providing multiple benefits. To identify and locate each of the features described above, SEWRPC staff completed an inventory of the detention basins, wetlands, and natural features such as woodlands within the watershed, using existing databases, mapping software, and aerial imagery. Additionally, to identify the extent and condition of shoreline buffers, SEWRPC staff completed a field assessment of the Lake Denoon shoreline during summer of 2014. These inventories are discussed below.

Few stormwater basins are located within the Lake Denoon watershed. Most are located in residential developments to the north of the Lake. If properly maintained, stormwater basins help limit the amount of pollution entering Lake Denoon from the connected residential areas. Consequently, <u>maintenance of these ponds should be considered a priority</u>. Recommendations related to this topic are provided in Chapter 3 of this report.

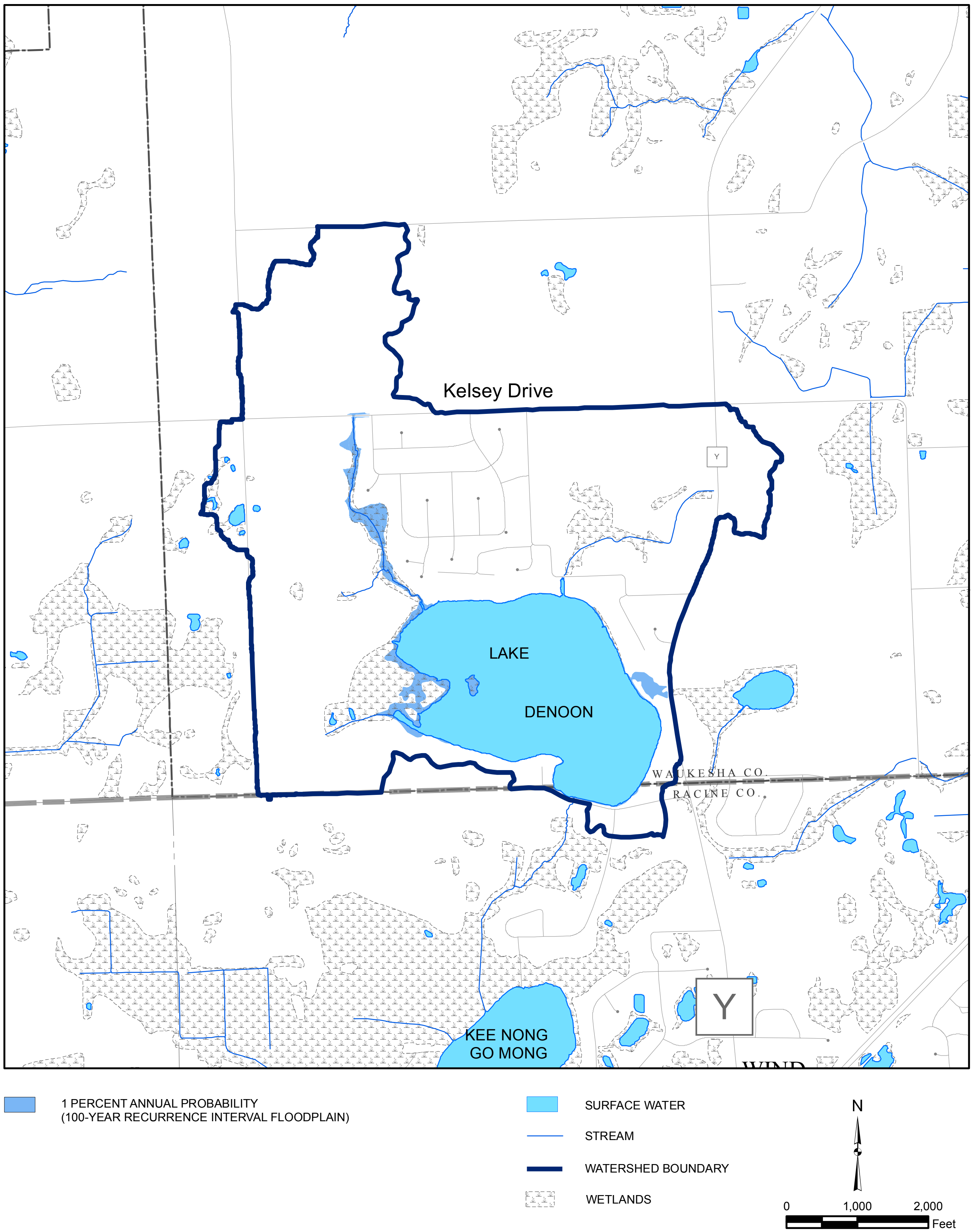
As of 2010, 7.5 percent of the Lake Denoon watershed was comprised of wetlands. Fortunately most wetlands are located along the tributary streams on the north side of the Lake and along the west shoreline (Map 2.5). Such wetland areas help shield the Lake from pollution and sediment from much of the watershed. They also provide valuable and diverse habitat function for aquatic, terrestrial, and avian life. The ability to naturally remove pollutants and detain floodwater, in combination with their critical ecological functions, underscores the importance of preserving and, if possible, enhancing remaining wetlands in the Lake Denoon watershed. Consequently, <u>recommendations related to maintaining and enhancing wetland functions are included in Chapter 3 of this report</u>.

Almost five percent of the Lake Denoon watershed is occupied by woodlands. Woodlands and other natural areas are particularly valuable when located in areas adjacent to the Lake or its tributaries (Map 2.5). Consequently, <u>these areas should be protected to the greatest extent practical to protect the water quality and overall environmental integrity of the Lake</u> (see Chapter 3 for recommendations).

Mapped floodplains occupy only about 20 acres of the land tributary to Lake Denoon (Map 2.10). As shown on the map, these areas are located primarily along the tributary streams on the north side of the Lake and adjacent to the marsh area at the west end of the Lake. The Lake elevation is controlled by an outlet dam, a feature that spills excess water downstream to avoid abnormally high Lake water elevations and flooding. Although floodplains occupy only a small area, they provide valuable functions such as providing quiescent floodwater detention, lowering the erosive power of tributary streams, and allowing sediments and entrained pollutants to be deposited in riparian areas instead of the Lake. Such areas may also encourage surface water infiltration, helping bolster dry weather flow to the Lake. Finally, floodplains are critical habitat to many aquatic species, including amphibians such as frogs and toads; they also serve as spawning and nursery areas for gamefish such as northern pike. <u>Even though small in size and extent, it is important to protect floodplains from development and enhance them where and when possible</u>.

The locations of artificial terrestrial buffers along the shoreline of Lake Denoon, and other shoreline protection measures (e.g., riprap), are shown on Map 2.11. As shown on the map, very few existing artificial terrestrial buffers exist, primarily small gardens along the shoreline. Such buffers can trap or detain pollution that could otherwise enter the Lake (e.g., lawn clippings, fertilizers, oils, sediment). Consequently, <u>installing</u>

Map 2.10
Floodplains Within the Lake Denoon Watershed



Source: SEWRPC

Map 2.11
Shoreline Characteristics and Existing Buffers Along Lake Denoon: 2014

and enhancing terrestrial buffers along Lake Denoon's shoreline should be considered a high priority. Recommendations related to terrestrial buffers, as well as nearshore aquatic vegetative buffers, are further discussed in Chapter 3 of this report.

Creating new buffers and enhancing existing buffers and wetlands should be important aspects of protecting Lake Denoon's long-term water quality. This reflects and agrees with the goals of the *Wisconsin's Healthy Lakes Implementation Plan*. This plan focuses on habitat restoration, runoff, and erosion control projects to improve and protect the health of our lakes through shoreline owner participation. Buffer and wetland maintenance and development should target portions of the watershed where such filtering features are currently absent or poorly developed. Such areas have a higher chance of allowing polluted runoff to directly enter the Lake or tributary streams. Some of these areas were identified by comparing the flow pathways within the watershed to the locations of the natural and artificial filtering features discussed above.[37] Significant volumes of runoff are currently directed through small natural wetlands along the tributary streams; buffer features that should help filter and reduce the pollutant loads to the Lake. Therefore, it is important that these small wetlands, and their streams, be protected and left intact, particularly in the northeast portion of the watershed where most of the residential development is planned to occur. Areas on the north side of the Lake located between tributary streams and most of the southern and eastern shoreline of the Lake drain directly to the Lake and do not pass through any protective wetland or buffer. Therefore, it is important to target these areas for pollution control and reduction efforts such as strict enforcement of stormwater management and construction site erosion control ordinances, active implementation of best management practices, naturalized landscaping, supplemental stormwater management ponds and "green" practices (e.g., vegetated drainage swales, porous pavement), buffer enhancement projects, erosion control and enhancement, and initiation of programs to reduce phosphorus loading from residential and urban areas (e.g., enhanced residential street leaf litter disposal, on-site detention such as rain gardens, naturalized landscaping). Chapter 3 provides water quality enhancement recommendations.

2.3 ISSUE 2: WATER QUANTITY

Lake Denoon is a seepage lake, and, therefore, it depends upon localized runoff and groundwater for its water supply. Water levels in such lakes fluctuate in response to rainfall patterns, as they have been documented to do on Lake Denoon for over 100 years. Fluctuating lake levels are a natural occurrence in seepage lakes, and are important to maintain desirable habitat. For example, fluctuating water levels promote the growth of diverse wet meadow and marshland plant species.[38] Species such as the bulrush need fluctuating water levels to disperse, establish themselves, and grow.

The amplitude of natural water level fluctuation was likely reduced by construction of the outlet dam, a change that allows high water to spill, reduces the highest water elevations during wet periods, increases water levels during certain times of the year, and leads to more consistent water levels during all but the driest periods. Nevertheless, the Lake is reportedly prone to excessively high water levels during periods of heavy runoff.[39] For this reason, careful inspection of the physical characteristics and hydraulics of the Lake Denoon outlet are recommended in Chapter 3.

Given that climate patterns are changing within Wisconsin,[40] future air temperatures could increase and/or precipitation could be different than that experienced during the past 150 years. If warmer and drier conditions prevail, lake levels could decline. Similarly, if groundwater supplies are reduced by climatic changes, pumping, or decreased infiltration caused by development, dry weather lake elevations could decrease. Increased precipitation, lower temperatures, and increased groundwater contribution could cause Lake levels to rise causing the spillway to pass higher flows for longer periods of time. The extent and nature of potential change is difficult to predict on a local level without a comprehensive local climate analysis,

---

[37] *Flow pathways within the Lake Denoon watershed were determined using land elevation data and field investigations.*

[38] *Keddy and Reznicek, "Great Lakes Vegetation Dynamics: The Role of Fluctuating Water Levels and Buried Seeds,"* Journal of Great Lakes Research *12(1), 1986, p. 25-36.*

[39] *Tom Zagar, op. cit.*

[40] *Wisconsin Initiative on Climate Change Impacts (WICCI),* Wisconsin's Changing Climate—Impacts and Adaptation*, 2011.*

which is beyond the scope of this study. In general, some climate models predict that certain future climate changes could alter hydrologic budgets, leading to changes in water levels or flows, and cause water levels to fluctuate more due to larger fluctuations in precipitation.[41]

In general, Lake elevations would be vulnerable to change if surface and groundwater inflow and/or outflow are manipulated, inconsistent, or lost over a season, if the Lake outlet elevation were to be changed, or if the boundaries of surface water or groundwater contributing watersheds were changed by human activity. For the long-term health of the Lake, it is important to focus on projects that can protect the Lake's sources of inflowing water. These projects generally address two primary factors that influence Lake water supply during periods of adequate rainfall and periods of drought. These factors are:

- The ability of the watershed to store and gradually release surface water runoff (i.e., surface water detention). Changes to this system typically influence fair and wet weather lake elevation.

- The recharge rates of aquifers (i.e., groundwater systems) that supply the baseflow of water to the Lake. Reduced groundwater recharge reduces groundwater inflow which thereby can lower lake elevations during dry weather.

Reducing the volume of either surface water or groundwater flow increases hydraulic residence time. Surface-water and groundwater factors are discussed in more detail below.

Source Water Protection

Surface Water Management

The speed at which precipitation and snowmelt leaves the land surface is controlled by many variables including the nature of underlying soils, the slope of the land surface, vegetation, and the amount of water detention available on the landscape. Detention can be provided by floodplains, ambient vegetation, localized ponding, stormwater detention basins, transient near-surface infiltration, buffers, or wetlands, all of which detain runoff, temporarily storing and gradually releasing stormwater, and, in some instances, allowing the water to soak deep into the ground where it becomes a component of groundwater recharge. Some of the water that infiltrates into the ground becomes part of the local groundwater flow system, moves slowly towards lakes and streams, and eventually discharges to a water body. Such discharge is critically important to certain species and overall lake health since the water released to the stream has a cool stable temperature, is relatively free of pollutants, and is available during times of drought.

If buffers, wetlands, and other features do not exist to temporarily store and gradually release the runoff, stormwater will enter a lake more rapidly, and (depending on the lake size and outlet characteristics) will quickly flow out of the lake. In this case, a smaller volume of relatively clean, cool water is available within the watershed to gradually supply the lake over time and during dry periods. Rapid runoff generally results in higher rates of erosion and greater concentrations of sediment and nutrients reaching lakes, streams, and wetlands.

Impervious surfaces increase the volume and velocity of stormwater runoff (see Figure 2.25).[42] Many studies directly link increases in impervious land surface to decreases in habitat quality and ecological integrity. For example, a 2003 study of 47 southeastern Wisconsin streams reported that fish and insect populations decline dramatically when impervious surfaces cover more than about 8 to 10 percent of the watershed, and streams with more than 12 percent watershed impervious surface consistently have poor fish communities.[43] Consequently, reducing or preventing impervious cover, or installing measures meant

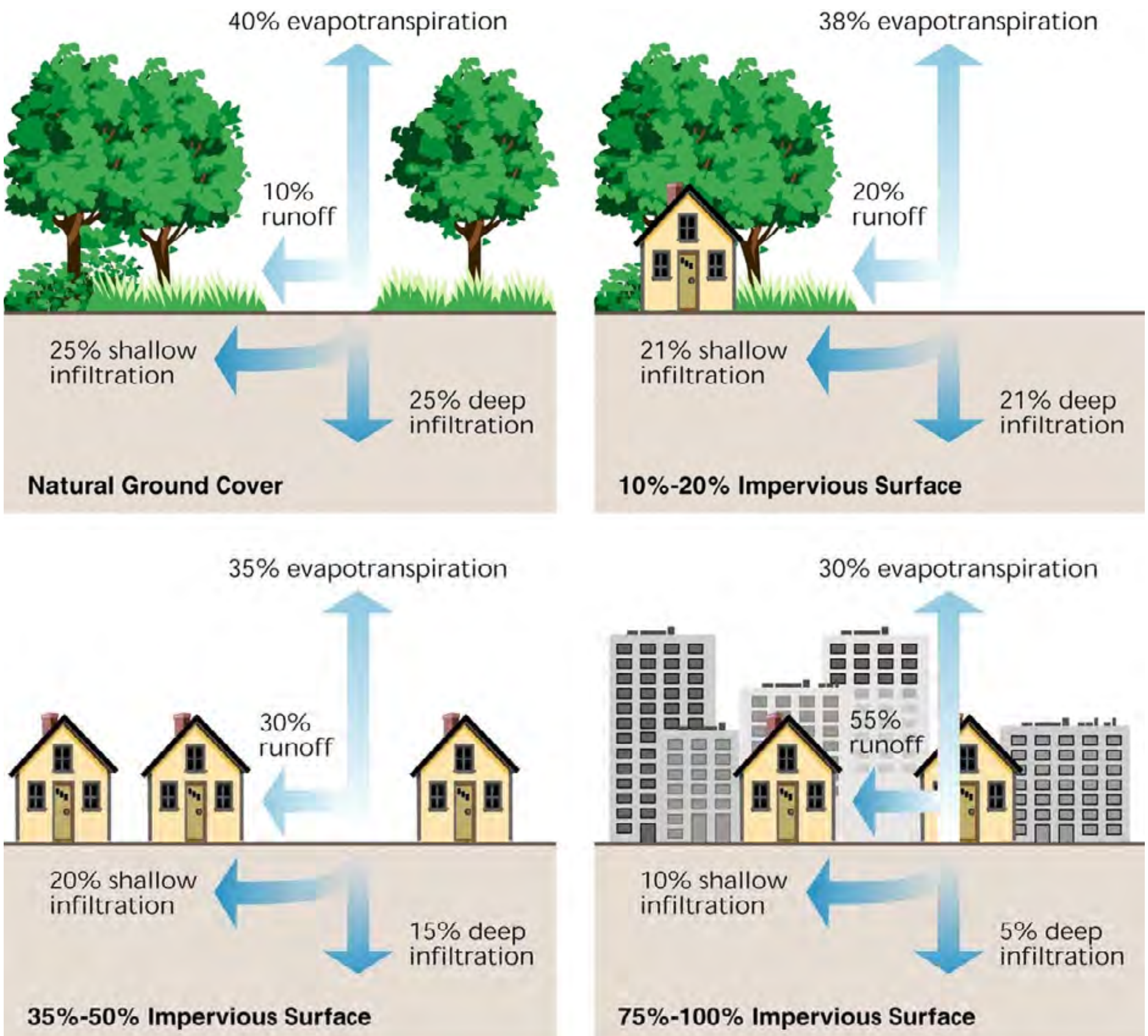
---

[41] *Ibid.*

[42] *Impervious surfaces are those that resist or prevent absorption or transmission of water (e.g., asphalt or concrete parking areas and roadways, sidewalks, rooftops)*

[43] Center for Land Use Education. Page 13. *www.uwsp.edu/cnr/landcenter/pdffiles/Imp_Surf_Shoreland_Dev_Density.pdf Research studies: Wang, L., J. Lyons, P. Kanehl, R. Bannerman, and E. Emmons 2000.* Watershed Urbanization and Changes in Fish Communities in Southeastern Wisconsin Streams. Journal of the American Water Resources Association. *36:5(1173-1187); Wang, L., J. Lyons, and P. Kanehl 2001.* Impacts of Urbanization on Stream Habitat and Fish Across Multiple Spatial Scales. Environmental Management. *28(2):255-266*.

Figure 2.25
Schematic of the Effects of Impervious Surfaces on Runoff and Groundwater Recharge



Source: Federal Interagency Stream Restoration Working Group and SEWRPC

to reduce the runoff from impervious surfaces (e.g., rain gardens and buffers), are critical components to help ensure adequate volumes of water supply to a lake during dry periods, and that stormwater runoff volumes are reduced during wet periods. The effect of impervious surfaces can be reduced in many ways, including the following examples:

- Limit the size of hard surfaces:
  - Limit driveway width or share between neighbors.
  - Minimize building footprints (i.e., build taller instead of wider or deeper, consistent with local zoning ordinances).
  - Remove unneeded sidewalks and parking areas.

- Opt for pervious materials:
  - Green roads (e.g., incorporate bioswales, grassed ditches, and similar design components).
  - Install mulch walkways as opposed to concrete walkways.
  - Use permeable pavers for walkways and driveways.
- Capture or infiltrate runoff:
  - Use rain barrels.
  - Establish rain gardens.
  - Channel gutters and downspouts to rain barrels, rain gardens, or places water can soak into the ground.
  - Assure that lawn area soils are not compacted
- Maintain and restore shoreline buffers (as discussed under "Issue 5: Shoreline Maintenance").

Additional information and ideas may be found in Appendix C.

To determine where improvements can be made to maintain and extend the volume of water supplied to Lake Denoon, several factors need to be assessed. These include understanding the location and extent of:

1. **Current urban land use within the watershed**—Urban land uses generally have a much higher percentage of impervious cover than rural land uses. Consequently, to assess where management efforts can be made to reduce the amount of impervious cover (or where efforts can be made to slow down or reduce the runoff leaving these areas), it is necessary to identify where urban land use exists.

2. **Planned land use changes within the watershed**—Since urban land use generates a higher percentage of impervious cover, it is important to know where rural land is expected to be converted to urban land in the future. In such cases, extra precautions can be taken to implement management efforts that will reduce post-development runoff velocity and/or volume.

3. **Natural areas and stormwater management structures**—Stormwater retention and detention basins and natural areas (e.g., buffers, grassy waterways, and woodlands) slow runoff velocity, in some cases to store and gradually release water, and to promote infiltration of water into the soils. Consequently, if runoff passes through such features, it can modulate runoff peaks and increase the time during which a volume of runoff is supplied to the Lake.

To help target water volume management efforts, SEWRPC staff inventoried the three preceding factors for Lake Denoon's watershed using geographic information system techniques and 2010 color digital orthophotography, collected under a regional orthophotography program administered by the Commission. Current and planned land uses are shown on Maps 2.5 and 2.7. Urban land use currently occupies about 45 percent of the area contributing runoff to Lake Denoon. By comparing 2010 and 2035 land use data, it can be seen that approximately 100 acres of the watershed which are currently used for agriculture will be converted to urban uses under planned year 2035 conditions (Map 2.8). This will increase urban land use to almost 60 percent of the watershed area. Though much of the land planned for conversion from agricultural to urban uses is currently well buffered, the proximity of this development area to the Lake may be a cause for concern if infiltration practices, stormwater management, and buffer enhancement are not implemented in these new developments. Consequently, recommendations for stormwater management related to this new planned development, as well as general recommendations for slowing, storing, and infiltrating runoff, are included in Chapter 3 of this report.

As was discussed in the "Water Quality" section, aside from near-shore residential areas, most runoff enters some form of natural feature that can help reduce small storm runoff volume and improve runoff quality through infiltration and/or filtering. Consequently, recommendations to increase water infiltration and filtering on near-shore residential areas are also included in Chapter 3.

Groundwater Management

Water that reaches the Lake via groundwater is commonly referred to as baseflow. Groundwater is replenished by precipitation that soaks into the ground and enters the aquifers. This is referred to as "groundwater recharge." Baseflow is especially important to Lake Denoon since it is a seepage lake with a small watershed, and it, therefore, receives little to no surface water during dry periods. Groundwater typically contains little to no sediment or phosphorus, has a more stable temperature regimen, and commonly contains a lower overall pollutant load when compared to surface water runoff – all of which are favorable to aquatic life and the ecology of waterbodies. Groundwater-derived baseflow sustains many wetlands and creeks during drier periods, enabling these features to maintain a diverse assemblage of plants and animals and enable them to provide unique ecological functions. Consequently, it is important to maintain recharge to local aquifers that supply Lake Denoon and the streams and wetlands that drain to the Lake.

Generally, humans deplete groundwater supplies to lakes in two ways: 1) pumping from an aquifer supplying baseflow, thereby reducing, or in extreme cases, eliminating, flow from springs and seeps and 2) reducing groundwater recharge through land uses that increase impervious cover. The first of these issues most commonly occurs when a high-capacity well, or multiple wells, are installed in the groundwatershed of a lake or a stream without considering the effect pumping may have on the naturally occurring groundwater discharge areas associated with the aquifer. Since there are no known high-capacity wells in the Lake Denoon groundwatershed and water levels in Lake Denoon have not reportedly decreased, sufficient quantities of groundwater apparently discharge to the Lake to maintain a desirable elevation. Since sufficient groundwater seems to discharge to the Lake to maintain its desired elevation during dry periods, groundwater depletion is not considered a priority issue of concern at the present time. However, if a high-capacity well or numerous additional smaller wells were proposed in the Lake's groundwatershed in the future, their effect on Lake level should be carefully investigated, and if those effects were found to be significant, they should be mitigated.[44] Whatever the case, actions that lessen consumptive use of groundwater in the Lake's groundwatershed should help maintain or enhance groundwater flow to the Lake, and should therefore be actively pursued wherever practical.

The second common cause of groundwater depletion is reduced groundwater recharge. Aquifer recharge can be reduced in many ways. Hastening stormwater runoff, eliminating native vegetative cover, ditching and tiling and otherwise draining wet areas, disconnecting floodplains from streams, and increasing the amount of impervious land surface can all contribute to reduced stormwater infiltration, increased runoff, and reduced groundwater recharge. Development and land management activities need to consider groundwater recharge,[45] and actions to protect and enhance recharge should be a priority.

Since the Lake's water surface elevation is reportedly remaining within a desirable range, groundwater pumping and impervious surfaces apparently are not unduly taxing water supplies or restricting recharge to the aquifers supporting the Lake's baseflow. Nevertheless, since groundwater flow systems react only slowly to change, decreases in baseflow may only be noticeable with time, and vigilance is warranted. Consequently, to maintain groundwater-sourced baseflow to Lake Denoon, it is necessary to identify high priority groundwater recharge areas for protection and watershed-wide practices that enhance recharge in all areas. To help support this activity, two factors need to be analyzed, including:

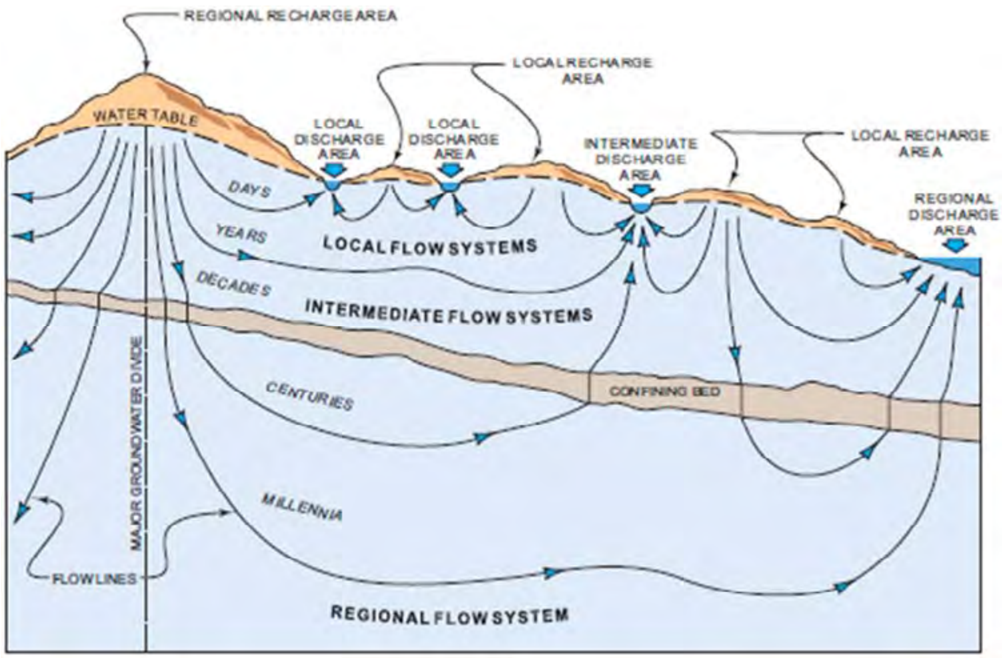
1. **The direction of groundwater flow**—To understand the dynamics of baseflow to a lake, it is important to know where groundwater recharge occurs and in what direction groundwater is flowing. In most instances, groundwater elevation is a subdued reflection of surface topography. Topographically higher areas are commonly recharge areas, while lakes, wetlands, and streams in valleys are commonly groundwater discharge areas. Groundwater recharge/discharge systems occur on many spatial scales: long regional recharge/discharge relationships and short localized

---

[44] *SEWRPC Planning Report No. 52,* A Regional Water Supply Plan for Southeastern Wisconsin*, December 2010.*

[45] *Ibid.*

Figure 2.26
Local Versus Regional Groundwater Flow Paths



Source: A. Zaporozec in SEWRPC Technical Report Number 37, Groundwater Resources of Southeastern Wisconsin, 2002

flow paths, both of which can be important contributors to a lake's overall water budget. While localized groundwater flow systems typically occur within the surface water watershed, regional groundwater flow paths may trace directions and distances out of phase with surface water feeding a lake. Therefore, the groundwater feeding a lake may originate in areas distant from the lake and/or outside the lake's surface water watershed boundary. The relationship between short and long distance flow paths is illustrated in Figure 2.26.

Smaller-scale local groundwater flow paths generally mirror surface water flow paths. However, to approximate the direction of deeper, more regionally extensive flow systems, groundwater elevation contours derived from elevation measurements collected in water supply or monitoring wells need to be consulted. Since water normally moves perpendicular to elevation contours, groundwater flow directions can be predicted. When performing such analysis, it is necessary to consider the locations and elevations of streams, ponds, and lakes other than the waterbody of interest. This relationship can be used to predict if a surface water body is fed by groundwater, recharges groundwater, or has little interaction with groundwater. By combining these data, maps can be prepared identifying land areas that likely contribute recharge and are therefore sources of baseflow to a surface water feature, and areas that convey groundwater to the lake.

2. **The groundwater recharge potential of the area feeding aquifers**—Groundwater recharge potential is related to slope, soil characteristics, the amount of impervious cover, and other factors. For example, a flat area with no impervious cover and highly permeable soils likely has high or very high groundwater recharge potential, whereas a hilly area with low permeability (e.g., clay soils) would be classified as low potential. Evaluating groundwater recharge potential helps identify the areas most important to sustainable groundwater supplies. The Commission evaluated groundwater recharge potential for all of Southeastern Wisconsin.[46] Such data can help planners decide which areas should not be covered with impervious surfaces or where infiltration basins would be most effective.

[46] *SEWRPC Technical Report No. 47,* Groundwater Recharge in Southeastern Wisconsin Estimated by a GIS-Based Water-Balance Method*, July 2008.*

To help determine where management efforts could be best employed to protect groundwater recharge to aquifers feeding Lake Denoon, SEWRPC staff analyzed groundwater elevation contours and the groundwater recharge potential in the areas surrounding the Lake.[47] This inventory was not confined to the surface watershed, as was the case for the other inventories completed in this report, because groundwater flow paths may extend beyond the area contributing surface-water runoff to the Lake. The results of these inventories are described below.

Map 2.12 shows the general water table elevation contours, in feet above National Geodetic Vertical Datum, 1929 adjustment (NGVD 29), in the Lake Denoon area as well as areas of high and moderately high potential for groundwater recharge. Where available, approximate water surface elevations are added for major water bodies. The regional groundwater flow system generally slopes to the southeast away from significant recharge areas located in highlands to the north and northeast of the Village of Big Bend. The Fox River is a significant groundwater discharge area. Although small amounts of groundwater may reach Lake Denoon from as far away as the Village of Big Bend, most groundwater-sourced baseflow appears to originate in a small area less than a mile and a half to the northwest of the Lake. Groundwater is likely to discharge to the Lake's northwest tributary, to the northwest corner of the Lake, and possibly to the wetlands abutting the western shoreline. Given what is known about the Lake's water elevation, the Lake likely loses water to the underlying shallow aquifer under the southeastern half of the Lake.

Localized flow systems likely contribute groundwater to the Lake from areas found primarily to the northwest of the Lake. The range of groundwater recharge potential of the lands near Lake Denoon is illustrated on Map 2.13. The area with the highest groundwater recharge potential lies near Denoon Park. Infiltration of precipitation and runoff into this and other areas enhances the amount of groundwater entering the Lake and reduces runoff volume. Reduced runoff volume usually correlates with lower erosion potential and decreased sediment and pollutant loading to downstream water bodies. The Denoon Park area may provide an excellent opportunity to protect and even enhance localized groundwater recharge, as is expanded upon in Chapter 3 recommendations.

The groundwater recharge potential of most of the remaining groundwatershed is classified as moderate. Many of the areas of moderate recharge potential found north of the Lake are urbanized, with impervious surfaces that decrease this area's ability to recharge local groundwater flow systems. <u>Opportunities to enhance stormwater infiltration should be actively pursued wherever practical in all areas to the northwest of the Lake</u>. However, in general, areas closer to the Lake have greater potential to influence groundwater flow to the Lake. The south shoreline area near the Lake's outlet may lose water to a localized flow system circumventing the dam and spillway and contributing baseflow to the outlet stream in Racine County.

Lake Denoon may act as a flow-through system, gaining water from the groundwater flow system along its northwest areas, and losing water to the groundwater flow system in southern and eastern portions of the Lake. This means that the Lake may receive little net gain of water from the groundwater flow system during dry periods. The excess water passed through the Lake's outlet may relate primarily to surface water inflow.

Even without detailed study, some projects can be undertaken to help maintain or improve the volume and timing of water delivered to the Lake. In the interest of encouraging these kinds of actions, <u>Chapter 3 presents recommendations focused on increasing infiltration in the moderate and high groundwater recharge potential areas that may contribute to Lake Denoon's baseflow</u>. These recommendations should be implemented wherever practical. Consideration should be given to promotion of stormwater infiltration practices. Examples of promotion includes providing incentives that encourage stormwater infiltration and/or promulgating ordinances that incorporate performance metrics that can be efficiently met using stormwater infiltration techniques.

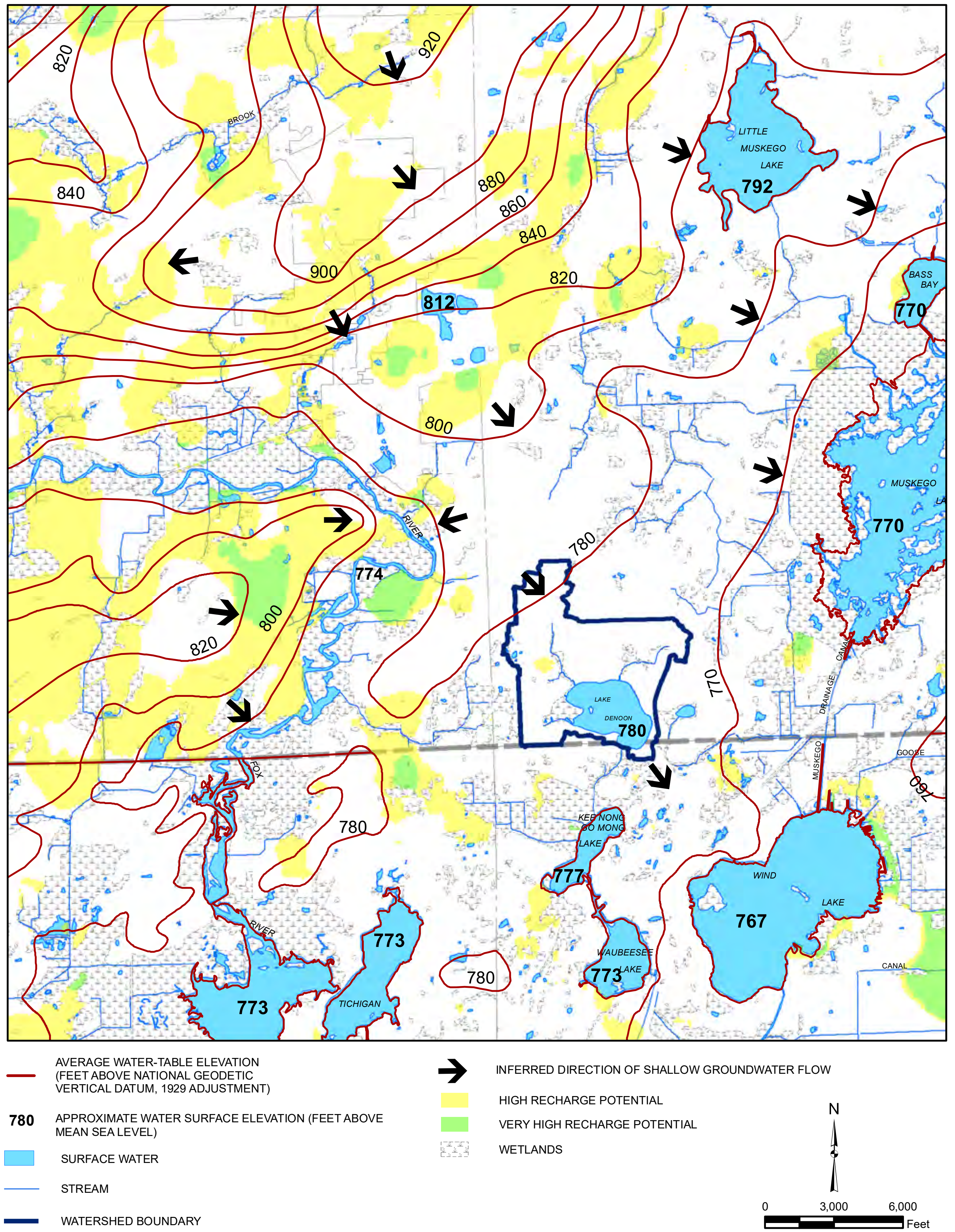
2.4 ISSUE 3: AQUATIC PLANT GROWTH

This section describes the general need for aquatic plant management by evaluating the current state of aquatic plants in Lake Denoon, comparing the current state with past surveys, and then discussing management alternatives.

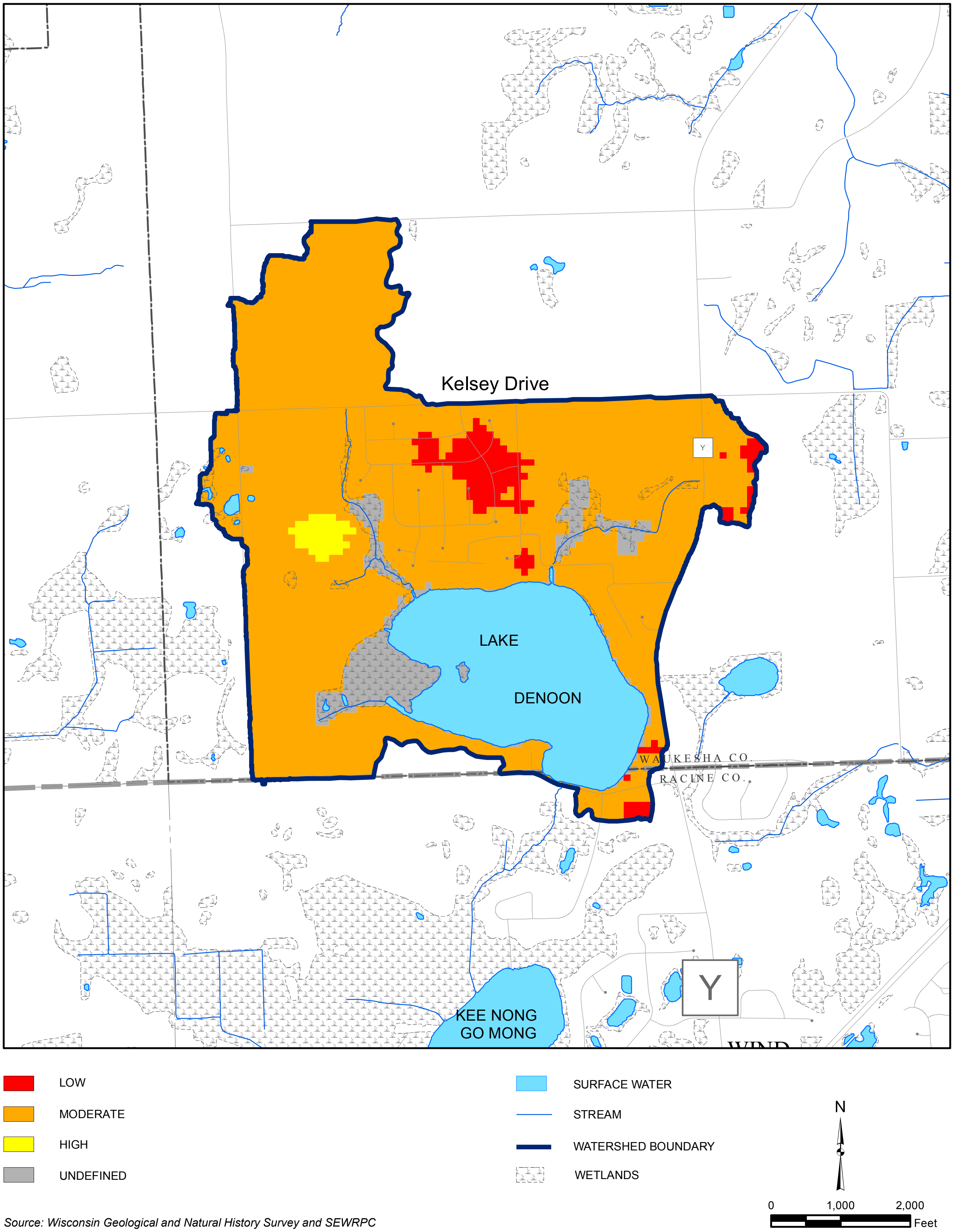
---

[47] *SEWRPC Planning Report No. 52, op. cit.*

Map 2.12
Groundwater Flow Directions Based on Well Elevations Along with High and Very High Estimates of Groundwater Recharge Potential



Map 2.13
Estimates of Groundwater Recharge Potential Within the Lake Denoon Watershed



Source: Wisconsin Geological and Natural History Survey and SEWRPC

Aquatic Plants in Lake Denoon

All lakes have plants. In fact, in a nutrient-rich lake such as Lake Denoon,[48] it is actually normal to have abundant aquatic plant growth in shallow areas. Additionally, it is important to note that native aquatic plants are an integral part of lake ecosystems. Aquatic plants serve a number of valuable functions including: improving water quality by using excess nutrients; providing habitat for invertebrates and fish; stabilizing lake bottom sediment; and supplying food and oxygen to a lake through photosynthesis. Given the importance of native aquatic plants to overall Lake health, it is desirable to periodically re-examine the abundance, distribution, and diversity of aquatic plants. Such data is contrasted to historical conditions in the Lake itself and other similar lakes, both comparisons help quantify the overall health of the aquatic plant community. A judgement can subsequently be made regarding the need for aquatic plant management, and the locations and methods that provide the most overall apparent benefit to the Lake's health and user needs. Data and interpretations related to Lake Denoon are presented below.

2013 Aquatic Plant Survey

To help determine the need for aquatic plant management SEWRPC staff completed an aquatic plant survey during July 2013 using the point-intercept method.[49] This was the first point-intercept survey for the lake.

The 2013 survey revealed that Lake Denoon's five most dominant native plant species, were, in descending order of abundance:

- Coontail (*Ceratophylum demersum*)
- Muskgrass (*Chara* spp.)
- White-stem pondweed (*Potamogeton praelongus*)
- Eel-grass/water celery (*Vallisneria americana*)
- White water lily (*Nymphaea odorata*).

Table 2.9 lists all aquatic plant species observed as part of the 2013 survey along with each plant's relative abundance and dominance, while Table 2.10 presents summary statistics for all the species. (See Appendix D for the field data for the aquatic plant survey.) Distribution maps for each species are included in Appendix E along with text explaining the ecological significance of each plant and identification guidance.

Sampling sites with water depths less than the 16-foot maximum rooting depth of plant growth in Lake Denoon had moderately heavy amounts of aquatic vegetation.[50] Most of these sites contained vegetation known to interfere with recreational use when growing in abundance (such as coontail). These results indicate that the Lake has types of plants growing at levels of abundance that can deter recreational use. Therefore, active aquatic plant management is warranted.

Since no comprehensive, point-intercept aquatic plant surveys were completed on Lake Denoon before 2013, data from earlier surveys is not directly comparable.[51] Point-intercept plant surveys should be

---

[48] Nutrient-rich lakes are very common in Southeastern Wisconsin due to nutrient-rich soils. Southeastern Wisconsin soils are rich in phosphorus, a key and oftentimes growth-limiting plant nutrient.

[49] The point-intercept method uses predetermined sampling locations arranged in a grid pattern across the entire lake surface as fixed sampling sites. Each site is located using global positioning system (GPS) technology and a single rake haul is taken at each site. A quantitative assessment of the rake fullness (on a scale of zero to three) is then made for each species identified. Further details on the methodology can be found in Wisconsin Department of Natural Resources, Publication No. PUB-SS-1068 2010.

[50] "Moderately heavy" vegetation in this context refers to an average rake fullness measurement of 2.36 on a scale of zero to three (see Appendix E for schematic of rake fullness ratings).

[51] The point intercept method uses predetermined points arranged in a grid pattern across the entire lake surface as sampling sites. Each site is located using global positioning system (GPS) technology and a single rake haul is taken at that site. A quantitative assessment of the rake fullness, on a scale of zero to three, is then made for each species identified. Further details on the methodology can be found at Wisconsin Department of Natural Resources, Publication No. PUB-SS-1068 2010.

Table 2.9
Abundance Data for Submerged and Floating Aquatic Plant Species in Lake Denoon: 2013

Aquatic Plant Species	Native or Nonnative	Number of Sites Found	Frequency of Occurrence[a]	Relative Density[b]	Dominance Value[c]
Floating Plants					
Nymphaea odorata (white water lily)	Native	25	12.1	2.4	29.0
Nuphar variegata (spatterdock)	Native	7	3.9	2.9	11.3
Submerged Plants					
Ceratophyllum demersum (coontail)	Native	154	74.4	2.1	156.2
Chara spp. (muskgrass)	Native	80	38.7	1.7	65.8
Potamogeton praelongus (white-stem pondweed)	Native	74	35.8	1.8	69.8
Myriophyllum spicatum (Eurasian water milfoil)	Nonnative	58	28.0	1.7	47.6
Valesneria americana (eel grass)	Native	59	28.5	1.3	37.0
Potamogeton gramineus (variable pondweed)	Native	32	15.5	1.2	18.6
Najas flexilis (bushy pondweed)	Native	28	14.5	1.3	18.8
Potamogeton pectinatus (Sago pondweed)	Native	19	9.2	1.0	9.2
Potamogeton richardsonii (clasping leaf pondweed)	Native	5	2.4	2.2	5.3
Zosterella dubia (water stargrass)	Native	11	5.3	1.0	5.3
Elodea canadensis (waterweed)	Native	5	2.4	1.4	3.4
Najas marina (spiny naiad)[d]	Native	5	2.4	1.2	2.9
Potamogeton crispus (curly-leaf pondweed)	Nonnative	2	1.0	1.0	1.0
Polygonum amphibium (water smartweed)	Native	1	0.5	1.0	0.5
Stuckenia filiformus (threadleaf pondweed)	Native	1	0.5	1.0	0.5

Note: Sampling occurred at 193 of the 207 sampling sites with vegetation.

a *Freqency of Occurrence is the number of occurrences of a species divided by the number of sampling sites with vegetation, expressed as a percentage. It is the percentage of times a particular species occurred when there was aquatic vegetation present.*

b *Relative Density is the sum of the density ratings for a species divided by the number of sampling points with vegetation. It presents an indication of how abundant the growth of a particular plant is throughout the lake.*

c *The* dominance value *of a species is the product of Relative Density multiplied by Frequency of Occurrence. It provides an indication of the dominance of a species within a community.*

d *Spiny naiad was added to the NR 40 list as a restricted species in 2015, meaning it is not allowed to be transported, transferred, or introduced without a permit. The species is not native to Wisconsin and can become quite abundant, especially in lakes of poor water quality with hard water. However, these conditions are not present in Lake Denoon; this plant can provide good habitat and food for fish and macroinvertebrates. Paul M. Skawinski, Aquatic Plants of the Upper Midwest 2nd Edition 2014; Through the Looking Glass: A Field Guide to Aquatic Plants 2nd Edition 2013.*

Source: SEWRPC

undertaken relatively frequently (three- to five-year intervals) to more accurately monitor plant populations and reinforce the ability to spot evolving trends in the plant community. Sampling frequency should be higher if negative developments are observed, such as loss of native species or rapid increase of plants, especially nonnatives. Nevertheless, earlier data does allow comparison of the presence and abundance of particular aquatic plants. For example, the study completed in 1967 identified eight dominant species of aquatic plants in the Lake. The list includes four of the five species identified as most dominant in 2013, but also includes yellow water lily (*Nuphar*, spp.), water milfoil (*Myriophyllum* spp.), floating-leaf pondweed (*Potamogeton natans*), and sago pondweed (*Stuckenia pectinata*).

A key aspect of the ability of an ecosystem to maintain ecological integrity is biological diversity, or *species richness*. Conserving ecosystem biodiversity not only helps sustain and increase the robustness of the existing system, but also helps preserves a spectrum of options for future management. Map 2.14 depicts the relative number of aquatic plant species observed at sampling sites during the 2013 survey. With sixteen different native submerged species of aquatic plants, eight of which were native pondweeds, and the two nonnative species in relatively small numbers compared to native plants, Lake Denoon appears to have excellent diversity of aquatic species, especially for a lake of its size. This may be due, in part, to the wide belt of shallow water around most of the Lake's perimeter. The presence of a diverse plant community (especially pondweeds) is generally considered indicative of a healthy lake with good habitat for fish and/or other aquatic life. Additionally, the presence of white-stem pondweed in the Lake, especially in such abundance (it was the third most abundant plant in the Lake), is especially encouraging since turbid waters and water quality degradation cause it to disappear from most disturbed systems. Furthermore, the abundance of muskgrass (the second most dominant plant) is encouraging since it is the plant largely responsible for marl formation and associated phosphorus sequestration. The existence of a healthy and robust native plant community in the Lake indicates that the native plant community should be protected to the greatest extent practical. Recommendations are presented in Chapter 3.

Table 2.10
Summary Statistics for all Aquatic Plant Species in Lake Denoon: 2013

Summary Statistics	2013
Total number of survey sites visited/sampled	193
Total number of survey sites with vegetation	206[a]
Total number of sites shallower than the maximum depth of plants	193
Frequency of occurrence at sites shallower that the maximum depth of plants	106.74
Simson Diversity Index	0.88
Maximum depth of plants (ft)	16.00
Number of sites sampled using rake on rope (R)	0
Number of sites sampled using rake on pole (P)	193
Average number of all species per site (shallower than max depth)	3.13
Average number of all species per site (veg. sites only)	3.01
Average number of native species per site (shallower than max depth)	2.80
Average number of native species per site (veg. sites only)	2.70
Species Richness	19
Species Richness (including visuals)	19

[a] *Thirteen additional sites were inaccessible due to abundant growth of white water lily. These additional 13 sites were vegetated by floating leaf plants, but the heavy shade cast by white water lily lessens the likelihood of significant numbers of rooted submerged aquatic plants from becoming established.*

Source: SEWRPC

The terms "nonnative" and "invasive" are often confused and incorrectly assumed to be synonymous. Nonnative is an overarching term describing living organisms introduced to new areas beyond their native range with intentional or unintentional human help. Nonnative species may not necessarily harm ecological function or human use values in their new environments. Invasive species are the subset of nonnative species that have damaging impacts on the ecological health of their new environments and/or are considered a nuisance to human use values. In summary, invasive species are non-native but not all non-native species are invasive.

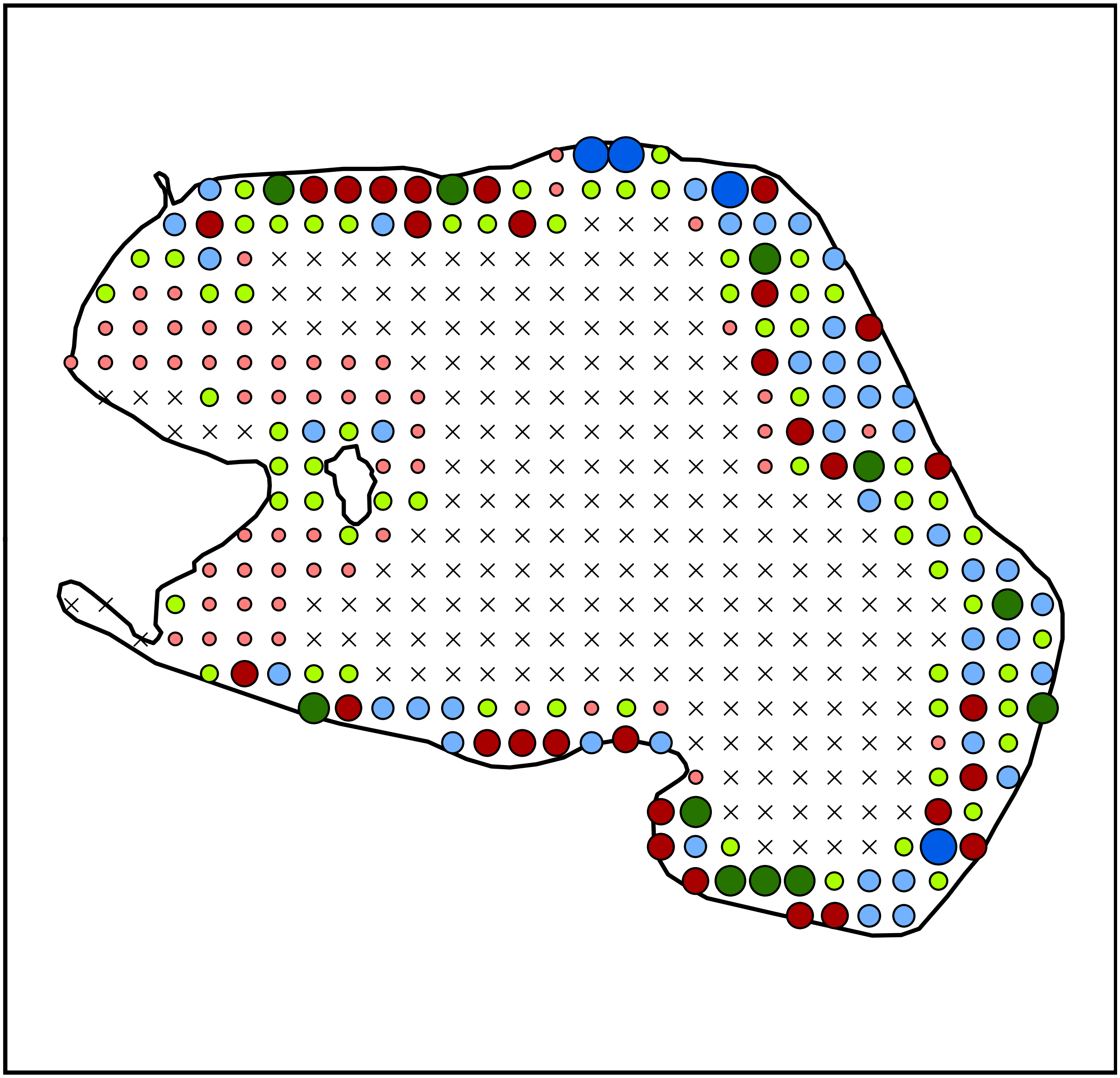
Invasive species, either plants or animals, can severely disrupt both terrestrial and aquatic natural systems. Invasive species reproduce prolifically and often have no natural predators to control their growth, factors that combine to allow them to out-compete native species for space and other necessary resources. This can devastate native species population that have well developed co-dependencies with native plants and animals.

Purple loosestrife, a nonnative shoreland plant that invades marshes and other wetlands, has been the subject of eradication measures focused on the marsh at the west end of the Lake since about 1999.[52] Purple loosestrife is no longer mapped on invasive species investigation maps covering the Lake Denoon watershed. Invasive species of high concern are continuously changing due to new introductions and successful management of past invasions. A list of common invasive wetland and aquatic plants of current concern in the Southeastern Wisconsin Region is found below. This list is based upon conversations with WDNR staff that took place during early 2016. A full list with photos may be found in Appendix F:

- Eurasian water milfoil (*Myriophyllum spicatum*)
- Curly-leaf pondweed (*Potamogeton crispus*)

[52] *Email from Tom Zagar, City of Muskego, to Michael Borst of the SEWRPC staff, August 19, 2013.*

Map 2.14
Aquatic Plant Survey Sites and Species Richness in Lake Denoon: August 2013



NOTE: The above diagram presents the data for number of species observed in Lake Denoon at each sampling site during the 2013 aquatic plant survey; sampling occurred at 206 sampling sites, 189 had vegetation. Samples were collected between August 19 and August 21, 2013.

NUMBER OF NATIVE SPECIES OBSERVED

- 1
- 2
- 3
- 4
- 5
- 6
- NOT SAMPLED

Source: Wisconsin Department of Natural Resources and SEWRPC

- Non-native phragmities (*Phragmities australis subspecies australis*)
- Reed canary grass (*Phalaris arundinaceae*)
- Hybrid cattail (*Typha x glauca*)
- Common buckthorn (*Rhamnus cathartica*)

A New Invasive Plant Species – Starry Stonewort

During fall 2014, the Wisconsin DNR confirmed that a new invasive aquatic plant species starry stonewort (*Nitellopsis obtusa*) was present in the State, specifically in southeastern Wisconsin.[53] This is a concern since starry stonewort can form extremely dense vegetative mats that may affect aquatic plant community species richness and can impede recreational use. Dense growth of starry stonewort can also interfere with life-cycle critical functions of fish and other animals, including fish spawning.[54] No management methods have yet been found to successfully manage its growth. The best control is to prevent its introduction to Lake Denoon.

Figure 2.27
Invasive Species in Lake Denoon and its Watershed

Curly-leaf Pond Weed | Eurasian Water Milfoil

Zebra Mussel | Reed Canary Grass

Source: Wisconsin Department of Natural Resources and SEWRPC

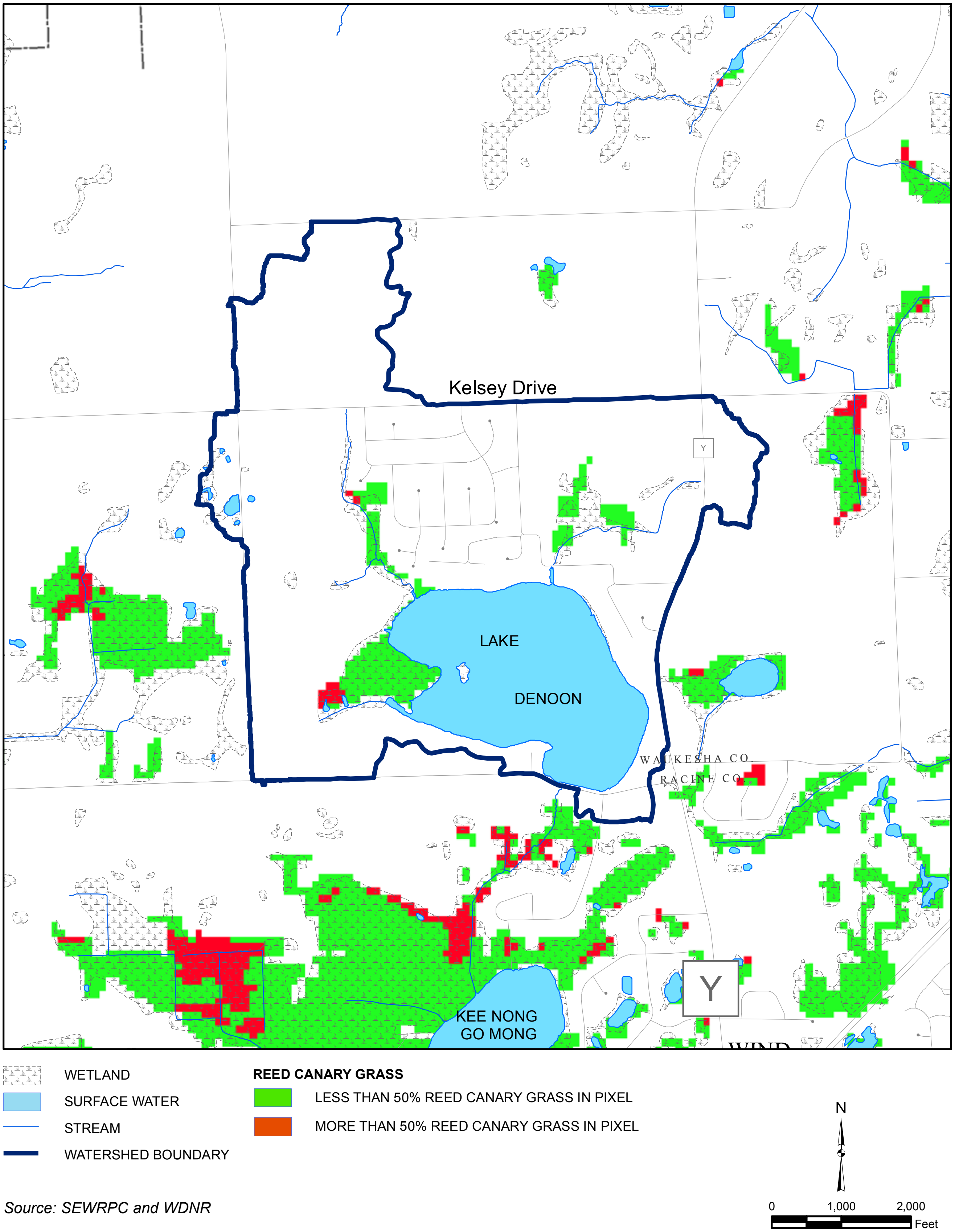
The WDNR officially lists three invasive plant species and one invasive animal species as present in Lake Denoon and its watershed: reed canary grass, curly-leaf pondweed, Eurasian water milfoil, and zebra mussels (Figure 2.27). Reed canary grass is found in wetlands throughout the watershed (Map 2.15), with the largest area of infestation being the large wetland that abuts the western shore of Lake Denoon. The remaining mapped invasive species only occur in the Lake itself. More detail regarding each is provided in the following paragraphs.

Curly-leaf pondweed was found in two sampling sites in the Lake during 2013 with a low average rake fullness value of one. Although present in the Lake, curly leaf pondweed's limited extent and small numbers make it a minor problem at present. The 2013 survey also revealed that Eurasian water milfoil (EWM, *Myriophyllum spicatum*) was overall the fourth most dominant species; EWM was found in about 30 percent of the sampling sites that had vegetation in Lake Denoon. Map 2.16 shows the distribution and density of the EWM infestations in Lake Denoon in 2013. As shown on the map, this plant is dispersed around most of the Lake's perimeter with the greatest concentrations found in the west end of the Lake. EWM has been known to cause severe recreational use problems in lakes within the Southeastern Wisconsin Region,

[53] *According to John Jung, President of the Pike Lake Advancement Association and Board Member of the Pike Lake Protection and Rehabilitation District, aquatic plants resembling starry stonewort were present in Pike Lake for many years before positive identification was made during 2014.*

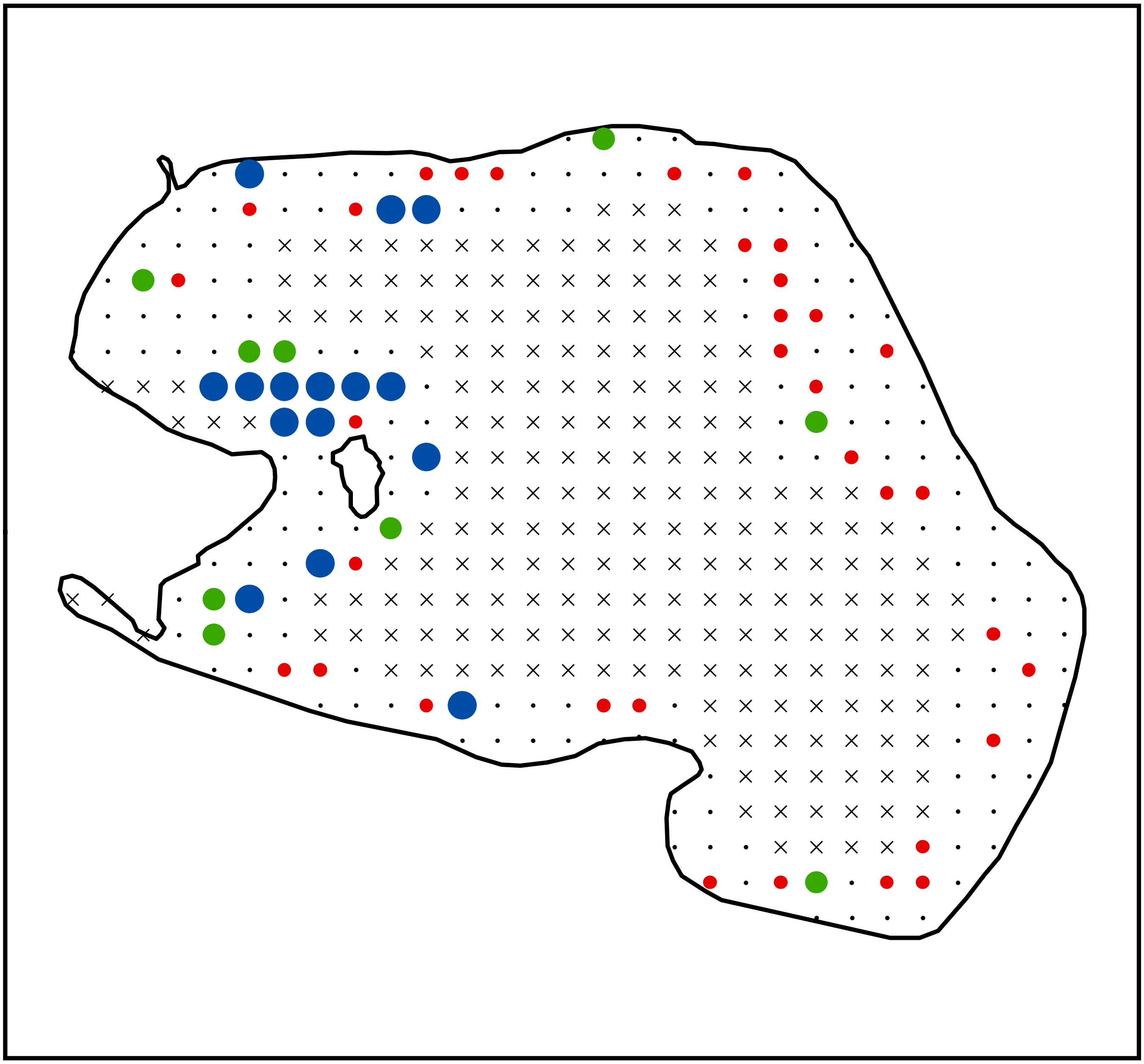
[54] *"Aquatic Invasive Species Quick Guide: Starry Stonewort* (Nitellopsis obtusa L.),*" Golden Sands Resource Conservation and Development Council, Inc., 2016 This Quick Guide is part of a series on aquatic invasive species, and may be reproduced for educational purposes. Visit www.uwsp.edu/cnr/uwexlakes/clmn or www.goldensandsrcd.org/our-work/water to download this series of handouts. Developed by Golden Sands Resource Conservation & Development Council, Inc. as part of an aquatic invasive species education program, supported by a grant from the Wisconsin Department of Natural Resources. Maintained and updated by the Wisconsin Citizen Lake Monitoring Network.*

Map 2.15
Reed Canary Grass Within the Lake Denoon Watershed



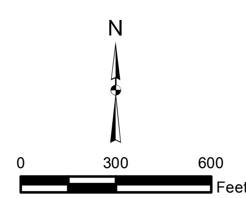
Source: SEWRPC and WDNR

Map 2.16
Eurasian Water Milfoil Occurrence in Lake Denoon: August 2013



NOTE: Samples were collected between August 19 and August 21, 2013.

RAKE FULLNESS RATING



• NO EURASIAN FOUND × NOT SAMPLED

Source: SEWRPC

Table 2.11
Chemical Controls Used in Lake Denoon: 1950-2015

Year	Sodium Arsenite (lbs)	2,4-D (oz)	Diquat (gals)	Glyphosate (gals)	Endothal/ Aquathol (gals)	Rodeo (gals)	Navigate (lbs)	Cutrine (gals)
1950	304	--	--	--	--	--	--	--
1951	304	--	--	--	--	--	--	--
1952	304	--	--	--	--	--	--	--
1953	304	--	--	--	--	--	--	--
1955	468	--	--	--	--	--	--	--
1956	516	--	--	--	--	--	--	--
1962	900 (2)	--	--	--	--	--	--	--
1997	--	--	--	--	--	1.5 (2)	--	--
1998	--	--	--	--	--	0.5 (3)	--	--
1999	--	40	--	--	--	--	--	--
2000	--	2,050 (2)	--	0.5 (2)	--	--	--	--
2001	--	1,700+320	--	*0.5 A	--	--	--	--
2002	2.5	89	1.25	--	5.75	--	--	--
2003	--	1,500	--	--	2	--	--	--
2004	--	--	--	--	5.5	--	1,050	1.5 (p)
2006	--	--	--	--	--	--	600	--
2007	--	--	--	--	--	--	1,760	--
2008	--	--	--	--	--	--	610+1,425	--
2010	--	--	--	--	--	--	1,190+1,425	--
2011	--	99.84	--	--	--	--	--	1.25 (p)+1.5 (u)
2012	--	267.5+40	--	--	--	--	75	--
2013	--	227.5+81	--	--	0.5	--	50	--
2014	--	556.25	--	--	5	--	--	--
2015	--	430	--	--	--	--	--	--
Total	4,002.5	9,451.1	1.25	1[a]	18.75	4.5	7,460	4.25

Note: Gallons represent liquid forms of chemical; pounds and ounces represent granular forms. The plus symbols indicate that there were two treatment dates with different amounts, whereas treatment dates with the same amounts are labeled with the number of applications in parenthesis. Cutrine (p) stands for Plus and (u) stands for Ultra.

[a] *No amount of Glyphosate was available in the report of the 2001 application.*

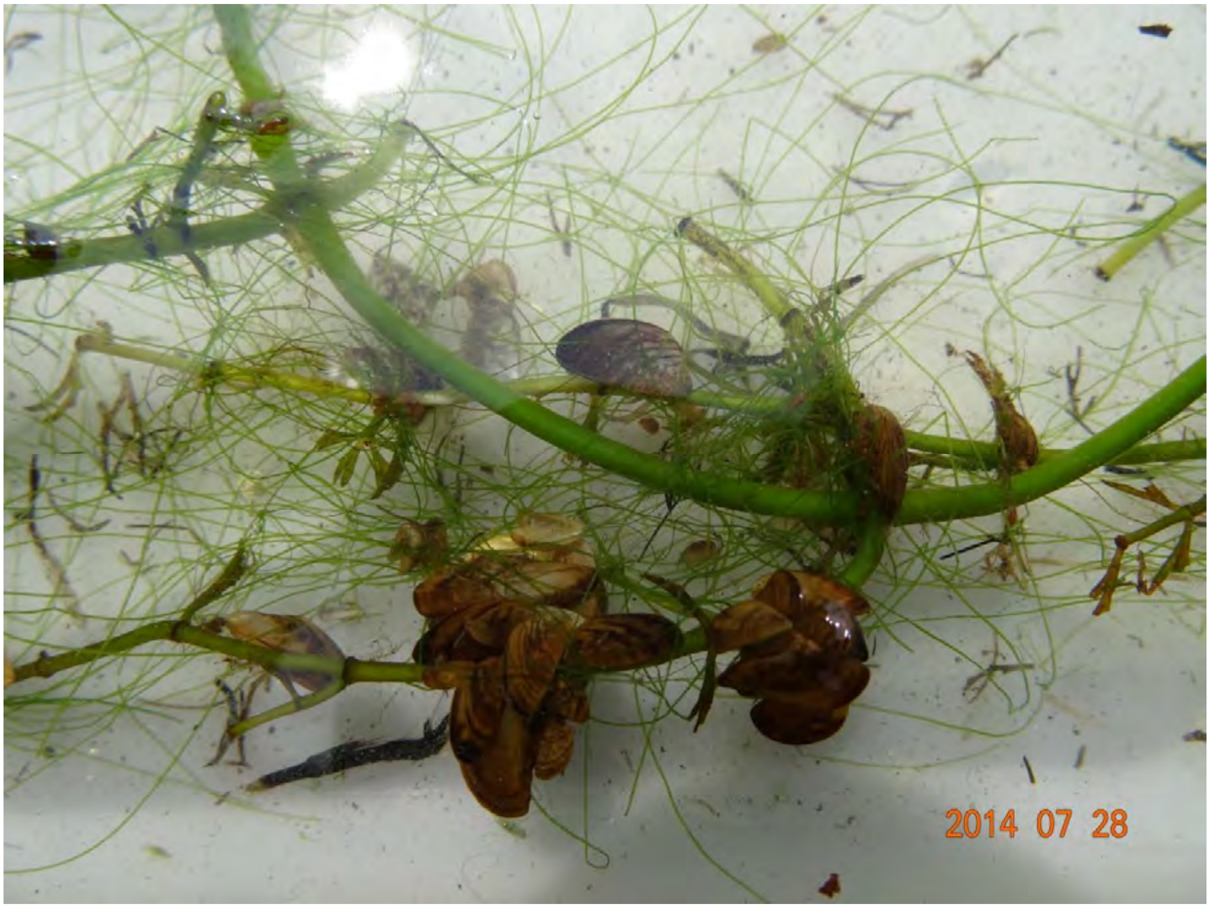
Source: Wisconsin Department of Natural Resources and SEWRPC

and EWM populations, as is indicative of invasive species, can displace native plant species and interfere with recreational use. Lake Denoon has been treated for EWM with 2,4-D herbicide since 1999 (Table 2.11). The abundance of this species suggests the need for continued active control of the EWM population.

The zebra mussel (*Dreissena polymorpha*) was positively identified to exist in Lake Denoon during September 2008. Zebra mussels are small fingernail-size clams with D-shaped shells. Adults typically range from one-quarter to one and one-half inches in size. The shells commonly have yellow and brownish stripes. This invasive species reproduces rapidly (females can produce up to a half million eggs per year) forming colonies on nearly any clean, hard, flat underwater surface. This behavior has caused the zebra mussel to become a costly nuisance to humans as massive populations of the mollusk have clogged municipal water intake pipes and fouled underwater equipment. Zebra mussels feed by filtering small plants, animals, and particles from the water column, an action that deprives native zooplankton (small aquatic animals that form an important food source for many larger organisms), native mussels, juvenile and larval fish, and many other organisms of key food sources.

The filter feeding proclivity of Zebra Mussels has improved water clarity in many lakes. Ironically, improved water clarity has sometimes, in turn, increased growth of rooted aquatic plants, including Eurasian water milfoil. A curious antagonistic interplay between zebra mussels, water clarity, Eurasian water milfoil, and native aquatic plants has been observed within the Southeastern Wisconsin Region. Zebra mussels have been observed to attach themselves to stems of the Eurasian water milfoil plants (Figure 2.28). The increased

Figure 2.28
Zebra Mussels Attached to Eurasian Water Milfoil



Source: SEWRPC

weight of the shells and live mussels drags the plant deeper below the surface and partially out of the photic zone (the depth to which sufficient sunlight penetrates lake water to support photosynthesis). This interferes with the competitive strategy of the Eurasian water milfoil plants and has sometimes contributed to regrowth of beneficial native aquatic plants. In other instances, decreased Eurasian Water Milfoil has led to nuisance growths of filamentous algae (which is too large to be ingested by the zebra mussels). Regardless of the seemingly beneficial impact of zebra mussels on water clarity, the overall environmental, aesthetic, and economic tolls of AIS on lake ecosystems and recreational resource values far outweigh positive factors. Methods for managing invasive species infestations are described in Chapter 3.

Aquatic Plant Management Alternatives

Competing and sometimes conflicting interests and goals commonly occur when it comes to aquatic plant management because pursuing one goal often interferes with accomplishing another important goal. For example, EWM could be eradicated with heavy chemical treatment. However, since Eurasian water milfoil often coexists with native plants (including a very similar looking native milfoil plant); this technique would fail to accomplish the goal of preserving native plant populations. Therefore, the aquatic plant management alternatives described in this section incorporate three sometimes conflicting goals: maintaining human access to the open waters of the Lake, controlling the extent and spread of Eurasian water milfoil and other nonnative species, and protecting native aquatic plant species.

Aquatic plant management measures used to kill nuisance and invasive plants can be classified into five groups:

1. *Physical measures*: lake bottom coverings

2. *Biological measures*: use of organisms (i.e., herbivorous insects)

3. *Manual measures*: manual removal of plants by individuals (i.e., raking or hand-removal)

4. *Mechanical measures*: harvesting or suction harvesting

5. *Chemical measures*: aquatic herbicides.

Additional details of each control measure are provided below. All are stringently regulated and most require a State of Wisconsin permit. Chemical controls, for example, require a permit and are regulated under Chapter NR 107, "Aquatic Plant Management," of the *Wisconsin Administrative Code*, while placing bottom covers (a physical measure) requires a Wisconsin Department of Natural Resources (WDNR) permit under Chapter 30 of the *Wisconsin Statutes*. All other aquatic plant management practices are regulated under Chapter NR 109, "Aquatic Plants: Introduction, Manual Removal and Mechanical Control Regulations," of the *Wisconsin Administrative Code*.

The aquatic plant management elements presented in this section consider alternative management measures consistent with the provisions of Chapters NR 103, "Water Quality Standards for Wetlands," NR 107, and NR 109 of the *Wisconsin Administrative Code*. Further, the alternative aquatic plant management measures are consistent with the requirements of Chapter NR 7, "Recreational Boating Facilities Program," of the *Wisconsin Administrative Code* and with the public recreational boating access requirements relating to eligibility under the State cost-share grant programs set forth in Chapter NR 1, "Natural Resources Board Policies," of the *Wisconsin Administrative Code*.

Physical Measures

Lake-bottom covers and light screens provide limited control of rooted plants by creating a physical barrier that reduces or eliminates plant-available sunlight. They are often used to create swimming beaches on muddy shores, to improve the appearance of lakefront property, and to open navigation channels for motorboats. Various materials can be used with varied levels of success. For example, pea gravel, which is usually widely available and relatively inexpensive, is often used as a cover material despite the fact that plants readily recolonize pea gravel bottom sediment after placement. Other options include synthetic materials, such as polyethylene, polypropylene, fiberglass, or nylon, which can provide relief from rooted plants for several years. However, due to susceptibility to disturbance by watercraft propellers and to gas build-up from decaying plant biomass trapped under the barriers, bottom screens and barriers generally have to be placed and removed annually. In the case of Lake Denoon, the need to encourage native aquatic plant growth while simultaneously controlling the growth of exotic species (often in the same location) suggests that <u>placing lake-bottom covers as a method to control aquatic plant growth is not viable since it is not consistent with the objective of encouraging native aquatic plant growth</u>.

Biological Measures

Biological controls offer an alternative approach to controlling nuisance plants. Classical biological control techniques use herbivorous insects to control nuisance plants and have been shown to be successful in some southeastern Wisconsin lakes.[55] However, given that high speed boat traffic is allowed on the Lake (a factor which often limits the efficacy these programs), Lake Denoon would likely not be a good candidate for this kind of project, specifically if Eurhychiopsis lecontei, an aquatic weevil species, is released for the purpose of controlling Eurasian water milfoil. In addition, these aquatic weevils are no longer commercially available; therefore, this option is not viable for any lakes in Wisconsin. Thus, <u>the use of *Eurhychiopsis lecontei* as a means of aquatic plant management control is not considered a viable option for use on Lake Denoon.</u>

[55] *B. Moorman, "A Battle with Purple Loosestrife: A Beginner's Experience with Biological Control,"* Lake Line*, Vol. 17, No. 3, September 1997, pp. 20-21, 34-3; see also, C.B. Huffacker, D.L. Dahlsen, D.H. Janzen, and G.G. Kennedy,* Insect Influences in the Regulation of Plant Population and Communities*, 1984, pp. 659-696; and C.B. Huffacker and R.L. Rabb, editors,* Ecological Entomology*, John Wiley, New York, New York, USA.*

Manual Measures

Manual removal of specific types of vegetation provides a highly selective means of controlling nuisance aquatic plant growth, including Eurasian water milfoil. Two common manual removal methods are used: raking and hand-pulling. More detail is provided in the following paragraphs.

Raking is conducted in nearshore areas using specially-designed hand tools. This method allows nonnative plants to be removed in shallow nearshore areas and also provides a safe and convenient method for controlling aquatic plants in deeper nearshore waters around piers and docks. Advantages of using these rakes includes: 1) they are relatively inexpensive ($100 to $150 each); 2) they are easy to use; 3) they produce immediate results; and 4) they immediately remove plant material (including seeds and plant fragments) from a lake, thereby preventing nutrient release and sedimentation from decomposing plant material and reducing the reproductive ability of target plants. Should Lake Denoon residents decide to implement this method of control, an interested party could acquire a number of these specially designed rakes for riparian owners to use on a trial basis. Therefore, <u>raking is considered a viable option to manage dense plant growth in areas where other control efforts are not feasible</u>.

The second type of manual control - hand-pulling of stems where they occur in isolated stands - provides an alternative means of controlling plants such as Eurasian water milfoil. This method is particularly helpful when attempting to target invasive plants in the high growth season, when native and nonnative species often coexist and intermix. This method is more highly selective than rakes, mechanical removal, and chemical treatments, and, therefore, is less damaging to native plant communities. Additionally, physical removal of the plants also prevents sedimentation and nutrient release from targeted plants, which incrementally helps maintain water depths and mitigate water quality concerns. Physical removal also reduces the amount of target plant seed and plant fragments, which reduces the ability of the target plant to reproduce. Given these advantages, <u>manual removal of Eurasian water milfoil through hand-pulling and removal is considered a viable option in Lake Denoon where practical</u>. It could be employed by volunteers or homeowners, as long as they are trained to properly identify Eurasian water milfoil. WDNR provides a wealth of guidance materials, including an instructional video, on manual aquatic plant removal.

Pursuant to Chapter NR 109 of the *Wisconsin Administrative Code*, both raking and hand-pulling of aquatic plants within a 30 by 100 foot area (30 linear feet along the shoreline, including the “use” area, extending 100 feet out into a lake), is allowed without a WDNR permit, provided that the hand-pulled plant material is removed from the lake. Any other manual removal requires a State permit unless employed to control designated nonnative/invasive species, such as Eurasian water milfoil. In general, State manual aquatic plant removal permits require all hand-pulled plant material to be removed from the lake. <u>Recommendations regarding hand-pulling and/or raking are included in Chapter 3</u>.

Mechanical Measures

Traditional Harvesting

Aquatic plants can be mechanically removed with specialized equipment known as harvesters. This equipment includes a cutting apparatus that extends up to a depth of five feet below the water surface and a collection system (e.g., a conveyor and a basket) that picks up most cut plant material. Mechanical harvesting can be a practical and efficient means of controlling sedimentation and plant growth, as it removes plant biomass which would otherwise decompose and release nutrients into a lake. Mechanical harvesting is particularly effective for larger scale projects.

An advantage of mechanical harvesting is that the harvester, when properly operated, ”mows” aquatic plants and therefore typically leaves enough living plant material in the lake to provide shelter for aquatic wildlife and to stabilize lake-bottom sediment. Aquatic plant harvesting also has been shown to facilitate growth of native aquatic plants by allowing light to penetrate to the lakebed. Finally, harvesting does not kill native plants in the way that other control methods do. Instead, this method simply cuts them back.

A disadvantage of mechanical harvesting is that the harvesting process may fragment plants and thereby unintentionally facilitate spread of Eurasian water milfoil, a plant that utilizes fragmentation as a means of propagation, particularly in areas where plant roots have been removed. This <u>further emphasizes the need to prevent harvesting that removes the roots of native plants</u>. Harvesting may also agitate bottom sediment in shallow areas, thereby increasing turbidity and creating other deleterious effects such as smothering of fish breeding habitat and nesting sites. Disrupting bottom sediment also could increase the risk of nonnative species recolonization, as invasive species tend to thrive under disturbed bottom conditions. To this end, most WDNR-issued permits do not allow deep-cut harvesting[56] in areas having a water depth of less than three feet, which would limit the utility of this alternative in some areas of Lake Denoon. Nevertheless, if applied correctly and carefully under suitable conditions, harvesting has been shown to benefit navigation lane maintenance and ultimately reduces regrowth of nuisance plants, while still maintaining native plant communities.

It should be noted that some cut plant fragments commonly escape the harvester's collection system. This negative side effect occurs fairly frequently on lakes where harvesting is used. Generally, to compensate for this, most harvesting programs include a plant pickup program. The plant pickup program often uses the harvester to collect large accumulations of floating plant debris as well as arranging pick up of cut plants from lakefront property owners who actively rake plant debris onto their docks. This kind of program, when applied systematically, can help alleviate the negative aesthetic consequences of plant debris accumulations on the lake shore.

Given the rather high typical cost of acquiring harvesting equipment, LDAA residents would need to demonstrate strong commitment to this management approach. For example, even the smallest harvester can easily result in an investment exceeding $100,000, which would typically include the harvester, standard trailer for transport, shore conveyor and dump truck for offloading. It will also be important to consider additional costs related to labor, salary requirements, maintenance of equipment, storage of equipment, and insurance. If the Lake community were willing to support the expense, harvesting should be considered a viable option for Lake Denoon.[57] If this program is selected, a plant collection program must be employed to prevent nuisance aquatic plant fragment accumulation. Additionally, all operators should be properly trained.[58] Other viable harvesting options would be either contract harvesting (two potential local providers) or the purchase of a harvester by a newly formed lake district.[59]

Cutting

Smaller versions of weed harvesting machines (weed cutters) typically do not have a means to retrieve plant cuttings from the water like larger harvesters. Instead, cut plants are generally left to be removed by hand raking – a labor intensive job. Although some cutters have been equipped with a basket arrangement to facilitate cut plant retrieval, weed cutters are better suited to small areas in shallower water, such as around piers. Therefore, weed cutters are not considered a viable option for Lake Denoon.

Suction Harvesting

An alternate aquatic plant harvesting method has emerged called Diver Assisted Suction Harvesting (DASH). First permitted in Wisconsin in 2014, DASH (also known as suction-harvesting) is a mechanical process where divers identify and pull aquatic plants by their roots from the lake-bottom and then insert the entire plant into a suction hose which transports the plant to the surface for disposal. The process is essentially a more efficient method for hand-pulling plants within a lake. Such labor–intensive work by skilled professional divers is, at present, a costly undertaking and long-term evaluations will need to determine the efficacy of the technique. However, there appear to be many advantages to the method when performed in small, isolated spots, including: 1) lower possibility of plant fragmentation in comparison to harvesting and traditional hand-pulling, thereby reducing regrowth of invasive plants like Eurasian water milfoil; 2) increased selectivity in terms of plant removal in comparison to a harvester, thereby reducing the loss of native plants, and 3) less fish habitat disturbances. Despite these advantages, considering the size of the area needing treatment in Lake Denoon, the type of plants present, and the cost associated with this type of management, DASH is not considered a viable option at this time, although it might be a viable alternative for individual landowners who would like plant removal around their piers.

[56] *Deep-cut harvesting is harvesting to a distance of only one foot from the lake bottom. This is not allowed in shallow areas because it is challenging to properly ensure that the harvester does not hit the lake-bottom in these areas.*

[57] *Another viable option*

[58] *WDNR staff can host training sessions to ensure that all harvester operators are aware of the terms of a harvesting permit.*

[59] *As per email of November 8, 2017, from Heidi Bunk, WDNR, to Dale Buser, SEWRPC.*

Regulation of Mechanical and Suction Harvesting

Both mechanical harvesting and suction harvesting are regulated by the WDNR and require a permit. Non-compliance with permit requirements is legally enforceable and may lead to fines and/or complete revocation of permits. The information and recommendations provided in this report will help frame permit applications. Permits can be granted for up to a five years.[60] At the end of that period, it would be necessary to develop a new aquatic plant management plan to determine the relative success of the implemented management techniques and strategies. The updated plan should be based on a new aquatic plant survey and should evaluate the aquatic plant management activities that occurred in the Lake in the time since the previous plan was completed.[61] These plans and plan execution are overseen by the WDNR aquatic invasive species coordinator for the region.[62] Recommendations regarding mechanical removal are included in Chapter 3.

Chemical Measures

Use of chemical herbicides in aquatic environments is stringently regulated and requires a WDNR permit and WDNR staff oversight during application. Chemical herbicide treatment is a short-term method to control heavy growth of nuisance aquatic plants. Chemicals are generally applied to growing plants in either liquid or granular form. The advantages of using chemical herbicides to control aquatic plant growth include relatively low cost, as well as the ease, speed, and convenience of application. The disadvantages associated with chemical control include:

1. **Unknown and/or conflicting evidence about long-term effects of chemicals on fish, fish food sources, and humans**—Chemicals approved by the U.S. Environmental Protection Agency to treat aquatic plants have been studied to rule out short-term (acute) effects on humans and wildlife. Additionally, some studies also examine the long-term (chronic) effects of the chemical on animals (e.g., the effects of being repeatedly exposed to these herbicides for many years). However, it is often impossible to conclusively state that no long-term effects exist due to the constraints of animal testing, time restraints, and other factors. Additionally, long-term studies have not been completed on all potentially affected species[63] and conflicting studies/opinions exist regarding the role of the chemical 2,4-D as a carcinogen in humans[64] (see Appendix G for further facts on 2,4-D). Therefore, for some lake property owners, the risks of using this chemical may be considered too great, despite the legality of use. Consequently, the concerns of lakefront owners should be considered whenever chemicals are used. If chemicals are used, they should be used as early in the season as practical and possible. This helps assure that the applied chemicals decompose before swimmers and lake users begin to actively use the lake.[65]

2. **A risk of increased algal blooms due to the suppression of macrophyte competitors**—Water-borne nutrients promote plant and algae growth. Generally, if rooted plants are not the primary user of nutrients, algae abundance tends to increase. Actions must be taken to avoid loss of native plants and excessive chemical use; particularly if fish populations are to be maintained at a healthy level (fish require aquatic plants for food, shelter, and oxygen). Further details on this topic are discussed in the "Issue 4: Blue-Green and Floating Algae" section of this chapter. Balance must be maintained between rooted aquatic plants and algae. When the population of one of the two declines, the other will increase in abundance.

---

[60] *Five-year permits are granted so that a consistent aquatic plant management plan can be implemented over that time. This process allows the aquatic plant management measures that are undertaken to be evaluated at the end of the permit cycle.*

[61] *Aquatic plant harvesters must report harvesting activities as a part of the permit requirements.*

[62] *Information on the current aquatic invasive species coordinator can be found on the WDNR website.*

[63] *U.S. Environmental Protection Agency, EPA-738-F-05-002,* 2,4-D RED Facts, *June 2005.*

[64] *M.A. Ibrahim, et al., "Weight of the Evidence on the Human Carcinogenicity of 2,4-D",* Environmental Health Perspectives, *Vol. 96, December 1991, p. 213-222.*

[65] *Though the labels allow swimming in 2,4-D-treated lakes after 24 hours, some swimmers may want more wait time to help assure that they receive less exposure to the chemical. Consequently, allowing extra time is recommended so residents and Lake users can feel comfortable that they are not being unduly exposed.*

3. **A potential increase in organic sediment, as well as associated anoxic conditions that can cause fish kills**—When chemicals are used to control large mats of aquatic plants, the dead plant material generally settles to the bottom of a lake and subsequently decomposes. This process leads to an accumulation of organic-rich sediment. This process can also deplete oxygen in the deep areas of a lake as bacteria use oxygen to decompose plant remains. Stratified lakes such as Lake Denoon are particularly vulnerable to oxygen depletion in deep areas. Extensive loss of oxygen can create conditions that inhibit a lake's ability to support fish, causing fish kills. This process emphasizes the need to limit chemical control to early spring, when Eurasian water milfoil has not yet formed dense mats.

4. **Adverse effects on desirable aquatic organisms due to loss of native species**—Native plants, such as pondweeds, provide food and life-cycle critical habitat for fish and other wildlife. Consequently, if native plants are unintentionally lost due to chemical application, fish and wildlife populations often suffer. Consequently, if chemical application occurs, only chemicals that specifically target Eurasian water milfoil should be used. These should be applied in the early spring when native plants have not yet emerged.

5. **A need for repeated treatments due to existing seed banks and/or plant fragments**—As mentioned previously, chemical treatment is not a one-time solution. The fact that plants are not actively removed from the lake increases the possibility for seeds/fragments to remain after treatment, thereby allowing for resurgence of the species the next year. Additionally, if large areas are left void of plants (both native and invasive) a disturbed area is created (i.e., an area without an established plant community). Eurasian water milfoil thrives in such areas. In short, applying chemical herbicides to large areas can allow the originally targeted plant, such as EWM, to recolonize due to the loss of competition from native plants. Consequently, repeated applications would likely be needed if chemical treatment is employed.

As discussed earlier, other complicating factors are associated with chemical application to lakes, namely the coincident growth patterns of Eurasian water milfoil and native species, the physical similarities between Northern water milfoil (a native species) and Eurasian water milfoil, and the presence of hybrid Eurasian water milfoil (HWM). However, due to the tendency for Eurasian water milfoil to grow early in the season, early spring chemical treatment application is an effective way to target non-native plants yet minimize the impact on native plants. Early spring application has the advantage of being more effective due to the colder water temperatures which enhance the herbicidal effect and reduce the concentrations needed for effective treatment. As discussed above, early spring treatment also reduces human exposure (e.g., swimming is not particularly popular in very early spring) and limits the potential for collateral damage to native species.

Another factor that normally warrants consideration is the way a lake has reacted to previous chemical treatments. Only one aquatic plant survey has been completed in Lake Denoon, therefore, the effectiveness of previous chemical treatments cannot be quantified. Nuisance levels of aquatic plants in Lake Denoon have historically been controlled with a variety of chemical herbicides since 1950 (Table 2.11). Sodium arsenite based herbicides were applied at increasing doses between 1950 and 1962. No chemicals were applied to the Lake between 1963 and 1997. Substantial quantities of chemical herbicides were applied to the Lake between 2000 and 2010. The quantities of chemicals have generally decreased since 2010, whether due to lower plant growth, use of alternative methods, more effective chemicals, improved application practices, or stricter regulations. Treatment with 2,4-D, an EWM specific herbicide, began in 1999 and has continued most years since that time. With only one plant survey on record for Lake Denoon (2013), it is not possible to deduce the effects of historical chemical treatments on past plant abundance and diversity.

According to WDNR staff, if chemicals are used to control EWM, low volumes of chemicals that specifically target EWM should be applied over the entire Lake as early as possible in the *spring* as opposed to treating specific areas of EWM infestation (spot treatments). Spot treatments are known to be less effective on the target species and more detrimental to native plant communities. Chemical herbicide use in aquatic environments is stringently regulated and requires a WDNR permit and WDNR staff oversight during application. To consider permitting a whole lake treatment for EWM, the WDNR requires that specific conditions be met. Specifically, for such treatment to be permitted, an aquatic plant survey using the point-intercept method must reveal:

- That the lake has a minimum of 35 percent frequency of occurrence of Eurasian water milfoil
- An EWM rake fullness density values of two or three over the majority of the sample sites (see Appendix E for schematic of rake fullness)
- Whether native aquatic plants occur that are susceptible to the proposed chemical application

The 2013 point-intercept survey of Lake Denoon (the most recent available) found EWM at about 30 percent of the vegetated sampling sites and had a rake fullness average of 1.67. Although a whole lake treatment was done in 2015, considering that the EWM population in Lake Denoon does not appear to satisfy the general WDNR abundance requirements for whole-lake treatments, the lack of success of EWM spot treatments, and the probable need of a chemical efficacy test, pending the outcome of the 2015 treatment and with consideration for potential changes in current conditions, subsequent whole-lake chemical treatments for EWM do not appear to be a viable option at this time. Recommendations for managing EWM are included in Chapter 3 of this report.

Other Aquatic Plant Management Issues of Concern

The recommendations presented in this section address monitoring and controlling aquatic plants that already grow in the Lake. However, many other activities can help *inhibit* or *prevent* future nuisance aquatic plant growth which, in turn, helps avoid adverse effects related to many in-Lake control alternatives. A number of factors create a Lake environment conducive to "excessive" plant growth, both in terms of Eurasian water milfoil and native plants. For example, poor water quality with high phosphorous content (which can result from polluted surface water runoff into the Lake or internal loading) provides the building blocks that all plants need to thrive and eventually reach what is perceived as nuisance levels. Consequently, <u>implementing recommendations that strive to improve water quality must be integral to any comprehensive aquatic plant management plan</u>. This is the reason why many of the issues of concern discussed in the water quality section of this chapter are also priorities for aquatic plant management. Recommendations related to these factors are included in Chapter 3 of this report.

2.5 ISSUE 4: CYANOBACTERIA AND FLOATING ALGAE

Before discussing excessive algae growth and management, it is important to note that algae are an important and healthy part of lake ecosystems. Algae are foundational components of lake food chains while producing oxygen in the same way as rooted plants. Many kinds of algae exist, from single-cell, colonial, and filamentous algae to blue-green algae (Figure 2.29). Most algae strains are beneficial to lakes when present at moderate levels. However, the presence of toxic strains (Figure 2.30) as well as excessive growth patterns (Figure 2.31) should be considered issues of concern. As with aquatic plants, algae generally grow faster in the presence of phosphorus (particularly in stagnant areas). Consequently, when toxic or highly abundant algae begin to grow in a lake, phosphorus enrichment or pollution may be present.

In general, the most permanent methods for preventing excessive and toxic algae growth are:

1. **Manage water quality with a focus on reducing phosphorus concentrations**—Phosphorus pollution is often the root cause of excessive algal growth. Consequently, the water quality recommendations discussed in Chapter 3 should be implemented.

2. **Maintain a healthy and active native plant community**—As mentioned in the "Chemical Measures" subsection of this chapter, maintaining a healthy, robust native plant community helps prevent excessive algal blooms. This is because plants and algae directly compete for phosphorus. Particular attention should be directed at fostering the extent and health of the bottom dwelling algae species responsible for the natural phosphorus sequestration process (i.e., muskgrass). Consequently, carefully implementing the aquatic plant management recommendations provided in Chapter 3 and communicating this nutrient-growth relationship to residents (to encourage land owners to employ conservative hand-pulling of vegetation and phosphorus-reducing landscaping and land use) should be a priority.

In addition to these approaches, in-lake measures and manual removal methods which could also be implemented include:

1. In-lake treatments. Floating algae uses nutrients that are dissolved or suspended in the water column to fuel growth. If water-column nutrient levels are reduced, the abundance of algae can be controlled. Water quality enhancement recommendations were discussed earlier in this chapter under "Issue 1: Water Quality." Both alternatives presented as feasible under this section could be considered to help control algae. These methods are summarized below for the reader's convenience. Additional information regarding this alternative can be found in the Water Quality sections of Chapters 2 and 3.

    a. **Alum treatment**—Alum treatment involves spreading a chemical (alum: hydrated potassium aluminum sulfate) over the surface of a lake. This chemical forms a solid that sinks, carrying algae and other solids to the bottom of the lake. This is a temporary solution to immediately improve water quality and can be cost prohibitive to treat individual blooms. However, alum-bound phosphorus precipitated to the lake bottom does not become soluble under anoxic water conditions and can help form a cap to reduce internal phosphorus loading. This can yield a long-term remedy to lower lake water phosphorus concentrations in lakes where internal phosphorous loading is occurring.

    b. **Hypolimnetic withdrawal and on-shore treatment**—Much of the phosphorus available to fuel algal growth is released from Lake bottom sediment during summer, is available to fuel algal growth when conditions are right, and is returned to the Lake bottom where it available to fuel algal growth in the future. At least some of this stored phosphorus is likely a legacy from periods of time when the Lake was heavily loaded with pollutants. Since the Lake has a relatively low capacity to flush pollutants downstream, actions to actively and permanently remove phosphorus from the Lake can help decrease future nutrient levels. Hypolimnetic withdrawal and on-shore treatment would use pumps or gravity (not an option for Lake Denoon) to remove nutrient-rich waters from deep within the Lake, treat the water on shore, and then allow the treated water to pass downstream or re-enter the Lake.[66] This approach can be

Figure 2.29
Different Types of Non-Toxic Algae

Source: Lewis Lab, University of New Mexico, Landcare Research

[66] *Local physiography and soil conditions are not conducive to gravity-induced flow to treatment cells near Lake Denoon. All known suitable and practical water treatment cell locations are well above the water surface elevation of Lake Denoon. Therefore, pumps must be employed to deliver water to treatment areas.*

Figure 2.30
Examples of Toxic Algae

Source: National Oceanic and Atmospheric Administration and St. John's River Water Management District

designed at a variety of scales, with the most intensive approaches yielding the quickest results. Less costly low-intensity approaches can operate essentially indefinitely and lead to incremental water quality improvement over decades.

2. **Manual removal**—Manual removal of algae using a suction device has recently been tested within the Region. This measure, though legal, is currently in the early stages of application. Additionally, "skimming" of algae has been tried by lake managers, with little success. Consequently, it would be necessary to further investigate these kinds of measures prior to implementation.

Alum treatment is generally used for direct algal control only when algal blooms become so excessive that they impede recreational use. This is because methods that target the algae itself are only temporarily effective and repeated or continual implementation can be cost prohibitive. Such a process is in essence treating the effect, and not the underlying cause. Since Lake Denoon has had only relatively minor issues with algal blooms in

Figure 2.31
Nuisance Levels of Algae

Source: SEWRPC

the past, direct control methods are not recommended at this time. However, phosphorus management is recommended to protect the Lake's overall health. The more permanent methods of algal control discussed above (i.e., nutrient control and plant community maintenance) are considered viable for Lake Denoon.

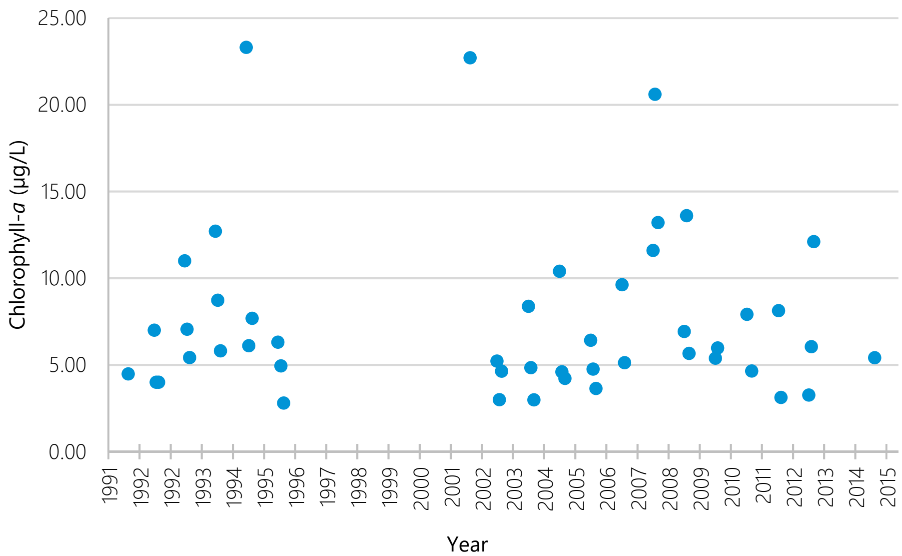
As a final note, although managing and preventing excess algae is crucial, it may also be advantageous to actively monitor algae. Two primary methods are typically used to monitor algae levels. The first is to collect chlorophyll-*a* samples which quantifies the concentration of suspended algae in the water column (i.e., the green color in water). Figure 2.32 shows summer chlorophyll-*a* measurements for Lake Denoon are often below the 10 ug/l level above which green colored water and algae blooms are more prevalent. The second is to collect algae samples to determine whether algae are non-toxic. If blooms become excessive and/or common, or if toxic algae are identified, regular monitoring should be considered.

2.6 ISSUE 5: SHORELINE MAINTENANCE

Many property owners abutting Lake Denoon are concerned with jointly maintaining the Lake's shorelines, recreational use, and aesthetic appeal, all without jeopardizing Lake health. This issue of concern is further emphasized by the fact that water quality, sedimentation, and aquatic plant growth can all be affected by shoreline maintenance practices.

Before discussing shoreline maintenance, it is important to understand the difference between two terms: *shoreline protection* and *buffers*. *Shoreline protection* encompasses various measures – engineered or natural – that shield the immediate shoreline (water-land interface) against the erosive forces of wave

Figure 2.32
Summer Chlorophyll-*a* Measurements Within Lake Denoon: 1992-2015



Source: City of Muskego and SEWRPC

action. *Buffers* are areas of plant growth – constructed or natural – in the riparian zone (lands immediately back from the shoreline) that trap sediment and nutrients emanating from upland and nearshore erosion (buffers were described in detail earlier in this report).

When it comes to shoreline protection, several artificial options are available to home owners. Most artificial shoreline protection structures are installed to check erosive forces, check shoreline recession and reduce soil loss to a lake, and oftentimes to provide a "finished" or "manicured" appearance to developed lots. These structures include 1) "bulkheads," where a solid, *vertical* wall of some material, such as poured concrete, steel, or timber, is erected; 2) "revetments," where a solid, *sloping* asphalt or concrete wall is used; and 3) "riprap," where rocks and/or stones are placed along the shoreline. See Figure 2.33 to view examples of several shoreline protection techniques. All structures listed above require permits from WDNR to construct.

It must be emphasized that, in certain cases, shoreline protection does not have to rely on artificial, engineered structures. Many types of natural shorelines offer substantial protection against erosive force. For example, boulders and rock cliffs function as natural rip-rap or bulkheads. Additionally, wetlands (such as those found at the west end of Lake Denoon) and areas of exposed cattail stalks and lily pads, such as those found around the Lake's nearshore area, effectively reduce shoreline erosive forces. Similarly, emergent plant stalks and leaves disperse and dampen waves by dissipating and absorbing energy.

"Hard" engineered seawalls of stone, riprap, concrete, timbers, and steel, once considered "state-of-the-art" shoreline protection, are now recognized as only one solution to protect and restore a lake's water quality, wildlife, recreational opportunities, and scenic beauty. Indeed, evidence suggests that, in some cases, the inability of hard shorelines to absorb wave energy increases wave energy in other portions of a lake since wave energy is reflected back into the lake. More recently, "soft" shoreline protection techniques, referred to as "vegetative shoreline protection" (see Figure 2.34), involving a combination of materials, including native plantings, are increasingly required pursuant to Chapter NR 328, "Shore Erosion Control Structures In Navigable Waterways," of the *Wisconsin Administrative Code*. Vegetative shoreline protection is becoming more popular as people living along lakes and streams become increasingly aware of the value of protecting their shorelines, improving their view and overall aesthetic appeal, and promoting natural and nature-like habitat for wildlife. Additionally, shorelines protected with vegetation help shield a lake from both land-based and shoreline pollution and sediment deposition.

Given the benefits of "soft" shoreline protection measures, the WDNR no longer permits construction of new "hard" structures in lakes that do not have extensive wave action threatening the shoreline. However,

Figure 2.33
Typical Shoreline Protection Techniques

RIPRAP

NATURAL VEGETATION

BULKHEAD

REVETMENT

Source: SEWRPC

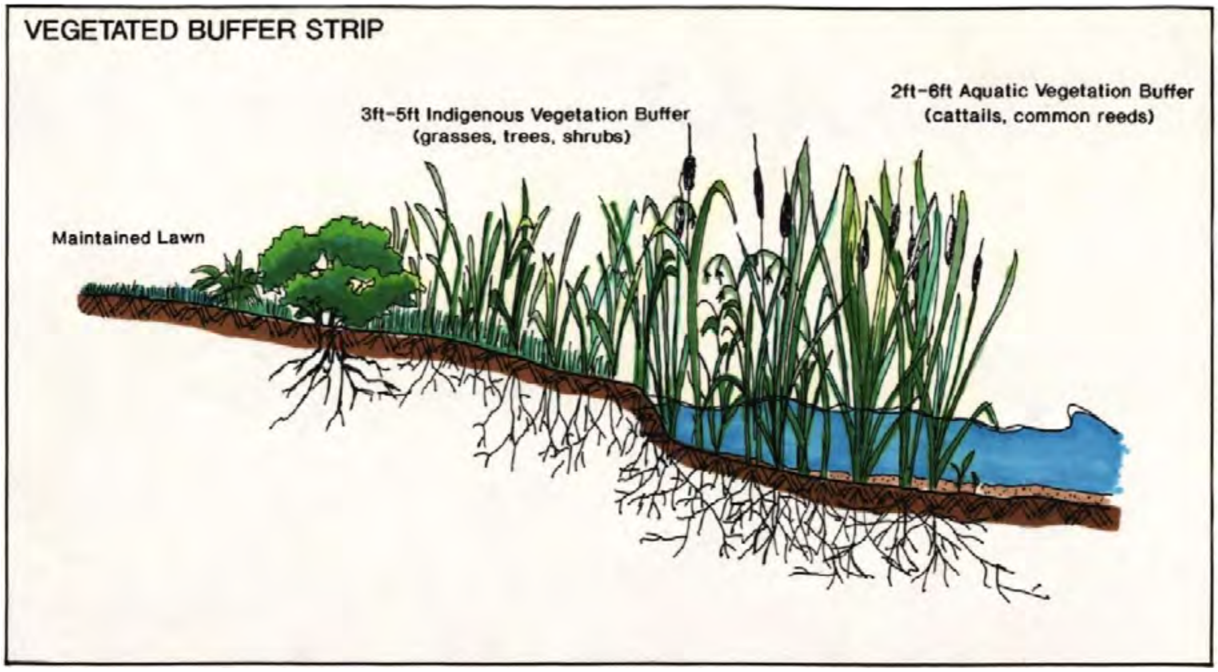
existing structures may be repaired. Consequently, the recommendations in this plan related to shoreline restoration focus on "soft" measures (see Figure 2.35), including native planting, maintenance of aquatic plants along shorelines, and use of "bio-logs". Beach areas, which legally need to be made from pea gravel,[67] are considered as a separate category. Placing pea gravel may be permitted; however, this must be evaluated by WDNR on a case-by-case basis.

Lake Denoon's Shoreline

To help quantify the shoreline restoration and maintenance needs of Lake Denoon, and to help develop recommendations related to shoreline maintenance and pollution reduction, SEWRPC staff inspected the Lake's shoreline during summer 2014. The results of this survey are shown on Map 2.11. As the map illustrates, few shoreline buffers are present along developed residential properties (a condition not unusual for lakes in the Region). <u>Educating shoreline property owners as to the importance and role of buffers (especially using native plants) to prevent pollution and shoreline erosion should be considered a priority</u>. Additionally, several areas around the Lake have failing or inadequate shoreline protection, and a number of sites exhibit eroding and/or undercut banks. Given the desire of Lake users to promote long-term Lake health and the need to preserve recreational use and aesthetics of the Lake, <u>priority should be given to repairing already installed shoreline structure where feasible, and maintaining/installing "soft" shoreline</u>

[67] *WDNR does not permit the use of sand because these materials quickly flow into a waterbody and contribute to the "fill-in" of the Lake.*

Figure 2.34
Natural Shoreline Buffer Schematic and Example



Source: Washington County Planning and Parks Department and SEWRPC

Figure 2.35
Vegetative Shoreline Protection Techniques

NATURAL SHORELINE

BIO-LOGS

BUFFERS (VEGETATIVE STRIPS)

CATTAILS

Source: Native Lakescapes and SEWRPC

protection such as vegetative shoreline protection (e.g., maintaining nearshore native plants) wherever and whenever possible. Further project recommendations for Lake Denoon's shoreline are included in Chapter 3 of this report.

2.7 ISSUE 6: RECREATION

Essentially all Lake residents and users want to ensure that Lake Denoon continues to support conditions favoring recreation and, relatedly, property value. Therefore, maintaining or enhancing the Lake's ability to sustain recreational use is a primary driving force behind essentially all issues of concern. Many of the topics discussed in this report (e.g., aquatic plants, water quality, algal blooms, water quantity, and wildlife) are related because each one of them can affect various recreational uses.

Boating

To evaluate the needs and habits of Lake Denoon users, a watercraft census (i.e., a boat count along the shoreline) and recreational survey (i.e., a count of active boats, users, and recreational use type on randomly selected weekdays and weekends) were completed These studies sought to identify the variability of Lake use, as well as to determine the primary uses of the Lake. The results are discussed in the following paragraphs.

SEWRPC staff counted the number and type of watercraft on Lake Denoon on randomly selected weekdays and weekends during summer 2013 (Tables 2.12 and 2.13). These numbers provide insight into the intensity

Table 2.12
Active Recreational Watercraft and Related Activities on Lake Denoon—Weekdays: Summer 2013

Category	Observation	Time and Date								
		6:00 a.m. to 8:00 a.m.	8:00 a.m. to 10:00 a.m.		10:00 a.m. to Noon		Noon to 2:00 p.m.		2:00 p.m. to 4:00 p.m.	
Category	**Observation**	Thursday July 25	Thursday August 1	Friday August 23	Tuesday August 20	Thursday August 29	Tuesday August 6	Tuesday August 27	Thursday July 18	Thursday August 29
Observation	Air Temperature (ºF)	60	69	73	83	84	82	91	93	87
	Sky Conditions	Clear	Clear	Clear	Clear	Clear	Hazy	Clear	Clear	Clear
Type of Watercraft (number in use)	Power/ski boat	0	0	2	0	0	0	1	1	0
	Pontoon boat	0	0	1	2	0	1	0	1	2
	Fishing boat	3	1	0	1	0	0	1	0	0
	Personal watercraft	0	0	0	0	0	0	0	0	0
	Kayak/canoe	0	0	1	0	0	0	0	0	0
	Rowboat	0	0	0	0	0	0	0	0	0
	Sailboat	0	0	0	1	0	0	0	0	0
	Wind board/paddle board	0	0	0	0	0	0	0	0	0
	Paddleboat (pedalboat)	0	0	0	0	0	0	0	0	0
	Other	0	0	0	0	0	0	0	0	0
Activity of Watercraft (number engaged)	Motorized cruise/pleasure	0	0	1	1	0	0	0	1	1
	Low speed	0	0	1	1	0	0	0	1	1
	High speed	0	0	0	0	0	1	0	0	0
	Fishing	3	1	1	0	0	0	0	1	0
	Skiing/tubing	0	0	1	2	0	0	0	0	1
	Sailing/windsurfing	0	0	0	1	0	0	0	0	0
	Rowing/paddling/ pedaling	0	0	1	0	0	0	0	0	0
	At anchor[a]	0	0	0	1	0	0	2	0	1
Total	On water	3	1	4	5	0	1	0	2	2
	Capable of high speed use	3	1	3	3	0	1	2	2	2
	In high-speed use at same time	0	0	1	2	0	1	0	0	0

[a] *At the west end of Lake Denoon there is a shallow sandbar that is a favorite gathering place for boaters to anchor and swim, play volleyball (there is a volleyball net located on the sandbar), or just socialize; its location off the principle tubing/water skiing circuit enhances its popularity.*

Source: SEWRPC

of watercraft use as well as the type of activities in which watercraft engage. From the 2013 data, it appears that weekday boat traffic is quite limited. The maximum number of boats on the water occurred during the late morning, when 5 boats were counted. In contrast, many more boats were found to be actively in use on the Lake during weekends, when up to 13 boats were present. The most popular boating activities included cruising, fishing, and water skiing/tubing. Smaller numbers of boats were engaged in sailing, paddling/rowing/peddling while a few were at anchor. No windsurfing or paddle board use was noted at any time during the survey.

The type of boating taking place varies by the day of the week, time of day, and prevailing weather conditions. According to a statewide survey that subdivided results by region,[68] boaters in Southeastern Wisconsin took to the water in the greatest numbers during July, with slightly lower numbers of boaters found on the water during June and August (Table 2.14). These months account for approximately two-thirds of the total number of boater-days logged in the Region for the entire year. About three to four times as many boaters use their boats on weekends than weekdays (Table 2.15). The weekday/weekend statistics compare favorably with SEWRPC 2013 Lake Denoon boat counts.

[68] *Penaloza, Linda J., "Boating Pressure on Wisconsin's Lakes and Rivers, Results of the 1989-1990 Wisconsin Recreational Boating Study, Phase 1,"* Wisconsin Department of Natural Resources Technical Bulletin *174, 1991.*

Table 2.13
Active Recreational Watercraft and Related Activities on Lake Denoon—Weekends: Summer 2013

Category	Observation	Time and Date				
		8:00 a.m. to 10:00 a.m.	10:00 a.m. to Noon	Noon to 2:00 p.m.		2:00 p.m. to 4:00 p.m.
		Saturday August 10	Sunday August 18	Saturday July 27	Sunday August 18	Saturday August 24
Observation	Air Temperature (°F)	67	75	59	81	83
	Sky Conditions	Overcast	Clear	Overcast	Clear	Clear
Type of Watercraft (number in use)	Power/ski boat	0	0	0	7	4
	Pontoon boat	0	2	1	2	2
	Fishing boat	1	3	2	1	4
	Personal watercraft	0	0	0	3	0
	Kayak/canoe	0	3	0	0	0
	Rowboat	0	0	0	0	0
	Sailboat	0	0	0	0	0
	Wind board/paddle board	0	0	0	0	0
	Paddleboat (pedalboat)	0	0	0	0	0
	Other	0	0	0	0	0
Activity of Watercraft (number engaged)	Motorized cruise/pleasure	0	2	0	2	2
	Low speed	0	2	0	2	2
	High speed	0	0	0	5	1
	Fishing	1	3	3	0	3
	Skiing/tubing	0	0	0	4	2
	Sailing/windsurfing	0	0	0	0	0
	Rowing/paddling/pedaling	0	3	0	0	0
	At anchor[a]	0	0	0	2	2
Total	On water	1	8	3	13	10
	Capable of high speed use	1	5	3	13	10
	In high-speed use at same time	0	0	0	5	3

[a] *At the west end of Lake Denoon there is a shallow sandbar that is a favorite gathering place for boaters to anchor and swim, play volleyball (there is a volleyball net located on the sandbar), or just socialize; its location off the principle tubing/water skiing circuit enhances its popularity.*

Source: SEWRPC

Table 2.14
Boating Activity in Southeastern Wisconsin by Month: 1989-1990

Activity	Percent Respondents Participating[a]						
	April	May	Jun	July	August	September	October
Fishing	68	57	49	41	44	42	49
Cruising	29	39	42	46	46	47	43
Water Skiing	3	9	20	27	19	16	8
Swimming	2	4	18	31	25	19	5
Average boating party size: 3.4 people							

[a] *Respondents may have participated in more than one activity.*

Source: Wisconsin Department of Natural Resources

Fishing was by far the most popular activity in Southeastern Wisconsin in both spring and fall, and remains a leading reason for boat use throughout the summer (Table 2.14). Again, the data produced by the Commission's 2013 boat count corresponds quite well with regional averages, suggesting that Lake Denoon's boating activity is fairly represented by regional averages. The typical boat used on inland lakes in Southeastern Wisconsin is an open hulled vessel measuring approximately 18 feet long powered by a motor producing approximately 90 horsepower (Tables 2.16 and 2.17). Sailboats comprise approximately 24 percent of boat traffic (15 percent non-powered and 9 percent powered), while other non-powered boats comprise only two percent of boats found on waterbodies in the region.

Only a few respondents to the WDNR boating survey felt that excessive boat traffic was present on Southeastern Wisconsin lakes.[69] Studies completed in Michigan attempt to quantify desirable levels of boat traffic on an array of lakes used for a variety of purposes. This study concluded that 10 to 15 acres of useable lake area provides a reasonable and conservative average maximum desirable boating density,[70] and covers a wide variety of boat types, recreational uses, and lake characteristics.[71] Use rates above this threshold are considered to negatively influence public safety, environmental conditions, and the ability of a lake to host a variety of recreational pursuits. High-speed watercraft require more space, necessitating boat densities less than the low end of the range. The suggested density for a particular lake is:

Minimum desirable acreage per boat = 10 acres + (5 acres x (high-speed boat count/total boat count))

The 2013 SEWRPC boat count demonstrates that highest boat use occurs during weekends. All boats in use during peak periods were capable of high-speed operation; however, less than half were actually being operated at high speed. If one assumes that half of the boats could potentially be operating at high speed during the day, the formula presented above suggests that 12.5 or more acres of useable open water should be available per boat. <u>Given that roughly 140 useable acres are available for boating in Lake Denoon, no more than 11 boats should be present on the lake at any one time to avoid use problems</u>. The density of boats actually observed on Lake Denoon is usually less than the maximum optimal density. However, boat density appears to slightly exceed the optimal maximum density during heavy use periods (weekends and holidays). This means that the potential for use conflicts, safety concerns, and environmental degradation is slightly higher than desirable on Lake Denoon during weekends and holidays. To help mitigate this concern, boating ordinances and regulations should be reviewed and if necessary modified. Such <u>ordinances and regulations should be</u>

Table 2.15
Daily Distribution of Boating in Southeastern Wisconsin: 1989-1990

Day of the Week	Percent Respondents Participating[a]
Sunday	46
Monday	16
Tuesday	14
Wednesday	16
Thursday	13
Friday	17
Saturday	46

[a] *Respondents may have participated in more than one day.*

Source: Wisconsin Department of Natural Resources

Table 2.16
Hull Types in Southeastern Wisconsin: 1989-1990

Type of Hull	Percent Respondents Participating[a]
Open	68
Cabin	17
Pontoon	9
Other	6
Average length: 18.4 ft	
Average beam width: 6.4 ft	

[a] *Respondents may have participated in more than one day.*

Source: Wisconsin Department of Natural Resources

Table 2.17
Propulsion Types in Southeastern Wisconsin: 1989-1990

Propulsion Type	Percent Respondents Participating[a]
Outboard	53
Inboard/outboard	14
Inboard	6
Other (powered)	1
Sail	15
Sail with power	9
Other (nonpowered)	2
Average horse power: 86.5	

[a] *Respondents may have participated in more than one day.*

Source: Wisconsin Department of Natural Resources

[69] *Ibid.*

[70] *Useable lake area is the size of the open water area that is at least 100 feet from the shoreline.*

[71] *Progressive AE,* Four Township Recreational Carrying Capacity Study, Pine Lake, Upper Crooked Lake, Gull Lake, Sherman Lake, *Study prepared for Four Township Water Resources Council, Inc. and the Townships of Prairieville, Barry, Richland, and Ross, May 2001.*

conscientiously enforced to help reduce the potential for problems related to boat overcrowding during periods of peak boat traffic. Additional details regarding this recommendation are presented in Chapter 3.

Two-hundred forty watercraft were observed moored or on the shore around the Lake on August 21, 2013 (Table 2.18). Approximately half of all docked or moored boats were motorized, with fishing boats and pontoon boats comprising approximately half the motorized boat total. Paddleboats and kayaks are the most popular types of non-motorized watercraft. The total number of boats present around the lake suggests that five to twelves boats will be in active use on the Lake during peak use periods.[72] Weekend boat counts were at the upper end of, or exceeded, this range, a condition likely attesting to the Lake's popularity with visiting boaters using the Denoon Park boat launch.

Public boating access to Lake Denoon is provided by a single-lane paved boat ramp located in a public park on the northwest side of the Lake (Map 2.1). Off-street parking for up to nine vehicle/trailer combinations and 81 additional vehicles is available within the park. The park is operated by the City of Muskego Park and Recreation Department. A fee of $7.00 per day is charged to launch trailered watercraft, while non-trailered watercraft may be launched free of charge. Season passes are offered with various fees depending upon residency and age. Power launching and loading of personal watercraft and boat mooring are prohibited. Given what is known about the site, boat launch facilities and fees appear to conform to the minimum requirements set forth in Chapter NR 1 of the *Wisconsin Administrative Code*. Compliance with this section is important, since certain grant and assistance funding is predicated by compliance with Chapter NR 1. It appears that the launch fee could be increased by at least $1.00.[73] Launch fees can influence the intensity of use of the launch facility, and can be considered as part of a program to help avoid excess boat densities on the Lake. This is discussed in more detail in Chapter 3.

Other Recreational Pursuits

Lake Denoon supports a wide range of recreation beyond boating. The Lake is generally supportive of all common lake-based recreational activities. However, as pointed out in previous sections, some activities could be more fully realized through focused management. Some of the recreational activities supported by Lake Denoon are wholly reliant upon the presence of the Lake and shoreline areas. These activities include swimming, ice and open-water fishing (see "Issue 7: Fish and Wildlife" below for more detail regarding fish populations), ice skating, winter motorsports upon the ice, waterfowl hunting, and trapping. Local aesthetic appeal, property value, and many other recreational activities (e.g., nature study, bird and wildlife viewing, hunting, general outdoor relaxation) benefit from the presence of the Lake. While many recreational activities are relatively passive, intense active use (e.g., excessively heavy fishing pressure, motorsport racing on the ice) and/or out-of-place use (e.g., swimming in high-speed boating areas, high-speed boating near shorelines or shallow areas) can create use conflicts and compromise the overall recreational value of the Lake. The City of Muskego has developed ordinances and regulations to regulate such issues (see Appendix H for the lake use ordinances). Relevant ordinances should be reviewed on a regular basis, amended to address current concerns, and conscientiously enforced.

Lake Denoon's non-boating recreational benefits extend beyond the riparian community. Denoon Park occupies 53 acres abutting the Lake. No swimming and very little access to shoreline fishing is available given the Park's configuration, however, a fishing pier is being considered as part of a new park plan. The presence of the Lake and boat ramp enhance the park's other amenities. These amenities include facilities for picnicking, playground activities, various team sports (e.g., baseball, soccer, and basketball), motor sports (snowmobiling), and nature study (walking trails, woodland and prairie conservation areas).

---

[72] *At any given time it is estimated that between about 2 percent and 5 percent of the total number of watercraft docked and moored will be active on the Lake.*

[73] *NR 1.91(11)a encourages free boat launching but allows a maximum one-day base fee equivalent to the one-day fee for residents to enter state parks ($8.00 at the time of this report). NR1.91(11)b allows additional surcharges based upon the presence of an attendant (20% base fee surcharge), the size of boats served (30% base fee surcharge for boats between 20 and 26 feet in length and 60% base fee surcharge for boats greater than 26 feet in length), and the presence of on-site toilet facilities (20% base fee surcharge).*

2.8 ISSUE 7: FISH AND WILDLIFE

Protecting and enhancing lake-dependent aquatic and terrestrial wildlife populations is an important consideration of any lake protection plan. Based on field work and study of the Lake and its watershed, SEWRPC staff identified the following factors related to aquatic and terrestrial wildlife:

1. Fishing was identified as an important recreational use of the Lake, as was verified by direct observations by Commission staff in 2013 (Tables 2.12, 2.13 and 2.18);

2. Lake Denoon is reported to contain one critical fish species, the lake chubsucker (*Erimyzon sucetta*), a State Special Concern species;

3. Lake Denoon is managed by the WDNR as a warmwater sport fishery;[74] About 12 species of amphibians and 13 species of reptiles are expected to be present in the Lake's watershed. Amphibians and reptiles, including frogs, toads, salamanders, turtles, and snakes, are vital components of a lake ecosystem;

4. The Lake's watershed likely supports a significant population of waterfowl, including mallards, wood duck, and blue-winged teal, particularly during the migration seasons; and

5. The Lake's watershed likely supports both small and large mammals, such as fox and whitetail deer.

Table 2.18
Moored Boats/Watercraft on Lake Denoon: August 21, 2013

Boat Type	Number Observed on the Lake or Shore
Speed/Ski	36
Pontoon	61
Jet-ski/Wave Runner	28
Paddleboat	33
Canoe	16
Sailboat	6
Kayak	25
Fishing	15
Rowboat	19
Paddleboard	1
Total	240

Source: SEWRPC

SEWRPC-Designated Natural Areas and Critical Species Habitat

As part of its regional planning program, and as a logical extension of its environmental corridor concept integrated within regional, county-, and local-level land use plans for southeastern Wisconsin,[75] SEWRPC has identified natural areas and critical species habitat sites within the Southeastern Wisconsin Region. [76] These areas reflect the attributes of the landscape that help:

1. Protect and preserve the ambience, natural beauty, and biological diversity of southeastern Wisconsin

2. Maintain public health and welfare, support and sustain economic development, and provide continuing choices and opportunities for future generations.

Areas identified as critical species habitat and/or natural areas were further qualified as being of local significance, regional significance, or State/national significance. As described below, two such areas were identified in the Lake Denoon watershed – the Lake Denoon Marsh and the Lake itself:

1. Lake Denoon Marsh: This privately-owned wetland is located at the west end of Lake Denoon and is classified as a critical species habitat due to the presence of the black tern (*Chlidonias niger*), a Wisconsin state endangered bird species

2. Lake Denoon: A seepage lake with good water quality, wildlife habitat, and other physical characteristics; it is a Natural Area classified as AQ-3, identifying it as a lake of local significance

[74] *SEWRPC Memorandum Report No. 93,* A Regional Water Quality Management Plan for Southeastern Wisconsin: An Update and Status Report*, March 1995*

[75] *See SEWRPC Planning Report No. 7,* The Regional Land Use-Transportation Study*, 1965, and subsequent editions; see also Bruce P. Rubin and Gerald H. Emmerich, Jr., "*Refining the Delineation of Environmental Corridors in Southeastern Wisconsin,*" SEWRPC Technical Record, Volume 4, Number 2, March 1981.*

[76] *SEWRPC Planning Report No. 42,* A Regional Natural Areas and Critical Species Habitat Protection and Management Plan for Southeastern Wisconsin*, September 1997.*

Aquatic and Terrestrial Habitat

Healthy fish, bird, amphibian, reptile, and mammal populations require 1) good water quality, 2) sufficient water levels, 3) healthy aquatic and terrestrial plant populations and species mixes, 4) access to life-cycle critical habitat, and 5) well preserved or maintained aquatic and terrestrial habitat. Wildlife populations can also be enhanced by implementing "best management practices." Since aquatic plant management, water quality, and water quantity have been discussed previously in this chapter, this section dwells on maintaining and expanding habitat and using best management practices to enhance wildlife populations. The actual practices employed vary and are influenced by the type of wildlife and habitat function to be enhanced. Therefore this section will first discuss aquatic wildlife enhancement and will then address terrestrial wildlife enhancement.

Aquatic Wildlife Enhancement

Aquatic wildlife populations can be enhanced by implementing best management practices and enhancing aquatic habitat. Each is discussed below.

Aquatic Best Management Practices

Aquatic best management practices can be implemented by homeowners, recreationalists, and resource managers. Such activities include catch and release angling and fish habitat enhancement, both of which help improve a lake's overall fishery. To determine the most needed and effective practices, it is important to consider the following:

1. **The population and size structure of the fish species present in a lake**—Studies that examine the species, populations, and size structure of the fish in a lake help managers understand issues that may face fish populations. For example, if low numbers of juvenile fish are found, this may suggest that the fish are not successfully reproducing in the lake, and, therefore, spawning and rearing habitat may need to be improved. Similarly, if abundant juveniles are found with few large fish, over-fishing may be a factor limiting the growth of fish, thereby suggesting that catch and release should be promoted in the lake. This type of information can, therefore, help lake managers target specific fish population enhancement efforts efficiently and effectively.

2. **The history of fish stocking in a lake**—To evaluate fish population studies, it is important to know the number, size, and species of fish introduced through stocking. If only large stocked fish exist in a lake, for example, it is likely that little to no effective natural spawning is actually taking place, which in turn means that the lake's fishery is highly dependent on fish stocking. This may suggest that enhanced or artificial spawning and rearing areas can add value to the lake's fishery.

Lake Denoon has been intermittently stocked by the WDNR. Approximately eight-thousand northern pike and over 87,000 walleye have been stocked since 1991 (Table 2.19). The WDNR reports that largemouth bass and northern pike are considered "common" in Lake Denoon, while panfish and walleye are "present."[77] General WDNR staff notations regarding the Lake Denoon fishery include the following:

- Above average abundance of largemouth bass with many year classes suggesting good recruitment in recent years. Largemouth bass are slightly larger than average for Waukesha County
- Bluegill and pumpkinseed are highly abundant
- Yellow perch, black crappie are present but are not as common as bluegill and pumpkinseed
- Northern pike and walleye are present
- Nongame species include lake chubsucker (a Wisconsin species of special concern), grass pickerel, and yellow bullhead

---

[77] *Department of Natural Resources Lake Page: dnr.wi.gov/lakes/LakePages/LakeDetail.aspx?wbic=746000.*

Table 2.19
Fish Stocked into Lake Denoon

Year	Species Stocked	Age Class	Number Stocked	Average Length (inches)
1991	Walleye	Fingerling	3,000	4.00
1992	Walleye	Fingerling	6,000	2.00
1996	Northern pike	Fingerling	351	4.30
1996	Walleye	Fingerling	10,100	1.60
1998	Northern pike	Small fingerling	775	--
1998	Walleye	Small fingerling	16,200	2.60
1999	Northern pike	Small fingerling	990	2.40
2000	Walleye	Small fingerling	16,200	2.00
2000	Northern pike	Small fingerling	800	3.70
2001	Northern pike	Small fingerling	1,086	2.60
2002	Walleye	Small fingerling	16,000	1.90
2002	Northern pike	Small fingerling	810	3.10
2005	Northern pike	Small fingerling	866	3.00
2006	Walleye	Small fingerling	8,112	1.90
2006	Northern pike	Small fingerling	810	2.50
2008	Northern pike	Large fingerling	933	10.20
2010	Walleye	Small fingerling	5,860	1.70
2012	Walleye	Small fingerling	5,670	1.51
2012	Northern pike	Large fingerling	334	7.90
2013	Northern pike	Large fingerling	257	10.00
2014	Northern pike	Large fingerling	324	9.10
2015	Walleye	Large fingerling	400	N/A
2015	Northern pike	Large fingerling	269	8.80

Source: Wisconsin Department of Natural Resources and SEWRPC

Size structure of bluegills is small with an average size of five inches. This is not surprising given the above average fishing pressure and dense aquatic plant community.[78] Fish surveys completed during 1951, 1986, 2002, and 2014 using electrofishing[79] and seine nets noted the presence of 21 species of fish in the Lake, including bowfin (Tables 2.20 through 2.24). The WDNR notes that promoting native aquatic plants and controlling nutrient levels in the Lake will help the fishery. Periodic fish stocking should continue if the present fishery species mix is to remain viable.

Aquatic Habitat

Aquatic habitat enhancement generally refers to encouraging native aquatic plant (particularly pondweed) growth within a lake, as these plants provide food, shelter, and spawning areas for fish. Aquatic habitat enhancement also involves protecting wetlands (see "Terrestrial Habitat" subsection below), maintaining good ecological connectivity between the lake and its watershed, and encouraging the presence of woody structure along the shorelines. Woody structure is found in abundance in natural environments, provides shelter for fish populations, act as basking and rest areas for herptiles (e.g., frogs and turtles), may provide perch areas for important birds and insects, and can also help protect shorelines from erosion in some instances.

To determine the status of aquatic habitat within the Lake beyond that identified as part of the summer 2013 aquatic plant survey (see "Issue 3: Aquatic Plant Growth" section), SEWRPC staff completed a shoreline assessment in the summer of 2014 (see "Issue 5: Shoreline Maintenance" section). The aquatic plant survey revealed that Lake Denoon has good plant diversity, with eight different pondweed species,80 while the shoreline assessment concluded that few areas along the Lake's shoreline have significant woody structure in the water (Map 2.11). These conclusions indicate that the current aquatic native plant community should be maintained to the greatest extent practical, and that projects should be implemented to provide more woody structure-based habitat along shorelines. Consequently, recommendations related to both are presented in Chapter 3 of this report.

The WDNR describes the lake-bottom as being comprised of 20 percent sand, 0 percent gravel, 0 percent rock, and 80 percent muck (generally a mixture of organic debris and silt). Sand is found in nearshore areas and is the predominate substrate along 56 percent of the shoreline. Marl, a carbonate mineral generally associated with lakes receiving mineral-rich groundwater, is also found near the north and south shorelines. Muck is found near the shore in the southwest corner of the Lake and in water depths greater than 10 feet. It is important to note that healthy aquatic ecosystems require a *variety* of habitat and substrate. For

[78] Email from Ben Heussner, fisheries biologist WDNR, to Michael Borst, SEWRPC, November 24, 2015.

[79] Electrofishing is a process where an electrical pulse is placed in the water, causing fish to be temporarily stunned and float to the top of the lake. This process allows for fisheries biologists to record fish types, counts, and sizes without harming the fish populations.

[80] Pondweed species are significant in a lake because they serve as excellent habitat for providing food and shelter to many aquatic organisms.

example, fish spawning, rearing, refuge, and feeding commonly take place is very different environments. Buffer installation, water quality management, removing fish passage impediments on perennial and intermittent streams, reconnecting floodplains to tributary streams, and maintaining nearshore vegetation and woody structure all promote fish populations. The shoreline maintenance recommendations in Chapter 3 of this report are further refined to promote healthy fish populations.

Terrestrial Wildlife

Two general practices can enhance terrestrial wildlife populations. These practices include active application of best management practices and aquatic habitat enhancement. Each is described in more detail below.

Terrestrial Best Management Practices

The way people manage their individual properties and interact with wild animals and natural plants can significantly affect terrestrial wildlife populations. Turtles, for example, often travel long distances from their home lake or stream to lay eggs. If pathways to acceptable habitats are unavailable, or are dangerous due to pets, fences, or traffic, turtle populations will likely decline. Many conservation organizations have developed "best management practices" or behaviors that homeowners and land managers can employ to sustain or even increase wildlife populations within a watershed.

Though some of these "best management practices" (BMPs) are species- or animal-type specific (e.g., spaying or neutering cats to control populations, reducing their desire to kill birds) many of these recommendations are basic practices that benefit all wildlife. In general, best management practices for wildlife enhancement targets agricultural and residential land uses. Agricultural measures tend to focus on encouraging land management practices that enhance habitat value, such as allowing

Table 2.20
Boom Shocker Fish Survey in Lake Denoon: May 28, 2014

Species Collected	Average Length (inches)	Maximum Length (inches)	Number Measured
Bluegill	5.03	8.0	52
Largemouth Bass	10.48	19.0	92
Yellow Perch	7.00	7.5	4
Black Crappie	9.00	9.0	2
Pumpkinseed	7.13	8.5	20

Note: Other species were found but not sampled for size.

Source: Wisconsin Department of Natural Resources and SEWRPC

Table 2.21
Boom Shocker Fish Survey in Lake Denoon: May 15, 2002

Species Collected	Average Length (inches)	Maximum Length (inches)	Number Measured
Bluegill	5.5	7.5	39
Northern Pike	18.5	18.5	1
Walleye	17.3	19.0	7
Largemouth Bass	11.2	17.0	146
Yellow Perch	6.9	7.5	3
Black Crappie	10.5	10.5	1
Pumpkinseed	5.6	6.5	4

Note: Other species were found but not sampled for size.

Source: Wisconsin Department of Natural Resources and SEWRPC

Table 2.22
Boom Shocker Fish Survey in Lake Denoon: May 30, 2002

Species Collected	Average Length (inches)	Maximum Length (inches)	Number Measured
Bluegill	6.9	8.0	8
Walleye	18.5	23.5	7
Muskellunge	19.3	19.3	1
Largemouth Bass	12.1	16.5	59
Black Crappie	9.5	9.5	1
Pumpkinseed	6.0	6.0	1

Note: Other species were found but not sampled for size.

Source: Wisconsin Department of Natural Resources and SEWRPC

Table 2.23
Boom Shocker Fish Survey in Lake Denoon: October 23, 1986

Species Collected	Average Length (inches)	Maximum Length (inches)	Number Measured
Bluegill	5.4	7.0	111
Walleye	16.0	16.0	2
Largemouth Bass	8.7	14.5	92
Northern Pike	20.5	21.0	2
Yellow Perch	5.5	7.0	20
Black Crappie	3.6	5.0	3
Pumpkinseed	5.1	5.5	10

Note: Other species were found but not sampled for size.

Source: Wisconsin Department of Natural Resources and SEWRPC

Table 2.24
Seine Fish Survey in Lake Denoon: June 1, 1951

Species Collected	Average Length (inches)	Maximum Length (inches)	Number Measured
Bluegill	6.1	9.0	100
Rock Bass	7.3	10.0	7
Largemouth Bass	10.2	19.5	100
Northern Pike	15.0	21.0	39
Yellow Perch	6.8	7.5	15
Black Crappie	7.5	11.0	42
Pumpkinseed	5.1	7.0	7

Note: Other species were found but not sampled for size.

Source: Wisconsin Department of Natural Resources and SEWRPC

fallen trees to naturally decompose where practical, or allowing uneven topography in certain landscapes (which can create microhabitats needed by certain plants and animals to procreate). In contrast, residential measures tend to focus on practices that owners of smaller parcels can initiate that provide habitat, enhance water quality, enhance aesthetics, and/or maintain natural communities. Examples include installing a rain garden, avoiding heavy applications of fertilizers and herbicides, landscaping to provide food and cover, and preventing the introduction of nonnative plants and insects. Other recommendations are generally applicable to all landowners. For example, indiscriminant or careless killing of native wildlife, particularly amphibians, reptiles, and birds, is discouraged.

Actively communicating best management practices to the public often provides an excellent means of encouraging wildlife populations without major investment of public funds. Consequently, implementing and increasing the acceptance of best management practices is included in the recommendations set forth in Chapter 3 of this report.

Terrestrial Habitat

Terrestrial wildlife needs relatively large, well-connected areas of natural habitat. Consequently, protecting, connecting, and expanding natural habitat is crucial if wildlife populations are to be maintained or enhanced. Open space natural areas can generally be classified as either wetlands or uplands, as described below:

1. **Wetlands**—Wetlands are defined based on hydrology, hydric soils and the presence of wetland plants. There are many types of wetlands (Figure 2.36), from the traditionally familiar cattail/bulrush wetland to forested wetlands. Most aquatic and terrestrial wildlife relies upon, or is associated with, wetlands for at least a part of their lives. This includes crustaceans, mollusks, aquatic insects, fish, amphibians, reptiles, mammals (e.g., deer, muskrats, and beavers), and resident bird species, (e.g., turkey, songbirds, and migrant species, such as sandhill and whooping cranes).

2. **Uplands**—Uplands are areas not classified as wetland or floodplain. They are often characterized by greater depth to groundwater and drier, less organic, more stable soil. Like wetlands, natural uplands also exist in many forms (e.g., prairies, woodlands) and also provide many critical functions for many upland game and nongame wildlife species through provision of critical breeding, nesting, resting, and feeding areas, as well as providing refuge from predators. Unlike wetlands, however, the dry and stable soils make uplands more desirable for urban development and, therefore, such areas are more challenging to protect.

As mentioned above, both wetlands and uplands are critical to wildlife populations. However, the dynamic interactions and free movement between these two types of land are also crucial because many terrestrial organisms spend part of their time in the wetlands and the rest of their time in upland areas. For example, some amphibians live most of their lives in upland areas but depend on wetlands for breeding and hibernation. Consequently, if the connections between the uplands and wetlands are compromised (e.g., if a large road is placed between the two land types) it becomes dangerous, if not impossible, for amphibians to gain access to breeding grounds, thereby reducing their ability to reproduce or seasonally migrate. In fact, habitat fragmentation (i.e., the splitting up of large connected habitat areas) has been cited as the primary global cause of wildlife population decreases.[81] Therefore, protecting and expanding uplands and wetlands, providing naturalized transition habitat, as well as maintaining or enhancing their connectivity, will help maintain or enhance wildlife.

[81] *Lenore Fahrig, "Effects of Habitat Fragmentation on Biodiversity,"* Annual Review of Ecology, Evolution, and Systematics, *Vol. 34, 2003, pp. 487-515.*

To determine the extent of upland and wetland habitat in the Lake Denoon watershed and gauge the state of the connections between these two habitat types, SEWRPC staff inventoried land use and condition. Wetland and woodland habitat areas are shown on Map 2.17. Most wetlands are located at the west end of the Lake and along the streams that enter the Lake from the north. These wetlands are primarily emergent and/or wet meadows or forested areas (Map 2.18). Upland habitat in the watershed includes deciduous woodlands and grassland, as shown on Map 2.19. These wetland and upland habitat complexes are likely ecologically connected. Assuming that it is a priority to maintain or enhance wildlife populations, the LDAA should maintain or enhance upland and wetland habitat whenever practicable. The intervening corridors should also be protected and naturalized to the full extent possible. It is important to note, however, that wetland and upland protection and enhancement require a number of actions, as listed below:

1. Prevent and/or limit development within wetlands, natural upland meadows, and woodlands.

2. Take steps to ensure new, reconstructed, or repaired infrastructure maintains or enhances environmental corridors and ecological connectivity between habitat areas.

3. Expand upland and/or wetland habitat areas where practical (e.g., reestablish wetlands that are currently farmed, create grasslands, or reforest cleared areas). Particular emphasis should be placed on connecting blocks of diverse habitat through naturalized corridors.

4. Control and/or remove invasive plant species introduced to wetlands and uplands, and avoid activities that can disrupt habitat value (e.g., excessive use of motorsport vehicles, intense pedestrian or pet use).

A comprehensive plan must consider each of these elements as important. Therefore, recommendations related to each of these actions are included in Chapter 3. Additionally, implementation guidance for these actions is included in the "Issue 8: Plan Implementation" section below and in Chapter 3.

Figure 2.36
Examples of Different Types of Wetlands

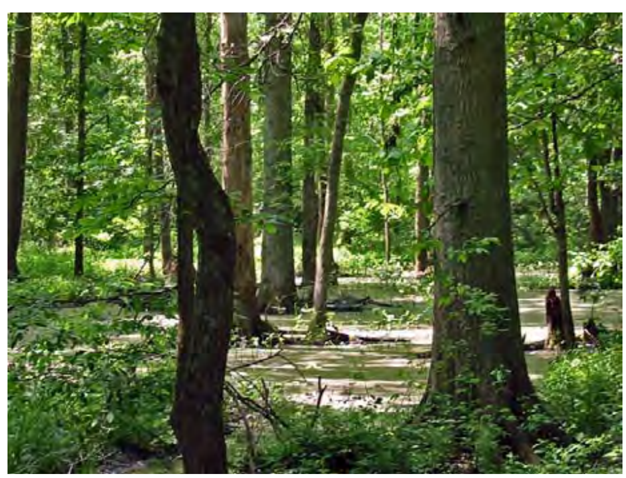
MARSH WETLAND

Source: SEWRPC

SCRUB/SHRUB WETLAND

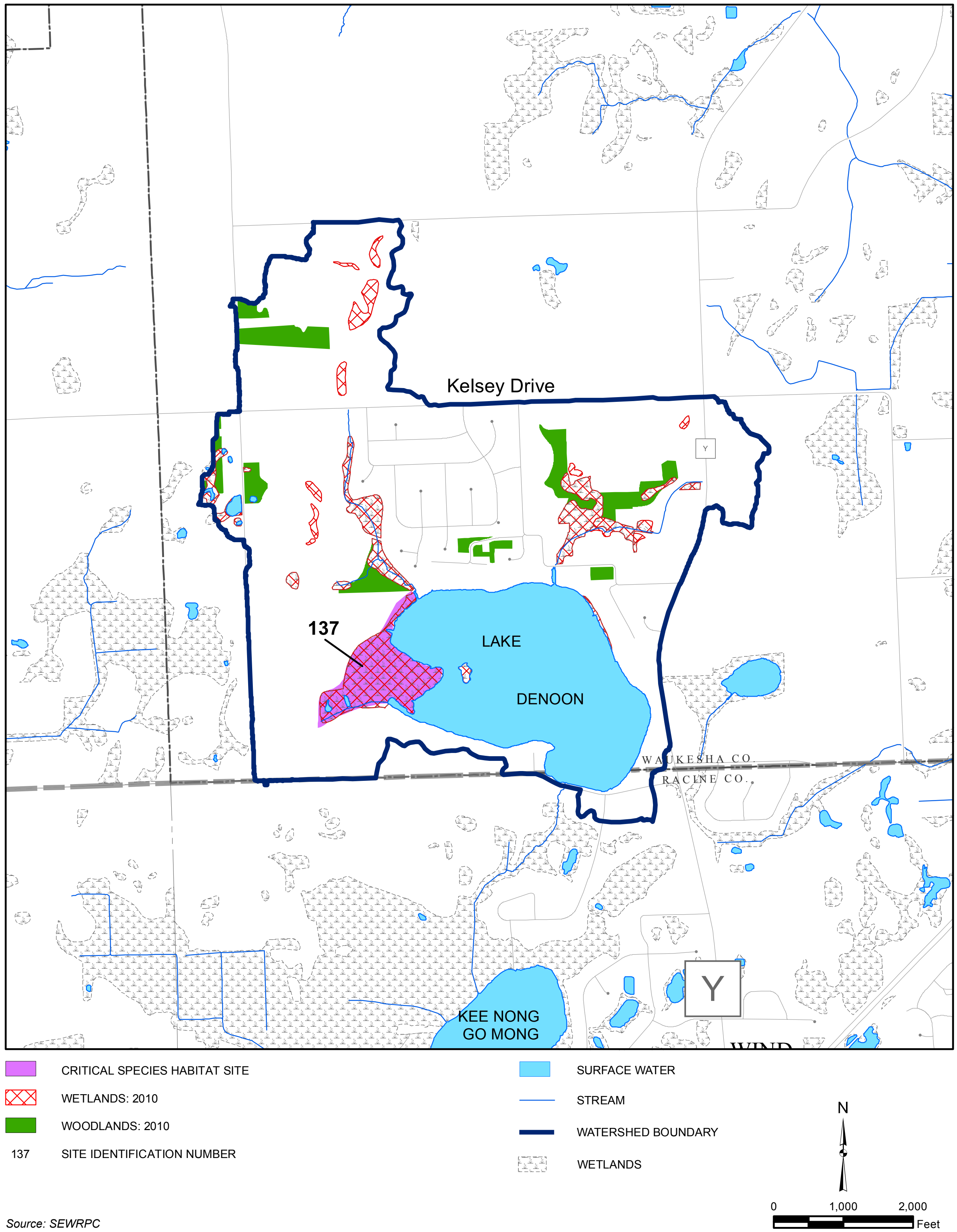
Source: University of New Hampshire Cooperative Extension

FORESTED WETLAND



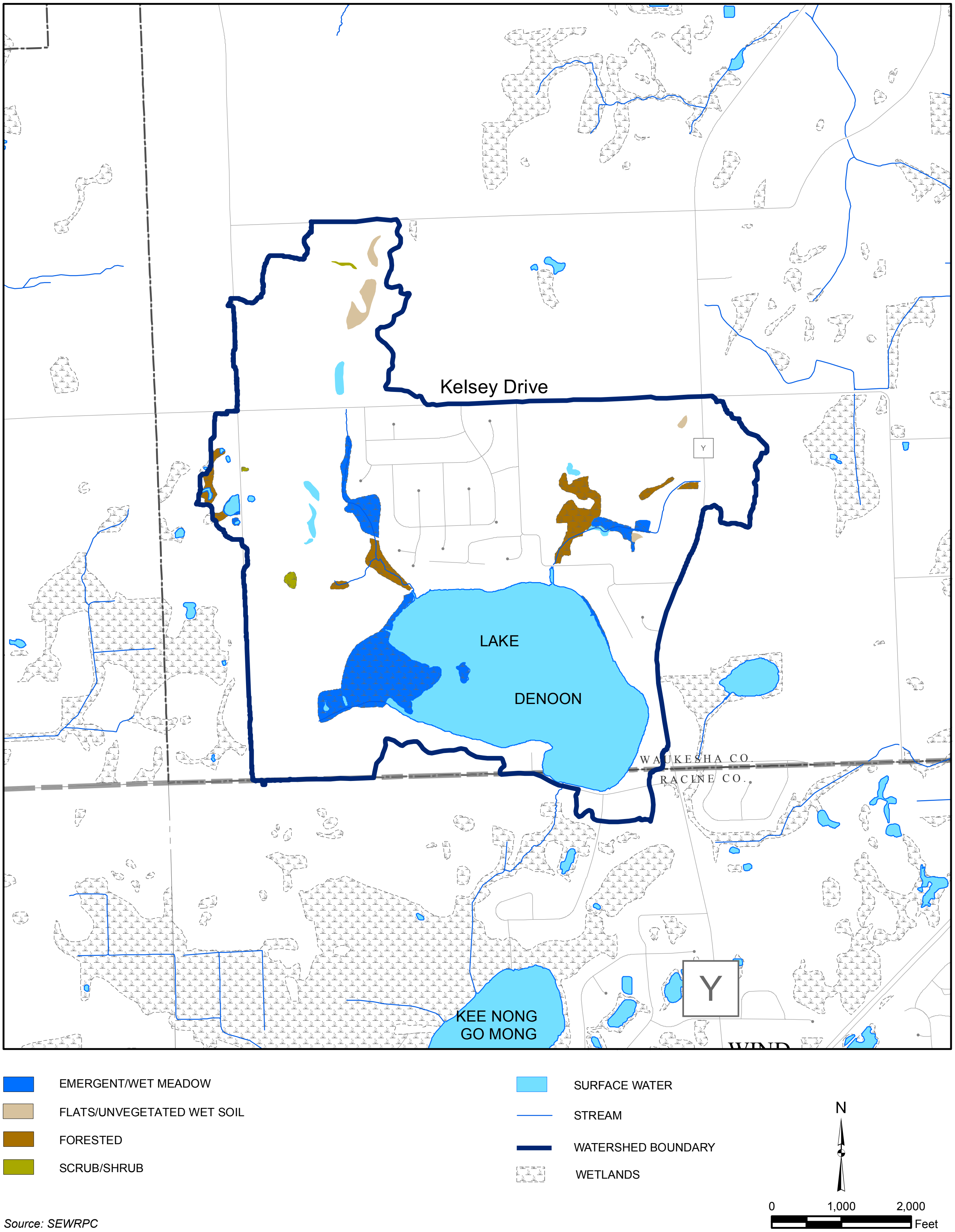
Source: Prince William Conservation Alliance

Map 2.17
Critical Species Habitat, Wetlands, and Woodlands Within the Lake Denoon Watershed



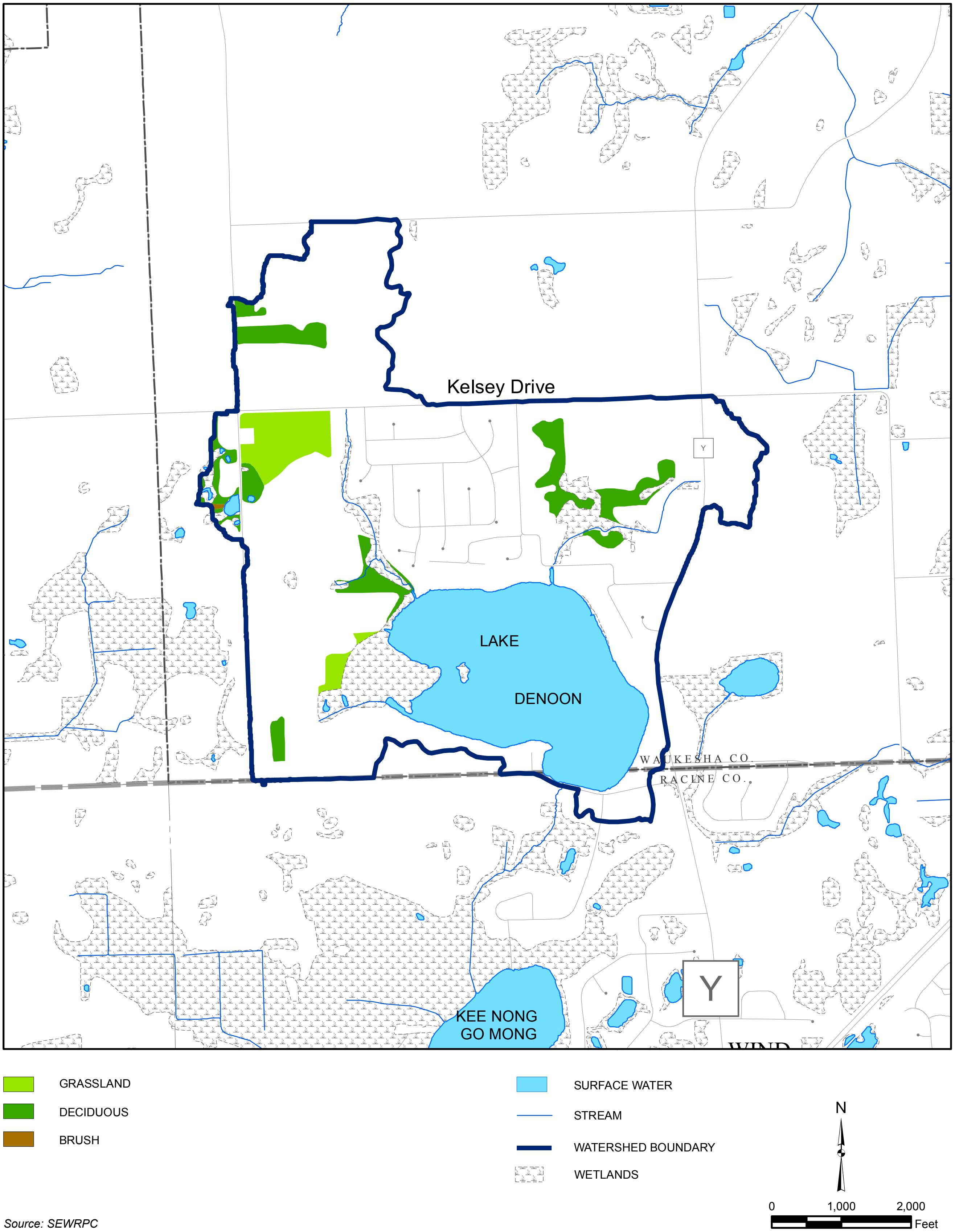
Source: SEWRPC

Map 2.18
Wetland Cover Types Within the Lake Denoon Watershed



Source: SEWRPC

Map 2.19
Upland Cover Types Within the Lake Denoon Watershed



Source: SEWRPC

Other Wildlife Issues

The presence of aquatic birds (primarily geese) on shorelines was also mentioned as an issue of concern. Though some management measures help control geese populations (e.g., oiling goose eggs to prevent hatching) the amount of geese observed on Lake Denoon does not currently appear to warrant such action. Nevertheless, the presence of naturally vegetated buffers can discourage geese from congregating along shoreline areas. Geese prefer mowed grass shorelines. Consequently, the recommendation related to installation of naturalized buffers is further emphasized in Chapter 3 of this plan as a wildlife recommendation.

2.9 ISSUE 8: PLAN IMPLEMENTATION

A core issue for any lake protection plan is the need for guidance to implement plan recommendations, tangible goals, and quantifiable metrics to measure progress and relative success. Developing an action plan with timelines, goals, and identified responsible parties is a significant step toward plan implementation. Target metrics can help implementing agencies gauge progress over time and can help motivate participants, ensuring that the plan is carried through in the long term. When developing an action plan, it is important to know what on-the-ground implementation involves.

Some recommendations can be best achieved using regulations while others involve new proactive management efforts. Both are described below.

Regulatory Implementation

Relative to this plan, regulatory implementation refers to the maintenance and improvement of water quality, water quantity, and wildlife populations through the use of local, State, and Federal rules and laws. A number of regulations already govern activities within the Lake Denoon watershed, including zoning ordinances, boating and in-lake ordinances, and State regulations related to water quality. These regulations already help protect the Lake by mitigating pollution, preventing or limiting development in sensitive areas, and encouraging the use of best management practices.

Ordinances

Zoning ordinances dictate where development can take place, the types of development allowed, and the terms that need to be met for development to proceed. Consequently, zoning can be a particularly effective tool to protect buffers, wetlands, uplands, and shorelands if environmental goals are integrated into ordinance development and formulation. One way to integrate environmental considerations is for the local zoning authorities and other regulatory agencies to use SEWRPC-designated environmental corridors (Figure 2.37). Environmental corridors can be integrated into conservancy zoning district regulations to help determine where development is permitted and not permitted, and to determine the extent of development allowed.

In the Lake Denoon watershed, three independent units of government have differing regulatory authorities that influence lake protection. These units of government included Racine County, Waukesha County, the City of Muskego, and the Town of Norway (Map 2.20, Table 2.25). The City of Muskego has zoning authority covering most of the watershed. Environmental corridor designations are used to set "no development" zones, as well as "limited development" zones depending on whether the area within the corridor is a lowland or upland, respectively. The fact that environmental corridors are used in zoning decisions means that many environmentally critical and/or sensitive areas within the Lake Denoon watershed that are well protected (Map 2.21).

In addition to general zoning, shoreland zoning and construction site erosion control and stormwater management ordinances also play a key part in protecting the resources within the watershed. Shoreland zoning, for example, which is primarily administered by the City of Muskego, follows statewide standards to

Figure 2.37
Synopsis of SEWRPC-Designated Environmental Corridors

SEWRPC has embraced and applied the environmental corridor concept developed by Philip Lewis (Professor Emeritus of Landscape Architecture at the University of Wisconsin-Madison) since 1966 with the publication of its first regional land use plan. Since then, SEWRPC has refined and detailed the mapping of environmental corridors, enabling the corridors to be incorporated directly into regional, county, and community plans and to be reflected in regulatory measures. The preservation of environmental corridors remains one of the most important recommendations of the regional plan. Corridor preservation has now been embraced by numerous county and local units of government as well as by State and Federal agencies. The environmental corridor concept conceived by Lewis has become an important part of the planning and development culture in southeastern Wisconsin.

Environmental corridors are divided into the following three categories.

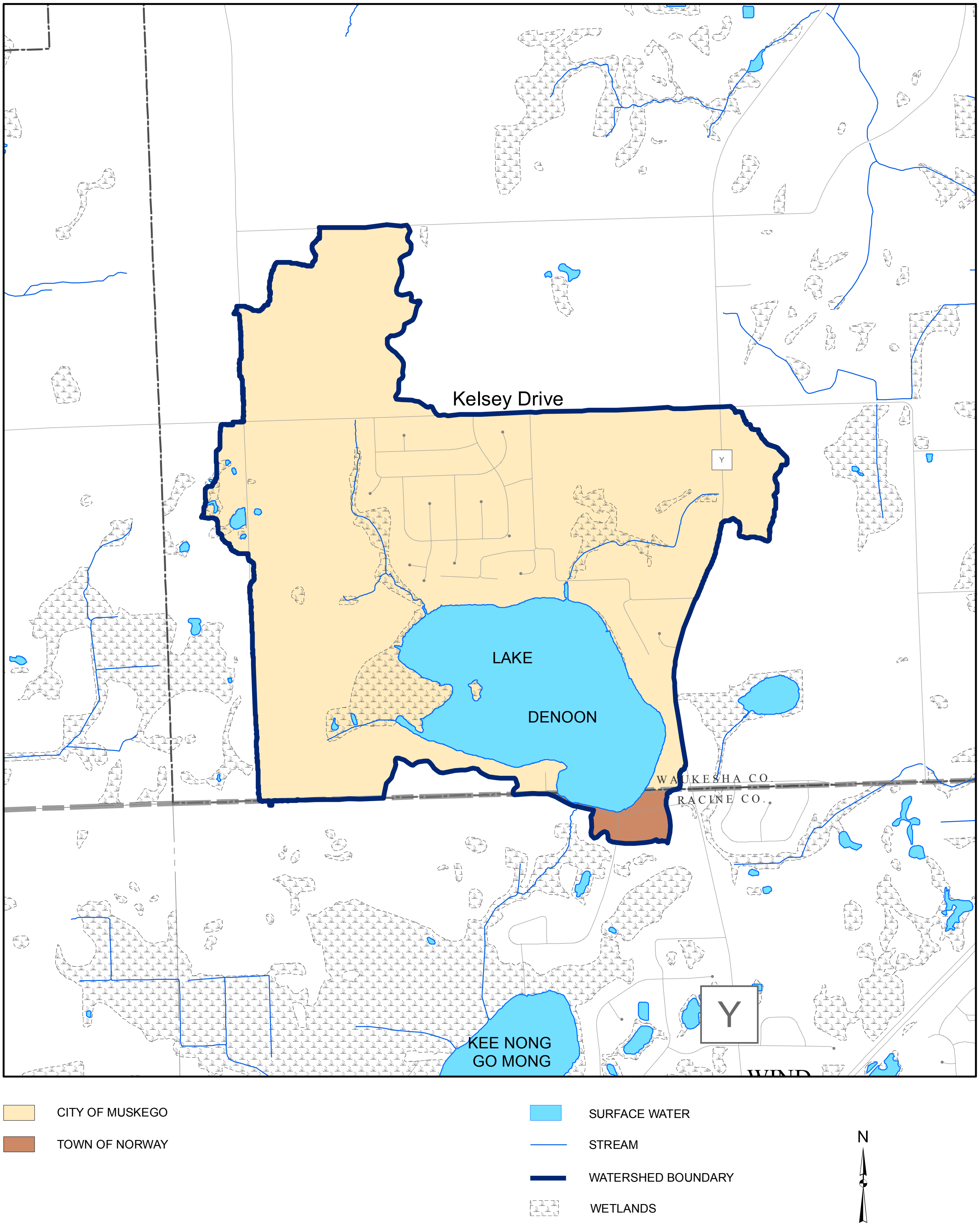
- **Primary environmental corridors** contain concentrations of our most significant natural resources. They are at least 400 acres in size, at least two miles long, and at least 200 feet wide.
- **Secondary environmental corridors** contain significant but smaller concentrations of natural resources. They are at least 100 acres in size and one mile long, unless they link primary corridors.
- **Isolated natural resource areas** contain significant remaining resources that are not connected to environmental corridors. They are at least five acres in size and at least 200 feet wide.

Key Features of Environmental Corridors

- Lakes, rivers, and streams
- Undeveloped shorelands and floodlands
- Wetlands
- Woodlands
- Prairie remnants
- Wildlife habitat
- Rugged terrain and steep slopes
- Unique landforms or geological formations
- Unfarmed poorly drained and organic soils
- Existing outdoor recreation sites
- Potential outdoor recreation sites
- Significant open spaces
- Historical sites and structures
- Outstanding scenic areas and vistas

Source: SEWRPC

Map 2.20
Civil Divisions Within the Lake Denoon Watershed: 2014



Source: SEWRPC

Table 2.25
Land Use Regulations Within the Lake Denoon Watershed, by Civil Division: 2014

	Type of Ordinance				
Community	General Zoning	Floodplain Zoning	Shoreland or Shoreland-Wetland Zoning	Subdivision Control	Construction Site Erosion Control and Stormwater Management
City of Muskego	Adopted	Adopted	Adopted	Adopted	Adopted
Racine County	Adopted[a]	Adopted[a]	Adopted[a]	Adopted[b]	Adopted[b]
Town of Norway	Regulated under County ordinance	Regulated under County ordinance	Regulated under County ordinance	Adopted[c]	Adopted[c]

[a] *The Racine County Zoning Ordinance applies in all unincorporated areas (towns) in the County. Shoreland and floodplain regulations are included in the zoning ordinance.*

[b] *The Racine County Subdivision Ordinance includes erosion control and stormwater management regulations. The ordinance applies only in unincorporated areas (towns) in the County.*

[c] *The Town of Norway Subdivision Ordinance includes erosion control and stormwater management regulations. Both the Town and County subdivision ordinances apply in the Town. In the event of conflicting regulations, the more restrictive regulation applies.*

Source: SEWRPC

create building setbacks around navigable waters.[82] Additionally, stormwater management and construction erosion control ordinances help minimize water pollution, flooding, and other negative impacts of development on water resources.

Boating and In-Lake Ordinances

Boating and in-lake ordinances regulate the use of the Lake in general, and when implemented properly, can help prevent inadvertent damage to the Lake such as excessive noise and wildlife disturbance, severe shoreline erosion from excessive wave action reaching the shoreline, and agitation of sediment and aquatic vegetation in shallow areas. The boating ordinance for the City of Muskego (including Lake Denoon) is provided in Appendix H. This ordinance is generally enforced by a warden or by the local law enforcement agency.

State Regulations

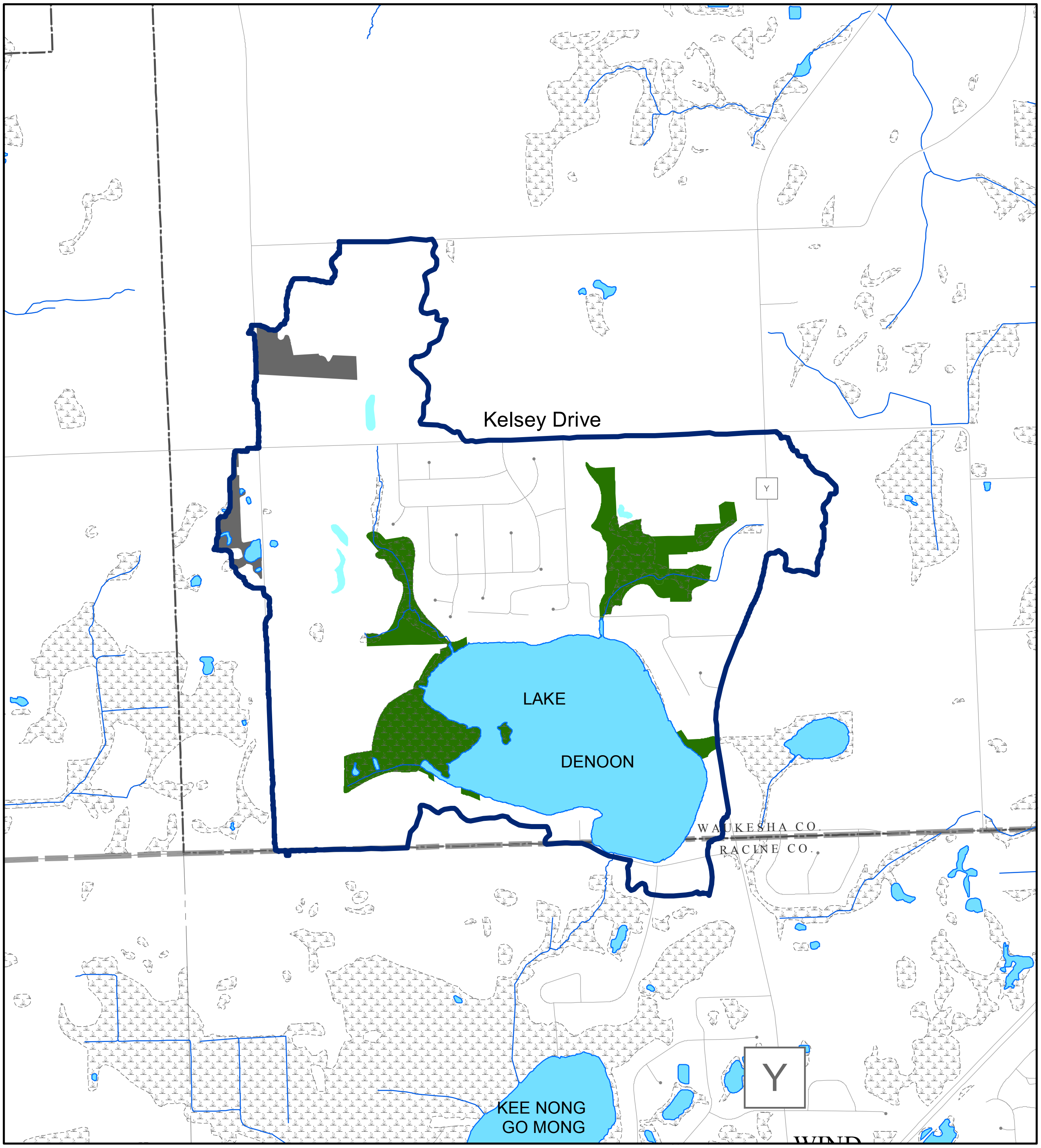
The State Legislature requires the WDNR to develop performance standards for controlling nonpoint source pollution from agricultural and nonagricultural land and from transportation facilities.[83] The performance standards, which are set forth in Chapter NR 151, "Runoff Management," of the *Wisconsin Administrative*

---

[82] *The 2015-2017 State Budget (Act 55) changed State law relative to shoreland zoning. Under Act 55, a shoreland zoning ordinance may not regulate a matter more restrictively that it is regulated by a Sate shoreland-zoning standard unless the matter is not regulated by a standard in Chapter NR 115, "Wisconsin's Shoreland Protection Program," of the* Wisconsin Administrative Code. *Examples of unregulated matters may involve wetland setbacks, bluff setbacks, development density, and stormwater standards. In addition, under Act 55, a local shoreland zoning ordinance may not require establishment or expansion of a vegetative buffer on already developed land and may not establish standards for impervious surfaces unless those standards consider a surface to be pervious if its runoff is treated or is discharged to an internally drained pervious area. Additional legislation relative to shoreland zoning enacted after the 2015-2017 State budget legislation includes Act 41, which addresses town shoreland zoning authority relative to county authority (effective date: July 3, 2015) and Act 167, which codifies and revises current Wisconsin Department of Natural Resources shoreland standards.*

[83] *The State performance standards are set forth in the Chapter NR 151, "Runoff Management," of the* Wisconsin Administrative Code. *Additional code chapters that are related to the State nonpoint source pollution control program include: Chapter NR 152, "Model Ordinances for Construction Site Erosion Control and Storm Water Management" (this Chapter will be revised in response to the 2013 Wisconsin Act 20 as noted in WDNR Guidance #3800-2014-3, "Implementation of 2013 Wisconsin Act 20 for Construction Site Erosion Control and Stormwater Management," October 2014.); Chapter NR 153, "Runoff Management Grant Program;" Chapter NR 154, "Best Management Practices, Technical Standards and Cost-Share Conditions;" Chapter NR 155, "Urban Nonpoint Source Water Pollution Abatement and Storm Water Management Grant Program;" and Chapter ATCP 50, "Soil and Water Resource Management." Those chapters of the* Wisconsin Administrative Code *became effective in October 2002. Chapter NR 120, "Priority Watershed and Priority Lake Program," and Chapter NR 243, "Animal Feeding Operations," were repealed and recreated in October 2002.*

Map 2.21
Environmental Corridors Within the Lake Denoon Watershed: 2010



PRIMARY ENVIRONMENTAL CORRIDOR
SECONDARY ENVIRONMENTAL CORRIDOR
ISOLATED NATURAL RESOURCE AREA
SURFACE WATER
STREAM
WATERSHED BOUNDARY
WETLANDS

N

0 1,000 2,000 Feet

Source: SEWRPC

Code, set forth requirements for best management practices. Regulations also cover construction sites, wetland protective areas, and buffer standards.

Water quality objectives are presented in Chapter NR 102, "Water Quality Standards for Wisconsin Surface Waters," of the *Wisconsin Administrative Code*. These rules set water quality standards that promote healthy aquatic ecosystems and public enjoyment of the water body. Some of the standards set in this rule applicable to Lake Denoon include the following:

- Dissolved oxygen greater than or equal to 5.0 mg/L
- pH between 6.0 and 9.0 SU
- Fecal coliform geometric mean less than or equal to 200 colonies per 100 milliliters, single sample maximum less than or equal to 400 colonies per 100 milliliters
- Total phosphorus (summer epilimnion) 20 μg/L
- Chloride acute toxicity 757 mg/L, chronic toxicity 395 mg/L

This rule further stipulates maximum temperatures for each month, with the highest standards applying to July and August when the following maxima apply: ambient water temperature of less than or equal to 77°F, sublethal water temperature of less than or equal to 80°F for one week or less, and acute water temperature of less than or equal to 87°F for one day or less.

The regulations discussed above play a crucial role in maintaining the health of the Lake and the resources within the Lake Denoon watershed. However, even though developers, residents, and Lake users are legally obligated to adhere to ordinances, limited resources within enforcement bodies at State, County, and municipal levels can sometimes make the task of ensuring compliance difficult. <u>Consequently, Chapter 3 recommends ways the LDAA can help regulatory agencies effectively enforce existing ordinances and regulations</u>.

Proactive Management Efforts

In addition to continued and enhanced regulatory enforcement, a number of recommendations made under this plan seek to proactively improve conditions within the Lake through voluntary management efforts. Chapter 3 provides details on these recommendations and guidance regarding implementation. However, several challenges can limit the ability of Lake residents and the Advancement Association to engage in certain management efforts recommended under this plan. Some of these challenges include:

1. **Lack of adequate funding**—The City of Muskego, as a taxing body, has authority to levy taxes to secure funding, including that necessary to manage land use and runoff within the Lake's watershed. In addition, grant funds may be available to help finance larger, more extensive projects that would otherwise exceed the LDAA's budgetary reach. Examples of potential funding sources are briefly described in Chapter 3.

2. **Institutional capacity**—Institutional capacity refers to assets available through agencies, universities, schools, service groups, and non-governmental organizations that can be used to implement projects. These assets can be defined in terms of knowledge, staff, equipment, and other resources. Many resources are available to help residents and lake users implement management measures. Nevertheless, some guidance will likely be necessary to ensure that those attempting management projects are completing the projects in an effective and efficient fashion consistent with plan recommendations.

3. **Volunteers** – To increase the advocacy, learning opportunities, and volunteer base for labor intensive or broad-based projects like hand-pulling or wetland invasive species monitoring, it is desirable to reach a broader stakeholder group. The stakeholder group should extend beyond lakeshore and near-lakeshore residents.

Chapter 3 provides recommendations and suggested actions that seek to ensure that the above capacity issues are addressed.

In addition to capacity building, openly sharing and communicating plan details is a crucial element to encouraging voluntary management efforts. For example, describing the difference between invasive, native, and nonnative plants and the fact that removing aquatic plants can spur algae growth. Communicating these examples helps ensure that homeowners understand why a "clean" shoreline is not always the best option for a lake, and that a healthy plant community is desirable on their shoreline. Consequently, another major recommendation in Chapter 3 is openly and actively communicating key plan elements.

2.10 SUMMARY

Many opportunities exist to help promote sustainable use of Lake Denoon and its watershed. All issues of concern expressed by Lake Denoon residents during plan development have merit, and specific recommendations for each concern are presented in Chapter 3. Addressing these issues will positively contribute to effectively managing the resources of Lake Denoon and its watershed and improving the overall health of the Lake.

LAKE MANAGEMENT RECOMMENDATIONS AND IMPLEMENTATION 3

Credit: SEWRPC Staff

3.1 INTRODUCTION

This chapter provides recommendations addressing issues of concern identified in Chapter 2. Implementing these recommendations helps maintain and enhance the health of Lake Denoon and encourages its continued enjoyment. The recommendations provided in this chapter are based upon concerns identified by stakeholders, subsequent data collection and analysis, and suggestions developed and presented in Chapter 2.

The recommendations made in this chapter cover a wide range of programs and seek to address a broad array of factors and conditions that significantly influence the health, aesthetics, and recreational use of Lake Denoon. Since the plan addresses a wide scope of issues, it may not be feasible to implement every recommendation in the immediate future. To promote efficient plan implementation, the relative importance and significance of each recommendation is noted to help Lake managers prioritize plan elements. Nevertheless, all recommendations should eventually be addressed, subject to possible revision based on analysis of yet-to-be collected data (e.g., future aquatic plant surveys and water quality monitoring results), project logistics, and/or changing/unforeseen conditions.

Those responsible for Lake Denoon planning and management should actively conceptualize, seek, and promote projects and partnerships that enable the recommendations of the plan to be implemented. The measures set forth in this chapter are primarily focused on those that can be implemented through collaboration between local entities, watershed property owners, and other local stakeholders who have a vested interest in Lake Denoon. Examples include the Lake Denoon Advancement Association (LDAA), Racine, and Waukesha Counties, the City of Muskego, the Town of Norway, and Lake Denoon residents. Additionally, collaborative partnerships formed among other stakeholders (e.g., the Wisconsin Department of Natural Resources (WDNR), developers, non-governmental organizations (NGOs), and other nearby municipalities) help promote efficient, affordable, and sustainable actions to assure the long-term ecological health of Lake Denoon.

As a planning document, this chapter provides concept-level descriptions of activities that can be undertaken to help protect and enhance Lake Denoon. The full logistical and design details needed to implement most recommendations would be developed independently when various components of the plan are executed. Grants are oftentimes available to take concepts and produce actionable design drawings and plans It is important to note that the recommendations provide implementing entities with guidance regarding the type and nature of projects to pursue to meet plan goals.

In summary, this chapter provides a context for understanding what needs to be done and what elements are believed to be relatively more important. In doing so, those implementing the plan can better envision what such efforts may look like and can more fully comprehend the overall intent. Such concepts can be invaluable for building coalitions and partnerships, writing competitive and meaningful grant requests, and initiating project design work.

3.2 ISSUE 1: WATER QUALITY

Available water quality data suggest that Lake Denoon is, and has historically been, a meso-eutrophic (moderate to high nutrient level) lake for at least the past 50 years. Nevertheless, the fact that many Lake residents express concern regarding various water-quality-related issues (e.g., sources of pollution in the watershed, the volume of aquatic plant growth, and algal growth) suggests that supplemental actions are warranted to safeguard or improve water quality. Evaluation of the existing data set reveals the following:

- Internal loading is likely a significant contributor to plant-available phosphorus in Lake Denoon and action can be taken to reduce this nutrient source
- Marl precipitation likely helps reduce in-lake phosphorus concentrations
- Because chloride concentrations are also an indicator of other human-sourced pollutants, the Lake likely receives significant loads of human-sourced chemicals
- The Lake has a lower than typical ability to flush pollutants downstream making it in some ways more vulnerable to water quality concerns

As explained in Chapter 2, management efforts to improve water quality in Lake Denoon should focus primarily on the following seven strategies:

1. **Protect and enhance buffers, wetlands, and floodplains**. Protecting these features helps safeguard areas that already benefit the Lake and require little to no additional inputs of money and labor. For this reason, protecting such areas should be considered a high priority. Enhancing these features is often a cost-effective way of increasing the level of lake protection and should be considered a medium priority. Efforts should begin by targeting direct residential inflow sources, (i.e., the Lake shoreline properties) and various sources from properties adjacent to the three mapped tributary streams. Efforts may extend to adjacent properties as suitable. Implementation of this recommendation could involve the following:

    a. Continue to carefully control and substantially limit development in primary environmental corridors (see Map 2.21 in Chapter 2) to protect existing natural buffers, floodplains, and wetlands systems. This may be accomplished through local zoning.

    b. Continue to enforce local (City of Muskego and Town of Norway) drainage and shoreland setback ordinances and land development protocol. These ordinances require setback from ordinary high water marks of surface waters, drainage channels, and watercourses; and prohibit filling and development of certain sensitive areas. Depending upon the particular purpose of the subject code, setbacks range from 10 to 75 feet.

    c. Provide information to shoreland property owners and landowners along mapped tributaries. This information should describe the benefits that near-shore aquatic and terrestrial buffers provide to the Lake with the goal of encouraging landowners to protect buffers where they still occur and to enhance, restore, or create buffers in other favorable areas where none remain. This information could include practice installation information and typical costs. Such programs would be most productive if accompanied by an incentive program that helps share the cost of installation or provides tax incentives.

Two examples of programs that could enhance buffers in the watershed include rain gardens in residential areas and U.S. Department of Agriculture Farm Service Agency programs such as the Conservation Reserve Program (CRP) and affiliated Conservation Reserve Enhancement Program (CREP) in agricultural areas. Both of these initiatives use vegetation to slow and filter stormwater runoff. If thoughtfully designed and located, groundwater recharge may also be enhanced. Grants may also be available for novel initiatives such as cropped buffers, where farmers receive a compensatory payment for growing crops that help filter runoff.

d. Consider a shoreline best management practice and shoreline buffer enhancement program. This program could encourage the development of rain gardens or buffers along the shoreline. WDNR recently introduced a "Healthy Lakes" grant program that could help fund some of these efforts (Appendix I).

e. Consider obtaining conservation easements and purchasing wetlands, floodplains, and uplands in key areas. Buffers can be preserved indefinitely and their ecological value can be enhanced to improve their habitat, filtering, and hydrologic functions.

f. Monitor and protect areas of natural vegetation and take steps to control invasive species that threaten ecological value. The major recommendation is to **monitor and control reed canary grass in wetlands and shorelands**. This species, a two to nine foot tall grass as shown in Figure 2.27, spreads and quickly displaces native wetland plants that help reduce polluted water from reaching the Lake and provide desirable habitat. Consequently, a visual survey of appropriate watershed and shoreline locations is recommended to determine whether reed canary grass is a problem. If it is found to be an issue, the infestation should be promptly eradicated naturalizing stream and wetland form and function.

g. Maintain or restore natural stream channel form and function. Natural stream channels temporarily store water in floodplains, improving water quality and reducing downstream flood peaks. Ditched and/or straightened channels should be naturalized to restore such function when possible.

2. **Monitor and actively manage woodlands**. Perhaps the largest threat too many woodlands in Southeastern Wisconsin is the combined problem of diseases and insects that destroy the native tree canopy and invasive plants such as buckthorn (common buckthorn *Rhamnus cathartica* and glossy buckthorn *Frangula alnus*) that inhibit or prevent native tree regeneration. Introduced pests have attacked ash, elm, butternut, and oak species. New pests are on the horizon that target black walnut, beech, and other trees. Existing woodlands should be kept free of invasive plant species and actions should be taken to prepare the woodland for the arrival of pests. For example, increasing the diversity of tree species through careful stand management and or planting can help assure that complete canopy loss does not occur in the future. State programs are available to assist woodland owners with stand management, tax implications, and professional forestry advice.[84] Woodland protection should be assigned a <u>medium priority</u>.

3. **Continue to carefully maintain stormwater detention basins**. Stormwater detention basin maintenance should be considered a high priority especially in those areas where additional residential development is planned to occur. Maintenance includes managing aquatic plants, removing and disposing of flotsam/jetsam, ensuring adequate water depth remains to settle and store pollutants, and actively and aggressively managing excess sediment. Specifications associated with the design of stormwater detention basins and mandated maintenance requirements help assure that basins are functioning properly.[85] It is important to remember that stormwater detention ponds occasionally

---

[84] *The following website provides an overview of WDNR forestry information and programs: dnr.wi.gov/topic/ForestLandowners/*

[85] *Technical standards for design and maintenance of wet detention basins and other stormwater management practices can be found at dnr.wi.gov/topic/stormwater/standards/postconst_standards.html.*

require dredging to maintain characteristics that protect the Lake. The frequency of dredging is highly variable and is dependent upon the design of the basin and the characteristics of the contributing watershed. Inspection of basins should be completed by the responsible regulatory entities in a manner consistent with current practices. Nevertheless, helping stormwater basin owners to comprehend the larger-scale importance of meeting performance requirements (through educational outreach) can help assure continued proper basin function.

4. **Stringently enforce construction site erosion control and stormwater management ordinances**. This should be considered a <u>medium priority</u> in the immediate future. However, **if in the future substantial new development is proposed in the watershed, this priority level should increase to <u>high</u>**. Ordinances must be enforced by the responsible regulatory entities in a manner consistent with current practices; however, local citizens can help by reporting potential violations to the appropriate authorities (see "Issue 8: Implementation" section).

   An excellent opportunity to reduce Lake sediment and nutrient loading will eventually become available in future. Much of the remaining agricultural land is planned to transition to largely residential use. Whereas this may have been perceived as a negative to Lake health in the past, state-of-the-art stormwater management practices that manage the rate, volume, and quality of urban stormwater can tangibly lessen pollution loads and modulate runoff volumes when compared to existing agricultural land use. Therefore, if carefully selected and constructed, stormwater management practices in the newly developed portions of the watershed may reduce the pollution load to the Lake and enhance dry weather baseflow. Moreover, future stormwater detention basins can be designed and located to provide more than pollutant trapping and runoff detention functions. If thoughtfully and carefully located, and managed properly (e.g., not maintained as mowed lawn), stormwater basins can provide valuable aquatic, riparian, and upland habitat values (e.g., a basin located adjacent to a natural area). Similarly, stormwater detention basins can be located in areas more prone to contribute to groundwater recharge, helping sustain valuable groundwater-derived baseflow to the Lake and its tributary streams and wetlands.

5. **Encourage pollution source reduction efforts along the shorelines (best management practices)**. Although the Lake is relatively nutrient rich, external loading of pollutants do not presently appear to be unduly influencing water quality. Nevertheless, as a stratified seepage lake with a low flushing rate, the Lake is more sensitive to nutrient enrichment than other lake types. Therefore, this practice is considered a <u>medium priority</u>, if water quality degradation issues are identified based on future monitoring efforts, the priority should increase. Pollution reduction measures include reducing fertilizer use to the maximum extent practical, ensuring vehicles and stored equipment are not leaking fluids on driveways, maintaining rain gardens to which runoff can drain, preventing soil erosion, properly disposing of leaf litter and grass clippings, and properly storing salt and other chemicals so they do not drain to the Lake. The City of Muskego collects leaves curbside in the fall, and residents can pick up free leaf mulch whenever it is available. Although leaf collection is available, some residents continue to burn or compost leaves at their own property.[86] Communicating these best management practices, and engaging in a campaign to encourage their use (e.g., offering to pick up grass clipping or leaves from homeowners) will likely yield a low-cost way to help reduce water quality problems.

6. **Manage in-lake phosphorus sources**. Lake Denoon has a very small watershed and is not known to have any large point source phosphorus loading, making the Lake an excellent candidate for in-Lake treatment. The available evidence suggests that high internal loading likely has been a problem since at least the 1960s. Since the Lake has been popular for over a century, and since water pollution control was not a priority in many areas until about 50 years ago, phosphorus loads may be an artifact of pollution that occurred in the early 20th century. Based upon the data analyzed as part of this report, internal loading is believed to be a significant source of phosphorus to aquatic plants in Lake Denoon.

   While the Lake exhibits relatively good overall health at the present time, overall habitat quality could likely be enhanced by decreasing key plant nutrients. This in turn would help the Lake achieve

[86] *Zagar, Tom (City of Muskego),* Leaf Disposal, *Email to Dale Buser (SEWRPC), April 14, 2016.*

less eutrophic conditions, lessen stress on the Lake's fish and aquatic life community, help assure that natural plant-induced phosphorus sequestration processes continue, and sustain a high-quality ecosystem with more long-term resilience. Reducing excess phosphorus is key to this dynamic; therefore, managing in-Lake phosphorus should be considered a <u>medium to high priority</u> at the present time. Additional data may need to be collected to more fully evaluate internal loading dynamics, estimate dosing, and/or monitor treatment effectiveness. For example, additional water chemistry profiles and sediment samples from the deep portion of the Lake may need to be collected to better quantify internal loading rates.

While a large variety of techniques can be used to reduce internal loading of phosphorus, two approaches appear to be the most promising for Lake Denoon. Additional details regarding each are provided below.

a. **Chemical inactivation using alum**. Alum is used to purify drinking water and has been used for over four decades to improve lake water quality. Although all types of lakes have been treated with alum, lakes that lack significant external sources of phosphorus and owe much of their plant-available phosphorus to internal loading are most amenable to this approach. <u>Lake Denoon fits both these criteria quite well, and appears well suited for alum treatment</u>.

   Alum treatments trap water-borne particles which in turn settle to the lake bottom and form a layer of sediment that does not release phosphorus to overlying lake water under oxygenated or anoxic conditions. After an alum treatment is completed, water is much clearer and phosphorus concentrations are markedly lower. Improved water clarity catalyzes additional synergistic responses that further limit phosphorus concentrations in the lake. Clearer water allows the plants that naturally produce marl to spread to greater depths, reinforcing the abundance of plant types that promote natural phosphorus sequestration. Lower phosphorus concentrations reduce the concentration of algae in open waters of the lake, increasing water clarity and decreasing the load of organic matter decomposed in the hypolimnion. Decreased oxygen demand related to reduced algal decomposition allows oxygen concentrations in deeper areas to increase and/or the volume of anoxic water to decrease. Since oxygen-deficient water is the catalyst for internal loading, reducing the volume (and hence extent) of anoxic water reduces a lake's overall internal loading potential.

   Care must be taken to achieve proper alum dosing. A dose should create a capping layer thick enough to form a nonreactive barrier above phosphorus-bearing sediment. Since alum is acidic, buffering agents are commonly applied with the treatment. According to the WDNR, the cost for an alum treatment averaged less than $500 per acre of lake surface area in 2003 (Appendix J). Assuming average conditions and adjusting for inflation, the WDNR cost data suggests that <u>an alum treatment for Lake Denoon may cost roughly $100,000</u>. Others report significantly higher costs.[87] Most information sources state that benefits from alum treatments can tangibly improve water quality in stratified lakes for decades. Alum treatments on deep stratified lakes such as Lake Denoon typically benefit the lake for 21 years. Alum treatments have reduced epilimnetic total phosphorus concentrations in some lakes for as long as 45 years following treatment.[88]

b. **Hypolimnetic withdrawal and on-shore treatment** involves drawing water from deep areas of a lake, piping it to a convenient location on the shoreline and manipulating water chemistry using natural processes and/or induced physical and/or chemical means to cause phosphorus to come out of solution. On-shore treatment may also be employed to treat stormwater before it enters a lake.

---

[87] *Bassett Creek Watershed Management Commission, "Twin Lake Phosphorus Internal Loading Investigation", March, 2011.*

[88] *Huser, Brian, Sara Egemose, Harvey Harper, Michael Hupfer, Henning Jensen, Keith. M. Pilgrim, Kasper Reitzel, Emil Yydin, and Martyn Futter,* Longevity and effectiveness of aluminum addition to reduce phosphorus release and restore lake quality, *Water Research, in press.*

Water can be treated in several ways. For example, it can be drawn from a lake or stream, or treated in-line in a stormwater conveyance system. Several treatment processes can be combined for the desired result. The treatment process can rely on common municipal/industrial treatment practices, often employing prefabricated treatment system components. Alternatively, nature-like processes can be promoted in purpose-built treatment cells to enhance water quality. Such treatment cells may take the appearance of ponds or wetlands. Examples of treatment processes that could benefit Lake Denoon include:

i. **Aeration**. The simplest form of on-shore treatment is aeration. Air is pumped through water, increasing water oxygen concentration. The oxygenated water is then returned to deeper portions of the lake. This helps reduce the volume of anoxic water, reducing the areal extent of sediment/water conditions prone to release phosphorus to the water column, and, thereby, decreasing the amount of phosphorus released to the lake from bottom sediment.

ii. **Dissolved phosphorus removal**. Dissolved phosphorus can be removed from the lake water by introducing certain compounds that combine with phosphorus forming a solid precipitate that is then collected and removed. Iron, alum, and lime can all be used to precipitate dissolved phosphorus under various pH and dissolved oxygen conditions. Since the treated water is in a controlled environment, water chemistry can be manipulated to allow any of these compounds to precipitate phosphorus.

iii. **Clarification**. Particles are removed from water by allowing the water to remain motionless for a period of time, by active filtration, or by centrifugal action. All of these clarification processes can be enhanced using flocculants such as alum.

iv. **Nature-like processes**. Water is allowed to flow, be detained, or otherwise handled in ways that help remove pollutants. An example includes pumping deep lake water to a dug pond or created wetland. Water is then aerated, comes in contact with plant material, filters through the underlying substrate, and is returned to the lake or a tributary of the lake through a diffuse path (e.g., created wetlands) or through the shallow groundwater system. This type of system would need to be built upon areas not occupied by natural wetlands. Significant open upland soils areas are found within a half mile of Lake Denoon.

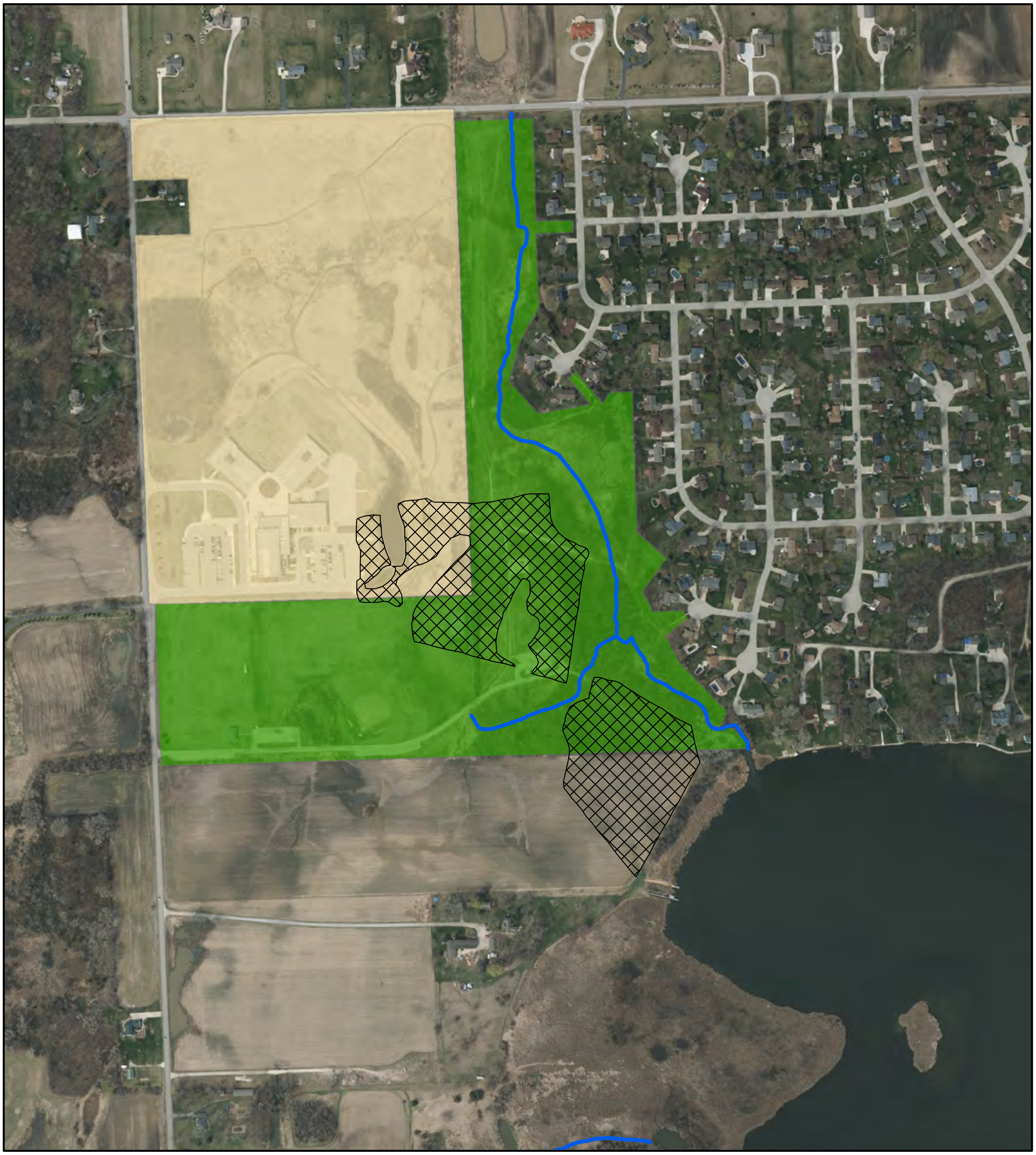
On-shore treatment is currently used to improve water quality in many other lakes. For example, an active treatment system operating on Crystal Lake (a 79 acre, 35-foot-deep lake in the Minneapolis metropolitan area) removed 200 pounds of phosphorus from stormwater and water drawn from the hypolimnion during its first full season of operation. This system is composed of a large vessel, operates between May and November, and can treat over one million gallons of water per day. This treatment volume equals about one-third of Crystal Lake's entire volume over the period of operation.[89] Another community chose to polish wastewater to remove phosphorus using constructed wetlands and a carefully engineered groundwater recharge area to supplement flow in a high quality river.

The prevailing water elevation and lake outlet flow rate influences the method chosen to withdraw water. If the rate of withdrawal could be expected to exceed the desired lake outlet discharge rate, the treated water should normally be returned to the lake to reduce the potential for lowered lake levels. In this case, lake water can be actively pumped to an area topographically higher than the lake, treated, and be allowed to return to the lake directly (via tributaries) or indirectly (via shallow groundwater). Large areas of upland soil suitable for dug ponds and created wetlands are present to the north and west of Lake Denoon, including portions of Denoon Park (Map 3.1). Prefabricated treatment equipment could also be situated in any number of areas.

---

[89] *Dullinger, Danielle,* "Robbinsdale Working to Clean Up Crystal Lake", *StarTribune, March 11, 2014, www.startribune.com/robbinsdale-working-to-clean-up-crystal-lake/249536501/.*

Map 3.1
Areas Underlain by Soils Favorable for Treatment Cell Construction and Operation: 2017



HYDROLOGIC AND SOIL CONDITIONS FAVORABLE FOR TREATMENT CELLS

DENOON PARK

LAKE DENOON MIDDLE SCHOOL

STREAM

DATE OF PHOTOGRAPHY: APRIL 2015

N

0 300 600 Feet

Source: SEWRPC

If lake elevations and outlet flow are moderate to high, water can be drawn from deep portions of the lake with little or no active pumping under favorable topographic conditions. Flashboards or gates can be used to prolong the period of time such a system could operate without reducing lake levels from normal elevation ranges. Water is treated prior to discharge. Unfortunately, suitable natural soils do not appear to exist near Lake Denoon at elevations enabling gravity discharge and nature-like treatment. However, prefabricated treatment equipment may possibly be situated in areas allowing gravity discharge with active treatment.

The cost of on-shore treatment varies widely and depends upon the type and intensity of treatment desired Custom-built on-shore treatment plants require significant capital investment to construct and continual input of labor, services, and consumable supplies over long periods of time. For example, the large system installed on Crystal Lake, Minnesota to resolve severe stormwater quality issues (see preceding paragraph) cost over one million dollars to build and $90,000 per year to operate. Equipment may sometimes be leased and delivered onto a site as a prefabricated package plant. In such a case, the risk of long-term commitment is reduced. Furthermore, smaller plants operating over extended periods of time can incrementally reduce the amount of phosphorus in a lake that does not suffer from heavy external loads. The cost of nature-like systems depends upon desired location and treatment capacity. In the right setting, little special investment may be needed aside from pumps, piping, and ongoing utility costs.

A solution may be available that synergistically addresses two lake management concerns. The lake outlet structure is poorly understood and is reportedly incapable of releasing water at sufficient rates during periods of high runoff. A supplemental spillway could be constructed to augment the existing outlet capacity. The supplemental spillway would include piping laid upon the lakebed and from the lake outlet and extending to the deepest portions of the lake. Such a piped spillway allows hypolimnetic water to be withdrawn from the lake. Preliminary inspection suggests that suitable soil areas are only found at elevations above the lake level, so pumping would be required. Water would then be fed to treatment equipment or cells as described above, and the treated water would be passed downstream and returned back to the Lake. Such a system would only operate during high water periods.

7. **Maintain healthy and robust native aquatic plant populations** should be considered a high priority. Native aquatic plants compete for nutrients with algae and undesirable plant species. Some species (particularly muskgrass) help remove phosphorus from the water column, reducing the fertility of the Lake. Additional information regarding aquatic plant management is given as part of "Issue 3: Aquatic Plant Growth."

8. **Continue to actively track key in-lake and tributary water quality parameters**. In-lake water quality monitoring is the barometer allowing the Lake's current condition and longer term changes to be understood, and is a key road map to maintaining and improving Lake health. Therefore, regularly recurring Lake water quality monitoring should be a high priority. To allow comparison with previously collected data and thereby allow trends to be identified, samples should continue to be collected at the site identified as the "deep hole" site (i.e., the point above the deepest part of the Lake, Map 2.1). Samples should be collected in early spring shortly after ice out (e.g., early April) and at least once during mid-summer (e.g., July). These samples should be sampled for the following parameters:

   a. Water clarity (i.e., Secchi depth in the Lake)[90]

   b. Total phosphorous (one near-surface sample, and one from near the deepest part of the Lake)

[90] If possible, Secchi disk measurements should be taken on dates that coincide with flight paths and dates used by satellites to remotely sense water clarity. This allows the WDNR to calibrate the satellite image with actual in-lake water clarity measurements which, in turn, makes it possible to more accurately measure water clarity for hundreds of lakes where in-lake measurements are not collected. For more information on scheduled satellite flight paths (Lake Denoon is located along satellite path 23) and dates, visit the WDNR's "Remote Sensing of Water Quality" website; satellite water clarity maps and data are available through the WDNR's Lakes Viewer

c. Total nitrogen (near-surface sample)

d. Chlorophyll-*a* (near-surface sample)

e. Chloride (near-surface sample)

f. Temperature (profiled over the entire water depth range at the deepest portion of the Lake with more frequent readings near the thermocline)

g. Dissolved oxygen (profiled over the entire water depth range at the deepest portion of the Lake with more frequent readings near the thermocline)

Monitoring chloride concentrations will allow the rate of concentration increase over time to be quantified. This will help discern the overall impact of cultural influence on the Lake and to evaluate if chloride concentrations are approaching levels that could damage the Lake's ecosystem. Supplemental temperature/oxygen profiles collected at other times of the year (e.g., other summer dates, fall, and winter) would be helpful. Additionally, oxygen profiles should be collected during midsummer in the nighttime hours just before sunrise to help evaluate diurnal oxygen concentration swings.

In addition to the in-lake monitoring, **water quality samples should be collected from mapped tributary streams (Map 2.1)**. Since the Lake does not appear to be unduly impaired by external loads at present, stream water quality sampling should be considered a medium priority. Samples should be collected for representative flow events. Notations should be made by the sampler regarding current and recent weather conditions, and a qualitative description should be recorded of flow and water quality (e.g., "creek is very high and muddy") and of the exact location, date, and time where the sample was collected. Sampling parameters should include the following:

a. Flow rate – at least weekly during sample collection periods

b. Stream flow (see methods in Appendix K)

c. Water clarity (transparency tubes, see below)

d. Total phosphorus

e. Total nitrogen

f. Chloride

g. Temperature

h. Dissolved oxygen

Flow rate information allows the mass load of phosphorus contributed from the tributaries and the areas they drain to be quantified and compared. Creek depths typically make direct clarity measurement impossible; however transparency tubes (sometimes called turbidity tubes) provide a convenient way to quantify water clarity in shallow water. Transparency tubes are available from several vendors and cost well under $100. Water Action Volunteer (WAV) stations may be established at important locations.

Additional parameters or more frequent sampling should ultimately be focused on the subwatersheds identified or suspected to have water quality issues. Depending upon the subwatershed and sample results, action should be taken to help reduce pollutant loadings, For example, if phosphorus was detected in high concentrations in a tributary draining residential areas, efforts to communicate "best management practices" (BMP's) to homeowners should be reinforced, stormwater management infrastructure inspected, actions to protect and expand wetlands and buffers increased, and other factors considered. Intensified and/or expanded monitoring may help pinpoint source areas for particular attention.

Implementation of these recommendations will significantly contribute to tracking and improving the water quality within Lake Denoon. **Regular review and revision of water quality monitoring recommendations** are assigned a high priority. This will help determine what type of water quality management efforts would provide the most benefit for Lake Denoon and the need for in-Lake treatments for internal loading.

3.3 ISSUE 2: WATER QUANTITY

As mentioned in the Chapter 2, maintaining water levels and flushing rates can be crucial to maintaining lake health. On the contrary, absolutely static water levels are unnatural in many settings and can compromise the ability for certain plants and animals to reproduce and flourish. In a seepage lake such as Lake Denoon, water levels are affected by variations in groundwater supply. Consequently, the following recommendations are made to address monitoring and water quantity measurements:

1. **A comprehensive water budget should be developed and the area contributing groundwater recharge to the Lake should be delineated**. Since water levels are not a topic of significant concern at the present time, and since development is not known to be planned in the immediate future in or near the watershed, this task should be considered a low priority. However, if water levels or Lake discharge regimens radically change in the future, or if large-scale development is being considered within or near the watershed (particularly to the north and northwest), this element should be assigned a medium to high priority. A well-refined water budget will help better forecast where groundwater supplied to Lake Denoon is coming from, and can help focus where management efforts (e.g., reduced impermeable cover, infiltration basins, careful attention to the placement and number of wells.) are best implemented to maintain or increase groundwater recharge or levels.

2. **Implement measures to promote infiltration in near-shore residential areas**. This is a medium priority. Implementation of this recommendation could involve:

   a. **Enhancing the ability of rainfall and snowmelt to infiltrate into soils and recharge small and large scale groundwater flow systems**. This could be most easily achieved by installing innovative BMPs associated with low-impact development, including rain gardens[91] (Figure 3.1) and other stormwater infrastructure specifically designed and carefully located to promote infiltration. Denoon Park is a prime location to implement infiltration BMPs as it has high groundwater recharge potential and seeing such BMPs in operation and learning of their purpose may provide inspiration to

Figure 3.1
Example of a Rain Garden

Note: Further details are provided on Natural Resource Conservation Service and Wisconsin Department of Natural Resources websites at:

- www.nrcs.usda.gov/Internet/fse_plantmaterials/publications/ndpmctn7278.pdf
- dnr.wi.gov/topic/Stormwater/raingarden/

Source: U.S. Department of Agriculture Natural Resource Conservation Service

[91] Rain gardens are depressed basins that maintain native plants and help water infiltrate into the ground rather than entering the Lake through surface runoff. The installation of rain gardens can help reduce the amount of erosion and unfiltered pollution entering the Lake and can stabilize baseflow to the Lake.

the public to implement similar BMPs. Some practices and projects, especially on public property, may qualify for partial funding through the WDNR "Healthy Lakes" initiative.

b. **Retrofitting current urban development with stormwater management infrastructure elements**. The intensity of this process can vary. An example of its simplest form is voluntarily directing stormwater to areas of permeable soil and favorable topography or encouraging reduction in the extent of impermeable surfaces. These can be promoted by active education outreach, providing instructions and supplies to the property owners, or through subsidies (some of which may be grant eligible). A step toward a more comprehensive approach would be an ordinance requiring onsite stormwater management practices such as porous pavement, as a condition of issuance of a building permit affecting the overall impermeable surface area of a parcel. More capital-intensive public works retrofit projects such as stormwater retention/ infiltration basins and bioswales can also help reduce the impact of existing development on groundwater recharge. In certain instances, stormwater infrastructure built for new development may be located and sized to manage stormwater runoff from existing development.

3. **Reduce the impacts of future urban development**. This is a high priority. This recommendation can be implemented by:

   a. **Protecting areas that have a high potential to contribute recharge to local and regional groundwater flow systems**. Consider purchasing, or obtaining conservation easements on, agricultural and other open lands with high groundwater recharge potential.

   b. **Considering groundwater conditions when designing new developments**. This could include encouraging developers to incorporate infiltration in stormwater management designs and local government considering groundwater recharge as an integral part of new development and infrastructure replacement proposals. Some Southeastern Wisconsin communities have integrated analysis of groundwater and surface water impact into the process through which developers obtain permission to build new buildings and subdivisions.[92]

4. **Continuing to protect wetlands and uplands by enforcing zoning and drainage ordinances** as discussed in the "Issue 1: Water Quality" section of this chapter. This is a high priority.

5. **Evaluating Lake outlet capacity and condition**. The Lake outlet controls high and low Lake water levels and the time it takes for flood conditions to recede. Confusion seems to exist regarding the location and identity of the structure actually regulating Lake water levels. The outlet should be inspected and described to assure that its design and condition is consistent with Lake management goals. Photographs, sketches, measurements, and notes should be added to LDAA and/or WDNR files. The hydraulic model developed for Federal Emergency Management Agency (FEMA) flood insurance and local floodplain zoning purposes should be reviewed after this data is compiled and modifications made to model input simulating components that could influence outlet hydraulics and capacity. The revised model output should then be compared to existing one-percent-annual-probability (100-year recurrence interval) flood elevations. If a flooding problem is identified that endangers public infrastructure or private property, consideration could be given to modifying the dam to change flood elevations. Reduced flood elevations may be desirable to upstream riparian property owners. Any modifications to the existing one-percent-probability flood elevations established by FEMA and applied for local zoning purposes must be officially revised by obtaining a letter of map revision from FEMA. Since this issue can influence property use and public welfare/safety, it should be considered a high priority.

As with the other recommendations made in this chapter, significant future changes in Lake elevation or outflow may spur the need for reevaluation and priority changes.

[92] *The Village of Richfield in Washington County is such an example. More information may be found at the Village's website: www.richfieldwi.gov/index.aspx?NID=300.*

3.4 ISSUE 3: AQUATIC PLANT GROWTH

As discussed in Chapter 2, Lake Denoon supports a diverse aquatic plant community capable of supporting a warm water fishery as well as a wide range of recreational uses. However, the 2013 survey (see Appendix E for plant distribution maps) also reveals reasons why an aquatic plant management plan should be considered a high priority, including overly abundant plants and algae deterring recreational use and existence of invasive Eurasian water milfoil (EWM), which could potentially threaten the long-term stability of the native aquatic plant community.

This section describes elements of a comprehensive aquatic plant management plan based on the preliminary recommendations provided in Chapter 2. The recommendations presented below form the nucleus of an aquatic plant management plan for Lake Denoon, and attempt to balance three major goals:

1. Ensure current recreational uses of the Lake (e.g., swimming, boating, and fishing) are maintained or enhanced to the greatest extent practical

2. Protect the native aquatic plant community

3. Effectively control invasive plants, especially EWM populations

The conceptual plan described below relies upon common, State-approved, aquatic plant management alternatives listed in Chapter 2 including manual, biological, physical, chemical, and mechanical aquatic measures.

Plant Management Recommendations

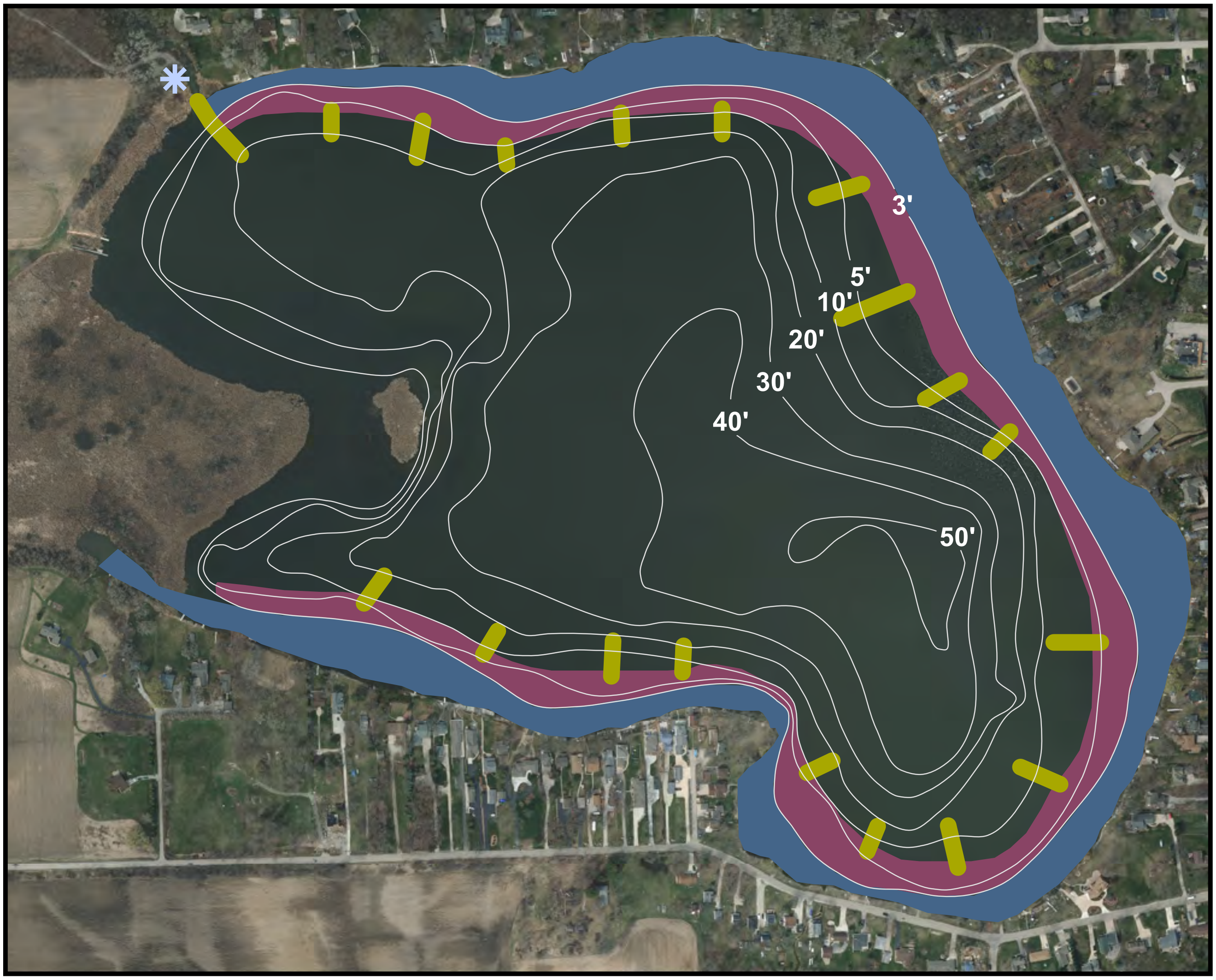
Nuisance and invasive aquatic plants can generally be most effectively controlled by simultaneously applying several methods and techniques. A "silver bullet" single-minded strategy rarely produces the most efficient, most reliable, or best result. Therefore, to enhance access to, and the health of, Lake Denoon, seven aquatic plant management recommendations are included in this plan, as described below:

1. **Creating navigation and access lanes by harvesting (preferred) or chemical means**, should be considered a high priority. As can be seen in Figure 3.2, *navigation and access lanes* are recommended in areas of the Lake that have dense aquatic plant growth impeding recreational boating and restricting access to the main body of the Lake. Priority access lanes should also be provided at the public access site. Due to the relatively extensive area that would be treated with chemical application to create adequate navigation and access lanes, consideration needs to be given to the impact of this method on the native plant population in the Lake.

   Several approaches can be used to employ aquatic plant harvesting on the Lake. Perhaps the most pragmatic approach for lakes without a history of harvesting is to retain a contractor who owns and operates harvesting equipment and cuts, gathers, and removes plants from designated areas. This would allow the LDAA to judge the effectiveness of this technique without needing to invest time, labor, and capital into equipment, insurance, and formation of an entity that operates a harvester devoted solely to Lake Denoon. Even the smallest harvesters (including supporting equipment) can easily result in an investment exceeding $100,000. Harvesters are expensive and require trained crew members, insurance, cut plant transporters and disposal areas, a WDNR permit, and other logistical support. Forming a lake district provides taxing authority that maintains a reliable budget to operate a harvesting program.

   Harvesters are constructed in a variety of sizes for a variety of purposes. Mid-size to large harvesters are generally used to harvest broad areas and long navigation lanes. Small maneuverable harvesters are also built that are well suited harvesting plants in constricted areas such as around docks and shallow near shore areas. Many of the lake management districts in southeastern Wisconsin, particularly on the larger lakes, own and operate one or more harvesters, trailers, offloading equipment, and dump trucks.

Figure 3.2
Aquatic Plant Management Plan for Lake Denoon: 2017



DATE OF PHOTOGRAPHY: APRIL 2015

LAKE DENOON AQUATIC PLANT MANAGEMENT PLAN

1. HARVEST FOR NAVIGATION LANES AND ACCESS LANES ONLY-
   A. SHALLOW CUT IN AREAS < 3 FEET DEEP
   B. ALWAYS LEAVE AT LEAST ONE FOOT OF PLANT MATERIAL
   C. ALWAYS REMOVE LIVE ANIMALS FROM HARVESTED PLANT MATERIAL

2. HANDPULL OR RAKE TO CONTROL EURASIAN WATER MILFOIL AND NEARSHORE NUISANCE PLANTS (PARTICULARLY IN AREAS < 3 FEET)

3. CONSIDER BIOLOGICAL CONTROLS OR EARLY SPRING CHEMICAL TREATMENT FOR EURASIAN WATER MILFOIL CONTROL ONLY IF EURASIAN WATER MILFOIL GREATLY DISPLACES THE NATIVE PLANT COMMUNITY

AQUATIC PLANT MANAGEMENT AREAS

MANUAL REMOVAL

NAVIGATION LANE

ACCESS CHANNEL

PUBLIC ACCESS SITE

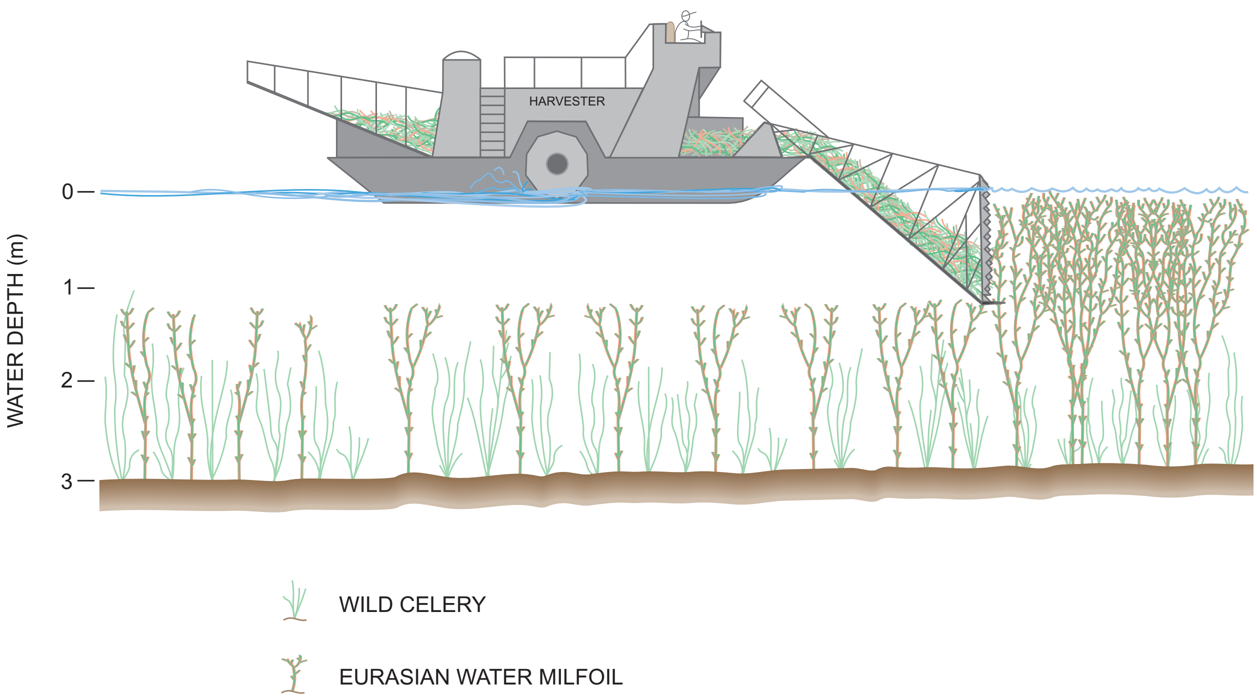
—20'— WATER DEPTH CONTOUR IN FEET

NOTE: PLANT HARVESTING IS PREFERRED FOR ALL LARGE-SCALE PLANT MANAGEMENT SINCE IT IS MORE PROTECTIVE OF THE LAKE'S ROBUST NATIVE PLANT COMMUNITY. CHEMICAL APPLICATIONS CAN BE USED FOR SMALL, DIFFICULT TO ACCESS AREAS.

LINE WIDTH AND SHADED AREA SIZE AND LOCATIONS ARE NOT SCALED AND ONLY ILLUSTRATE OVERALL CONCEPT.

Source: SEWRPC

Figure 3.3
Plant Canopy Removal or "Top Cutting" with an Aquatic Plant Harvester



Note: Selective cutting or seasonal harvesting can be done by aquatic plant harvesters. Removing the canopy of Eurasian water milfoil may allow native species to reemerge.

Source: Wisconsin Department of Natural Resources and SEWRPC

If mechanical means (harvesting, as opposed to simple cutting) are utilized, several details should be specified to protect continued recreational use of the Lake and the health of the native plant community, including:

a. **Leave at least one foot of uncut plant material just above the Lake bottom** to reduce sediment disturbance and ensure native plant communities are maintained. Disturbing the Lake bottom can uproot native plants and promote colonization of new areas by EWM. Leaving one foot of uncut plant material will likely not present an implementation problem where water depths are greater than three feet. Harvesting should not normally be employed in portions of the Lake where water is less than three feet deep, or where the harvester cannot leave one foot of uncut plant. In such areas, raking and hand-pulling should be substituted. Consequently, as depicted in Figure 3.2, all areas less than three feet deep are designated "manual removal" zones. Although harvesting may be conducted in portions of the Lake from three to about seven feet deep, it should be restricted to shallow, top-cutting techniques (Figure 3.3) to provide a navigational lane around the Lake's perimeter. To promote navigational access to the plant-free deep water areas, aquatic plants should be trimmed more aggressively, creating deeper cut channels leading toward the center of the Lake from the perimeter navigational lane (Figure 3.2). This is especially important in the area leading from the public boat launch site.

b. **Inspect all cut plants for live animals. Live animals should be immediately returned to the Lake**. Some animals can get caught in the harvester, particularly when cutting larger plant mats. Consequently, cut materials must be carefully examined to avoid inadvertent harvest of fish, crustaceans, amphibians, turtles, and other animals.

c. **Harvesting should not occur in the early spring**. This is an important element to protect spring spawning fish.

d. **All harvester operators must successfully complete WDNR training to help assure adherence to harvesting permit specifications and limitations**. Training should be provided by the regional WDNR aquatic invasive species coordinator and should cover, at a minimum: 1) "deep-cut" versus "shallow-cut" techniques and when to employ each; 2) review of the aquatic plant management plan, associated permit, with special emphasis focused on review of the need to restrict cutting in shallow areas; and 3) plant identification to encourage preservation of native plant communities. Additionally, the training must inform all harvester operators of their obligation to record pertinent information on the harvesting operation for inclusion in the annual harvesting reports required under the permit.

e. Harvesting can fragment plants. Fragments may accumulate on shorelines and can encourage the spread of undesirable plants such as EWM. The harvesting program should include **a comprehensive plant pickup program** that all residents can use. This helps assure that harvesting does not become a nuisance for Lake residents. The program could include residents raking plant fragments, placing them in a convenient location accessible to the harvester (e.g., the end of a pier), and weekly pickup or some other regular effort by harvester operators to pick up cut plants. This effort should be as collaborative as practical.

f. **All plant debris collected from harvesting activities should be collected and disposed of at the designated disposal sites**. Special care should be taken to assure that no plant debris is disposed in wetland locations or within a floodplain (high priority). It is prohibited to dispose any aquatic plant material within identified floodplain and wetland areas.

Small-scale herbicide applications have been used in the past to create navigation and access lanes. Small-scale ("spot") chemical treatments have more recently believed to be comparatively ineffective, have significant potential to damage nearby native aquatic plant communities, and are now discouraged. Studies have shown that small-scale Eurasian water milfoil treatment using 2,4-D have proven to have highly variable results. For example, a recent study concluded that the effective herbicide concentration in 98 small treatment areas (0.1 to 10 acres) were far below target concentrations due to dissipation, hence limiting the effectiveness of the applications. Eurasian water milfoil was effectively controlled in only about half of the small treatment areas.[93]

If **herbicide spot treatments** are used to create navigation and access lanes, several guidelines should be followed:

a. Spot treatments should be limited to areas accessible to harvesters or inappropriate for other aquatic plant control methods

b. Chemicals should only be applied to areas where invasive aquatic plants (i.e., EWM or curly leaf pondweed) are displacing the native plant community

c. Herbicides should be applied in the early spring when human contact and risks to native plants are limited[94]

d. Herbicides that display selective control for EWM, hybrid milfoil, and curly leaf pondweed (e.g., 2, 4-D and Endothall) should be used to reduce loss of native plant species.

e. A WDNR permit and WDNR staff supervision are required to implement this alternative

f. Lake property owners need to be notified of the chemical treatment and permit conditions before chemical application

g. Chemical residue monitoring is recommended

---

[93] *Nault, Michelle, Susan Knight, Scott Van Egeren, Eddie Heath, John Skogerboe, Martha Baton, and Scott Provost,* Control of Invasive Aquatic Plants on a Small Scale, *Lakeline, Spring 2015, North American Lake Management Society (NALMS), pp. 35-39.*

[94] *Wisconsin Department of Natural Resources PUBL-WR-236 90,* Chemical Fact Sheet: 2,4-D, *May 1990; Wisconsin Department of Natural Resources PUBL-WR-237 90,* Chemical Fact Sheet: Endothall, *May 1990.*

2. **Hand-pulling and/or raking for nuisance plant growth, including EWM, in the near-shore areas** should be considered a medium priority in areas too shallow or otherwise unsuitable for plant harvesting. A permit is generally not required for individual riparian land owners clearing a 30-foot-long stretch of their own shoreline (including recreational use area such as rafts and piers) that does not extend more than 100 feet into the Lake, provided that all resulting plant materials are removed from the Lake. A permit is required if a lake district or some other group wants to actively engage in these activities. Prior to the "hand-pulling" season, an educational campaign should be actively promoted to assure that shoreline residents know the value of native plants, the relationship between algae and plants (i.e., more algae will grow if fewer rooted plants remain), the basics of plant identification, and the specifics about the actions they are allowed to legally take to "clean up" their shorelines.[95] DASH methodology, which was described earlier in this report, is a viable option for individual homeowners on their own lakefront properties; however, DASH is an expensive procedure and may not be feasible for a single riparian owner to incur the costs alone.

3. **Chemical treatment** has historically been the primary method used to manage aquatic plants in Lake Denoon. Recently (2015), a whole-lake chemical treatment strategy was conducted to manage EWM. The efficacy of this treatment was still under review at the time of this writing. However, the WDNR considers such treatments on a lake-by-lake basis. Should follow-up treatments be deemed appropriate, **the LDAA should work with the proposed chemical applicator to review the following information**:

   a. A list of proposed alternatives for chemicals and or admixtures

   b. Target concentrations and treatment methodologies

   c. Probable cost and schedule

   d. The anticipated longevity of the treatment

   A WDNR permit and WDNR staff supervision are required to implement this alternative. The WDNR considers the following elements when reviewing a whole-lake permit application:

   a. **Lake volume**. The entire lake volume needs to be calculated. The volume of the epilimnion layer needs to be estimated because the amount of chemical applied is based on the volume of water in the epilimnion alone.[96]

   b. **Water temperature profile**. Whole-lake treatments are most effective and typically required to be implemented in spring as soon as possible after a lake stratifies. Lake temperature profiles should be monitored to ensure the lake is fully stratified. The temperature of the epilimnion needs to be monitored to ensure the minimum temperature requirements specified on the chosen chemicals are met.

   c. **Target plant density**. The thresholds for applying a whole lake treatment depend upon the lake. A typical threshold is an average Eurasian and hybrid water milfoil rake fullness rating of between two and three at a minimum of 35 percent of vegetated sampling sites, based on a recent comprehensive point-intercept survey. However, other factors such as distribution, water depths, and history of plant abundance are also taken into account.

   d. **Native Plants**. The type and abundance of native plant populations and their sensitivity to chemical treatments are considered.

   e. **Distribution**. A determination would be made of whether native plant communities are more monotypic or are mixed with invasives.

---

[95] *SEWRPC and WDNR staff could help review this document.*

[96] *When completely stratified, the epilimnion is the top layer of the lake that is warmer and less dense. The chemicals will mix throughout that layer but are unable to break through the underlying thermocline layer, which acts as a barrier.*

Care must be exercised to carefully choose herbicides that selectively control EWM, hybrid water milfoil, and curly-leaf pondweed to prevent loss of native aquatic species. Additionally, lakeshore property owners need to be informed of the chemical treatment and permit conditions before applying chemicals, and **residual chemical concentrations should be monitored** after application is complete. Generally, chemical residue monitoring is undertaken as a standard component of whole-lake treatments to determine if applied chemicals are well dispersed throughout the lake.

A further complication of the whole lake treatment scenario is the presence of hybrid water milfoil (HWM). Although HWM was not observed in Lake Denoon during the 2013 survey, hybrid strains of EWM are becoming more widespread throughout the Region and properly adjusting the treatment dosage can be a difficult task. Too high a dosage can significantly damage the native plant population while too low a dosage could actually promote evolution of herbicide-resistant HWM by killing the more-susceptible plants but leaving the heartier strains to propagate into an infestation that would be increasingly difficult to control with chemicals. Furthermore, accurate dosage relies on precise and current lake bathymetry and confirmed HWM identification (possibly through DNA analysis), and may require that multiple samples of HWM be collected from the Lake and tolerance tested (through a process known as "challenge testing") to accurately determine the plant's susceptibility to various chemical mixes. Because whole-lake treatments are a significant investment, an ineffective dosage is a very significant waste of time, equipment, and funds.

Overall, other less complicated approaches may effectively achieve plant management goals in Lake Denoon. For this reason, pending final assessment of the 2015 treatment, whole-lake treatment is assigned a <u>low priority</u> at the present time.

4. **Protect native plants and actively control invasive plants**. A number of actions should be taken to retain native aquatic plants whenever practical and focus control efforts on aquatic invasive plants. Figure 3.2 helps aquatic plant managers implement aquatic plant management plan recommendations. They are collectively considered a <u>high priority</u>. These recommendations include:

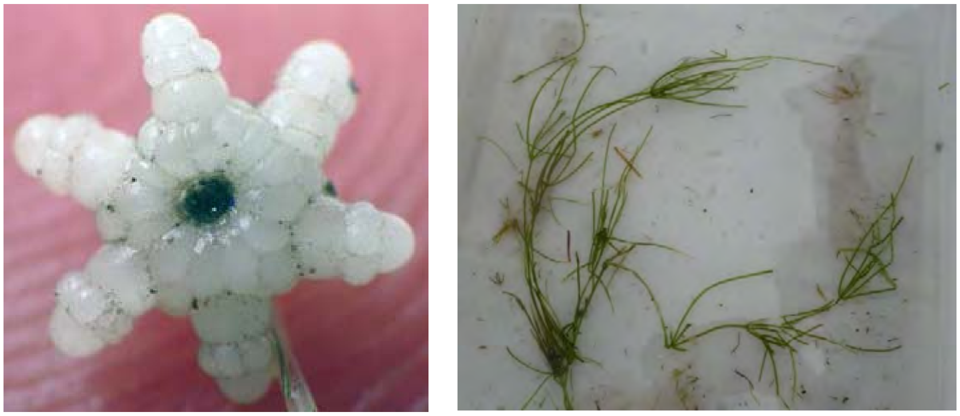
    a. Protecting native aquatic plants to the highest degree feasible through careful application of aquatic plant management and water quality recommendations. Lake Denoon has many species that provide excellent wildlife habitat and there are rare species that have been classified as Wisconsin Special Concern species. Muskgrass growth is particularly beneficial as it enhances marl formation and sequestration of phosphorous from the water column.

    b. Invasive species are highly damaging to native plant and wildlife communities and are a nuisance to lake recreation. Consequently, invasive species management is recommended. The most problematic invasive species currently in or around Lake Denoon are EWM, curly leaf pondweed, and reed canary grass. All of these may be treated through manual, mechanical, or chemical methods as discussed earlier. Mechanical and chemical aquatic plant control methods should follow best management practices to avoid spreading invasive plants and to lower the stress imposed by invasive species on the native plant community.

    c. Avoid disrupting bottom sediment or leaving large areas of bottom sediment devoid of vegetation. Such areas are prone to nonnative species recolonization. Invasive species tend to thrive under disturbed bottom conditions. EWM in particular thrives in such areas.

    d. Both EWM and curly leaf pondweed grow early in the season, earlier than many native aquatic plants. Implementing control methods as early as practical in the spring can help minimize damage to native aquatic plant communities. Moreover, early spring chemical applications are more effective due to colder water temperatures, a condition enhancing the herbicidal effect and reducing the concentrations needed for effective treatment. Early spring chemical treatment also helps reduce human exposure through lower human contact with lake water when water temperatures are still cold. Early season eradication of curly leaf pondweed helps lower production of turions (a dormant plant propagule) that is the dominant preproduction method for this plant.

Figure 3.4
Aquatic Invasive Species Watchlist



STARRY STONEWORT
(*Nitellopsis obtuse L.)*

- Distinctive star-shaped bulbils
- Side branches arranged in whorls or 4-6 branchlets; more robust than other members of family

Source: Paul Skawinski, Skawinski, P. M. (2014). *Aquatic Plants of the Upper Midwest: A Photographic Field Guide to Our Underwater Forests.* Wausau, Wisconsin, USA: Self-Published., *Wisconsin Department of Natural Resources, Vic Ramey, University of Florida, Minnesota Sea Grant, Ohio Sea Grant, and SEWRPC*

5. The introduction of new invasive species is a constant threat. **Preventing introduction of new invasive species** is crucial to maintaining healthy lakes and is considered a <u>high priority</u>. Starry stonewort (see Figure 3.4), though not discussed in Chapter 2, is the newest invasive species posing a distinct risk to the Lake. To help decrease the chance of this occurring, the following recommendations are given:

   a. **Educate residents as to how they can help prevent invasive species from entering the Lake** (Appendix F and L);

   b. The LDAA should consider **enrolling in the Clean Boats Clean Waters program** (a State program targeting invasive species prevention)[97] to proactively encourage Lake users to clean boats and equipment before launching and using them in the Lake. This will help lower the probability of invasive species entering Lake Denoon;

   c. Since boat launches are likely entry point for alien species, **boat launch sites should be targeted for focused aquatic plant control**, and

   d. If a new alien species infestation is found in the Lake, efforts to eradicate the new species should immediately be evaluated and, if possible, be employed. The WDNR has funding that can aid in early eradication efforts, particularly as it pertains to aquatic plants (Table 3.1). Therefore, **citizen monitoring for new invasive species is recommended**. The Wisconsin Citizen Lake Monitoring Network (CLMN) provides training to help local citizens engage in these efforts.

6. As described in Chapter 2, excessive nutrients can promote nuisance-level abundance and growth of aquatic plants. Accordingly, efforts to improve water quality through actions in the Lake and its watershed can reduce the amount of plant growth in general. Consequently, **implementing the recommendations highlighted in the "Issue 1: Water Quality" section** of this chapter is an important facet of overall aquatic plant management and is given a <u>high priority</u>.

7. Figure 3.2 helps aquatic plant managers implement aquatic plant management plan recommendations. However, aquatic plant management must react to what is actually occurring at the time of treatment. The composition of the aquatic plant community, water quality and weather changes, new invasive species, recreational use and intensity, and other factors are constantly and sometimes independently changing. For this reason, new data and aquatic plant management goals and recommendations should be frequently reviewed for relevance and overall fit. Moreover, aquatic plant management plans

[97] *Further information about Clean Boats Clean Waters can be found on the WDNR website at: dnr.wi.gov/lakes/cbcw/.*

Table 3.1
Example WDNR Grant Programs Supporting Lake Management Activities

Category	Program	Grant Program	Maximum Grant Award	Minimum Financial Match	Application Due Date	Examples of Potentially Eligible Issues as designated in Chapters 2 and 3
Water	Surface Water Grants	Aquatic Invasive Species (AIS) Prevention and Control	Education, Prevention, and Planning Projects: **$150,000**	25%	December 10	Issue 3
			Established Population Control Projects: **$200,000**	25%	February 1	
			Early Detection and Response Projects: **$20,000**	25%	Year-Round	
			Research and Development: annual funding limit of **$500,000**	25%	Year-Round	
			Maintenance and Containment: **permit fee reimbursement**	25%	Year-Round	
		Lake Classification and Ordinance Development	**$50,000**	25%	December 10	Issues 1, 2, 5, 6
		Lake Protection	**$200,000**	25%	February 1	All
		Lake Management Planning: Large and Small Scale	Small-Scale: **$3,000**	33%	December 10	
			Large Scale: **$25,000**	33%	December 10	
	Citizen-Based Monitoring Partnership Program		**$4,999**		Spring	Issues 1, 2
	Targeted Runoff Management	--	Small-Scale: **$150,000**	30%	April 15	Issues 1, 3, 4
			Large-Scale: **$1,000,000**	30%	April 15	
	Urban Nonpoint Source & Stormwater Management	--	Design/construction: **$150,000**	50%	April 15	
			Property Acquisition: **$50,000**	50%	April 15	
Conservation & Wildlife	Knowles-Nelson Stewardship Program	Acquisition of Development Rights	--	--	May 1	Issues 1, 2, 3, 4, 5, 7
		Natural Areas		--	February 1, August 1	
		Sport Fish Restoration		50%	February 1	Issue 7
		Streambank Protection		--	February 1, August 1	Issues 1, 2, 3, 4, 7
Boating	Boat Enforcement Patrol	--	Up to **75% reimbursement**	None	Various	Issue 6
	Recreational Boating Facilities	--	Up to **$100,000 per state**	50%	--	
Recreation	Knowles-Nelson Stewardship Program	Acquisition and Development of Local Parks	--	--	May 1	Issues 6, 7
		Habitat Area	--	--	February 1, August 1	
		Urban Green Space	--	--	May 1	

Note: More information regarding these example grant programs may be found online at the following address: dnr.wi.gov/aid/grants.html. Additional Federal, state, and local grant opportunities are available.

Source: Wisconsin Department of Natural Resources and SEWRPC

must be renewed at five-year intervals, a requirement that mandates collection and interpretation of new data. This effort includes a comprehensive point-intercept aquatic plant survey and a summary of aquatic plant management activities actually completed during the expiring permit period. This will help Lake managers quantify and judge the effectiveness of the aquatic plant management plan described in this report and make appropriate adjustments. For these reasons, periodic plant monitoring and plan review are given a high priority.

3.5 ISSUE 4: CYANOBACTERIA AND FLOATING ALGAE

Although algae are an issue of concern, **there is no strong evidence supporting the immediate need for specially targeted in-lake algal control efforts**. However, actions taken to improve water quality will contribute to limiting algal growth. Consequently, the recommendations provided in this section focus on monitoring algal growth, preparing Lake residents to respond to excessive algal growth (should any occur in the future), and promoting conditions that help suppress algae. The four recommendations are:

1. **Monitor water-borne algae populations**. This effort should focus on tracking chlorophyll-*a* concentrations (high priority), as was described in the water quality monitoring recommendation above. However, if large amounts of suspended algae begin to grow in the future, monitoring should be expanded to include toxic algae identification. At present, algal identification is given a low priority. However, should nuisance level algae regularly appear in the future, this effort should be made a high priority.

2. **Residents should be warned to not enter the water in the event of an algal bloom**. This should be considered a high priority unless testing positively confirms the absence of toxic algal strains. Therefore, a method to quickly communicate water conditions adverse to body contact should be developed.

3. **Maintain and improve water quality** through implementing recommendations provided in the "Issue 1: Water Quality" section of this chapter. This is assigned a high priority.

4. **Maintain a healthy aquatic plant community** to compete with algal growth. This can be promoted by implementing recommendations provided in the "Issue 3: Aquatic Plant Growth" section of this chapter. This is assigned a high priority.

Implementing the above recommendations will help assure that algae growth does not preclude or significantly inhibit use of the Lake. However, **if future monitoring reveals excessive or greatly increased algal growth, or should toxic algae be identified, these recommendations should be reevaluated (high priority). Reevaluation should include rethinking of all relevant-Lake management efforts**.

3.6 ISSUE 5: SHORELINE MAINTENANCE

The 2014 shoreline assessment revealed areas of erosion, unprotected shoreline, a large portion of unbuffered shoreline, and areas with failing shoreline protection. Based upon these findings, shoreline maintenance should be assigned an overall medium to high priority, with higher priorities assigned to sites with the highest potential for improvement. The major recommendations related to shoreline maintenance are:

1. **Encourage repair or removal of failing "hard" shoreline structures**. This should be considered a high priority and could be done by educating private landowners and establishing a donation-based cost-share program. Removal may require technical expertise. Therefore, it is also recommended that WDNR and shoreline restoration experts be consulted and integrated into the process.

2. **Educate residents and shoreline property owners on the importance of buffers and appropriate shoreline protection measures** consistent with Lake use and guidelines established under the WDNR/Wisconsin Lakes Partnership Healthy Lakes Initiative (Appendix I). This should be considered a high priority.

3. **Encourage installation of "soft" or "natural" shoreline protection** (e.g., bio-logs, buffers, native shoreline plantings, and native aquatic plantings) **whenever appropriate**. **Focus on areas where little to no shoreline protection exists or where erosion is currently taking place**. Natural shoreline protection has the additional benefit of deterring nuisance geese from congregating along shorelines. This action should be considered a medium priority. Should these shoreline protections take the form of shoreline buffers (as recommended in the "Issue 1: Water Quality" section of this chapter), funding may be available through WDNR's "Healthy Lakes Initiative."[98]

4. **Ensure shoreline setbacks/shoreland zoning rules are enforced** as discussed in the "Issue 1: Water Quality" section.

Implementing programs that encourage stable and ecologically friendly shorelines will significantly contribute to the health of the Lake in terms of wildlife populations, sedimentation, and water quality. To track success, **shoreline restoration goals should be established and a new shoreline assessment should be completed after a shoreline restoration program has been implemented** (medium priority). This will help document progress and may be useful in future reports and/or grant applications.

3.7 ISSUE 6: RECREATIONAL USE AND FACILITIES

Lake Denoon is popular with boaters who live on the Lake and who trailer watercraft to the Lake. The City of Muskego operates a public boat launch that meets the requirements necessary for the Lake to receive public funding. Although little work is needed at the present time, maintaining the public boat launch should be considered a high priority. This could include incorporation of elements that help reduce the chance of spreading invasive species such as deploying trained volunteers to inspect boats and distribute literature during high use periods.

Boat counts suggest that Lake Denoon is subject to boat densities at the upper end or slightly exceeding desirable levels during high use periods. Excessive boat density decreases the ability of the Lake to safely, sustainably, and satisfactorily support a wide range of activities. This means that the potential for use conflicts, safety concerns, and environmental degradation is slightly higher than desirable on Lake Denoon during weekends and holidays. To help avoid such problems, existing boating regulations should be reviewed for compatibility with current conditions and expectations (high priority), and the ordinances should be conscientiously enforced. Given the variability of boating density, enforcement should be considered a low priority for week days, but a high priority for weekends and holidays.

Demand for power boating on Lake Denoon is on the verge of exceeding desirable supply. Common economic theory suggests that demand can be reduced if costs increase. Costs can include the price paid to launch a boat or other factors such as convenience. Certain changes can be made that both benefit the long-term health of the Lake and may place negative pressure on demand. These changes include the following:

- Review water-based recreation ordinances and modify as necessary. Stringently enforce the regulations, especially during holidays and weekends. Consider a water patrol. Grants are available to assist with revision and development of ordinances and with water patrols.

- Increase the current base boat launch fees from $7.00 to $8.00 as allowed by State law.

- Consider surcharges, particularly on weekends and holidays, such as the following:

  - 20 percent surcharge for toilet facilities. Potentially apply to weekday rates as well to enhance revenue available for weekend/holiday attendant.

  - Large boat surcharges on weekends. An attendant would need to be on site for effective application.

---

[98] *WDNR has a number of resources available on its website designed to assist shoreland owners: dnr.wi.gov/topic/shorelandzoning/.*

- Have an attendant on duty during all summer weekends and holidays. The attendant's primary duty would be to implement Clean Boats/Clean Waters watercraft inspections (Appendix L) and distribute literature to help lake users understand invasive species issues. A surcharge of 20 percent may be charged when an attendant is on duty, and the attendant can also be responsible for launch surcharges for large boats.

Increasing launch fees is assigned an overall medium priority, the implementation of which is dictated by the needs and perceptions of Lake users. Nevertheless, an attendant trained in Clean Boats/Clean Waters inspection protocol should be considered even if no increase in launch fees is desired. Such an inspector can help reduce the probability of the spread of invasive species into the Lake and other lakes, and should be considered a high priority for high use periods (i.e., weekends and holidays) and a low to medium priority for low use periods.

3.8 ISSUE 7: FISH AND WILDLIFE

Wildlife relies upon the Lake's health. The presence of wildlife increases the Lake's recreational use, aesthetic appeal, and overall enjoyment by humans and the functionality of the Lake as an ecosystem. To enhance wildlife within the Lake Denoon watershed, the following recommendations are made:

1. **Continue current fish stocking practices**. The Lake has a healthy population of many desirable fish, but must be stocked to retain fishable populations of certain game fish. Given what is currently known about Lake Denoon's fishery, stocking must continue to maintain game fish, which will allow this situation to continue and should therefore be considered a high priority. Stocking helps assure that the fishery is maintained while efforts to better support natural fish propagation and fish health are developed and implemented.

2. Promote maintenance of the current healthy fishery **by continuing current fishing practices and enforcement of ordinances**.[99] This requires no direct action or change but should nevertheless be considered a high priority.

3. **Identify and remove fish and aquatic organism passage barriers**. Even ephemeral streams, which only flow seasonally, can provide fish passage to spawning and nursery grounds. All four streams with mapped connections to the Lake run through wetlands, which are critical feeding, breeding, and spawning habitat for many fish species, including northern pike. Fish and aquatic organism passage barriers are often categorized by scale. Small-scale barriers include debris jams, sediment and railroad ballast accumulations, and overgrowth of invasive plants. Large-scale barriers include dams and culverts that are perched, too narrow, or too long. These barriers vary greatly in their ease of removal. Best practices include prioritization of barrier removal along a single reach, with highest habitat benefits and highest ease of removal given the highest rank for remediation. Ozaukee County's Fish Passage Program is highly developed and a good resource when establishing a fish passage program.[100] Removing fish passage barriers should be considered a medium priority.

4. **Improve in-Lake aquatic habitat by maintaining or installing large woody structure and/or vegetative buffers along shorelines**. The vegetative community along the Lake's shorelines have been simplified through traditional landscaping practices, a situation that reduces habitat for aquatic organisms. Improving in-Lake habitat should be considered a medium priority. Implementing this recommendation could take the form of educational or incentive-based programs to encourage riparian landowners to install "fish sticks"[101] (Figure 3.5), to allow fallen trees to remain in the water, and to develop buffer systems along the shoreline. WDNR grant money is available through the

[99] Should residents be interested in reducing carp populations, it may be advantageous for anglers to catch and remove carp and to release northern pike caught within Lake Denoon.

[100] See website at www.co.ozaukee.wi.us/619/Fish-Passage.

[101] Natural shorelines generally have hundreds of fallen trees per mile along the shoreline. "Fish sticks" is a term coined for engineered installation of woody structure (logs) along lake shorelines to mimic these natural conditions. Generally these projects involve anchoring logs into the shore so that the log is oriented perpendicular to the shoreline. See Appendix I,"Healthy Lakes Initiative."

"Healthy Lakes" program on a competitive basis for the implementation of "fish sticks" projects. Installing buffers will have the added benefit of deterring geese populations from congregating on shoreline properties and promotes better water quality.

5. **Adopt best management practices to improve wildlife habitat**. This should be considered a medium priority, although this should increase to a higher priority if wildlife populations decline. The acceptance and employment of best management practices can be fostered through voluntary, educational, or incentive-based programs for properties adjacent to the shoreline, and by directly implementing these practices on public and protected lands. Some special interest non-governmental organizations ("NGOs", e.g., Pheasants Forever, Ducks Unlimited, Trout Unlimited) foster habitat improvement projects and collaborate with land owners to install beneficial projects. If this recommendation is implemented, a detailed list of best management practices and relevant NGOs should be compiled and provided to landowners.

Figure 3.5
Examples Of Completed "Fish Sticks" Projects

Source: Wisconsin Department of Natural Resources

6. **Ensure proper implementation of the aquatic plant management plan** described earlier in this chapter (see "Issue 3: Aquatic Plant Growth" section) specifically as it relates to avoiding inadvertent damage to native species. This should be assigned a high priority.

7. **Preserve and expand wetland and terrestrial wildlife habitat, while making efforts to ensure connectivity between these natural areas**. This could be achieved through implementation of the buffer and wetland protection recommendations provided in the "Issue 1: Water Quality" section of this chapter. Benefit could also be accrued by reconnecting floodplains to ditched and straightened tributary streams. These reconnected floodplains detain floodwater, may enable groundwater recharge, and provide seasonally wet areas that are of great value for a wide range of birds, fish, amphibians, insects, and terrestrial animals. This should be assigned a high priority.

8. **Mitigate water quality stress on aquatic life and maximize areas habitable to desirable fish**. The primary issue in this category is presently low oxygen and supersaturated oxygen concentrations during some seasons at certain depths. The water quality recommendations discussed earlier in this chapter incorporate this element and should be considered a high priority. Other stressors may develop in the future (e.g., new invasive species and other water quality concerns) and conditions should be carefully monitored for their impact on aquatic life.

9. In general, tracking the diversity and abundance of fish and wildlife will help future Lake managers detect change. Consequently, **continued monitoring of fish populations and periodic recording of the types of animals found on and in the Lake and within its watershed** is also a high priority. Monitoring data can be collected from government agencies, non-governmental organizations (e.g., Audubon), and from volunteers around the Lake and throughout the watershed.

3.9 ISSUE 8: IMPLEMENTATION

The methods to implement the plan vary with the type of recommendation made. For example, several important recommendations related to municipal or county ordinance enforcement (e.g., shoreline setbacks, zoning, construction site erosion control, drainage, and boating). Such agencies often have limited resources at their disposal to assure rules are respected and properly applied. Consequently, the following recommendations, assigned medium priority, are aimed at local citizens and management groups, and are made to enhance the ability of the responsible entities to monitor and enforce existing regulations. **These tasks should be considered central to the LDAA's mission**.

1. **Maintain and enhance relationships with County and municipal zoning administrators as well as law enforcement officers**. This helps build open relationships with responsible entities and facilitates efficient communication and collaboration whenever needed. High priority.

2. **Keep abreast of activities within the watershed** (e.g., construction, filling, erosion) that have the potential to affect the Lake, **maintain good records** (e.g., notes, photographs), and judiciously notify relevant regulatory entities of problems whenever appropriate. High priority.

3. **Educate watershed residents about relevant ordinances and update ordinances as necessary to face evolving use problems and threats**. This will help ensure that residents know why these rules are important, that permits are required for almost all significant grading or construction, and that such permits offer opportunities to regulate activities that could harm the Lake. High priority.

In addition to regulatory enforcement, a number of voluntary and/or incentive-based programs can be considered, all of which focus proactive efforts to protect and manage the Lake.

A number of factors commonly handicap local citizens and management groups from effectively executing lake management projects. Consequently, the following suggestions are offered to enhance project execution:

4. **Encourage key players to attend meetings, conferences, and/or training programs to build their lake management knowledge**, all of which enhance institutional knowledge and capacity. In recognition of limitations on financial resources available for such activities, this element is assigned medium priority. Some examples of capacity-building events are the Wisconsin Lakes Conference (which targets local lake managers) and the "Lake Leaders" training program (which teaches the basics of lake management and provides ongoing resources to lake managers). Both are hosted by the University of Wisconsin-Extension. In-person and online courses, workshops, training, regional summits, and general meetings can also be of value. Attendance at these events should include follow-up documents/meetings so that the lessons learned can be communicated to the larger Lake group.

5. **Continue to reinforce stakeholder inclusivity and transparency with respect to all Lake management activities**. If stakeholders do not fully understand the aims and goals of a project, or if they do not trust the process, excess energy can be devoted to conflict, a result that benefits no one. For this reason, this element is assigned high priority. These efforts should be implemented through public meetings, social media, newsletters, emails, and any other mechanism that helps gather a full suite of information and build consensus. In this way, all data and viewpoints can be identified and considered; and conflicts can be discussed, addressed, and mitigated prior to finalizing plans and implementing projects.

6. **Foster and monitor efforts to communicate concerns, goals, actions, and achievements to future Lake managers**. Institutional knowledge is a powerful tool that should be preserved whenever possible. Actions associated with this are sometimes embedded in organization bylaws (e.g., minutes), and are therefore assigned high priority. Open communication helps further increase the capacity of Lake management entities. This may take the form of annual meetings, internet websites, social media, newsletters, emails, reports and any number of other means that help compile and report action, plans, successes, and lessons learned. These records should be kept for future generations.

7. **Apply for grants when available** to support implementation of programs recommended under this plan (Appendix M). This should be considered a high priority. This process requires coordination, creativity, and investment of stakeholder time to be effective. Table 3.1 provides a list of grant application opportunities that can potentially be used to implement plan recommendations.

8. **Encourage Lake users and residents to actively participate in future management efforts**. Not only does this effort help assure community support, but also supplements the donor and volunteer pool working toward improving the Lake. This should be considered a medium priority.

9. **Consider formation of a Lake District** with the authority to levy taxes. Although currently a medium-high priority, this recommendation should be considered a high priority if WDNR grant funds prove to be insufficient to cover the cost of Lake management efforts.

In addition to the items listed above, a major recommendation that should be considered a high priority is **creation of an action plan/schedule which highlights goals, accomplishment, timelines, logistical needs, and responsible parties**. This document will help assure that plan recommendations are implemented in a timely, comprehensive, transparent, and effective manner. Additionally, an action plan can help ensure that all responsible parties are held accountable for their portions of plan implementation. As a final note, a major recommendation to promote implementation of this plan is education of Lake residents, users, and governing bodies on the content of this plan. Additionally, it must be understood that concerns, conditions, and knowledge base continually change, making it critical to constantly adapt the plan to the best available information and interpretation. A campaign to communicate the relevant information in the plan and update its goals should therefore be given a high priority.

3.10 SUMMARY AND CONCLUSIONS

Lake Denoon is a valuable and cherished natural resource. Those charged with the responsibility of protecting it need to consider not only the Lake's current condition, but also its near- and far-future condition. This plan was therefore developed, and is intended to be implemented, to address the needs of both the present and the future. Managing any issue or set of issues requires the vision to see the Lake system and stakeholder needs as a whole.

The future is expected to bring change to Lake Denoon's watershed. Projections suggest that much of the agricultural land use in the watershed of today will give way to urban residential land use. It is critical that proactive measures be actively pursued that lay the groundwork for effectively dealing with and benefiting from future change. Working relationships with appropriate local, County and State entities need to be nurtured now and in the future to help protect critical natural areas in the watershed during development, to initiate actions (such as residential street leaf litter pickup and disposal), and to instill attitudes among current and future residents that will foster cooperation and coordination of effort on many levels.

To help implement plan recommendations, Table 3.2 summarized and highlights recommendations and their priority level. Additionally, Figure 3.2, and Maps 3.2 and 3.3 illustrate where these recommendations should be implemented. These maps will provide current and future Lake Denoon managers with a visual representation of where to target management efforts.

As stated in the introduction, this chapter is intended to stimulate ideas and action. The recommendations should, therefore, provide a starting point for addressing the issues identified in Lake Denoon and its watershed. Successful implementation of the plan requires vigilance, cooperation, diligence, and enthusiasm from local management groups, State and regional agencies, Counties, municipalities, and Lake residents. The recommended measures will help provide the water quality and habitat protection necessary to maintain and enhance conditions suitable for maintaining and improving the natural beauty, ecological value and ambience of Lake Denoon and its ecosystems. This in turns helps safeguard the enjoyment of the Lake by its human population today and in the future.

Table 3.2
Summary of Recommendations for Lake Denoon: 2017

Recommendation Number	Strategies and Tactics	Suggested Priority Level
	Issue 1: Water Quality	
1	Protect and enhance buffers, wetlands, and floodplains	
a	Control/ limit development in primary environmental corridors	
b	Review and enforce shoreland and drainage ordinances to protect drainage corridors and riparian areas	
c	Describe benefits of buffers and financial incentives to shoreland property owners and landowners along tributaries	PROTECTION HIGH
d	Implement shoreline best management practices and shoreline buffer enhancement programs. Subsidize as possible.	ENHANCEMENT MEDIUM
e	Consider obtaining conservation easements and purchasing wetlands, floodplains, and uplands in key areas	
f	Monitor and protect natural vegetation from AIS infestation	
g	Maintain or restore natural stream channel form and function	
2	Monitor and actively manage woodlands	MEDIUM
3	Monitor and maintain stormwater detention basins, especially in areas of active construction	HIGH
4	Stringently enforce construction site erosion control and stormwater management ordinances:	
a	Periods of low construction or grading activity	MEDIUM
b	Periods of substantial new construction or grading work	HIGH
5	Encourage pollutant source reduction along shorelines through best management practices	MEDIUM
6	Actively manage in-Lake phosphorus sources using chemical inactivation or on-shore treatment processes	MEDIUM-HIGH
7	Maintain healthy and robust populations of desirable native aquatic plants, including muskgrass, a critical component of the natural in-Lake phosphorus sequestration process	HIGH
8	Monitor and evaluate water quality parameters	
a	In-lake	HIGH
b	Tributary streams	MEDIUM
c	Periodically reevaluate monitoring protocol to evaluate questions or problems	HIGH
	Issue 2: Water Quantity	
1	Develop comprehensive water budget and quantify groundwatershed	
a	No water quantity issues identified (current situation)	LOW
b	Lake levels or discharge regimes radically change or large-scale development is considered	MEDIUM-HIGH
2	Implement measures to protect and enhance infiltration in near-shore residential areas	MEDIUM
a	Employ best management practices	
b	Retrofit current urban development with modern stormwater management infrastructure	
3	Reduce impacts of future urban development	HIGH
a	Protect high recharge potential areas	
b	Consider groundwater conditions when designing new developments	
4	Continue to protect wetlands and uplands by enforcing zoning ordinances	HIGH
5	Evaluate lake outlet configuration, capacity, and condition. Consider floodplain influences	HIGH
	Issue 3: Aquatic Plant Growth	
1	Create navigation lanes, through either chemical or mechanical means	HIGH
2	Hand-pull and/or rake nuisance plant growth in the near-shore area	MEDIUM
3	Whole-lake chemical treatment	LOW
4	Protect native plants and actively control invasive plants	HIGH
5	Prevent introduction of new invasive species	HIGH
6	Improve water quality	HIGH
7	Monitor conditions and periodically revise plan	HIGH
	Issue 4: Blue Green And Floating Algae	
1	Monitor water-borne algae populations	--
a	Track chlorophyll-*a* concentrations	HIGH

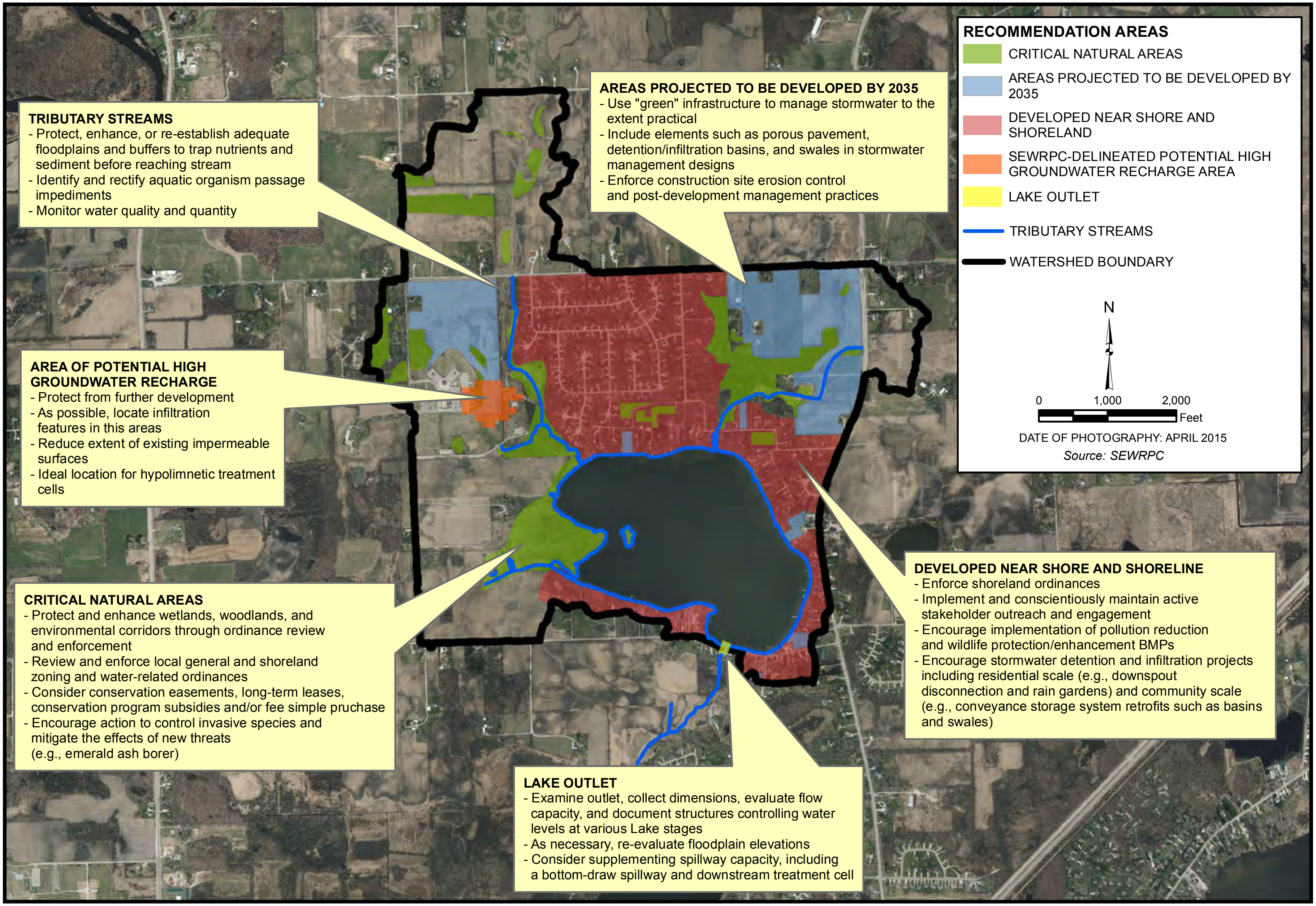
Table continued on next page.

Table 3.2 (Continued)

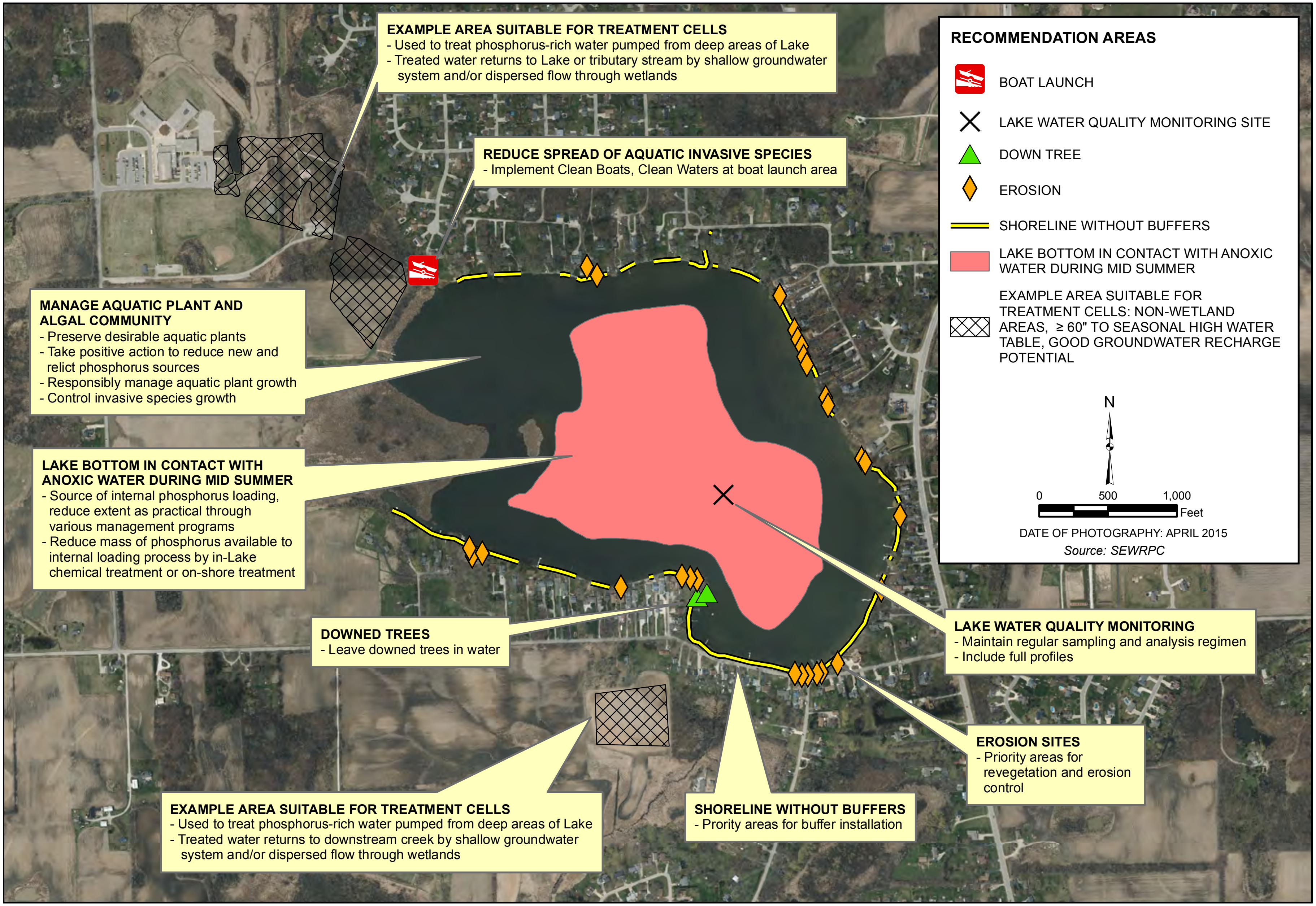
Recommendation Number	Strategies and Tactics	Suggested Priority Level
b	Identify algal species	LOW (Few algal blooms) HIGH (if algal blooms regularly occur)
2	Warn residents not to enter the water in event of an algal bloom	HIGH
3	Maintain and improve water quality	HIGH
4	Maintain healthy aquatic plant community	HIGH
5	Reevaluate if monitoring reveals excessive, greatly increased, or toxic algae	HIGH
	Issue 5: Shoreline Maintenance	
1	Encourage regular repair or removal of failing "hard" shoreline structures	HIGH
2	Educate residents and shoreline property owners on importance of buffers	HIGH
3	Encourage "soft" or "natural" shoreline protection features	MEDIUM
4	Ensure shoreline setbacks/shoreland zoning rules are enforced	HIGH
5	Establish shoreline protection goals and track progress	MEDIUM
	Issue 6: Recreational Use and Facilities	
1	Maintain public boat launch	HIGH
2	Review existing boating regulations for compatibility with current conditions and expectations and revise as necessary	HIGH
3	Conscientiously enforce boating and water-based recreation ordinances:	
a	Weekdays	LOW
b	Weekends and holidays	HIGH
4	Increase boat launch fees:	
a	Weekdays	LOW
b	Weekends and holidays	HIGH
5	Establish boat launch attendant trained in Clean Boats/Clean Waters inspection protocol	
a	Weekdays	LOW-MEDIUM
b	Weekends and holidays	HIGH
	Issue 7: Fish and Wildlife	
1	Continue current fish stocking practices	HIGH
2	Continue enforcing current fishing practices and ordinances	HIGH
3	Identify and remove fish passage barriers	MEDIUM
4	Maintain or install large woody debris and/or vegetative buffers along shorelines	MEDIUM
5	Adopt best management practices to improve wildlife habitat	MEDIUM
6	Ensure proper implementation of aquatic plant management plan	HIGH
7	Preserve and expand wetland and terrestrial wildlife habitat, while making efforts to ensure connectivity between natural areas	HIGH
8	Monitor and evaluate fish and wildlife population trends	HIGH
	Issue 8: Implementation	
1	Maintain and enhance relationships with County and municipal zoning administrators and law enforcement officials	HIGH
2	Keep abreast of activities within the watershed	HIGH
3	Educate watershed residents about relevant ordinances	HIGH
4	Encourage key players to attend meetings, conferences, and/or training programs	MEDIUM
5	Continue to reinforce stakeholder inclusivity and transparency with respect to all Lake management activities	HIGH
6	Foster and monitor efforts to communicate concerns, goals, actions, and achievements to future Lake managers	HIGH
7	Prepare and submit high quality grant applications	HIGH
8	Encourage Lake users and residents to actively engage themselves in future management efforts	MEDIUM
9	Consider formation of a Lake District with the authority to levy taxes	MEDIUM-HIGH
10	Actively share the content of the current lake management plan and encourage continual revision.	HIGH

Source: SEWRPC

Map 3.2
Selected Recommendations for the Lake Denoon Watershed: 2017



Map 3.3
Selected In-Lake, Shoreline, and Institutional Recommendations for Lake Denoon: 2017



APPENDICES

(This page intentionally left blank)

APPENDIX A

OUTLET DAM RECORDS

IN RE APPLICATION OF HARRY G. OAKLAND ET AL. FOR AN ORDER FIXING MAXIMUM AND MINIMUM LEVELS OF LAKE DENOON IN RACINE AND WAUKESHA COUNTIES

Submitted June 6, 1919. Decided August 22, 1919

Applicants allege that unknown persons have removed portions of a dam at the outlet of Lake Denoon, thus lowering the level of the water, and causing loss and damage to them and to the public. Applicants request the erection of bench marks and authority to construct a dam to maintain the water at an indicated elevation.

The present outlet is an artificial ditch constructed some sixty years ago. About fourteen years ago a small dam of boulders and earth was constructed across this ditch at the outlet by certain of the owners of summer homes on the lake, who claim that the height of this dam was a matter of general agreement between them and other property owners. The dam is a very small structure, the highest point being but 8 inches or 10 inches above the natural bed of the stream at that point. On June 5, 1919, the Commission's engineers set Bench Mark No. 101 near the dam which has an assumed elevation of 99.26 feet.

***Held:* In view of all evidence presented at the hearing and obtained through investigations, if a dam be constructed with an elevation of 92.60 and having a clear spillway width of not less than 35 feet, the fluctuations of the lake will be normal.**

ORDER accordingly.

An application in the above matter signed by H. G. Oakland and 20 other persons who are owners of cottages on the shore of Lake Denoon was received in January, 1919. This application sets forth and alleges that a long time ago certain owners of portions of the surrounding land changed the original outlet of the lake to its present outlet, thereby considerably lowering the level of the water. It further alleges that during the existence of the present outlet, the level of the water has been maintained by a dirt and stone dam, but that some person or persons, unknown to the applicants, have, at various times removed portions of the dam, thus drawing off large quantities of water and materially lowering the level of the water. That a large majority of the persons owning the lake frontage use this property for summer residences, and together with a comparatively large number of persons, use the lake for boating, fishing and bathing. That the lowering of the lake, as set forth, causes great inconvenience, loss and damage to these owners and to the public by depriving them of the use and enjoyment of the lake and by depreciating greatly the value of the property.

The applicants request the erection of bench marks to indicate the level of the water in the lake to which they are now entitled and ask for authority to construct a permanent dam to maintain the level of the water at the elevation indicated by such bench marks.

After due notice of investigation a hearing was held at Muskego Center on June 6, 1919, at which *Dr. Harry G. Oakland* appeared in his own behalf and others similarly situated, *Mr. G. R. Ferguson*, town clerk, Muskego; and *G. A. Gulbranson* in his own behalf and others similarly situated.

From the testimony offered and investigations made by our engineers it appears that the present outlet of Lake Denoon is an artificial ditch constructed some sixty years ago, and that about thirteen or fourteen years ago a small dam consisting of boulders and earth was constructed across this ditch just at the outlet of the lake. This was constructed by certain of the owners of summer homes on the lake, who claim that it was done with the consent of the property owners, who were most affected, and that the height of this dam was a matter of general agreement between them.

It is claimed that for several years from time to time the owners of farms on the lake have removed parts of the dam or cut channels around it in such a manner that the water has been allowed to drop lower than the agreement called for. The farm owners admit having done this, but claim, on the other hand, that the summer home owners have been adding material to the dam and raising the water level, which is denied by the latter.

The dam is a very small structure which can raise the water only a few inches at most and is so constructed of boulders with dirt between that it is impossible to tell just what would be considered as the height of the dam. The highest point is but eight inches or ten inches above the natural bed of the stream at that point.

On June 5, 1919, the Commission's engineers set a bench mark near the dam. This consists of a brass tablet set in the top of a concrete post on the south side of the highway near the property fence, at a point on the top of a knoll about one hundred and twenty-five feet westerly from the highway bridge spanning the outlet of the lake. This is Bench Mark No. 101, and has an assumed elevation of 99.26 feet.

The elevation of the water with respect to this bench mark has been taken at three different times by our engineers and is as follows:

November 21, 1918,	elevation of water	91.67
June 5, 1919,	" " "	92.51
July 30, 1919,	" " "	91.92

On November 21, 1918, and on July 30, 1919, no water was passing through the outlet, which was entirely dry. Even had there been no dam there no water would have passed, since the elevation of the lowest part of the bed of the stream is about 92.00 feet, while the water level was lower.

It is a well known fact, however, that the summer of 1918 was abnormally dry, and it is also true that the season preceding July 30, 1919, was so dry as to cause the level of the lake to drop to an abnormal stage.

In addition to the above measurements, the engineers have made investigations at various points on the shores of the lake with a view of determining where the normal level of the lake is.

Taking into account all evidence presented at the hearing and that obtained through the investigations of our engineers we find that if a dam be constructed with an elevation of 92.60 and having a clear spillway width of not less than 35 feet, the fluctuations of the lake will be normal.

It is clear that the construction of a new dam as above specified will not insure the water in the lake remaining at its normal level. In dry seasons it will fall a great deal, but the dam will prevent the running off of any water below the stage of 92.60 and this will tend to improve the inevitable conditions produced by evaporation. With a spillway 35 feet in width the level should never reach a stage much above the normal except as the escape of the water may be retarded by conditions in the outlet below the dam.

The present dam has an elevation varying from a few inches above to a few inches below the elevation 92.60.

It is Therefore Ordered, That the dam across the outlet of Lake Denoon in the NW. 1/4, NW 1/4, Sec. 5, T. 4 N., R. 20 E., Racine county, be so built or maintained that it shall have a surface with a uniform elevation of 92.60 feet when referred to Railroad Commission Bench Mark No. 101.

It is Further Ordered, That the dam shall have a clear spillway width of thirty-five (35) feet.

The lake is oriented NW-SE and as a result, the south and east shores are wave washed and free of encroaching vegetation. These are the shores most heavily developed for housing. With nearly a mile of fetch (length free of obstructions to winds), the theoretical maximum wave height is about 1.25 feet and active sorting can take place to depths of about 4 feet. On the protected west shore and on the lee side of a projecting peninsula on the south shore, floating-leaved and submergent vegetation is abundant and the shoreline in the first instance is encroaching marsh.

Drainage Characteristics

Inlets to Denoon Lake are intermittent relatively short channels with low seasonal flow. The outlet has been obstructed by a spillway with 0.4-foot head which serves to maintain the lake level. The first dam was earth and boulders constructed in 1904. In 1949, a concrete sill was poured and has since served as the control with a single stoplog in place at some times. Flow is intermittent, though in April, 1967, a discharge of 0.775 cfs was measured and the water level was 0.45 feet above the outlet sill. An exchange rate was not computed for Denoon Lake since perennial flow is lacking.

The lake receives and discharges groundwater; however, the rate of such exchange must be very low as the water table is nearly level in this region.

Climate and Hydrology

Climatological data for Waukesha approximates conditions at Denoon Lake. These data are presented in Table 2. Over half the annual precipitation falls as rain from May through September. As the lake does not discharge continually during this period, it can be reasoned that evapotranspiration, lake surface evaporation and groundwater recharge account for all precipitation during this period.

The watershed of about 1,234 acres receives 3,095 acre feet of water per year; 625 acre feet are assumed to run off to the lake, 406 acre feet fall directly on it. During the course of the year, lake evaporation accounts for the loss of 397 acre feet. The remainder either is discharged or serves to recharge the groundwater table. From April through October, it is probable that more water is evaporated from the lake surface than actually falls on it, and the lake level is no doubt maintained solely by the limited runoff that occurs and by the groundwater table.

Soils

Silt loams and loams predominate on the south, north and northeast shores. Marshy soils border the west end, the inlets on the north shore, and constitute a narrow band of low, wet soil east from the lake. Northwest of the lake, a sandy loam soil and some loamy sand extend to the shore. Marl borders some of the east and southeast shores.

Detailed Information for Dam LAKE DENOON

Dam Key Seq No	1439	Field File No	51.07
Size	SMALL	NID	10464
Popular Name	RIPARIANS	Former Name	

Location

County	Racine		
Latitude	42.833381	Longitude	-88.173936
Permitted TRS		**Located TRS**	
QQQ:NE QQ:NW Q:NW - Sec:05 T:04N R:20		QQ:NW Q:NW - Sec:5 T:4N R:20	

Contacts

Owner		**Alternate**	
Organization	RIPARIANS	Organization	
Name		Name	

Waterbody

Drainage Basin (sq mi)	3.00		
Stream		**Impoundment**	
Local Name	LAKE DENOON OUTLET	Local Name	LAKE DENOON
Row and Official Name		Row and Official Name	
Navigable?	non-navigable	Size (acres)	162.00
When was navigability determined?		Maximum Depth (ft)	55.00

Regulatory/Inspection

NR 333 Years	EAP: IOM: HYD: STAB: ZONE:		
Auth. Approval Desc	2WP170	Regulatory Agency	WIDNR
Hazard Rating	None	Estimated Hazard Rating	Low
Ferc. No		Exempt Issue Date	
Ferc. Inspection Year		License Expiration Year	

Construction Characteristics

Normal Storage (acre-ft)	60.00	Max Storage (acre-ft)	150.00
Structural Height (ft)	2.00	Hydraulic Height (ft)	1.00
Crest Length (ft)	30.00	Spillway Type	
Discharge Through Principal Spillway (cfs)	710.00	Width/Diameter of Principal Spillway (ft)	30.00
Total Discharge Through All Spillways (cfs)	710.00	Total Width/Diameter of All Spillways (ft)	
Core Type		Position	
Foundation Type		Foundation Certainty	
Purposes		Structural Types	

Detailed Information for Dam LAKE DENOON

Water Levels

	Normal		Winter	
	MSL	Datum	MSL	Datum
Minimum				
Normal				
Maximum				

Construction History

Designer	Construction Firm	Complete Year
		1926

Outlet Gates

No data found.

Inspection History

Inspection Date	Inspection Report Date	DNR Engineer Initials	Inspection Type
8/12/1981		XXX	LEVEL
8/22/1967	9/5/1967	XXX	LEVEL
3/30/1962	4/11/1962	XXX	LEVEL
6/19/1961	6/28/1961	XXX	LEVEL
6/19/1961		XXX	GEN
8/5/1960	2/10/1961	XXX	LEVEL
4/22/1960	2/7/1961	XXX	LEVEL
6/1/1951	6/8/1951	XXX	LEVEL
6/6/1947	9/12/1947	XXX	LEVEL
7/10/1941	5/2/1942	XXX	LEVEL
8/30/1933	8/30/1933	XXX	LEVEL
9/1/1926	11/16/1926	XXX	LEVEL
4/10/1924		XXX	CHECK
6/23/1919		XXX	LEVEL
6/20/1919		XXX	GEN

Followups

No data found.

Approvals

Approval Month	Approval Year	Docket ID	Approval Type	DNR Engineer Initials
8	1919	WP-108	LEVELS; STAT 31.02	XXX

Orders

No data found.

Inspection Schedule

No data found.

APPENDIX B

RIPARIAN BUFFER GUIDE

Managing the Water's Edge

Making Natural Connections

Problem Statement:
Despite significant research related to buffers, there remains no consensus as to what constitutes optimal riparian buffer design or proper buffer width for effective pollutant removal, water quality protection, prevention of channel erosion, provision of fish and wildlife habitat, enhancement of environmental corridors, augmentation of stream baseflow, and water temperature moderation.

Southeastern Wisconsin Regional Planning Commission

Our purpose in this document is to help protect and restore water quality, wildlife, recreational opportunities, and scenic beauty.

This material was prepared in part with funding from the U.S. Environmental Protection Agency Great Lakes National Program Office provided through CMAP, the Chicago Metropolitan Agency for Planning.

Introduction

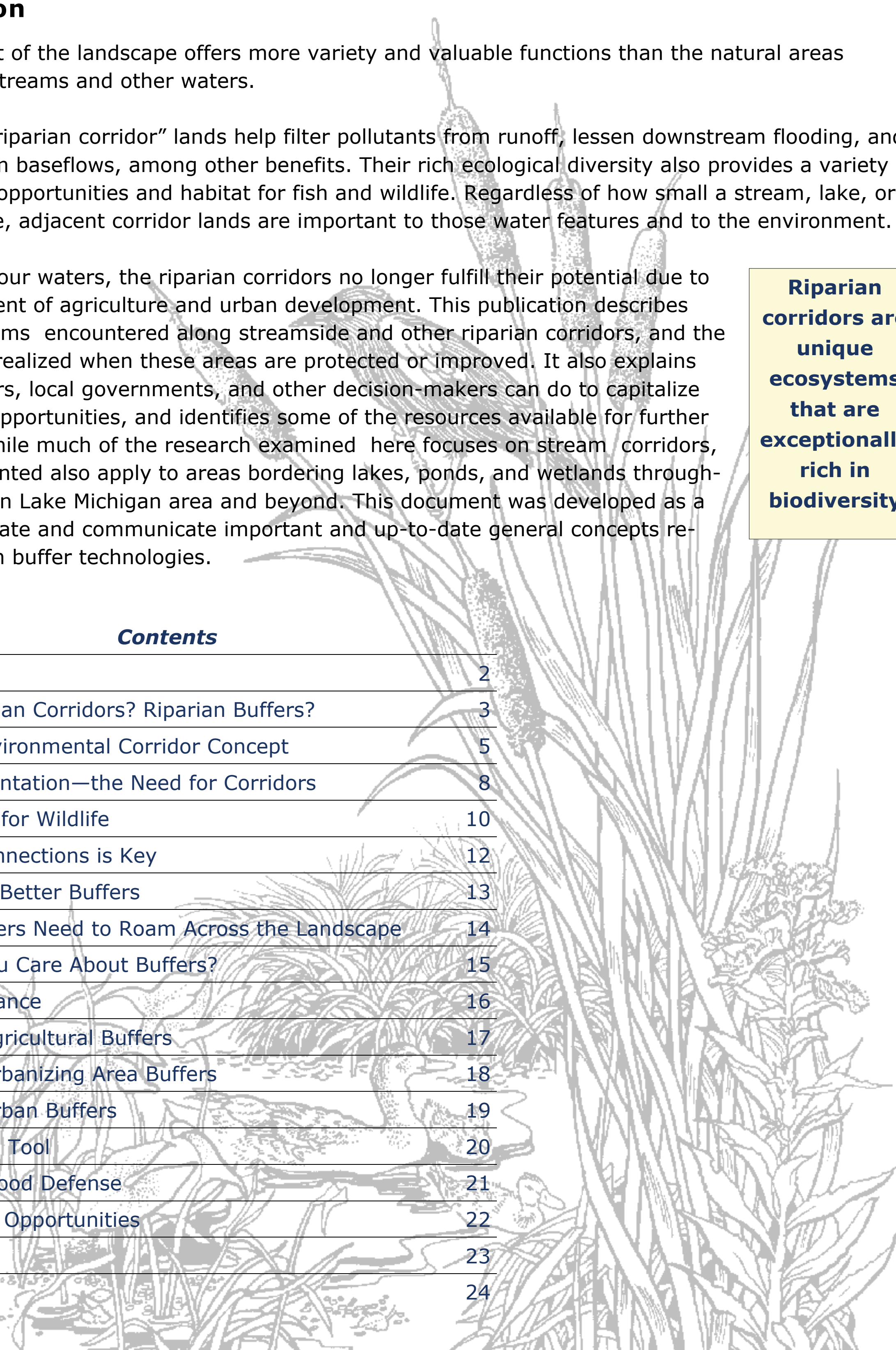
Perhaps no part of the landscape offers more variety and valuable functions than the natural areas bordering our streams and other waters.

These unique "riparian corridor" lands help filter pollutants from runoff, lessen downstream flooding, and maintain stream baseflows, among other benefits. Their rich ecological diversity also provides a variety of recreational opportunities and habitat for fish and wildlife. Regardless of how small a stream, lake, or wetland may be, adjacent corridor lands are important to those water features and to the environment.

Along many of our waters, the riparian corridors no longer fulfill their potential due to the encroachment of agriculture and urban development. This publication describes common problems encountered along streamside and other riparian corridors, and the many benefits realized when these areas are protected or improved. It also explains what landowners, local governments, and other decision-makers can do to capitalize on waterfront opportunities, and identifies some of the resources available for further information. While much of the research examined here focuses on stream corridors, the ideas presented also apply to areas bordering lakes, ponds, and wetlands throughout the southern Lake Michigan area and beyond. This document was developed as a means to facilitate and communicate important and up-to-date general concepts related to riparian buffer technologies.

Riparian corridors are unique ecosystems that are exceptionally rich in biodiversity

Contents

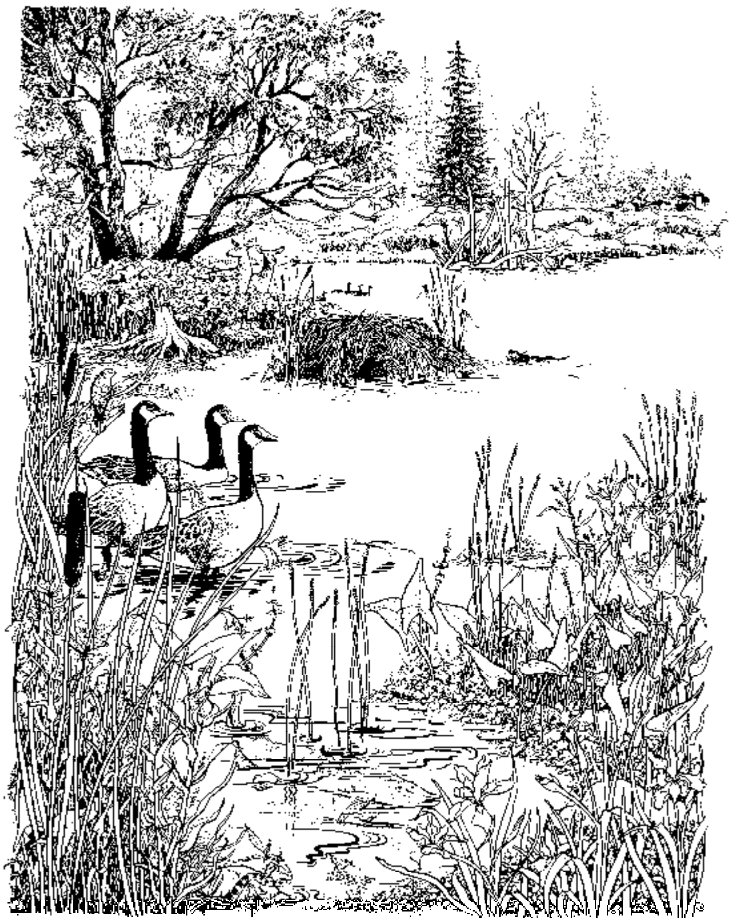


University of Wisconsin—Extension

Managing the Water's Edge

What Are Riparian Corridors? Riparian Buffer Zones?

The word riparian comes from the Latin word *ripa*, which means bank. However, in this document we use riparian in a much broader sense and refer to land adjoining any water body including ponds, lakes, streams, and wetlands. This term has two additional distinct meanings that refer to 1) the "natural or relatively undisturbed" corridor lands adjacent to a water body inclusive of both wetland and upland flora and fauna and 2) a buffer zone or corridor lands in need of protection to "buffer" the effects of human impacts such as agriculture and residential development.



University of Wisconsin—Extension

The word buffer literally means something that cushions against the shock of something else (noun), or to lessen or cushion that shock (verb). Other useful definitions reveal that a buffer can be something that serves to separate features, or that is capable of neutralizing something, like filtering pollutants from stormwater runoff. Essentially, buffers and buffering help protect against adverse effects.

Riparian buffer zones function as core habitat as well as travel corridors for many wildlife species.

Riparian buffers are zones adjacent to waterbodies such as lakes, rivers, and wetlands that simultaneously protect water quality and wildlife, including both aquatic and terrestrial habitat. These zones minimize the impacts of human activities on the landscape and contribute to recreation, aesthetics, and quality of life. **This document summarizes how to maximize both water quality protection and conservation of aquatic and terrestrial wildlife populations using buffers.**

Managing the Water's Edge

What Are Riparian Corridors? Riparian Buffer Zones?

Buffers **can** include a range of complex vegetation structure, soils, food sources, cover, and water features that offer a variety of habitats contributing to diversity and abundance of wildlife such as mammals, frogs, amphibians, insects, and birds. Buffers can consist of a variety of canopy layers and cover types including ephemeral (temporary-wet for only part of year) wetlands/seasonal ponds/spring pools, shallow marshes, deep marshes, wetland meadows, wetland mixed forests, grasslands, shrubs, forests, and/or prairies. Riparian zones are areas of transition between aquatic and terrestrial ecosystems, and they can potentially offer numerous benefits to wildlife and people such as pollution reduction and recreation.

In the water resources literature, riparian buffers are referred to in a number of different ways. Depending on the focus and the intended function of a buffer, or a buffer-related feature, buffers may be referred to as stream corridors, critical transition zones, riparian management areas, riparian management zones, floodplains, or green infrastructure.

It is important to note that within an agricultural context, the term buffer is used more generally to describe filtering best management practices most often at the water's edge. Other practices which can be interrelated may also sometimes be called buffers. These include grassed waterways, contour buffer strips, wind breaks, field border, shelterbelts, windbreaks, living snow fence, or filter strips. These practices may or may not be adjacent to a waterway as illustrated in the photo to the right. For example, a grassed waterway is designed to filter sediment and reduce erosion and may connect to a riparian buffer. These more limited-purpose practices may link to multipurpose buffers, but by themselves, they are not adequate to provide the multiple functions of a riparian buffer as defined here.

U.S. Department of Agriculture, Natural Resource Conservation Service, Ohio Office.

Managing the Water's Edge

Beyond the Environmental Corridor Concept

The term "environmental corridors" (also known as "green infrastructure") refers to an inter-connected green space network of natural areas and features, public lands, and other open spaces that provide natural resource value. Environmental corridor planning is a process that promotes a systematic and strategic approach to land conservation and encourages land use planning and practices that are good for both nature and people. It provides a framework to guide future growth, land development, and land conservation decisions in appropriate areas to protect both community and natural resource assets.

Environmental corridors are an essential planning tool for protecting the most important remaining natural resource features in Southeastern Wisconsin and elsewhere. Since development of the environmental corridor concept, there have been significant advancements in landscape ecology that have furthered understanding of the spatial and habitat needs of multiple groups of organisms. In addition, advancements in pollutant removal practices, stormwater control, and agriculture have increased our understanding of the effectiveness and limitations of environmental corridors. In protecting water quality and providing aquatic and terrestrial habitat, there is a need to better integrate new technologies through their application within riparian buffers.

SEWRPC has embraced and applied the environmental corridor concept developed by Philip Lewis (Professor Emeritus of Landscape Architecture at the University of Wisconsin-Madison) since 1966 with the publication of its first regional land use plan. Since then, SEWRPC has refined and detailed the mapping of environmental corridors, enabling the corridors to be incorporated directly into regional, county, and community plans and to be reflected in regulatory measures. The preservation of environmental corridors remains one of the most important recommendations of the regional plan. Corridor preservation has now been embraced by numerous county and local units of government as well as by State and Federal agencies. The environmental corridor concept conceived by Lewis has become an important part of the planning and development culture in Southeastern Wisconsin.

Beyond the Environmental Corridor Concept

Environmental corridors are divided into the following three categories.

- **Primary environmental corridors** contain concentrations of our most significant natural resources. They are at least 400 acres in size, at least two miles long, and at least 200 feet wide.

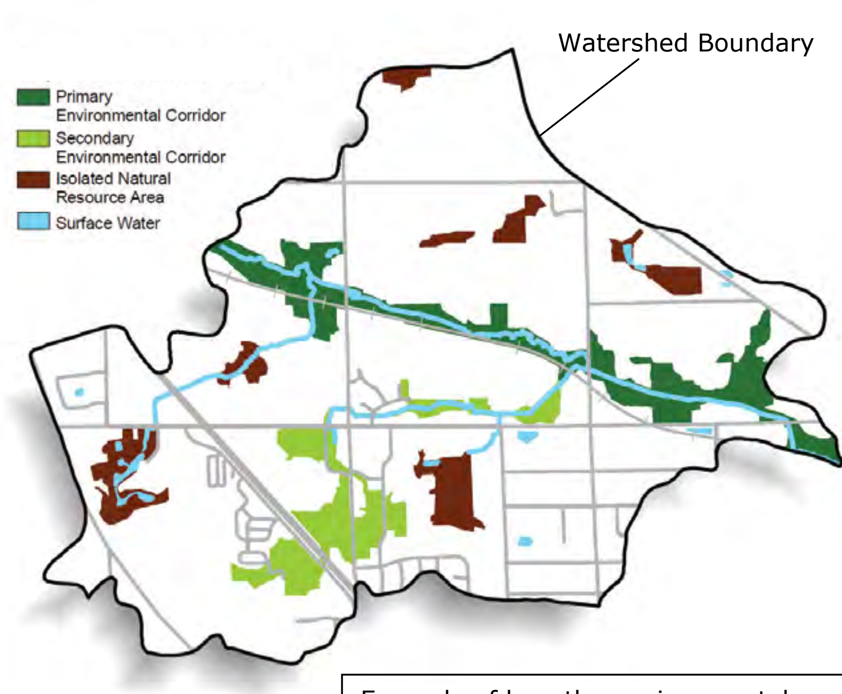
- **Secondary environmental corridors** contain significant but smaller concentrations of natural resources. They are at least 100 acres in size and at least one mile long, unless serving to link primary corridors.

- **Isolated natural resource areas** contain significant remaining resources that are not connected to environmental corridors. They are at least five acres in size and at least 200 feet wide.

Key Features of Environmental Corridors

- Lakes, rivers, and streams
- Undeveloped shorelands and floodlands
- Wetlands
- Woodlands
- Prairie remnants
- Wildlife habitat
- Rugged terrain and steep slopes
- Unique landforms or geological formations
- Unfarmed poorly drained and organic soils
- Existing outdoor recreation sites
- Potential outdoor recreation sites
- Significant open spaces
- Historical sites and structures
- Outstanding scenic areas and vistas

Beyond the Environmental Corridor Concept

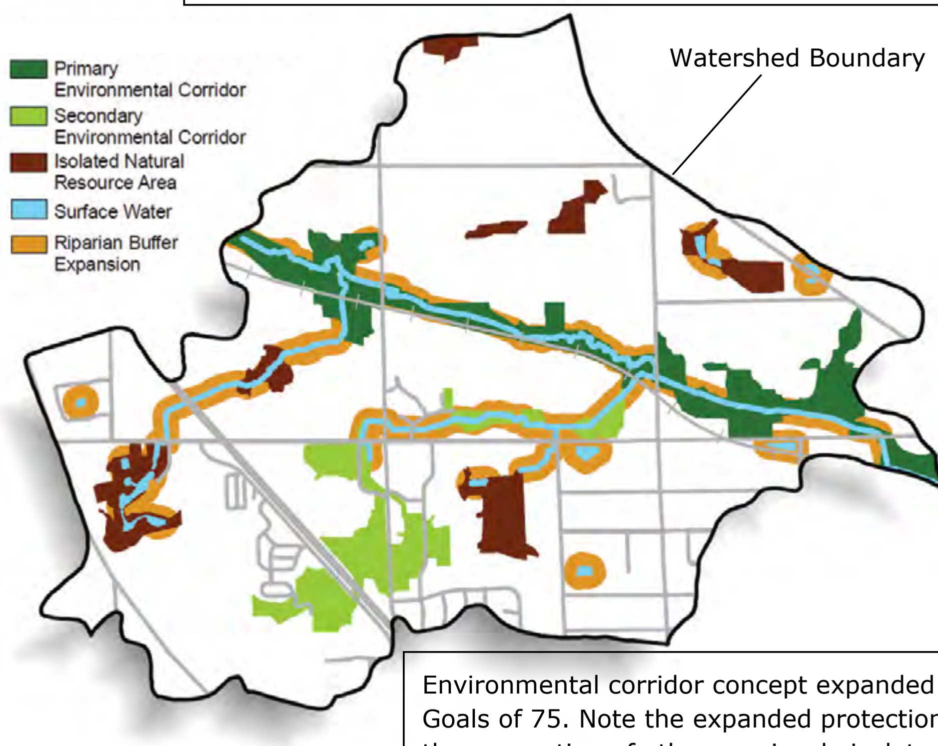


The Minimum Goals of **75** within a Watershed

75% minimum of total stream length should be naturally vegetated to protect the functional integrity of the water resources. (Environment Canada, How Much Habitat is Enough? A Framework for Guiding Habitat Rehabilitation in Great lakes Areas of Concern, Second Edition, 2004)

75 foot wide minimum riparian buffers from the top edge of each stream bank should be naturally vegetated to protect water quality and wildlife. (SEWRPC Planning Report No 50, A Regional Water Quality Management Plan for the Greater Milwaukee Watersheds, December 2007)

Example of how the environmental corridor concept is applied on the landscape. For more information see "Plan on It!" series **Environmental Corridors: Lifelines of the Natural Resource Base** at www.sewrpc.org/SEWRPC/LandUse/EnvironmentalCorridors.htm



Environmental corridor concept expanded to achieve the Goals of 75. Note the expanded protection in addition to the connection of other previously isolated areas.

Habitat Fragmentation—The Need for Corridors

Southeastern Wisconsin is a complex mosaic of agricultural and urban development. Agricultural lands originally dominated the landscape and remain a major land use. However, such lands continue to be converted to urban uses. Both of these dominant land uses fragment the landscape by creating islands or isolated pockets of wetland, woodland, and other natural lands available for wildlife preservation and recreation. By recognizing this fragmentation of the landscape, we can begin to mitigate these impacts.

New developments should incorporate water quality and wildlife enhancement or improvement objectives as design criteria by looking at the potential for creating linkages with adjoining lands and water features.

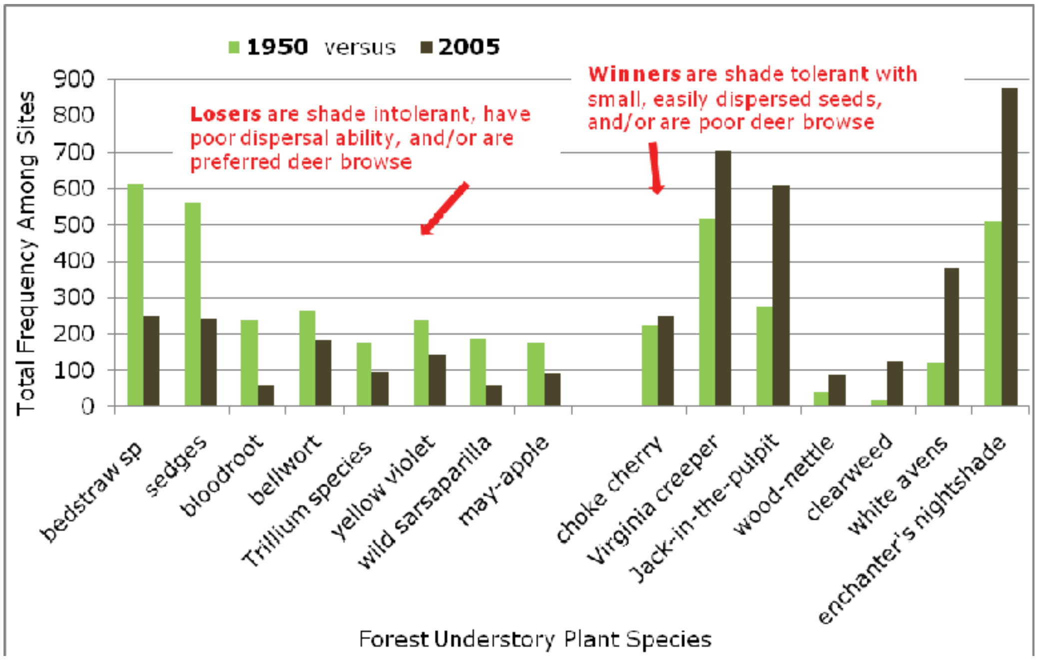
At the time of conversion of agricultural lands to urban uses, there are opportunities to re-create and expand riparian buffers and environmental corridors reconnecting uplands and waterways and restoring ecological integrity and scenic beauty locally and regionally. For example, placement of roads and other infrastructure across stream systems could be limited so as to maximize continuity of the riparian buffers. This can translate into significant cost savings in terms of reduced road maintenance, reduced salt application, and limited bridge or culvert maintenance and replacements. This simple practice not only saves the community significant amounts of money, but also improves and protects quality of life. Where necessary road crossings do occur, they can be designed to provide for safe fish and wildlife passage.

Overland travel routes for wildlife are often unavailable, discontinuous, or life endangering within the highly fragmented landscapes of Southeastern Wisconsin and elsewhere.

State Threatened Species: Blanding's turtle

Habitat Fragmentation—The Need for Corridors

Forest understory plant species abundance among stands throughout Southern Wisconsin

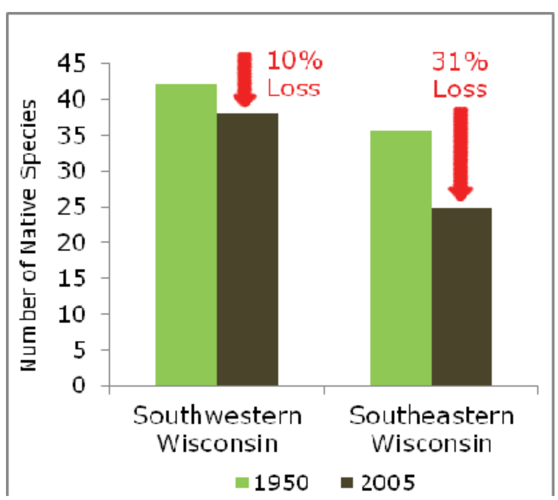


Forest fragmentation has led to significant plant species loss within Southern Wisconsin

(Adapted from David Rogers and others, 2008, Shifts in Southern Wisconsin Forest Canopy and Understory Richness, Composition, and Heterogeneity, Ecology, 89 (9): 2482-2492)

"...these results confirm the idea that large intact habitat patches and landscapes better sustain native species diversity. It also shows that people are a really important part of the system and their actions play an increasingly important role in shaping patterns of native species diversity and community composition. Put together, it is clear that one of the best and most cost effective actions we can take toward safeguarding native diversity of all types is to protect, enhance and create corridors that link patches of natural habitat."
Dr. David Rogers, Professor of Biology at the University of Wisconsin-Parkside

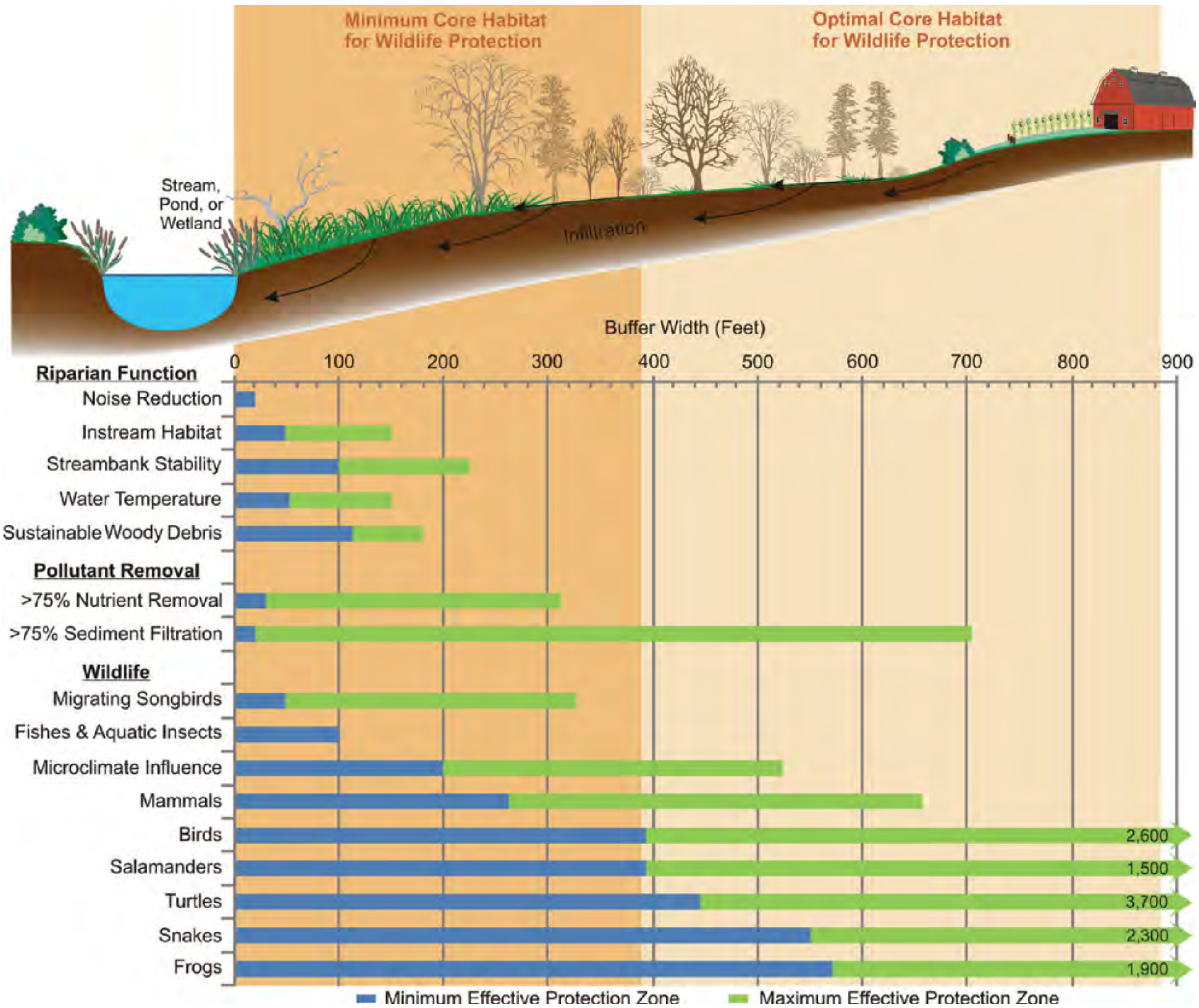
Since the 1950s, forests have increasingly become more fragmented by land development, both agricultural and urban, and associated roads and infrastructure, which have caused these forests to become isolated "islands of green" on the landscape. In particular, there has been significant loss of forest understory plant species over time (shrubs, grasses, and herbs covering the forest floor.) It is important to note that **these forests lost species diversity even when they were protected as parks or natural areas**.



One major factor responsible for this decline in forest plant diversity is that routes for native plants to re-colonize isolated forest islands are largely cut-off within fragmented landscapes. For example, the less fragmented landscapes in Southwestern Wisconsin lost fewer species than the more fragmented stands in Southeastern Wisconsin. In addition, the larger-sized forests and forests with greater connections to surrounding forest lands lost fewer species than smaller forests in fragmented landscapes.

Wider is Better for Wildlife

Why? Because buffer size is the engine that drives important natural functions like food availability and quality, access to water, habitat variety, protection from predators, reproductive or resting areas, corridors to safely move when necessary, and help in maintaining the health of species' gene pools to prevent isolation and perhaps extinction.



One riparian buffer size does not fit all conditions or needs. There are many riparian buffer functions and the ability to effectively fulfill those functions is largely dependent on width. Determining what buffer widths are needed should be based on what functions are desired as well as site conditions. For example, as shown above, water temperature protection generally does not require as wide a buffer as provision of habitat for wildlife. Based on the needs of wildlife species found in Wisconsin, the minimum core habitat buffer width is about 400 feet and the optimal width for sustaining the majority of wildlife species is about 900 feet. Hence, the value of large undisturbed parcels along waterways which are part of, and linked to, an environmental corridor system. The minimum effective buffer width distances are based on data reported in the scientific literature and the quality of available habitats within the context of those studies.

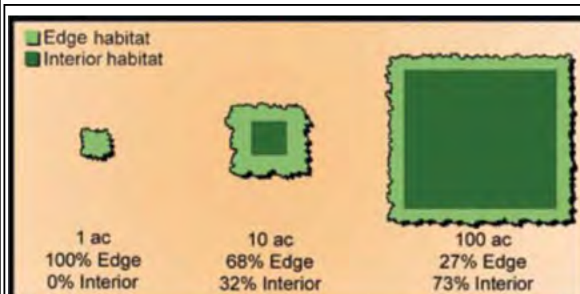
Wider is Better for Wildlife

Although *Ambystoma* salamanders require standing water for egg laying and juvenile development, most other times of the year they can be found more than 400 feet from water foraging for food.

Wildlife habitat needs change within and among species. **Minimum Core Habitat and Optimum Core Habitat distances were developed from numerous studies to help provide guidance for biologically meaningful buffers to conserve wildlife biodiversity.** These studies documented distances needed for a variety of biological (life history) needs to sustain healthy populations such as breeding, nesting, rearing young, foraging/feeding, perching (for birds), basking (for turtles), and overwintering/dormancy/hibernating. These life history needs require different types of habitat and distances from water, for example, one study found that Blanding's turtles needed approximately 60-foot-wide buffers for basking, 375 feet for overwintering, and up to 1,200 feet for nesting to bury their clutches of eggs. Some species of birds like the Blacked-capped chickadee or white breasted nuthatch only need about 50 feet of buffer, while others like the wood duck or great blue heron require 700-800 feet for nesting. Therefore, **understanding habitat needs for wildlife species is an important consideration in designing riparian buffers.**

Wisconsin Species	Mimimum Core Habitat (feet)	Optimum Core Habitat (feet)	Number of Studies
Frogs	571	1,043	9
Salamanders	394	705	14
Snakes	551	997	5
Turtles	446	889	27
Birds	394	787	45
Mammals	263	No data	11
Fishes and Aquatic Insects	100	No data	11
Mean	388	885	

This approach was adapted from *R.D. Semlitsch and J.R. Bodie, 2003, Biological Criteria for Buffer Zones around Wetlands and Riparian Habitats for Amphibian and Reptiles, Conservation Biology, 17(5):1219-1228*. These values are based upon studies examining species found in Wisconsin and represent mean linear distances extending outward from the edge of an aquatic habitat. The Minimum Core Habitat and Optimum Core Habitat reported values are based upon the mean minimum and mean maximum distances recorded, respectively. Due to a low number of studies for snake species, the recommended distances for snakes are based upon values reported by *Semlitsch and Bodie.*



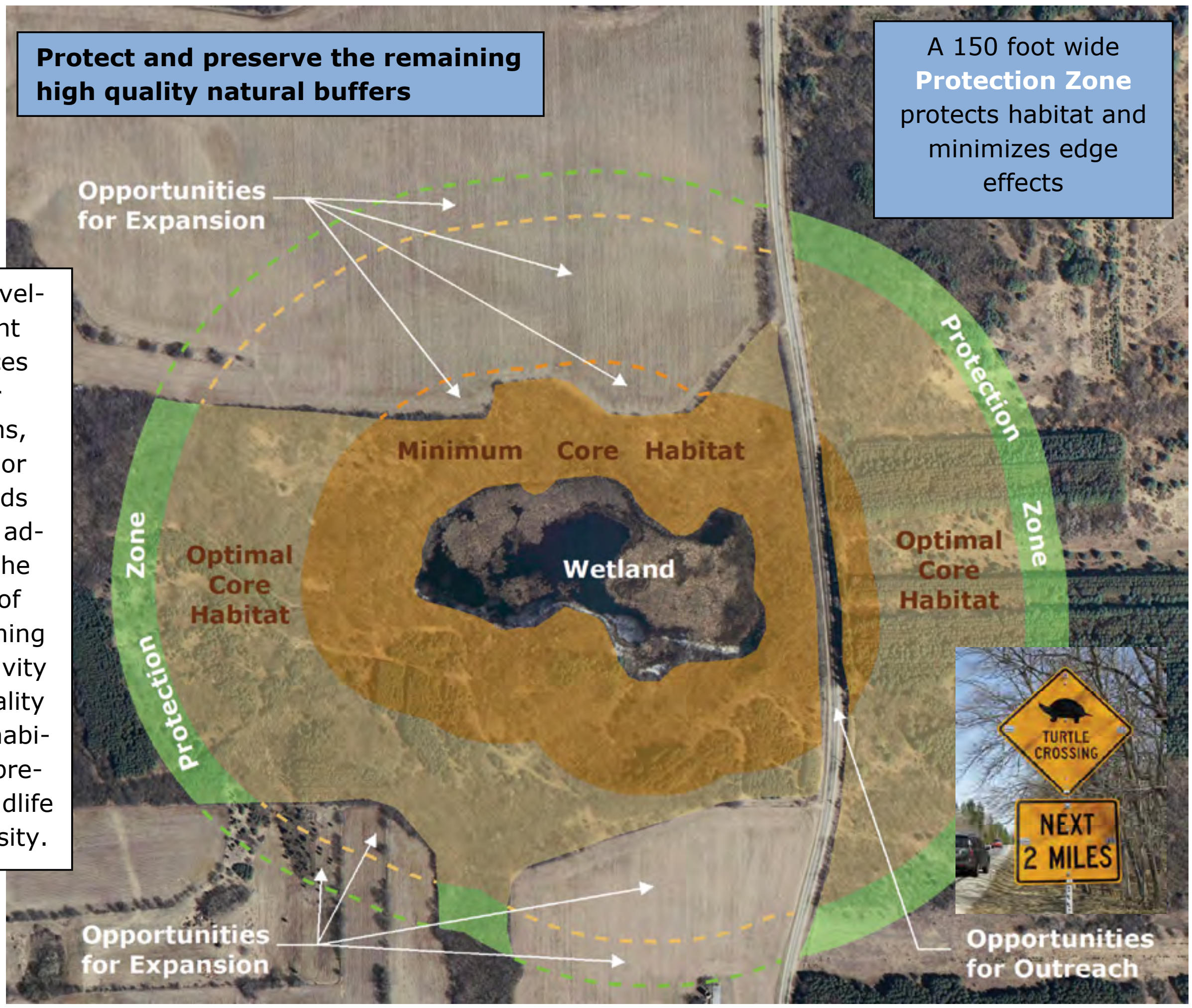
"Large patches typically conserve a greater variety and quality of habitats, resulting in higher species diversity and abundance." *Larger patches contain greater amounts of interior habitat and less edge effects, which benefits interior species, by providing safety from parasitism, disease, and invasive species.*

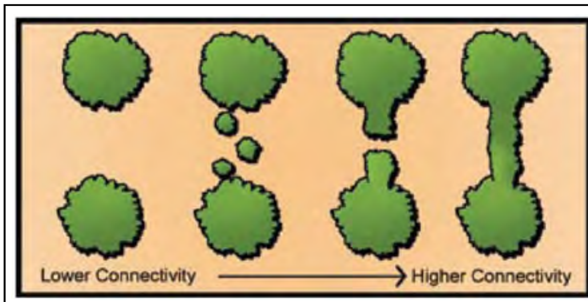
(Bentrup, G. 2008. Conservation buffers: design guidelines for buffers, corridors, and greenways. Gen. Tech. Rep. SRS-109. Asheville, NC: Department of Agriculture, Forest Service, Southern Research Station)

Maintaining Connections is Key

Like humans, all forms of wildlife require access to clean water. Emerging research has increasingly shown that, in addition to water, more and more species such as amphibians and reptiles cannot persist without landscape connectivity between quality wetland and upland habitats. Good connectivity to upland terrestrial habitats is essential for the persistence of healthy sustainable populations, because these areas provide vital feeding, overwintering, and nesting habitats found nowhere else. Therefore, both aquatic and terrestrial habitats are essential for the preservation of biodiversity and they should ideally be managed together as a unit.

Land development practices near streams, lakes, or wetlands need to address the issue of maintaining connectivity with quality upland habitats to preserve wildlife biodiversity.





Increasing connectivity among quality natural landscapes (wetlands, woodlands, prairies) can benefit biodiversity by providing access to other areas of habitat, increasing gene flow and population viability, enabling recolonization of patches, and providing habitat (Bentrup 2008).

Managing the Water’s Edge

Basic Rules to Better Buffers

Protecting the integrity of native species in the region is an objective shared by many communities. The natural environment is an essential component of our existence and contributes to defining our communities and neighborhoods. Conservation design and open space development patterns in urbanizing areas and farm conservation programs in rural areas have begun to address the importance of maintaining and restoring riparian buffers and connectivity among corridors.

There are opportunities to improve buffer functions to improve water quality and wildlife habitat, even in urban situations

- Channelized ditch
- Historic floplain fill
- Invasive species dominate

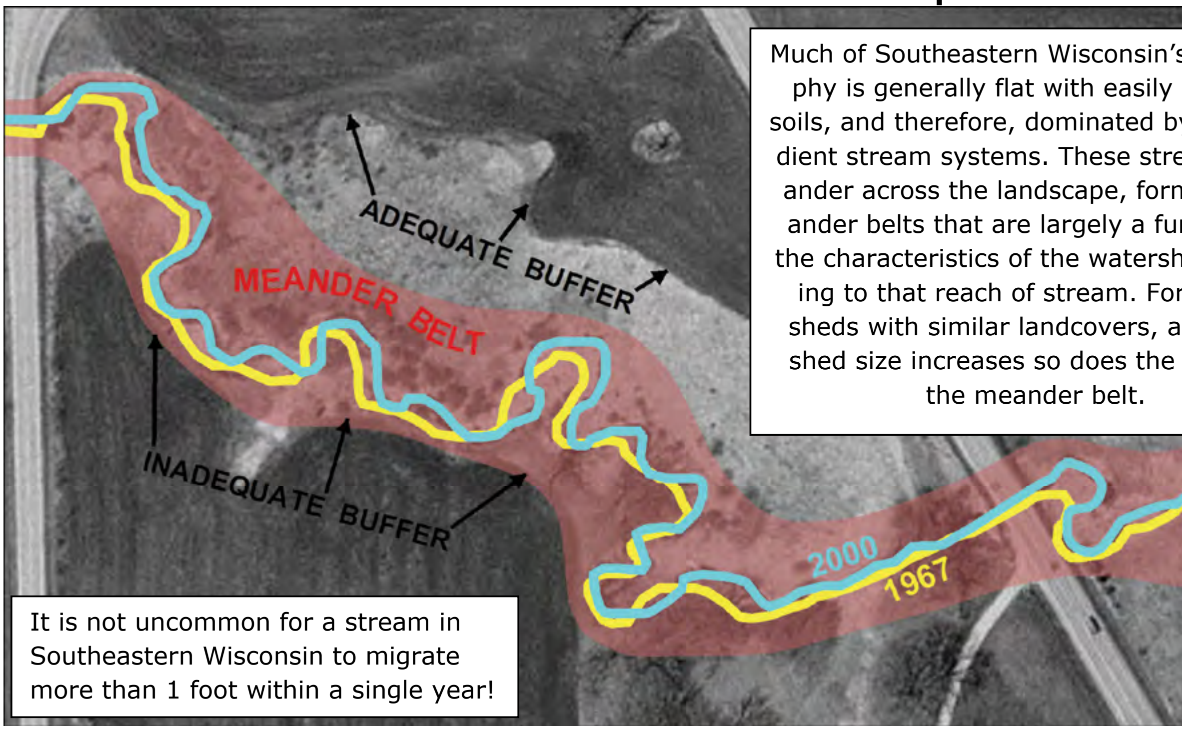
- Meandered stream
- Reconnected floodplain
- Wetland diversity added
- Native species restored

How wide should the buffer be? Unfortunately, there is no one-size-fits all buffer width adequate to protect water quality, wildlife habitat, and human needs. Therefore, the answer to this question depends upon the predetermined needs of the landowner and community objectives or goals.
As riparian corridors become very wide, their pollutant removal (buffering) effectiveness may reach a point of diminishing returns compared to the investment involved. However, the prospects for species diversity in the corridor keep increasing with buffer width. For a number of reasons, 400- to 800-foot-wide buffers are not practical along all lakes, streams, and wetlands within Southeastern Wisconsin. Therefore, communities should develop guidelines that remain flexible to site-specific needs to achieve the most benefits for water resources and wildlife as is practical.

Key considerations to better buffers/corridors:

- Wider buffers are better than narrow buffers for water quality and wildlife functions
- Continuous corridors are better than fragmented corridors for wildlife
- Natural linkages should be maintained or restored
- Linkages should not stop at political boundaries
- Two or more corridor linkages are better than one
- Structurally diverse corridors (e.g., diverse plant structure or community types, upland and wetland complexes, soil types, topography, and surficial geology) are better than corridors with simple structures
- Both local and regional spatial and temporal scales should be considered in establishing buffers
- Corridors should be located along dispersal and migration routes
- Corridors should be located and expanded around rare, threatened, or endangered species
- Quality habitat should be provided in a buffer whenever possible
- Disturbance (e.g. excavation or clear cutting vegetation) of corridors should be minimized during adjacent land use development
- Native species diversity should be promoted through plantings and active management
- Non-native species invasions should be actively managed by applying practices to preserve native species
- Fragmentation of corridors should be reduced by limiting the number of crossings of a creek or river where appropriate
- Restoration or rehabilitation of hydrological function, streambank stability, instream habitat, and/or floodplain connectivity should be considered within corridors.
- Restoration or retrofitting of road and railway crossings promotes passage of aquatic organisms

Creeks and Rivers Need to Roam Across the Landscape



Much of Southeastern Wisconsin's topography is generally flat with easily erodible soils, and therefore, dominated by low gradient stream systems. These streams meander across the landscape, forming meander belts that are largely a function of the characteristics of the watershed draining to that reach of stream. For watersheds with similar landcovers, as watershed size increases so does the width of the meander belt.

It is not uncommon for a stream in Southeastern Wisconsin to migrate more than 1 foot within a single year!

Healthy streams naturally meander or migrate across a landscape over time. Streams are transport systems for water and sediment and are continually eroding and depositing sediments, which causes the stream to migrate. When the amount of sediment load coming into a stream is equal to what is being transported downstream—and stream widths, depths, and length remain consistent over time—it is common to refer to that stream as being in a state of **"dynamic equilibrium."** In other words the stream retains its physical dimensions (equilibrium), but those physical features are shifted, or migrate, over time (dynamic).

Room to Roam

Riparian buffer widths should take into account the amount of area that a stream needs to be able to self-adjust and maintain itself in a state of dynamic equilibrium. … These are generally greater than any minimum width needed to protect for pollutant removal alone.

Streams are highly sensitive, and they respond to changes in the amounts of water and sediment draining to them, which are affected by changing land use conditions. For example, streams can respond to increased discharges of water by increased scour (erosion) of bed and banks that leads to an increase in stream width and depth—or "degradation." Conversely, streams can respond to increased sedimentation (deposition) that leads to a decrease in channel width and depth—or "aggradation."

Why Should You Care About Buffers?

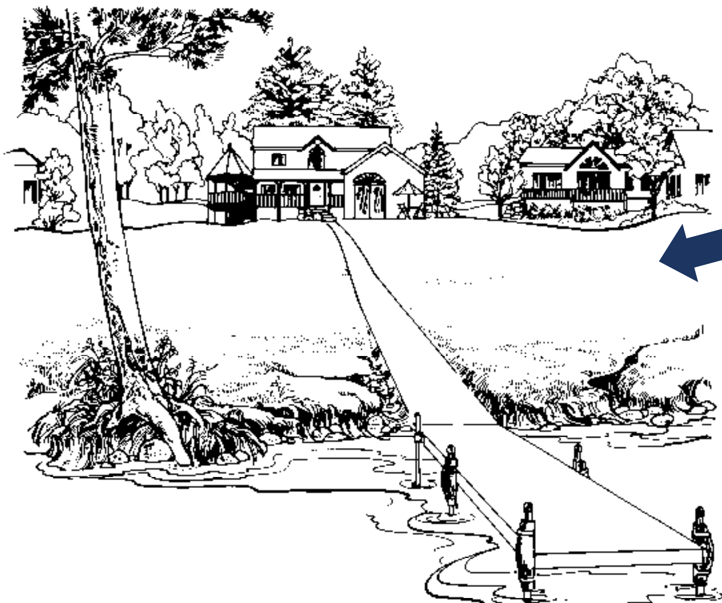
Economic Benefits:
- Increased value of riparian property
- Reduced lawn mowing time and expense
- Increased shade to reduce building cooling costs
- Natural flood mitigation protection for structures or crops
- Pollution mitigation (reduced nutrient and contaminant loading)
- Increased infiltration and groundwater recharge
- Prevented loss of property (land or structures) through erosion
- Greater human and ecological health through biodiversity

Recreational Benefits:
- Increased quality of the canoeing/kayaking experience
- Improved fishing and hunting quality by improving habitat
- Improved bird watching/wildlife viewing quality and opportunities
- Increased potential for expansion of trails for hiking and bicycling
- Opportunities made available for youth and others to locally reconnect with nature

Riparian buffers make sense and are profitable monetarily, recreationally, and aesthetically!

Social Benefits:
- Increased privacy
- Educational opportunities for outdoor awareness
- Improved quality of life at home and work
- Preserved open space/balanced character of a community
- Focal point for community pride and group activities
- Visual diversity
- Noise reduction

A Matter of Balance



University of Wisconsin—Extension

Although neatly trimmed grass lawns are popular, these offer limited benefits for water quality or wildlife habitat. A single house near a waterbody may not seem like a "big deal," but the cumulative effects of many houses can negatively impact streams, lakes, and wetlands.

All the lands within Southeastern Wisconsin ultimately flow into either the Mississippi River or the Great Lakes systems. The cumulative effects of agriculture and urban development in the absence of mitigative measures, ultimately affects water quality in those systems. Much of this development causes increases in water runoff from the land into wetlands, ponds, and streams. This runoff transports water, sediments, nutrients, and other pollutants into our waterways that can lead to a number of problems, including flooding that can cause crop loss or building damage; unsightly and/or toxic algae blooms; increased turbidity; damage to aquatic organisms from reduced dissolved oxygen, lethal temperatures, and/or concentrations of pollutants; and loss of habitat.

Riparian buffers are one of the most effective tools available for defending our waterways. Riparian buffers can be best thought of as forming a living, self-sustainable protective shield. This shield protects investments in the land and all things on it as well as our quality of life locally, regionally, and, ultimately, nationally. Combined with stormwater management, environmentally friendly yard care, effective wastewater treatment, conservation farming methods, and appropriate use of fertilizers and other agrichemicals, **riparian buffers complete the set of actions that we can take to minimize impacts to our shared water resources.**

Lakeshore buffers can take many forms, which require a balancing act between lake viewing, access, and scenic beauty. Lakeshore buffers can be integrated into a landscaping design that complements both the structural development and a lakeside lifestyle. Judicious placement of access ways and shoreline protection structures, and preservation or reestablishment of native vegetation, can enhance and sustain our use of the environment.

University of Wisconsin—Extension

Case Study—Agricultural Buffers

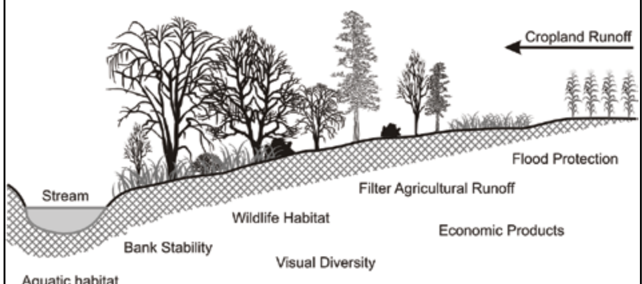
Agricultural nonpoint source pollution runoff continues to pose a threat to water quality and aquatic ecosystems within Wisconsin and elsewhere. In an effort to address this problem, the Wisconsin Buffer Initiative was formed with the goal of designing a buffer implementation program to achieve science-based, cost-effective, water quality improvements (report available online at www.soils.wisc.edu/extension/nonpoint/wbi.php).

While it is true that riparian buffers alone may not always be able to reduce nutrient and sediment loading from agricultural lands, WBI researchers found that “…***riparian buffers are capable of reducing large percentages of the phosphorus and sediment that are currently being carried by Wisconsin streams. Even in watersheds with extremely high loads (top 10%), an average of about 70% of the sediment and phosphorus can be reduced through buffer implementation***.” (*Diebel, M.J. and others, 2009, Landscape planning for agricultural nonpoint source pollution reduction III: Assessing Phosphorus and sediment reduction potential, Environmental Management, 43:69-83.*).

Challenge:
Buffers may take land out of cultivated crop production and require additional cost to install and maintain. Cost sharing, paid easements, and purchase of easements or development rights may sometimes be available to offset costs.
Benefits:
Buffers may offset costs by producing perennial crops such as hay, lumber, fiber, nuts, fruits, and berries. In addition, they provide visual diversity on the landscape, help maintain long-term crop productivity, and help support healthier fish populations for local enjoyment.

Federal and state natural resource agencies have long recognized the need to apply a wide range of Best Management Practices on agricultural lands to improve stream water quality. Although there are many tools available in the toolbox to reduce pollutant runoff from agricultural lands, such as crop rotations, nutrient and manure management, conservation tillage, and contour plowing, riparian buffers are one of the most effective tools to accomplish this task. Their multiple benefits and inter-connectedness from upstream to downstream make riparian buffers a choice with watershed-wide benefits.

Determine what benefits are needed.



The USDA in *Agroforestry Notes* (AF Note-4, January 1997) outlines a four step process for designing riparian buffers for Agricultural lands:

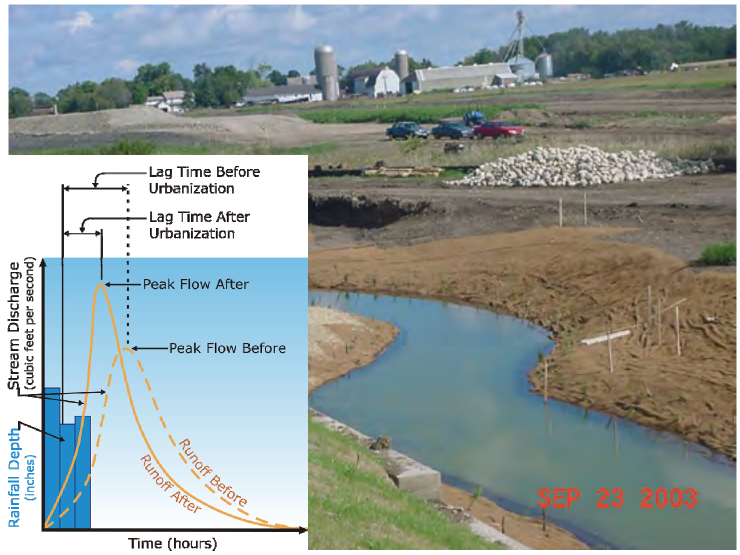
1-Determine what buffers functions are needed
2-Identify the best types of vegetation to provide the needed benefits
3-Determine the minimum acceptable buffer width to achieve desired benefits
4-Develop an installation and maintenance plan

Drain tiles can bypass infiltration and filtration of pollutants by providing a direct pathway to the water and “around” a buffer. This is important to consider in design of a buffer system which integrates with other agricultural practices.

Case Study—Urbanizing Area Buffers

When development occurs near a waterbody, the area in driveways, rooftops, sidewalks, and lawns increases, while native plants and undisturbed soils decrease. As a result, the ability of the shoreland area to perform its natural functions (flood control, pollutant removal, wildlife habitat, and aesthetic beauty) is decreased. In the absence of mitigating measures, one the consequences of urban development is an increase in the amount of stormwater, which runs off the land instead of infiltrating into the ground. Therefore, **urbanization impacts the watershed, not only by reducing groundwater recharge, but also by changing stream hydrology** through increased stormwater runoff volumes and peak flows. This means less water is available to sustain the baseflow regime. The urban environment also contains increased numbers of pollutants and generates greater pollutant concentrations and loads than any other land use. This reflects the higher density of the human population and associated activities, which demand measures to protect the urban water system.

Mitigation of urban impacts may be as simple as not mowing along a stream corridor or changing land management and yard care practices, or as complex as changing zoning ordinances or widening riparian corridors through buyouts.

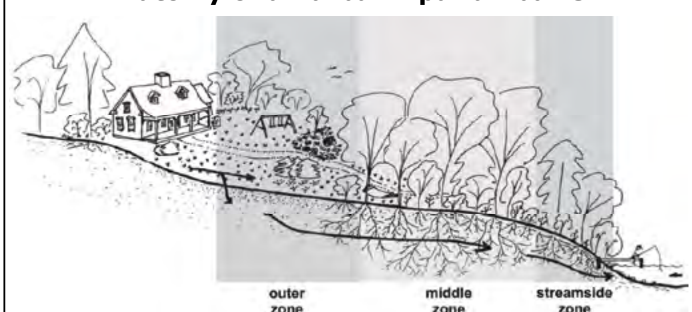


Comparison of hydrographs before and after urbanization. Note the rapid runoff and greater peak streamflow tied to watershed development. (Adapted from Federal Interagency Stream Restoration Working Group (FISRWG), Stream Corridor Restoration: Principles, Processes, and Practices, October 1998)

Challenge:
Urban development requires balancing flood protection, water quality protection, and the economic viability of the development.

Opportunities:
Buffers may offset costs by providing adequate space for providing long-term water quantity and water quality protection. In addition, they provide visual diversity on the landscape, wildlife habitat and connectedness, and help maintain property values.

Anatomy of an urban riparian buffer



The most effective urban buffers have three zones:

Outer Zone-Transition area between the intact buffer and nearest permanent structure to capture sediment and absorb runoff.

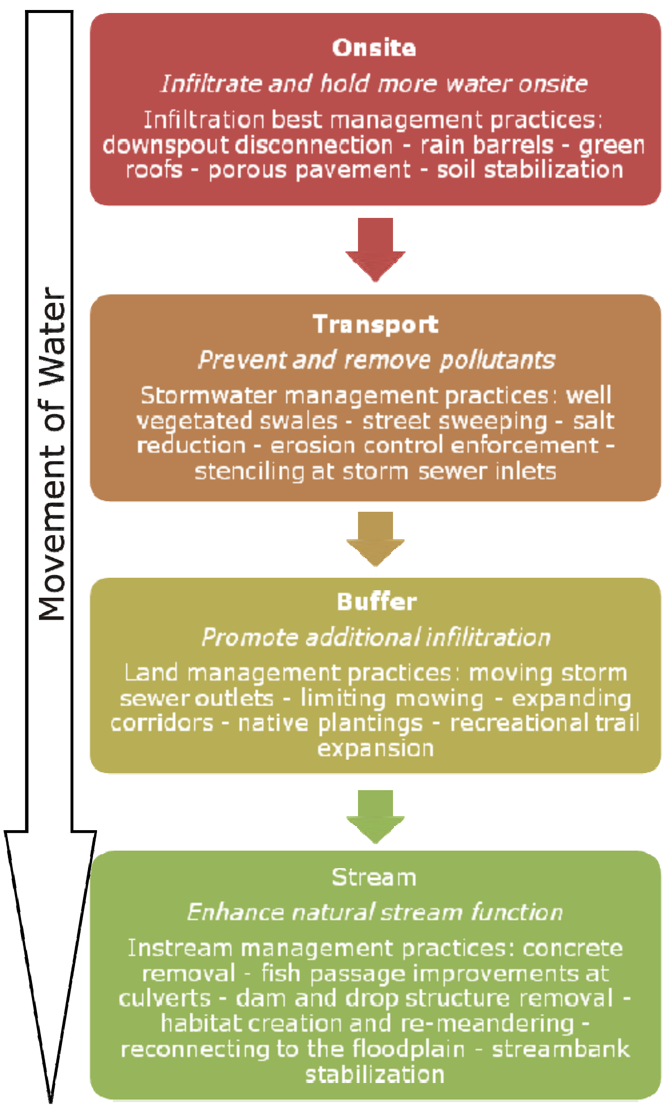
Middle Zone-Area from top of bank to edge of lawn that is composed of natural vegetation that provides wildlife habitat as well as improved filtration and infiltration of pollutants.

Streamside Zone-Area from the water’s edge to the top of the bank or uplands that provides critical connection between water, wetland, and upland habitats for wildlife as well as protect streams from bank erosion

(Fact sheet No. 6 Urban Buffer in the series Riparian Buffers for Northern New Jersey)

Case Study—Urban Buffers

Placement of riparian buffers in established urban areas is a challenge that requires new and innovative approaches. In these areas, historical development along water courses limits options and requires balancing flood management protection versus water quality and environmental protection needs. Consequently, some municipalities have begun to recognize the connections between these objectives and are introducing programs to remove flood-prone structures and culverts from the stream corridors and allow recreation of the stream, restoring floodplains, and improving both the quality of life and the environment.



In urban settings it may be necessary to limit pollution and water runoff before it reaches the buffer.

Challenge:
There are many potential constraints to establishing, expanding, and/or managing riparian buffers within an urban landscape. Two major constraints to establishment of urban buffers include:

1) **Limited or confined space to establish buffers** due to encroachment by structures such as buildings, roadways, and/or sewer infrastructure;

2) **Fragmentation of the landscape** by road and railway crossings of creeks and rivers that disrupt the linear connectedness of buffers, limiting their ability to provide quality wildlife habitat.

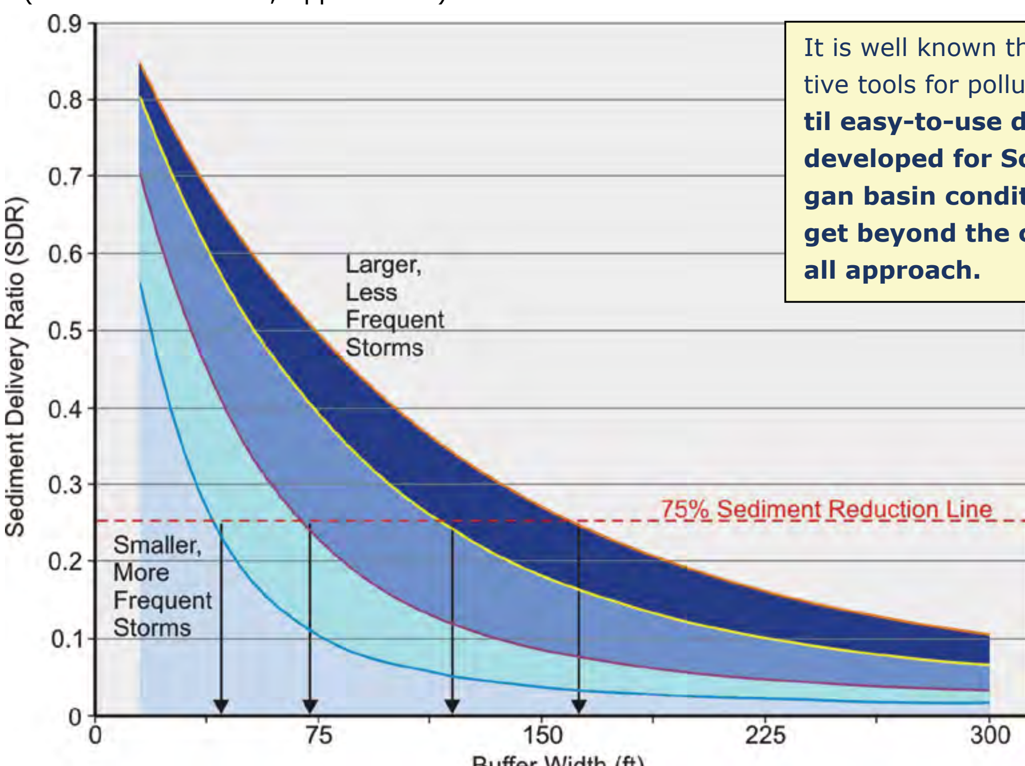
Much traditional stormwater infrastructure intercepts runoff and diverts it directly into creeks and rivers, bypassing any benefits of buffers to infiltrate or filter pollutants. This is important to consider in design of a buffer system for urban waterways, which begin in yards, curbsides, and construction sites, that are figuratively as close to streams as the nearest storm sewer inlet.

A Buffer Design Tool

Design aids are needed to help municipalities, property owners, and others take the "guesswork" out of determining adequate buffer widths for the purpose of water resource quality protection. While there are various complex mathematical models that can be used to estimate sediment and nutrient removal efficiencies, they are not easily applied by the people who need them including homeowners, farmers, businesses and developers.

To fill this gap, design aid tools are being developed using factors such as slope, soils, field length, incoming pollutant concentrations, and vegetation to allow the user to identify and test realistic buffer widths with respect to the desired percent pollutant load reduction and storm characteristics. By developing a set of relationships among factors that determine buffer effectiveness, the width of buffer needed to meet specific goals can be identified.

In the example below, 50-foot-wide buffers are necessary to achieve 75 % sediment removal during small, low intensity storms, while buffers more than 150 feet wide are necessary to achieve the same sediment reduction during more severe storms. Based on this information, decision-makers have the option of fitting a desired level of sediment removal into the context of their specific conditions. Under most conditions, a 75-foot width will provide a minimum level of protection for a variety of needs (SEWRPC PR No. 50, Appendix O.)



It is well known that buffers are effective tools for pollutant removal, but **until easy-to-use design aid tools are developed for Southern Lake Michigan basin conditions, we can never get beyond the current one size fits all approach.**

This generalized graph depicts an example of model output for an optimal buffer width to achieve a 75% sediment reduction for a range of soil and slope, vegetation, and storm conditions characteristic of North Carolina. *(Adapted from Muñoz-Carpena R., Parsons J.E.. 2005. VFSMOD-W: Vegetative Filter Strips Hydrology and Sediment Transport Modeling System v.2.x. Homestead, FL: University of Florida. carpena.ifas.ufl.edu/vfsmod/citations.shtml)*

Buffers Are A Good Defense

> ***"Riparian ecosystems are naturally resilient,*** *provide linear habitat connectivity, link aquatic and terrestrial ecosystems, and create thermal refugia for wildlife: all characteristics that can contribute to ecological adaptation to climate change."*
>
> *(N. E. Seavy and others, Why Climate Change Makes Riparian Restoration More Important Than Ever: Recommendations for Practice and Research, 2009, Ecological Restoration 27(3):330-338)*

Today's natural resources are under threat. These threats are immediate as in the case of chemical accidents or manure spills, and chronic as in the case of stormwater pollution carrying everything from eroded soil, to fertilizer nutrients, to millions of drips from automobiles and other sources across the landscape. Non-native species have invaded, and continue to invade, key ecosystems and have caused the loss of native species and degradation of their habitats to the detriment of our use of important resources.

A more subtle, but growing, concern is the case of stresses on the environment resulting from climate change. Buffers present an opportunity for natural systems to adapt to such changes by providing the space to implement protective measures while also serving human needs. **Because riparian buffers maintain an important part of the landscape in a natural condition, they offer opportunities for communities to adjust to our changing world.**

Well-managed riparian buffers are a good defense against these threats. In combination with environmental corridors, buffers maintain a sustainable reserve and diversity of habitats, plant and animal populations, and genetic diversity of organisms, all of which contribute to the long-term preservation of the landscape. Where they are of sufficient size and connectivity, riparian buffers act as reservoirs of resources that resist the changes that could lead to loss of species.

Refuge or protection from increased water temperatures as provided by natural buffers is important for the preservation of native cold-water, cool-water, and warm-water fishes and their associated communities.

Buffers Provide Opportunities

River, lake, and wetland systems and their associated riparian lands form an important element of the natural resource base, create opportunities for recreation, and contribute to attractive and well-balanced communities. These resources can provide an essential avenue for relief of stress among the population and improve quality of life in both urban and rural areas. Such uses also sustain industries associated with outfitting and supporting recreational and other uses of the natural environment, providing economic opportunities. Increasing access and assuring safe use of these areas enhances public awareness and commitment to natural resources. Research has shown that property values are higher adjoining riparian corridors, and that such natural features are among the most appreciated and well-supported parts of the landscape for protection.

We demand a lot from our riparian buffers!

Sustaining this range of uses requires our commitment to protect and maintain them.

Managing the Water's Edge

Summary

The following guidance suggestions highlight key points to improve riparian corridor management and create a more sustainable environment.

Riparian corridors or buffers along our waters may contain varied features, but all are best preserved or designed to perform multiple important functions.

Care about buffers because of their many benefits. Riparian buffers make sense and are profitable monetarily, recreationally, aesthetically, as well as environmentally.

Enhance the environmental corridor concept. Environmental corridors are special resources which deserve protection. They serve many key riparian corridor functions, but in some cases, could also benefit from additional buffering.

Avoid habitat fragmentation of riparian corridors. It is important to preserve and link key resource areas, making natural connections and avoiding habitat gaps.

Employ the adage "wider is better" for buffer protection. While relatively narrow riparian buffers may be effective as filters for certain pollutants, that water quality function along with infiltration of precipitation and runoff and the provision of habitat for a host of species will be improved by expanding buffer width where feasible.

Allow creeks and rivers room to roam across the landscape. Streams are dynamic and should be buffered adequately to allow for natural movement over time while avoiding problems associated with such movement.

Consider and evaluate buffers as a matter of balance. Riparian buffers are a living, self-sustainable shield that can help balance active use of water and adjoining resources with environmental protection.

Agricultural buffers can provide many benefits. Riparian buffers in agricultural settings generally work well, are cost-effective, and can provide multiple benefits, including possibly serving as areas to raise certain crops.

Urban buffers should be preserved and properly managed. Though often space-constrained and fragmented, urban buffers are important remnants of the natural system. Opportunities to establish or expand buffers should be considered, where feasible, complemented by good stormwater management, landscaping, and local ordinances, including erosion controls.

A buffer design tool is needed and should be developed. Southeastern Wisconsin and the Southern Lake Michigan Basin would benefit from development of a specific design tool to address the water quality function of buffers. Such a tool would improve on the currently available general guidance on dimensions and species composition.

Buffers are a good defense. Combined with environmental corridors, riparian buffers offer a good line of defense against changes which can negatively impact natural resources and the landscape.

Managing the Water's Edge

MORE TO COME

Future editions in a riparian buffer planning series are being explored with the intent of focusing on key elements of this critical land and water interface. Topics may include:

- Information sharing and development of ordinances to integrate riparian buffers into existing land management plans and programs
- Integration of stormwater management practices and riparian buffer best management practices
- Application of buffers within highly constrained urban corridors with and without brownfield development
- Installation of buffers within rural or agricultural lands being converted to urban uses
- Utilization of buffers in agricultural areas and associated drainage systems
- Integration of riparian buffers into environmental corridors to support resources preservation, recreation and aesthetic uses
- Preservation of stream courses and drainageways to minimize maintenance and promote protection of infrastructure
- Guidance for retrofitting, replacement, or removal of infrastructure such as dams and road crossings, to balance transportation, recreation, aesthetic, property value, and environmental considerations.
- Protection of groundwater recharge and discharge areas
- Protection of high quality, sensitive coastal areas, including preservation of recreational potential

MORE INFORMATION

This booklet can be found at http://www.sewrpc.org/RBMG-no1 . Please visit the website for more information, periodic updates, and a list of complementary publications.

* * *

W239 N1812 Rockwood Drive, Waukesha, WI, 53187-1607
262-547-6721.

Staff Acknowledgements:

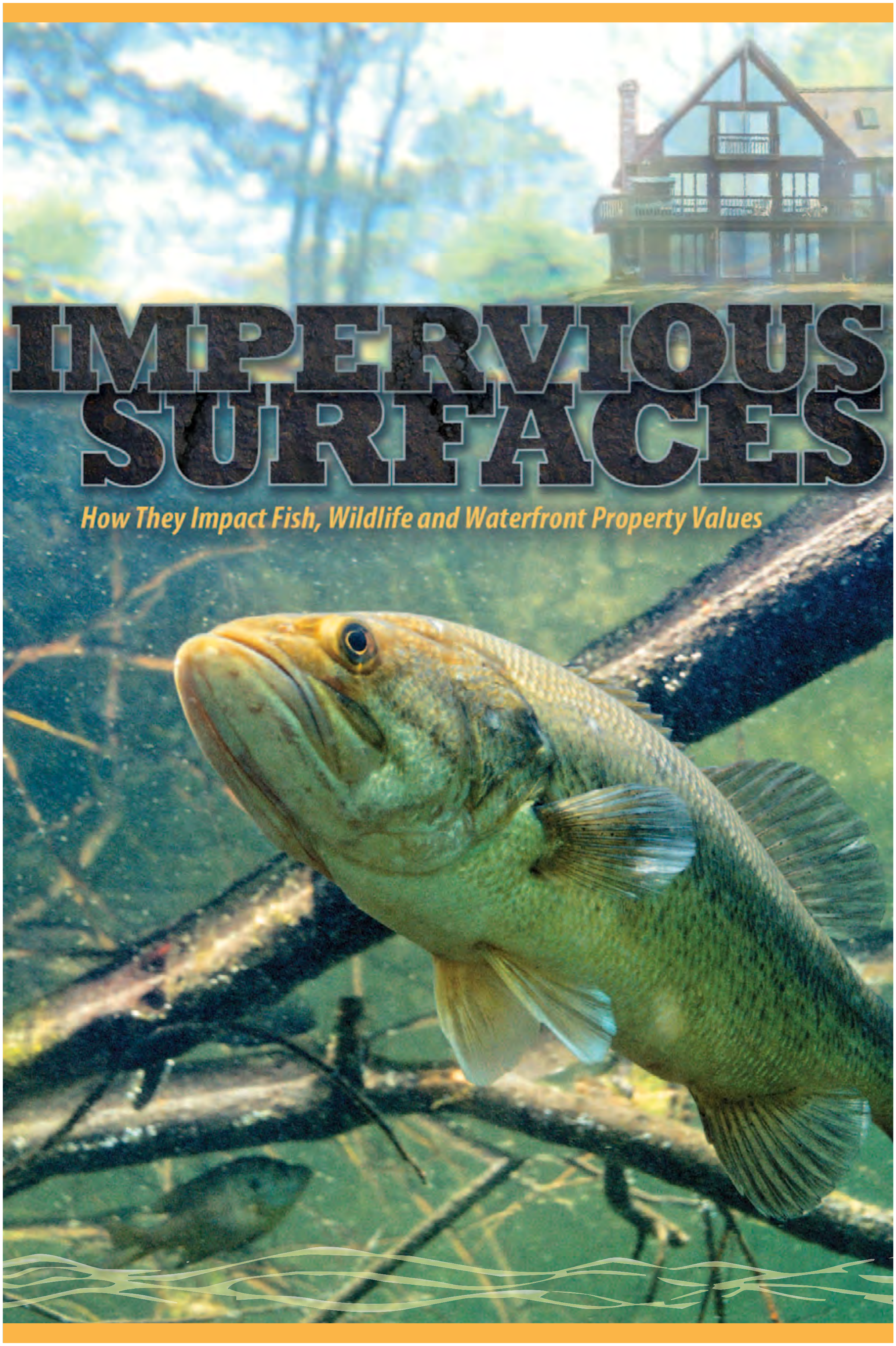
Principal Author: Tom Slawski, PhD, Principal Planner

Michael Hahn, P.E., P.H., Chief Environmental Engineer
Laura Kletti, P.E., Principal Engineer
Gary Korb, Regional Planning Educator, UW-Extension/SEWRPC
Ed Schmidt, GIS Planning Specialist
Mike Scott, GIS Application Specialist
Sara Teske, Research Analyst
Jeff Thornton, PhD, Principal Planner

www.sewrpc.org

May 7, 2010

IMPERVIOUS SURFACES
APPENDIX C


IMPERVIOUS SURFACES
How They Impact Fish, Wildlife and Waterfront Property Values

Healthy lakes, rivers and streams are truly the basis for creating fond memories of time spent near the water, like walleye fishing on a crisp fall morning, swimming with the kids in the afternoon, and entertaining friends on the evening shoreline. Healthy fish, abundant wildlife, and clear, clean water all depend on the individual decisions that we make about our waterfront properties.

Photo by Jesse Kloempken

When we develop waterfront lots, trees and native plants are replaced by impervious (hard) surfaces. Driveways, rooftops, and other hard surfaces decrease the ability of the shoreland area to serve its natural functions. Removing trees and native plants eliminates the food sources and shelter on which wildlife depend. Water can no longer soak into the ground, which increases stormwater runoff that carries pollutants to lakes and streams. Fish eggs die when they are covered in a blanket of silt from runoff and erosion. A decline in water quality often lowers property values and our enjoyment of lakes.

Although the effects of one lot's development may not result in a measurable change in the water quality of a lake or stream, the cumulative effects of many developed lots can be substantial.

Photo by Robert Korth

How do impervious surfaces IMPACT lakes and streams?

This publication was developed for waterfront property owners and local officials to help answer this question. It does not discuss all of the potential impacts of impervious surfaces; rather, it primarily focuses on impacts to:

1. **Waterfront property values**
2. **Fishing**
3. **Wildlife**

The decisions we make as individual landowners, whether small renovations or new development plans, have an additive effect on our waterbodies and the fish and wildlife that call these places home. For this reason, each and every property owner has a unique opportunity to help protect our lakes and streams.

For how-to information about minimizing impervious surfaces and their impacts, take a look at the publications described on page 9. Every property owner has a unique opportunity to help protect our lakes and streams.

What are impervious surfaces and how do they affect our waters?

Virtually any form of shoreland development leads to more impervious surfaces. Impervious surfaces are hard, man-made surfaces such as rooftops, driveways, parking areas, and patios that change the fate of precipitation – instead of soaking into the ground and being naturally filtered, water runs downhill directly into our lakes and streams.

Runoff from impervious surfaces washes pollutants such as sediments, nutrients, bacteria, car fluids and other chemicals into our lakes and streams. Runoff and the erosion it causes can be a serious problem for both the property owner and the lake. Gullies or large eroded channels are unsightly and may result in loss of land when soil is carried to the lake.

***SHORELAND ZONING** is in place to protect our lakes and rivers. Wisconsin Administrative Code NR 115 provides minimum standards for shoreland zoning. Many counties have chosen to adopt more protective standards. See your county zoning office for more information.*

Photos by Jeffrey Strobel

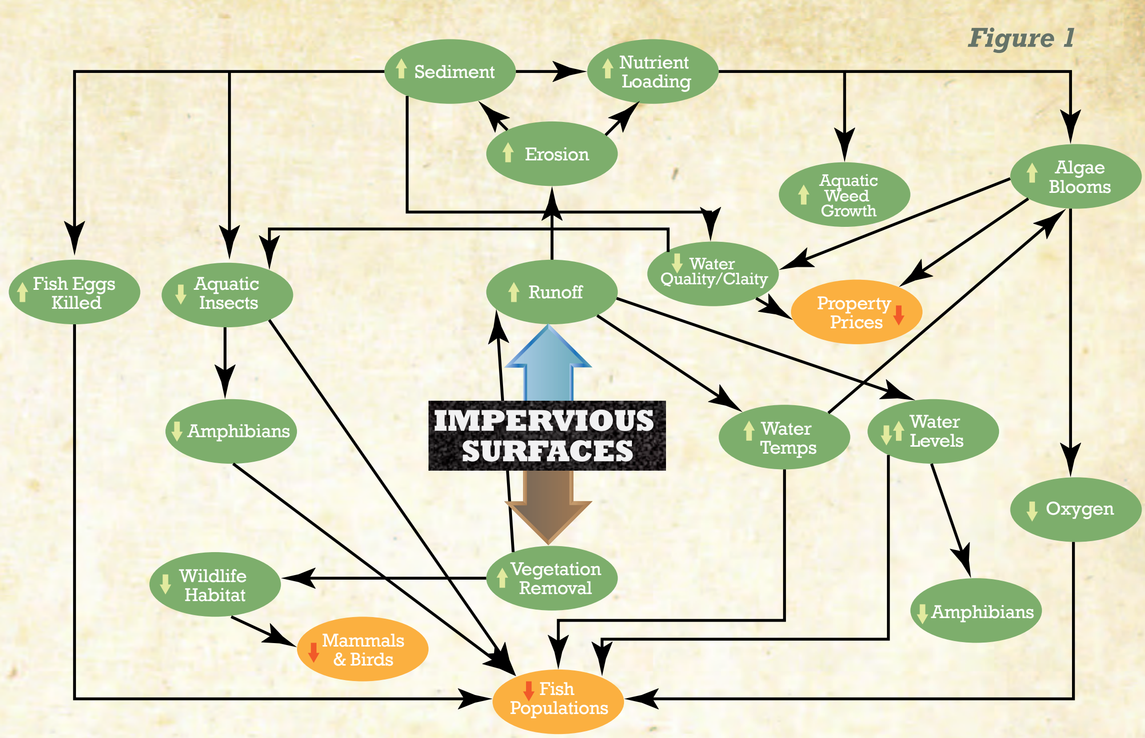


Figure 1: Impervious surfaces can cause a variety of negative impacts to lake and stream ecosystems. The orange ovals in this diagram indicate the three areas of impact that are discussed in this publication. The diagram illustrates how they are intricately connected to lake health. *For a comprehensive overview of how impervious surfaces affect waterbodies, see *Impacts of Impervious Cover on Aquatic Systems* from the Center for Watershed Protection.[1]

3 REASONS TO MINIMIZE IMPERVIOUS SURFACES

1 Waterfront Property Values

We are drawn to shoreland properties for a variety of reasons. Some of us enjoy playing in the water on a hot afternoon in July, while others enjoy ice fishing during the frost-nipping cold of January.

Often, people choose to purchase a waterfront property based on how they plan to enjoy the water – be it for enjoying the peaceful, natural setting or the abundant fishing, swimming, or boating opportunities. In fact, a UW-Extension survey found that enjoyment of peace and quiet, natural beauty, and hunting and fishing opportunities were the top three reasons people enjoyed lakes.[2]

Minimizing the presence of impervious surfaces in the shoreland area can help to ensure that many of these qualities we care about are preserved, helping to protect property investments.

While many opinions exist over what the perfect shoreline looks like, most of us agree that clear water is desirable. Studies have found that the market value of a waterfront property can decrease if the lake has cloudy or murky water.[3] Water clarity can be influenced by the presence of impervious surfaces in two ways. First, runoff increases erosion resulting in more soil being washed into the water, making it cloudy. Second, runoff from impervious surfaces carries additional phosphorus to the water. An unfertilized, developed waterfront lot that has 20% impervious surface carries six times more phosphorus to the lake than an undeveloped lot of the same size (see **Figure 2**). This additional phosphorus can fuel algae growth in our waters, which lowers water clarity and overall aesthetic appeal.

A recent study that tracked over 1,000 waterfront property sales in Minnesota found that when all other factors remained equal, properties on lakes with clearer water commanded significantly higher prices.[3] A similar study conducted in Maine found that changes in water clarity of three feet can change lakefront property prices by as much as $200 per frontage foot.[4] This means that a three-foot increase in water clarity could increase the property value by as much as $20,000 on a lot with 100 feet of water frontage. Perhaps more important, an identical decrease in water clarity would decrease property values by significantly more than $20,000.[4]

Is gravel considered impervious?

A common question is whether gravel driveways or walkways are considered impervious surfaces. Noncompacted gravel "mulch," such as that used as landscaping material, is generally not considered impervious. On the other hand, gravel used for driveways, parking lots, or other high-use surfaces becomes compacted. **After compaction, gravel driveways and parking areas will create runoff even during minor rain events.** If gravel is used, it should be free of clay and other fine particles to help prevent compaction and "clogging" of spaces between gravel particles.[5] Half-inch or ¾-inch "clear" crushed rock is a good choice for this application. "Clear" indicates that the gravel is virtually free of fine particles.

Figure 2

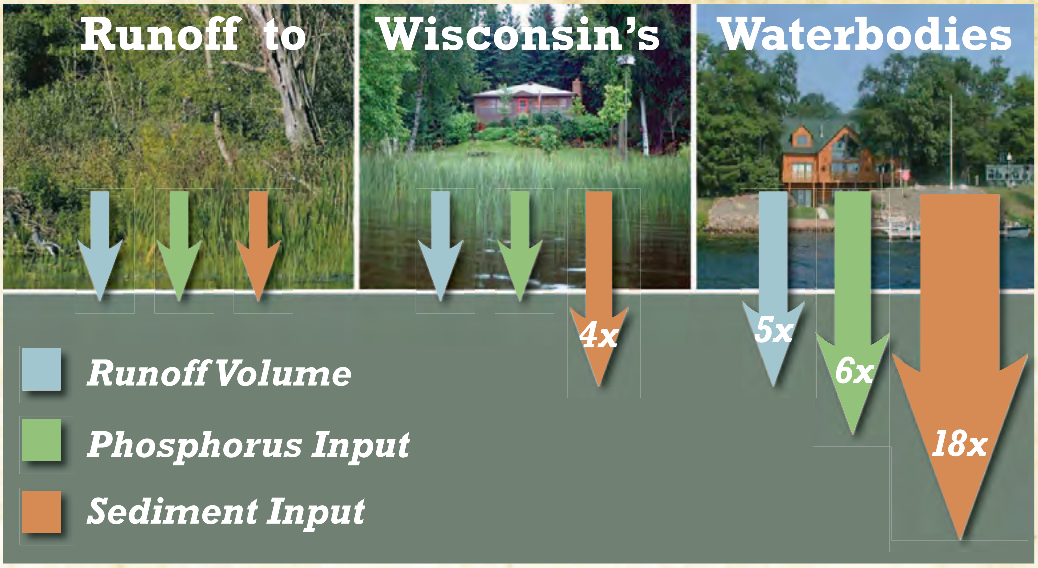


Figure 2: The far left picture indicates a half-acre undeveloped shoreland lot that causes minimal runoff, phosphorus and sediment inputs to the lake. The middle picture portrays a typical 1940s shoreland development with approximately 8% of its area covered by impervious surfaces. The picture to the right shows a shoreland lot with approximately 20% of its area covered by impervious surfaces. Notice how sediment inputs drastically increase as impervious surface coverage increases.[6]

2 Fishing

Fishing gives us a chance to sit back, relax and visit with friends and family while waiting for the familiar tug of an unseen fish on our line. Many of Wisconsin's lakes and rivers are prime designations for those in search of walleye, bass, musky or crappie, But runoff that carries sediments, nutrients and other pollutants into lakes and streams leads to decreased populations of many of these fish.

This is largely because:

- **More nutrients** result in less oxygen in the water, which fish need to survive
- **More sediments** and algae growth make it difficult for some predator species that hunt by sight to find their food

  More sediments cover spawning beds of fish such as smallmouth bass, walleye, and crappie, potentially inhibiting reproduction.[7]

Streams are particularly sensitive to the effects of impervious surfaces because of increased potential for flooding during rainstorms. In addition, impervious surfaces reduce groundwater recharge causing lower water levels in streams during dry periods when stream flow comes from groundwater. Fluctuating water levels can degrade fish and amphibian habitat.[1] Another significant impact to streams is warm runoff coming from hot pavement and rooftops during warmer months. This increases stream temperatures, putting stress on fish that require cold water, such as trout.[8]

Figure 3

More Impervious Surfaces in Watershed →

Fish found in streams when impervious surface in the watershed was: Less than 8%	8 - 12%	Greater than 12%
Iowa darter Black crappie Channel catfish Yellow perch Rock bass Horneyhead chub Sand shiner Southern redbelly dace		
Golden shiner Northern pike Largemouth bass Bluntnose minnow Johnny darter Common shiner	Golden shiner Northern pike Largemouth bass Bluntnose minnow Johnny darter Common shiner	
Creek chub Fathead minnow Green sunfish White sucker Brook stickleback	Creek chub Fathead minnow Green sunfish White sucker Brook stickleback	Creek chub Fathead minnow Green sunfish White sucker Brook stickleback

Fewer species of fish →

Figure 3: The number of different stream fish species found in streams declines as the effects of impervious surfaces kill off more sensitive species.[9]

Numerous studies on stream watersheds have shown that fish populations decline as impervious surface coverage increases. A study of 47 streams in south-eastern Wisconsin found that when impervious surfaces covered 8-12% of a watershed – the land that drains to the stream – the number of fish species was reduced.[10] In watersheds with impervious surface coverage even slightly above 12%, researchers found that the overall number of fish species plummeted (see **Figure 3**). The same study also indicated that impervious surfaces immediately adjacent to the water, especially within the first 150 feet, had a significant impact on streams.

What can you do to minimize the effects of impervious surfaces?

For more information on particular topics, see numbered resources below:

Minimize hard surfaces like rooftops and driveways on your property

- Share driveways with neighbors where possible
- Use narrow driveways
- Minimize building footprints - build "up" instead of "out"
- Remove unneeded hard surfaces, such as extra parking spots

Use pervious materials where possible

- Green roofs
- Mulch walkways
- Permeable pavers for walkways or driveways 1

Capture or infiltrate runoff

- In rain barrels 1
- In gutters & downspouts 1
- In rain gardens 2

Control erosion during construction and after development 5

Minimize fertilizer use

- Have soil tested first to see if fertilizers are needed, and use as little as possible.

Maintain or restore shoreline plants to slow runoff and provide habitat 3 4

- Maintain or restore at least a 35-foot wide shoreline buffer
- Let nature reestablish the shoreline!

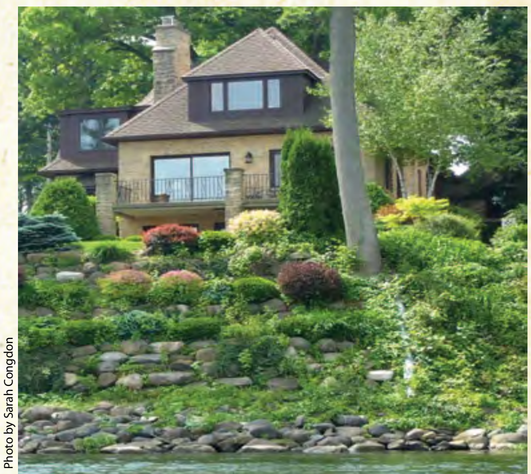
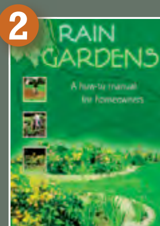


Photo by Sarah Congdon

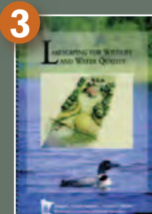
Where to find these excellent resources:

1 

Controlling Runoff and Erosion from Your Waterfront Property: A Guide for Landowners. Available at **www.burnettcounty.com/DocumentView.aspx?DID=119**

2 

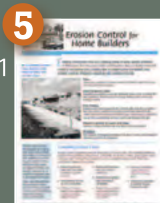
Rain Gardens: A How-To Manual For Homeowners. DNR publication no. WT-776 2003, UW-Extension publication No. GWQ037. Available at **http://learningstore.uwex.edu/assets/pdfs/GWQ037.pdf**

3 

Lakescaping for Wildlife and Water Quality. 176 pages, $19.95, available from the Minnesota Bookstore at 800-657-3757. Wisconsin DNR staff recommend this book as the best detailed planning guide for shoreland restoration projects.

4 

The Shoreland Stewardship Series: Protecting and Restoring Shorelands. Available at **http://clean-water.uwex.edu/pubs/pdf/protect.pdf**

5 

Erosion Control for Home Builders. UW-Extension publication No. GWQ001 and Wisconsin DNR No. WT-457-96. Available at **www.bldgpermit.com/erosion control.pdf**

9

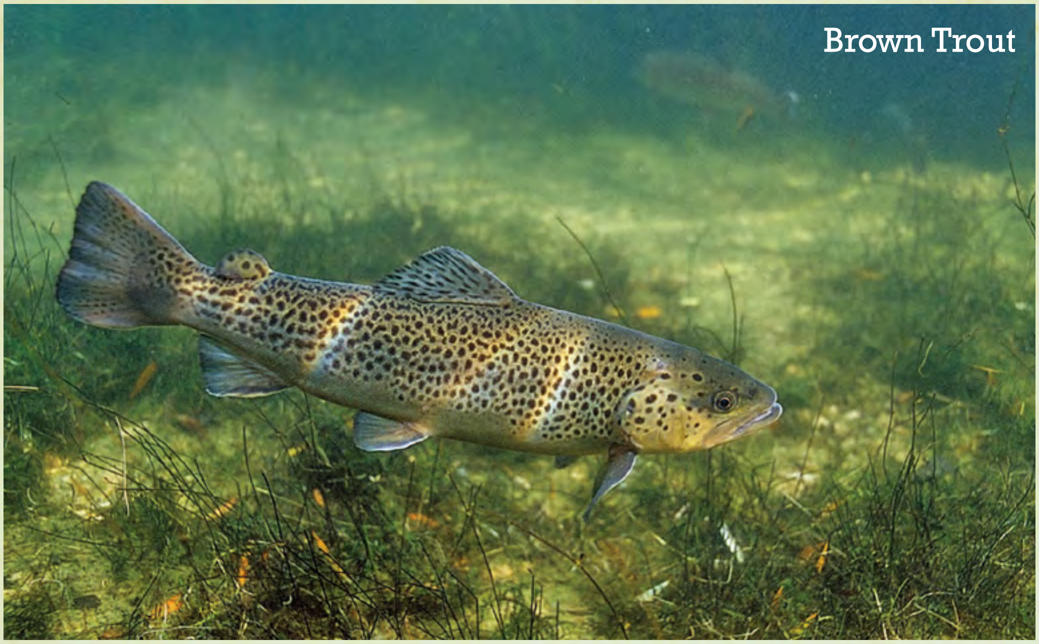


Photo by Eric Engbretson

Brook Trout and Brown Trout

Both brook trout and brown trout are found in many streams in Wisconsin, and require cold, clean water to survive. Both species are sensitive to pollution and low oxygen conditions. A study conducted on 33 coldwater streams in Wisconsin and Minnesota found that when impervious surfaces covered more than 11% of a watershed, trout were eliminated from streams.[8]

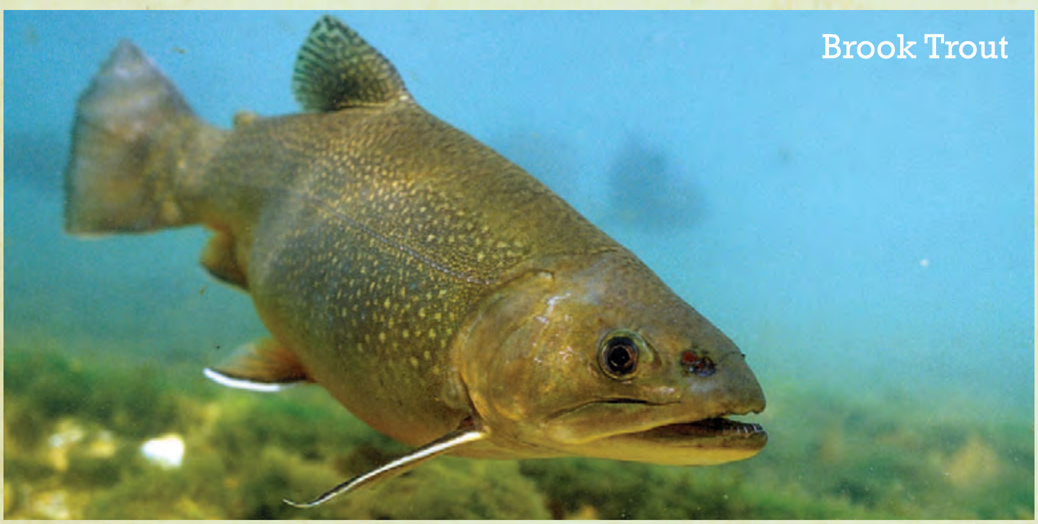


Photo by Eric Engbretson

The brook trout is the only trout species native to Wisconsin's waters. Part of their diet consists of aquatic insects and small fish, whose populations are negatively impacted by increased runoff and sedimentation.

The tendency for more impervious surfaces to lead to fewer fish species in streams also holds true for lakes, though less is known about specific thresholds where fish begin to be impacted. A 2008 study of 164 Wisconsin lakes found that certain fish species tended to be less common in lakes surrounded by high levels of impervious surfaces than in lakes surrounded by minimal impervious surfaces. Some of these species included game fish, like smallmouth bass and rock bass, but also nongame species, such as blackchin shiners, blacknose shiners, and mottled sculpin.[11] Many of the smaller, nongame species serve as vital food sources for game fish such as walleye, smallmouth bass, and northern pike. Increased impervious surfaces, removal of aquatic vegetation, and installation of beaches all contribute to the destruction of near-shore habitat for both larger fish and the smaller prey fish these predators depend on.[12] Fewer food options for game fish will likely lead to lower numbers of game species in the long run.

Walleye

Wisconsin is walleye country. Impervious surfaces can reduce walleye reproduction by causing soil erosion which leads to sedimentation. Although impervious surfaces aren't the only cause of sedimentation, when sediments cover spawning grounds, the spaces between the rocks and gravel become blanketed with silt. This can quickly cause walleye eggs to die because of inadequate water flow and oxygen deprivation.[13, 14] Adult walleyes are often able to cope under these conditions, but harming the success of eggs and embryos puts the survival of a healthy walleye population at risk.[15]

Photo by Eric Engbretson

Walleye typically spawn between mid-April and early May in Wisconsin when spring runoff is highest. Rock- and gravel-covered bottoms are their preferred spawning grounds due to the requirements of their sensitive eggs.

11

3 Wildlife

Whether looking out the front window of a waterfront home or from the bow of a canoe, opportunities to observe shoreland wildlife are abundant. The shoreline is a busy place. Northern pike, bluegills, bass and other fish spawn in the shallow water along the shore. Loons, ducks, geese and other water birds nest along the banks. Wildlife such as frogs, otters and mink live there too. Shoreline areas – on land and into the shallow water – provide essential habitat for fish and wildlife that live in or near Wisconsin's lakes and rivers. Overdeveloped shorelands can't support the fish, wildlife and clean water that are so appealing to the people attracted to the shoreline.[16]

Impervious surfaces can be thought of as biological deserts where animals cannot find food or shelter, making them easy prey. Disturbed open spaces increase wildlife mortality rates and decrease their chances of successfully raising young.

Although it may seem obvious, the creation of impervious surfaces in the shoreland area removes essential habitat for numerous species. Driveways, cemented paths, buildings and other types of impervious surfaces make our shorelands less inviting to wildlife. These areas can be thought of as biological deserts where animals cannot find food or shelter, making them easy prey. Shoreland habitat fragmented by impervious surfaces, mowing, or brushing are generally avoided by wildlife. These disturbed open spaces increase wildlife mortality rates and decrease their chances of successfully raising young.[17]

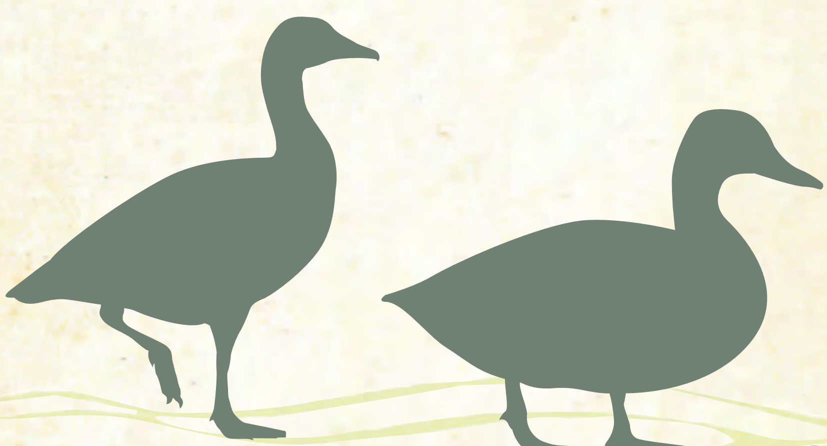
Habitat connectivity is key. Some animals like loons and frogs depend on habitat relatively close to the water. River otters, on the other hand, often choose denning sites in upland areas further from the water's edge.[18] By minimizing how much of the shorelines we develop with impervious surfaces and maintaining habitat connectivity, we maximize the potential for seeing the unique wildlife that so intimately depend on natural shoreland habitats.

In addition, the impact of impervious surfaces on wetlands can pose a risk to waterfowl. Wetlands provide critical breeding and feeding grounds for mallards as well as many other waterfowl species. Increased impervious surfaces can cause water level fluctuations in wetlands due to increased runoff volumes.[19] Rising water levels during the nesting season can make it difficult for ducklings to survive.[20]

Mallard

The familiar raspy "quack" of a mallard is a sound common to Wisconsin's water bodies. When we see mallards dabbling in ponds with a following of ducklings, they are often in search of aquatic insects. During the first two weeks of a mallard duckling's life, its diet is comprised almost exclusively of aquatic insects. The same dietary needs also hold true for many other species of ducks.[21] Research has shown that sedimentation tends to decrease aquatic insect densities.[22] Without an adequate food source, mallards will have to move elsewhere to raise their young.

Photo by Mark Lasnek



13

Replacing impervious surfaces or manicured lawns with a reestablished shoreline vegetated buffer can have a positive impact on wildlife. The same types of plants that provide animals with cover often provide diverse food sources as well, especially for birds.[23] Dead trees (standing or on the ground) provide homes and cover for species such as wood ducks and ruffed grouse.

Wildlife depend on three "layers" of native vegetation along the shore for their habitat: trees, shrubs, and lower-growing wildflowers and grasses. For an introduction to shoreland buffers, see ***The Shoreland Stewardship Series: Protecting & Restoring Shorelands***, available at county UW-Extension offices and at **clean-water.uwex.edu/pubs/pdf/protect.pdf** For greater detail, see the publication *Lakescaping for Wildlife and Water Quality* described on page 9.

Figure 4

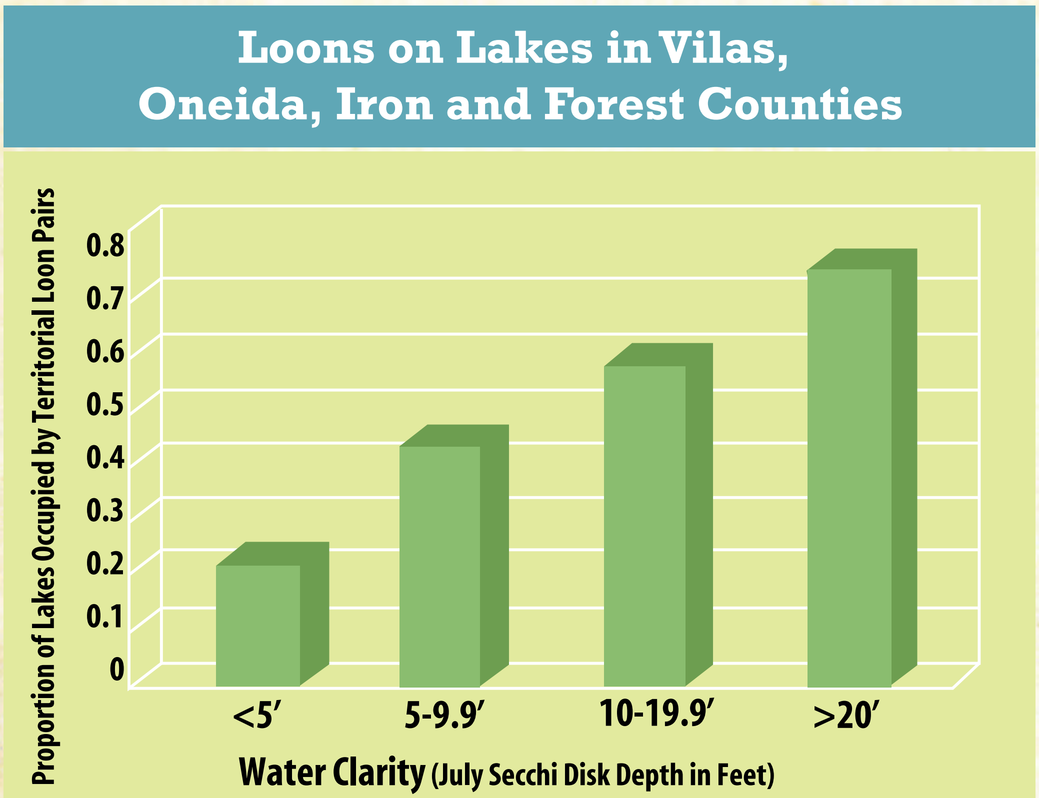


Figure 4: In northern Wisconsin, the number of loon pairs in lakes decreases as water clarity decreases. In southern Wisconsin shoreland development has caused loons to avoid lakes because of poor water quality and habitat degradation.[24]

Common Loon

Common loons, famous for their primeval nighttime "laughter" heard echoing across lakes in Northern Wisconsin evoke a true sense of the Northwoods. Loons have been pushed northward, in part due to the effects of shoreland development.[25] Loons can be impacted by runoff from impervious surfaces that reduces water clarity. Loons search for fish from the water's surface, making clear water key to finding food. Because of this, loon pairs appear to favor lakes with clearer water, as shown by **Figure 4**.[24] Additionally, nest predators like raccoons have been found to be more common on highly developed lakes. A recent study found that raccoons often raid northern Wisconsin loon nests in search of eggs. This naturally decreases the success of loon nests.[26]

Photo by Michele Woodford

Loons nest near the water on either solid ground or floating vegetation and often construct nests out of needles, leaves, or other materials.[25] It's easy to see how vulnerable these nests can be to predators like raccoons.

Photo by John Haack

Conclusion

An undeniable connection exists between the decisions we make about our shoreland properties and the health of Wisconsin's lakes and streams. Each property is part of a bigger picture – a living waterfront of plants, wildlife, fish and people that are all interconnected.

When we establish impervious surfaces on our properties, we decrease the ability of the shorelands to serve their natural functions. Specifically, removing trees and native plants eliminates unique habitat required by the shoreland wildlife we enjoy watching. Increased runoff carries pollutants to our lakes and streams. Fish spawning grounds become unproductive when they are blanketed in silt. Decreased water clarity can also affect us by lowering waterfront property values.

On the other hand, when we leave shorelands in a more natural state, we all can enjoy healthy lakes and streams. Clean water allows our children to safely swim and play along our shorelines. Shoreland habitat and excellent water quality provide us with ample opportunities for memorable fishing trips and entertaining wildlife watching. Let's all do our part to give future generations these same opportunities.

REFERENCES:

1. Center for Watershed Protection. 2003. Impacts of impervious cover on aquatic systems. Watershed Protection Research Monograph No. 1. ***www.mckenziewaterquality.org/documents/ImpactsofImperviousCover-CWPReport.pdf***

2. Korth, Robert, M. Dresen, and D. Snyder. 1994. Lake Tides survey. Wisconsin Lakes Program, University of Wisconsin-Extension, Stevens Point. Volume 19 No. 2. ***www.uwsp.edu/cnr/uwexlakes/laketides/vol19-2_summer1994/vol19-2.pdf***

3. Krysel, Charles, Elizabeth Marsh Boyer, Charles Parson, and Patrick Welle. 2003. Lakeshore property values and water quality: evidence from property sales in the Mississippi Headwaters region. Mississippi Headwaters Board and Bemidji State University. ***www.friendscvsf.org/bsu_study.pdf***

4. Michael, Holly, Kevin Boyle, and Roy Bouchard. 1996. Water quality affects property prices: a case study of selected Maine lakes. Maine Agricultural and Forest Experiment Station. University of Maine. Miscellaneous Report 398. ***www.umaine.edu/mafes/elec_pubs/miscrepts/mr398.pdf***

5. Clemens, Cheryl. 2008. Controlling runoff and erosion from your waterfront property: a guide for landowners. Burnett County Land and Water Conservation Department. ***dnr.wi.gov/waterways/shoreland/RunoffGuide_LR_locked.unlocked[1].pdf***

6. Panuska, John. Adapted from Wisconsin DNR memo, Nov. 6, 1994.

7. Wagner, Carmen, John Haack, and Robert Korth. 2003. Protecting and restoring shorelands, The shoreland stewardship series. Number 2. University of Wisconsin-Extension, Wisconsin Lakes Partnership, Wisconsin Department of Natural Resources, Wisconsin Association of Lakes, and the River Alliance of Wisconsin. WI DNR Publication No. WT-748 2003, UWEX Publication No. GWQ038. ***http://clean-water.uwex.edu/pubs/pdf/protect.pdf***

8. Wang, Lizhu, John Lyons, and Paul Kanehl. 2003. Impact of urban land cover on trout streams in Wisconsin and Minnesota. *Transactions of the American Fisheries Society*. 132(5):825-839

9. Wang, Lizhu, John Lyons, P. Kanehl, Paul Kanehl, Roger Bannerman and Edward Emmons. 2000. Watershed urbanization and changes in fish communities in southeastern Wisconsin streams. *Journal of the American Water Resources Association*. 36(5):1173-1187.

10. Wang, Lizhu, John Lyons, and Paul Kanehl. 2001. Impacts of urbanization on stream habitat across multiple spatial scales. *Environmental Management*. 28(2):255-266.

11. Garrison, Paul, Martin Jennings, Alison Mikulyuk, John Lyons, Paul Rasmussen, Jennifer Hauxwell, David Wong, Jodi Brandt, and Gene Hatzenbeler. 2008. Implementation and interpretation of lakes assessment data for the Upper Midwest. Final report to the U.S. EPA.

12. Lyons, John. Personal Communication, March 6, 2012.

13. Kerr, S. J., B. W. Corbett, N. J. Hutchinson, D. Kinsman, J. H. Leach, D. Puddister, L. Stanfield, and N. Ward. 1997. Walleye habitat: a synthesis of current knowledge with guidelines for conservation. Percid Community Synthesis Walleye Habitat Working Group. ***www.mnr.gov.on.ca/stdprodconsume/groups/lr/@mnr/@letsfish/documents/document/226887.pdf***

14. Becker, George C. 1983. *Fishes of Wisconsin*. University of Wisconsin Press. 1052 p.

15. Leis, Amy L. and Michael G. Fox. 1994. Effect of mine tailings on the in situ survival of walleye (stizostedionvitreum) eggs in a northern Ontario river. *Ecoscience*. 1(3):215-222.

16. State of Wisconsin Department of Natural Resources. 2000. The Water's Edge: Helping Fish and Wildlife on Your Waterfront Property. Adapted from Minnesota DNR, Section of Fisheries publication: The Water's Edge. DNR Publication No. FH-428 00. ***dnr.wi.gov/fish/pubs/thewatersedge.pdf***

17. Volkert, William. 1997. General observations on bird and small mammal use of shorelines and riparian corridors in Wisconsin. Chapter from *Effectiveness of shoreland zoning standards to meet statutory objectives: a literature review with policy implications*, prepared by Thomas Bernthal. Wisconsin Department of Natural Resources Publication No. WT-505-97. ***dnr.wi.gov/waterways/shoreland/documents/WT50597.pdf***

18. Erb, John, Brock McMillan, Daniel Martin, and Jessica Homyack. 2006. Site characteritics of river otter (Lontra canadensis) natal dens in Minnesota. *The American Midland Naturalist*. 156:109-117. ***http://filebox.vt.edu/users/gormant/Gorman.etal.2006a.pdf***

19. Reinelt, Lorin, Richard Horner, and Amanda Azous. 1998. Impacts of urbanization on palustrine (depressional freshwater) wetlands-research and management in the Puget Sound region. *Urban Ecosystems*. 2:219-236.

20. US Environmental Protection Agency. 1993. Natural wetlands and urban stormwater: Potential impacts and management. Office of Wetlands, Oceans, and Watersheds, Washington, DC. ***http://water.epa.gov/type/wetlands/restore/upload/1998_01_29_wetlands_stormwat.pdf*** Grant no. X7-83254601. Wisconsin Department of Natural Resources, Bureau of Science Services and Aquatic Sciences Section. p. 45-48.

21. Cox, Robert R., Mark A. Hanson, Christianne C. Roy, Ned H. Euliss, Jr., Douglas H. Johnson, andMalcolm G. Butler. Mallard duckling growth and survival in relation to aquatic invertebrates. *The Journal of Wildlife Management*. 62(1):124-733. ***www.npwrc.usgs.gov/pdf/npwrc1022_aquaduck.pdf***

22. Zweig, Leanna D. and Charles F. Rabeni. 2001. Biomonitoring for deposited sediment using benthic invertebrates: a test on 4 Missouri streams. *Journal of North American Benthological Society.* 20(4):643-657

23. Byford, James L. 1990. Assessing/evaluating/improving your potential for wildlife. Proceedings from the Conference on: Income Opportunities for the Private Landowner through Management of Natural Resources and Recreational Access. West Virginia Extension Service, Rural Development Publication No. 740:169-183.

24. Meyer, Michael W. 2006. Final Report: Evaluating the impact of multiple stressors on common loon population demographics-an integrated laboratory and field approach. Wisconsin Department of Natural Resources. EPA Grant Number R82-9085.

25. McIntyre, Judith W. 1988. *The Common Loon: Spirit of Northern Lakes*. Minneapolis, MN: University of Minnesota Press.

26. McCann, Nicholas, Daniel Haskell, and Michael Meyer. 2004. Capturing common loon nest predators on 35mm film. *Passenger Pigeon*. 66(4):351-361. ***http://images.library.wisc.edu/EcoNatRes/EFacs/PassPigeon/ppv66n04/reference/econatres.pp66n04.mccann01.pdf***

Written by Lynn Markham and Ross Dudzik – UW-Extension Center for Land Use Education. 2012
Cover photo by Eric Engbretson, inside cover photo by Jesse Kloepmken, back cover photo by John Haack
Interior photography by Mark Lasnek, Eric Engbretson, Michelle Woodford, John Haack, Robert Korth, Jeffrey Strobel and Sarah Congdon

Design and Production by the ERC Publications Unit
ENVIRONMENTAL RESOURCES CENTER
Graphic Design by Amy B. Torrey / 11.2012

Assistance and review from:
Roger Bannerman, Tom Blake, Heidi Bunk, Paul Garrison, Heidi Kennedy, Gina LaLiberte,
John Lyons, Mike Meyer, Carroll Schaal, Sean Strom and Mike Wenholz – Wisconsin Department of Natural Resources
Paul McGinley and Nancy Turyk – UW-Stevens Point Center for Watershed Science and Education
Cheryl Clemens – Harmony Environmental
Chad Cook and John Haack – UW-Extension Natural Resource Educators
Patrick Goggin and Amy Kowalski – UW-Extension Lakes
Tracy Hames – Wisconsin Wetlands Association
Cleo Herrick – Dunn County Zoning
Amy Kelsey – Cooper Engineering Company, Inc.
Kevin Kenow – U.S. Geological Survey
Erica LeMoine – LoonWatch
Jay Michels – Emmons & Olivier Resources, Inc.
Terry Ochs – Dodge County Land Resources and Parks
Steve Rannenberg – Douglas County Planning and Zoning
Jeff Reed – Minnesota Department of Natural Resources
Bret Shaw – UW-Madison Department of Life Sciences Communication
Julie A. Schmelzer – Calumet County Resource Management
Susan Tesarik – Wisconsin Lakes
CeCe Tesky – Rusk County Zoning

DNR Publication
WT-990 2012

WISCONSIN DEPT. OF NATURAL RESOURCES

UWEX Publication
GWQ061 I-10-2012

UW-Extension Center for
Land Use Education

NEW LEAF PAPER®

ENVIRONMENTAL BENEFITS STATEMENT

of using post-consumer waste fiber vs. virgin fiber

University of Wisconsin-Madison saved the following resources by using 4202 pounds of Reincarnation Matte, made with 60% post-consumer waste and manufactured with electricity that is offset with Green-e® certified renewable energy certificates.

trees	water	energy	solid waste	greenhouse gases
27 fully grown	12445 gallons	11 Million BTUs	789 pounds	2760 pounds

Calculations based on research by Environmental Defense Fund and other members of the Paper Task Force.

www.newleafpaper.com

Cooperative Extension publications are subject to peer review.

University of Wisconsin-Extension, Cooperative Extension, in cooperation with the U.S. Department of Agriculture and Wisconsin counties, publishes this information to further the purpose of the May 8 and June 30, 1914, Acts of Congress. An EEO/AA employer, the University of Wisconsin-Extension, Cooperative Extension provides equal opportunities in employment and programming, including Title IX and ADA requirements. If you need this information in an alternative format, contact Equal Opportunity and Diversity Programs, University of Wisconsin-Extension, 432 N. Lake St., Rm. 501, Madison, WI 53706, diversity@uwex.edu, phone: (608) 262-0277, fax: (608) 262-8404, TTY: 711 Wisconsin Relay.

This publication is available from your county UW-Extension office (www.uwex.edu/ces/cty), from Cooperative Extension Publishing (to order, call toll-free: 1-877-947-7827 [WIS-PUBS] or visit this website: learningstore.uwex.edu), and it is available from DNR Service Centers.

2013 AQUATIC PLANT SURVEY RAW DATA AND SUMMARY STATISTICS FOR LAKE DENOON

APPENDIX D

Table D.1

Lake Denoon Point-Intercept Aquatic Plant Survey Data: August 19-21, 2013

	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL
1	sampling point	Latitude (need electronic copy of site locations)	Longitude (need electronic copy of site locations)	Depth (ft)	Dominant sediment type (1=Silt 2=Silt Sand 3=Sand	Sampled holding rake pole (P) or rake rope (R)?	comments	Total Rake Fullness	*Myriophyllum spicatum*, Eurasian water-milfoil or Hybrid water-milfoil	*Potamogeton crispus*, Curly-leaf pondweed	*Ceratophyllum demersum*, Coontail	*Chara* sp., Muskgrasses	*Elodea canadensis*, Common waterweed	*Heteranthera dubia*, Water star-grass	*Najas flexilis*, Slender naiad	*Najas marina*, Spiny naiad	*Nuphar variegata*, Spatterdock	*Nymphaea odorata*, White water lily	*Polygonum amphibium*, Water smartweed	*Potamogeton gramineus*, Variable pondweed	*Potamogeton praelongus*, White-stem pondweed	*Potamogeton richardsonii*, Clasping-leaf pondweed	*Stuckenia filiformis*, Fine-leaved pondweed	*Stuckenia pectinata*, Sago pondweed	*Vallisneria americana*, Wild celery	Filamentous algae	Zebra Mussels, Dreissena polymorpha	sp3	sp4	sp5	sp6
2	1	42.85032	-88.169237	1.5	3			1				1																			
3	2	42.850312	-88.168747	2	2			3	2		3		3			1		3			2			1							
4	3	42.850304	-88.168258	2	2			3			3	2		1	2			3			1					1					
5	4	42.850296	-88.167769	2.5	3			1			1														1						
6	5	42.850038	-88.174141	3	1			3			3										2				1						
7	6	42.85003	-88.173651	3	2			3	3		3										1					1					
8	7	42.850022	-88.173162	3	3			3			1	3				1					1				1						
9	8	42.850015	-88.172673	2.5	3			1			1	2									1				1						
10	9	42.850007	-88.172183	2	3			3			1							1						1	1						
11	10	42.849999	-88.171694	2	3			3				3	1							1					1						
12	11	42.849991	-88.171205	2	2			2	1		1	2								1					2						
13	12	42.849983	-88.170715	2	2			3	1		1	2								3				1	1	1					
14	13	42.849975	-88.170226	3	2			3	1	1	1			1	1					3											
15	14	42.849968	-88.169737	2	2			1				1			1																
16	15	42.84996	-88.169247	2	3			1				1																			
17	16	42.849952	-88.168758	2	3			1			1	1																			
18	17	42.849944	-88.168269	2	3			1			1	1																			
19	18	42.849936	-88.16778	3	3			1	1			1													1						
20	19	42.849928	-88.16729	3.5	3			3			1							1			3					1					
21	20	42.849921	-88.166801	2.5	3			2	1		1			1	1			1			1				1	1					
22	21	42.849913	-88.166312	1.5	3			1				1	1		1							1									
23	22	42.849686	-88.17464	5.5	1			3			3										3				2						
24	23	42.849678	-88.174151	4.5	3			2			1	1	1								1										
25	24	42.84967	-88.173662	7	3			3	1		3										3										
26	25	42.849662	-88.173173	9	3			3			3										3						1				
27	26	42.849655	-88.172683	6	3			3			3										3										
28	27	42.849647	-88.172194	5.5	3			3	1		2										3										
29	28	42.849639	-88.171705	3	3			3	3		1			1							2										
30	29	42.849631	-88.171215	3.5	3			3	3		3			1							2				1						
31	30	42.849623	-88.170726	3	3			1			1	1																			
32	31	42.849615	-88.170237	3	3			1			1	1																			
33	32	42.849608	-88.169747	3.5	3			3			1	3								1					1						
34	33	42.8496	-88.169258	9.5	3			3			3										1										
35	34	42.849592	-88.168769				Not Sampled																								
36	35	42.849584	-88.168279				Not Sampled																								
37	36	42.849576	-88.16779				Not Sampled																								
38	37	42.849568	-88.167301	16	3			3			3																1				
39	38	42.849561	-88.166812	5.5	3			3			1										3				1						
40	39	42.849553	-88.166322	2.5	3			1			1	1								1											
41	40	42.849545	-88.165833	1.5	3			2				2			1					1											
42	41	42.849334	-88.17514														3	3													
43	42	42.849326	-88.174651								3										3										
44	43	42.849318	-88.174162	11.5	3			3			3	1									3										

Table continued on next page.

Table D.1 (Continued)

	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL
1	sampling point	Latitude (need electronic copy of site locations)	Longitude (need electronic copy of site locations)	Depth (ft)	Dominant sediment type (1=Silt 2=Silt Sand 3=Sand	Sampled holding rake pole (P) or rake rope (R)?	comments	Total Rake Fullness	*Myriophyllum spicatum*, Eurasian water-milfoil or Hybrid water-milfoil	*Potamogeton crispus*, Curly-leaf pondweed	*Ceratophyllum demersum*, Coontail	*Chara* sp., Muskgrasses	*Elodea canadensis*, Common waterweed	*Heteranthera dubia*, Water star-grass	*Najas flexilis*, Slender naiad	*Najas marina*, Spiny naiad	*Nuphar variegata*, Spatterdock	*Nymphaea odorata*, White water lily	*Polygonum amphibium*, Water smartweed	*Potamogeton gramineus*, Variable pondweed	*Potamogeton praelongus*, White-stem pondweed	*Potamogeton richardsonii*, Clasping-leaf pondweed	*Stuckenia filiformis*, Fine-leaved pondweed	*Stuckenia pectinata*, Sago pondweed	*Vallisneria americana*, Wild celery	Filamentous algae	Zebra Mussels, Dreissena polymorpha	sp3	sp4	sp5	sp6
45	44	42.84931	-88.173672	15	3			1			1																				
46	45	42.849302	-88.173183				Not Sampled																								
47	46	42.849294	-88.172694				Not Sampled																								
48	47	42.849287	-88.172205				Not Sampled																								
49	48	42.849279	-88.171715				Not Sampled																								
50	49	42.849271	-88.171226				Not Sampled																								
51	50	42.849263	-88.170737				Not Sampled																								
52	51	42.849255	-88.170247				Not Sampled																								
53	52	42.849248	-88.169758				Not Sampled																								
54	53	42.84924	-88.169269				Not Sampled																								
55	54	42.849232	-88.168779				Not Sampled																								
56	55	42.849224	-88.16829				Not Sampled																								
57	56	42.849216	-88.167801				Not Sampled																								
58	57	42.849208	-88.167312				Not Sampled																								
59	58	42.849201	-88.166822	7	3			3	1		3										2										
60	59	42.849193	-88.166333	3	3			2	1		1	1			1					1					1						
61	60	42.849185	-88.165844	2	3			1			1	1																			
62	61	42.849177	-88.165354	1	3			2				2			1										1						
63	62	42.848981	-88.17564														3	3													
64	63	42.848973	-88.175151						2		3																				
65	64	42.848966	-88.174662	9	2				1		3																				
66	65	42.848958	-88.174172	12	2			3			3										2						1				
67	66	42.84895	-88.173683	15	2			3			3										1										
68	67	42.848942	-88.173194				Not Sampled																								
69	68	42.848934	-88.172704				Not Sampled																								
70	69	42.848927	-88.172215				Not Sampled																								
71	70	42.848919	-88.171726				Not Sampled																								
72	71	42.848911	-88.171237				Not Sampled																								
73	72	42.848903	-88.170747				Not Sampled																								
74	73	42.848895	-88.170258				Not Sampled																								
75	74	42.848888	-88.169769				Not Sampled																								
76	75	42.84888	-88.169279				Not Sampled																								
77	76	42.848872	-88.16879				Not Sampled																								
78	77	42.848864	-88.168301				Not Sampled																								
79	78	42.848856	-88.167811				Not Sampled																								
80	79	42.848848	-88.167322				Not Sampled																								
81	80	42.848841	-88.166833	9.5	3			3			3										2										
82	81	42.848833	-88.166344	4	3			3	1		2				1						2				1						
83	82	42.848825	-88.165854	2.5	3			1			1	1																			
84	83	42.848817	-88.165365	1.5	4			1			1	1																			
85	84	42.848621	-88.175651	5	2						3															1					
86	85	42.848613	-88.175162	8.5	2						3																				
87	86	42.848606	-88.174672	8.5	2			3			3																				

Table continued on next page.

Table D.1 (Continued)

	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL
1	sampling point	Latitude (need electronic copy of site locations)	Longitude (need electronic copy of site locations)	Depth (ft)	Dominant sediment type (1=Silt 2=Silt Sand 3=Sand	Sampled holding rake pole (P) or rake rope (R)?	comments	Total Rake Fullness	*Myriophyllum spicatum*, Eurasian water-milfoil or Hybrid water-milfoil	*Potamogeton crispus*, Curly-leaf pondweed	*Ceratophyllum demersum*, Coontail	*Chara* sp., Muskgrasses	*Elodea canadensis*, Common waterweed	*Heteranthera dubia*, Water star-grass	*Najas flexilis*, Slender naiad	*Najas marina*, Spiny naiad	*Nuphar variegata*, Spatterdock	*Nymphaea odorata*, White water lily	*Polygonum amphibium*, Water smartweed	*Potamogeton gramineus*, Variable pondweed	*Potamogeton praelongus*, White-stem pondweed	*Potamogeton richardsonii*, Clasping-leaf pondweed	*Stuckenia filiformis*, Fine-leaved pondweed	*Stuckenia pectinata*, Sago pondweed	*Vallisneria americana*, Wild celery	Filamentous algae	Zebra Mussels, Dreissena polymorpha	sp3	sp4	sp5	sp6
88	87	42.848598	-88.174183	12.5	2			1			1																				
89	88	42.84859	-88.173694	14.5	2			1			1																				
90	89	42.848582	-88.173204				Not Sampled																								
91	90	42.848574	-88.172715				Not Sampled																								
92	91	42.848567	-88.172226				Not Sampled																								
93	92	42.848559	-88.171736				Not Sampled																								
94	93	42.848551	-88.171247				Not Sampled																								
95	94	42.848543	-88.170758				Not Sampled																								
96	95	42.848535	-88.170269				Not Sampled																								
97	96	42.848528	-88.169779				Not Sampled																								
98	97	42.84852	-88.16929				Not Sampled																								
99	98	42.848512	-88.168801				Not Sampled																								
100	99	42.848504	-88.168311				Not Sampled																								
101	100	42.848496	-88.167822				Not Sampled																								
102	101	42.848488	-88.167333				Not Sampled																								
103	102	42.848481	-88.166844					1			1																				
104	103	42.848473	-88.166354	6	3			3	1		3										2										
105	104	42.848465	-88.165865	2.5	3			1	1		1	1														1					
106	105	42.848457	-88.165376	2.5	3			1			1	1								1											
107	106	42.848449	-88.164886	1.5	3			1			1	1								1				1							
108	107	42.848269	-88.176151	5	2			3			3																				
109	108	42.848261	-88.175661	5	2			3			3																				
110	109	42.848253	-88.175172	8.5	2						3																				
111	110	42.848246	-88.174683	10	2			3			3															1					
112	111	42.848238	-88.174194	11	2			3														3					1				
113	112	42.84823	-88.173704	9	2			3	2		3																1				
114	113	42.848222	-88.173215	6.5	2			3	2		3																1				
115	114	42.848214	-88.172726	12.5	2			3			3																				
116	115	42.848207	-88.172236	13.5	2			3			3																				
117	116	42.848199	-88.171747	10.5	2			3			3																1				
118	117	42.848191	-88.171258				Not Sampled																								
119	118	42.848183	-88.170768				Not Sampled																								
120	119	42.848175	-88.170279				Not Sampled																								
121	120	42.848167	-88.16979				Not Sampled																								
122	121	42.84816	-88.169301				Not Sampled																								
123	122	42.848152	-88.168811				Not Sampled																								
124	123	42.848144	-88.168322				Not Sampled																								
125	124	42.848136	-88.167833				Not Sampled																								
126	125	42.848128	-88.167343				Not Sampled																								
127	126	42.848121	-88.166854				Not Sampled																								
128	127	42.848113	-88.166365	6	3			3	1		3										2			1	2						
129	128	42.848105	-88.165876	3.5	3			1			1										1			1							
130	129	42.848097	-88.165386	3	3			1				1			1						1										

Table continued on next page.

Table D.1 (Continued)

	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL
1	sampling point	Latitude (need electronic copy of site locations)	Longitude (need electronic copy of site locations)	Depth (ft)	Dominant sediment type (1=Silt 2=Silt Sand 3=Sand	Sampled holding rake pole (P) or rake rope (R)?	comments	Total Rake Fullness	*Myriophyllum spicatum*, Eurasian water-milfoil or Hybrid water-milfoil	*Potamogeton crispus*, Curly-leaf pondweed	*Ceratophyllum demersum*, Coontail	*Chara* sp., Muskgrasses	*Elodea canadensis*, Common waterweed	*Heteranthera dubia*, Water star-grass	*Najas flexilis*, Slender naiad	*Najas marina*, Spiny naiad	*Nuphar variegata*, Spatterdock	*Nymphaea odorata*, White water lily	*Polygonum amphibium*, Water smartweed	*Potamogeton gramineus*, Variable pondweed	*Potamogeton praelongus*, White-stem pondweed	*Potamogeton richardsonii*, Clasping-leaf pondweed	*Stuckenia filiformis*, Fine-leaved pondweed	*Stuckenia pectinata*, Sago pondweed	*Vallisneria americana*, Wild celery	Filamentous algae	Zebra Mussels, Dreissena polymorpha	sp3	sp4	sp5	sp6
131	130	42.848089	-88.164897	1.5	4			1	1		1	1								1											
132	131	42.847901	-88.175672				Not Sampled																								
133	132	42.847893	-88.175183				Not Sampled																								
134	133	42.847886	-88.174693				Not Sampled																								
135	134	42.847878	-88.174204	6.5	2			3	3		3										1										
136	135	42.84787	-88.173715	6	2			3	3		3																1				
137	136	42.847862	-88.173226	6	2			3	3		3																1				
138	137	42.847854	-88.172736	7	2			3	3		3																				
139	138	42.847847	-88.172247	6	2			3	3		3																1				
140	139	42.847839	-88.171758	6.5	2			3	3		3																1				
141	140	42.847831	-88.171268	14.5	2			3			3																1				
142	141	42.847823	-88.170779				Not Sampled																								
143	142	42.847815	-88.17029				Not Sampled																								
144	143	42.847807	-88.169801				Not Sampled																								
145	144	42.8478	-88.169311				Not Sampled																								
146	145	42.847792	-88.168822				Not Sampled																								
147	146	42.847784	-88.168333				Not Sampled																								
148	147	42.847776	-88.167843				Not Sampled																								
149	148	42.847768	-88.167354				Not Sampled																								
150	149	42.84776	-88.166865				Not Sampled																								
151	150	42.847753	-88.166376	8	3			3			3																				
152	151	42.847745	-88.165886	4	3			3	1		2										3					1					
153	152	42.847737	-88.165397	3	3			1			1	1									1										
154	153	42.847729	-88.164908	2.5	3			1			1	1								1											
155	154	42.847721	-88.164418	1.5	3			1			1	1													1						
156	155	42.847526	-88.174704				Not Sampled																								
157	156	42.847518	-88.174215				Not Sampled																								
158	157	42.84751	-88.173725				Not Sampled																								
159	158	42.847502	-88.173236	3	2			3	3		3							1													
160	159	42.847494	-88.172747	3	2			3	3		3						3	3													
161	160	42.847487	-88.172258	1.5	3			3	1		1	3																			
162	161	42.847479	-88.171768	2	3			3			1	3								1							1				
163	162	42.847471	-88.171279	10	3			3			3																				
164	163	42.847463	-88.17079				Not Sampled																								
165	164	42.847455	-88.1703				Not Sampled																								
166	165	42.847447	-88.169811				Not Sampled																								
167	166	42.84744	-88.169322				Not Sampled																								
168	167	42.847432	-88.168833				Not Sampled																								
169	168	42.847424	-88.168343				Not Sampled																								
170	169	42.847416	-88.167854				Not Sampled																								
171	170	42.847408	-88.167365				Not Sampled																								
172	171	42.8474	-88.166875				Not Sampled																								
173	172	42.847393	-88.166386	7	3			3			3																				

Table continued on next page.

Table D.1 (Continued)

	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL
1	sampling point	Latitude (need electronic copy of site locations)	Longitude (need electronic copy of site locations)	Depth (ft)	Dominant sediment type (1=Silt 2=Silt Sand 3=Sand 4=...)	Sampled holding rake pole (P) or rake rope (R)?	comments	Total Rake Fullness	*Myriophyllum spicatum*, Eurasian water-milfoil or Hybrid water-milfoil	*Potamogeton crispus*, Curly-leaf pondweed	*Ceratophyllum demersum*, Coontail	*Chara* sp., Muskgrasses	*Elodea canadensis*, Common waterweed	*Heteranthera dubia*, Water star-grass	*Najas flexilis*, Slender naiad	*Najas marina*, Spiny naiad	*Nuphar variegata*, Spatterdock	*Nymphaea odorata*, White water lily	*Polygonum amphibium*, Water smartweed	*Potamogeton gramineus*, Variable pondweed	*Potamogeton praelongus*, White-stem pondweed	*Potamogeton richardsonii*, Clasping-leaf pondweed	*Stuckenia filiformis*, Fine-leaved pondweed	*Stuckenia pectinata*, Sago pondweed	*Vallisneria americana*, Wild celery	Filamentous algae	Zebra Mussels, Dreissena polymorpha	sp3	sp4	sp5	sp6
174	173	42.847385	-88.165897	5	3			3	2		3										1			1	1						
175	174	42.847377	-88.165408	3.5	3			1			1	1									1										
176	175	42.847369	-88.164918	2.5	3			1			1																				
177	176	42.847361	-88.164429	2	3			1			1	1								1											
178	177	42.847142	-88.173247	2	2												3	3													
179	178	42.847134	-88.172758	2	2												3	3													
180	179	42.847119	-88.171779	1.5	3			1				1																			
181	180	42.847111	-88.17129	4	3			3	3		3																				
182	181	42.847103	-88.1708				Not Sampled																								
183	182	42.847095	-88.170311				Not Sampled																								
184	183	42.847087	-88.169822				Not Sampled																								
185	184	42.84708	-88.169333				Not Sampled																								
186	185	42.847072	-88.168843				Not Sampled																								
187	186	42.847064	-88.168354				Not Sampled																								
188	187	42.847056	-88.167865				Not Sampled																								
189	188	42.847048	-88.167375				Not Sampled																								
190	189	42.84704	-88.166886				Not Sampled																								
191	190	42.847033	-88.166397	N/A	N/A			3			3																				
192	191	42.847025	-88.165908	9	3			3			3										1										
193	192	42.847017	-88.165418	4.5	3			3	1			3									1			1	1						
194	193	42.847009	-88.164929	3.5	3			3			1	3								1	2				1						
195	194	42.847001	-88.16444	2.5	3			1												1					1						
196	195	42.846993	-88.16395	1	4			1				1			1					1		1									
197	196	42.846782	-88.173257	2	2												3	3													
198	197	42.846774	-88.172768	2	2												3	3													
199	198	42.846759	-88.17179	2.5	3			1			1	1																			
200	199	42.846751	-88.1713	12	3			3			3										2						1				
201	200	42.846743	-88.170811				Not Sampled																								
202	201	42.846735	-88.170322				Not Sampled																								
203	202	42.846727	-88.169832				Not Sampled																								
204	203	42.84672	-88.169343				Not Sampled																								
205	204	42.846712	-88.168854				Not Sampled																								
206	205	42.846704	-88.168365				Not Sampled																								
207	206	42.846696	-88.167875				Not Sampled																								
208	207	42.846688	-88.167386				Not Sampled																								
209	208	42.84668	-88.166897				Not Sampled																								
210	209	42.846673	-88.166407				Not Sampled																								
211	210	42.846665	-88.165918				Not Sampled																								
212	211	42.846657	-88.165429				Not Sampled																								
213	212	42.846649	-88.16494	5.5	3			2	1		2										1				2		1				
214	213	42.846641	-88.16445	3	3			1	1			1			1																
215	214	42.846633	-88.163961	2	3			1			1	1																			
216	215	42.84643	-88.173757		3													3													

Table continued on next page.

Table D.1 (Continued)

1	H sampling point	I Latitude (need electronic copy of site locations)	J Longitude (need electronic copy of site locations)	K Depth (ft)	L Dominant sediment type (1=Silt 2=Silt Sand 3=Sand 4=...)	M Sampled holding rake pole (P) or rake rope (R)?	N comments	O Total Rake Fullness	P *Myriophyllum spicatum*, Eurasian water-milfoil or Hybrid water-milfoil	Q *Potamogeton crispus*, Curly-leaf pondweed	R *Ceratophyllum demersum*, Coontail	S *Chara* sp., Muskgrasses	T *Elodea canadensis*, Common waterweed	U *Heteranthera dubia*, Water star-grass	V *Najas flexilis*, Slender naiad	W *Najas marina*, Spiny naiad	X *Nuphar variegata*, Spatterdock	Y *Nymphaea odorata*, White water lily	Z *Polygonum amphibium*, Water smartweed	AA *Potamogeton gramineus*, Variable pondweed	AB *Potamogeton praelongus*, White-stem pondweed	AC *Potamogeton richardsonii*, Clasping-leaf pondweed	AD *Stuckenia filiformis*, Fine-leaved pondweed	AE *Stuckenia pectinata*, Sago pondweed	AF *Vallisneria americana*, Wild celery	AG Filamentous algae	AH Zebra Mussels, Dreissena polymorpha	AI sp3	AJ sp4	AK sp5	AL sp6
217	216	42.846422	-88.173268		3													3													
218	217	42.846414	-88.172779		3													3													
219	218	42.846406	-88.172289	1.5	3			2				2									1										
220	219	42.846399	-88.1718	3	3			3	2		3															1					
221	220	42.846391	-88.171311				Not Sampled																								
222	221	42.846383	-88.170822				Not Sampled																								
223	222	42.846375	-88.170332				Not Sampled																								
224	223	42.846367	-88.169843				Not Sampled																								
225	224	42.84636	-88.169354				Not Sampled																								
226	225	42.846352	-88.168865				Not Sampled																								
227	226	42.846344	-88.168375				Not Sampled																								
228	227	42.846336	-88.167886				Not Sampled																								
229	228	42.846328	-88.167397				Not Sampled																								
230	229	42.84632	-88.166907				Not Sampled																								
231	230	42.846313	-88.166418				Not Sampled																								
232	231	42.846305	-88.165929				Not Sampled																								
233	232	42.846297	-88.16544				Not Sampled																								
234	233	42.846289	-88.16495				Not Sampled																								
235	234	42.846281	-88.164461	13	3			3			2										2						1				
236	235	42.846273	-88.163972	3	3			1			1	1									1										
237	236	42.846265	-88.163482	1.5	2			1			1	1																			
238	237	42.846078	-88.174257															3													
239	238	42.84607	-88.173768															3													
240	239	42.846062	-88.173279	4	3			3				3																			
241	240	42.846054	-88.172789	6	2			3	3		3																1				
242	241	42.846046	-88.1723	5	2			3	1		3																1				
243	242	42.846039	-88.171811				Not Sampled																								
244	243	42.846031	-88.171322				Not Sampled																								
245	244	42.846023	-88.170832				Not Sampled																								
246	245	42.846015	-88.170343				Not Sampled																								
247	246	42.846007	-88.169854				Not Sampled																								
248	247	42.845999	-88.169364				Not Sampled																								
249	248	42.845992	-88.168875				Not Sampled																								
250	249	42.845984	-88.168386				Not Sampled																								
251	250	42.845976	-88.167897				Not Sampled																								
252	251	42.845968	-88.167407				Not Sampled																								
253	252	42.84596	-88.166918				Not Sampled																								
254	253	42.845953	-88.166429				Not Sampled																								
255	254	42.845945	-88.165939				Not Sampled																								
256	255	42.845937	-88.16545				Not Sampled																								
257	256	42.845929	-88.164961				Not Sampled																								
258	257	42.845921	-88.164472				Not Sampled																								
259	258	42.845913	-88.163982	11	3			3			3										2										

Table continued on next page.

Table D.1 (Continued)

	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL
1	sampling point	Latitude (need electronic copy of site locations)	Longitude (need electronic copy of site locations)	Depth (ft)	Dominant sediment type (1=Silt 2=Silt Sand 3=Sand ...	Sampled holding rake pole (P) or rake rope (R)?	comments	Total Rake Fullness	*Myriophyllum spicatum*, Eurasian water-milfoil or Hybrid water-milfoil	*Potamogeton crispus*, Curly-leaf pondweed	*Ceratophyllum demersum*, Coontail	*Chara* sp., Muskgrasses	*Elodea canadensis*, Common waterweed	*Heteranthera dubia*, Water star-grass	*Najas flexilis*, Slender naiad	*Najas marina*, Spiny naiad	*Nuphar variegata*, Spatterdock	*Nymphaea odorata*, White water lily	*Polygonum amphibium*, Water smartweed	*Potamogeton gramineus*, Variable pondweed	*Potamogeton praelongus*, White-stem pondweed	*Potamogeton richardsonii*, Clasping-leaf pondweed	*Stuckenia filiformis*, Fine-leaved pondweed	*Stuckenia pectinata*, Sago pondweed	*Vallisneria americana*, Wild celery	Filamentous algae	Zebra Mussels, Dreissena polymorpha	sp3	sp4	sp5	sp6
260	259	42.845905	-88.163493	2.5	3			1				1								1	1										
261	260	42.845898	-88.163004	2	3			2				1			1					1											
262	261	42.845749	-88.176225				Not Sampled																								
263	262	42.845741	-88.175736				Not Sampled																								
264	263	42.845725	-88.174757		2												2	3													
265	264	42.845718	-88.174268	6.5	2			3	2		3																1				
266	265	42.84571	-88.173779	6	2			3	3													3					1				
267	266	42.845702	-88.173289	9	2			3														3					1				
268	267	42.845694	-88.1728				Not Sampled																								
269	268	42.845686	-88.172311				Not Sampled																								
270	269	42.845679	-88.171821				Not Sampled																								
271	270	42.845671	-88.171332				Not Sampled																								
272	271	42.845663	-88.170843				Not Sampled																								
273	272	42.845655	-88.170354				Not Sampled																								
274	273	42.845647	-88.169864				Not Sampled																								
275	274	42.845639	-88.169375				Not Sampled																								
276	275	42.845632	-88.168886				Not Sampled																								
277	276	42.845624	-88.168397				Not Sampled																								
278	277	42.845616	-88.167907				Not Sampled																								
279	278	42.845608	-88.167418				Not Sampled																								
280	279	42.8456	-88.166929				Not Sampled																								
281	280	42.845592	-88.166439				Not Sampled																								
282	281	42.845585	-88.16595				Not Sampled																								
283	282	42.845577	-88.165461				Not Sampled																								
284	283	42.845569	-88.164972				Not Sampled																								
285	284	42.845561	-88.164482				Not Sampled																								
286	285	42.845553	-88.163993				Not Sampled																								
287	286	42.845545	-88.163504	3.5	3			3			2										2										
288	287	42.845538	-88.163015	3	3			1			1	1			1					1	1										
289	288	42.84553	-88.162525	1.5	2			2			2	2													1						
290	289	42.845373	-88.175257				Not Sampled																								
291	290	42.845365	-88.174768					3										3													
292	291	42.845358	-88.174278	5	2			3	2		3																				
293	292	42.84535	-88.173789	8	2			3			3																				
294	293	42.845342	-88.1733	9.5	3			3			3																1				
295	294	42.845334	-88.172811				Not Sampled																								
296	295	42.845326	-88.172321				Not Sampled																								
297	296	42.845319	-88.171832				Not Sampled																								
298	297	42.845311	-88.171343				Not Sampled																								
299	298	42.845303	-88.170854				Not Sampled																								
300	299	42.845295	-88.170364				Not Sampled																								
301	300	42.845287	-88.169875				Not Sampled																								
302	301	42.845279	-88.169386				Not Sampled																								

Table continued on next page.

Table D.1 (Continued)

	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL
1	sampling point	Latitude (need electronic copy of site locations)	Longitude (need electronic copy of site locations)	Depth (ft)	Dominant sediment type (1=Silt 2=Silt Sand 3=Sand	Sampled holding rake pole (P) or rake rope (R)?	comments	Total Rake Fullness	*Myriophyllum spicatum*, Eurasian water-milfoil or Hybrid water-milfoil	*Potamogeton crispus*, Curly-leaf pondweed	*Ceratophyllum demersum*, Coontail	*Chara* sp., Muskgrasses	*Elodea canadensis*, Common waterweed	*Heteranthera dubia*, Water star-grass	*Najas flexilis*, Slender naiad	*Najas marina*, Spiny naiad	*Nuphar variegata*, Spatterdock	*Nymphaea odorata*, White water lily	*Polygonum amphibium*, Water smartweed	*Potamogeton gramineus*, Variable pondweed	*Potamogeton praelongus*, White-stem pondweed	*Potamogeton richardsonii*, Clasping-leaf pondweed	*Stuckenia filiformis*, Fine-leaved pondweed	*Stuckenia pectinata*, Sago pondweed	*Vallisneria americana*, Wild celery	Filamentous algae	Zebra Mussels, Dreissena polymorpha	sp3	sp4	sp5	sp6
303	302	42.845272	-88.168896				Not Sampled																								
304	303	42.845264	-88.168407				Not Sampled																								
305	304	42.845256	-88.167918				Not Sampled																								
306	305	42.845248	-88.167429				Not Sampled																								
307	306	42.84524	-88.166939				Not Sampled																								
308	307	42.845232	-88.16645				Not Sampled																								
309	308	42.845225	-88.165961				Not Sampled																								
310	309	42.845217	-88.165472				Not Sampled																								
311	310	42.845209	-88.164982				Not Sampled																								
312	311	42.845201	-88.164493				Not Sampled																								
313	312	42.845193	-88.164004				Not Sampled																								
314	313	42.845185	-88.163514	6.5	3			3	1		3										3				1						
315	314	42.845178	-88.163025	2.5	3			1				1									1				1						
316	315	42.84517	-88.162536	1.5	3			1				3			1																
317	316	42.844998	-88.174289	2	4			2							2			2													
318	317	42.84499	-88.1738	2	4			3							2	2		1		1											
319	318	42.844982	-88.17331	3	4			2	1			1		1											1						
320	319	42.844974	-88.172821	5	3			3	1		1										3										
321	320	42.844966	-88.172332	7.5	3			3			3										2										
322	321	42.844958	-88.171843				Not Sampled																								
323	322	42.844951	-88.171353				Not Sampled																								
324	323	42.844943	-88.170864				Not Sampled																								
325	324	42.844935	-88.170375				Not Sampled																								
326	325	42.844927	-88.169886				Not Sampled																								
327	326	42.844919	-88.169396				Not Sampled																								
328	327	42.844912	-88.168907				Not Sampled																								
329	328	42.844904	-88.168418				Not Sampled																								
330	329	42.844896	-88.167929				Not Sampled																								
331	330	42.844888	-88.167439				Not Sampled																								
332	331	42.84488	-88.16695				Not Sampled																								
333	332	42.844872	-88.166461				Not Sampled																								
334	333	42.844865	-88.165971				Not Sampled																								
335	334	42.844857	-88.165482				Not Sampled																								
336	335	42.844849	-88.164993				Not Sampled																								
337	336	42.844841	-88.164504				Not Sampled																								
338	337	42.844833	-88.164014	15	3			3			3										1						1				
339	338	42.844825	-88.163525	5	3			3			2										3				2						
340	339	42.844818	-88.163036	3	3			1	1			1								1											
341	340	42.84481	-88.162547	1.5	2			3			1	3												1							
342	341	42.844614	-88.172832	2	4			2				1		1	2									1	1						
343	342	42.844606	-88.172343	4	3			3			1			1							3				1						
344	343	42.844598	-88.171853	4	3			1			1				1						1										
345	344	42.844591	-88.171364	5	3			3	1		1										2				3		1				

Table continued on next page.

Table D.1 (Continued)

	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL
1	sampling point	Latitude (need electronic copy of site locations)	Longitude (need electronic copy of site locations)	Depth (ft)	Dominant sediment type (1=Silt 2=Silt Sand 3=Sand ...	Sampled holding rake pole (P) or rake rope (R)?	comments	Total Rake Fullness	*Myriophyllum spicatum*, Eurasian water-milfoil or Hybrid water-milfoil	*Potamogeton crispus*, Curly-leaf pondweed	*Ceratophyllum demersum*, Coontail	*Chara* sp., Muskgrasses	*Elodea canadensis*, Common waterweed	*Heteranthera dubia*, Water star-grass	*Najas flexilis*, Slender naiad	*Najas marina*, Spiny naiad	*Nuphar variegata*, Spatterdock	*Nymphaea odorata*, White water lily	*Polygonum amphibium*, Water smartweed	*Potamogeton gramineus*, Variable pondweed	*Potamogeton praelongus*, White-stem pondweed	*Potamogeton richardsonii*, Clasping-leaf pondweed	*Stuckenia filiformis*, Fine-leaved pondweed	*Stuckenia pectinata*, Sago pondweed	*Vallisneria americana*, Wild celery	Filamentous algae	Zebra Mussels, Dreissena polymorpha	sp3	sp4	sp5	sp6
346	345	42.844583	-88.170875	5	3			3	3		1													1	3		1				
347	346	42.844575	-88.170385	12	3			3			3														1		1				
348	347	42.844567	-88.169896	15	3			3			3																1				
349	348	42.844559	-88.169407	8	3			3			3										1						1				
350	349	42.844552	-88.168918	6	3			3	1		3																1				
351	350	42.844544	-88.168428	8	3			3	1		3			1													1				
352	351	42.844536	-88.167939	14.5	3			3			3																1				
353	352	42.844528	-88.16745				Not Sampled																								
354	353	42.84452	-88.166961				Not Sampled																								
355	354	42.844512	-88.166471				Not Sampled																								
356	355	42.844505	-88.165982				Not Sampled																								
357	356	42.844497	-88.165493				Not Sampled																								
358	357	42.844489	-88.165004				Not Sampled																								
359	358	42.844481	-88.164514				Not Sampled																								
360	359	42.844473	-88.164025	11	3			3			3										2						1				
361	360	42.844465	-88.163536	4.5	3			3			3				1						3		1								
362	361	42.844457	-88.163047	2	3			1			1	1																			
363	362	42.84445	-88.162557	1.5	3			2			1	1			1						1				2						
364	363	42.844223	-88.170885	2.5	4			1				1									1				1		1				
365	364	42.844215	-88.170396	4	3			3			1			1							2				3		1				
366	365	42.844207	-88.169907	4	3			3				2			3						2				1						
367	366	42.844199	-88.169418	2.5	3			3			1				1					3					2	1	1				
368	367	42.844192	-88.168928	2	4			1							1					1					1	1	1				
369	368	42.844176	-88.16795	1.5	4			1		1	1													1	1						
370	369	42.844168	-88.167461				Not Sampled																								
371	370	42.84416	-88.166971				Not Sampled																								
372	371	42.844152	-88.166482				Not Sampled																								
373	372	42.844145	-88.165993				Not Sampled																								
374	373	42.844137	-88.165504				Not Sampled																								
375	374	42.844129	-88.165014				Not Sampled																								
376	375	42.844121	-88.164525				Not Sampled																								
377	376	42.844113	-88.164036					3			3																				
378	377	42.844105	-88.163546	4.5	3			3	1		1										3				1						
379	378	42.844097	-88.163057	1.5	3			1				2			1																
380	379	42.843808	-88.167471	12	3			3			3																1				
381	380	42.8438	-88.166982				Not Sampled																								
382	381	42.843792	-88.166493				Not Sampled																								
383	382	42.843784	-88.166003				Not Sampled																								
384	383	42.843777	-88.165514				Not Sampled																								
385	384	42.843769	-88.165025				Not Sampled																								
386	385	42.843761	-88.164536				Not Sampled																								
387	386	42.843753	-88.164046	12	3			3			3										1										
388	387	42.843745	-88.163557	3	3			3			1	3								1					1						

Table continued on next page.

Table D.1 (Continued)

	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL
1	sampling point	Latitude (need electronic copy of site locations)	Longitude (need electronic copy of site locations)	Depth (ft)	Dominant sediment type (1=Silt 2=Silt Sand 3=Sand -	Sampled holding rake pole (P) or rake rope (R)?	comments	Total Rake Fullness	*Myriophyllum spicatum*, Eurasian water-milfoil or Hybrid water-milfoil	*Potamogeton crispus*, Curly-leaf pondweed	*Ceratophyllum demersum*, Coontail	*Chara* sp., Muskgrasses	*Elodea canadensis*, Common waterweed	*Heteranthera dubia*, Water star-grass	*Najas flexilis*, Slender naiad	*Najas marina*, Spiny naiad	*Nuphar variegata*, Spatterdock	*Nymphaea odorata*, White water lily	*Polygonum amphibium*, Water smartweed	*Potamogeton gramineus*, Variable pondweed	*Potamogeton praelongus*, White-stem pondweed	*Potamogeton richardsonii*, Clasping-leaf pondweed	*Stuckenia filiformis*, Fine-leaved pondweed	*Stuckenia pectinata*, Sago pondweed	*Vallisneria americana*, Wild celery	Filamentous algae	Zebra Mussels, Dreissena polymorpha	sp3	sp4	sp5	sp6
389	388	42.843737	-88.163068	1.5	3			1			1	1													1						
390	389	42.843456	-88.167971	2	4			1							1			3		1					1						
391	390	42.843448	-88.167482	4	3			3			1	3	1											1	1						
392	391	42.84344	-88.166993				Not Sampled																								
393	392	42.843432	-88.166503				Not Sampled																								
394	393	42.843424	-88.166014				Not Sampled																								
395	394	42.843417	-88.165525				Not Sampled																								
396	395	42.843409	-88.165036				Not Sampled																								
397	396	42.843401	-88.164546				Not Sampled																								
398	397	42.843393	-88.164057	7	3			3			3										3			1							
399	398	42.843385	-88.163568	2	2			3			1	3																			
400	399	42.843096	-88.167982	2	3			3			1	2												1	2						
401	400	42.843088	-88.167492	3	3			3				3				1									1		1				
402	401	42.84308	-88.167003	5.5	3			3			3														1		1				
403	402	42.843072	-88.166514				Not Sampled																								
404	403	42.843064	-88.166025				Not Sampled																								
405	404	42.843057	-88.165535				Not Sampled																								
406	405	42.843049	-88.165046				Not Sampled																								
407	406	42.843041	-88.164557	7.5	3			3	1		3										3						1				
408	407	42.843033	-88.164068	4	3			3			1	3			1				1		1				1						
409	408	42.843025	-88.163578	1.5	2			3			2	3								1	1										
410	409	42.842728	-88.167503	2	3			3	1		1	3						1							2						
411	410	42.84272	-88.167014	2.5	3			3				3			2	1					1			1							
412	411	42.842712	-88.166525	3	3			3	1		1	2			1									1	2		1				
413	412	42.842704	-88.166035	5	3			3	2			3		1							1			1	1						
414	413	42.842697	-88.165546	6.5	3			3			3										2						1				
415	414	42.842689	-88.165057	5.5	3			3	1		2										3			1			1				
416	415	42.842681	-88.164568	3.5	3			3	1		1										3				2						
417	416	42.842673	-88.164078	1.5	3			3				3								1											
418	417	42.842344	-88.166046	1.5	3			3				3						1		1					1						
419	418	42.842337	-88.165557	2.5	3			3			1	3								2					2						
420	419	42.842329	-88.165068	2	3			3				3									1				1						
421	420	42.842321	-88.164578	1.5	2			1				1								1					1						
422	367a	42.844205	-88.168354	2	3			2			1				2					1					1						

Source: SEWRPC

Table D.2
Summary Statistics for the Lake Denoon Point-Intercept Aquatic Plant Survey: August 19-21, 2013

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X
1	**STATS**	Total vegetation	*Myriophyllum spicatum* ,Eurasian water milfoil	*Potamogeton crispus* ,Curly-leaf pondweed	Ceratophyllum demersum, Coontail	Chara sp., Muskgrasses	Elodea canadensis, Common waterweed	Heteranthera dubia, Water star-grass	Najas flexilis, Slender naiad	Najas marina, Spiny naiad	Nuphar variegata, Spatterdock	Nymphaea odorata, White water lily	Polygonum amphibium, Water smartweed	Potamogeton gramineus, Variable pondweed	Potamogeton praelongus, White-stem pondweed	Potamogeton richardsonii, Clasping-leaf pondweed	Stuckenia filiformis, Fine-leaved pondweed	Stuckenia pectinata, Sago pondweed	Vallisneria americana, Wild celery	Filamentous algae	Zebra Mussels, Dreissena polymorpha	sp3	sp4	sp5
2	Lake Denoon																							
3	Racine County																							
4	WBIC: 761300																							
5	Survey Date:August 19-21, 2013																							
6	**INDIVIDUAL SPECIES STATS:**																							
7	**Frequency of occurrence within vegetated areas (%)**		28.16	0.97	74.76	38.83	2.43	5.34	14.56	2.43	3.88	12.14	0.49	15.53	35.92	2.43	0.49	9.22	28.64	5.83	20.87			
8	**Frequency of occurrence at sites shallower than**		30.05	1.04	79.79	41.45	2.59	5.70	15.54	2.59	4.15	12.95	0.52	16.58	38.34	2.59	0.52	9.84	30.57	6.22	22.28			
9	**Relative Frequency (%)**		9.3	0.3	24.7	12.8	0.8	1.8	4.8	0.8	1.3	4.0	0.2	5.1	11.9	0.8	0.2	3.0	9.5	1.9	6.9			
10	Relative Frequency (squared)	0.12	0.01	0.00	0.06	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00			
11	**Number of sites where species found**		58	2	154	80	5	11	30	5	8	25	1	32	74	5	1	19	59	12	43			
12	**Average Rake Fullness**	2.36	1.67	1.00	2.05	1.73	1.40	1.00	1.27	1.20	2.88	2.40	1.00	1.22	1.82	2.20	1.00	1.00	1.31	1.00	1.00			
13	**#visual sightings**																							
14	**present (visual or collected)**		present	present	present	present	present	present	present	present	present	present	present	present	present	present	present	present	present	present	present			
15																								
16	**SUMMARY STATS:**																							
17	**Total number of sites visited**	**193**																						
18	**Total number of sites with vegetation**	**206**																						
19	**Total number of sites shallower than maximum depth of plants**	**193**																						
20	**Frequency of occurrence at sites shallower than maximum depth of plants**	**106.74**																						
21	**Simpson Diversity Index**	**0.88**																						
22	**Maximum depth of plants (ft)****	**16.00**																						
23	**Number of sites sampled using rake on Rope (R)**	**0**																						
24	**Number of sites sampled using rake on Pole (P)**	**0**																						
25	**Average number of all species per site (shallower than max depth)**	**3.13**																						
26	**Average number of all species per site (veg. sites only)**	**3.01**																						
27	**Average number of native species per site (shallower than max depth)**	**2.80**																						
28	**Average number of native species per site (veg. sites only)**	**2.70**																						
29	**Species Richness**	**19**																						
30	**Species Richness (including visuals)**	**19**																						

Source: SEWRPC

APPENDIX E

AQUATIC PLANT DISTRIBUTION

Figure E.1
Rake Fullness Ratings

Source: Wisconsin Department of Natural Resources and SEWRPC.

SOURCES OF INFORMATION:

Borman, S., Korth, R., & Temte, J. (1997). *Through the Looking Glass: A Field Guide to Aquatic Plants.* Stevens Point, WI, USA: Wisconsin Lakes Partnership.

Robert W. Freckman Herbarium: wisplants.uwsp.edu

Skawinski, P. M. (2011). *Aquatic Plants of the Upper Midwest: A Photographic Field Guide to Our Underwater Forests*. Wausau, Wisconsin, USA: Self-Published.

University of Michigan Herbarium: www.michiganflora.net/home.aspx

Ceratophyllum demersum Coontail
Native

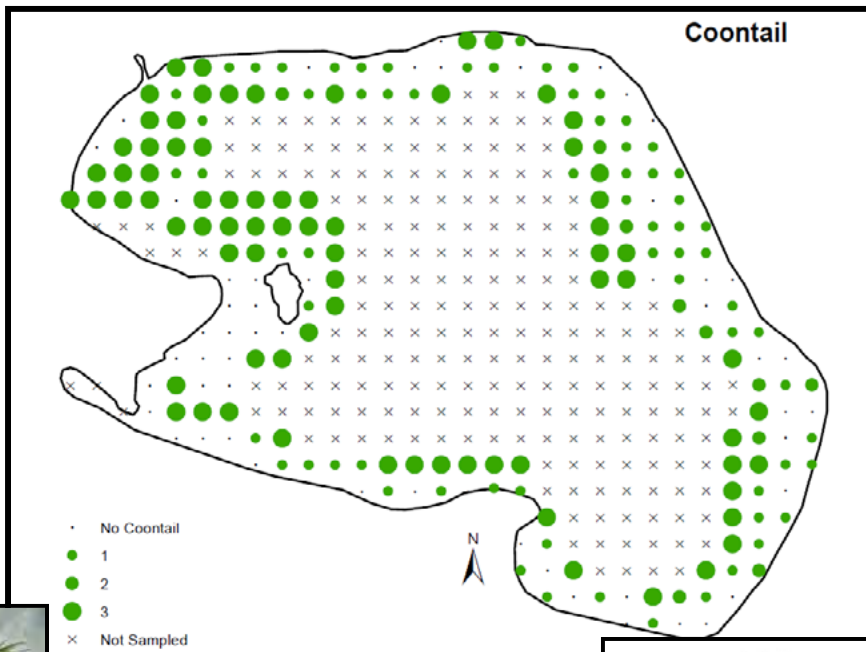
Identifying Features

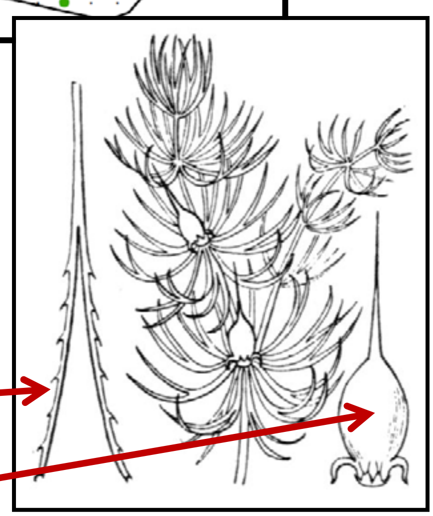
- Often bushy near tips of branches, giving the raccoon tail-like appearance ("coontail")
- Whorled leaves with one to two orders of branching and small teeth on their margins
- Flowers (rare) small and produced in leaf axils

Coontail is similar to spiny hornwort (*C. echinatum*) and muskgrass (*Chara* spp.), but spiny hornwort has some leaves with three to four orders of branching, and coontail does not produce the distinct garlic-like odor of muskgrass when crushed

Ecology

- Common in lakes and streams, both shallow and deep
- Tolerates poor water quality (high nutrients, chemical pollutants) and disturbed conditions
- Stores energy as oils, which can produce slicks on the water surface when plants decay
- Anchors to the substrate with pale, modified leaves rather than roots
- Eaten by waterfowl, turtles, carp, and muskrat





Second-Order Leaf Branching
First-Order Leaf Branching
Toothed Leaf Margins
Fruit (rare)

Chara spp. — Native

Muskgrasses — Algae (not vascular plants)

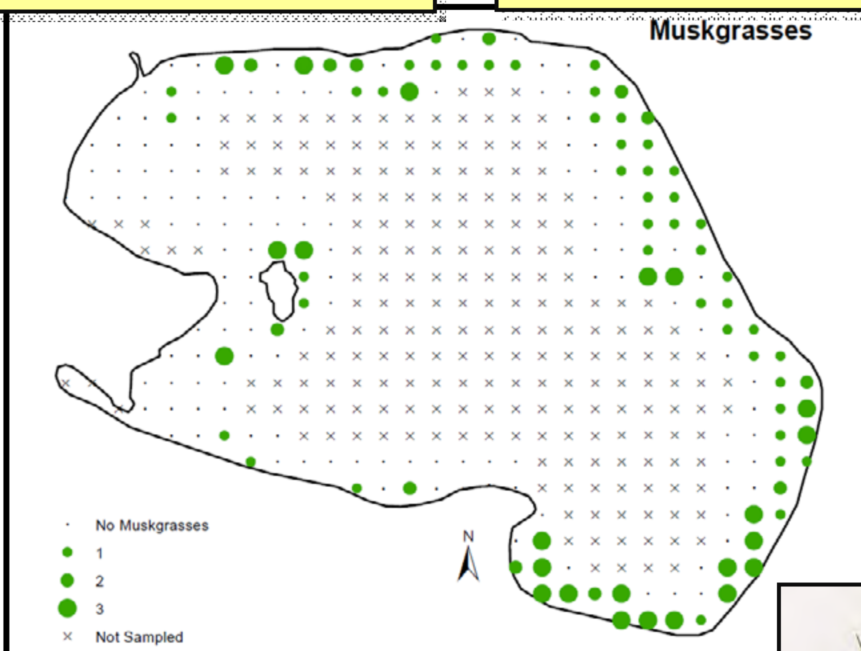
Identifying Features

- Leaf-like, ridged side branches develop in whorls of six or more
- Often encrusted with calcium carbonate, which appears white upon drying (see photo on left, below)
- Yellow reproductive structures develop along the whorled branches in summer
- Emits a garlic-like odor when crushed

Stoneworts (*Nitella* spp.) are similar large algae, but their branches are smooth rather than ridged and more delicate

Ecology

- Found in shallow or deep water over marl or silt, often growing in large colonies in hard water
- Overwinters as rhizoids (cells modified to act as roots) or fragments
- Stabilizes bottom sediments, often among the first species to colonize open areas
- Food for waterfowl and excellent habitat for small fish
- Important To natural phosphorus co-precipitation and sequestration process



Elodea canadensis — Common Waterweed

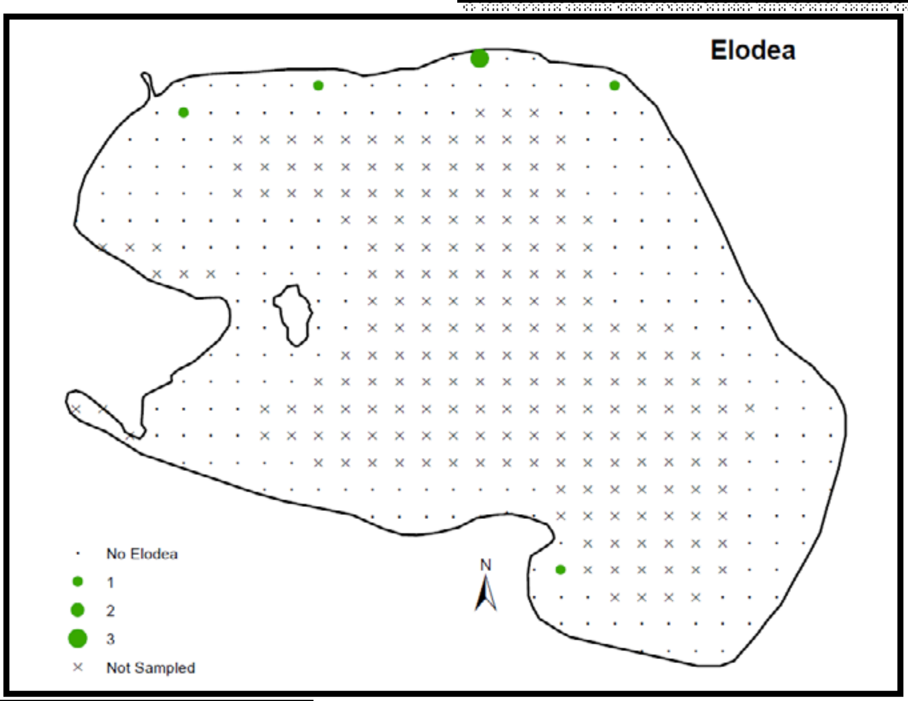
Native

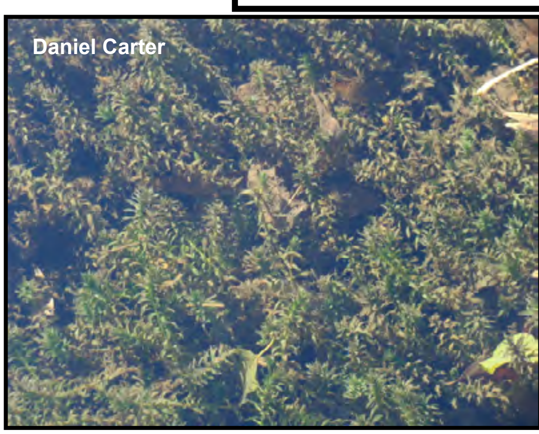
Identifying Features

- Slender stems, occasionally rooting
- Leaves lance-shaped, in whorls of three (rarely two or four), 6.0 to 17 mm long and averaging 2.0 mm wide
- When present, tiny male and female flowers on separate plants (females more common), raised to the surface on thread-like stalks

Ecology

- Found in lakes and streams over soft substrates tolerating pollution, eutrophication and disturbed conditions
- Often overwinters under the ice
- Produces seeds only rarely, spreading primarily via stem fragments
- Provides food for muskrat and waterfowl
- Habitat for fish or invertebrates, although dense stands can obstruct fish movement





Myriophyllum spicatum — Eurasian Water Milfoil

Invasive

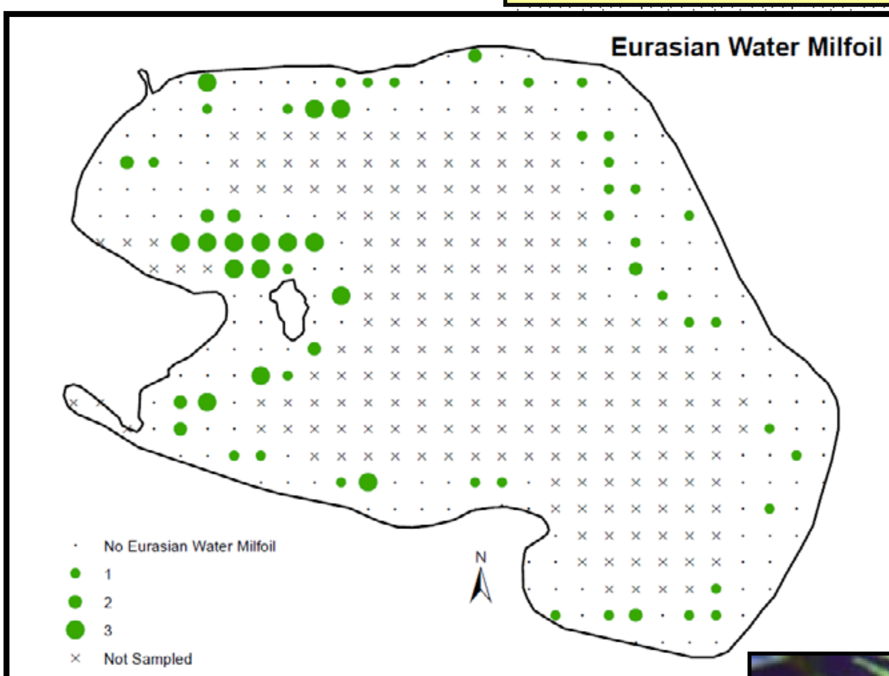
Identifying Features

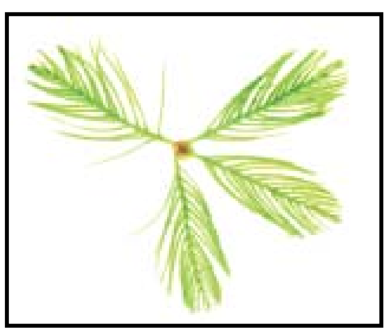
- Stems spaghetti-like, often pinkish, growing long with many branches near the water surface
- Leaves with 12 to 21 pairs of leaflets
- Produces no winter buds (turions)

Eurasian water milfoil is similar to northern water milfoil (*M. sibiricum*). However, northern water milfoil has five to 12 pairs of leaflets per leaf and stouter white or pale brown stems

Ecology

- Hybridizes with northern (native) water milfoil, resulting in plants with intermediate characteristics
- Invasive, growing quickly, forming canopies, and getting a head-start in spring due to an ability to grow in cool water
- Grows from root stalks and stem fragments in both lakes and streams, shallow and deep; tolerates disturbed conditions
- Provides some forage to waterfowl, but supports fewer aquatic invertebrates than mixed stands of aquatic vegetation





Najas flexilis — Bushy Pondweed or Slender Naiad

Native

Identifying Features

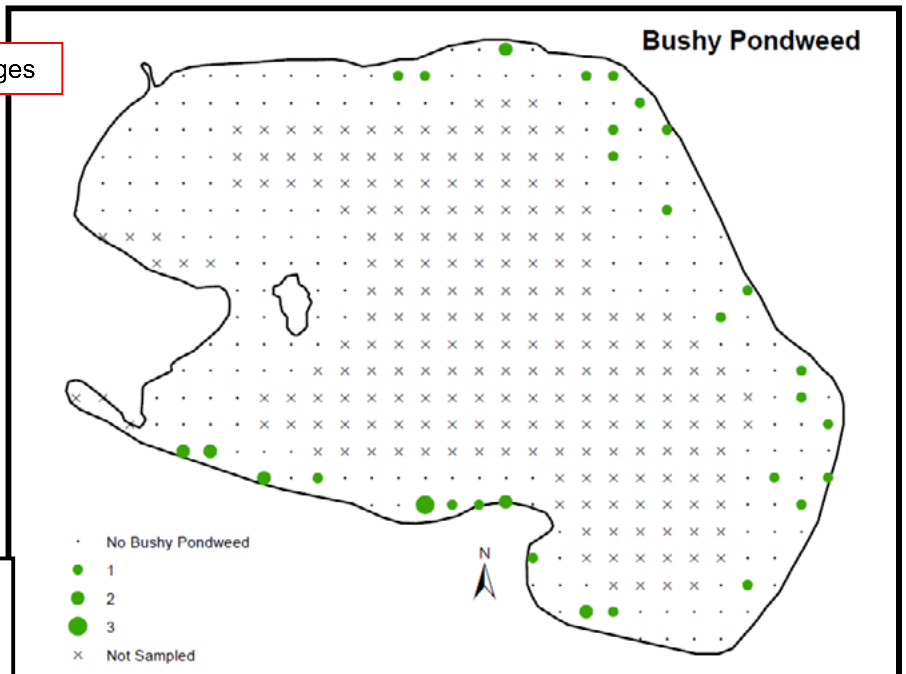
- Leaves narrow (0.4 to 1.0 mm) and pointed with broader bases where they attach to the stem and finely serrated margins
- Flowers, when present, tiny and located in leaf axils
- Variable size and spacing of leaves, as well as compactness of plant, depending on growing conditions

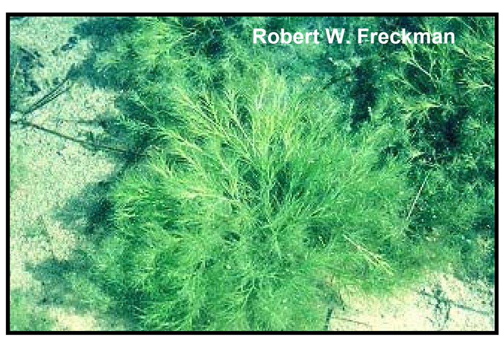
Two other *Najas* occur in southeastern Wisconsin. Southern naiad (*N. guadalupensis*) has wider leaves (to 2.0 mm). Spiny naiad (*N. marina*) has coarsely toothed leaves with spines along the midvein below

Ecology

- In lakes and streams, shallow and deep, often in association with wild celery
- *One of the most important forages of waterfowl*
- An annual plant that completely dies back in fall and regenerates from seeds each spring; also spreading by stem fragments during the growing season

Leaves narrow with serrated edges





Nuphar variegata Native

Spatterdock

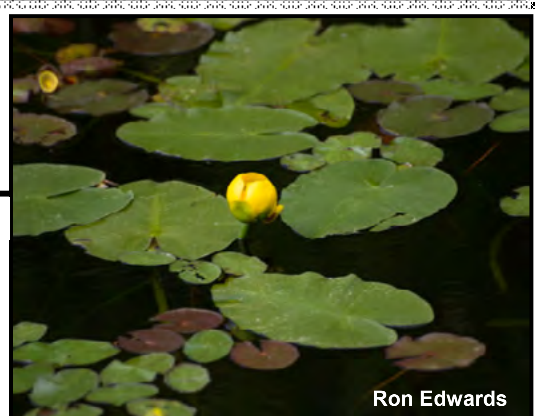
Identifying Features

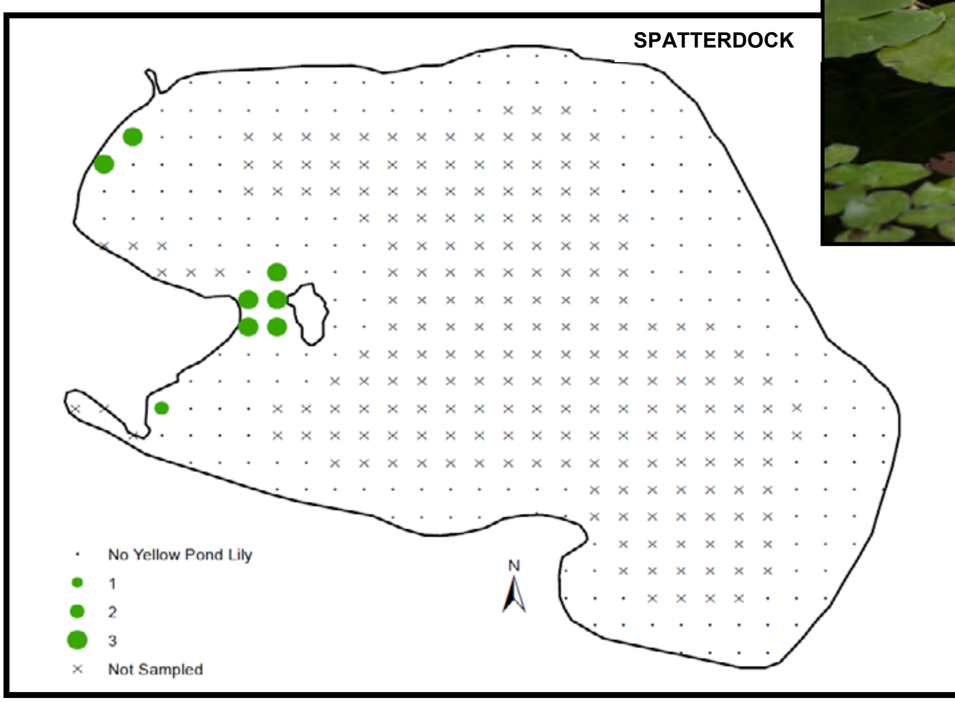
- Leaf stalks winged in cross-section
- Most leaves floating on the water surface, heart-shaped, and notched, with rounded lobes at the base
- Yellow flowers, 2.5 to 5.0 cm wide, often with maroon patches at the bases of the sepals (petal-like structures) when viewed from above

Unlike spatterdock, the similar yellow pond lily (*Nuphar advena*) has leaf stalks that are not winged in cross-section, leaves that more often emerge above the water surface, and leaf lobes that are more pointed. Spatterdock is superficially similar to water lilies (*Nymphea* spp.), but it has yellow versus white flowers and leaves somewhat heart-shaped versus round. American lotus (*Nelumbo lutea*) is also similar, but its leaves are round and un-notched, and its flowers are much larger

Ecology

- In sun or shade and mucky sediments in shallows and along the margins of ponds, lakes, and slow-moving streams
- Overwinters as a perennial rhizome
- Flowers opening during the day, closing at night, and with the odor of fermented fruit
- Buffers shorelines
- Provides food for waterfowl (seeds), deer (leaves and flowers), and muskrat, beaver, and porcupine (rhizomes)
- Habitat for fish and aquatic invertebrates





Nymphaea odorata — White Water Lily
Native

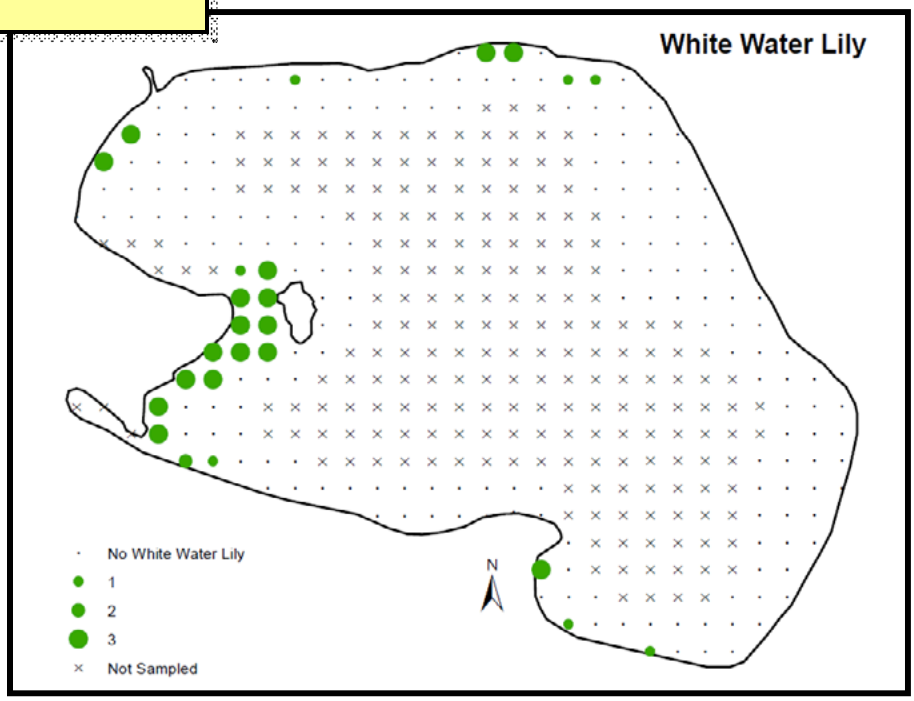
Identifying Features

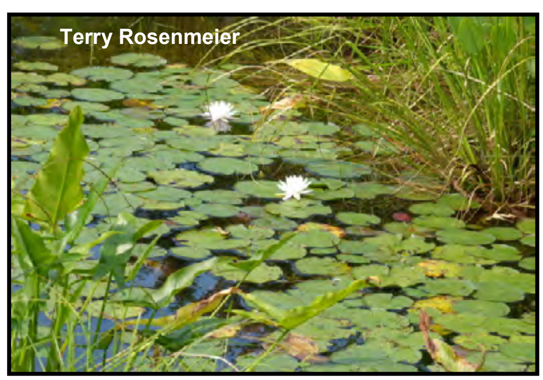
- Leaf stalks round in cross-section with four large air passages
- Floating leaves round (four to 12 inches wide under favorable conditions), *with a notch* from the outside to the center, and reddish-purple underneath
- Flowers white with a yellow center, three to nine inches wide

Pond lilies (*Nuphar* spp.) are superficially similar, but have yellow flowers and leaves somewhat heart-shaped. American lotus (*Nelumbo lutea*) is also similar, but its leaves are *unnotched*

Ecology

- Found in shallow waters over soft sediments
- Leaves and flowers emerge from rhizomes
- Flowers opening during the day, closing at night
- Seeds consumed by waterfowl, rhizomes consumed by mammals





Stuckenia pectinata — Sago Pondweed

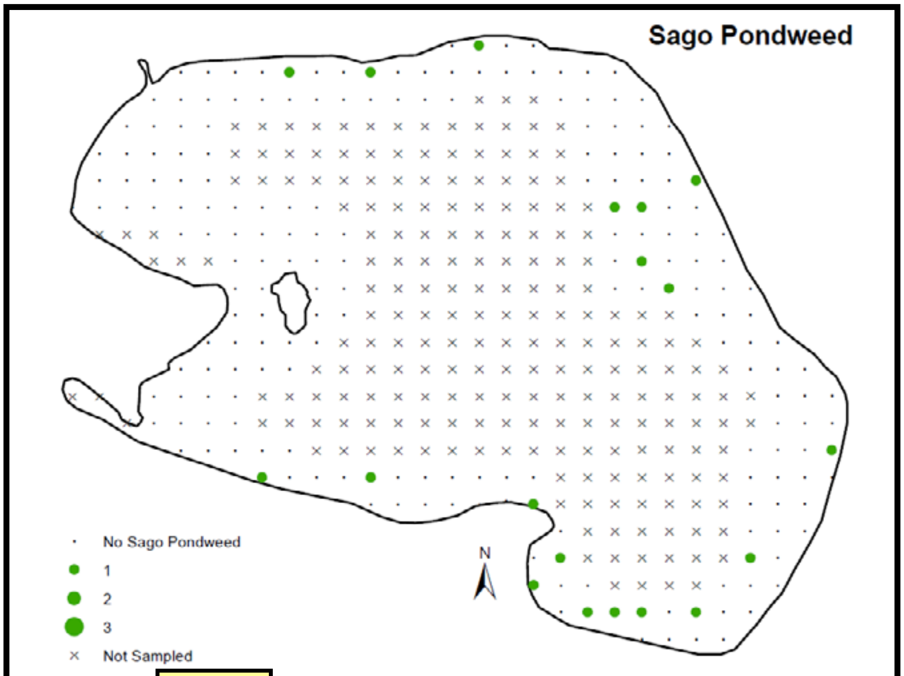
Native

Identifying Features

- Stems often *slightly zig-zagged* and forked multiple times, yielding a fan-like form
- Leaves one to four inches long, very thin, and ending in a sharp point
- Whorls of fruits spaced along the stem may appear as beads on a string

Ecology

- Lakes and streams
- Overwinters as rhizomes and starchy tubers
- Tolerates murky water and disturbed conditions
- Provides abundant fruits and tubers, which are an *important food for waterfowl*
- Provides habitat for juvenile fish



Fruits

Vallisneria americana — Eelgrass

Native

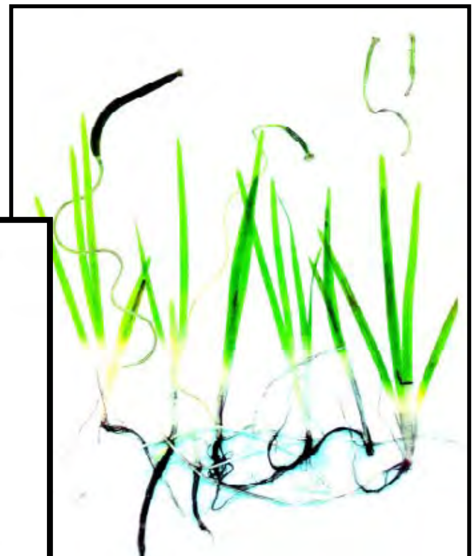
Identifying Features

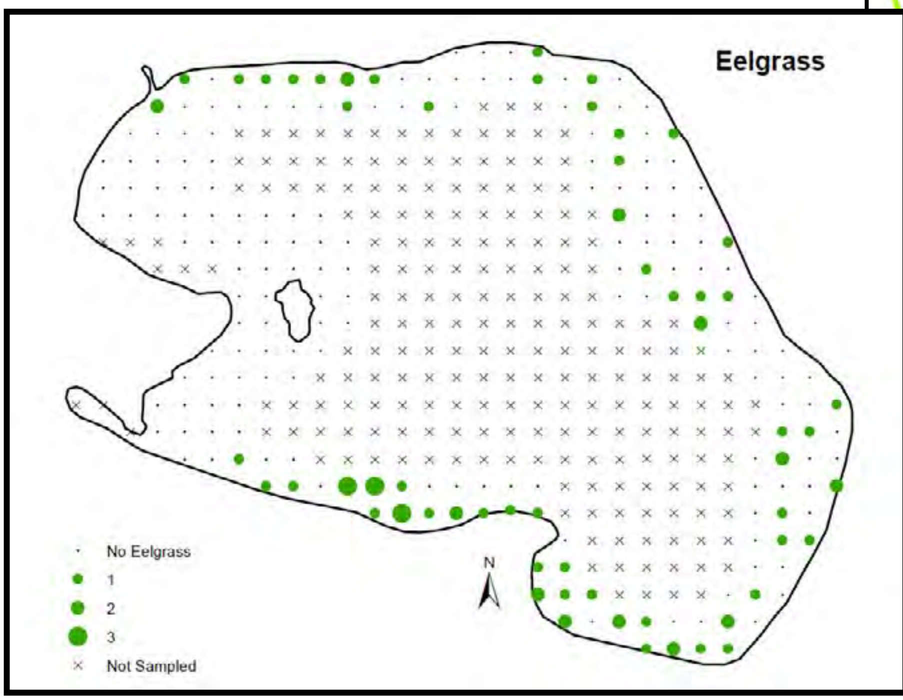
- Leaves ribbon-like, up to two meters long, with a prominent stripe down the middle, and emerging in clusters along creeping rhizomes
- Male and female flowers on separate plants, female flowers raised to the surface on spiral-coiled stalks

The foliage of eelgrass could be confused with the submersed leaves of bur-reeds (*Sparganium* spp.) or arrowheads (*Sagittaria* spp.), but the leaves of eelgrass are distinguished by their prominent middle stripe. The leaves of ribbon-leaf pondweed (*Potamogeton epihydrus*) are also similar to those of eelgrass, but the leaves of the former are alternately arranged along a stem rather than arising from the plant base

Ecology

- Firm substrates, shallow or deep, in lakes and streams
- Spreads by seed, by creeping rhizomes, and by offsets that break off and float to new locations in the fall
- All portions of the plant consumed by waterfowl; an especially important food source for Canvasback ducks
- Provides habitat for invertebrates and fish





Heteranthera dubia — Water Stargrass

Native

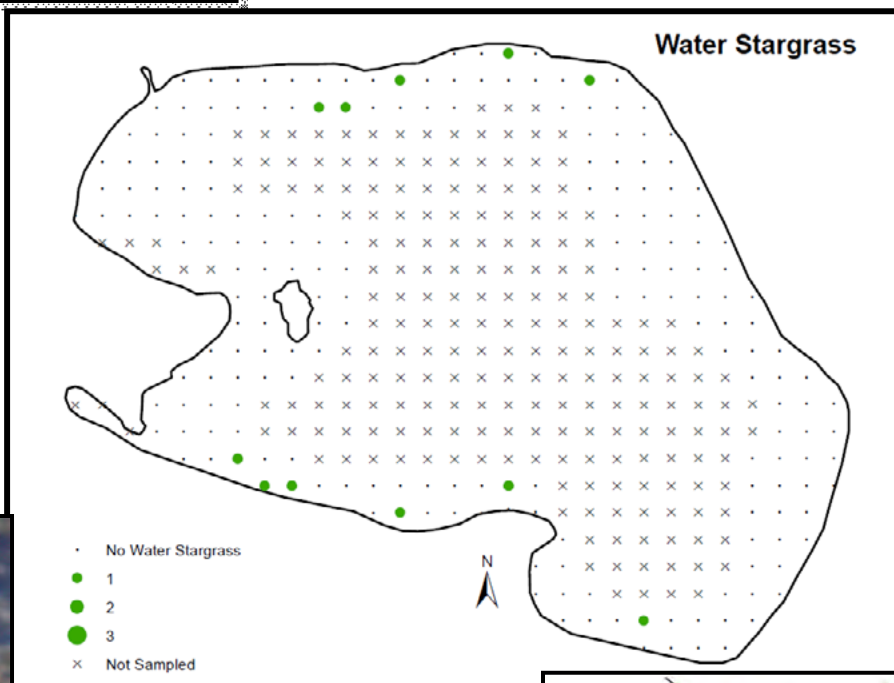
Identifying Features

- Stems slender, slightly flattened, and branching
- Leaves narrow, alternate, with no stalk, and lacking a prominent midvein
- When produced, flowers conspicuous, yellow, and star-shaped (usually in shallow water) or inconspicuous and hidden in the bases of submersed leaves (in deeper water)

Yellow stargrass may be confused with pondweeds that have narrow leaves, but it is easily distinguished by its lack of a prominent midvein and, when present, yellow blossoms

Ecology

- Found in lakes and streams, shallow and deep
- Tolerates somewhat turbid waters
- Overwinters as perennial rhizomes
- Limited reproduction by seed
- Provides food for waterfowl and habitat for fish



Potamogeton richardsonii — CLASPING-LEAF PONDWEED

Wisconsin Special Concern plant

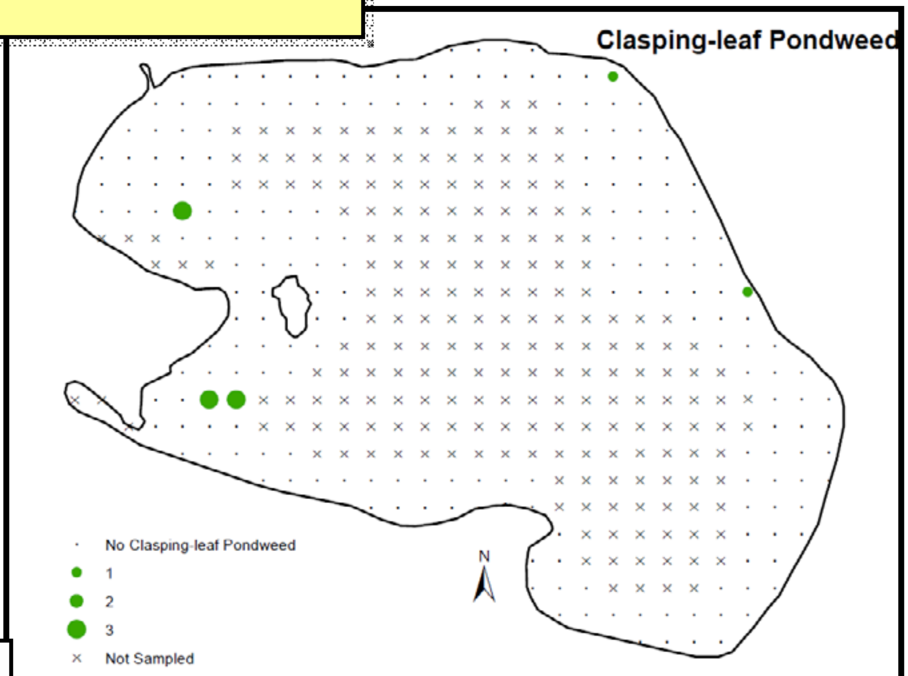
Identifying Features

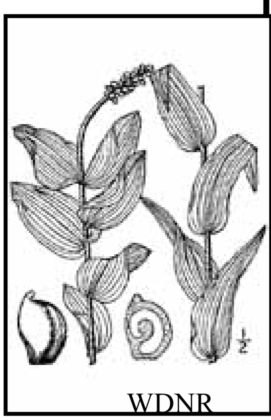
- Leaves alternate, 1 to 7 cm, round, often with finely toothed tip and perfoliate leaves (stalk appears to pass through leaf)
- Fruit greenish-brown, up to 3 mm with short beak, shallow pits and three ridges
- Flowers spike unbranched, cylndric 1 to 7 cm

Clasping-leaf pondweed may be confused with Richardson's pondweed that have clasping leaves, but it is distinguished by perfoliate leaves (cordate bases wrapping entirely around stem), more slender stems, and ovate leaves

Ecology

- Found in lakes and streams, with sandy or rocky substrate
- Moderate associate with deep seepage lakes
- Blooms and Fruits July to October
- Overwinters as perennial rhizomes
- Provides food for waterfowl and habitat for fish





Potamogeton crispus — CURLY LEAF PONDWEED

Invasive

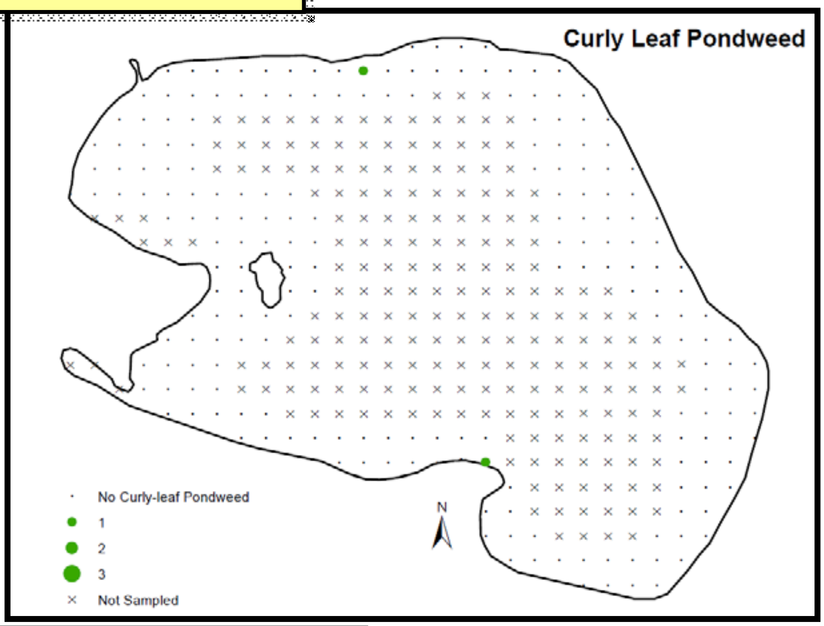
Identifying Features

- Leaves stiff and crinkled, 1/2 –in wide, 2 in length, alternate, dense toward branch ends, small teeth along leaf edge
- Appears reddish brown in water, but is green when examined closely
- Produces winter buds

Curly leaf pondweed may be confused with clasping leaf pondweed, but it is distinguished by the teeth lining the edge of its leaves

Ecology

- Grows from shallow depths to 15ft
- Begins growing in early spring before most pondweeds and dies back in midsummer
- Flowers in June
- Forms dense mats which inhibit the growth of native species
-



Najas marina — SPINY NAIAD

Non-native

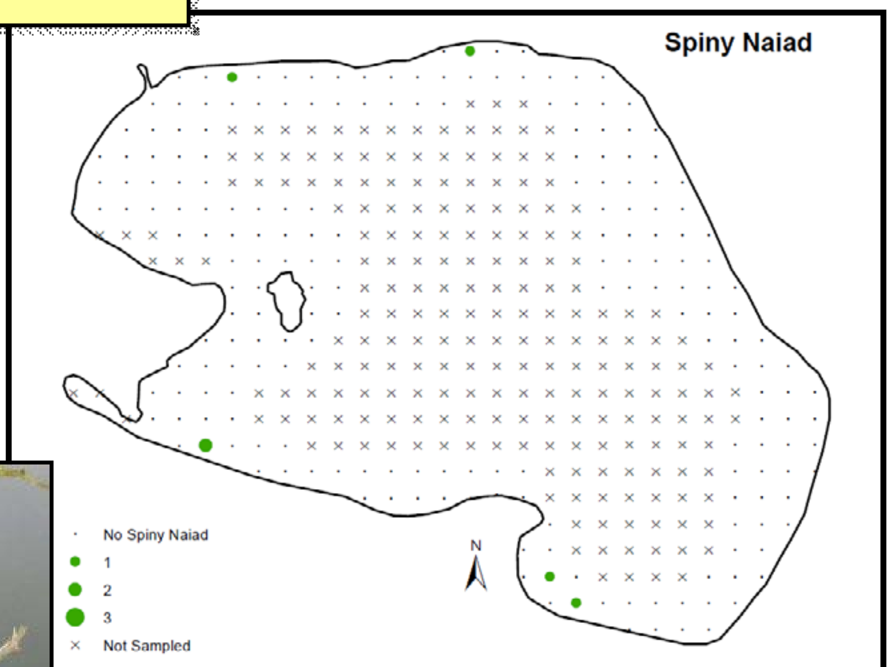
Identifying Features

- Leaves opposite or whorls of three, 8-13 triangular teeth along leaf margins and prickles on the underside of the midrib
- Stems brittle and branched upward, conspicuous internodes on stem with brown, prickly teeth
- Seeds brown, hard, and oval

Native species of naiad exist in Wisconsin may be confused with, but it is easily distinguished by their lack of prickles or easily visible teeth. Najas minor is also invasive in Wisconsin, has visible teeth along leaf edges, but lack prickles at the internodes

Ecology

- Commonly grows in lakes, ponds, reservoirs, or slow moving rivers and streams
- Not native to Wisconsin and may pose a threat due to forming dense mats in suitable habitats (movement restricted)
- Flowering occurs late summer to autumn
- Seed dispersal by water



WDNR

Polygonum amphibium — WATER SMARTWEED

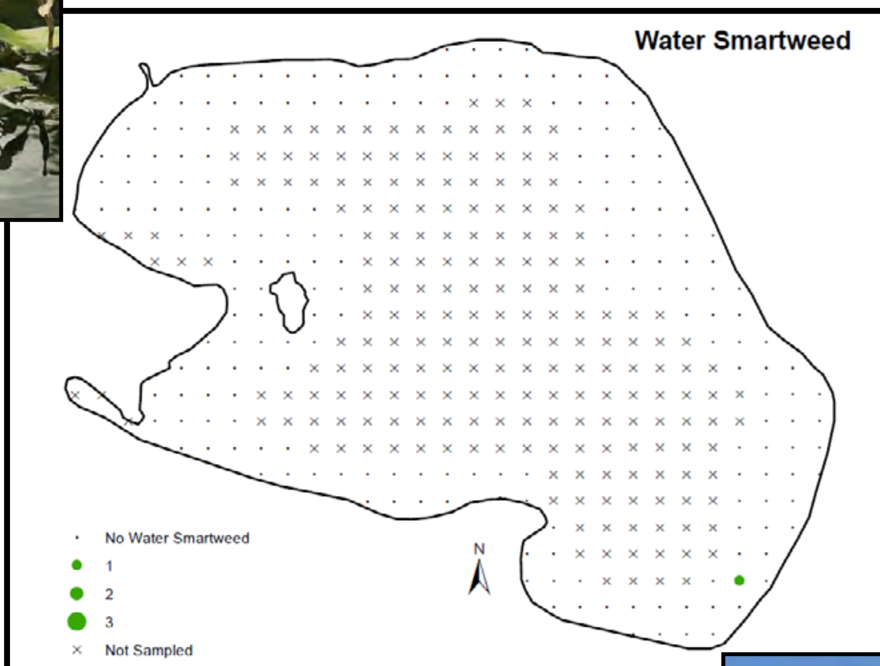
Native

Identifying Features

- Stems hairless, erect, branching up to 40 in
- Leaves alternate, oval, sharply pointed, leathery green
- Small flowers in thick spikes of pink on tall leafless stalk

Ecology

- Grows submerged in water, floating on surface, along lake shores and on waterlogged wetland soils
- When growing on land, stems and leaves are densely hairy
- Blooms June-October
- Perennial, often forming dense colonies
- Medicinal use for itching and swelling; Food source for Native American Great Plains tribes



Suckenia filliformis — THREAD-LEAF PONDWEED

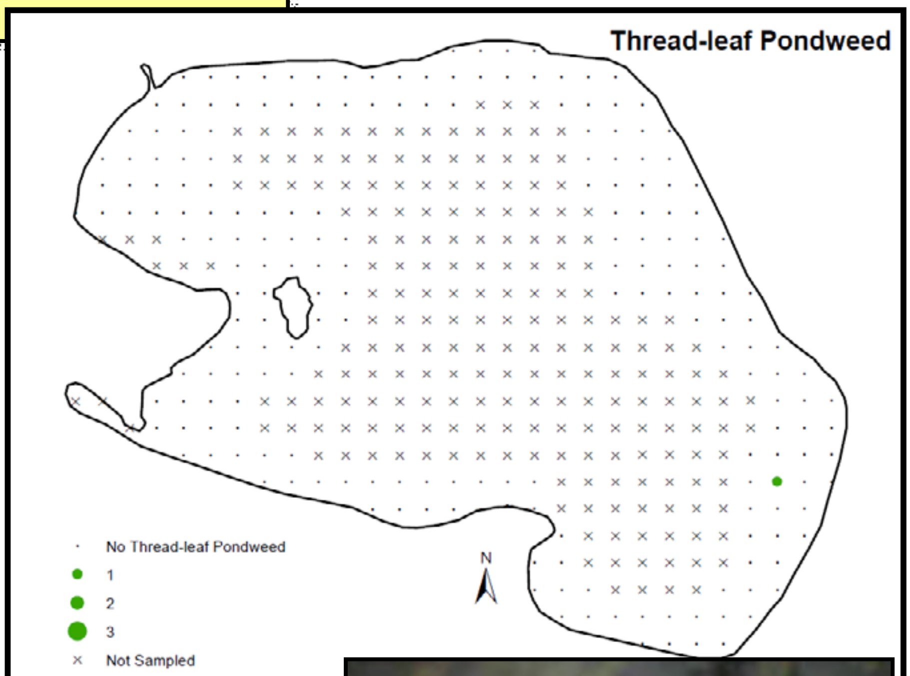
Wisconsin Special Concern plant

Identifying Features

- Thread-like and slender, 20 in
- Stems 0.04 in wide and slightly flattened, branched into two at plant base
- Leaves thin submerged: linear to filiform, 0.4- 4 in length with single or 3 main veins; floating (not always produced): lance-elliptic to roundish, 3-17 veins strongly visible beneath, stipule covers end of leaf attached to stem
- Fruits with lateral, entire, or toothed ridge on each side of dorsal keel, 1-2 mm with minute beak

Ecology

- Perennial in shallow water
- Stems emerge from buried rhizomes that can form tubers
- Blooms mid-July through August
- Emergent aquatic forb
- Highly associated with submergent marshes



Graves Lovell

Graves Lovell

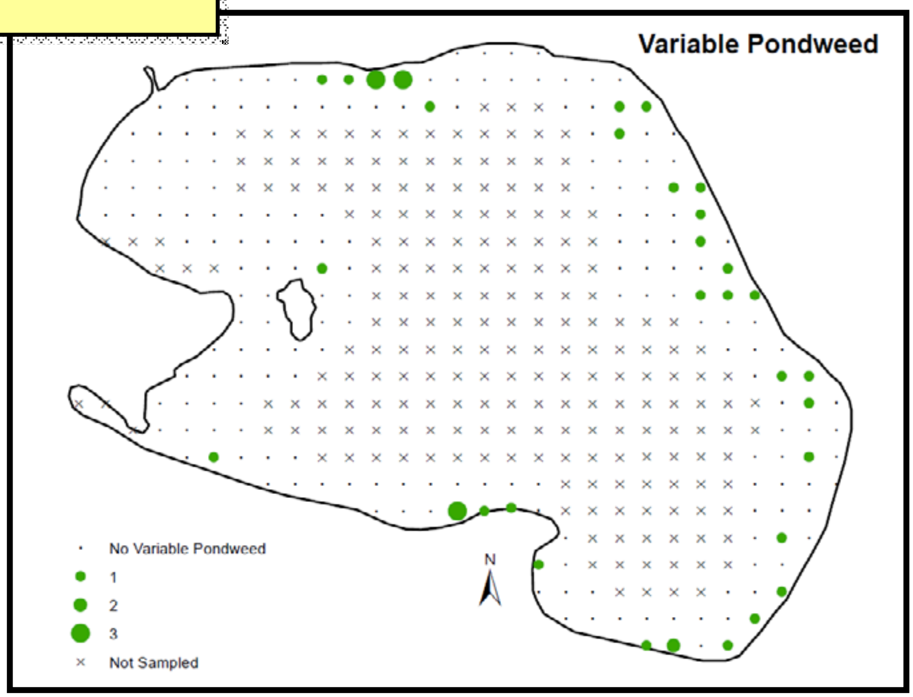
Potamogeton gramineus — VARIABLE PONDWEED
Native

Identifying Features

- Leaves submerged: thin, less than 1/8 in wide, ¾ to 2 ¼ in long, obvious midvein and pointed tip; floating: leathery, oval to elliptical 1/2 – 5 in long, pinitole 1 to 2 times as long as blade
- Fruits flat, 1/8 in wide and grow from axis of floating leaves
- Flowering spikes emerge from both submerged and floating leaves; submerged: short and spherical, floating: club-like

Ecology

- Perennial in shallow, slow-moving or still water
- Submerged portions provide habitat for aquatic organisms that support fish and other wildlife and the seeds are a food source for water fowl



Potamogeton praelongus — WHITE-STEM PONDWEED

Native

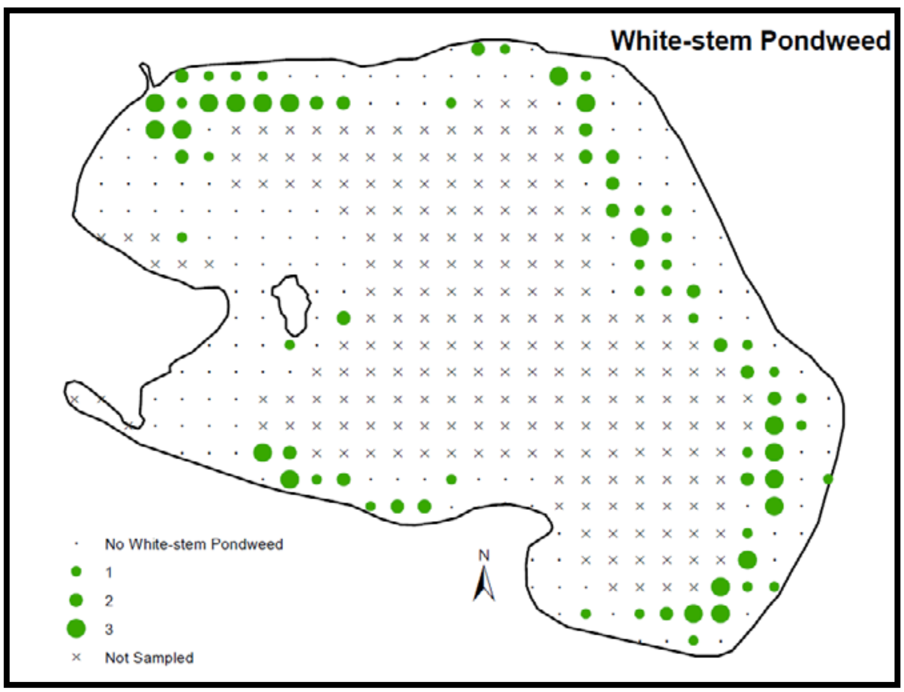
Identifying Features

- Leave shiny, alternate, stalkless, heartshaped bases that clasp stem, 2-14 in long; often appear wavy or twisted with hooded or prow-shaped tips, 5+ distinct veins, wider below middle of leaf
- Stem whitish, zig-zag branching toward top, up to 10ft long
- Flower small, clustered on 6-12 whorls of emergent spikes up to 2 in in length

May be confused with Richardson's pondweed, but distinguished by zip-zag branching stem

Ecology

- Found in deep clear lakes up to 20 ft depth
- Perineal that forms winter buds and has stout rhizomes
- Provides food and habitat for aquatic organisms and water fowl



APPENDIX F

INVASIVE AQUATIC AND WETLAND SPECIES

Regulated Aquatic Invasive Plants in WI

Please report any **prohibited** species (as indicated by the red frame box) to the WDNR.
Report by email to: Invasive.Species@wi.gov or **by phone at: (608) 266-6437**
OR to find out more information, for information on reporting restricted species and whom to contact go to:
http://dnr.wi.gov/invasives/aquatic/whattodo/

Flowering rush
(Butomus umbellatus)

Purple loosestrife
(Lythrum salicaria)

Curly-leaf pondweed
(Potamogeton crispus)

Eurasian water milfoil
(Myriophyllum spicatum)

Australian swamp stonecrop *(Crassula helmsii)*

Brazilian waterweed
(Egeria densa)

Hydrilla
(Hydrilla verticillata)

European frog-bit
(Hydrocharis morsus-ranae)

African elodea
(Lagarosiphon major)

Parrot feather
(Myriophyllum aquaticum)

Brittle waternymph
(Najas minor)

Yellow floating heart
(Nymphoides peltata)

Water chestnut
(Trapa natans)

Fanwort
(Cabomba caroliniana)

Didymo or rock snot (alga)
(Didymosphenia geminata)

Starry stonewort (alga)
(Nitellopsis obtusa)

Restricted Species   Prohibited Species

For more information about NR 40 (WI's Invasive Species Rule), Restricted, or Prohibited species please visit: www.dnr.wi.gov/invasives/classification

Bureau of Watershed Management
Wisconsin Department of Natural Resources
Box 7921
Madison, WI 53707-7921

DNR PUB-WT-960-2011

PRINTED ON RECYCLED PAPER

The Wisconsin Department of Natural Resources provides equal opportunity in its employment, programs, services, and functions under an Affirmative Action Plan. If you have any questions, please write to Equal Opportunity Office, Department of Interior, Washington, D.C. 20240

This publication is available in alternative format (large print, Braille, audio tape, etc.) upon request. Please call (608) 267-7694.

Design and Layout by Bonnie Reichert

Chapter NR 40:
Invasive Species Identification Classification and Control
Aquatic Invasive Plants Summary

The Invasive Species Rule (Chapter NR 40) went into effect on September 1, 2009. The rule establishes a comprehensive, science-based way to classify and regulate invasive species in Wisconsin. The rule divides species into 2 categories, "Prohibited" and "Restricted," with different regulations and control requirements. The rule also establishes "Preventative Measures" to show what actions we can take to slow the spread of invasive species. Chapter NR 40 covers over 128 species, including plants, animals, and microorganisms.

WI Statute 23.22 defines **Invasive Species** as "nonindigenous species whose introduction causes or is likely to cause economic or environmental harm or harm to human health." Not all nonnative plants are harmful, so NR 40 helps us determine which ones are invasive.

Prohibited Invasive Plants *

- These species are not yet in the state or only in a few places
- These species are likely to cause environmental and/or economic harm
- It is still possible to eradicate these species and prevent their spread statewide

Regulations: **Cannot transport, possess, transfer (buy or sell), or introduce without a permit**
Control Authority: Control is required. DNR may order or conduct a control effort

Restricted Invasive Plants *

- These species are already widely established in the state
- High environmental and/or economic impacts are evident with these species
- Complete eradication of these species is unlikely

Regulations: **Cannot transport, transfer (buy or sell), or introduce without a permit**
Control Authority: Control is encouraged but not required

*All viable part of the species (including seeds) are covered by these regulations.

What This Means for You

The primary goal of NR 40 is to slow the spread of invasive species in Wisconsin. The Department is using a "stepped enforcement" protocol, which emphasizes education and voluntary compliance. However, citations may be issued for aquatic invasive species violations. Remember:

- **It is illegal to buy, sell, give away, or barter any species listed under Chapter NR 40.**
- **Please become familiar with the listed plants and their regulated status for your county.**
- **You are responsible to comply with all elements of Chapter NR 40.**

Regulations differ slightly for certain species. Please go to the WDNR website to see listed exemptions for NR40, as well as the rule's implications for aquatic invertebrates, fish, and terrestrial species:

www.dnr.wi.gov/invasives/classification

STOP AQUATIC HITCHHIKERS!
Prevent the spread of invasive species, it's the law

For more information contact the WDNR
Invasive Species Project Coordinator at:
Email: Invasive.Species@wi.gov
Phone: (608) 266-6437

CS.v.8/30/11

Common Wetland Invasive Plants in WI

Please report **prohibited** species (as indicated by red on the maps) and all other species marked with an asterisk(*) when found in or near wetlands or shores. Provide the following data: exact location, land ownership (if known), population size, a photo or voucher specimen, and your contact information.

To report a sighting: send an email to: Invasive.Species@wi.gov or CALL 608-267-5066

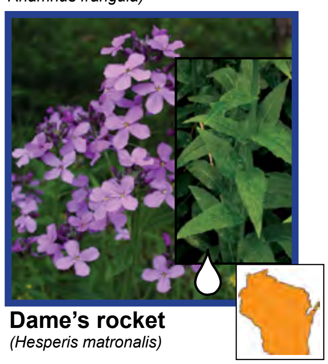
Common buckthorn
(Rhamnus cathartica)

Glossy buckthorn
(Frangula alnus = Rhamnus frangula)

Non-native bush honeysuckles
(Lonicera spp.)

Canada thistle
(Cirsium arvense)

Common forget-me-not
(Myosotis scorpioides)



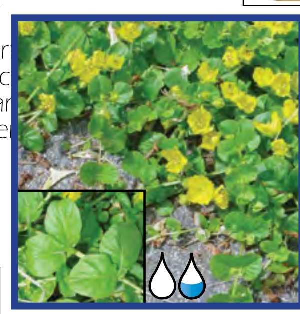
Dame's rocket
(Hesperis matronalis)

***Flowering rush**
(Butomus umbellatus)

***Garden valerian or heliotrope** *(Valeriana officinalis)*

Garlic mustard
(Alliaria petiolata)

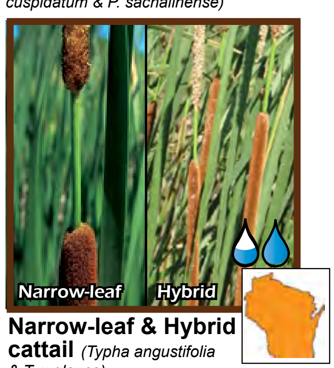
***Japanese & Giant knotweed** *(Polygonum cuspidatum & P. sachalinense)*



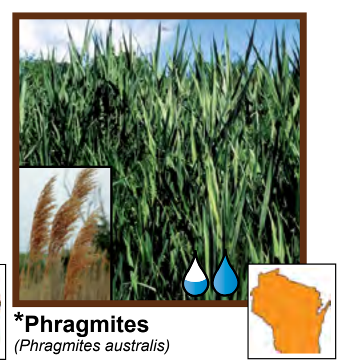
Moneywort
(Lysimachia nummularia)

***Purple loosestrife**
(Lythrum salicaria)

Watercress
(Nasturtium officinale)



Narrow-leaf & Hybrid cattail *(Typha angustifolia & T. x glauca)*



***Phragmites**
(Phragmites australis)

Reed canary grass
(Phalaris arundinacea)

Restricted Species | Prohibited/Restricted Species | Prohibited Species | Tree | Vine | Grass | Shrub | Forb

Species without a map are not regulated by NR 40 (WI's Invasive Species Rule)

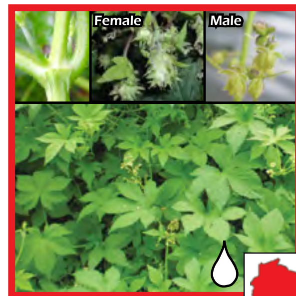
SOMEWHAT WET (Floodplain forests, Seasonally flooded basins) | WET (Wet meadows, Shrub swamps, Wooded swamps) | VERY WET (Deep marsh, Shallow marsh)

Early Detection Wetland Invasive Plants in WI

Early detection plants are either not yet present in WI or not widespread but have the potential to become widespread.

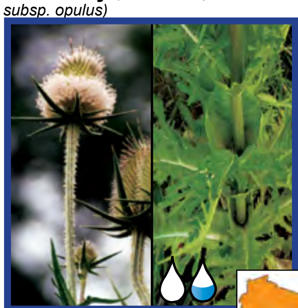
European high-bush cranberry *(Viburnum opulus* L. *subsp. opulus)*


***Chinese yam**
(Dioscorea oppositifolia)



***Japanese hops**
(Humulus japonicus)

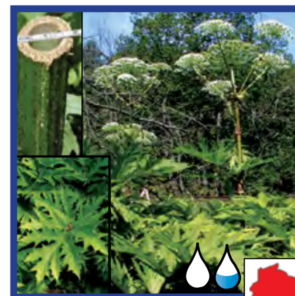
Annual salt marsh aster
(Symphyotrichum subulatum)




Cut-leaved teasel
(Dipsacus laciniatus)


***European marsh thistle** *(Cirsium palustre)*

False spirea
(Sorbaria sorbifolia)




***Giant hogweed**
(Heracleum mantegazzianum)


***Hairy willow herb**
(Epilobium hirsutum)


***Poison hemlock**
(Conium maculatum)

Queen-of-the-meadow
(Filipendula ulmaria)

Seaside goldenrod
(Solidago sempervirens)

Yellow garden loosestrife
(Lysimachia vulgaris)

***Yellow iris**
(Iris pseudacorus)


***Japanese stilt grass**
(Microstegium vimineum)


***Tall or Reed manna grass** *(Glyceria maxima)*

For more information about NR 40 (WI's Invasive Species Rule), Restricted, or Prohibited species please visit:
www.dnr.wi.gov/invasives/classification
For more information about the plant species please visit: http://dnr.wi.gov/wetlands/invasive.html

Bureau of Endangered Resources
and Division of Forestry
Wisconsin Department of Natural Resources
Box 7921
Madison, WI 53707-7921

PRINTED ON RECYCLED PAPER

DNR PUB-WT-930-2010

Design and Layout by Bonnie Reichert

APPENDIX G

2,4-D CHEMICAL FACT SHEET

Wisconsin Department of Natural Resources

January 2012

2,4-D Chemical Fact Sheet

Formulations

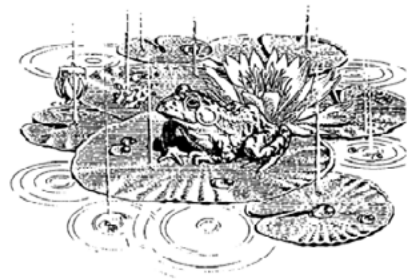
2,4-D is an herbicide that is widely used as a household weed-killer, agricultural herbicide, and aquatic herbicide. It has been in use since 1946, and was registered with the EPA in 1986 and re-reviewed in 2005. The active ingredient is 2,4-dichloro-phenoxyacetic acid. There are two types of 2,4-D used as aquatic herbicides: dimethyl amine salt and butoxyethyl ester. Both liquid and slow-release granular formulations are available. 2,4-D is sold under the trade names Aqua-Kleen, Weedar 64 and Navigate (product names are provided solely for your reference and should not be considered endorsements nor exhaustive).

Aquatic Use and Considerations

2,4-D is a widely-used herbicide that affects plant cell growth and division. It affects primarily broad-leaf plants. When the treatment occurs, the 2,4-D is absorbed into the plant and moved to the roots, stems, and leaves. Plants begin to die in a few days to a week following treatment, but can take several weeks to decompose. Treatments should be made when plants are growing.

For many years, 2,4-D has been used primarily in small-scale spot treatments. Recently, some studies have found that 2,4-D moves quickly through the water and mixes throughout the waterbody, regardless of where it is applied. Accordingly, 2,4-D has been used in Wisconsin experimentally for whole-lake treatments.

2,4-D is effective at treating the invasive Eurasian watermilfoil (*Myriophyllum spicatum*). Desirable native species that may be affected include native milfoils, coontail (*Ceratophyllum demersum*), naiads (*Najas* spp.), elodea (*Elodea canadensis*) and duckweeds (*Lemna* spp.). Lilies (*Nymphaea* spp. and *Nuphar* spp.) and bladderworts (Utricularia spp.) also can be affected.



Post-Treatment Water Use Restrictions

There are no restrictions on eating fish from treated water bodies, human drinking water or pet/livestock drinking water. Following the last registration review in 2005, the ester products require a 24-hour waiting period for swimming. Depending on the type of waterbody treated and the type of plant being watered, irrigation restrictions may apply for up to 30 days. Certain plants, such as tomatoes and peppers and newly seeded lawn, should not be watered with treated water until the concentration is less than 5 parts per billion (ppb).

Herbicide Degradation, Persistence and Trace Contaminants

The half-life of 2,4-D (the time it takes for half of the active ingredient to degrade) ranges from 12.9 to 40 days depending on water conditions. In anaerobic lab conditions, the half-life has been measured up to 333 days. After treatment, the 2,4-D concentration in the water is reduced primarily through microbial activity, off-site movement by water, or adsorption to small particles in silty water. It is slower to degrade in cold or acidic water, and appears to be slower to degrade in lakes that have not been treated with 2,4-D previously.

There are several degradation products from 2,4-D: 1,2,4-benzenetriol, 2,4-dichlorophenol, 2,4-dichloroanisole, chlorohydroquinone (CHQ), 4-chlorophenol and volatile organics.

Impacts on Fish and Other Aquatic Organisms

Toxicity of aquatic 2,4-D products vary depending on whether the formulation is an amine or an ester 2,4-D. The ester formulations are toxic to fish and some important invertebrates such as water fleas (*Daphnia*) and midges at application rates; the amine formulations are not toxic to fish or invertebrates at application rates. Loss of habitat following treatment may cause reductions in populations of invertebrates with either formulation, as with any herbicide treatment. These organisms only recolonize the treated areas as vegetation becomes re-established.

Available data indicate 2,4-D does not accumulate at significant levels in the bodies of fish that have been tested. Although fish that are exposed to 2,4-D will take up some of the chemical, the small amounts that accumulate are eliminated after exposure to 2,4-D ceases.

On an acute basis, 2,4-D is considered moderately to practically nontoxic to birds. 2,4-D is not toxic to amphibians at application rates; effects on reptiles are unknown. Studies have shown some endocrine disruption in amphibians at rates used in lake applications, and DNR is currently funding a study to investigate endocrine disruption in fish at application rates.

As with all chemical herbicide applications it is very important to read and follow all label instructions to prevent adverse environmental impacts.

Human Health

Adverse health effects can be produced by acute and chronic exposure to 2,4-D. Those who mix or apply 2,4-D need to protect their skin and eyes from contact with 2,4-D products to minimize irritation, and avoid inhaling the spray. In its consideration of exposure risks, the EPA believes no significant risks will occur to recreational users of water treated with 2,4-D.

Concerns have been raised about exposure to 2,4-D and elevated cancer risk. Some (but not all) epidemiological studies have found 2,4-D associated with a slight increase in risk of non-Hodgkin's lymphoma in high exposure populations (farmers and herbicide applicators). The studies show only a possible association that may be caused by other factors, and do not show that 2,4-D causes cancer. The EPA determined in 2005 that there is not sufficient evidence to classify 2,4-D as a human carcinogen.

The other chronic health concern with 2,4-D is the potential for endocrine disruption. There is some evidence that 2,4-D may have estrogenic activities, and that two of the break-down products of 2,4-D (4-chlorophenol and 2,4-dichloroanisole) may affect male reproductive development. The extent and implications of this are not clear and it is an area of ongoing research.

For Additional Information

Environmental Protection Agency
Office of Pesticide Programs
www.epa.gov/pesticides

Wisconsin Department of Agriculture, Trade, and Consumer Protection
http://datcp.wi.gov/Plants/Pesticides/

Wisconsin Department of Natural Resources
608-266-2621
http://dnr.wi.gov/lakes/plants/

Wisconsin Department of Health Services
http://www.dhs.wisconsin.gov/

National Pesticide Information Center
1-800-858-7378
http://npic.orst.edu/

Wisconsin Department of Natural Resources
Box 7921
Madison, WI 53707-7921

DNR PUB-WT-964 2012

CITY OF MUSKEGO PUBLIC WATERS AND BEACHES ORDINANCE

APPENDIX H

CITY OF MUSKEGO

CHAPTER 20 - PUBLIC WATERS AND BEACHES

20.01 STATE STATUTES ADOPTED
The statutory provisions describing and defining regulations with respect to boats and boating, and particularly Section 30.50 to 30.71, Wisconsin Statutes and any amendments thereto, exclusive of any provisions therein relating to the penalties to be imposed or the punishment for violation thereof, are hereby adopted. Any act required to be performed or prohibited by any such statute, which are incorporated herein by reference is required or prohibited by this section. (Ord. #725 - 5-12-92)

20.02 ADDITIONAL REGULATIONS - Motorboats. (Ord. #462 - 9-13-83)
(1) (2) and (4) are deleted. (Ord. #462 - 9-13-83)
(3) No person may operate a motorboat within 150 feet of any dock, pier, or buoyed restricted area at a speed in excess of slow-no-wake. (Ord. #983 - 04-13-99)
(5) Excessive Motor Noise. Motorboats shall not be continuously operated without the motor cover firmly secured.
(6) Mufflers. The engine of every motorboat propelled by an internal combustion engine shall be equipped with a muffler which is so constructed and kept in constant operation that it prevents excessive or unusual noise at all times while the engine is in operation. (Ord. #443 - 11-23-82)

20.025 LITTLE MUSKEGO LAKE - SPEED RESTRICTIONS. (Ord. #502 - 10-9-84)
No one shall operate a motorboat upon Little Muskego Lake between the hours of 8:30 P.M. and 8:00 A.M. at a speed in excess of slow-no-wake.

20.03 ADDITIONAL REGULATIONS - WATER SKIING (CR. #167)
(1) Whenever a boat is used for towing purposes, for water sports or otherwise, there shall be no less than 2 persons in the towing boat, one to operate the boat and one to be in charge of the tow line.
(2) When pulling a skier or another boat the tow rope shall not exceed 75 feet in length.
(3) Any person operating a boat or watercraft on Lake Denoon or Big Muskego Lake's Bass Bay which is towing a person or persons engaged in water skiing, aqua planing, or similar sport or activity must operate in a counterclockwise direction on the lake. A counterclockwise direction is determined by viewing the direction of travel of the boat or watercraft as viewed from a bird's-eye view of the entire lake. (Ord. #953 - 02/19/98)

20.04 EMERGENCY ASSISTANCE (Cr. #167)
When the operator of a boat observes the display on a boat or by a person with an orange flag approximately 18 by 30 inches, he shall render to the boat or person displaying the flag, such assistance as may be necessary to save the boat or persons, or to minimize the damages to them, in so far as is possible to do so without serious danger to his own boat or the persons on board. No person shall display such a flag unless he is in need of assistance to prevent bodily injury or destruction of property.

20.05 WATER SKI JUMPS (Ord. #413 - 06-09-81)
(1) Permit Required. No person shall place or maintain or permit to be placed or maintained any so called "water ski jump" on any lake in the City without a permit from the Council. Such permit shall be for a period of not more than 6 months and shall state the limitations of use.
(2) Application. An application for a permit hereunder shall set forth the following:
(a) Name and address of the owner of the structure.
(b) A scale map of the location of the structure, drawn to a scale of not less than one inch to 200 feet.
(c) Proposed method of securing the structure.
(d) A description of the life and warning devices to be used which shall conform to the rules of the Wisconsin Department of Natural Resources and the U.S. Coast Guard.
(e) Length of time for which the permit is requested.

(f) A copy of a policy of public liability insurance applicable to the structure and its use in an amount of not less than $100,000.00.
(g) A proposed plan for safeguarding the area during jumps from 150 feet before the take off to 100 feet after the landing.
(h) The daylight hours during which the jump will be used.
(3) No person shall tow another person on water skis for the purpose of using a water ski jump which is in violation of this section.
(4) In granting such a license, the City expressly reserves the right to revoke any such license for any reason if it is felt by the City that said license is no longer in the best interest of the public.
(5) A permit fee of $10.00 shall be paid at the time of application. (Ord. #599 03-17-88)

20.06 RACES ON ICE
(1) License Required. No person shall sponsor, promote, participate or engage in any automobile or motorcycle race or other contest on the ice of any lake or other public waters located in the City of Muskego, unless said race or contest has first been specially licensed by the Council and the permit fee therefore as hereinafter provided, has been paid to the City of Muskego.
(2) Application. Application for such a license shall be made to the Council at least 20 days prior to the date on which said race or other contest is to be held. The application for such license shall state:
(a) The name of the person or organization promoting said race or contest;
(b) The type of race or contest and the number of vehicles to be involved;
(c) The names and addresses of the persons who will participate therein;
(d) The time and place of said race or contest;
(e) The number of persons who it is anticipated will attend said race of contest;
(f) The time at which said race or contest will conclude.
(3) License Fee. Each application for such permit shall be accompanied by cash or a certified check in the amount of $200.00, and if a license is granted, the minimum sum of $25 shall be retained as and for the license fee and such an additional sums shall be retained as is necessary for the purposes stated in (4). (Ord. #523 - 04-09-85)
(4) Purposes of Section. The purpose of this section is to promote and protect the safety, health and welfare of the citizens of the City and persons attending such contest, and amount of license fee theretofore, provided is to be a reasonable sum for making an investigation as to the circumstances of the application to provide for necessary additional police protection and to clean up the area after the event. (Ord. #523 - 04-09-85)

20.07 OPERATION OF MOTOR VEHICLES ON ICE
(1) Operation prohibited on Bass Bay. No person shall use or operate any automobile or other motor driven vehicle in excess of 750 pounds gross vehicle weight upon the ice surface of that part of Big Muskego Lake known as Bass Bay, which is the Bay located at the Northwest end of said Big Muskego Lake.
(2) Operations Regulated. No person shall use or operate any automobile or other motor driven vehicle upon the ice surface of any lake or part thereof located in the City:
(a) In any manner so as to endanger persons engaged in skating or in any other winter sport or recreational activity being engaged in upon the ice.
(b) At a speed in excess of 10 miles per hour
(c) When more than 4 persons occupy said vehicle.
(d) To tow, pull or push any person or persons on sleds, skis, skates, toboggan or device or thing of any kind.
(e) Between the hours of 9:30 p.m. and 5:30 a.m. (Am #94)
(f) Unless the operator of the motor vehicle has a valid operator's license, if the motor vehicle is an automobile, truck, motorcycle or moped. (Ord. #597 - 03-03-88)
(3) Propeller driven vehicles prohibited. No person shall operate any propeller driven vehicle, device or thing, whether or not designed for the transporting of a person or persons upon the ice surface of any lake or part thereof located in the City.
(4) Definitions:
(a) The "automobile" as used in this section shall mean all motor vehicles of the type and kind

permitted to be operated on the highways in the State of Wisconsin.
(b) "Motor Driven Vehicle", as used in this section, shall mean any kind of device or thing designed or utilized for propulsion or movement upon the ice using a motor, whether of internal combustion design or not.
(5) No City liability. All traffic on the ice-bound waters lying within the City shall be at the risk of the traveler as set forth in sec. 30.81(3), Wis. Stats., and nothing in this section shall be construed as rendering the enacting authority liable for any accident to those engaged in permitted traffic while this Code is in effect.
(6) Exceptions. Use of snowmobiles and all-terrain vehicles as defined by statutes of the State of Wisconsin, shall not be governed by this section. (Ord. #638 - 04-06-89)

20.08 SKIN DIVING (Ord. #417 - 01-26-82)
(1) No person may engage in underwater diving or swimming with the use of swimming fins or skin diving in waters other than marked swimming areas or within 150 feet of shoreline, and no person may engage in underwater diving or swimming with the use of self-contained underwater breathing apparatus in waters other than marked swimming areas, unless the location of such diving or swimming is distinctly marked by driver's flag, not less than 12 inches high and 15 inches long, displaying one diagonal white stripe 3 inches wide on a red background, and of height above the water so as to be clearly apparent at a distance of 100 yards under normal conditions, and so designed and displayed as to be visible from any point on the horizon. Except in case of emergency, anyone engaging in such diving or swimming shall not rise to the surface outside of a radius of 50 feet from such flag. No person engaged in such diving or swimming in established traffic lanes; nor shall any such person alone or with another, intentionally or unintentionally, block or obstruct any boat in any manner from proceeding to its destination where a reasonable alternative is unavailable. A reasonable alternative route is available when the otherwise unobstructed boat can proceed to its destination without reducing its lawful speed, by passing to the right or to the left of a marked diving operation.
(2) Swimming. When swimming without the use of self-contained underwater breathing apparatus, a suitable boat (motor or otherwise) shall accompany any person or persons swimming more than 150 feet from the shoreline or 75 feet from any anchored swimming raft on any waters within the City of Muskego, and upon adoption of an identical ordinance by the Town of Norway.

20.09 PERMITS REQUIRED FOR SWIMMING BEACHES.
(1) No person shall maintain a swimming beach which is open to the public upon payment of an entrance fee in the City without having first obtained a permit in writing therefore from the Council. Such permit, if issued, shall be for a period of not to exceed one year, and shall not be transferable or assignable.
(2) Before a permit will be issued, an application in writing must be filed with the City Clerk. Such application shall set forth in detail:
(a) The name and address of the owner of the property on which the commercial beach is to be operated.
(b) Length of time for which the permit is requested.
(c) The proposed plan for safeguarding the area during the hours of operation.
(d) The hours during which the commercial venture will be operated.
(3) No person shall operate a commercial beach unless the swimming area is distinctly and clearly marked off by buoys, and it is further required that during the hours that the beach is used by swimmers there shall be a lifeguard on duty who shall possess a Red Cross Life Saving Certificate or its equivalent and who shall be capable of rendering immediate assistance to persons in distress in the water. (Am. #167)

20.10 UNIFORM AIDS TO NAVIGATION: WATERWAY MARKERS. (Cr. #111)
(1) Definitions. A waterway marker is any device designed to be placed in, on or near any navigable water within the City, to convey an official message to a boat operator on matters which may affect health, safety or well-being. Aids to navigation refer to buoys, beacons and other fixed objects in the water which are used to mark obstructions to navigation or to direct navigation through safe channels.
(2) Waterway Markers Used On Waters Within The City. No waterway markers shall be placed in, on or near any navigable waters within the City, except such buoys or other markers as have

been established by the Department of Natural Resources and the United States Coast Guard as uniform navigational aids. The rules and regulations of the Department of Natural Resources and the United States Coast Guard with respect to specifications, color schemes, lettering and marking requirements of waterway markers and aids to navigation shall be kept on file in the Office of the City Clerk. (Reference Wisconsin Administrative Code, Chapter WCD5, Boat Regulations and Registration)

(3) Display of Waterway Markers. No waterway marker shall be displayed, except in conformity with the requirements of the Department of Natural Resources. (Reference Wisconsin Administrative Code as per Section 2). The areas in Big Muskego Lake, Bass Bay, Little Muskego Lake, and Lake Denoon to be marked with regulatory markers requiring slow, no-wake speed shall be as from time to time established by Resolution of the Common Council. (Ord. #929 - 07-03-97)

(4) Authority To Place Markers: Permit Required.

(a) No person shall place any waterway marker or aid to navigation in any navigable waters within the City without a permit to do so issued by the Common Council. Application for a permit shall be made in duplicate on forms provided by the City and filed with the City Clerk. The application shall be set forth in detail:

1. The name and address of applicant.
2. Description of real estate of owner or occupant.
3. Type of marker requested.
4. A sketch showing proposed location of the markers.

(b) The application shall be accompanied by a permit fee as determined from time to time by the Common Council. The permit when authorized shall be issued by the City Clerk, and it shall not be transferable or assignable. The permit shall remain in effect unless surrendered by the applicant, or canceled or revoked by the Common Council for one year.

(5) Maintenance of Waterway Markers. Waterway markers shall be maintained in proper condition or be replaced or removed.

(6) Exemptions. The temporary placement of mooring buoys, race course markers and water ski course markers for special events may be reviewed and authorized by the Finance Committee on an annual basis. (Ord. #1067 - 05-03-2001)

20.11 ADDITIONAL REGULATIONS

The Common Council may from time to time adopt local regulations not contrary to or inconsistent with state statute relative to the equipment, use, or operation of boats, pursuant to Section 30.77(3) and (4) Statutes. Any regulations so adopted shall be promptly posted at all public access points within the jurisdiction of the City of Muskego and a copy thereof shall also be filed with the Department of Natural Resources. (Ord. #313; 6-8-76.)

20.12 NAMING OF PUBLIC WATERS (Ord, #979 - 02/18/99)

Note: Proposed names for public waters require approval of the Wisconsin Geographic Names Council in order to be recognized on maps outside the City.

(1) Requests to name or rename a creek, stream, river or lake shall be made in writing and brought before the Committee of the Whole for recommendation to the Common Council. The person(s) who submitted the request shall provide background information into the rationale behind the request, including biographical information if to be named after a person. Any letters from appropriate organizations and individuals which provide evidence of substantial local support for the proposal shall be submitted at that time. If the creek, stream, river or lake is included in a Lake Protection and Rehabilitation District, approval from the district must be obtained prior to the submittal of the request to the City. Upon approval of the Common Council, the proposed name change shall be submitted to the Wisconsin Geographic Names Council for approval. The Council meets every February to act on all requests.

(2) Once a public body of water is named after a person, the name of the public body of water cannot be changed for a period of one hundred years.

(3) All costs associated with the naming, including the cost of any recording necessary and the cost of signage shall be paid by the person(s) submitting the request. This cost may be waived by the Common Council.

20.13 PENALTIES (Ord. #979 - 02/18/99)
Wisconsin State boating penalties as found in Section 30.80 Wisconsin Statutes and deposits as established in the Uniform Deposit and Bail Schedule established by the Wisconsin Judicial Conference, are hereby adopted by reference with all references to fines amended to forfeitures and all references to imprisonment deleted. The penalty for violation of local regulations not contrary to or inconsistent with State Statute shall be as provided in Chapter 25 of the Municipal Code, unless a specific penalty for a specific ordinance or regulation contained in Chapter 20 or adopted pursuant thereto is adopted. (Ord. #942 - 08-21-97)

ORDINANCE NO. 93-1

AN ORDINANCE TO CREATE CH 8 OF THE CODE OF ORDINANCES OF THE TOWN OF NORWAY PERTAINING TO THE REGULATION OF WATER TRAFFIC, BOATING, AND WATER SPORTS UPON THE WATERS OF LONG,' (KEE-NONG-GO-MONG) LAKE, WAUBEESEE LAKE, WIND LAKE, THE MUSKEGO CHANNEL, THE WIND LAKE CHANNEL, AND THE ANDERSON CHANNEL

The Town Board of the Town of Norway, Racine County, Wisconsin, do hereby ordain as follows:
1. That Chapter 8 of the Municipal Code of the Town of Norway, pertaining to the regulation of water traffic, boating, and water sports is created as follows:

"CHAPTER 8
WATER TRAFFIC. BOATING AND WATER SPORTS

8.01 Intent.
The intent of this ordinance is to provide safe and healthful conditions for the enjoyment of aquatic recreation consistent with public rights and interest and the capability of the water resource.

8.02 Applicability and Enforcement.
The provisions of this ordinance shall apply to the Waters of Long (KEE-NONG-GO-MONG) Lake, Waubeesee Lake, Wind Lake, the Muskego Channel, the Wind Lake Channel, and the Anderson Channel within the jurisdiction of the Town of Norway. The provisions of this Ordinance shall be enforced by the Officers of the Town of Norway Lake Patrol.

8.03 Definitions.
The definitions set forth in Wis. Stat. §30.50, and any amendments thereto, are incorporated herein by reference as though fully set forth.

8.04 Boating Regulations.

(1) Speed.
(a) No motorboat shall be operated outside the traffic lane at a speed in excess of slow-no-wake speed.
(b) No person shall operate a motorboat at a speed greater than is reasonable and prudent under the conditions and having regard for the actual and potential hazards then existing. The speed of a motorboat shall be so controlled as to avoid colliding with any object lawfully in or on the water or with any person, boat or other conveyance in or on the water in compliance with legal requirements and exercising due care. In no event shall any person operate a motorboat at a speed in excess of 50 m.p.h.
(c) Except as set forth under Section 8.07(3) and unless an area is otherwise marked, no person may operate a watercraft within 300 feet of any main shoreline on any lake at a speed in excess of slow-no-wake speed.
(d) No person may operate a personal watercraft at a speed in excess of slow-no-wake within 100 feet of any other boat. This paragraph does not apply if Section 8.07(3)(a), (c) or (d) apply to the operation of the personal watercraft.

(2) Right-Of-Way.
Every person operating a boat shall comply with the following traffic rules, except when deviation there from is necessary to comply with federal pilot rules while operating on the navigable waters of the United States:
(a) When 2 motorboats are approaching each other "head and head," or so nearly so as to involve risk of collision, each boat shall bear to the right and pass the other boat on its left side.
(b) When 2 motorboats are approaching each other obliquely or at right angles, the boat which has the other on her right shall yield the right-of-way to the other. "Right" means from dead ahead, clockwise to 2 points abaft the starboard beam.
(c) When a motorboat and a boat propelled entirely by sail or muscular power are proceeding in such a direction as to involve risk of collision,
the motorboat shall yield the right-of-way to the other boat.

(d) A boat may overtake and pass another boat on either side if it can be done with safety but the boat doing the overtaking shall yield the right-of-way to the boat being overtaken, notwithstanding any other rule in this section to the contrary.
(e) A boat granted the right of way by this section shall maintain her course and speed, unless to do so would probably result in a collision.
(f) Boats leaving a dock or pier shall have
the right-of-way over all other approaching motorboats.

(3) Contests.
No person shall operate a motorboat in a contest of speed or maneuverability unless such race or contest is authorized by the Town Board.

(4) Operation Near Swimmers and Skin Divers.
No person may operate a motorboat repeatedly in a circuitous course around any other boat, or around any person who is swimming, if such circuitous course is within 200 feet of such boat or swimmer; nor shall any boat or water skier operate or approach closer than 100 feet to any skin diver's flag or any swimmer unless the boat is part of the skin diving operation or is accompanying the swimmer, or unless physical conditions make compliance impossible.

(5) Negligent Operation.
No person may operate or use any boat, or manipulate any water skis, aquaplane or similar device in a careless, negligent or reckless manner so as to endanger that person's life, property or person or the life, property or person of another.

(6) Searchlights.
No person shall continually or repeatedly cause the rays of a searchlight to rest upon the pilot of another boat.

(7) Operation By Minor.
(a) No person under the age of 10 years may operate a motorboat. Persons at least 10 and less than 12 years of age may operate a motorboat only if they are either accompanied in the boat by a parent or guardian or a person at least 18 years of age designated by a parent or guardian. Persons at least 12 and less than 16 years of age may operate a motor of any horsepower, but only if they are either accompanied by a parent or guardian or a person at least 18 years of age designated by a parent or guardian, or in possession of a certificate issued under Wis. Stat. §30.74(1). This paragraph does not apply to personal watercraft.
(b)
1. No person under the age of 12 years may operate, lease or rent a personal watercraft.
2. No person who is at least 12 years
of age but under 16 years of age may rent or lease a personal watercraft.
3. No person who is at least 12 years
of age but under 16 years of age may operate a personal watercraft unless he or she is in possession of a certificate issued under Wis. Stat. §30.74(1).
(c) A violation of Paragraphs (a) or (b) done with the knowledge of a parent or guardian shall be deemed a violation by the parent or guardian, and punishable under Section 8.14.

8.05 Hours of Operation.
(1) Wind Lake. No motorboat shall be propelled upon the waters of Wind Lake at a speed in excess of slow-no-wake between sunset and 9:00 a.m.
(2) Waubeesee and Long Lakes. No motorboat shall be propelled upon the waters of Waubeesee or Long Lakes at a speed in excess of slow-no-wake between 6:00 p.m. and 9:00 a.m., Daylight Saving Time or between 5:00 p.m. and 9:00 a.m. Central Standard Time.

8.06 Swimming Regulated.
No person shall swim within the water traffic lane unless accompanied by a staffed boat and shall remain within 50 feet of the boat at all times.

8.07 Water Skiing Regulated.
(1) Prohibited At Certain Times; Exceptions.
(a) Except as provided in par. (b) no person may operate a motorboat towing a person on water skis, aquaplane or similar device unless there is in the boat a competent person in addition to the operator in a position to observe the progress of the person being towed. An observer shall be considered competent if that person can in fact observe the person being towed and relay any signals to the operator. This observer requirement does not apply to motorboats classified as Class A motorboats by the Department actually operated by the persons being towed and so constructed as to be incapable of carrying the operator in or on the motorboat.No person may engage in water skiing, aquaplaning or similar activity, at any time from sunset to sunrise.
(b) In addition to complying with par. (a), no person may operate a personal watercraft that is towing a person who is on water-skis, an aquaplane or similar device unless the personal watercraft is at least 9 feet 11 inches in length and is designed to seat at least 3 persons.

(2) Careful And Prudent Operation.
A person operating a motorboat having in tow a person on water skis, aquaplane or similar device shall operate such boat in a careful and prudent manner and at a reasonable distance from persons and property so as not to endanger the life or property of any person.

(3) Restriction.
(a) No person operating a motorboat that is towing persons engaged in water skiing, aquaplaning or similar activity may operate the motorboat within 100 feet of any occupied anchored boat, any personal watercraft or any marked swimming area or public boat landing.
(b) No person who is engaged in water skiing, aquaplaning or similar activity may get within 100 feet of a personal watercraft or allow the tow rope while in use to get within 100 feet of a personal watercraft.
(c) No person may operate a personal watercraft within 100 feet of any of the following:
1. A motorboat towing a person who is engaged in water skiing, aquaplaning or similar activity.
2. The tow rope of a motorboat towing a person who is engaged in water skiing, aquaplaning or similar activity.
3. A person who is engaged in water skiing, aquaplaning or similar activity.
(d) Paragraphs (a) and (c) do not apply to pickup or drop areas that are marked with regulatory markers and that are open to operators of personal watercraft and to persons and motorboats engaged in water skiing.

(4) Intoxicated Operation.
No person may use water skis, an aquaplane or a similar device while under the influence of an intoxicant to a degree which renders him or her incapable of safely using water skis, an aquaplane or a similar device, or under the combined influence of an intoxicant and any other drug to a degree which renders him or her incapable of safely using waterskis, an aquaplane or a similar device.

(5) Two Skiers Allowed.
No motorboat operator shall tow more than 2 waterskiers, without prior authorization from the Town Board. All downed or dropped skiers, skis, boards and similar contrivances shall be picked up immediately.

(6) Wake-Surfing Prohibited.
No wake surfing shall be permitted (i.e., riding on surfboard or similar contrivance on wake of the boat without the control of a rope connected to a boat).

8.08 Construction of Ramp Prohibited.
No person shall construct, install or use in any manner, a ramp for skiing, jumping or for any purpose whatsoever, without prior authorization from the Town Board.

8.09 Littering Prohibited.
No person shall deposit, place or throw from any boat, raft, pier, platform or similar structure or from the shore, any cans, papers, bottles, debris, refuse, garbage, solid or liquid waste on or into the lake.

8.10 Possession of Glass Prohibited.

No person shall possess or have under his or her control any bottle, jar, container, cup, other receptacle or any other object made of glass, ceramic, earthenware or similar breakable material while on any lake within the Town, whether the lake is frozen or unfrozen. This prohibition does not extend to eyeglasses, lenses or glass which is an integral part of sporting equipment used on the lake.

8.11 Seaplane Landings Prohibited.
No person shall operate on the surface of any waters of the Town any seaplane or aircraft capable of landing on water. All waters shall be designated by standard marking devices to show the prohibition of such use.

8.12 Conduct at Public Access Sites.
(1) In this section the term "public access site" shall refer to any parcels of land on lakes in the Town of Norway owned, under easement, leased or administered by the State of Wisconsin and under the management, supervision and control of the Department of Natural Resources.
(2) No person shall operate or park any vehicle, as defined in §340.01(74), Wis. Stat., as amended from time to time, and which is required to be registered by law, on any public access site, except as may be specifically authorized by law or administrative rule.
(3) No person may enter or be within the boundaries of any public access site, including any posted parking areas therein, between the hours of 11:00 p.m. and the following 6:00 a.m., except as permitted under the rules and regulations of the Department of Natural Resources, as amended from time to time.
(4) No person shall park, stop or leave standing, whether attended or unattended, any vehicle or watercraft within a public access site, contrary
to any posted notice therein.
(5) No person may engage in violent, abusive, indecent, boisterous, unreasonably loud or otherwise disorderly conduct which tends to cause or provoke a disturbance or create a breach of the peace while within the boundaries of any public access site.
(6) No person shall dispose of waste material in any manner at or within a public access site, except by placing the same in receptacles or other locations provided for that purpose.
(7) No person shall engage in any activity or do any act which is contrary to the lawfully posted notices of the Department of Natural Resources at a public access site.

8.13 Uniform Aids to Navigation: Waterway Markers
(1) Definitions.
(a) "Waterway marker" is any device designed to be placed in, or near any water within the Town, to convey an official message to a boat operator on matters which may affect health, safety, or well-being.
(b) "Regulatory marker" is a marker which has no equivalent in the U. S. Coast Guard aid to navigation.
(c) "State aid to navigation" is a waterway marker which is the equivalent of a U. S. Coast Guard aid to navigation.
(d) "Buoy" is any device designed to float which is anchored in the water and which is used to convey a message.

(2) Authority to Place Markers.
No waterway markers shall be placed in, on or near any waters within the Town, except such buoys or other markers as have been authorized by the Town or other political subdivision of the state or federal government.

(3) Waterway Markers used on Waters within the Town of Norway.
All state aids to navigation and regulator markers are to be marked and displayed in conformity with the regulations set forth in Section NR 5.09 of the Wisconsin Administrative Code, which section and amendments thereto are incorporated herein by reference as though fully set forth.

(4) Wind Lake Waterway Markers to be as follows:

2-Slow-No-Wake buoys out 300' from the ordinary high water line at the DNR boat launch (South Wind Lake Road); Map 1 #A & B; GPS locationsA: N42 49.893, W088 08.152, water depth 6 ft.; B: N42 49.871, W088 08.148, water depth 6 ft.

2-Slow-No-Wake buoys out 300' from the ordinary high water line from the property lines of 25313 W. Loomis Road (a.ka. Sportsman's); Map 1 #C & D; GPS locations: C: N42 49.870, W088 08.408; water depth 7 ft.; D: N42 49.893, W088 08.379, water depth 7 ft.

1-Danger Sandbar buoy located 150' from ordinary high water line from 25713 W. Loomis Road; Map 1 #G; GPS location: N42 49.649, W088 08.616; water depth 1.5 ft.

2-Red channel markers on northwest and southeast edge of Weed Island; Map 1 #H & I; GPS locations: H: N42 49.571, W088 08.523; water depth 4 ft. I: N42 49.358, W088 08.219, water depth 3 ft.

1-Green channel marker 300' from the ordinary high water line of 25713 W. Loomis Road; Map 1 #J; GPS location: N42 49.620, W088 08.601, water depth 4 ft.

1-Green channel marker south of the channel marked on the north by the red channel marker 1; Map 1 #K; GPS location: N42 49.342, W088 08.194, water depth 6 ft.

1-Danger Rock buoy 300' out from ordinary high water line of 7157 W. Wind Lake Road; Map 1 #L; GPS location: N42 49.048, W088 08.124, water depth 2.5 ft.

1 -Danger Rock buoy 500' out from ordinary high water line of 7300 W. Wind Lake Road; Map 1 #M; GPS location: N42 49.113, W088 08.146, water depth 3 ft.

1-Danger Rock buoy on east edge of entrance to the bay at Breezy Point Road; Map 1 #N; GPS location: N42 49.144, W088 08.406, water depth 2.5 ft.

1-Danger Rock buoy located due south of 26111 W. Loomis Road and south of Wood Island; Map 1 #P; GPS location: N42 49.193, W088 08.945, water depth 2.5 ft.

2-Center of Channel buoys located 150' and 300' south of the centerline of the Muskego Inlet Canal; Map 1 #Q & R; GPS locations: Q: N42 50.030, W088 08.141, water depth 3 ft.; R: N42 50.006, W088 08.145, water depth 3 ft.

1-Slow-No-Wake buoy located 300' from the ordinary high water line of 26335 Schad Drive; Map 1 #S; GPS location: N42 49.332, W088 08.304, water depth 5 ft.

1-Center of Channel buoy on the centerline of the channel between Wood Island and mainland; Map 1 #S; GPS location: N42 49.332, W088 08.304, water depth 3 ft.

2-Center of Channel buoys, one located near the northern edge of the navigational channel and the other midway between the two Center-of Channel buoys; Map 1 #U & V; GPS location: U: N42 49.482, W088 08.367, water depth 4 ft.; V: N42 49.447, W088 08.352, water depth 3.5 ft.

4-Slow-No-Wake buoys placed 400' apart and 400' from the wooded shoreline of DNR Wooded Island; Map 1 #ZA to ZD; GPS locations: ZA: N42 49.599, W088 08.171, water depth 9 ft.; ZB: N42 49.562, W088 08.141, water depth 7.5 ft.; ZC: N42 49.520, W088 08.095, water depth 7 ft.; ZD: N42 49.429, W088 08.009, water depth 7 ft.

3-Slow-No-Wake buoys placed 400' apart 400' northeast of Weed Island; Map 1 #ZE to ZG; GPS locations: ZE: N42 49.586, W088 08.355, water depth 4.5 ft.; ZF: N42 49.541, W089 08.321, water depth 5 ft.; ZG: N42 49.489, W088 08.256, water depth 5 ft.

3-Slow-No-Wake buoys placed 400' apart 400' southwest of Weed Island; Map 1 #ZH to ZJ; GPS locations: ZH N42 49.446, W088 08.488, water depth 3 ft.; ZI: N42 49.398, W088 08.411, water depth 4 ft.; ZJ: N42 49.336, W088 08.349, water depth 4 ft.

(5) Waubeesee Lake Waterway Marks to be as follows:

1- Slow-No-Wake buoy located in middle of channel behind 7718 Martha Circle

1- Slow-No-Wake buoy located in middle of channel behind 27107 Waubeesee Lake Drive

1- Slow-No-Wake buoy located 300' behind 27009 Waubeesee Lake

Drive
1- Slow-No-Wake buoy located 300' from 26625 Roosevelt Lane

1- Slow-No-Wake buoy located 300' out from 26619 Roosevelt Lane

1- Slow-No-Wake buoy located 300' out from 7236 South Loomis Road 1- Slow-No-Wake buoy located 300' out from 7152 South Loomis Road

(6) Installation.
Removal and Maintenance. Waterway markers shall be installed and removed by the Town of Norway Lake Patrol. Off season transportation, maintenance and storage are to be performed by the Department of Public Works.

8.14 Penalty.
(1) Except as set forth below, any person, firm, association or corporation violating any provision of this chapter shall forfeit not more than $50.00 upon conviction for a first offense and not more than $100.00 upon conviction of the same offense, a second or subsequent time within one year, together with the costs of prosecution in accordance with state law.

(2) Any person violating Section 8.04(5) shall be fined not more than $200.00, together with the costs of prosecution in accordance with state law. Any person violating Section 8.04(5) shall be required to obtain a certificate of satisfactory completion of a safety course under Wis. Stat. §30.74(1).

8.15 Severability.
The provisions of this Ordinance shall be deemed severable and it is expressly declared that the Town Board would have passed the other provisions of this Ordinance irrespective of whether or not one or more provisions may be declared invalid. If any provision of this Ordinance or the application to any person or circumstance is held invalid, the remainder of the Ordinance and the application of such provision to other persons or circumstances shall not be affected."

Submitted to the State of Wisconsin, Department of Natural Resources for Advisory Review this 3rd day of February, 1993.

Approved by the State of Wisconsin, Department of Natural Resources this 7 day of April, 1993.
Adopted by the Town Board of the Town of Norway, Racine County, Wisconsin, this 12 day of April, 1993.

HEALTHY LAKES INIATIVE

APPENDIX I

Green Lake, Green Lake County - Lisa Reas

WISCONSIN'S HEALTHY LAKES IMPLEMENTATION PLAN

TABLE OF CONTENTS

Team Members:
Dave Ferris, Burnett County Land and Water Conservation Department
Pat Goggin, Lake Specialist, UW-Extension Lakes
Jane Malischke, Wisconsin DNR Environmental Grants Specialist
Tom Onofrey, Marquette County Zoning Department
Carroll Schaal, Wisconsin DNR Lakes and Rivers Section Chief
Pamela Toshner, Wisconsin DNR Lake Biologist

The statewide Healthy Lakes initiative is a true, collaborative team effort. The Healthy Lakes Implementation Plan describes relatively simple and inexpensive best practices that lakeshore property owners can implement. The Plan also includes funding/accountability, promotion, and evaluation information so we can grow and adapt the Plan and our statewide strategy to implement it into the future. Working together, we can make Healthy Lakes for current and future generations.

Design and layout by Amy Kowalski, UWEX Lakes

INTRODUCTION

Wisconsin's lakes define our state, local communities, and our own identities. Fond memories of splashing in the water, seeing moonlight reflect off the lake, and catching a lunker last a lifetime. With over 15,000 lakes dotting the landscape, it's no surprise that fishing alone generates a $2.3 billion economic impact each year , and the majority of property tax base rests along shorelines in some of our counties. Unfortunately, we've learned through science that our love for lakes causes management challenges, including declines in habitat and water quality. In fact, the loss of lakeshore habitat was the number one stressor of lake health at a national scale. Lakes with poor lakeshore habitat tend to have poor water quality. Working together to implement *Wisconsin's Healthy Lakes Implementation Plan* (Plan), we can improve and protect our lakes for future generations to enjoy, as well.

This Plan identifies relatively simple habitat and water quality best practices that may be implemented on the most typical lakeshore properties in Wisconsin. We encourage do-it-yourselfers to use these practices but have also created a Wisconsin Department of Natural Resources (DNR) Lake Classification and Protection Grant *Healthy Lakes* sub-category for funding assistance. Furthermore, local partners like lake groups and counties may choose to integrate the Plan into their lake management, comprehensive planning, and shoreland zoning ordinance efforts.

It's important to consider this plan in the context of the lake and local community's management complexity. The best practices' effectiveness will increase cumulatively with additional property owner participation and depend on the nature and location of the lake. For example, if every property owner implemented appropriate Healthy Lakes best practices on a small seepage lake, also known as a pothole or kettle lake, within a forested watershed, the impact would be greater than on a large impoundment in an agricultural region of Wisconsin. Nevertheless, all lakes will benefit from these best practices, and even with limited impact, they are a piece of the overall lake management puzzle that lakeshore property owners can directly control. More lakeshore property owners choosing to implement Healthy Lakes best practices through time means positive incremental change and eventually success at improving and protecting our lakes for everyone.

GOALS AND OBJECTIVES

Wisconsin's Healthy Lakes Implementation Plan goal is to protect and improve the health of our lakes by increasing lakeshore property owner participation in habitat restoration and runoff and erosion control projects.

- Statewide objective: single-parcel participation in Healthy Lakes will increase 100% in 3 years (i.e. 2015 to 2017).
- Individual lake objective: lake groups or other partners may identify their own habitat, water quality, and/or participation goal(s) through a local planning and public participation process.
  - Partners may adopt this Plan, as is by resolution, or integrate the Plan into a complimentary planning process such as lake management or comprehensive planning.

Wisconsin's Healthy Lakes Implementation Plan, and the diversion and rock infiltration practices in particular, are not intended for heavily developed parcels, sites with large volumes of runoff, or sites with complex problems that may require engineering design. Technical assistance and funding are still available for these sites; contact your county land and water conservation department or local DNR lakes biologist for more information.

The target audience for this Plan and implementation of the associated practices is lakeshore property owners, including: permanent and seasonal homeowners, municipalities, and businesses.

It will be necessary to do additional planning work to implement Wisconsin's Healthy Lakes Plan and, again, the level of effort will depend on the complexity of the lake and its local community. Planning could be as simple as site-specific property visits and development of design plans, to integrating the Plan into a broader and more comprehensive effort. Your lake group, county land and water conservation department, non-profit conservation association, UW-extension lakes specialist or local educator, and/or DNR lake biologist can provide planning guidance or contacts.

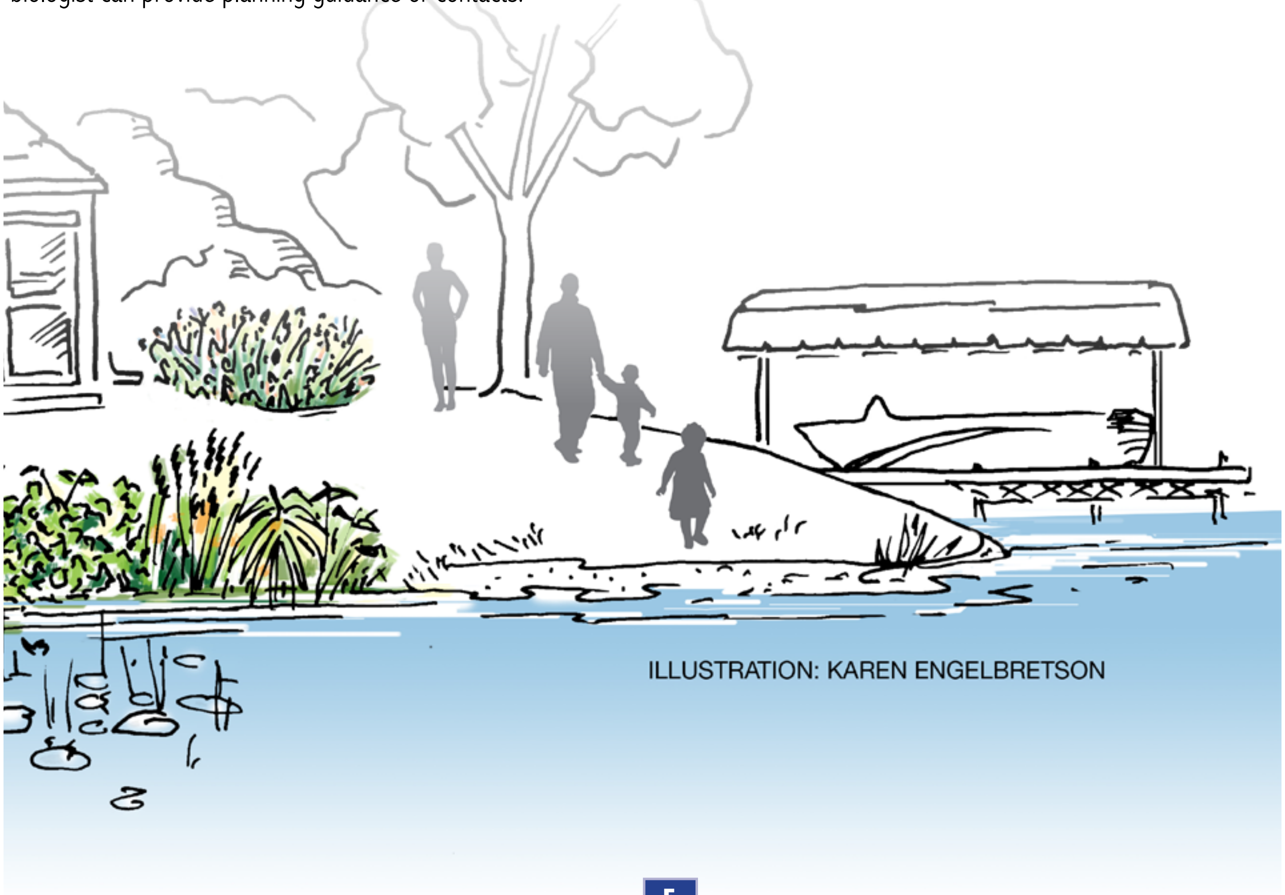


ILLUSTRATION: KAREN ENGELBRETSON

DEFINITIONS

Best practice: a working method, described in detail, which has consistently shown results.

Divert: redirect runoff water.

Habitat: where a plant or animal lives.

Infiltrate: soak into the ground.

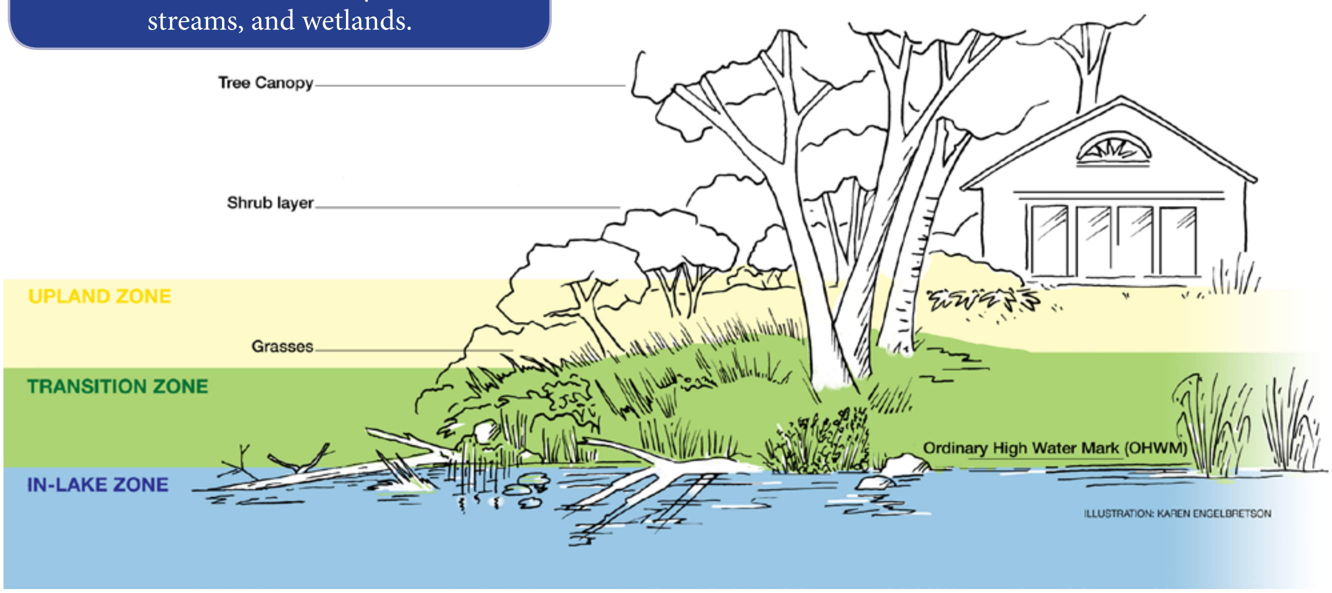
Installed: project cost that includes all materials, labor, and transportation.

Runoff: rain and snowmelt that doesn't soak into the ground and instead moves downhill across land and eventually into lakes, streams, and wetlands.

Wisconsin's Healthy Lakes Implementation Plan divides a typical lakeshore parcel into the following 3 management zones: 1) in-lake, 2) transition, and 3) upland (see illustration below). Best practices are identified for each zone. A team selected these practices based on customer feedback. These practices are:

- relatively simple and inexpensive to implement,
- appropriate for typical lakeshore properties, and
- beneficial to lake habitat and/or water quality.

The Plan also provides cost ranges and averages and technical, regulatory, and funding information for each practice. Fact sheets for each best practice support the Plan and provide more technical detail, and additional guidance is referenced if it currently exists. There is also a funding and administration FAQ fact sheet for those considering pursuing Healthy Lakes grants.



HEALTHY LAKES PLAN

BEST PRACTICES

Best practice descriptions follow. Each description defines the practice, identifies lake health benefits, provides cost ranges and averages based on recent projects, and identifies additional technical and regulatory information. The costs provided are installed costs, which include all materials, labor, and transportation but do not include technical assistance, including design and project management/administration work. Cost ranges are a result of geographic location, property conditions like soils and slopes, and contractor supply and proximity to the project site.

ZONE 1: IN-LAKE

PRACTICE 1 | FISH STICKS

...large woody habitat structures that utilize whole trees grouped together resulting in the placement of more than one tree per 50 feet of shoreline. Fish Sticks structures are anchored to the shore and are partially or fully submerged.

LAKE HEALTH BENEFITS	Improve fish and wildlife habitat Prevent shoreline erosion
COSTS	<u>Range</u> - \$100-\$1000 per cluster (3-5 trees), installed <u>Average</u> - Cost per unit (3-5 trees) averages \$500, installed
TECHNICAL REQUIREMENTS	Healthy Lakes Fact Sheet Series: *Fish Sticks* http://tinyurl.com/healthylakes DNR Fish Sticks Best Practices Manual http://dnr.wi.gov (search for *Fish Sticks best practices*)
REGULATORY INFORMATION	DNR: **Habitat Structure - Fish Sticks General Permit** (\$303 fee unless DNR grant-funded) Fish Sticks must comply with the local shoreland zoning ordinance. Consult with your county or municipal zoning staff.
HEALTHY LAKES GRANT FUNDING	Maximum of \$1000/cluster of 3-5 trees Fish Sticks may be a stand-alone grant activity only if the vegetation protection area (i.e. buffer) complies with local shoreland zoning. If not, the property owner must commit to leaving a 350 ft^2 area un-mowed at the base of the cluster(s) or implement native plantings (Practice 2).

7

ZONE 2: TRANSITION

PRACTICE 2 | 350 FT^2 NATIVE PLANTINGS

...template planting plans with corresponding lists of native plants suited to the given function of the plan. The 350 ft^2 area should be planted adjacent to the lake and include a contiguous area, rather than be planted in patches. Functions are based on the goals for the site. For example, one property owner may want to increase bird and butterfly habitat while another would like to fix an area with bare soil. Native planting functions include the following: lakeshore, bird/butterfly habitat, woodland, low-growing, deer resistant, and bare soil area plantings.

LAKE HEALTH BENEFITS	Improve wildlife habitat Slow water runoff Promote natural beauty 
COSTS	<u>Range</u> - \$480-\$2400 for 350 ft^2 area, installed <u>Average</u> - \$1000 per 350 ft^2, installed
TECHNICAL REQUIREMENTS	Healthy Lakes Fact Sheet Series: *350 ft^2 Native Plantings* <u>http://tinyurl.com/healthylakes</u> 350 ft^2 Native Plantings Best Practices Manual
REGULATORY INFORMATION	DNR: an aquatic plant chemical control permit may be necessary if using herbicides in or adjacent to the lakeshore. Native plantings must comply with the local shoreland zoning ordinance. Consult with your county or municipal zoning staff.
HEALTHY LAKES GRANT FUNDING	Maximum of \$1000/350 ft^2 native plantings installed and implemented according to the technical requirements. Only one 350 ft^2 native planting per property per year is eligible for funding. The native plantings dimension must be 350 ft^2 of contiguous area at least 10 feet wide and installed along the lakeshore. Final shape and orientation to the shore are flexible.

ZONE 2: TRANSITION

PRACTICE 3 | DIVERSION PRACTICE

...includes a water bar, diverter, and broad-based dip. These practices use a berm or shallow trench to intercept runoff from a path or road and divert it into a dispersion area. Depending on the site, multiple diversion practices may be necessary.

LAKE HEALTH BENEFITS	Divert runoff water.
COSTS	**Range** - $25-$3750, installed **Average** - $200, installed
TECHNICAL REQUIREMENTS	Healthy Lakes Fact Sheet Series: *Diversion Practice* http://tinyurl.com/healthylakes
REGULATORY INFORMATION	DNR: none. Diversion practices must comply with the local shoreland and floodplain zoning ordinance. Consult with your county or municipal zoning staff.
HEALTHY LAKES GRANT FUNDING	Maximum of $1000/diversion practice installed and implemented according to the technical requirements. Healthy Lakes diversion practice grant funding is not intended for large, heavily developed parcels, sites with large volumes of runoff, or sites with complex problems that may require engineering design.

ZONE 3: UPLAND

PRACTICE 3 | DIVERSION PRACTICE

...includes a water bar, diverter, and broad-based dip. These practices use a berm or shallow trench to intercept runoff from a path or road and divert it into a dispersion area. Depending on the site, multiple diversion practices may be necessary.

LAKE HEALTH BENEFITS	Divert runoff water.
COSTS	<u>Range</u> - $25-$3750, installed <u>Average</u> - $200, installed
TECHNICAL REQUIREMENTS	Healthy Lakes Fact Sheet Series: *Diversion Practice* http://tinyurl.com/healthylakes
REGULATORY INFORMATION	DNR: none. Diversion practices must comply with the local shoreland and floodplain zoning ordinance. Consult with your county or municipal zoning staff.
HEALTHY LAKES GRANT FUNDING	Maximum of $1000/diversion practice installed and implemented according to the technical requirements. Healthy Lakes diversion practice grant funding is not intended for large, heavily developed parcels, sites with large volumes of runoff, or sites with complex problems that may require engineering design.

ZONE 3: UPLAND

PRACTICE 4 | ROCK INFILTRATION PRACTICE

...ian excavated pit or trench filled with rock that reduces runoff by storing it underground to infiltrate. A catch basin and/or perforated pipe surrounded by gravel and lined with sturdy landscape fabric may be integrated into the design to capture, pre-treat, and redirect water to the pit or trench. Pit and trench size and holding capacity are a function of the area draining to it and the permeability of the underlying soil.

Deer Lake, Polk County - Cheryl Clemens

LAKE HEALTH BENEFITS	Divert runoff water. Clean runoff water. Infiltrate runoff water.
COSTS	<u>Range</u> - $510-$9688 per rock infiltration practice, installed <u>Average</u> - $3800 per rock infiltration practice, installed
TECHNICAL REQUIREMENTS	Healthy Lakes Fact Sheet Series: *Rock Infiltration Practice* http://tinyurl.com/healthylakes
REGULATORY INFORMATION	DNR: none. Rock infiltration practices must comply with the local shoreland zoning ordinance. Consult with your county or municipal zoning staff.
HEALTHY LAKES GRANT FUNDING	Maximum of $1000/rock infiltration practice installed and implemented according to the technical requirements. Healthy Lakes rock infiltration practice grant funding is not intended for heavily developed parcels, sites with large volumes of runoff, or sites with complex problems that may require engineering design.

ZONE 3: UPLAND

PRACTICE 5 | RAIN GARDEN

...a landscaped shallow depression with loose soil designed to collect roof and driveway runoff.

LAKE HEALTH BENEFITS	Improve wildlife habitat. Divert runoff water. Clean runoff water. Infiltrate runoff water. Promote natural beauty.
COSTS	Range - \$500-\$9000 per rain garden, installed Average - \$2500 per rain garden, installed
TECHNICAL REQUIREMENTS	Healthy Lakes Fact Sheet Series: *Rain Garden* http://tinyurl.com/healthylakes *Rain Gardens: A How-to Manual for Homeowners* http://dnr.wi.gov/topic/Stormwater/documents/RgManual.pdf
REGULATORY INFORMATION	DNR: none. Rain gardens must comply with the local shoreland zoning ordinance. Consult with your county or municipal zoning staff.
HEALTHY LAKES GRANT FUNDING	Maximum of \$1000/rain garden installed and implemented according to the technical requirements. Healthy Lakes rain garden grant funding is not intended for heavily developed parcels, sites with large volumes of runoff, or sites with complex problems that may require engineering design.

12

FUNDING AND ACCOUNTABILITY

Administrative details and the application process are described in detail in the DNR's Water Grant Application and Guidelines (http://dnr.wi.gov/ search for surface water grants) and the Healthy Lakes website (http://tinyurl/healthylakes) and *Administration and Funding FAQ* fact sheet.

Healthy Lakes grant funding highlights:

- 75% state share grant with a maximum award of $25,000, including up to 10% of the state share available for technical assistance and project management. Technical assistance and project management do not include labor and are based on the entire state share of the grant, not the best practice caps.
- 25% match from sponsors, participating property owners or other partners. The grant sponsor may determine individual property owner cost share rates, provided the state's share of the practice caps ($1000) and total grant award (75%) are not exceeded. The grant sponsor's match may include technical assistance and project management costs beyond the state's 10% share.
- Sponsor may apply on behalf of multiple property owners, and the property owners do not have to be on the same lake.
- Standard 2-year grant timeline to encourage shovel-ready projects.
- Landowners may sign a participation pledge to document strong interest in following through with the project.
- Standard deliverables, including a signed Conservation Commitment with operation and maintenance information and 10-year requirement to leave projects in place. Also:
  - Native plantings must remain in place according to local zoning specs if within the vegetation protection area (i.e. buffer).
  - Fish Sticks projects require a 350 ft^2 native planting at shoreline base or commitment not to mow, if the property does not comply with the shoreland vegetation protection area (i.e. buffer) specifications described in the local shoreland zoning ordinance.
- Standardized application and reporting forms and process.
- 10% of projects randomly chosen each year for self-reporting and/or professional site visits.

PROMOTION

Wisconsin's Healthy Lakes Implementation Plan will be supported and promoted as a statewide program. Lake groups, counties, towns, villages, cities, and other partners may choose to adopt and implement the Plan as is or to integrate into their own planning processes. Statewide promotion, shared and supported by all partners, includes the following:

- A Healthy Lakes logo/brand.
- A website with plan, practice, and funding detail to be housed on the Wisconsin Department of Natural Resources' and University of Wisconsin-Extension Lakes' websites. It may also include the following:
  - Link to science and supporting plans.
  - Shoreline restoration video.
  - How-to YouTube clips.
  - Tips on how to communicate and market healthy lakeshores.
  - Maps with project locations without personally identifiable information.

EVALUATION OF RESULTS

Wisconsin's Healthy Lakes Implementation Plan and results will be evaluated annually and updated in 2017, if warranted. Best practices may be modified, removed, or added depending on the results evaluation.

The following information will be collected to support an objective evaluation:

- County and lake geographic distribution and participation in Healthy Lakes projects.
- Lakeshore property owner participation in Healthy Lakes projects, including numbers and locations of best practices implemented.
- Standardized Healthy Lakes grant project deliverable report including:
  - Numbers of Fish Sticks trees and clusters.
  - Dimensional areas restored.
  - Structure/floral diversity (i.e. species richness).
  - Impervious surface area and estimated water volumes captured for infiltration.

The results may be used to model nutrient loading reductions at parcel, lake, and broader scales and to customize future self-reporting options, like plant mortality and fish and wildlife observations, for lakeshore property owners.

ACKNOWLEDGEMENTS

L to R: Patrick Goggin, Jane Malischke, Pamela Toshner, Carroll Schaal, Tom Onofrey, Dave Ferris

Wisconsin's Healthy Lakes Implementation Plan and corresponding technical information and grant funding are the results of a collaborative and participatory team effort. We would like to thank the staff, agency, business, and citizen partners, including *Advanced Lake Leaders*, who provided feedback for our team, including the many partners who completed a customer survey and provided valuable comments during the public review of proposed DNR guidance. We would like to express our gratitude to the following contributors and information sources, respectively: Cheryl Clemens, John Haack, Dave Kafura, Amy Kowalski, Jesha LaMarche, Flory Olson, Tim Parks, Bret Shaw, Shelly Thomsen, Scott Toshner, Bone Lake Management District, Maine Lake Smart Program, and Vermont Lake Wise Program.

We appreciate your continued feedback as our Healthy Lakes initiative evolves into the future. Please contact DNR Lake Biologist Pamela Toshner (715) 635-4073 or pamela.toshner@wisconsin.gov if you have comments or questions.

TREATING LAKES WITH ALUM

APPENDIX J

ALUM TREATMENTS TO CONTROL PHOSPHORUS IN LAKES

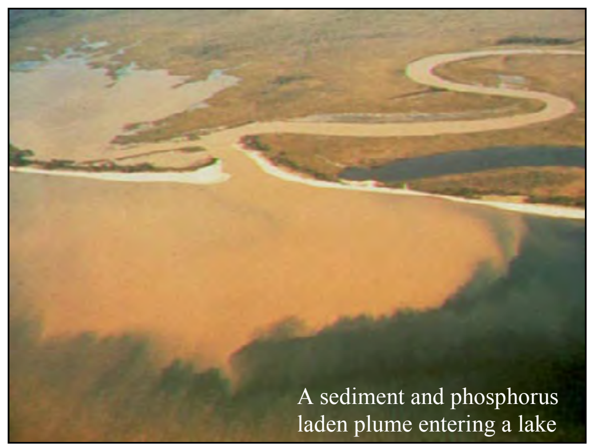
March 2003

What is alum and how does it work?

ALUM (aluminum sulfate) is a nontoxic material commonly used in water treatment plants to clarify drinking water. In lakes alum is used to reduce the amount of the nutrient **phosphorus** in the water. Reducing phosphorus concentrations in lake water can have a similar clarifying effect by limiting the availability of this nutrient for algae production. Phosphorus enters the water either **externally**, from run-off or ground water, or **internally**, from the nutrient rich sediments on the bottom of the lake. Phosphorus is released from the sediments under anoxic conditions that occur when the lake stratifies and oxygen is depleted from the lower layer. Even when external sources of phosphorus have been curtailed by best management practices, the internal recycling of phosphorus can continue to support explosive algal growth. Alum is used primarily to control this internal recycling of phosphorus from the sediments of the lake bottom. On contact with water, alum forms a fluffy aluminum hydroxide precipitate called **floc**. Aluminum hydroxide (the principle ingredient in common antacids such as Maalox) binds with phosphorus to form an aluminum phosphate compound. This compound is insoluble in water under most conditions so the phosphorus in it can no longer be used as food by algae organisms. As the floc slowly settles, some phosphorus is removed from the water. The floc also tends to collect suspended particles in the water and carry them down to the bottom, leaving the lake noticeably clearer. On the bottom of the lake the floc forms a layer that acts as a phosphorus barrier by combining with phosphorus as it is released from the sediments.

Why treat a lake with alum?

Increased nutrient loading, particularly phosphorus has accelerated eutrophication of lakes and consequently reduced their ecological health and recreational value. Frequent and pervasive algal blooms, low water transparency, noxious odors, depletion of dissolved oxygen, and fish kills frequently accompany cultural eutrophication. External sources of phosphorus delivered in run-off from the watershed are often the main contributor of excessive phosphorus to lakes.


A sediment and phosphorus laden plume entering a lake

Typically, the first steps taken in a lake rehabilitation effort target the control the external sources of phosphorus and can include: encouraging the use of phosphorus free fertilizers; improving agricultural practices, reducing urban run-off; and restoring vegetation buffers around waterways.

Lake researchers have learned that lakes are very slow to recover after excessive phosphorus inputs have been eliminated. Furthermore, it's extremely difficult to achieve recovery of lake conditions without additional in-lake management. This is due to the fact that lake sediments become phosphorus rich and can deliver excessive amounts of phosphorus to the overlying water. When dissolved oxygen levels decrease in the bottom waters of the lake (anaerobic conditions), large amounts of phosphorus trapped in the bottom sediments are released into the overlying water. This process is often called **internal** nutrient loading or recycling.

Is alum toxic to aquatic life?

Some studies have been conducted to determine the toxicity of aluminum for aquatic biota. Freeman and Everhart (1971) used constant flow bioassays, to determine that concentrations of dissolved aluminum below 52 μg Al/L had no obvious effect on rainbow trout. Similar results have been observed for salmon. Cooke, et al (1978) adopted 50 mg Al/L as a safe upper limit for post-treatment dissolved aluminum concentrations. Kennedy and Cooke (1982) indicate that: Since, based on solubility, dissolved aluminum concentrations, regardless of dose, would remain below 50 μg Al/L in the pH range 5.5 to 9.0, a dose producing post treatment pH in this range could also be considered environmentally safe with respect to aluminum toxicity. Guidelines for alum application require that the ph remain with the 5.5-9.0 range.

According to Cooke et al (1993) the most detailed study of the impact of alum treatments on benthic insects was that of Narf (1990). He assessed the long term impacts on two soft water and three hardwater Wisconsin lakes. He found that benthic insect populations either increased in diversity or remained at the same diversity after treatment. The treatment of lakes with alkalinities above 75 mg/L as $CaCO_3$ are not expected to have chronic or acute effects to biota. Fish related problems associated with alum treatments have been primarily documented in soft water lakes. However, many softwater lakes have been successfully treated with alum, when the treatments are ph buffered.

Health concerns for people?

Concerns about a connection between aluminum and Alzheimer's have been debated for some time. More recent research points to a gene rather than aluminum as the cause. In addition, aluminum is found naturally in the environment. Some foods, such as tea, spinach and other leafy green vegetables, are high in aluminum. Use of aluminum cookware has not been found to contaminate food sources.

How much does an alum treatment cost?

Costs of alum application are primarily dependent on the form of alum used (wet or dry), dosage rate, area treated, equipment rental or purchase, and labor. Liquid alum has been used when large alum doses were needed. Treatment costs range from $280/acre to $700/acre ($450=approximate average) depending on the dosage requirements and costs to mobilize equipment.

How effective are alum treatments, and how long do they last?

A number of case studies have been conducted on lakes that have undergone nutrient inactivation with alum. Eugene Welch and Dennis Cooke (1995) evaluated the effectiveness and longevity of treatments on twenty one lakes across the United States. They concluded that the treatments were effective in six of the nine shallow lakes, controlling phosphorus for at least eight years on average. Applications in stratified lakes were highly effective and long lasting. Percent reduction in controlling internal phosphorus loading has been continuously above eighty percent. The study did however find that alum treatment of lakes with high external loading was not effective.

References

Cooke, Dennis G. Restoration and Management of Lakes and Reservoirs, Second Edition. Lewis Publishers, 1993.

Cooke, G.D., R.T. Heath, R.H. Kennedy, and M.R. McComas. 1978. Effects of diversion and alum application on two eutrophic lakes. EPA-600/3-81-012.

Freemen, R.A. and W.H. Everhart. 1971. Toxicity of Aluminum Hydroxide Complexes in neutral and basic media to rainbow trout. Transactions of the American Fisheries Society 100: 644-658.

Kennedy, R. and Cooke, G. 1982 . Control of Lake Phosphorus with Aluminum Sulfate: Dose Determination and Application Techniques". Water Resources Bulletin 18:389-395.

Narf, R.P. 1990. Interaction of Chrionomidae and Chaoboridae (Diptera) with alumninum sulfate treated lake sediments. Lake Reserv. Manage. 6: 33-42.

Welch, E.B. and G.D. Cooke. 1999. Effectiveness and longevity of phosphorus inactivation with alum. J. Lake and Reserv.Manag. 15:5-27.

APPENDIX K

MEASURING STREAM FLOW

Water Action Volunteers

Volunteer Monitoring Factsheet Series

2006

Stream Flow:

Flow Speaks Volumes

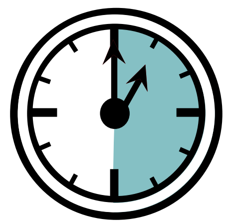
Why are we concerned?

Stream flow, or *discharge*, is the volume of water moving past a cross-section of a stream over a set period of time. It is usually measured in cubic feet per second (cfs). Stream flow is affected by the amount of water within a *watershed*, increasing with rainstorms or snowmelt, and decreasing during dry periods. Flow is also important because it defines the shape, size and course of the stream. It is integral not only to water quality, but also to habitat. Food sources, spawning areas and migration paths of fish and other wildlife are all affected and defined by stream flow and velocity. Velocity and flow together determine the kinds of organisms that can live in the stream (some need fast-flowing areas; others need quiet, low-velocity pools). Different kinds of vegetation require different flows and velocities, too.

Stream flow is affected by both forces of nature and by humans. *(continued on page 2)*

Time Needed:

30 minutes



Equipment Needed:

— Tape Measure

— Yardstick or marked D-frame net pole

— Surveying flags/flagging

— Float (an orange works best)

— Net (Can use D-frame net to catch the float)

— Stopwatch or digital watch

— Calculator

— Form to record data

— Pencil

— Hip boots or waders

— String (optional)

— Stakes (optional)

Definition of Terms

Discharge: Another term for stream flow, or the volume of water moving past a designated point over a set period of time.

Flow Regime: The pattern of stream flow over time, including increases with stormwater runoff inputs and decreases to a base-flow level during dry periods.

Impervious Surface: A surface that does not allow water (e.g., rain) to pass through (infiltrate).

Rating Curve: A graphical representation of the relationship between the stage height and the discharge (flow).

Run: An area of a stream that has swift water flow and is slightly deeper than a riffle (a run will be about knee/thigh deep).

Stage Height: Height of the water in a stream above a baseline.

Watershed: An area of land that drains to a main water body.

In undeveloped watersheds, soil type, vegetation, and slope all play a role in how fast and how much water reaches a stream. In watersheds with high human impacts, water flow might be depleted by withdrawals for irrigation, domestic or industrial purposes. Dams used for electric power generation may affect flow, particularly during periods of peak need when stream flow is held back and later released in a surge. Drastically altering landscapes in a watershed, such as with development, can also change *flow regimes*, causing faster runoff with storm events and higher peak flows due to increased areas of *impervious surface*. These altered flows can negatively affect an entire ecosystem by upsetting habitats and organisms dependent on natural flow rates.

Tracking stream flow measurements over a period of time can give us baseline information about the stream's natural flow rate.

Safety considerations

You will need to enter the stream channel to make width and depth measurements and to calculate velocity. Be aware of stream velocity, water depth, and bottom conditions at your stream-monitoring site. Do not attempt to measure stream flow if water velocity appears to be fast enough to knock you down when you are working in the stream. If you are unsure of water depth across the width of the stream, be sure to proceed with caution as you move across the stream, or choose an alternate point from which to measure stream flow.

Determining Stream Flow (Area x Velocity = Flow)

The method you are going to use in determining stream flow is known as a velocity-area approach. The task is to find out the volume of water in a 20-ft. (at least) section of stream by determining both the stream's velocity and the area of the stream section. You will first measure the width of the stream, and then measure water depth at a number of locations across the width to find the average depth at your monitoring site. Then by multiplying the average depth by the width, you can determine the average cross-sectional area (ft^2) of the stream. Water velocity (ft/sec) is determined simply by measuring the number of seconds it takes a float to travel along the length of stream you are studying. Since water velocity varies at different depths, (surface water moves more quickly than subsurface water because water moving against rough bottom surfaces is slowed down by friction) you will need to multiply velocity by a correction factor to adjust your measurement to account for the effect of friction. The actual equation you will use to determine flow is this: Flow=Area x Corrected Velocity. This method was developed and adapted from several sources (see bibliography). Alternative methods that may be better for your monitoring site are featured in the sidebar below.

Stream Flow Monitoring Methods: Professional and Home-Made

The type of monitoring station used by professionals depends on the conditions at the site including size, slope, accessibility, and sedimentation of the stream. Flow can also be measured at spillways, dams, and culverts or by using a weir or flume, which are man-made structures within a stream that provide a fixed stage-flow relation. Another method, using a home-made combination staff/crest gage, allows volunteer monitors to measure the water level (stage) both at the time of inspection and at the highest level reached since last inspected. This tool is made of PVC pipe, granulated cork and other materials. For more information, including how to make your own, visit:

www.epa.gov/owow/monitoring/volunteer/newsletter/volmon07no2.pdf

Measuring and Calculating Stream Flow

Site location

1. At your monitoring site, locate a straight section of stream that is at least 20 feet in length and has a uniform width. The water should be at least 6 inches deep, and have some movement. Unobstructed runs or riffles are ideal sites to choose.

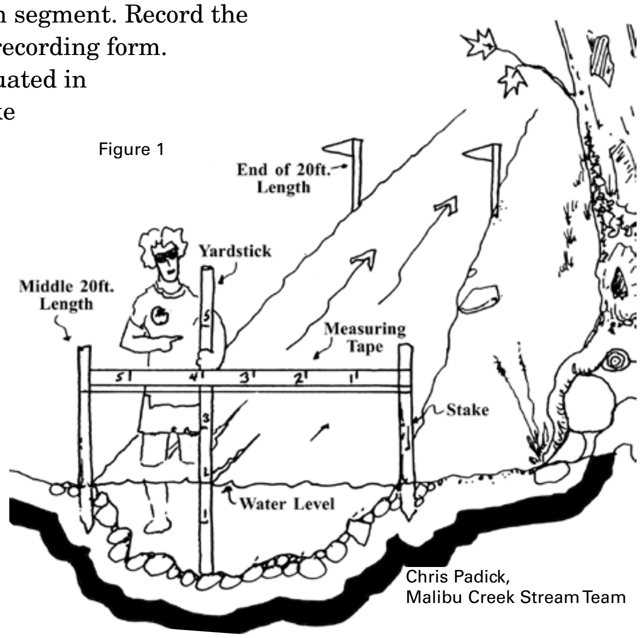
2. Measure 20 feet along the length of your chosen stream segment with your measuring tape and mark both the up and downstream ends of the section with flagging.

Width and depth measurements

3. Working with a partner, measure stream width (wetted edge to wetted edge) by extending a measuring tape across the stream at the midway point of your marked stream segment. Record the width in feet on your recording form. (A tape measure graduated in tenths of feet will make calculations easier.)

4. Secure the measuring tape to both shores so that the tape is taut and above the surface of the water. You might choose to attach the tape or a length of string to two stakes secured on opposite banks to create a transect line across the stream if it is impractical to secure the tape using shoreline vegetation. (Figure 1)

Figure 1



Chris Padick, Malibu Creek Stream Team

5. Using your yardstick or pre-marked (in tenths of feet) D-frame net pole, measure the water depth (ft) at one-foot intervals across the stream where you measured width (and secured the measuring tape). Be sure to measure depth in tenths of feet, not in inches (See conversion chart from inches to tenths of feet on data recording form). Record depth measurements (ft) on the recording form. If your stream is greater than 20 feet wide, measure depth in 20 equal intervals across the stream.

Velocity measurement

Velocity will be measured by tracking the time it takes a floating object to move the marked 20-foot length of stream. You will time the floating object (in seconds) a total of four times, at different locations across the stream. Repeating your measurements across the stream, in both slower and faster areas, will help to ensure the closest approximation to the stream's true velocity. This in turn will make your flow calculations more accurate. However, be sure your float travels freely downstream (during every float trial) without catching in slack water areas of the stream. For narrower streams (less than 10 feet), you can conduct only three float trials to assess velocity.

6. Position the person who will release the float upstream from the upper flag. Position the timekeeper on the stream bank (or out of the main flow path) at the downstream flag with the stopwatch. Position the person who will catch the float downstream from the timekeeper (Note: Unless velocity is very fast, the timekeeper should be able to catch the float with a net after they have finished timing its run down the stream).

7. The float-releaser will gently drop the float into the stream a few feet upstream from the upper flag, and will alert the timekeeper to begin timing as the float passes the upstream flag (the float should have time to get up to speed by the time it passes the upper flag into the marked length of stream). If the float gets stuck on a log, rock or other obstruction, it should be released from the starting point again.

8. The timekeeper should stop the stopwatch as the float passes the downstream flag and retrieve the float using the net.

9. Record the float time for the first trial on the recording form.

10. Repeat steps 7-9 for each of the remaining float time trials in different sections of the stream. Record the float time (seconds) for each trial on the recording form.

Calculating stream flow

11. To determine the average depth at the site, first find the sum of your depth measurements. Then divide the sum of the depths by the number of depth measurements (intervals) you made. Record the average depth (ft) in the appropriate location on your recording form.

12. Next, multiply your average depth by the stream width. This is the average cross-sectional area (ft^2) of the stream. Record this in the appropriate box on your recording form.

13. Determine the average float time by first determining the sum of float times measured. Then divide the sum of the times by the number of float time measurements taken. Record this average float time (seconds) on your recording form.

14. Divide the length of your stream segment (e.g., 20 feet) by the average float time (seconds) to determine the average surface velocity at the site. Record the average surface velocity (ft/sec) on your recording form.

15. Determine the correction factor below that best describes the bottom of your stream and multiply it by the average velocity measurement to account for the effects of friction with the stream bottom on water velocity. Record your corrected average surface velocity on your recording form.

a. Correction factor for rough, loose rocks, course gravel or weeds: 0.8

b. Correction factor for smooth mud, sand, or bedrock: 0.9

16. Multiply the average cross-sectional area (ft^2) by the corrected average surface velocity (ft/sec) to determine stream flow. Record stream flow (ft^3/sec or cfs) in the space provided on your recording form.

Bibliography:
We reviewed and adapted information and methods from Missouri Stream Team Program, the WI DNR, the *EPA Volunteer Stream Monitoring Methods Manual* (EPA 841-B-97-003), the *Nohr Network of Monitors*, the Washington Co. (WI) Waterways Program, Hoosier Riverwatch, Project SEARCH, and California's Nonpoint Source Pollution Control Program as well as other technical information.

Water Action Volunteers is a cooperative program between the University of Wisconsin-Extension and the Wisconsin Department of Natural Resources. For more information, contact the Water Action Volunteers Coordinator at 608/264-8948.

What is a Staff Gage?

A staff gage is a tool that is often used in conjunction with other methods to determine stream flow. It looks like a large ruler placed vertically within a stream in a position least likely to catch floating debris, and that will be stable during high water flows and the winter freeze. Staff gages are calibrated in tenths of feet and allow a monitor to read and record the stage height (the height of water in the stream at a certain level) any time a monitor has the opportunity to visit the stream site. Staff gages are often placed at the stream's edge on a bridge abutment. WAV monitors may choose to place a staff gage at their monitoring site. You may need a permit to do this, however. Contact your local DNR Service Center for more information on permits.

If a staff gage is installed, monitors can simply record the water level on the staff gage without measuring flow. This method will provide added detail when assessing other parameters. However, scores cannot be compared between sites because each reading is germane only to that site.

Monitors may also choose to install a staff gage at their monitoring site and then, at a number of different water levels, record the stage height and determine the flow in the stream by following methods provided in this fact sheet. This type of monitoring is similar to what professionals do to determine a *rating curve* for a stream discharge monitoring station. The rating curve will reveal the stream's unique relationship between flow and stage height. Eventually, a monitor could determine stream flow simply by reading the stage height on the staff gage and looking at the site's rating curve to see what the flow is at that stage height. Caution must be used with this method since weeds, ice, or other factors can cause ponding of the stream water or movement of the staff gage over time, thus affecting rating curve results.

UW Extension

WISCONSIN DEPT. OF NATURAL RESOURCES

APPENDIX L

WATERCRAFT INSPECTION

FOR MORE INFORMATION

If you would like more information about aquatic invasive species, the problems they cause, regulations to prevent their spread, or methods and permits for their control, contact one of the following offices:

Wisconsin Department Of Natural Resources
888-WDNRINFO
DNR.WI.GOV search "Aquatic Invasives"

University of Wisconsin- Extension
(715) 346-2116
WWW.UWSP.EDU/CNR/UWEXLAKES

Wisconsin Sea Grant
(608) 262-0905
WWW.SEAGRANT.WISC.EDU
WWW.PROTECTYOURWATERS.NET

Thanks to the following for supporting educational efforts on aquatic invasive species:

- ***U.S. Fish and Wildlife Service***
- ***Great Lakes Indian Fish and Wildlife Commission***
- ***National Park Service***

PUB WT-801 2011

Graphic Design by Amy Torrey, Environmental Resources Center, UW-Extension

Photo Credits: Sea Grant, UW-Extension, DNR

STOP Aquatic HITCHHIKERS

ENJOYING THE GREAT OUTDOORS

Enjoying the great outdoors is important to many of us. Boating, fishing, hunting, and wildlife watching are traditions that we want to preserve for our children and their children. Today, these traditions are at risk. Aquatic invaders such as zebra mussels, purple loosestrife, Eurasian water-milfoil, bighead and silver carp, threaten our valuable waters and recreation. These and other non-native, or exotic, plants and animals do not naturally occur in our waters and are called invasive species because they cause ecological or economic harm.

These invasive species can get into lakes, rivers, and wetlands by "hitching" rides with anglers, boaters, and other outdoor recreationists, who transport them from one waterbody to another.

Once established, these "aquatic hitchhikers," can harm native fisheries, degrade water quality, disrupt food webs and reduce the quality of our recreational experiences.

The good news is that the majority of waters are not yet infested with invasive species and by taking the necessary steps you can help protect our valuable waters.

If you think you have found an INVASIVE SPECIES:

REPORT NEW SIGHTINGS

If you suspect a new infestation of an invasive plant or animal, save a specimen and report it to a local Department of Natural Resources or Sea Grant office. Wisconsin has "ID" cards, websites, and volunteer monitoring networks to help you identify and report invasive species.

CONSULT YOUR NATURAL RESOURCE AGENCY

Do-it-yourself control treatments may be illegal and can make matters worse by harming native fish, wildlife, and plants. Before attempting to control an invasive species or add new plants along your shoreline, contact your local Department of Natural Resources office. DNR staff can provide recommendations and notify you what permits are required.

DNR.WI.GOV search "Aquatic Invasives"

STOP AQUATIC HITCHHIKERS ▶ IS A NATIONAL CAMPAIGN THAT HELPS RECREATIONAL USERS TO BECOME PART OF THE SOLUTION TO STOP THE TRANSPORT AND SPREAD OF AQUATIC INVASIVE SPECIES.

IN WISCONSIN IT IS THE LAW...

Aquatic hitchhikers can spread in many ways such as on recreational equipment, and in water. Fortunately, there are a few simple actions you can take to prevent them from spreading.

INSPECT boats, trailers, and equipment

REMOVE all attached aquatic plants, animals, and mud before launching and before leaving the water access.

Many invasive species spread by attaching themselves to boats, trailers, and equipment and "hitching a ride" to another waterbody. Therefore, Wisconsin law requires that you remove these aquatic hitchhikers before you launch your boat or leave the access area.

DRAIN all water from your boat, motor, bilge, live wells, bait containers and all equipment before leaving the water access.

Many types of invasive species are very small and easily overlooked. In fact, some aquatic hitchhikers, like zebra mussel larvae, are invisible to the naked eye. To prevent the transport of these aquatic hitchhikers drain water from all equipment before you leave the access area.

For more information visit:
DNR.WI.GOV and search "bait laws"

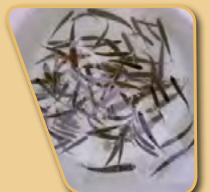
Draining ballast water and lake or river water can prevent the spread of aquatic invasive species and fish diseases, like VHS.

NEVER MOVE plants or live fish away from a waterbody.

In Wisconsin, it is illegal to transport any aquatic plants, mud, live fish or live fish eggs away from any state waterbody. This includes live gamefish and roughfish, like gizzard shad. There are exceptions for minnows obtained from a Wisconsin licensed bait dealer or registered fish farm, which may be transported away live and used again:

- *On the same waterbody, or*
- *On any other waterbody if no lake or river water, or other fish were added to their container*

BUY minnows from a Wisconsin licensed bait dealer.



For more information on collecting your own minnows visit:
DNR.WI.GOV and search "VHS Prevention"

DISPOSE of unwanted bait and other animals or aquatic plants in the trash.

If possible, dispose of ALL unwanted bait (including earthworms) in a trash can at the boat landing or access point. Otherwise, take them home and dispose of them by placing them in the trash, composting them, or using them in a garden as fertilizer. Likewise, other aquatic plants or animals that you collect, or buy in a pet store, should NEVER be released into the wild.

When possible, dispose of unwanted bait in the trash at access points. Never release them into the environment.

WISCONSIN REGULATION

Wisconsin has several laws to prevent the spread of aquatic invasive species and the fish disease Viral Hemorrhagic Septicemia (VHS). Failure to follow Wisconsin law can result in fines up to or exceeding **$2000**. Don't be caught unaware!

ADDITIONAL STEPS:

Although not required by WI law, additional steps are highly recommended, particularly if you are transporting a boat and/or equipment from one waterbody to another. Additional steps include:

SPRAY, RINSE, or DRY boats and recreational equipment to remove or kill species that were not visible when leaving a waterbody. Before transporting to another water: ***Spray/rinse with high pressure, and/or hot tap water (above 104° F or 40° C), especially if moored for more than a day. OR Dry for at least five days.***

DISINFECT boats and recreational equipment to kill species and fish diseases that were not visible when leaving a waterbody. Many aquatic hitchhikers can survive out of water for some period of time. ***To prevent their spread, you can sanitize your boat, trailer or equipment by washing it with a mixture of 2 Tbs of household bleach per 1 gallon of water.***

OTHER WATER USES:

Don't get caught spreading aquatic invasive plants or animals! Wisconsin laws, as highlighted above, can apply to many types of water activities, not just boating and fishing. Although these activities might not seem dangerous, they CAN establish and spread invasive species. It is important you follow the steps above for all water activities in order to prevent the spread of aquatic invasive species. These activities include:

- ***Using personal watercraft***
- ***Shore and fly-fishing***
- ***Sailing***
- ***Scuba Diving***
- ***Waterfowl hunting***

FAILURE TO FOLLOW WISCONSIN LAWS CAN LEAD TO FINES.

For additional information contact your local DNR staff or visit:
DNR.WI.GOV

Protect Your Boat

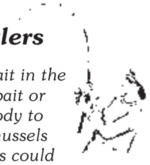
Zebra mussels attach to a variety of materials, including fiberglass, aluminum, wood, and steel and may damage a boat's finish. Veligers are extremely small and can be drawn into engine passages. Once they settle out in the engine cooling system, they can grow into adults and may block intake screens, internal passages, hoses, seacocks, and strainers. The best ways for boat owners to avoid these types of damage are:

- **Use a boatlift** to completely remove the watercraft from the water when not in use.

- **Run your boat regularly** if it is moored in zebra mussel infested waters. Run the engine at least twice a week at slow speeds (about 4-$\frac{1}{2}$ mph) for 10 to 15 minutes. Monitor engine temperatures – if you notice an increase, it may mean that zebra mussels are clogging your cooling system. Immediately inspect the system and remove any zebra mussels. The end of boating season is also a good time to inspect and clean the cooling system.
- **Lift the motor out of the water between uses if mooring.** Fully discharge any water that may still remain in the lower portion of the cooling system.
- **Tip down the motor and discharge the water when leaving a waterbody** to reduce the likelihood of transporting veligers (in water) to another waterbody.
- **Clean your boat and equipment.** Physically remove (scrape) adult mussels from your boat, trailer, and equipment by hand. Young zebra mussels and veligers may be too small to see. Wash your boat with high-pressure hot water (use water >104˚F if possible). Use high-pressure cold water if hot water is not available. *(Avoid pressure washing classic wooden boats or others not made of metal.)*
- **Apply anti-fouling paints or coatings to the hull and the engine's cooling system** to prevent zebra mussel attachment. It is best to purchase these from an area boat dealer or your local marina. Anti-fouling paints that are copper based can be used in Wisconsin, and typically need to be reapplied every one to two years. In-line strainers can also be installed in the engine's cooling system.
- **Use motor "muffs", also known as motor flushers, to remove zebra mussels and other materials from your boat engine or personal watercraft.** Clamp the motor flusher onto the lower unit over the cooling inlets on either side of the motor, and screw the nozzle of your garden hose into it. Run the boat engine for approximately 10 minutes or as suggested by the manufacturer.

Amy Bellows, WI DNR

Special note of caution for anglers



Dispose of unwanted bait in the trash - do not transfer bait or water from one waterbody to another. Larval zebra mussels or other invasive species could be present in the water with the bait.

Help prevent aquatic hitchhikers from catching a ride on your boat or equipment:

- ✓ **Inspect** and **remove** aquatic plants and animals,
- ✓ **Drain** water,
- ✓ **Dispose** of unwanted bait in the trash,
- ✓ **Rinse** with hot and/or high-pressure water, OR
- ✓ **Dry** for 5 days.

Clean Boats . . . Clean Waters

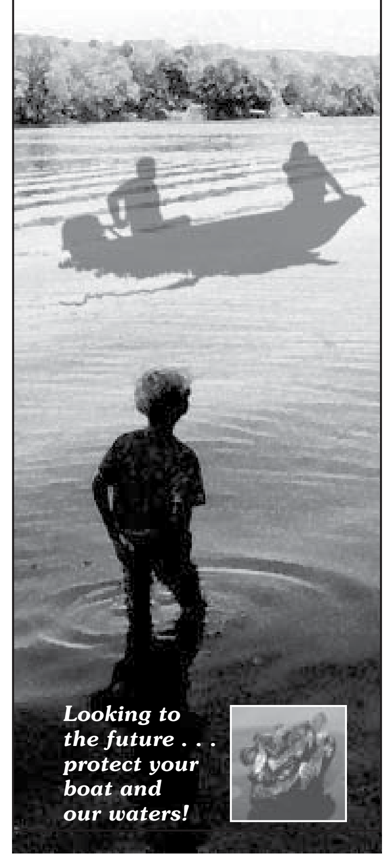
For a list of known zebra mussel infested waters, visit:

www.dnr.wi.gov/org/water/wm/GLWSP/exotics/zebra.html

WISCONSIN DEPT. OF NATURAL RESOURCES
UW Extension
STOP AQUATIC HITCHHIKERS!
PRINTED ON RECYCLED PAPER
Sea Grant

Cover photo: L. Pohlod. Inset: Great Lakes Sea Grant Network
Designed by L. Pohlod, Blue Sky Design, LLC PUB-WT-383 2004

Zebra Mussel Boater's Guide



Zebra mussel identification and life cycle

Mature zebra mussels look like small D-shaped clams. Their yellowish-brown shells have alternating light and dark stripes.

Ohio Sea Grant

Zebra mussels can reach a maximum of 2 inches in length, though most are smaller than an inch. They are typically found attached to solid objects, often growing in large clusters.

Ontario Ministry of Natural Resources

Amy Bellows, WI DNR

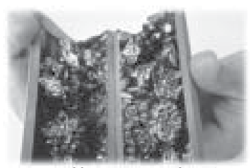
Zebra mussels begin as eggs, then develop into free-swimming larvae (called **veligers**), which are microscopic. The veliger photos shown above were taken with the aid of a microscope. Veligers are spread by currents; after about three weeks, they settle out and firmly attach themselves to hard surfaces, where they grow into adults. Their lifespan is typically three to five years. They begin to reproduce after a year or two - females can release up to one million eggs per year!

James Lubner, University of Wisconsin Sea Grant

What do zebra mussels do?

Zebra mussels are **filter feeders** that can filter large volumes of water (up to 1 Liter/day). In some cases they can filter the whole volume of a lake in a few months. They remove plankton – tiny plants and animals – from the water. What they eat (and what they don't eat) ultimately ends up on the lake or river bottom. Plankton is an important food source for young fish, native mussels, and other aquatic organisms. Zebra mussels may concentrate this food at the bottom, leaving open water species with **less to eat**!

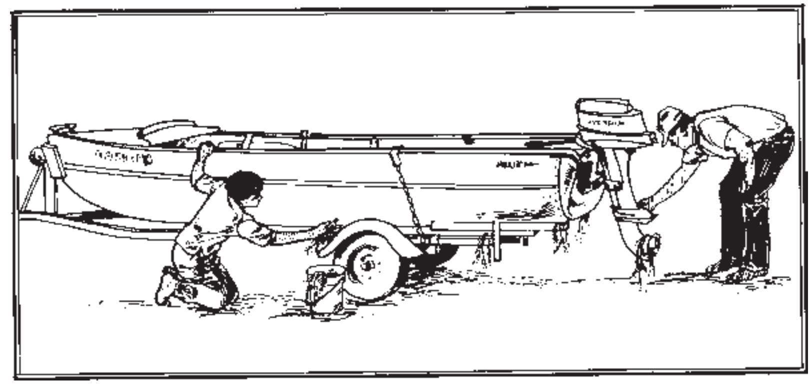
Because they are so good at filtering, zebra mussels often **make water clearer**. This may force **light-sensitive fish**, like salmon and walleye, into deeper water to seek shelter from the sun. Increased light penetration allows aquatic plants to grow in deeper water and spread to a larger area. This may help smaller fish to survive by giving them places to hide, but makes it harder for large, predatory fish to find food. **Thicker plant growth** may also cause problems for boaters and anglers.



Don Schloesser, Great Lakes Science Center, National Biological Services

Zebra mussels cause people additional problems. They **clog water intakes and pipes** – large water users on the Great Lakes spent $120 million from 1989 to 1994 to combat zebra mussels. They also **attach to piers, boatlifts, boats, and motors,** which can cause damage requiring costly repair and maintenance. Even when they die, their **sharp shells** wash up on beaches, creating foul odors and cutting the feet of swimmers.

How can I help prevent the spread of zebra mussels?



Microscopic veligers may be carried in livewells, bait buckets, bilge water – any water that's transported to another waterbody. They can also travel in currents to downstream waters. Adults can attach to boats or boating equipment that are moored in the water. They frequently attach to aquatic plants, which themselves may hitch a ride on boats and equipment. For these reasons, it is important to take the following steps to prevent the spread of zebra mussels and other aquatic invasive species while boating:

Before moving your boat from one water body to another:

✓ **Inspect** and **remove** aquatic plants, animals, and mud from your boat, trailer, and equipment,

✓ **Drain** all water from your equipment (boat, motor, bilges, transom wells, live wells, etc.),

✓ **Dispose** of unwanted bait in the trash, not in the water,

✓ **Rinse** your boat and equipment with hot (> 104˚F) and/or high pressure water, particularly if moored for more than one day, OR

✓ **Dry** your boat and equipment thoroughly (in the sun) for five days.

Pressure washing note:

Avoid pressure washing classic and wooden boats, along with canoes and kayaks that are not made of metal. These types of boats should be drained, cleared of all plant and animal materials, and left in the sun to dry completely.

Effective May 2002, Section 30.715, WI Act 16 prohibits launching a boat or placing a boat or trailer in navigable waters if it has aquatic plants or zebra mussels attached.

Watercraft Inspector Handbook

2014 Edition

Wisconsin Lakes Partnership

PUB-WT-780 2014

Acknowledgments:

The *Watercraft Inspector Handbook* is a guide for people who are passionate about "their" lake and who have a vision for future generations. The "Clean Boats, Clean Waters" program is sponsored and promoted by the Wisconsin Department of Natural Resources, UW-Extension, and Wisconsin Lakes.

Authors: Erin McFarlane

Contributors: Julia Solomon, Frank Koshere, Laura Herman, Brock Woods, Patrick Goggin, Robert Korth, Tamara Dudiak

Editor: Erin McFarlane

University of Wisconsin - Extension Lakes
College of Natural Resources
University of Wisconsin - Stevens Point
800 Reserve St.
Stevens Point, WI 54481
715-346-2116 uwexlakes@uwsp.edu
www.uwsp.edu/cnr/uwexlakes/

Wisconsin Department of Natural Resources
Water Division
101 S. Webster St.
P.O. Box 7921
Madison, WI 53707-7921
dnr.wi.gov

Wisconsin Lakes
4513 Vernon Blvd., Suite 101
Madison, WI 53705
608-661-4313 info@wisconsinlakes.org
wisconsinlakes.org

PRINTED ON RECYCLED PAPER

Welcome to the Clean Boats, Clean Waters Watercraft Inspection Program!

Aquatic invasive species have long been recognized as a serious threat to the United States. According to Cornell University, in 1999, introduced species of animals, plants, and microbes cost the U.S. economy at least $138 billion a year. In 2001, Wisconsin spent over $600,000 on aquatic and terrestrial plants and exotic birds, thousands more for sea lamprey control and hundreds of thousands for control of zebra mussels. These facts make folks a little nervous about the future of Wisconsin inland water bodies.

Wisconsin's 15,081 lakes are fortunate to have volunteers who monitor water clarity, water chemistry, aquatic plants, and invasive plants. Since 1986, these folks have functioned as the "eyes" of aquatic biologists. With the arrival of aquatic invasive species, now more than ever citizens are needed to help preserve and protect Wisconsin's water bodies. The "Clean Boats, Clean Waters" program is an opportunity for citizens to help stop the spread of invasive species across the state.

Through "Clean Boats, Clean Waters," inspectors are trained to organize and conduct a watercraft inspection and education program in their community. This program originated in northern Wisconsin as a middle school project. The "Milfoil Masters" program alerted adults and youth that citizen volunteers can make a difference in helping prevent the spread of invasive species.

To continue statewide volunteer efforts, the **"Clean Boats, Clean Waters" Watercraft Inspection Program** was created in the fall of 2003. The mission of this program is to promote water resource stewardship by actively involving individuals in preventing the spread of harmful aquatic invasive species. To accomplish this goal, the program sponsors statewide training workshops and has developed resource handbooks, tool kits, and educational information; a statewide coordinator now supports inspection efforts.

Wisconsin realizes that passionate citizens are the keys to reaching hundreds of recreationalists visiting the state. Inspectors who instruct boaters on how to perform watercraft inspections are helping to prevent new invasions and are helping to maintain Wisconsin's valuable water resource.

Thank you for taking the time to learn, act, and protect Wisconsin's waters from invasive species! The rewards of these efforts will be appreciated by many generations to come.

Contents

Contents

Section 1: What is the program all about?

Section 2: What do watercraft inspections involve?

Section 3: How do inspectors share their inspection data?

Section 4: How can inspectors take care of their boat landings?

Section 1:
What is the program all about?

Wisconsin's Comprehensive Management Plan

To Prevent Further Introductions and Control Existing Populations of Aquatic Invasive Species, created in 2003

Aquatic invasive species (AIS) have long been recognized as a serious problem in Wisconsin. The Department of Natural Resources, in cooperation with the University of Wisconsin Sea Grant and the Great Lakes Indian Fish and Wildlife Commission, has prepared a plan to coordinate responses to the problems associated with AIS. This plan is one component of a comprehensive state effort to control invasive species that involves all affected state agencies and tribal governments working together to prevent the further introductions of invasive species (both aquatic and terrestrial) into Wisconsin's ecosystems. This plan focuses on prevention as the key strategy for limiting the impacts of aquatic invasive species by controlling the initial introduction and subsequent transfer from one water body to another. Prevention strategies rely heavily on information, education, and communication. Therefore, this plan includes the full range of those activities in order to implement an effective prevention program.

However, prevention techniques alone are inadequate for limiting the negative impacts caused by aquatic invasive species. This plan also suggests that control, mitigation, or elimination strategies must be considered. It incorporates information and education/ outreach activities, watercraft inspection efforts, and policy, and legislative initiatives as key components of the overall program.

The goals of Wisconsin's comprehensive management plan are designed to address different stages of the AIS invasion:

1. The initial introductions of AIS into Wisconsin waters from other parts of the continent or world;
2. The spread of AIS populations to previously unaffected state waters; and
3. The colonization of self-sustaining AIS populations within water bodies, including the harmful impacts resulting from such colonization.

Goal 1:

Implement procedures and practices to prevent new introductions of AIS into Lakes Michigan and Superior, Wisconsin's boundary waters (the Mississippi and St. Croix Rivers), and the inland waters of the state.

Because of the limited experience with most AIS, the long-term consequences of their impacts are not yet known. With a more robust global economy, it is anticipated that without a new prevention program, new introductions are highly likely. For that reason, prevention actions at the national and regional level, as well as at the individual jurisdictional level, are critical. The highest prevention priority is the control of ballast water discharges.

Several other potential transport mechanisms could result in releases of AIS into the Great Lakes and inland state waters. Some of these vectors are: the transportation and rearing systems related to the aquaculture industry, commercial barge traffic, and recreational boating; inter-Great Lake boating associated with research or management activities; scuba diving; the sale and distribution of fishing bait; the transfer and disposal of nonindigenous pets; plant nurseries; fish stocking activities and individual releases by anglers.

Three of the potential AIS transport mechanisms have been selected for specific actions: the sale and distribution of bait, aquaculture and aquarium industries, and ballast water discharges.

Specific actions related to this goal are: work with the bait industry, agriculture, and aquarium industries and transoceanic shipping to collect information about vectors and AIS transport mechanisms in general, and evaluate new technologies or management practices for effective control of AIS.

Goal 2:

Establish management strategies to limit the spread of established populations of AIS into inland waters of the state.

The introduction of AIS into the Great Lakes has resulted in the spread of AIS to inland waters. The spread of established populations of AIS is primarily caused by human activities such as transfer of boats, bait handling, and water transport. Water resource user groups are frequently not aware of which waters are infested with AIS, the problems associated with AIS and the precautions they should take to limit the spread of AIS.

Specific actions related to this goal are: determine which species pose the greatest problems; determine the level of monitoring needed to document AIS distribution; assess the sampling and monitoring programs for priority invasive species; implement education and outreach programs to increase public awareness and improve coordination efforts on AIS by encouraging cooperation with partner organizations, agencies, and volunteers.

Goal 3:

Abate harmful ecological, economic, social, and public health impacts resulting from infestation of AIS and, where possible, eliminate those impacts.

Appropriate strategies to control AIS and abate their impacts may not be technically, economically, or environmentally feasible. Control strategies must always be designed so as not to cause significant environmental impacts.

Specific actions related to this goal are: assess the public health, social, economic, and ecological impacts of AIS to Wisconsin waters; determine control actions that are appropriate to limit impacts, that are cost-effective approaches, and that provide long-term solutions; evaluate the effectiveness of the control strategies after they have been implemented.

This plan provides the generalized approaches that must be followed to protect indigenous species and the socioeconomic benefits that are threatened by aquatic invasive species. It is likely that management plans for individual species, such as zebra mussels and Eurasian water-milfoil, will be developed as a result of this plan.

For detailed information about this plan, visit: http://dnr.wi.gov/topic/Invasives/documents/compstateansplanfinal0903.pdf.

Wisconsin's comprehensive state management plan was approved by the National Aquatic Nuisance Species Task Force at their November 2003 meeting. Their approval qualifies the state for federal funding to implement the specific actions as detailed in the plan.

The Aquatic Invasive Species Volunteer Program Vision

The Aquatic Invasive Species Volunteer Program promotes water resource stewardship by actively involving individuals in preventing the spread of aquatic invasive species that can harm Wisconsin's ecosystems, economy, and recreational opportunities.

Citizen involvement in watercraft inspections and monitoring for invasives increases public awareness about the potential impacts of aquatic invasive species. Volunteers serve to inform and educate the public about how people can help prevent the spread of invasives by inspecting their watercraft and removing aquatic plants and animals from their boats and equipment before leaving an access site.

To accomplish these objectives, the volunteer program supports:

- Watercraft inspections for aquatic invasive species.
- Communication with the public about the laws and issues surrounding the existence, spread, and effects of invasives to Wisconsin's waters.
- Distribution of educational resources and publications.
- Collection of data to evaluate the potential spread of invasive species, public awareness of invasive species issues, and the effectiveness of the invasive species program.
- Response to technical inquiries from the public concerning invasive species.

"If there is magic on this planet, it is contained in water."

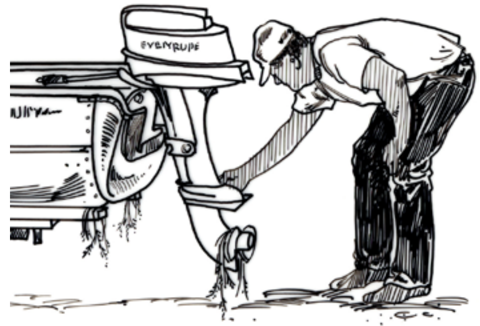
- Loren Eiseley

The Immense Journey, 1957

Section 2:

What do watercraft inspections involve?

Getting Started



Recreational boating is a significant corridor for the spread of invasive species between water bodies in Wisconsin. This pathway is a concern because of the more than 610,000 registered boaters moving around Wisconsin's 15,081 lakes. Inspecting watercraft for invasive species offers a frontline defense at the lake landing to prevent further destruction of lake ecosystems. Watercraft inspections are designed to increase public awareness about invasive species and to assist boaters in taking preventive steps to avoid further spreading of critters.

Attending a "Clean Boats, Clean Waters" training workshop provides you with all the tools you need to start a watercraft inspection program in your community. Developing an effective program requires patience, time, and an eye for organizing a working schedule. A group that consists of a inspection cooordinator and a committee of several people is the best way to distribute the tasks equally and prevent volunteer burnout. When planning a watercraft program, consider the five Ws: Whom, What, When, Where, and Why.

WHOM will you recruit for the watercraft inspection team?

Volunteers, both adults and youth, can be recruited through your lake association newsletter, local schools, 4-H, or Boy and Girl Scout groups. Many service organizations are looking for community involvement opportunities. We recommend at least two people at the landing. Ideally, an adult should work with a youth volunteer. Boaters are very cooperative when a young person is giving the message: "Clean Boats, Clean Waters, please."

WHAT are the duties of a watercraft inspector?

Before you build a watercraft inspection team, decide what skills and tasks volunteers need for an effective interaction with the public at the boat landings. Generally, inspectors perform three duties: verbally share educational materials and information about aquatic invasive species and how they're spread, visually check boats and recreational equipment for any hitchhiking plants or animals, and demonstrate how to clean recreational equipment and what prevention steps boaters need to take every time they leave the water.

Additional duties, such as recording data on the Watercraft Inspection Report Form (see Section 3), assist us in collecting information about the recreational use of the lake, traveling patterns of boaters, and whether the boaters are performing the prevention steps. Inspectors should also be ready to collect, accurately label, and store any suspect plant or animal that is attached to any recreational equipment.

Here are some specific skills to consider:

- **Congenial**: able to meet new people courteously at the landings.
- **Communicative**: effectively educate the public on invasive species.
- **Flexible**: be willing to work weekends and holiday hours.
- **Informed**: understand the harmful impacts of aquatic invasive species.
- **Physically able**: able to inspect watercraft and trailers for invasive species.

- **Accurate**: document verbal surveys, record, and submit any suspect invasive species specimens to local/regional DNR service station.
- **Computer knowledgeable**: able to submit watercraft inspection data to DNR Web site at http://dnr.wi.gov/lakes/cbcw-data.

To identify the watercraft inspection team at the boat landing, all volunteers should have their own royal blue "Clean Boats, Clean Waters" T-shirt. Inspectors need to wear this T-shirt to signify that they are working for a specific program, "Clean Boats, Clean Waters," and not harassing boaters at the landings. Two T-shirts are included in each of the resource kits and more may be purchased by calling UW Extension-Lakes at 715-346-2116. As an added bonus, 'Clean Boats, Clean Waters' logo stickers are included in the resource kit to use when the weather is inclement and short-sleeve T-shirts just won't work. Just peel off the protective backing on the logo, and place the sticker on your sweatshirt or coat. No matter what the weather, boaters will be able to identify the watercraft inspection team at a glance.

WHEN is the best time to inspect at the boat landing?

When recruiting volunteers, be specific about the amount of time you want them to work. For example, a volunteer is more likely to agree to a three-hour shift once or twice a month rather than an open invitation to volunteer all summer on the weekends and holidays. Volunteers will more readily step up if they know the expectations and how much time is realistically needed.

To get the most "bang for your buck," become acquainted with the activity on your lake and when the lake is the busiest. Are the weekends a flurry of activity from Friday night at 4 p.m. until 8 p.m. Sunday? Or is Saturday morning from 6 a.m. until 10 a.m. the active time at the landings? Usually, holiday weekends during the summer are the busiest times at the landings. Anglers are usually up and on the lake by dawn and always out on opening day of fishing season. Recreational boaters usually use the lake in the afternoon, and sunny, warm days draw lots of people to the lake! Do not forget about fishing tournaments and special lake events that draw many boats at the landings. Remember, the boat landing is the first place an aquatic invasive species takes hold.

WHERE will the watercraft inspection process take place?

It is a good idea to find out who owns the boat landing before you begin to schedule work shifts for your inspectors. The landing may be owned and maintained by one of several entities: the federal government, state, township, lake association, or a private individual. To check ownership, you might need to contact several organizations, such as the Wisconsin Department of Natural Resources, county zoning offices, town halls, or local businesses. Knowing ownership will be helpful if you are thinking about installing signage, waste disposal containers, or boat washing facilities (see Section 4).

If you have limited inspection resources and many public and private landings, determine which landings receive the most boat traffic. Think about which landing is most likely to be the first place a hitchhiking invasive will appear.

WHY is this inspection program necessary?

Be prepared to answer this question. Often lake owners are frustrated with the public trust doctrine that mandates public use of all waters in Wisconsin. Lake owners feel it is unfair that they bare the brunt of the cost of managing an aquatic invasive species. The Wisconsin Department of Natural Resources is allocating some money toward the management of invasive species, but not nearly enough for 15, 081 lakes. Therefore, any proactive steps in preventing the introduction and spread of invasive species are more cost-effective than waiting for them to arrive.

Preventing aquatic invasive species is a better management option than the expensive alternative. For example, treating Eurasian water-milfoil infestations with chemicals on average costs around $300 to $500 per acre. Eurasian water-milfoil can grow two inches per day and can fragment into hundreds of new plants within hours, so it would not take long for Eurasian water-milfoil to cover hundreds of acres. If this fact does not impress you, contact members of a lake organization struggling with an invasive species. They would be happy to discuss the tremendous impact that one invasive species caused in their community. Remember, prevention is worth a pound of cure.

Online Resources

There are tons of useful online resources available to aid you in your aquatic invasive species (AIS) outreach efforts! Many of these resources are available on either the UW-Extension Lakes website or the WI Department of Natural Resources (DNR) website.

UW-Extension Lakes: http://www.uwsp.edu/uwexlakes

DNR Invasive Species: http://dnr.wi.gov/topic/invasives

AIS Publications

Many AIS-specific resource materials (such as brochures, stickers, etc.) are available to assist you in your outreach efforts. A list of the publications currently available can be found at http://dnr.wi.gov/lakes/invasives/AISPubList.pdf.

These free publications can be ordered by e-mailing DNRAISinfo@wisconsin.gov or calling 608-267-9868.

AIS Contacts

We have numerous AIS staff available to assist you – with general questions, trainings, grant applications, and more! You can search our online database of AIS contacts by their location in the state or by their role/specialty.

AIS Contact List: http://dnr.wi.gov/lakes/invasives/topics.aspx

AIS Distribution Information

Find out what lakes and rivers have AIS in your area! You can view lists of AIS waters by county, region, or Great Lakes basin, or see a statewide list.

View Distribution Info by Waterbody: http://dnr.wi.gov/lakes/invasives/AISByWaterbody.aspx

You can also search by species, selecting a specific aquatic invasive and viewing all of the waterbodies in which it is present.

View Distribution Info by Species: http://dnr.wi.gov/lakes/invasives/BySpecies.aspx

AIS Control Grants

Grant funding is available for AIS projects conducted on any waters of the state. They can be used for education, prevention, planning, early detection, rapid response, and established invasives control projects. Check out the DNR's AIS Grants webpage for more information and details on eligibility, the application process, and more.

AIS Grants: http://dnr.wi.gov/Aid/AIS.html

CBCW Supplies & More!

For all things CBCW, visit the UWEX-Lakes CBCW website. You can check out the CBCW supplies and ordering info, view the current workshop schedule, download the CBCW Handbook, and more.

CBCW Watercraft Inspection: http://www.uwsp.edu/uwexlakes/cbcw

Liability

Watercraft inspections are Wisconsin's main aquatic invasive species containment and prevention tool! More and more lake communities are organizing watercraft inspection teams for youth and adults interested in preventing the spread of aquatic invasive species. Inspection teams that perform watercraft inspections at boat landings can often find themselves in the midst of heavy boat launching activity.

So, can there be liability risks associated with sponsoring a volunteer watercraft inspections program?

The answer is yes. The purpose of this information is to summarize some of the basic issues that lake associations, lake districts, and individuals should keep in mind when deciding to sponsor a watercraft inspection program. This information addresses the issues associated with accident liability. *The following is not meant to be a substitute for legal advice; organizations should seek assistance from an attorney for answers to specific questions.*

Liability Risks for Organization and Individuals

A number of parties may be held responsible for an accident occurring on the boat landing. The **individual** who may be most directly connected to the incident may be held responsible as well as the **lake association**, **lake district,** and **any other entity** that may be hosting the event.

Liability Risks of Organizations:

- **Nonprofit corporations organized under chapter 181** may be held liable if an accident occurs. However, incorporation insulates the individual members' assets from liability in the event of a lawsuit. Only the assets of the corporation, not those of individual members, will become available to satisfy a court judgment.

- **Nonprofit associations not organized under chapter 181** may also take advantage of a law passed in 1997 that insulates the assets of individual members from being used to satisfy a judgment against the association (Chapter 184, Wis. Stats.). According to the law, a nonprofit association is an entity with three or more members that mutually agree to pursue a nonprofit purpose. A "member" under the law is an individual who may take part in the selection of persons to manage the operation of the association. According to state law, in the case of an unincorporated association with three or more "members," only the assets of the association will be used to satisfy a judgment.

- **Public inland lake and rehabilitation districts** organized under chapter 33 of the state statutes may also be subject to a lawsuit. A judgment against a lake district cannot exceed $50,000 (§ 893.80 Wis. Stats.), but any judgment against a lake district must be added to the next tax levy.

- **Workers' compensation** laws come into play when an employee of a lake association or a lake district commissioner is injured while performing the duties of his or her position. If a lake association has three or more paid employees and pays in any one-calendar quarter compensation in excess of $500.00, the association or employer may be required to pay the medical bills incurred for an injury that occurred while the person was on the job (Chapter 102, Wis. Stats.). If the association relies on volunteers, these laws may be avoided. A lake management district may be held responsible for a job-related injury of an elected commissioner regardless of whether or not compensation is received.

Liability Risks for Individuals:

- **If lake district officers**, **board members,** or **employees** are held personally responsible for an injury while acting within the scope of their duties as officers, board members, and employees, the lake district must pay the cost of any judgment rendered against them (§§ 895.46 Wis. Stats).- Incorporated lake associations must indemnify directors or officers in most cases (§181.0872 Wis. Stats.)

- **Individuals who provide services** to nonprofit corporations organized under chapter 181 for free, in other words volunteers, cannot be sued in most cases. However, volunteers who operate a motor vehicle or other vehicle that requires a license or operator's permit may be held personally liable should an accident occur (§181.0670 Wis. Stats.)

- **Federal law also protects volunteers of nonprofit corporations, associations, and governmental entities from liability** provided no compensation, aside from reimbursement for expenses, is received.–This law, however, does not protect individuals who are operating a motorized vehicle or vessel that requires an operator's license or permit (42 U.S.C. § 14501, Volunteers Protection Act of 1997).

Insurance

All insurance policies are different. The following points are intended to cover the most basic issues:

- Lake districts and incorporated and unincorporated associations can purchase insurance to protect against the risk of personal injury.

- Homeowner and automobile policies typically protect the owner of the policy against accidents that occur when the individual is acting as a volunteer. Coverage, however, is often not provided when the individual is an employee or employer or when an admission or rental fee is charged. Any volunteer who is operating a boat should be required to have homeowner's, automobile, or boat insurance. The policy should be checked to make sure volunteer work is covered.

Prepared by Tamara A. Dudiak, University of Wisconsin Extension-Lakes

For additional discussion on liability issues for lake organizations, see T. Mentkowski, 1999, *Liability Risks and Protections for Wisconsin Lake Organizations.*

Materials to Have When Working at a Boat Landing

Not all your materials need to be taken to the boat landings. It's better to sort through the materials and decide what educational information is best suited for your area. The "Clean Boats, Clean Waters" program provides a tote bag in which to store all the educational materials in the resource kit. We recommend at least one resource kit for every landing you are monitoring. By using multiple resource kits, each inspection team can have all the materials they need at hand.

A key brochure to distribute to all boaters is "Help Stop Aquatic Hitchhikers" (WT-801). This brochure not only has pictures of the different aquatic invasive species, but also describes the prevention steps that boaters need to take every time they leave the water. In addition, the brochure describes Wisconsin's illegal-to-launch law and the penalties that can occur if an invasive species is not removed before the boat is launched. This brochure is a good reminder to all boaters, whether or not they have talked with a watercraft inspector.

When talking with anglers or when questions regarding Wisconsin's live bait laws come up, the "Fishing with Bait" brochure and "Wisconsin anglers remember" sticker are excellent to have on hand. These two publications clearly outline Wisconsin's rules on the use of live bait and are excellent resources to share with folks who are confused by the detailed regulations.

Select other materials to take to the boat launch based on which aquatic invasive is most threatening in your area. Perhaps Eurasian water-milfoil is really a pressing issue for your lake; then it makes sense to give boaters an EWM/NWM identification card in addition to the "Help Stop Aquatic Hitchhikers" brochure. Resist the temptation to give the boater one of every card in the resource kit because boaters will often discard them. It's best to start by handing out a little bit of information and have additional brochures available if the boaters want to learn more about a particular invasive species.

Boat landings can be very busy during the summer, and you may need more materials before the end of boating season. It's easy to order more of these free publications! The Aquatic Invasive Species Publication List and instructions on how to order more materials are available online. Refer to your "AIS Online Resources" handout or visit: http://dnr.wi.gov/lakes/invasives/AISPubList.pdf

Additional boat launch items to consider:

- Clipboard and pencil.
- Copy of the boat landing script (see Section 2).
- Watercraft Inspection Report Form and Watercraft Inspection Prompts Handout (see Section 3).
- Listing of lakes with AIS presence in your area.
- Wisconsin map.
- "Stop Aquatic Hitchhikers" stickers.
- "WI Anglers: Minnow Use Reminder" stickers.
- "Fishing with Bait" brochures.
- Other selected (free!)AIS publications.
- Cell phone and local contact phone numbers for emergencies.
- Digital camera.
- Plastic bags, permanent marker, and cooler to collect and store any suspect specimens.

Watercraft Inspection Tips

Use the following DO and DON'T lists to prepare your boat landing message.

The DO List

- ✓ Wear the "Clean Boats, Clean Waters" T-shirt to promote the message. This message gives credibility to the program and to the efforts that inspectors are making across the state.
- ✓ Always introduce yourself and mention the organization you are working for and why you are at the landing.
- ✓ Try to approach boat owners before they are on the ramp.
- ✓ Always ask if the boater would mind answering a few questions.
- ✓ Be polite and courteous to all boaters you encounter.
- ✓ Listen to a boater's concerns. Remember that you are encouraging boaters to take an interest in invasive species.
- ✓ Make sure boaters know that they can make a difference!

The DON'T List

- ✕ Don't begin asking questions immediately upon approaching boaters, because as they might be confused about who you are and why they should give you their time.
- ✕ Avoid delaying boaters too much or causing a backup.
- ✕ Never preach to a boater; your mission is to educate, not alienate.
- ✕ Do not emphasize the idea that fines are involved, because this approach can make people hostile or defensive.
- ✕ If the boater is reluctant to cooperate, hand out educational material and record whatever information you can.

An effective watercraft inspection team is prepared to raise boater awareness and to encourage and demonstrate the necessary steps to avoid spreading invasive species. On very rare occasions, you may be uncomfortable about a situation or person. Always back away from a potentially dangerous or violent situation. Never encourage confrontation, no matter how strongly you might feel about the subject. **Remember, you are not enforcers of rules and should never jeopardize your own safety**. If you are suspicious of someone (for example, a loiterer or someone who is not intending to go boating), do not hesitate to leave the launch site. You are better to be safe than sorry. If you feel that a boat launch site is unsafe in any way, please notify the organization you are working for.

Boat Landing Message

Getting out and speaking to the public can be intimidating. New inspectors can feel a little anxious and nervous. This prepared script will help inspectors practice and role-play before their first boater shows up at the landing. Practicing with other folks will give them the confidence it takes to greet a boater. If new inspectors really want to watch a "pro," they just need to ask a few kids to get involved. Are kids intimidated? No way!

This prepared script is only one example of the many methods of addressing boaters at the landings and performing watercraft inspections. Each inspector should develop his or her own style and learn how to adapt in a variety of boat landing experiences. Try to approach boaters before they are on the ramp, and use the Watercraft Inspection Report form to record the information about the boater (see Section 3). At times you may have only 30 seconds to talk to the boater; other times, long lines at the landings may provide you with lots of time to talk. Remember, if the boater is not interested, just hand out educational material and record whatever information you can.

No matter what style you use to approach boaters, any watercraft inspection process should include these points:

1. Tell them who you are, whom you represent, and why you are there.
2. Ask if they have a short time to answer some questions.
3. Use the Watercraft Inspection Report form to assist you in your conversation and record boater responses.
4. Ask if they are familiar with the AIS prevention steps that are required by law, such as draining all water from boats, livewells, and equipment before leaving the landing. Briefly explain why these steps are important, using the Prompts to assist you. Be sure to share your local concerns and highlight what species are found in (or nearby) your area.
5. Ask if they will join you in an inspection of their boat and equipment.
6. Talk while inspecting, and point out watercraft checkpoints. If they do not want to assist you in the inspection, continue to talk about invasive species as you inspect.
7. Give your final message, the prevention steps:
    - Inspect your boat, trailer and equipment and
    - Remove any attached aquatic plants, animals, and mud.
    - Drain all water from boats, vehicles, and equipment (including live wells and containers holding your catch).
    - Never move live fish away from a waterbody.
8. Offer them the "Stop Aquatic Hitchhikers" brochure and sticker, along with any other educational materials pertinent to their questions or your lake.
9. Thank them for their time and cooperation!

Sample Script

As the boat approaches, write down the time of the boat inspection and if the boat is entering or leaving the water.

Introduce yourself:

Good Morning / Afternoon. I am from ______. We are working with state agencies and local groups to talk with boaters about invasive species and help them check their boats for Eurasian water-milfoil (EWM) and zebra mussels (ZM). We are trying to keep EWM/ZM and other harmful invasives from spreading from lake to lake. I have a few quick questions I would like to ask you, and then I would like to walk around your watercraft with you and point out a few places where these species can attach to boats and trailers.

Ask the questions and record on the Watercraft Inspection Report Form:

1. Have you been contacted by a watercraft inspector this season?
2. Are you willing to answer a few questions?
3. Was boat used during the past 5 days on a different waterbody?

   (If the answer is yes) Where?

Use conversational approach to <u>discuss the AIS prevention steps</u> listed on the form with the boater, <u>asking the follow-up questions</u> to engage the boater. Use the educational prompts on the "Prompts" handout as needed to explain the importance of each step and discuss local AIS concerns.

Wisconsin law requires boaters to take the following steps when leaving a boat landing:

<u>Steps 1 & 2</u>: **Inspect** boat, trailers, and equipment and **remove** any attached plants/animals.

Have you heard of this before? (see prompt)

<u>Step 3</u>: **Drain** all water from **boats**, vehicles, and equipment.

Do you have any questions? (see prompt)

<u>If angler, state the following steps</u>:

<u>Step 4</u>: **Drain** water from **livewells** and containers holding your catch.

This is a relatively new law. Were you aware that this is required? (see prompt)

Do you use live bait? (<u>If YES, share message below</u>.)

<u>Bait Message</u>: If live bait comes in contact with lake/river water, it can only be used on that same waterbody or discarded in trash. (bait=minnows/leeches/worms)

Do you have any questions on this law as it can be a little confusing? (If yes, see prompt and offer bait sticker/brochure.)

Perform a watercraft check:

If you would walk around your boat with me, I can show you some areas to look for invasive hitchhikers.

Make sure you talk aloud as you inspect; it helps reinforce the "Clean, Boats, Clean Waters" behavior. Talk to boaters about inspecting and cleaning their watercraft and about draining the water from their boat—such as the bilge, bait buckets and live wells—before they leave the access.

Vegetation can be found on motor boats, the motor/prop, anchors, bunks, rollers, the trailer axle, lights/wiring; for jet skis, it can be found in the intake grate and propeller; and for sailboats, it can be found in the centerboards. Check your anchor and anchor line to see if any plants are clinging to it. Since water is another way invasives are spread, livewells, motors, and equipment need to be drained.

Some aquatic invasives, such as zebra mussels, are also found on the motor/prop, on the sides and bottom of boat below the waterline, on the anchor, and clinging to vegetation. Always inspect the hull and sides of your boat for aquatic invasives; if it feels gritty or sandy, it may be that new zebra mussels are attached. An extra precaution that you can take to eliminate other aquatic invasives is to wash your boat with warm tap water or take your boat through a car wash or dry your boat and equipment in the sun for five days before entering another lake.

Leave boaters with a final message:
"Clean Boats = Clean Waters"

Please make it a habit to:

- **Inspect** your boat, trailer and equipment and
- **Remove** any attached aquatic plants, animals, and mud.
- **Drain** all water from boats, vehicles, and equipment (including live wells and containers holding your catch).
- Never move live fish away from a waterbody.

Offer boaters the "Stop Aquatic Hitchhikers" brochure and sticker, which can be placed on the side of the trailer winch post or hitch. Tell them that this sticker can serve as a reminder of the AIS prevention steps. Offer anglers the "Wisconsin Anglers: Minnow Use Reminder" sticker and "Fishing with Bait" brochure. Tell them that those two items describe Wisconsin's bait laws clearly, in case they have any questions.

Thank the boaters for their time and cooperation!

After you've contact the boater, record the number of people who heard your prevention message and indicate how confident you feel about the boater's understanding of the AIS prevention steps. This completes the Watercraft Inspection Report Form!

Potential Scenarios/Questions from Boaters

“Why are you out here wasting resources when the plant is going to come anyway?”

Even the most educated will ask this question. Just be prepared mentally for such viewpoints and think about why you are out here and what you will say in reply. Expect the unexpected. Here are some suggested responses:

Even if we cannot keep the plants out completely, we can prevent a lot of widespread damage. Prevention also gives us time to adopt new control methods as they are developed in the future. The longer we keep invasives out of a lake, the longer we put off the enormous costs of management and property devaluation.

“Aren’t all plants bad anyway?”

It is important to clear up this misconception! This is what you can say:

Native plants are essential lifelines for an aquatic ecosystem, providing the basis for all life within. The problem lies with non-native, invasive plants that have no natural inhibitors and, therefore, outcompete native plants, lowering the water body’s aquatic diversity.

“I don’t have time for this... I know all about it already!”

This remark is fairly common. If the boaters do not wish to help you with the survey, you must respect their rights and let them be. In such a situation, the suggested action would be to offer them a brochure and wish them a nice day.

“Why did it take Wisconsin so long to do something, when milfoil has been a national problem for over a decade?”

There is no good answer to this question because it’s a very good point. Here is how you can respond:

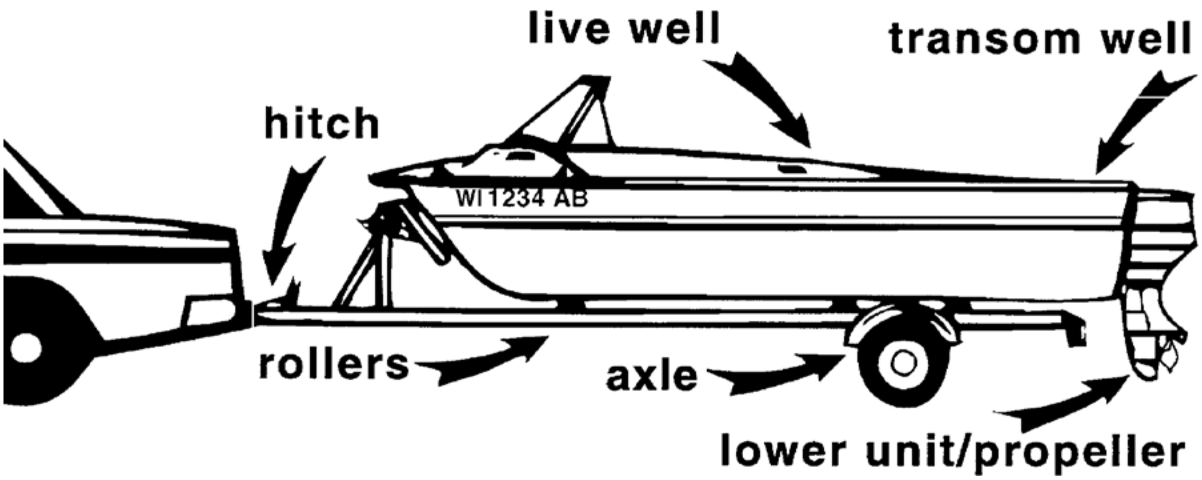
Traditionally, environmental problems become established before we do anything about them. In this case, we have learned from other states, and are trying to take action well before these plants spread to many of our sensitive environments. Instead of focusing on what could have been done, we should focus energies on the present and future.

“Why do I have to take these prevention steps when I only use my boat in one lake?”

This question gives you the opportunity to talk about the value of changing our behaviors and why it is important.

That’s a great question! Although you always visit the same lake, it is still useful for you to take these prevention steps every time you boat. Repeating these steps helps the actions become a regular part of your boating behavior, so that if you do ever decide to take your boat to another lake, you will remember to take the prevention steps. Prevention is the key to stopping the spread of aquatic invasive species.

Watercraft Check Points



Trailer:

- ❑ Axle
- ❑ Bunks
- ❑ Frame
- ❑ License Plate
- ❑ Lights/wiring
- ❑ Rollers
- ❑ Spare Tire
- ❑ Wheels
- ❑ Winch Rope

Boat:

- ❑ Floor
- ❑ Hull
- ❑ Livewell
- ❑ Transom Well

Motor:

- ❑ Intake Pipe
- ❑ Prop
- ❑ Lower Unit

Boat Accessories:

- ❑ Anchor
- ❑ Bow Line
- ❑ Ladder
- ❑ Tow Rope
- ❑ Transducer

Other Accessories:

- ❑ Bait Bucket
- ❑ Fishing Line
- ❑ Landing Net
- ❑ Tackle

How to Handle Violations

With thousands of boaters traveling throughout the state and with many of those boaters jumping from lake to lake within one day, it is very realistic to expect someone to try to launch a weed-filled trailer at your landing. Since 2001, it has been illegal to launch a boat or trailer with aquatic plants or zebra mussels attached, and in 2009 it became illegal to transport aquatic vegetation or water from one place to another, in addition to other AIS laws (see Section 3 for more details). Not all folks know about Wisconsin's AIS laws. Even after a number of publications, news articles, and television programs concerning invasive species, not all boaters realize the importance of their action or lack of action in preventing the spread. Keep in mind that you should first try to educate the public.

If you choose to report launching violations, make sure you have done your homework. Contact your local DNR Conservation Warden and local law enforcement to let them know that you'll be doing inspections. Ask if they are willing to provide you with support in the case of a violation, what information is necessary for enforcement, and more importantly, ask whether the enforcement officer will be willing be act on a violation if he or she has not witnessed the event. Knowing these answers before the event will certainly predict a better outcome.

So what happens when a boater violates an AIS law? Several options can occur, from the least offensive reaction to the strongest objections to remove and comply with the law.

The soft touch: Boaters who are unaware of the AIS laws will probably put the boat in the water and think nothing about it. Unfortunately, this has been the practice for many years, which is one reason Wisconsin is struggling to control the spread of aquatic invasive species. However, you have an opportunity to educate that boater about the dangers of invasive plants and the prevention steps that boaters need to take each time they leave a body of water. With luck, boaters will listen to your message and remove aquatic plants and drain all water without any assistance.

An assertive approach: So what do you do if a boater doesn't get the point? Offer to assist the boater in checking and removing any aquatic plants. Always ask permission first before you touch any boat, trailer, or personal equipment. If the boater gives you permission, go ahead and help remove the plants and ask if you can keep a sample, especially if you suspect an invasive species. Let the boater know that you're just trying to prevent them from receiving a citation from any law enforcement or wardens that stop by, because the wardens are stepping up the number of citations they're issuing for AIS violations.

The strongest approach: And what if the boater refuses to remove the aquatic plants or drain water from their boat and equipment? At this time, you really stress the fact that it is illegal to not comply with the prevention steps that you're recommending, and you use the Violation Report form to record the basic information that a law enforcement officer requires in order to pursue the complaint. If you take a picture, it should include the boat registration number and attached plants. Usually, by this last step, the boater complies, the plants come off the boat, and the lake remains safe from another invasive arrival.

If the boater chooses to launch after all your efforts, then you can report the facts to a law enforcement officer. The definition of "law enforcement officer" for purposes of section 30.715 (4), Wisconsin Statutes, is noted at section 30.50 (4s), Wisconsin Statutes, which reads:

30.50 (4s) "Law enforcement officer" has the meaning specified under s. 165.85 (2) (c) and includes a person appointed as a conservation warden by the department under s. 23.10 (1).

Section 165.85 (2) (c), Wisconsin Statutes, in turn defines "law enforcement officer" as any person employed by the state or any political subdivision of the state, for the purpose of detecting and preventing crime and enforcing laws or ordinances and who is authorized to make arrests for violations of the laws or ordinances that the person is employed to enforce.

The definition of "law enforcement officer" is obviously very broad and would clearly allow law enforcement officers of counties and municipalities throughout the state to enforce the AIS regulations and laws. Your best resource is your regional DNR Water Guard or local DNR Conservation Warden. Before you pursue any enforcement action, make contact with your local warden to know what information the warden expects from you. The warden will decide how to process the violation.

We are excited to now have DNR Conservation Wardens devoted primarily to providing education and enforcement on the AIS laws and regulations. Each DNR region in Wisconsin has at least one Water Guard; in some cases, more than one.

Photo provided by WDNR

AIS Violation Report Form

Boat Landing/Location:____

Date:____________________ Time:____________________ AM or PM

County:____________________ Town/Village/City:____________________

Vehicle License Number:____________________ State Registered:____________________

Boat Registration:____________________ State Registered:____________________

Car/Boat/Personal Watercraft Information -

Year:__________ Make:__________ Model:__________ Color:__________

Violator Information: Male or Female

Name of Boat Operator:____

Hair:__________ Eyes:__________ Approx. Height/Weight:____________________

Other Description (clothing, etc.):____

Photo Taken of Violation: Yes or No

Description of Violation/Comments:____

____

____

____

CBCW Inspector's Contact Information -

Name:______________________________ Phone Number:____________________

Address:____

❐ Please check box if law enforcement may contact you for more information about the violation. You will remain confidential in this case.

❐ Please check box if you do not want law enforcement to contact you for more information about the violation.

Regional Water Guard Contact Info:	**To report the violation, contact your area Water Guard or DNR Warden OR call 1-800-TIP-WDNR**	Local DNR Warden Contact Info:
____________________ ____________________		____________________ ____________________

Section 3:

How do inspectors share their inspection data?

Collecting & Reporting Inspection Data

As a part of conducting watercraft inspections, data is collected by volunteer and paid Clean Boats, Clean Waters inspectors at boat landings and recorded on the Watercraft Inspection Report form. This form contains questions that help citizens and the state better understand boaters' knowledge and behaviors regarding aquatic invasive species. The data gathered at the boat landings is then entered into a large online database, called the Surface Water Integrated Monitoring System or SWIMS, by watercraft inspectors.

Data collected at boat landings provides citizens and the state with valuable information.

Photo by Robert Korth

There are **many advantages** to keeping records for the watercraft inspection program:

- With limited state resources, it makes sense for each inspection team to track their own data.

- Collecting data helps the inspection team discover traveling patterns of boaters who visit their lake.

- The data may be useful information if the local lake association or lake district applies for a DNR Lake Planning and Management Grant or an Aquatic Invasive Species Prevention and Control Grant.

- The data could also be useful for local ordinance reviews that pertain to the boat landing or waterbody use.

- **Most importantly**, by recording and sharing information on SWIMS online database, inspection teams will assist lake managers with invasive species prevention and control and will quantify the impacts that both paid and volunteer inspectors are having on invasive species. **Having this information helps justify the continued need to support the invasive species programs.**

How to Use the Watercraft Inspection Report Form

Each day that you conduct watercraft inspections, you will be collecting data about boater behaviors and awareness on the Watercraft Inspection Report form. The forms are designed to be used at one boat landing for one day. Each day you inspect boats, you will use a new report form, and you may use multiple report forms if you visit more than one boat landing in a day. If you run out of room on the report form during your time at the landing that day, it's no problem - just start a new form and staple it to the other forms that you complete at that boat landing for that date. Below are a few guidelines to assist you in effectively collecting and recording the correct information on your form.

Preparing the Form for Inspections

To get your inspection form ready to enter data, fill in the top section with the who, what, when, and where information. This information can be typed into the form and printed out ahead of time or written on the form by hand.

- Inspector Name(s): Enter your name here. You may include the names of any other inspectors who are working with you at the boat landing on that day.
- Date: Enter the date you are conducting inspections. Remember, data forms can only be used for one day on one waterbody at one boat landing. If you go to another boat landing the same day, start using a new form.
- Start Time & End Time: Enter what time you are starting inspections and what time you will wrap-up inspections for the day.
- Total Hours Spent: Indicate whether you are volunteering your time or being paid to do inspections by entering the total number of hours you spend at the boat landings on either the "Volunteer" or "Paid" lines.
- Waterbody Name: Enter the name of the lake where you are conducting inspections.
- County: Enter the name of the county in which you are conducting inspections. Since many lakes have similar names, this helps us know the exact location.
- Landing Location Description: Enter the name of the boat landing where you are inspecting. If the landing has no name, describe your location on the lake as thoroughly as possible. Later when you're ready to enter your data into the online database, we can make sure the correct landing names are available for your waterbody.

Collecting Data During Inspections

Now you're ready to begin inspections. When you encounter a boater, you will introduce yourself and begin your conversation with them about AIS. The questions to ask them are outlined on the form as follows, and you will record their responses, in most cases by marking the appropriate boxes on the data form.

- In the "Boat Was…" section, note if the boat or trailer was entering the water or leaving the water. On waters that have aquatic invasive species already present, inspections should take place as boaters and anglers are leaving the landing. Sharing information with them as they leave the water helps ensure the AIS are being contained in that waterbody and not being spread elsewhere. On waters free of AIS, inspectors have a choice of educating boaters when they're entering or leaving the water. Either time offers a good opportunity to share information.

- The "Questions to Ask Boater" section includes three questions that you should talk about with the boater.

  - **Have you been contacted by an inspector this season?** Answers to this question help prevent you from sharing the same AIS prevention message with the same boaters over and over. We don't want to over-saturate the same boaters with the same message - this could frustrate them. This question also helps us to learn more about how many boaters and anglers we are reaching with inspections. It also tells you about the boater's potential awareness of AIS and boat inspections. Boaters who have never talked to an inspector before will often need more information than someone who has been inspected previously.
  - **Are you willing to answer a few questions?** If the answer is yes, continue on to the next question. If the answer is no, thank the boater for their time and tell them to have a nice day. Your conversation with them is complete.
  - **Was the boat used during the past five days on a different waterbody?** If the answer if yes, record the name (and county and state, if possible) of the last waterbody. This allows state and local groups to compile information on boater traveling patterns. If the answer is no or I don't know, please indicate that my marking the corresponding box.

- You're now ready to engage the boater in an educational conversation, using the questions and prompts listed under the "Discuss Following Prevention Steps with Boater" section.

  - Following the steps listed on the form, share the prevention message step by step and ask the follow-up questions listed after each step with the boater. Use the prompts provided on the "AIS Prevention Steps Prompts" handout to assist you with localizing your message and answering any questions you receive.

- For all anglers, share the additional step and follow-up question regarding draining livewells. If the angler uses live bait, please share the bait message and follow-up question included on the form. This information can also be shared with boaters who have questions about bait laws.

- The last two questions on the form are observations and opinions to be recorded by the inspector. These are not questions that should be asked of the boater.
  - The "Number of People Contacted" question refers to the number of people who heard your message. This can include any children who were listening while their parents prepared to launch their boats or individuals who were simply visiting the landing.
  - The "I feel confident that boater understands the steps necessary to prevent the spread of AIS" question asks for your **opinion**. After talking with the boater about the prevention steps, indicate your level of confidence that the boater **understands** the prevention steps. This is not the same as whether of not you feel the boater will take the steps - just how confident you are that they received the AIS message.

Wrapping Up After Inspections

Once you've completed your inspections at that boat landing for the day, you may have one form or many forms full of the data that you've collected. Before you put the forms aside to enter later, be sure to do just a few quick things to make sure your data form is complete.

- Fill in any additional thoughts or comments you'd like to record in the "Comments" section at the bottom of the form, such as the weather conditions, if there were any unusual occurrences that day, or anything else you'd like to share.

- Data is collected and entered for each landing each day. If you have multiple data sheets, use the "Sheet__of__" spot to indicate how many total sheets you have for that day and number each sheet accordingly.

- Lastly, total each column on the datasheet and enter the total number in the last row titled **"Totals"**. To do this, count the number of checks or marks you have made in each column and record that number in the "Totals" row (the exception being the waterbody and county/state names as they cannot be totaled). Don't forget, data is collected and entered for each landing each day. So, if you have multiple datasheets, you'll count the column marks on all of the datasheets and have a grand total for each column that includes the data from all sheets.

Now you're ready to enter your data into the online database known as SWIMS (Surface Water Integrated Monitoring System). More information and instructions on how to enter data can be found in the following pages. **Best of luck in your watercraft inspection program, and remember to let boaters know that they're making a difference by following the prevention steps!**

State of Wisconsin
Department of Natural Resources
Wisconsin Lakes Partnership

Watercraft Inspection Report

Form 3200-120 (R 4/14)

Notice: Information is collected under s. 33.02, Wis. Stats. Personally identifiable information, including names of volunteers, will be broadly distributed in conjunction with lakes data.

Inspector Name(s)	Date	Start Time ◯am ◯pm	End Time ◯am ◯pm	Total Hours Spent: Paid: ______ Volunteer: ______
Waterbody Name	County	Landing Location		

Questions to Ask Boater

Boat Was... Entering	Boat Was... Leaving	Have you been contacted by a watercraft inspector this season? Y	N	Are you willing to answer a few questions? Y	N	Was boat used during the past 5 days on a different waterbody? Y	N	If YES, where? Waterbody Name / County / State	Don't know	Number of People Contacted	I feel confident that boater understands the steps necessary to prevent the spread of AIS. (Check one) Strongly Agree	Agree	Disagree	Strongly Disagree
TOTALS														

Discuss Following Prevention Steps with Boater

WI Law requires boaters to take the following steps when leaving a boat landing:

Steps 1 & 2: **Inspect** boat, trailers and equipment and **remove** any attached plants/animals.

» Have you heard of this before? (see prompt)

Step 3: **Drain** all water from **boats**, vehicles and equipment.

» Do you have any questions? (see prompt)

If angler, state following steps:

Step 4: **Drain** water from **livewells** and containers holding your catch.

» This is a relatively new law. Were you aware that this is required? (see prompt)

Do you use live bait? (If YES, share message below.)

Bait Message: If live bait comes in contact with lake/river water, it can only be used on that same waterbody or discarded in trash. (bait=minnows/leeches/worms)

» Do you have any questions on this law as it can be a little confusing? (If yes, see Prompt and offer bait sticker/brochure)

TOTALS: Enter the totals & waterbody information into SWIMS at **http://dnr.wi.gov/lakes/cbcw-data**

Comments:

Sheet ____ of ____

Sharing Information

Everyone who attends a "Clean Boats, Clean Waters" training workshop is entered into the watercraft inspector database. Each participant's name, address, and contact information is collected during the workshop and reported in the inspector database. This helps us keep track of the inspection efforts that are going on around the state.

Obtain a SWIMS User ID & Password

Ready to enter your inspection data? Watercraft inspectors must obtain a user ID and password before they can enter any information into the SWIMS online database. Here's how:

1. Go to: **https://on.wisconsin.gov**.
2. Click on the link labeled **"Self-Registration"**.
3. Scroll all the way down to the bottom of the page and click **"Accept"**.
4. Fill in your name and e-mail address. (Note: Only fields with a red asterik* next to them need to be filled out. Leave the postal address field blank. Addresses for inspectors are kept in a separate database.)
5. Choose a User ID, password, and a secret question (used in case you forget your account information.)
6. Click **"Submit"**. Now check your e-mail account. You should have an e-mail from "wisconsin.gov". Open the e-mail and **click on the link in the e-mail**. Log in with your new User ID and password.
7. You're almost done! **The final step is to e-mail your User ID to: jennifer.filbert@wisconsin.gov.** In the e-mail, **state that you are a part of Clean Boats, Clean Waters and say where you are going to be inspecting** (i.e. Big Lake in Shawano County). Also, **mention if your inspection efforts are part of a DNR lake or AIS grant**. Within a couple of business days, your User ID will be entered into the SWIMS database, and you will be sent an e-mail letting you know that you're all set up to enter data.

Common Questions/Issues & Tips:

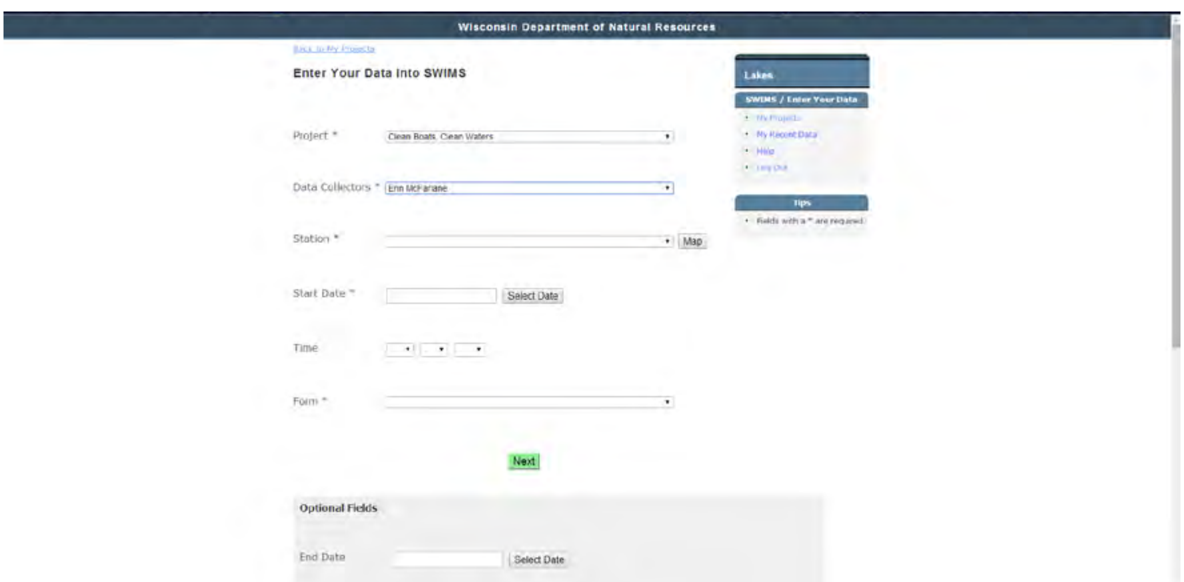
- ***When I open the e-mail to click the link, the link doesn't work.*** If the link in the e-mail wraps to the second line and if you click and don't get a log in page, try copying and pasting the part that wrapped around onto the end of the URL.
- ***I don't know what to put for the Secret Question.*** The secret question should be something you can easily remember that doesn't change. You want to pick something where there aren't too many ways to type the answer. For example, name of first pet, color of first car you owned. The secret question has nothing to do with your password, but if you forget your password, it's a way for the computer to tell that it's really you.
- ***I don't have an e-mail address.*** If you don't have an email address, there are many places on the Web where you can get a free email account from Google, Hotmail (MSN), Yahoo!, etc.

- ⇨ ***When I try to fill in my information (name, address, etc.), it doesn't accept it.*** There is a bug with entering postal addresses, so leave the address blank. Also note: even if you don't fill in the address, addresses for inspectors are kept in a separate database system, so we will still have your address if you have already given it to us.
- ⇨ ***I got a user id and password, but when I try to log into SWIMS, but it won't recognize me.*** Be sure to e-mail your user ID to Jennifer (see step 8).

Entering Your Data Into SWIMS

After you receive your user ID and password, you will be able to enter the information you have collected during the watercraft inspections. Online data entry involves entering the numbers in the"Totals" row located at the bottom of your report form. Here are step-by-step instructions on how to enter your inspection data into SWIMS:

1. Go to: **http://dnr.wi.gov/lakes/cbcw-data** (this web address is also listed on the Watercraft Inspection Report form).
2. **Log in with your user ID and password.** If you forget your password, just click on "Forgot Your Password?"
3. Your "My Projects" page will list your active CBCW projects. Projects are often specific to the lake being inspected (example: Clean Boats, Clean Waters - Long Lake). If you are inspecting many waterbodies in a county, your project may be broken down by county and year (example: Clean Boats, Clean Waters - Oneida County). Click **"Enter Data"**.
4. Ensure the correct project is listed by using the dropdown menu. Then, **select the data collectors and station (boat landing)**. If there are additional data collectors that you'd like to add but they're not listed in the dropdown menu, send jennifer.filbert@wisconsin.gov a list of names, and she will add them to you dropdown box. Alternatively, inspector names can be listed in the "Comments" field.



5. **Select the Start date and time** (when you started working at the landing that day). End date and time are optional.
6. Under Form, ensure the **Watercraft Inspection Report (Revised 3/2014)** is selected.
7. Down below, you have the option of entering the End Date and Time, as well as your written observations in the **comments** box (i.e. weather, wildlife).
8. **Click "Next" to begin filling in your totals**. The data you enter will be in the "Totals" row found at the bottom of your report form.
9. When you've filled in the totals, **click "Next" and you can enter any waterbody names that boaters reportedly visited during the past five days**.
10. Then, **click "Next Date" to continue entering data for another day, or click "Next Station" to enter data collected at another boat landing. If you're finished with data entry, click "Done"**. When you click "Done", you will see the data you recently entered.

Editing Existing Data

You can edit data you've entered during the current inspection season. Here's how:

1. Log into SWIMS at: <u>http://dnr.wi.gov/lakes/cbcw-data</u>.
2. Click **"Edit Data"** listed under your CBCW project. Click the **pencil icon** for the date you want to edit.
3. You can edit comments, etc. on the first page if necessary, and then click **"Next"**. You can now edit your results. If you hit **"Save and Return to List"**, your changes will save, and you'll return to the list of data entries.

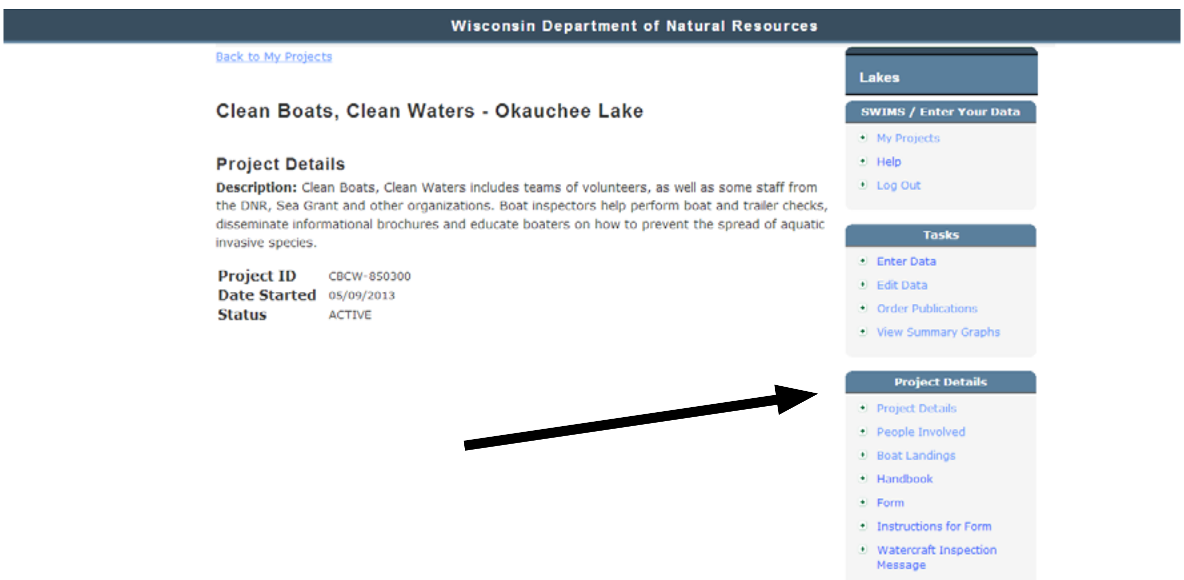
Common Question:

- ⇨ ***What if the landing I need isn't listed? What if I'm not sure?*** You can select a landing and click "Show Map" to see where it is located. Otherwise, contact Jennifer at jennifer.filbert@wisconsin.gov to have a landing added or to suggest a better description for the landing.

If you need assistance with anything related to reporting your data, feel free to contact Jennifer at jennifer.filbert@wisconsin.gov.

Project Details

After logging into SWIMS, you will see your "My Projects" page that lists all of the projects you are associated with. By clicking "More" under a specific project, you can view the details of that project. You can also access a variety of project details and resources located in the tool bar on the right-hand side of the page. This includes information like: a list of the landings associated with the project, a list of inspectors involved in the project, data download and summary graphs of the project data, and links to the CBCW manual, Watercraft Inspection Report form, and more.



"Anything else you're interested in is not going to happen if you can't breathe the air and drink the water. Don't sit this one out. Do something. You are by accident of fate alive at an absolutely critical moment in the history of our planet."

- Carl Sagan

Section 4:

How can inspectors take care of their boat landings?

Boat Landing Inventory

The "Clean Boats, Clean Waters" program offers an excellent opportunity for inspectors to inventory the boat landings on their lake. Oftentimes the signage is old or damaged and needs to be replaced. Boat ramps and piers may need servicing or trash buckets may be missing. If the landing has a message board or kiosk, inspectors can post informational brochures about invasive species and contact numbers if a questionable plant or animal is found. Remember, the boat landing is the first opportunity for inspectors to educate boaters. The watercraft inspection team cannot be there for every boater, so inspectors must be prepared to offer education and information at any time.

It is important to know who owns the landing and who to contact when maintenance needs to be done. Inspectors should always seek permission prior to making any changes at the landing site.

If the landing is in need of signage, inspectors can contact their local DNR service center for the appropriate sign (see the following pages for the sign posting information and an image of the AIS landing sign). To assist inspectors in developing an educational message, the "Clean Boats, Clean Waters" resource kit and the "Clean Boats, Clean Waters" Web site: http://www.uwsp.edu/cnr/uwexlakes/cbcw contain examples of brochures and flyers that can be customized for each community.

Photo by UW-Extension Lakes

Instructions for AIS Sign Installation

Thank you for posting Wisconsin's new AIS signs! AIS signs are an effective tool for reminding and educating boaters about AIS prevention steps and Wisconsin's AIS Law. It is our goal to place AIS signs at all public boat landings in the state.

Before Installation...

Required:

Contact Diggers Hotline before you install any post at a boat landing. Although new posts may not be required, it is helpful to contact Diggers Hotline to avoid surprises in the field. The request to Diggers Hotline can be submitted electronically. For more information, visit: http://www.diggershotline.com and click on "Ready to file? Click here!". Always call before you dig or put a post in the ground!
Diggers Hotline - Wisconsin's One-Call Center: **CALL 811 or (800) 242-8511 | (877) 500-9592 (emergency only)**

Recommended steps:

Taking the time to put together a map, obtain permission, and plan a route saves time and miles in the field. Plan ahead and follow these recommended steps:

1. Delineate township lines on map copied from Wisconsin Gazetteer and County plat books.
2. Identify lake and river landings on maps.
3. Obtain permission from landing owners by contacting Federal agencies, DNR (Forestry/ Fisheries) department, county (Land and Water Conservation, Forestry or Parks), cities, towns, villages, and private owners. Boat landing operators and managers can also be searched online within the "more information" section at: http://dnr.wi.gov/topic/lands/boataccess. County clerks offices also frequently have this information available. Please see attached sample permission letter and form for details.
4. Gather additional needed materials, such as printing off boat landing survey forms for each boat landing that will receive a new sign (see page 8-10 for survey form). This may also be a good opportunity to replenish publications at kiosks. To place AIS publication orders, please email orders to DNRAISinfo@wisconsin.gov.
5. Contact local officials for directions to landings and for locations of commonly used private landings not on the map. They often can provide names or phone numbers of private landing owners and other helpful information.

Current signs at boat landings:

There are three AIS signs that the DNR has provided in the past and you will likely encounter at boat landings. The intent of the new sign is to replace these old signs. Therefore, we recommend you take down these signs during your visit and return them to your local DNR office. These signs will be recycled for the new signs, which will greatly reduce our costs. These signs are:

1. “Exotic Species Advisory”

2. “HELP Prevent the Spread of Aquatic Exotic Plants and Animals”

3. “Please Stop and Remove All Aquatic Plants and Animals and Drain Water from Boat and Trailer”

Sign Installation

Equipment you will need:

- ✓ 7-8 foot metal U-posts (U channel posts).
- ✓ Post pounder/sledge hammer
- ✓ Step Stool
- ✓ Hammer
- ✓ Cordless drill and drill bits
- ✓ 5/16" socket and wrench
- ✓ 5/16" x 2 ½" Hex bolts for securing yellow signs to post.
- ✓ 5/16" x 2 ½" Carriage bolts for securing metal signs (no washer needed).
- ✓ 5/16" Lock nuts (with plastic threads so no lock washer needed)
- ✓ 5/16" Tufnut (anti-theft) security nuts, bolts, and washers for posting areas where signs tend to disappear.
- ✓ Maps:
  - Wisconsin Gazetteer
  - Lake Maps
  - Plat Books
- ✓ Other:
  - Boat landing survey form (1 form/sign), see attached
  - Permission slips, see attached
  - Directions to landings
  - Boat Landing Inventory Form (water resistant paper suggested)
  - Ear plugs/muffs
  - Gloves
  - Hard Hat
  - Cell Phone
  - Digital Camera
  - Regional DNR Telephone Directory
  - Warden Contact Numbers
  - Sun block
  - Sunglasses
  - Pencils
  - Permanent marker
  - Clip Board
  - Watercraft Inspection Report (to record any watercraft inspection efforts)
  - Brochures, Wild Cards to distribute to the public at the landings

How to install a sign:

1. Contact Diggers Hotline before you install and request permission to install a new sign.
2. Find ideal sign location facing water, that is easily visible to boat landing users.
3. Make sure sign is out of way of vehicle traffic. In order to maintain public safety, NO signs should ever be installed on traffic regulatory sign posts. If there are any questions about appropriate sign location at public access sites, please consult the property manager.
4. Use post pounder or sledge hammer and secure U-post 2-3 feet in ground making sure the open end of "U" faces the water.
5. Align top of sign with top of U-post and insert bolts from front of sign through predrilled hole in the top and bottom of the sign and post. (Make sure both holes line up with holes in post before securing with nut or tufnut).
6. Use socket and/or wrench to secure nut or tufnut to bolt.
7. Make sure sign is secure.
8. Place red "this waterbody is known to contain…" sticker, if applicable. Check online at http://dnr.wi.gov/lakes/invasives/AISByWaterbody.aspx for a list of waterbodies known to contain AIS.
9. FILL OUT boat landing survey form and upload information into SWIMS or return by mail.
10. Repeat at next landing.

What to do after new signs have been installed:

1. Recycle metal and plastic signs, posts, and hardware to a local recycling facility. You may also keep them if you think you may be able to use them in the future.
2. Remember to enter your boat landing survey form into SWIMS or to mail it back to:

AIS Education Specialist
Wisconsin DNR- WT/4
101 S. Webster St.
Madison, WI 53703

If you have additional questions/comments please contact Bob Wakeman at robert.wakeman@wisconsin.gov. Thank you again for your efforts in protecting Wisconsin's waters!

The new AIS boat landing sign is 18" wide by 24" high and is made from reflective metal.

Sample Permission Letter

State of Wisconsin / DEPARTMENT OF NATURAL RESOURCES

WISCONSIN
DEPT. OF NATURAL RESOURCES

Jim Doyle, Governor
Scott Hassett, Secretary
William H. Smith, Regional Director

Northern Region Headquarters
107 Sutliff Ave.
Rhinelander, Wisconsin 54501-3349
TELEPHONE 715-365-8900
FAX 715-365-8932
TTY 715-365-8957

Date:

Subject: Permission to post signs at boat landings

Dear Town Board of Supervisors,

One of the ways the Wisconsin Department of Natural Resources (WDNR) is addressing the challenge of combating invasive species in Wisconsin's waters is by posting signs at boat landings. These signs alert boaters to invasive species present in the waterbody and provide tips to prevent their spread to other lakes and streams. Other strategies to combat this problem include monitoring lakes for invasive species, training volunteers to monitor their own boat landings through the Clean Boats/ Clean Waters workshops, watercraft inspection efforts by agency staff and dissemination of education/outreach materials.

Your assistance is requested to help us post the signs. *Please forward to us a list of boat landings under your ownership.* We will then inform you which lakes contain invasive species and thus should be posted with the warning signs. *Your written permission granting authority to the WDNR to place signs at your boat landings is also necessary before sign placement can occur.*

Enclosed are copies of three metal signs. The plastic "yellow exotics advisory" sign is placed at boat landings on infested waters and the "Help Prevent…" sign is placed on uninfested waters. Both these signs are placed near the launch site. The "Stop" sign is posted as they leave the launch site as a reminder to boaters to clean their boats and equipment.

Feel free to contact me with any questions or concerns. **Please return the authorization form and the list of landings to me at the address above.**

Thank you for your interest and cooperation.

Sincerely,

Contact information

www.dnr.state.wi.us
www.wisconsin.com

Quality Natural Resources Management
Through Excellent Customer Service

Printed on Recycled Paper

Sample Permission Form

State of Wisconsin / DEPARTMENT OF NATURAL RESOURCES

WISCONSIN DEPT. OF NATURAL RESOURCES

Jim Doyle, Governor
Scott Hassett, Secretary
William H. Smith, Regional Director

Northern Region Headquarters
107 Sutliff Ave.
Rhinelander, Wisconsin 54501-3349
TELEPHONE 715-365-8900
FAX 715-365-8932
TTY 715-365-8957

Authorization to Post Signs at Boat Landings

The County Board of ________________________________ hereby grants permission to the Wisconsin Department of Natural Resources to place signs at boat landings under our ownership and/or control. The signs are to alert and educate boaters to the problem of invasive species in our waters.

Granted this day of ______________________________

____ Signature

Authorized Representative

BOAT LANDINGS UNDER OUR OWNERSHIP

________________________	________________________
________________________	________________________
________________________	________________________
________________________	________________________
________________________	________________________
________________________	________________________

www.dnr.state.wi.us
www.wisconsin.com

Quality Natural Resources Management
Through Excellent Customer Service

Printed on Recycled Paper

Boat Landing Sign Survey

Our goal is to have new aquatic invasive species (AIS) signs on every public boat landing in the state of Wisconsin. In order to meet this goal, we need to determine which boat landings have received the new AIS signs and which boat landings we still need to visit. **Please fill out a separate survey for each Wisconsin DNR AIS sign that you install at an access point. This survey information can be uploaded to SWIMs or mail to:**

AIS Education Specialist
Wisconsin DNR- WT/4
101 S. Webster St.
Madison, WI 53703

The information you provide will help us greatly. Thanks for all of your hard work to protect Wisconsin's waters!

Name__________________________________**Date of Installation** _______________________

Location of Access Point

Please fill out all known information.

County:______________________________

Municipality Name: ____

Waterbody Type:

- ❒ Lake
- ❒ River
- ❒ Wetland with navigable waterway
- ❒ Other __________________

Waterbody Name: ____

Boat Landing Name: ____

Address/Closest Named Road:

____

____

____

Follow-up Questions
Please fill in all known information.

Question 1: What type of access point was this?
- ❒ Ramp
- ❒ Carry-in
- ❒ Other

  If Other, please explain:____

Question 2: Before you installed the new AIS sign, 'Prevent the Spread…', were there other AIS signs at the access point?

Circle one: Yes / No

If Yes, check all that apply:
- ❒ Yellow 'Exotic Species Advisory' sign
- ❒ Green and white 'Help…. Prevent the Spread…' sign
- ❒ Green, white and red stop sign 'Please Stop and…'
- ❒ County ordinance sign
- ❒ Lake Association sign
- ❒ Other: ____

NOTE: Once new AIS signs are installed, we ask that you please remove all other DNR AIS signs. This includes the yellow 'Exotic Species Advisory' sign, the green and white 'Help Prevent the Spread…' sign, and the green, white and red stop sign.

Question 3: Did you remove any of these signs during your visit, or do you have plans to in the near future?

Circle one: Yes / No

If Yes, check all that apply:
- ❒ Yellow 'Exotic Species Advisory' sign
- ❒ Green and white 'Help…. Prevent the Spread' sign
- ❒ Green, white and red stop sign 'Please Stop and…'
- ❒ County ordinance sign
- ❒ Lake Association sign
- ❒ Other: ____

Question 4: When installing the sign, were you able to reuse the post from previous DNR signs?

Circle one: Yes / No

Question 5: Was this waterbody known to contain invasive species? (List of waters known to contain AIS at http://dnr.wi.gov/lakes/invasives/AISByWaterbody.aspx)

Circle one: Yes / No / Unsure

If Yes, was the red sticker "This Waterbody Is Known to Contain Invasive Species" applied to the bottom of the sign? Circle one: Yes / No

Question 6: Was the sign installed facing the water so people leaving the water could read it or facing the launching area so people launching could read it?

Circle one: Water / Land

Question 7: The ideal location for an AIS sign is at the access point, facing the water. However, we recognize this is not always possible. Please indicate the location that best represents where this sign is currently located (Check one):

- ❒ Next to the access point, facing water
- ❒ Next to access point, facing launch area
- ❒ On a pier or dock
- ❒ Next to or on a shelter or kiosk
- ❒ Next to the parking lot entrance or exit
- ❒ Other: ______________________________

Question 8: Does the access point appear to be in proper working order? Yes / No

If No, please explain: ____
____

Question 9: How many people installed the sign?

Circle one: 1 / 2 / 3 / Other:________

Question 10: How would you describe yourself? (Check one that best applies.)

- ❒ DNR employee
- ❒ County employee
- ❒ Municipal employee
- ❒ Boat landing owner/operator
- ❒ Lake Association Member
- ❒ CBCW Volunteer
- ❒ Other: ________________________

Again, thank you for your efforts to protect Wisconsin Waters! **Please contact Christal Campbell with any questions: 608-266-0061 / christal.campbell@wisconsin.gov.**

Boat Landing Questions

Invasive species are posing an increasing threat to the quality of water experiences in Wisconsin. Communities are looking at developing a campaign to educate boaters at the landings on the possibilities and consequences of moving aquatic invasives. Other communities are developing plans to look at their water resources and prevent or slow the spread of aquatic invasives. The following is a list of questions that we have been hearing from communities as they consider various prevention plans.

Landing Ownership and Maintenance

How can I find out who owns the boat landing?

Ownership of boat landings can be determined through a variety of methods. Plat maps are one useful source, as are searches at the register of deeds office for the county in which the landing is located. Department of Natural Resources (DNR)–owned and leased boat landings are identified on the DNR Web site under the "State Parks and Forests" Web pages. The DNR Web site also provides a page that contains links to the Web sites of county-owned parks.

Do state-owned parks operate under different rules than county, village, or city parks?

State-owned parks with boat landings are regulated under ch. 26, Wis. Stats. and ch. NR 45, Wis. Adm. Code. County, village, and cities that own parks with boat landings usually operate such parks and boat landings under local ordinances.

Who is responsible for maintaining the boat landings?

Whoever owns or operates a boat landing is responsible for its maintenance.

Can boat landings be closed or have special launch hours?

State-operated boat landings are required to operate under the same hours as the state parks. Most Wisconsin state parks, recreation areas, trails, and forest campgrounds are open from 6 a.m. to 11 p.m. Occasionally, DNR sites have different hours as required under conditional use permits. Boat landings that have been funded by the DNR and that are operated under lease from the DNR must maintain the same hours. Other locally owned sites are subject to hours established by the local unit of government. The state does not regulate launch hours unless the hours create a significant impediment to public use of the site. Once a boat has been launched, it must be allowed to exit from the lake, even if after the prescribed launching hours.

What signage and items (composting bins, garbage cans) are acceptable and legal at landings?

Informational signs at DNR public access sites can be installed and should be located in compliance with shoreland zoning and other local regulations whenever practicable. Boat landings that are the responsibility of other governmental entities or private individuals or businesses are not exempt from the requirements of local zoning ordinances, and responsible parties will need to apply for any permits that may be required under applicable zoning ordinances. Signs may be required to be set back 75 feet from the ordinary high-water mark of navigable waters (although the DNR is likely to propose some changes to ch. NR 115, Wis. Adm. Code, that would exempt from county shoreland setback requirements certain regulatory and informational signs that meet specified standards). Composting bins and garbage containers that are large and relatively immobile will need to be set back at least 75 feet from the ordinary high-water mark of navigable waters. However, the DNR's shoreland zoning program has taken the position for some time that small items that are easily moved by hand (such as movable garbage cans and picnic tables) are not subject to shoreland setback requirements in county shoreland zoning ordinances, even though the definition of "structure" found in dictionaries, ch. NR 116, Wis. Adm. Code (floodplain zoning ordinance rules), and in many local zoning ordinances is broad enough to theoretically include such items. Small structures that are easily moved by hand are likely to be specifically exempted from shoreland setback requirements when ch. NR 115, Wis. Adm. Code, is revised.

Launching fees

Are there state guidelines for communities that are considering boat launching fees?

The DNR encourages free boat launching. However, under s. NR 1.91(11), Wis. Adm. Code, a reasonable launch fee may be charged under authority of s. 30.77, Stats., for the purpose of operating and maintaining a boat access site owned or operated by municipalities, lake management districts, and other access providers. Excessive, unjustified, or unreasonable boat launching fees restrict or prohibit public boating access and use of navigable waters in the state. A reasonable launch fee for the purposes of s. 30.77, Stats., is one that does not exceed the maximum allowable amount under criteria identified in s. NR 1.91(11), Wis. Adm. Code. The base fee that can be charged for a state resident is that fee that is charged a state resident vehicle for entrance to the state parks.

Under s. NR 1.91(11), Wis. Adm. Code, public boating access surcharges may be added to a base fee for specific services identified in that code section. However, prior approval by the DNR is required when a public boating access provider proposes to charge a fee in excess of the resident state park daily entry fee. In addition, no more than the base fee may be charged for nonmotorized or nontrailered boats. Surcharge fees may be charged for vehicles with trailers at boat landings in the following circumstances: when an attendant is on duty, for on-site toilet facilities, at Great Lakes sites, for boats that are at least 20 feet in length but less than 26 feet in length, and for boats that are greater than 26 feet in length.

Do the fees have to be used for a particular item?

Boat launch fees are to be used for operation and maintenance of a boat launch site. Boat launch fees cannot exceed amounts established in s. NR 1.91, Wis. Adm. Code. The DNR's jurisdiction or authority is limited to whether the fee amounts comply with the s. NR 1.91, Wis. Adm. Code requirements.

Can the fees include the costs of operating a boat wash facility?

Boat launch fees may only be used for the operation and maintenance of a boat launch site, which could include a boat wash facility. However, as noted above, additional fees cannot be charged for a boat wash facility.

Can a special nonresident or out-of-state resident fee be charged?

Under s. NR 1.91(11)(g), Wis. Adm. Code, local units of government, including lake management districts that maintain and operate public boating access sites, may charge differential fees on the basis of residency within the unit of government maintaining or operating the access. If a fee is charged, the fees for a nonresident may not exceed 150% of the fee charged a resident and may not exceed the maximum allowable amounts except when surcharges for boats longer than 20 feet are in place.

Can a special fee be charged by someone who is not a riparian owner?

As noted above, differential fees can only be charged on the basis of residency within the unit of government maintaining or operating an access site. A special fee based only on riparian ownership or lack thereof would not be appropriate.

Can the launch fee be increased over time to assist in lake management costs, for example, controlling invasive species?

Boat launch fees can not exceed the maximum allowable amount established under s. NR 1.91 (11), Wis. Adm. Code.

Can the launch fee include nonmotorized equipment such as canoes, scuba equipment, or kayaks?

Under s. 30.50(2), Stats., a boat means "every description of watercraft used or capable of being used as a means of transportation on water, except a seaplane on the water and a fishing raft." This definition means that canoes and kayaks could be required to pay a launch fee, but a fee could not be charged for scuba equipment. However, no more than the base fee may be charged for a canoe or kayak because they are nonmotorized or nontrailered boats. A nonmotorized boat is a boat that is not a motorboat but that is designed and constructed to be used as a boat for transportation of a person or persons on water. The term includes, but is not limited to, any canoe, sailboat, inflatable boat or similar device, rowboat, raft, and dinghy that is not a motorboat.

If a fee is charged, how can it be collected?

Normally, launch fees are collected through the use of launch attendants who are on duty during the day or through the use of an honor system, in which the user voluntarily pays for launching when no attendant is on duty.

Do funds need to be reported?

Launch fees are the responsibility of the municipality that is operating the launch site. Any questions or concerns concerning the reporting of launch fees should be directed to the municipality that maintains the launch site. The DNR's jurisdiction or authority is limited to whether the fee amounts comply with s. NR 1.91, Wis. Adm. Code.

What is the public trust doctrine?

The Wisconsin Constitution establishes a state-administered public trust for navigable waters of the state. Under the public trust doctrine, the state holds the beds of navigable bodies of water in trust for all its citizens and has an obligation to protect public rights in navigable waters.

What is the relationship of the public trust doctrine to local regulations?

The public trust doctrine plays a substantial role in any decision relating to the public's access to and use of public waterways. The doctrine provides that the government holds all navigable waters in trust for the benefit of, and unrestricted use by, the public as a whole. This doctrine essentially creates a property right for the public as a whole in the waterways within a state. Access and use of waters may be restricted only under the police powers of the state for the protection and conservation of the public health, safety, and welfare, including environmental conservation and recreational purposes. Any regulation of the use of waterways must be reasonable in respect to the public interest being protected.

Under s. 30.77, Stats., no municipality, public inland lake protection and rehabilitation district, or town sanitary district may enact any ordinance or local regulation that requires local numbering, registration, or licensing of boats or any ordinance or local regulation that charges fees for inspection.

In addition, these entities may not, except as provided in subs. 30.77 (2) and (3), Stats., enact any ordinance or local regulation that in any manner excludes any boat from the free use of the waters of this state or that pertains to the use, operation, or equipment of boats or that governs any activity regulated by ss. 30.50 to 30.71, Stats.

Under s. 30.77(2), Stats., any municipality may enact ordinances that are in strict conformity with ss. 30.50 to 30.71, Stats., or rules of the DNR promulgated under those sections. Under s. 30.77(3), Stats., any town, village, or city may, in the interest of public health, safety, or welfare, including the public's interest in preserving the state's natural resources, enact ordinances applicable on any waters of this state within its jurisdiction if the ordinances are not contrary to or inconsistent with that chapter and if the ordinances relate to the equipment, use, or operation of boats or to any activity regulated by ss. 30.60 to 30.71. These ordinances are subject to advisory review by the DNR (s. 30.77(3)(d), Stats.).

Boat Wash Facilities

Are there state guidelines for construction, placement, and use of a permanent boat wash station at a landing?

There are no existing state guidelines for the construction, placement, and use of permanent boat wash stations.

Are there state guidelines for portable washing stations?

There are no state guidelines for portable washing stations.

Can a lake association, district, or municipality require boat washing as a condition of access to public waters?

Washing as a condition of access may be required only if a boat wash facility is readily available for public use, if no fee is required for the use of the boat wash facility, and if the requirement does not unreasonably exclude any boat from access to public waters.

Could a lake association or district place a boat wash facility on an access area owned by the state?

A lake association or district would need the permission of the DNR to place a boat wash facility on an access area owned by the state. In such circumstances the lake association or district would need to enter into a land use agreement (lease) with the DNR. Such agreements would include an assumption of all risk by the operator and an insurance requirement.

Could lake association or district volunteers manage a boat wash facility on a state-owned access area? What conditions (such as liability waivers) would need to exist?

Yes, a volunteer-run boat wash facility on a state-owned access area could be accomplished through an operational lease that included indemnification clauses.

Is there any permissible basis for closing a public launch site?

The closing of a public launch site by a county or town would be viewed as an abandonment of a public access, which would require DNR approval. The DNR may grant an abandonment only if the access site or part thereof proposed to be abandoned or discontinued is replaced prior to granting the petition, or if the access proposed to be abandoned does not contribute to the quality or quantity of public access on the body of water. In addition, an access site may be abandoned if environmental degradation is occurring at the site as a result of existing use and if abandonment of the access will reduce or eliminate the degradation without reducing public interests in access to that body of water.

The DNR's authority does not apply to cities and villages, but court approval may still be required if the access site is part of a platted subdivision or if the site is considered part of a highway and objections from adjoining landowners are received.

Could a local ordinance place conditions on the use of a launch site and limit access if boats are not washed?

A local ordinance may place conditions on the use of a launch site and limit access if boats are not washed only if a boat wash facility is readily available for public use, if no fee is required for the use of the boat wash facility and if the requirement does not unreasonably exclude any boat from access to public waters.

Boat Washing Facilities

A number of inquiries have been received by DNR and UW-Extension staff on the feasibility of installing boat washing stations at water access sites. The stations could be used as a tool by lake communities to reduce the risk of transport of aquatic nuisance species by recreational boaters. Wisconsin has not conducted any studies to determine the feasibility of using a boat wash facility. However, other states and provinces (Minnesota and Ontario) have tested various applications of boat washing stations, both permanent and portable, under mandatory and volunteer situations. Here is what was learned:

Boat washing facilities are not considered a substitute for the steps that the aquatic invasive species program asks boaters to take when leaving the launch site. The cornerstone of Wisconsin's "Clean Boats, Clean Waters" program is a consistent list of precaution steps that are emphasized in all public education brochures, pamphlets, watch cards, public service announcements, and signage. Those steps are:

1. INSPECT your boat, trailer and equipment
2. REMOVE any attached aquatic plants or animals (before launching, after loading and before transporting on a public highway).
3. DRAIN all water from boats, motors and all equipment.
4. NEVER MOVE live fish away from a waterbody.

Boat washing is just one of the prevention steps, and installation of a wash station should accompany other education efforts that focus on all the steps listed here.

Boat washing stations are a costly alternative to an effective watercraft inspection program and a well-planned education campaign. Several issues need to be considered before the installation of washing stations:

1. costs for construction and maintenance of these facilities;
2. physical constraints for installation of the stations;
3. that washing cannot be made mandatory for all boaters;
4. safety of the facility and liability;
5. practical concerns about how best to capture and treat the wastewater;
6. boater acceptance of delays due to washing; and
7. unsolved legal questions related to whether fees could be charged for cleaning boats as a condition of launching.

There are circumstances and situations under which it may be advisable to install a boat wash facility:

1. if prevention and containment is a serious issue or a condition of a permit, or

2. if the venue is one in which heavy use is occurring as a result of a specific activity (boating and fishing tournaments or sailing regattas) or heavy boating periods (July 4th and Labor Day).

   In these situations a portable washing unit could work well as an educational and awareness tool to show boaters how to properly clean their boats.

If lake associations are going to install and operate a boat wash station, here are some guidelines that they should follow:

- Make sure that the boat washing station is part of an overall watercraft inspection and education program; not use it as a substitute for the other prevention steps boaters are asked to take.
- Do not require washing as a condition of launching; rather, treat boat washing as a voluntary option so boaters can feel assured that they are doing everything possible to protect the resource.
- Use common sense in designing the facility—do not drain the water back to the lake, and compost all waste or put it in the trash.
- Give some serious thought as to whether the facility should be manned or unmanned, portable or permanent.
- Make sure that a reliable construction firm is in charge of the design, construction, and maintenance of the facility.
- Be aware of the safety and liability issues of a wash station and follow all OSHA regulations.
- Seek feedback on boater acceptance of the facility, if possible. Such information adds to the DNR's understanding and research of boat landing facilities.
- Consider installing a boat washing facility for boaters leaving an infested water body to prevent the spread of invasive aquatic species.
- Place any wash station at least 75 feet back from the lake to avoid conflicts with shoreland zoning regulations.
- Use the lake water as a source for the washing facility if possible.
- Restrict the use of detergents, algaecides, or disinfecting agents that could harm the lake or nearby residents.
- Provide clear instructions on how to use the boat washing facility properly and safely and include an educational message as to why it's important.
- Use high-pressure hot water for the wash facility if possible (it is most effective).
- Charge only a reasonable fee for cleaning a boat before launching (such a fee would be based on the resident state park daily entrance fee).

Please note that specifications on the types of boat washing facilities that are most effective are not readily available and are likely to vary based on specific needs. Therefore, they were not included in the guidelines. Lake associations can contact their local DNR staff to obtain information on vendors in their area who could help the community decide what type of washer would be most effective for their particular use.

Lake organizations, watershed associations, or other local units of government that may be interested in installing a boat washing facility need to understand the following message: wash stations are a poor substitute for an effective education and watercraft inspection program that emphasizes inspection and removal, *but* washing stations can be one component of an overall prevention and control strategy.

APPENDIX M

WDNR GRANTS

Lake Classification and Local Ordinance Development Grants
NR 191.30, Wis. Admin. Code

Overview:
Lake Classification projects will be conducted by counties to study the characteristics of lakes and assign them into different management classifications for the purpose of implementing lakes-based protection activities. Protection activities may be regulatory (such as improved Shoreland), land or lake use ordinances, or other best management practices or protection activities for protecting and improving water quality or aquatic habitats. Lake classification projects can be used to implement the prescribed management activities.

Development of local regulations or ordinance projects will be conducted by any unit of local government to protect or improve a lake's water quality or its natural ecosystem. Lake Classification and Local Ordinance Development projects can be funded separately or jointly. Because of their similar nature, these two grant project types are combined into one grant subprogram. Although technically "management" grants by statute, the activities associated with each are fundamentally planning and, therefore, the DNR has grouped them in with other planning grants with application deadline of Dec. 10 each year.

Lake Classification

Purpose:
Lake Classification grants provide financial opportunities for Wisconsin counties to assist in lake protection efforts. Using existing and collected lake data, county lakes with similarities can be grouped to assist in the administration of shoreland zoning or land and water conservation programs.

Eligible Projects

Classification:

- Data collection, analysis using GIS, and mapping to place waters in classes. Types of data may include lake size, depth, shape, and water quality, watershed size, potential nonpoint pollution sources, land uses and development patterns, recreational uses, fish and wildlife habitat, etc.
- Objective setting for the classification system.
- Investigation and selection of appropriate classification criteria.
- Investigation and assignment of appropriate protection and management tools. All projects must propose lake protection activities for each classification.
- Assist the DNR in setting lake water quality standards.

Note: Projects may not result in lowering existing state minimum standards designed to protect lakes.

Protection and Implementation:

- Development of educational materials and training programs to improve the understanding and compliance with the lake classification.
- Compliance monitoring and enforcement.
- Technical assistance to landowners to comply and implement protection activities.
- Developing or improving administrative procedures and processes.
- Ordinance development: zoning, watercraft regulation, construction site erosion control, public water access, piers and moorings, etc.
- Adoption of policies which encourage management of waters based on the specific needs of each waterbody.
- Implementation of alternative management tools: purchase of land or development rights, conservation easements, development of individual lake and watershed plans, etc.

NOTE: A county must have adopted a lake classification system prior to the date of application to be eligible for an implementation grant.

Ineligible Projects:
Projects not eligible for funding under this subchapter include water safety patrols.

Note: Lake Classification projects may be conducted to assist the department in setting lake water quality standards. However, any proposal for the classification of lakes to be used in setting lake water quality standards or for enacting requirements for the implementation of water quality standards based on new or existing classifications only become effective when adopted by the department as rules under s. 281.15, Wis. Stats.

Local Ordinance Development

Purpose:
Lake Ordinance development grants are intended for local governments and lake districts to create or improve regulations that will protect or improve a lake's water quality or its natural ecosystem.

Eligible Projects:
To be eligible for funding consideration, all projects must include the development of an ordinance to be presented for adoption by the local governing board with an assessment of the administration and enforcement capacity and cost to implement the ordinance. Land use planning alone is not an eligible activity.

Types of ordinances may include: boating or lake use, conservancy, wetland, shoreland, floodplain, construction erosion control, stormwater control or other ordinances with water quality or lake protection benefit. Boating ordinances that assist in managing the recreational use of surface waters should be focused on addressing the environmental impacts of lake use rather than just safety concerns.

Typical activities and eligible project costs include:

- Review and evaluation of an existing regulation or ordinance effectiveness, including necessary surveys.
- Mapping of environmental features, land use planning, and related activities as needed limited to what is necessary to the development of the proposed regulation. These activities should not be the main focus of the projects.
- Legal fees to develop regulation or ordinance language.
- Public meetings and materials, printing, postage, surveys, mailing, and similar costs related to community education on the need for and implementation of an ordinance or regulation.
- Training of officials and citizens for compliance and enforcement of an existing or new regulation or ordinance.
- Labor costs required to carry out activities identified in the grant agreement provided they require additional staff or increased hours of existing staff. Costs of additional staff positions or increased staff hours shall be based on management unit rates for the position including salary, fringe benefits and other items determined to be appropriate by the DNR.
- Other costs determined by the DNR to be necessary to carry out the development of a regulation or ordinance.

Legal fees incurred in appealing DNR decisions are not reimbursable costs. Lake associations and nonprofit conservation organizations do not have regulatory authority and therefore are not eligible for ordinance development projects unless there are clear commitments from the regulatory authority to the project. The management unit that is adopting the ordinance should be the sponsor.

If the project is an ordinance update or upgrade project specific to s. NR 115 Wisconsin's Shoreland Protection Program, s. NR 117 Wisconsin's City and Village Shoreland-Wetland Protection Program or s. NR 118 Standards for Lower St. Croix Scenic Waterway, it will need to be reviewed and certified by DNR staff. You can search the DNR staff directory under contacts on the DNR home page using "Shoreland Zoning" in the subject box to find the appropriate person to conduct the review and certification. It's recommended that you make this contact before you begin your application. Appropriate DNR staff should be advised of the process from the start of any shoreland ordinance project. For all other ordinance development projects local adoption or DNR approval is not required. However, the proposed regulation must be presented to the county or town board for adoption.

Routine ordinance enforcement is not an eligible cost for any grant in this subsection. However, site inspections and enforcement can be eligible for local ordinance development projects or lake classification if it is proposed as developing or enhancing the enforcement process. The project might create and test new forms or procedures such as compliance audits, automated record keeping or explore new information management technologies. A report on the "findings" of this element is a deliverable.

Funding Possibilities:
Maximum amount of grant is 75% of the total project costs, not to exceed $50,000.

Lake Management Planning Grants
Section 281.68, Wis. Stats., NR 190, Wis. Admin. Code

Overview:
Lake management planning grants are intended to provide financial assistance to eligible applicants for the collection, analysis, and communication of information needed to conduct studies and develop management plans to protect and restore lakes and their watersheds. Projects funded under this subprogram often become the basis for implementation projects funded with Lake Protection grants. There are two categories of lake management planning grants: small-scale and large-scale.

Small Scale Lake Planning
NR 190, Wis. Admin. Code

Purpose:
Small-scale projects are intended to address the planning needs of lakes where education, enhancing lake organizational capacity, and obtaining information on specific lake conditions are the primary project objectives. These grants are well suited for beginning the planning process, conducting minor plan updates, or developing plans and specification for implementing a management recommendation.

Eligible Projects:
- Specific monitoring and assessment projects. Collect and report chemical, biological, and physical data about lake ecosystems for a Tier I assessments, Tier II diagnostic or Tier III project evaluation.
    - Tier I if initial basic monitoring is needed to assess the general condition or health of the lake.
    - Tier II if an assessment has been conducted and more detailed data collection is needed to diagnose suspected problems and identify management options.
    - Tier III if the monitoring and assessment will be used to evaluate the effectiveness of a recently implemented project or lake management strategy.
- Collecting and disseminating existing information about lakes for the purpose of broadening the understanding of lake use, Lake Ecosystem conditions and lake management techniques.
- Conducting workshops or trainings needed to support planning or project implementation.
- Projects that will assist management units as defined in s. NR191.03 (4) & s. NR 190.003 (4) the formation of goals and objectives for the management of a lake or lakes.

Ineligible Projects:
Projects not specifically mentioned above.

Funding Possibilities:
Maximum amount of grant funding is 67% of the total project costs, not to exceed $3,000.

(see next page for Large Scale Projects)

Large Scale Projects
NR 190, Wis. Admin. Code

Purpose:
Large-scale projects are intended to address the needs of larger lakes and lakes with complex and technical planning challenges. The result will be a lake management plan; more than one grant may be needed to complete the plan.

Eligible Projects:

- Collection of new or updated, physical, chemical and biological information about lakes or lake ecosystems.
- Definition and mapping of Lake Watershed boundaries, sub-boundaries and drainage system components.
- Descriptions and mapping of existing and potential land conditions, activities and uses within lake watersheds that may affect the water quality of a lake or its ecosystem.
- Assessments of water quality and of fish, aquatic life, and their habitat.
- Institutional assessment of lake protection regulations - review, evaluation or development of ordinances and other local regulations related to the control of pollution sources, recreational use or other human activities that may impact water quality, fish and wildlife habitat, natural beauty or other components of the lake ecosystem.
- Collection of sociological information through surveys or questionnaires to assess attitudes and needs and identify problems necessary to the development of a long-term lake management plan.
- Analysis, evaluation, reporting and dissemination of information obtained as part of the planning project and the development of management plans.
- Development of alternative management strategies, plans and specific project designs, engineering or construction plans and specifications necessary to identify and implement an appropriate lake protection or improvement project.

Ineligible Projects:
Any project not specified above.

Funding Possibilities:
Maximum amount of grant funding is 67% of the total project costs, not to exceed $25,000. Multiple grants in sequence may be used to complete a planning project, not to exceed $100,000 for each lake. The maximum grant award in any one year is $50,000 for each lake. If phasing is necessary, all phases should be fully identified and a timeline identified in the initial application.

Lake Protection Grant Program
Sections 281.69 and 281.71, Wis. Stats., NR 191, Wis. Admin. Code

Overview:
Lake protection and classification grants assist eligible applicants with implementation of lake protection and restoration projects that protect or improve water quality, habitat or the elements of lake ecosystems. There are four basic Lake Protection subprograms:

a) Fee simple or Easement Land Acquisition
b) Wetland and Shoreline Habitat Restoration
c) Lake Classification and Local Ordinance Development
d) Lake Plan implementation

Land/Easement Acquisition
NR 191.10, Wis. Admin. Code

Purpose:
Grants under this subprogram are intended for the acquisition of property or property rights (also called easements) to protect lakes and their ecosystems. Land acquisition projects are reviewed and processed by DNR environmental grant specialists. All other types of surface water protection grant projects are reviewed by DNR Lake and River Grant Coordinators. A list of environmental grant specialists appears in the front of this guide.

Eligible Costs:
- The fair market value of the property as determined by DNR-approved appraisals
- Cost of appraisal(s)
- and survey fees
- Relocation payments
- Land stabilization
- Title insurance and gap insurance
- Recording fees
- Historical and cultural assessments (if required by the DNR)
- Baseline documentation for natural resources (required for conservation easements)
- Environmental inspections and audits
- Attorney fees not to exceed $2,000
- Closing costs
- Building demolition may be an eligible cost based on the degree to which the demolition contributes to lake protection or restoration.

Ineligible Costs:
- Acquisition of any property that is subject to a reversionary right or has restrictions or covenants which would prevent the property from being managed for purposes consistent with this grant program
- Land acquired through eminent domain or condemnation; projects where landowners were not treated fairly and negotiations were not conducted on a willing buyer-willing seller basis
- Acquisition of land on which a dam is located
- Environmental clean-up costs
- Brokerage fees paid by the buyer
- Real estate transfer taxes
- Any other cost not identified as eligible above

Funding Possibilities:
Maximum amount of grant funding is 75% of total costs, not to exceed $200,000.

Wetland and Shoreline Habitat Restoration
NR 191.20, Wis. Admin. Code

Purpose:
Wetland and shoreland habitat restoration grants are intended to provide financial assistance to protect or improve the water quality or natural ecosystem of a lake by restoring adjacent degraded wetlands or tributary to lakes. Shoreline habitat restoration grants are intended to provide financial assistance, including incentive payments, to owners of developed lake front lots to re-establish riparian habitat.

Eligible Projects:
- Development of plans, specifications and environmental assessment, including pre- and post-engineering and design costs.
- Construction, earth moving, or structure removal costs.
- Native plant stock or seeds for re-establishing vegetation.
- Incentive payments per landowner not to exceed $250.
- Public meetings and education and promotional materials, mailing and similar costs related to the distribution of information about restoration.
- Necessary monitoring in order to measure success in achieving the ecologic function of restoration activities.
- Purchase of fee simple or easement land acquisition on which wetland restoration activities will take place. The cost of preparing and filing deed restrictions on the property where restoration will take place.
- Labor costs required to carry out activities identified in the grant agreement including technical assistance.
- Other costs determined by the DNR as necessary to carry out a successful wetland or shoreline habitat restoration.
- Water regulatory permits required for the project. Reasonable planning, engineering and design costs necessary to complete the permit application incurred within 12 months prior to the application deadline become eligible for reimbursement for projects awarded a grant.
- Technical assistance provided to individuals seeking building permits if the intent is to improve the site's habitat conditions or comply with mitigation conditions.

Ineligible Projects:
- Environmental cleanup,
- Stairs
- Walkways
- Piers
- Costs of actual restoration that is intended to comply with a regulatory action, including wetland or shoreland mitigation projects.

Funding Possibilities:
Maximum amount of grant funding is 75% of the total project costs, not to exceed $100,000

Lake Management Plan Implementation
NR 191.40, Wis. Admin. Code

Purpose:
Lake management plan implementation grant provides financial assistance to eligible applicants that have completed a lake management plan to implement the plan's DNR-approved recommendations.

Eligible Projects:
Typical projects will include watershed or shoreland best management practices (BMPs) for nonpoint source pollution control or in-lake restoration actions like an alum treatment. s. NR 154, Wis. Admin.

Code, Best Management Practices (BMP) and Cost Share Conditions, provide DNR grant policy on the implementation of 42 nonpoint source pollution control practices. These have been established in partnership with other state and federal agencies and approved by the US Environmental Protection Agency as part of the State's Nonpoint Source Program Management Plan. Adherence to these BMPs assures eligibility for federal cost-share funds and the ability to use state-funded projects as match Clean Water Act Section 319 funds received by the DNR.

Providing grant funding for lake restoration activities that improve the recreational or environmental values of a lake are defined as natural resource enhancement services under s. NR 1.91, Wis. Admin. Code. Grant funding for these services can only be provided for lake and river projects where the public has been afforded a minimum level of public boating access as defined in s. NR 1.91(4) d. Typical projects funded by surface water grants that fall into this category are "in-water" activities such as aeration, aquatic plant management, alum treatments, bio-manipulation, drawdown, fish stocking and fishery rehabilitation, habitat restoration, and hypolimnetic withdrawal. An additional eligibility requirement for funding these activities is that the sources or causative factors of the problems to be remediated should have been or very likely will be controlled prior to implementation.

Habitat improvement or protection activities or any other type of project that will work toward protecting or improving lakes and lake ecosystems may be eligible as long as the recommendation presented in the lake management plan has been officially approved by the DNR. An application for all necessary permits must be filed with the DNR by the date on which a grant application is submitted.

Eligible Costs:

- Construction, labor, materials, supplies, laboratory costs related to eligible activities.
- Planning and engineering, landscape or construction design plans and specifications that is necessary to determine appropriate options and recommendations for lake protection improvement.
- Other costs as approved by the DNR and necessary for implementing a recommendation in an approved lake management plan.

Ineligible Project Costs:
Any project not specified above.

Funding Possibilities:
Grants are based on 75% of the total eligible project costs not to exceed the maximum grant amount of $200,000.

Healthy Lakes Projects
NR 190, Wis. Admin. Code

Purpose:
The Healthy Lakes grants are a sub-set of Plan Implementation Grants intended as a way to fund increased installation of select best management practices (BMPs) on waterfront properties without the burden of developing a complex lake management plan. Details on the select best practices can be found in the Wisconsin Healthy Lakes Implementation Plan and best practice fact sheets.

Eligible Projects:
Eligible best practices with pre-set funding limits are defined in the Wisconsin Healthy Lakes Implementation Plan, which local sponsors can adopt by resolution and/or integrate into their own local planning efforts. By adopting the Wisconsin Healthy Lakes Implementation Plan, your lake organization is immediately eligible to implement the specified best practices. Additional technical information for each of the eligible practices is described in associated factsheets.

The intent of the Healthy Lakes grants is to fund shovel-ready projects that are relatively inexpensive and straight-forward. The Healthy Lakes grant category is not intended for large, complex projects, particularly those that may require engineering design. All Healthy Lake grants have a standard 2-year timeline.

Ineligible Projects:
Any project not specified in the Wisconsin Healthy Lakes Implementation Plan.

Eligible Costs:
Best practices in the Wisconsin Healthy Lakes Implementation Plan are defined for each of 3 zones on a typical developed lake shore residential lot identified.

- Zone 1 (shallow near shore water) includes fish sticks, a practice that places trees in the water to improve fish and aquatic life habitat and protect shorelines;
- Zone 2 (transition) includes various 350 square foot native planting plots and diversion practices to improve habitat and slow runoff;
- Zone 3 (upland) includes rain gardens, diversion practices and rock infiltration practices as eligible best practices to manage runoff from structures and other impervious surfaces.

Technical assistance costs may be reimbursed not to exceed 10% of the state share of project costs.

Funding Possibilities:
Maximum amount of grant funding is 75% of the total project cost, not to exceed $25,000. Grants run for a 2-year time period. Maximum costs per practice are also identified in the Wisconsin Healthy Lakes Implementation Plan.