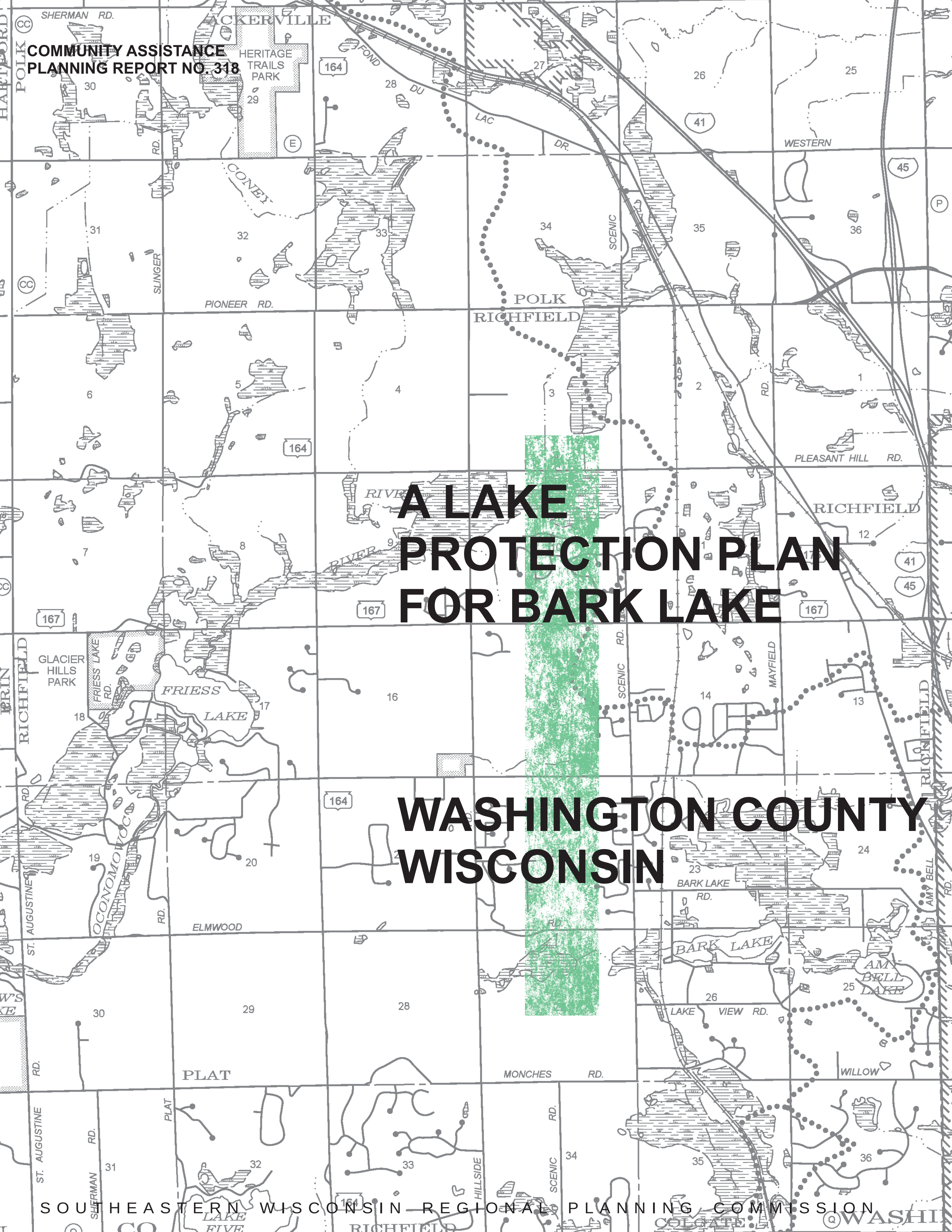
COMMUNITY ASSISTANCE
PLANNING REPORT NO. 318

A LAKE PROTECTION PLAN FOR BARK LAKE

WASHINGTON COUNTY WISCONSIN



SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

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A LAKE PROTECTION PLAN FOR BARK LAKE WASHINGTON COUNTY, WISCONSIN

Prepared by the

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Chapter I

INTRODUCTION

PURPOSE OF PLAN

Research shows that the health of a lake or stream is usually a direct reflection of the use and management of the land within its watershed. Research also shows that interventions are often necessary to maintain or improve the conditions of these resources. Located within U.S. Public Land Survey Sections 23 and 26, Township 9 North, Range 19 East, in the Village of Richfield, Washington County (see Map 1), Bark Lake, together with its tributaries, and associated wetlands, is a high-quality natural resource. The purpose of this plan is to provide a framework to protect and improve the land and water resources of Bark Lake and its watershed with a focus on *protecting* this existing high-quality resource from human impacts and *preventing* future water pollution or resource degradation from occurring. The recommendations provided in the plan are appropriate and feasible watershed management measures for enhancing and preserving the water quality of Bark Lake as well as for providing the public with opportunities for safe and enjoyable recreation within the Lake's watershed.

It is important to note that this plan complements other existing programs and ongoing management actions in the Bark Lake watershed and represents the continuing commitments of government agencies, municipalities, and citizens to diligent land use planning and natural resource protection. Additionally, it was designed to assist State and local units of government, nongovernmental organizations, businesses, and citizens in developing strategies that will benefit the natural assets of Bark Lake and protect sensitive habitats within the watershed. By using the strategies outlined in this plan, results will be achieved that enrich and preserve the natural environment.

This planning program was funded, in part, through a Chapter NR 190 Lake Management Planning Grant awarded to the Bark Lake Association (BLA), in collaboration with the Village of Richfield and Washington County, and administered by the 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.*[1]

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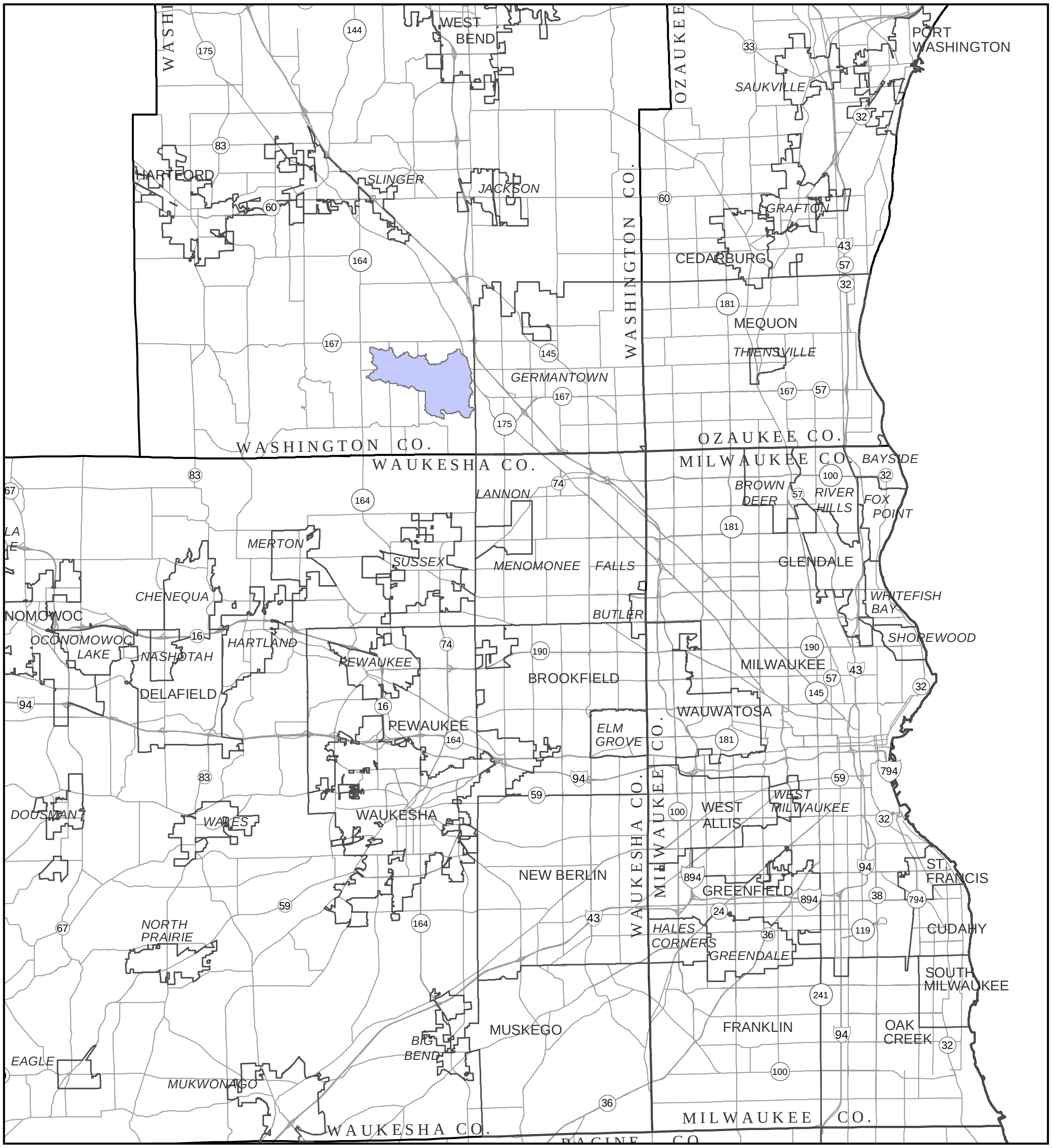
[1]*This plan has been prepared pursuant to the standards and requirements set forth in the following chapters of the* Wisconsin Administrative Code*: Chapter NR 1, "Public Access Policy for Waterways;" Chapter NR 40, "Invasive Species Identification, Classification and Control;" Chapter NR 103, "Water 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

LOCATION OF THE BARK LAKE WATERSHED WITHIN THE REGION



BARK LAKE WATERSHED

N

0 0.5 1 Miles

0 2,500 5,000 Feet

Source: SEWRPC.

LAKE PROTECTION PROGRAMS AND GOALS

General lake protection goals and objectives for Bark Lake, which this plan helps to meet, were developed in consultation with the BLA Board members. These goals and objectives, which also directly address goals established in the Washington County multi-jurisdictional comprehensive plan,[2] include:

1. To describe existing conditions in the Bark Lake watershed including identification and quantification of potential point and nonpoint sources of pollution, nutrient and contaminant inputs, and nutrient and contaminant balances—This plan identifies pollution sources, as well as provides nutrient loading calculations for the purpose of directing pollution control management efforts;

2. To document the aquatic plant community and fishery of Bark Lake, with emphasis on the occurrence and distribution of nonnative species—This plan details the aquatic plant survey completed by SEWRPC staff in 2012 for the purpose of understanding the aquatic plant community;

3. To identify the extent of any existing and potential future water quality problems likely to be experienced in the Lake, including an assessment of the Lake's water quality using water quality monitoring data being collected as part of ongoing programs and estimates of changes in these conditions in the future—This plan provides a comprehensive collection of water quality data collected in Bark Lake and identifies the relevant conclusions from that data; and

4. To formulate appropriate lake protection programs, including public information and education strategies and other possible actions necessary to address the identified problems and issues of concern—This plan uses the information detailed above to develop lake protection recommendations and provides recommendations related to the issues and concerns of Bark Lake residents.

In addition to these goals and objectives, this plan provides a comprehensive set of specific goals, actions to achieve those goals, and standards for gauging success for the purpose of guiding future efforts to protect and enhance Bark Lake. Implementation of the recommended actions set forth herein should serve as an important step in achieving the stated lake use objectives over time.

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[2]*SEWRPC Community Assistance Planning Report No. 287*, A Multi-Jurisdictional Comprehensive Plan for Washington County: 2035, *April 2008*, *p. 298.*

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Chapter II

ISSUES AND CONCERNS

INTRODUCTION

This chapter provides a brief background of Bark Lake as well as a detailed description of the issues and concerns addressed in this report. This chapter should be used to better understand the many factors that affect the "health" of Bark Lake, as well as to better understand the recommendations made in Chapter III of this plan.

BACKGROUND

It is impossible to form a feasible and effective lake protection plan without first understanding the geographical, historical, and social influences related to the Lake. Appendix A of this report details all of the relevant information collected about Bark Lake and explains the meaning and importance of this information. This section briefly summarizes the most pertinent information so that the issues and concerns, as well as the recommendations given in this report, can be fully understood. More detail can be found in Appendix A.

Lake Characteristics

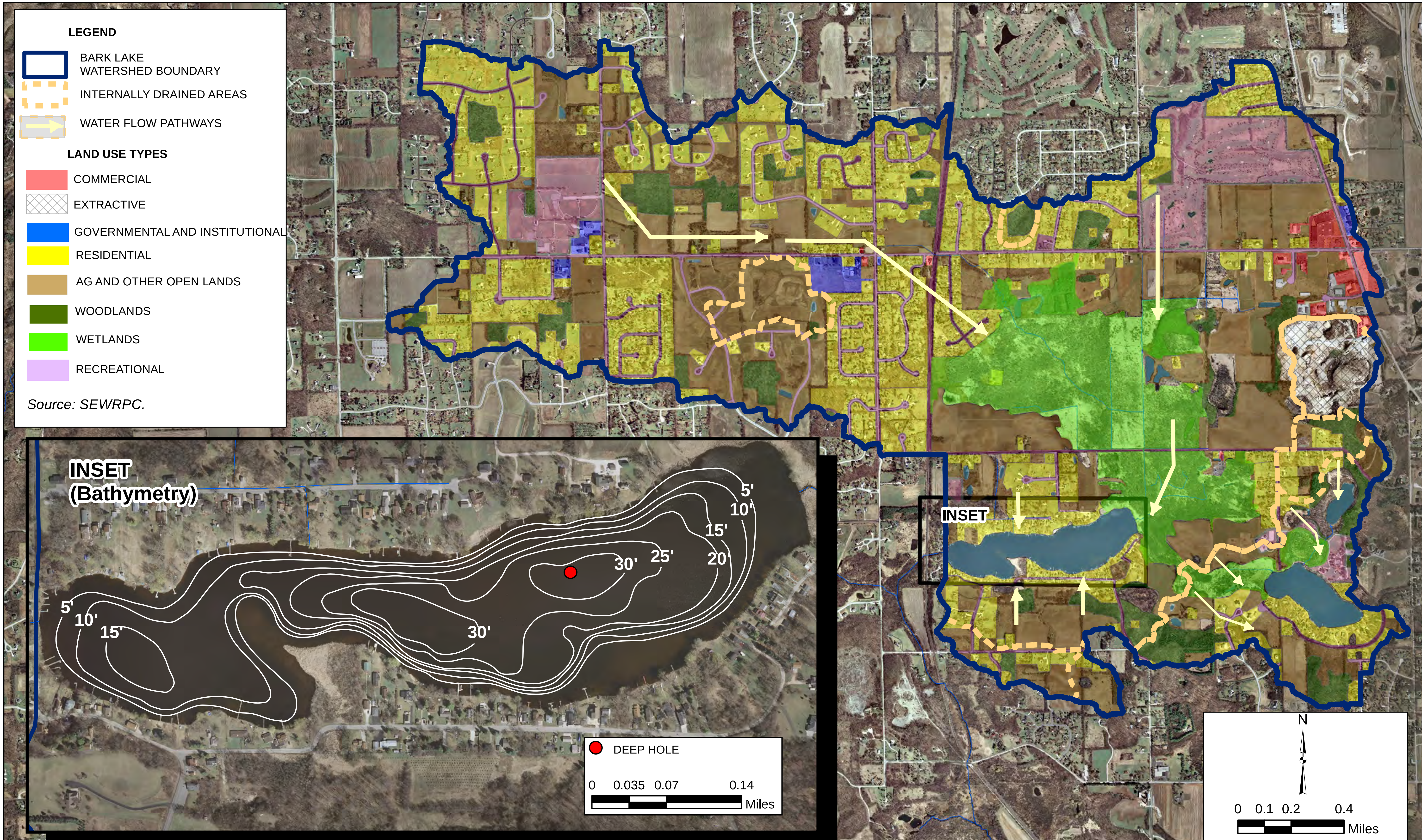
Bark Lake is a 62-acre lake that forms the headwaters of the Bark River. It has a maximum water depth of 34 feet with about 16 percent of the lake having a depth of less than three feet, as shown on Map 2. The Wisconsin Department of Natural Resources (WDNR) has classified the Lake as a drained, or headwater, lake, meaning that the Lake has a defined outflow and that the inflow to the Lake is dependent on groundwater and surface water that drains to the Lake (i.e., its watershed). Water is discharged from Bark Lake mainly through the outflow channel at the west end of the Lake (although some does exit the Lake through infiltration into the groundwater below). The Lake has a residence time (i.e., the average amount of time in which water stays within the Lake) of 136 days.

Bark Lake's watershed (i.e., the area which drains to the Lake, also shown on Map 2) is approximately 3,400 acres, or a little over five square miles. Of this area, 45 percent is in urban land use (i.e., residential, commercial, industrial etc.) and 30 percent is agricultural lands under year 2010 conditions (see Map 2). Almost 23 percent of the watershed is considered a type of "natural area" with over 12 percent of the total watershed area being encompassed in the wetland located to the east and north of the Lake.[1] Bark Lake is a recreational lake with an associated residential community situated within close reach of the greater Milwaukee metropolitan area

[1]*Further details about land use in the Bark Lake watershed can be found in Appendix A in the Existing and Planned Land Use subsection.*

Map 2

LAKE AND WATERSHED CHARACTERISTICS FOR BARK LAKE INCLUDING BATHYMETRY AND 2010 LAND USE



(see Map 1 in Chapter I of this report). The lakeshore forms a popular year-round residential area, with the watershed having a population of about 2,392 people within 930 households.[2]

In general, the water quality of the Lake is considered "fair" to "poor," with the Lake being classified as eutrophic (i.e., nutrient rich).[3] The Lake does stratify[4] in the both in the summer and winter;[5] however, the Lake supports a fairly good fishery, likely due to the extensive aquatic habitat that exists on the east side of the Lake, as well as the "good" dissolved oxygen levels in the surface waters of the Lake.[6] Additionally, the Lake's watershed is capable of supporting a diverse amount of wildlife.[7] This Lake is an asset to the residents of the Lake and the State of Wisconsin, particularly due to its role as a headwater lake.

Lake Management

Activities in the Bark Lake watershed are governed by the General, Floodplain, Shoreland, Subdivision, and Construction Site Erosion Control zoning ordinances[8] as well as boating ordinances (see Appendix B) that were adopted by the Village of Richfield, which incorporated in February, 2008. These ordinances are enforced both by the Village of Richfield and by Washington County.

Additionally, the Bark Lake Association (BLA) acts as a resource for collecting, coordinating, and disseminating information on the Lake and its watershed and for lakewide planning and management programs. This report was designed as part of an ongoing program of lake-related information gathering, evaluation, and management being undertaken by the BLA in cooperation with other governmental and nongovernmental organizations and agencies, including the WDNR, Washington County, the Village of Richfield, and the Southeastern Wisconsin Regional Planning Commission (SEWRPC). To this end, the BLA maintains an ongoing program of lake management, focusing on aquatic plant management, the control of nonnative aquatic species, water quality improvement, and citizen informational programming.

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[2]*Population and households data is based on 2010 Census Data. Further details about historical urban growth and population and household growth can be found in Appendix A in the Urban Growth and Population and Households sections.*

[3]*The "fair" to "poor" water quality rating is based on phosphorous, water clarity, and chlorophyll-*a *measurements taken in Bark Lake between 1979 and 1997. The eutrophic standing is based on "trophic status" calculations made from that same data. Details about each of these parameters, the data used, and its relevance can be found in Appendix A in the Water Quality in Bark Lake and Trophic Status subsections.*

[4]*Stratification refers to Lake waters forming temperature differences between deep and shallow waters which, in turn, act as a physical barrier to mixing (due to density differences). This phenomenon can cause dissolved oxygen to become depleted in the deep waters. Further details about this process can be found in Appendix A in the Thermal Stratification subsection.*

[5]*Temperature loggers were deployed in Bark Lake over the span of a year. This study confirmed both summer and winter stratification. More details about this study can be found in Appendix A in the Water Temperature Data subsection.*

[6]*Dissolved oxygen in water, often caused by plants producing the oxygen, is a crucial need for fish. Without this oxygen fish would not be able to survive. More details on dissolved oxygen, as well as the specific data, can be found in Appendix A in the Dissolved Oxygen Levels subsection.*

[7]*Details on wildlife in the Bark Lake watershed can be found in Appendix A in the Fish and Wildlife section.*

[8]*More details related to the importance and uses of these ordinances can be found in Appendix A in the Local Ordinances section.*

ISSUES AND CONCERNS

Bark Lake is able to support a variety of recreational opportunities[9] and is a natural asset to southeastern Wisconsin. However, a number of existing and potential future problems and issues of concern were identified in the process of developing this lake protection plan. Though aquatic plant management is the primary issue of concern for this management plan, there are also several other issues of concern which, if addressed, will help lead to a "healthier" Lake, and, in turn, help control aquatic plants in general by dealing with issues at the source, such as pollution. The concerns, identified by members of the Bark Lake Association (Bark Lake residents), as well as SEWRPC staff, are:

1. The presence of invasive aquatic plants within the Lake and need for management of these species without the endangerment of native aquatic plants (this is the primary issue of concern which spurred the development of this management plan);

2. Water depth in the Lake and the rate of sedimentation, particularly as it relates to the sandbar located on the southern shore of the Lake;

3. Potential pollution sources within the Lake's watershed and their potential effect on water quality;

4. Possible Lake outflow restrictions or blockages affecting the current outflow channel;

5. Potential risks associated with the newly constructed public access site on the southern shore of Bark Lake, including over-crowding/noise, overfishing, and invasive species introduction;

6. Lack of data, particularly as it relates to water chemistry;

7. Water quantity issues, spurred by the fact that the inlet stopped flowing in the most recent drought, and by the potential effects of climate change;

8. Potential for wildlife population enhancement; and

9. Risks associated with any loss of wetlands.

This chapter presents a summary of each of these issues of concern, along with information to support the recommendations set forth in Chapter III of this report. The chapter should be read using Map 3 as a reference to locate the major areas of concern.

AQUATIC INVASIVE SPECIES

A major component of this planning effort was the completion of an aquatic plant survey in the summer of 2012[10] for the purpose of guiding aquatic plant management within the Lake. Bark Lake was found to have a healthy plant population, with 16 native plant species (and one naturalized native) being found at various points throughout the Lake. Table 1 provides the list of aquatic plants found in the Lake as well as statistics as to their dominance in the Lake. The distribution of each of these native plants, as well as discussions on their identification and importance, are included in Appendix C of this report.

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[9]*Further details about a recreational survey conducted by SEWRPC staff can be found in Appendix A in the Recreational Uses section.*

[10]*Complete details about the aquatic plant survey conducted by SEWRPC staff, as well as the importance of aquatic plant communities, are discussed in Appendix A in the Aquatic Plants section.*

Map 3

AREAS OF CONCERN WITHIN THE BARK LAKE WATERSHED

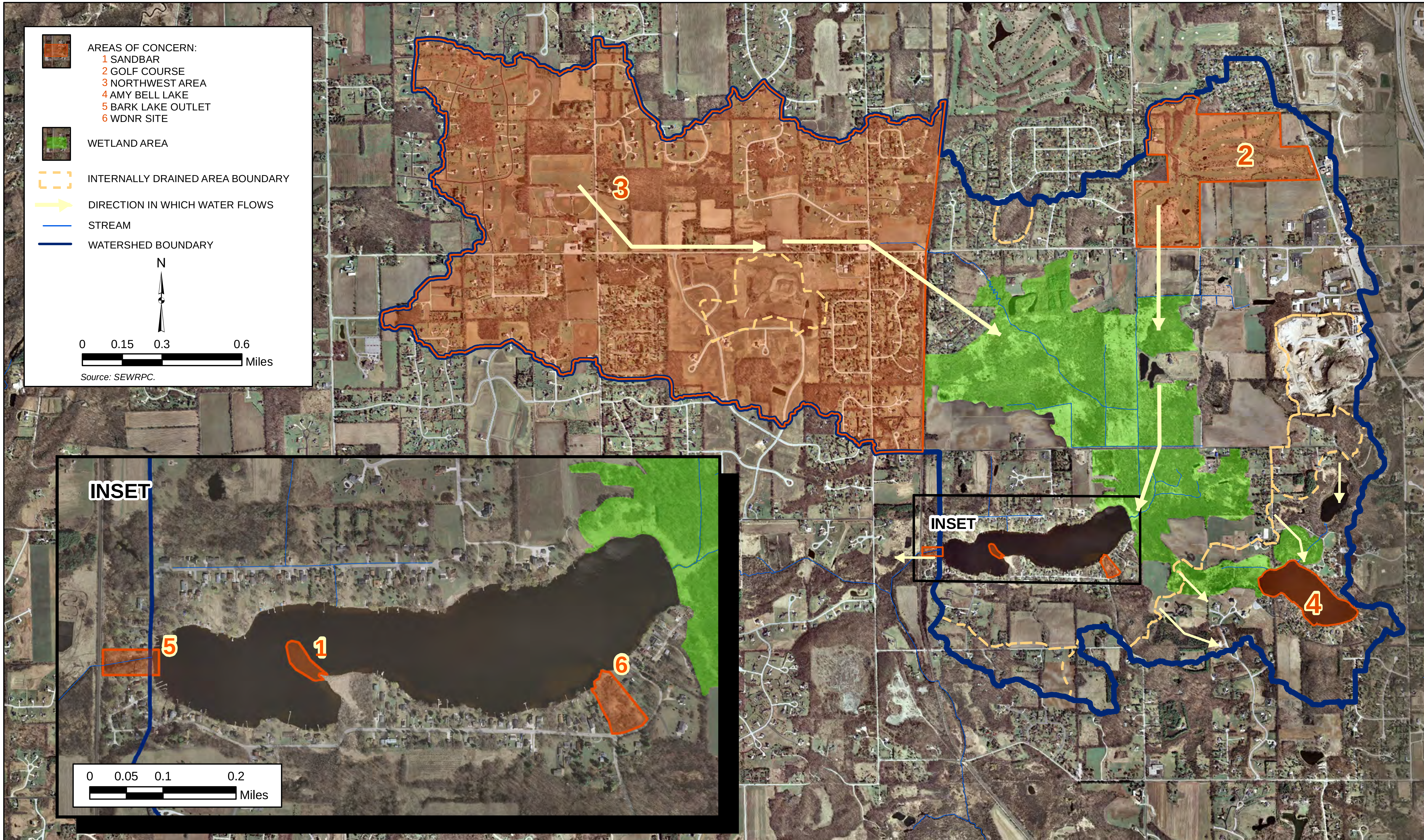


Table 1

ABUNDANCE DATA FOR SUBMERGED AQUATIC PLANT SPECIES IN BARK LAKE: 2012

Aquatic Plant Species	Number of Sites Found	Frequency of Occurrence[a] (percent)	Relative Density[b, c]	Importance Value[d]
Floating Plants				
Nymphaea odorata (white water lily)	54	46.20	3.90	177.80
Nuphar variegata (spatterdock)	4	3.40	2.50	8.60
Nelumbo lutea (American lotus)	1	0.90	3.00	2.60
Submerged Plants				
Myriophyllum spicatum (Eurasian water milfoil)	100	85.47	3.59	306.84
Chara spp. (muskgrass)	51	43.59	4.29	187.18
Potamogeton illinoensis (Illinois pondweed)	33	28.21	3.15	88.89
Ceratophyllum demersum (coontail)	37	32.62	2.51	79.49
Utricularia vulgaris (bladderwort)	21	17.95	1.86	33.33
Stuckenia pectinata (Sago pondweed)	15	12.82	2.33	29.91
Potamogeton gramineus (variable pondweed)	9	7.69	3.22	24.79
Potamogeton praelongus (white-stem pondweed)	9	7.69	2.67	20.51
Myriophyllum sibiricum (native milfoil)	8	6.84	2.50	17.09
Najas marina (spiny, or brittle, naiad)	5	4.27	2.00	8.55
Potamogeton richardsonii (clasping-leaf pondweed)	2	1.71	2.00	3.42
Elodea canadensis (waterweed)	1	0.85	3.00	2.56
Najas flexilis (bushy pondweed)	2	1.71	1.00	1.71
Potamogeton robinsii (Robbins pondweed)	1	0.85	2.00	1.71
Zosterella dubia (water stargrass)	1	0.85	1.00	0.85

NOTE: Sampling occurred at 167 sampling sites; 117 had vegetation.

[a]*The percent frequency of occurrence is the number of occurrences of a species divided by the number of samplings with vegetation, expressed as a percentage. It is the percentage of times a particular species occurred when there was aquatic vegetation present.*

[b]*The relative density is the sum of the abundance scores—the field assessment of the abundance, on a scale of 1 to 3, of a particular species at each sampling site—for a species divided by the number of sampling points where that species was found. It is an indication of how abundant a particular plant is throughout a lake.*

[c]*The abundance, or density was surveyed using a scale of 1 to 3, while the relative density is 1, 3 and 5. Therefore, if density = 2, then relative density = 3, etc.*

[d]*The importance value is the product of the frequency of occurrence and the relative density, expressed as a percentage. It provides an indication of the dominance of a species within a community.*

Source: SEWRPC.

As can be seen in Table 1, despite this healthy aquatic plant population, one regulated nonnative aquatic plant species (AIS) was found, namely Eurasian water milfoil (*Myriophyllum spicatum)*, which had a frequency of occurrence of 85.47 percent. Eurasian water milfoil can be particularly detrimental to lakes because it often outcompetes native aquatic plants. Without management, it frequently dominates the plant communities in the lakes of Southeastern Wisconsin—to the detriment of native plant species and the fish and wildlife that feed on native plants.[11]

The Bark Lake Association has been managing the presence of Eurasian water milfoil with chemical controls since 1997 (see Table 2). In fact, an extensive chemical treatment was done in August 2012, a month after SEWRPC completed the aforementioned aquatic plant survey, and subsequently, in the following year (2013), a

[11]*Eurasian water-milfoil* (Myriophullum spicatum), *Wisconsin Department of Natural Resources;* http://dnr.wi.gov/topic/Invasives/fact/EurasianWatermilfoil.html.

Table 2

CHEMICAL CONTROLS ON BARK LAKE: 1979-2003

Year	Algae Control		Macrophyte Control					
	Cutrine Plus	Copper Sulfate	Sodium Arsenite	2,4-D	Hydrothol	Diquat	Glyphosate	Endothall/ Aquathol
1997	- -	- -	- -	100 lbs.	- -	- -	- -	- -
2002	- -	- -	- -	20 gallons	- -	- -	- -	- -
2003	- -	- -	- -	7 gallons	- -	- -	- -	- -
2012	- -	25 lbs.	- -	- -	- -	- -	- -	- -
2013	- -	- -	- -	5 lbs.	- -	- -	- -	- -
Total	- -	- -	- -	27 gallons + 100 lbs.	- -	- -	- -	- -

Source: Wisconsin Department of Natural Resources and SEWRPC.

field survey[12] noted that, though Eurasian water milfoil was present in the Lake, it was no longer a dominant species (favoring instead bladderwort, white-water lily, Illinois pondweed, chara, coontail, and spatterdock). None the less, even with this effective management, the continued presence of Eurasian water milfoil in the Lake suggests that aquatic plant management is an ongoing issue.

Unfortunately, the management of Eurasian water milfoil is not as simple as treating the entire lake with large doses of herbicides in an attempt to eradicate the target aquatic plant species. The process is often complicated by a variety of factors that have been cited as the major reasons why chemical treatment was limited by WDNR staff in the summer of 2013 (another issue of concern expressed by residents of the Lake). These complicating factors include:

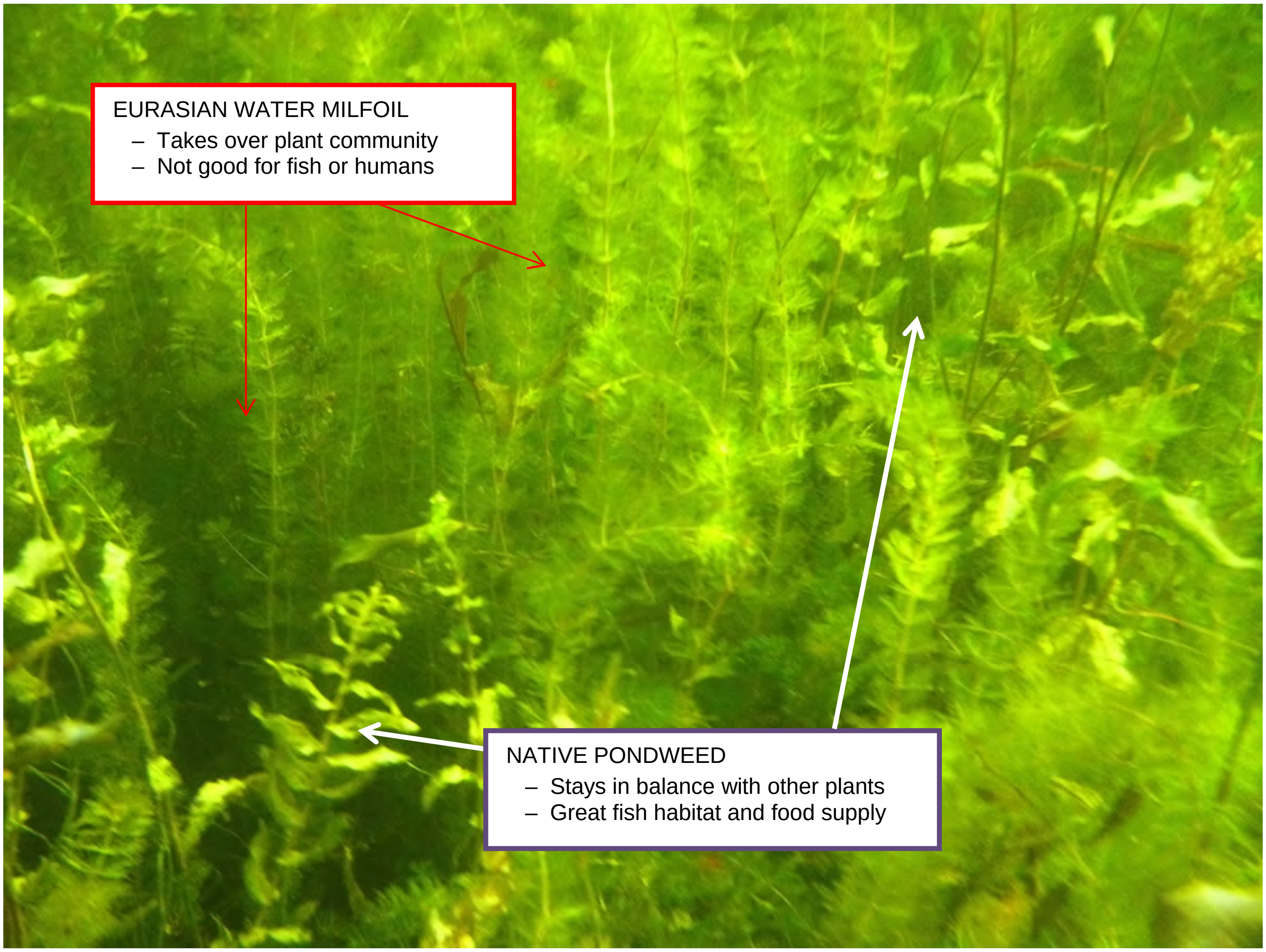
1. The coincidence of Eurasian water milfoil with native aquatic plants during the high growth season—Native aquatic plant species are of benefit to a lake due to their ability to filter pollutants from water, provide fish habitat, and provide an overall “healthy” lake ecosystem. Native aquatic plant species are specifically adapted to local aquatic environments and many kinds of wildlife depend exclusively on the presence of specific plant species for survival. Therefore, any attempt at managing Eurasian water milfoil, or any invasive species, must be done so as to minimize negative impacts on native plant populations. As Eurasian water milfoil is often present in areas of concentrated native plant communities during the peak growth season (Figure 1 shows an example of this coincidence), it is important to take extra precaution to prevent inadvertent native species loss. This coincidence was also well-documented during the aquatic plant survey completed in 2012, as shown on Map 4, which demonstrated the native species richness (i.e., the number of native plants at each sampling point) as well as the points where Eurasian water milfoil was also found. This coincidence of native and nonnative plants was cited as a major reason why WDNR did not allow extensive chemical treatment during the summer of 2013.

2. The presence of native milfoil species, which are often mistaken for Eurasian water milfoil—as reported in Chapter II of this report, native milfoil (*Myriophyllum sibiricum*) is present in Bark Lake. Due to the similarity in appearance of native milfoil to Eurasian water milfoil (as shown in Figure 2),

[12]*This field survey was completed in the summer of 2013 by WDNR staff prior to chemical application.*

Figure 1

COINCIDENCE OF EURASIAN WATER MILFOIL AND NATIVE PONDWEED



Source: SEWRPC.

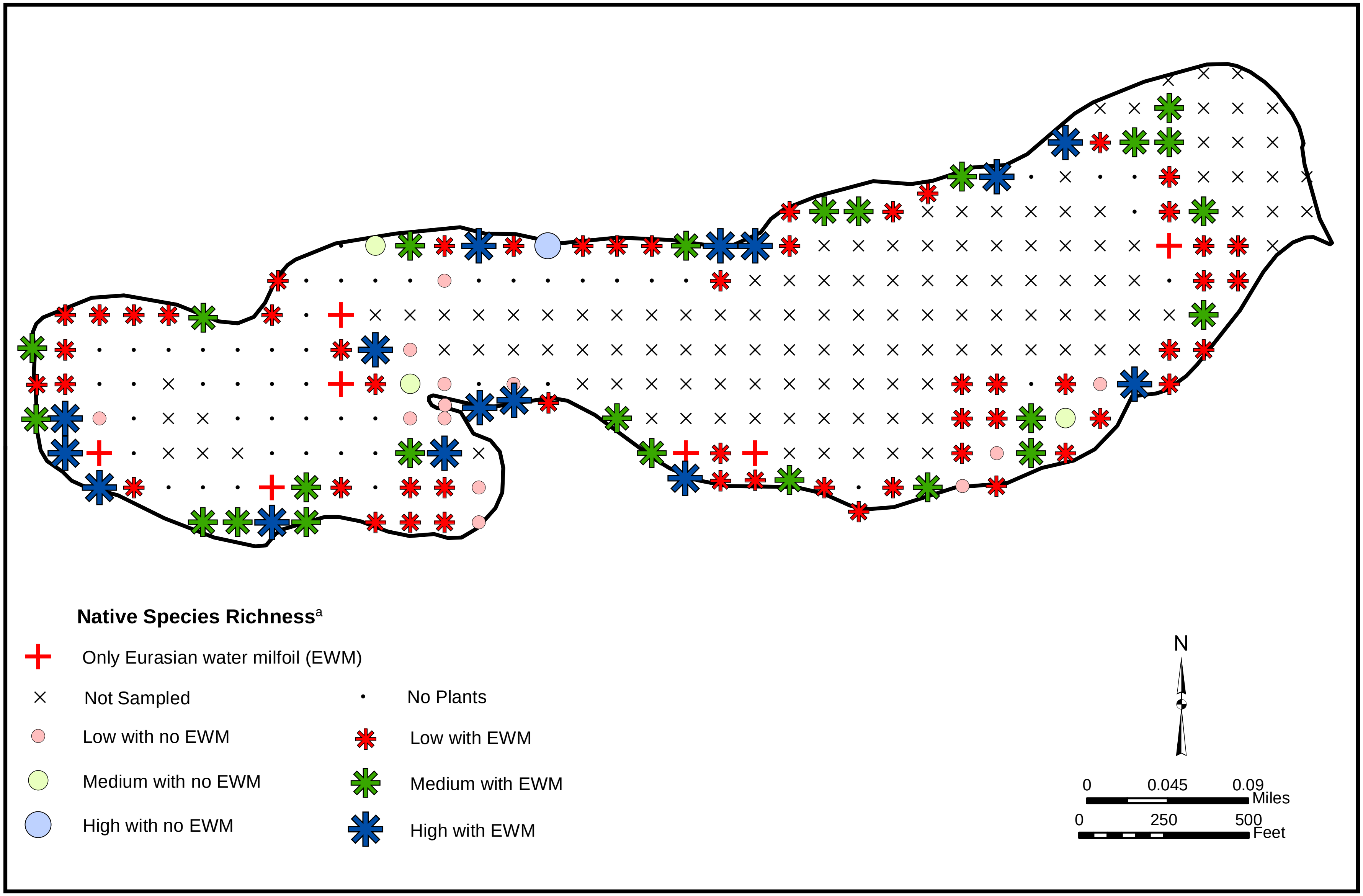
particularly when observed by untrained eyes, extra precaution should be taken to prevent the eradication of this native species as an inadvertent effect of treating Eurasian water milfoil. According to WDNR staff, treatment was restricted in the areas of Bark Lake where this native species was present during the 2013 treatment period in order to prevent its unintentional removal.

3. The presence of hybrid milfoil species, which calls for further investigation prior to treatment—Eurasian water milfoil sometimes hybridizes (cross pollinates) with native milfoil species, thereby creating a species which is more difficult to distinguish as an invasive or native. This species, in fact, is also more difficult to treat with chemicals and therefore may need a different dosage, depending on the type of hybrid. Therefore, WDNR sometimes needs to perform genetic tests on certain species prior to treatment to determine whether they are invasive. This further emphasizes the need for trained personnel to be involved in the identification of plant species in treatment areas.

Fortunately, even with these complications, there are approaches to better target Eurasian water milfoil in a way that does not risk native aquatic species. Consequently, recommendations relating to these methods are included in Chapter III of this report, in addition to an overall aquatic plant management plan.

Map 4

COINCIDENCE OF EURASIAN WATER MILFOIL WITH NATIVE AQUATIC PLANTS: 2012

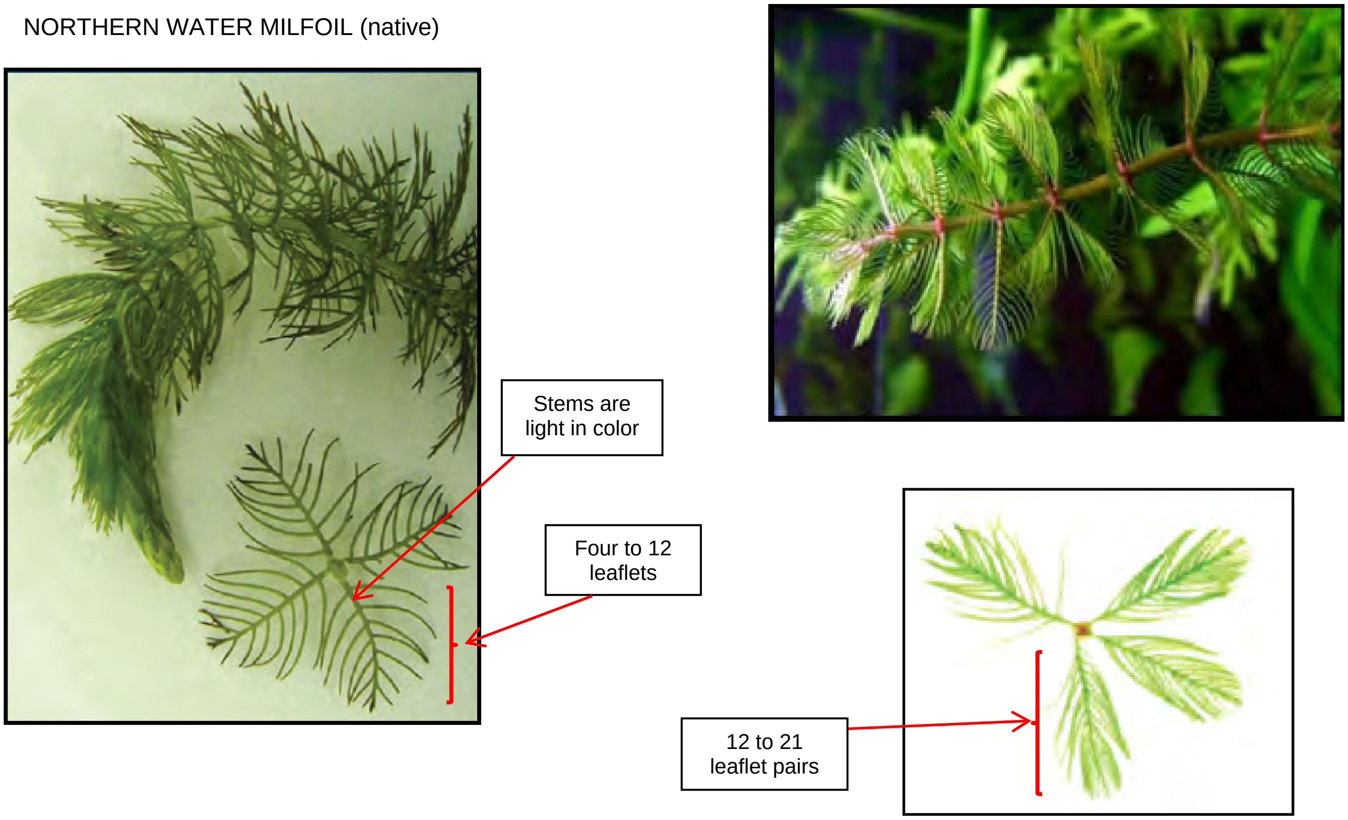


[a]*Native species richness refers to the number of native plants present at sampling site: Low=1 or 2; Medium=3; and High=4 or 5.*

Source: SEWRPC.

Figure 2

COMPARISON OF NATIVE AND EURASIAN WATER MILFOIL



Source: SEWRPC.

It is important to note that aquatic plant management is not confined solely to dealing with the plants themselves. A number of factors in lakes lead to the creation of a lake environment conducive to “excessive” plant growth, both in terms of Eurasian water milfoil and native plants. Poor water quality with high phosphorous content (which can result from sediment pollution and surface water runoff into the Lake), for example, provides the building blocks that all plants need in order to thrive, and eventually reach what is perceived as a nuisance level. Consequently, the implementation of recommendations that seek to prevent pollution, sediment disturbances, invasive species introduction, and water loss need to be a part of any comprehensive aquatic plant management plan. This is why the issues of concern discussed below are considered a priority in this report. Management techniques that seek to address these core issues will improve the overall “health” of the Lake and likely also lead to a more manageable aquatic plant population. Details of these kinds of recommendations, as well as how they will contribute to the control of aquatic plant species, are included in Chapter III of this report.

SEDIMENTATION AND WATER DEPTH

Sediment deposition resulting from erosion and plant death in a lake can cause several issues. The mud and loose sediment that is characteristic of sedimentation, for example, can inundate or cover the sand and gravel substrates known as “parent material.” This process can degrade fish habitat and cause a loss of aquatic organisms due to the fact that species such as sunfish (e.g., largemouth bass, bluegill, and green sunfish), darters and minnows (e.g., common shiner, sand shiner, and spotfin shiner) are dependent upon the sand and gravel substrates for feeding, nesting, and rearing of juveniles. In addition, the loss of water depth can limit the total population of fish able to reside in a lake and can reduce the quality of deep water habitat in a lake.

Sedimentation, either episodic or chronic, can also eventually result in lack of adequate water depth in which to safely operate watercraft, thereby reducing or restricting the amount of usable areas for such recreational activities as cruising (either low- or high-speed), waterskiing, tubing, wakeboarding, personal watercraft use, and fishing. This can lead to overcrowding and increased risk to boaters and others in the water (e.g., swimming, waterskiing, tubing). In addition, loosely consolidated bottom sediments deposited in shallow areas or high boat-traffic areas can result in damage to boat motors as a result of cooling systems clogged by muck and debris; loss of aesthetic value; fear that swimmers, fishers, and boaters could become mired in unconsolidated sediment; and related concerns, such as the inability to operate boat lifts at piers or gain pier access.

As is noted in the inventory findings presented in Appendix A of this report, Bark Lake is considered to have water quality conducive to full recreational uses. Summer recreational uses include active recreational uses, such as powerboating, waterskiing and tubing, fishing, paddleboating, canoeing, kayaking, and swimming. Popular wintertime activities include ice fishing and cross-country skiing. The summer recreational uses involve both full and partial body contact, such as swimming and tubing, as well as noncontact recreational uses, such as boating and fishing. All of these activities, both winter and summer, are active recreational pursuits, while passive pursuits, such as scenic viewing, are also engaged in year-round. Consequently, perceived increases in sedimentation, and the associated decreases in lake water depth, are an issue of concern, as those could affect the ability of the Lake to provide quality recreational experiences.

Sedimentation in Bark Lake

The major issue of concern with regard to sedimentation within Bark Lake is the perceived growth of the sandbar along the southern shore of the Lake (see Map 3, Area of Concern No. 1). Lake residents have expressed concern about this perceived growth of the sandbar and have discussed the possibility of dredging as a mitigation technique. However, dredging is often prohibitively expensive and can result in significant negative consequences to the aquatic environment, including loss of fish habitat and disturbed conditions that favor growth of invasive plant species over native species. Consequently, it was important to investigate the extent of possible sandbar growth or sediment accumulation.

There are two possible explanations for this perceived “growth”: 1) the sandbar itself is growing due to erosion coming in from the outside of the lake; and 2) soft sediments are accumulating around the sandbar. In order to determine the extent of growth in the sandbar itself, the following investigations were performed:

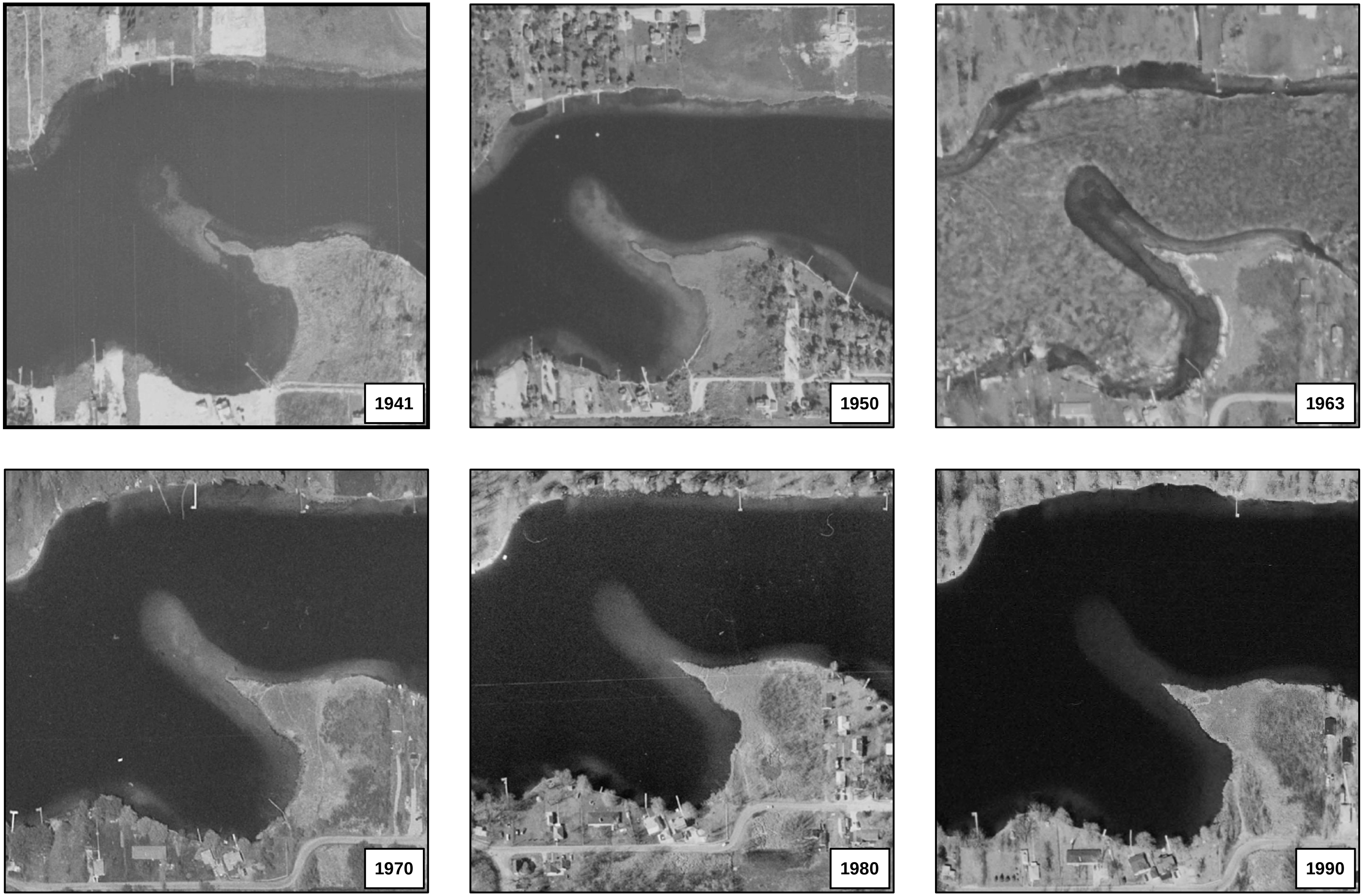
1. Eleven aerial photographs of the sandbar on Bark Lake, dating from 1941 through 2010, were compiled and compared by SEWRPC staff to determine if the sandbar was expanding over time. As demonstrated in Figure 3, this analysis shows that, over time, even though the sandbar may seem larger in certain years, these times seem to be followed by a retreat of the sandbar in following years, thereby indicating that water levels are a more likely cause of historical sandbar expansion than sedimentation.

2. Field inspections of the land areas draining into the sandbar region, during and after a storm event, were also conducted by SEWRPC staff to determine if sediments were, in fact, entering the Lake in the area of the sandbar. This was done because typically when extensive sedimentation is occurring in a lake, the source of sediment is very evident in the landscape and would include “scouring areas” (i.e., areas where erosion is clearly taking place and/or areas where sediments are accumulating on the landscape as shown in Figure 4). During field observations, though SEWRPC staff was able to find erosion on the side of the road opposite to the Lake in the area of the sandbar, there was no clear evidence that these sediments were entering the Lake in large enough quantities to have an effect.

Overall, these two investigations have indicated that the sandbar itself is likely not growing, leading to the conclusion that in-lake soft sediment accumulation, likely from plant death and sediment re-suspension and deposition around the sandbar, is likely the major cause of the perceived growth. In order to investigate this

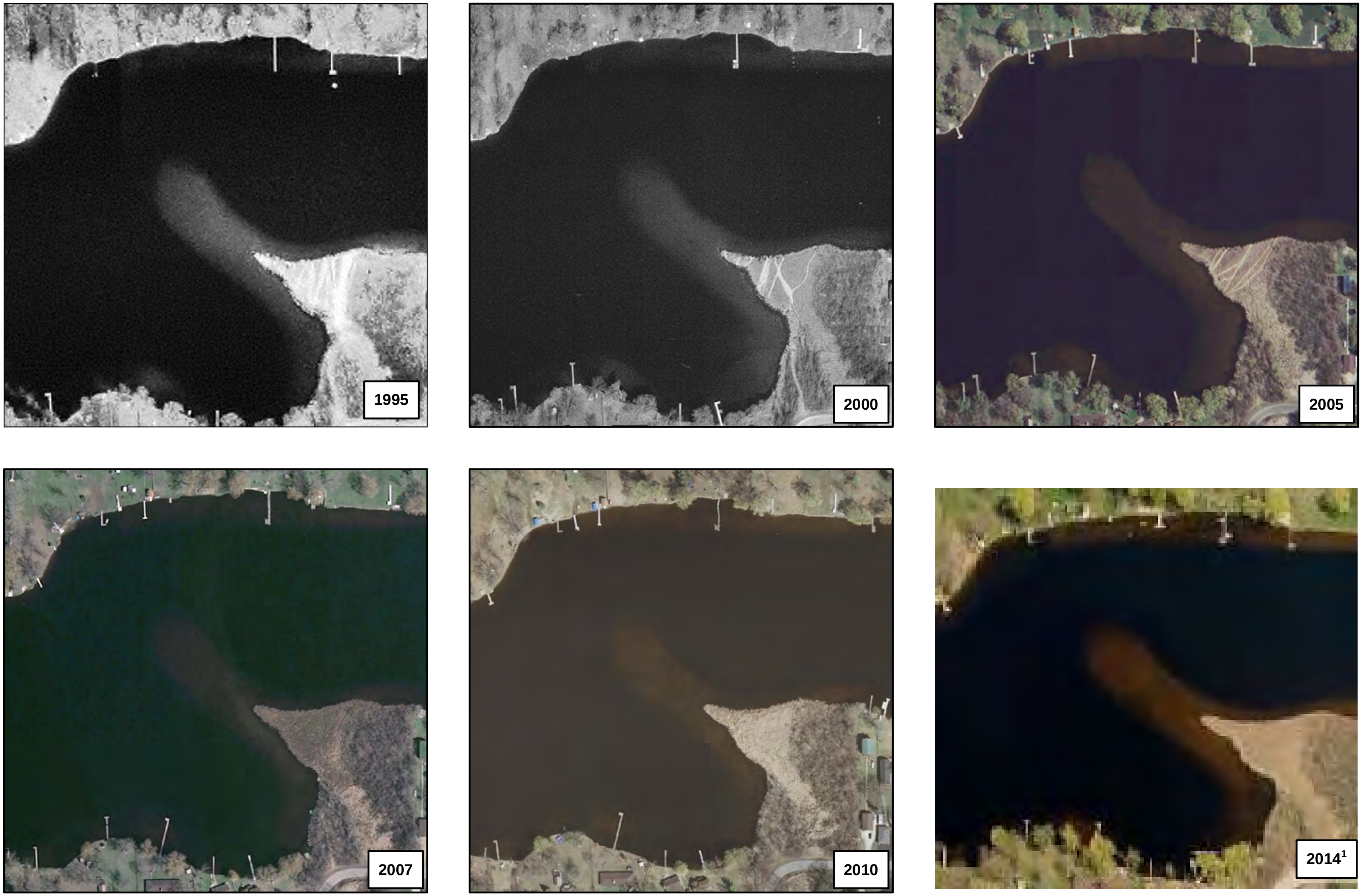
Figure 3

AERIAL PHOTOGRAPHS OF THE SAND BAR ON BARK LAKE: 1941-2014



Source: SEWRPC.

Figure 3 (continued)



[1] The difference in picture quality results fromdifferent sources of photography. The 2014 photography was clipped from a Bing image by MacDonald, Dettwiler and Associates (MDA) Geospacial Services Inc., 2012.

Source: MDA Geospatial Services Inc. and SEWRPC.

Figure 4

EXAMPLES OF SCOURING AND EROSIONAL DEPOSITION CHARACTERISTIC IN AREAS WITH HIGH SEDIMENTATION

Source: SEWRPC.

accumulation, a sediment depth survey was completed in the Lake in July 2012. This revealed that the areas around the sandbar did have some of the deepest soft sediments in the Lake, with sediment depths directly around the sandbar to ranging from three to 11.5 feet, while most of them were between six and nine feet[13] (see Map 5). Additionally, the location of the deeper measurements of sediment depths, as well as observations by residents, imply a potential cause of this expansion, namely the re-suspension of sediments within the Lake by recreational use which re-deposited around the sandbar where the water is forced to slow down; however, this would need to be further investigated. This, cause would, however, account for the observations of local residents, who state that the Lake is being "cut off" in this region.

As the rate of sediment accumulation is currently unknown, further monitoring of sediment depths should take place. However, given that the soft sediment accumulation around the sandbar is threatening recreational use, the removal of these sediments may be warranted. These recommendations are further discussed in Chapter III of this report.

WATER QUALITY

Actual and perceived water quality continues to be an important issue in Bark Lake. This is evidenced by the fact that the most recent water quality data collected in Bark Lake in 1997 indicate that the Lake has "fair" water quality.[14] Additionally, several potential pollutant sources were cited by Bark Lake residents as issues of concern with relation to water quality, thereby confirming that this is an issue of concern among residents.

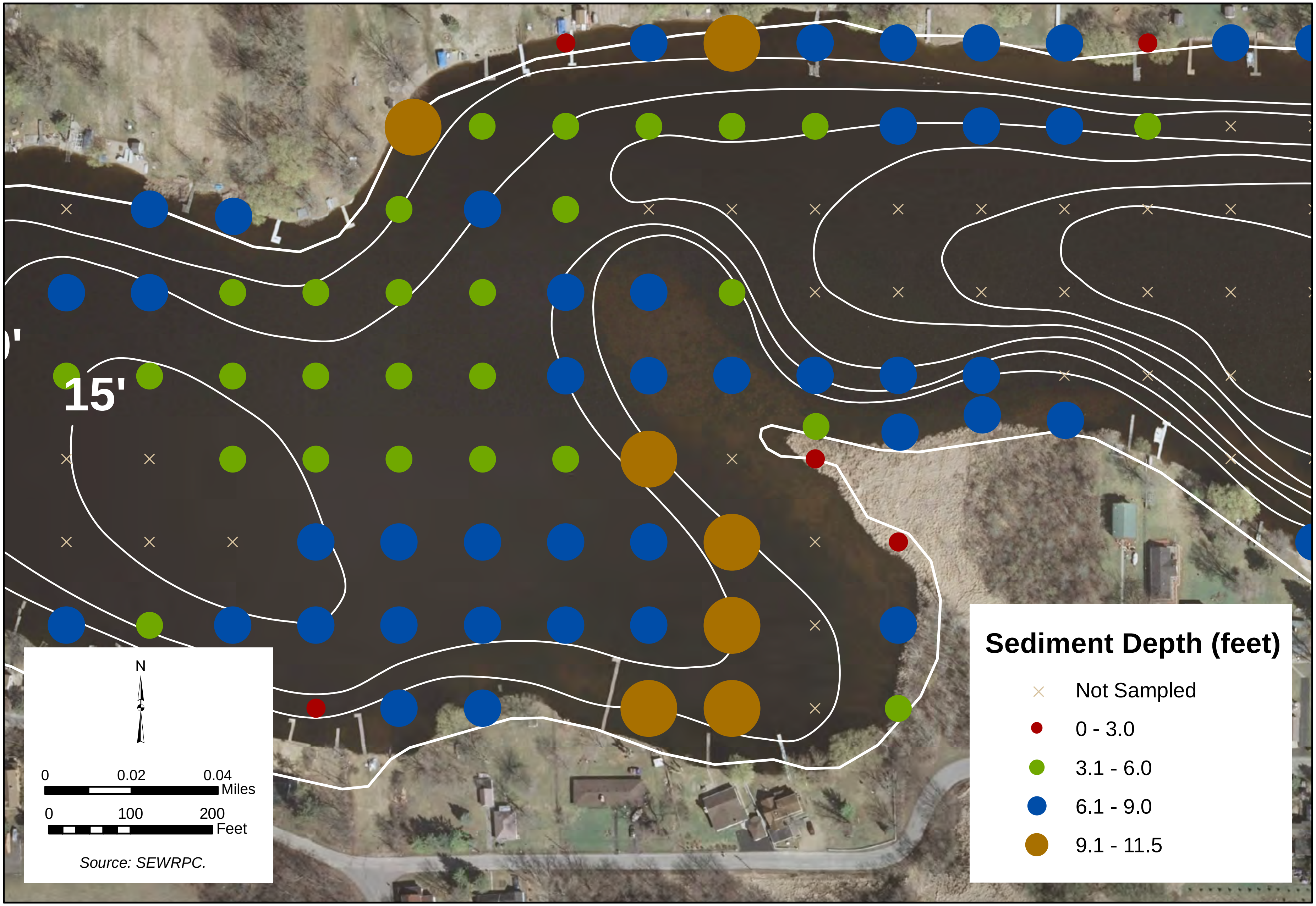
Sources of pollution are not confined solely to pollutants that drain directly into a lake. They also include pollutants that enter a lake through its tributaries (rivers, streams, and springs). This means that activities within

[13]*Further details about sediment depths in the entire Lake are shown on Map A-3 in Appendix A.*

[14]*"Fair" water quality rating is based on a phosphorous concentration of 38µg/l taken in 1997, which is above the phosphorous water quality standards set by WDNR (i.e., 30µg/l in stratified lakes).*

Map 5

SOFT SEDIMENT DEPTHS AROUND THE SANDBAR WITHIN BARK LAKE



the entire watershed have the potential to cause issues in a lake. This section seeks to explain the major potential sources of pollution within the Bark Lake watershed, as identified by Bark Lake residents and SEWRPC staff, and to evaluate their potential risk to the Lake. These potential sources include:

1. The Kettle Hills golf course located in the northern part of the watershed;
2. The residential and agricultural areas located in the northwestern portion of the watershed;
3. The "internally drained areas"[15] in the watershed as potential groundwater pollution sources, with specific emphasis on Amy Bell Lake located in the eastern portion of the watershed;
4. The potential increases in pollution deposition from future urban development;
5. Septic systems located throughout the watershed; and
6. The land use and the activities that occur along the shoreline of the Lake.

Golf Course

Golf courses can be sources of pollution within watersheds. Overuse of pesticides, overuse of fertilizers, lack of adequate buffering capacity, use of invasive species in landscaping, and overwatering—each of which can occur in golf course management—can cause water quality problems in a watershed, especially if runoff from the golf course grounds enters the tributaries to the lake or enters the groundwater supply. The Kettle Hills golf course (see Map 3, Area of Concern No. 2) is located directly upstream from Bark Lake, in addition to being located in a "high groundwater recharge potential" area in the Bark Lake watershed.[16] The golf course is, therefore, an area of concern.

Due to the absence of adequate water chemistry data for Bark Lake, it is difficult to assess the extent to which the golf course may be affecting the water quality of the Lake. However, since the golf course runoff filters through a large wetland at the inlet of Bark Lake,[17] as is seen on Map 3, and since there is a seemingly thriving fish population, an absence of fish kills, and healthy aquatic plant growth in the Lake, it is likely that pollution in runoff from the golf course has not caused significant damage to the water quality of the Lake. That does not mean that pollution from the golf course would not have the potential to affect the water quality of the Lake in the future. Additionally, there is a risk that the pollution from the golf course, in combination with increases in certain pollutant loads that could result from land use changes, could exceed the natural filtration capacity of the wetlands. Therefore, recommendations related to reducing pollution from the Kettle Hills golf course have been included in Chapter III of this report.

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[15] *"Internally drained areas" are areas which, as a result of their surface topography, trap surface waters and prevent them from entering Bark Lake via surface runoff (although the water which enters these areas may still drain to the Lake through a groundwater connection).*

[16] *High groundwater recharge potential relates to soil permeability and the subsequent ability of water to percolate into the ground below. More information can be found in Appendix A in the Groundwater Recharge subsection.*

[17] *Wetlands have the natural ability to filter pollution such as nutrients and metals as well as the natural ability to reduce suspended sediments. Consequently, the presence of a wetland at the inlet of the Lake likely plays a significant role in reducing pollution that would otherwise have affected the Lake.*

Northwestern Area of the Watershed

As can be seen on Map 3 (Area of Concern No. 3), about a third of the Bark Lake watershed is located in the northwestern section. This area consists largely of residential land with some interspersed agricultural land. Given the land use in this area and its size relative to the watershed, this area is likely a significant source of urban and agricultural pollutants draining to Bark Lake, especially during high rainfall events. Urban runoff can contain various pollutants, including nutrients and pesticides from fertilization and treatment of lawns; oils and gasoline from accumulation on impervious surfaces like driveways and roads; and chlorides from deicing of roadways during the winter.[18] Additionally, agricultural runoff can contain nutrients from fertilizer applications and pesticides.[19] The potential inputs of these pollutants from this part of the Bark Lake watershed is therefore a concern.

In order to assess the level of risk associated with this area, SEWRPC staff conducted two investigations. The first was an estimation of phosphorous, sediment, and heavy metal loads entering the Lake from this part of the watershed. This analysis revealed that about 65 percent of the residential land use within the watershed is located in this area and just over 50 percent of the agricultural land use is located in this area. Consequently, the residential and agricultural land use in this area contributes about 45 percent of the phosphorous loads within the watershed and about 40 percent of the sediment loads. Additionally, the roadways and other pavement in this area contribute a significant proportion of the total heavy metal pollution entering the Bark Lake surface water system.[20]

Second, a field investigation was conducted to determine the pathway that runoff from this area would follow in flowing to the Lake. The results of this investigation are shown in the flow pathways illustrated on Map 3. Upon review of the pathway, it is clear that this northwest portion of the watershed is draining to the tributary which flows into the Lake at its northeast shore and is, therefore, passing through the large wetland area north of the Lake. This likely explains why development in the northwest area does not appear to have caused significant, observable damage to the water quality of the Lake, although, lack of adequate water chemistry data for Bark Lake makes it difficult to assess to what extent the Lake's water quality may be impaired as a result of runoff from this area.

As with the golf course, it is possible that the pollution inputs from this northwest area, in combination with future urban development in the watershed, could lead to impacts to the Lake. Consequently, recommendations related to reducing these risks are further detailed in Chapter III of this report.

Internally Drained Areas, Including Amy Bell Lake

Bark Lake residents have expressed concern that pollution associated with Amy Bell Lake (see Area of Concern No. 4 on Map 3) could be conveyed to Bark Lake during high-flow periods. In response to this concern, SEWRPC staff investigated potential surface water connections between the two lakes, and identified none. This was further confirmed when delineating the Bark Lake surface watershed, when it was determined that Amy Bell Lake is one of seven internally drained areas (areas that, due to their depressional topography, trap surface waters and prevent them from entering Bark Lake via surface runoff) within the Bark Lake watershed.

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[18]*U.S. Environmental Protection Agency, EPA 841-F-03-003,* Urban Nonpoint Source Fact Sheet, *2003;* http://water.epa.gov/polwaste/nps/urban_facts.cfm.

[19]*U.S. Environmental Protection Agency, EPA 841-F-05-001,* Agricultural Nonpoint Source Fact Sheet, *2005;* http://water.epa.gov/polwaste/nps/agriculture_facts.cfm.

[20]*Loading percentages were developed using a Unit Area Loading model. This model, as well as the loading calculations for the entire watershed, is discussed in Appendix A in the Pollutant Loadings section.*

In addition to ruling out the surface water connection, SEWRPC staff also investigated the general flow direction of groundwater within the Bark Lake watershed by looking at groundwater table elevation data[21] to determine if Amy Bell Lake was contributing to the baseflow of Bark Lake (water which enters the Bark Lake system through groundwater). This analysis revealed that groundwater generally flows in a southeasterly direction, indicating that Amy Bell Lake also does not have a groundwater connection to Bark Lake. This analysis did, however, reveal that two of the internally drained areas, specifically the one located in the northeastern portion of the watershed and the extractive site on the northeast side, could contribute to baseflow to Bark Lake. Consequently, efforts to reduce pollution in these two internally drained areas are included as recommendations in Chapter III of this report.

Future Urban Development

As mentioned above, urban land use often coincides with poorly planned nutrient and chemical application on lawns and gardens, oil deposition on pavement, and salt application on roadways. These pollutants are generally washed off the land surface during rain events and can then enter a downstream lake. Consequently, increases in urban development within the Bark Lake watershed have the potential to change the nature of, and potentially increase the amount of pollutants entering Bark Lake through surface water runoff and groundwater pollution.

Through comparing existing 2010 land use data and 2035 planned land use,[22] it is possible to delineate the areas where agriculture and open space lands are planned to be converted into residential and commercial uses. Map 6 shows the results of this analysis, and it also shows where areas of high and very high groundwater recharge potential (as discussed in Appendix A) coincide with planned development. This is done to highlight how much future development is planned, as well as how much of that development could affect the surface water and groundwater resources of Bark Lake. As can be seen on Map 6, there is a significant aggregate area that is planned for development, much of which is located within high groundwater recharge areas. Consequently, pollution from future development is an issue of concern and recommendations that seek to reduce this risk to Bark Lake's water quality are included in Chapter III of this report.

Private Onsite Wastewater Treatment (POWTS or Septic) Systems

Improper maintenance of POWTS or septic systems is a common source of pollution to groundwater. This type of pollution can cause excessive nutrient (i.e., phosphorus and nitrogen) deposition and elevated chloride levels in Lakes, as well as bacterial contamination.[23] Given that Bark Lake is currently served solely by septic systems,[24] and given the age of many of the houses located on the shoreline, the Lake is likely at risk for pollution associated with septic system malfunctions. Unfortunately, as with the other potential sources of pollution to Bark Lake, lack of data prevents any conclusions regarding the effect of septic leakage on Bark Lake. However, septic maintenance, particularly in the residential areas surrounding the Lake, is an issue of concern. Therefore, recommendations regarding preventive measures to ensure the maintenance and potential improvement of Bark Lake's water quality through encouraging septic system maintenance are included in Chapter III of this report.

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[21]*Groundwater table elevations are based on recorded water elevations in wells in the Region. Details about these elevations are included in Appendix A in the Groundwater Table Elevations subsection.*

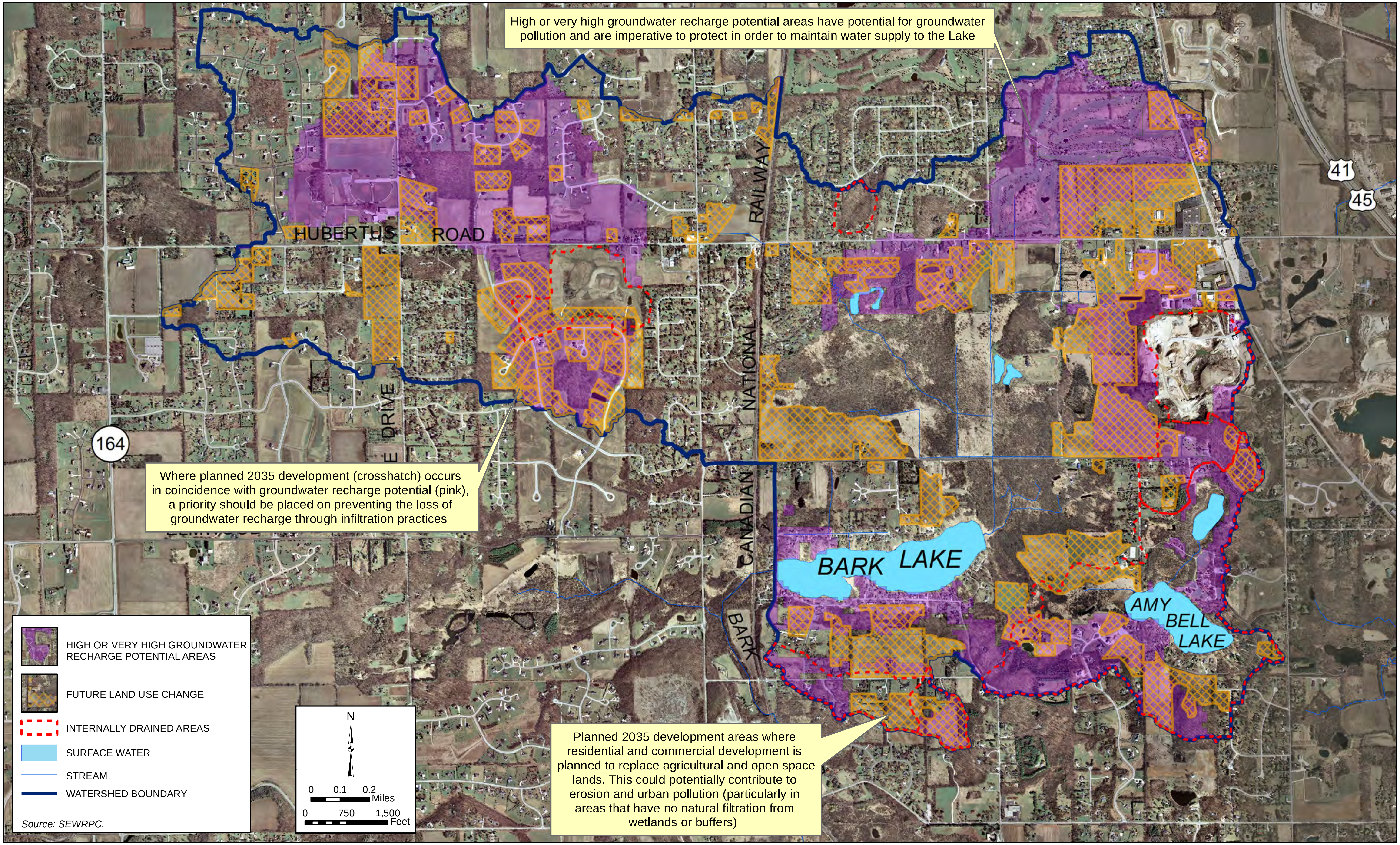
[22]*Existing 2010 and planned 2035 Land Use in the Bark Lake watershed can be found on Maps A-13 and A-14 in Appendix A in the Existing and Planned Land Use subsection.*

[23]*R. Ohrel,* Dealing with Septic System Impacts. Watershed Protection Techniques, *Volume 32, No. 1, 2000, pp. 233-238.*

[24]*SEWRPC keeps track of which areas are serviced by sanitary sewers. No areas within the Bark Lake watershed fall under jurisdiction of any sanitary sewer services, thereby leading to the conclusion that only septic systems are used in the entire Bark Lake watershed.*

Map 6

GROUNDWATER RECHARGE POTENTIAL IN AREAS OF 2035 PLANNED LAND USE CHANGES IN THE BARK LAKE WATERSHED



Lake Shoreline and Adjacent Properties

Aside from the pollution inputs that enter a lake through its inlets and tributaries, another significant source of pollution for lakes are areas that drain directly into the lake from its shorelines. This kind of pollution is generally a direct result of the land management practices of the landowners surrounding the lake. Fertilization and pesticide application on the lawns along the shoreline of a lake, for example, can be significant sources of nutrient and chemical pollution, as these contaminants enter a lake without any filtration through wetlands or other natural pollution reduction processes. This pollution can then cause excessive plant growth or even fish kills. This also applies to pollutants from oil spills on driveways and roads around a lake, which enter the lake during rainfalls, as well as sediments that can enter the lake as a result of eroded shorelines (which often happens due to wave action and lack of man-made or natural shoreline protection).[25] Therefore, shoreline land management is an issue of concern.

Though there was not an adequate amount of water chemistry data to determine if there were significant pollution inputs from the shorelines, it is safe to assume that the pollution entering the Lake from the shoreline does have a significant impact. This is because this source of pollution, which represents about 14 percent of the total residential areas in the watershed, is the only residential pollution source that enters the Lake without the natural filtration provided by the wetlands to the east of the Lake (as can be seen on Map 2). One way to achieve natural filtration would be for buffers to be located along the shoreline. However, it was found by SEWRPC staff in a 2013 shoreline assessment that the Lake's shoreline currently provides little natural buffer protection from polluted runoff (see Map 7). Additionally, there were also areas of erosion along the shoreline, indicating that soils from the shorelines may also be contributing to pollution of the Lake. Consequently, recommendations related to the restoration of this shoreline to include buffers,[26] as well as recommendations related to installing best management practices to reduce pollution, are included in Chapter III of this report.

It is also important to note that agricultural areas also drain directly to the Lake without passing through the wetlands east of the Lake. Such areas can be seen on Map 2 directly north and south of the Lake. Similarly to the shoreline properties, these areas should be considered an issue of concern because runoff from these areas may not be naturally filtered prior to entering the Lake. Consequently, in addition to the shoreline buffer development recommendation (which would play a significant role in filtering some of these pollutants prior to entering the Lake), recommendations related to agricultural best management practices have also been included in Chapter III.

Finally, in 2035 the agricultural areas that drain directly to the Lake are planned to be developed (as can be seen on Map 6). This development could have significant impact on the Lake in terms of erosion related to construction, as well as in relation to urban pollution loading, in the absence of the installation of adequate construction erosion control and stormwater management practices. Consequently, recommendations related to these areas are included in Chapter III of this report.

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[25]*Further details about the specific shoreline protections along Bark Lake that do not have buffering capacity are included in Appendix A in the Shoreline Protection and Erosion Controls section. This section also includes photos of these kinds of shoreline protection and an inventory of these measures.*

[26]*Buffers are areas of natural vegetation that can intercept pollution and runoff prior to entering the Lake. Buffers have the ability to filter pollution like nutrients and sediments so that they do not affect the "health" of the Lake. Further details are included in Appendix A in the Onshore Buffer Zones subsection and in SEWRPC Riparian Buffer Management Guide No. 1,* Managing the Water's Edge: Making Natural Connections, *published in May 2010 (see Appendix D).*

Map 7

SHORELINE PROTECTION AND BUFFERING CAPACITY ON BARK LAKE: 2013

Figure 5

BARK LAKE OUTLET AND DOWNSTREAM CULVERTS

Source: SEWRPC.

LAKE OUTFLOW RESTRICTIONS AND BLOCKAGES

Bark Lake citizens have expressed concern about a periodic blockage of the Bark Lake outlet (see Map 3, Area of Concern No. 5) by debris accumulation. SEWRPC staff were unable to determine the extent of the outflow restrictions in Bark Lake; however, it is suspected that the outlet could potentially be at a lower elevation than the Canadian National Railway culverts located just downstream of the outlet, thereby contributing to the reported issues. Both the outlet and the culverts are shown in Figure 5. Given that outflow blockages can be an issue during rain events, the investigation of this issue of concern is considered a priority. Consequently, recommendations related to the investigation of this issue, as well as recommendations related to the continued clearing of these debris jams, are further detailed in Chapter III of this report.

WDNR PUBLIC ACCESS SITE

The WDNR owns a plot of land on the southern shoreline of Bark Lake (see Map 3, Area of Concern No. 6). Preconstruction work took place in December 2013, in preparation for the installation of a public recreational boating access site, consistent with the standards set forth in Chapter NR 1 of the *Wisconsin Administrative Code*. The WDNR has entered into a 20-year lease agreement with the Village of Richfield, which will build, operate, and manage the boat launch. According to WDNR, the site, which was still under construction during preparation of this plan, will cover 2.1 acres and include four trailer parking stalls and three vehicle-only parking stalls (with two Americans with Disabilities Act-compliant parking stalls). The ramp will be made of concrete and will include a removable boarding pier, a driveway, and parking lot made of gravel (with potential to be paved in the future). Additionally, all disturbed areas will be restored with native seed mixtures. This public access site is a part of WDNR efforts to meet the *Wisconsin Administrative Code* goal of developing public access for all lakes in Wisconsin.[27]

The installation of a public access boat launch, in accordance with WDNR standards, provides Bark Lake residents and managers with more access to WDNR funding that can be applied to lake planning and management efforts. Specifically, lakes that have adequate public access sites are considered higher priorities for funding than those that do not. For example, the WDNR Lake Protection Grant program, which can be used for land purchases

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[27]Wisconsin Administrative Code, *NR 1.91 Public boating access standards;* http://docs.legis.wisconsin.gov/code/admin_code/nr/001/1/91.

and protection, prioritizes grant applications for lakes that have public access sites. Additionally, the presence of a public boat launch also qualifies lakes for WDNR funded fisheries assessments and fish stocking.[28]

Despite the opportunities that public access will provide several access site-related issues of concern have been expressed by residents within the Bark Lake community, including:

1. The potential for overcrowding and loss of tranquility on Bark Lake—Residents of Bark Lake have traditionally enjoyed a fairly "private" Lake;[29] consequently, there is concern that public access will provide individuals the opportunity to overcrowd the lake. Given that only seven parking spaces will be provided at the public access site, this concern may not materialize. However, there are scenarios where individuals unfamiliar with the Lake may choose to cause disturbances, thereby making this an issue of concern that should be addressed.

2. The potential for overfishing—Overfishing can inhibit naturally reproducing fish populations by limiting the size structure distribution of fish through the catching of "desirable fish species" (i.e., larger-sized fish). Limiting the potential for this to occur in Bark Lake in the future is, therefore, considered an issue of concern.

3. The potential for the introduction of aquatic invasive species—Two aquatic invasive species of particular concern are zebra mussels[30] and curly leafed pondweed (see Figure 6), which have been spreading throughout the Southeastern Wisconsin Region. However, many other invasive species also have the ability to enter lakes through "hitching a ride" on boats and other items (e.g., bait buckets and fishing equipment) which go from an infected Lake to a noninfected one. Invasive species can be a major issue due to a lack of natural predators in the affected areas and subsequent excessive growth of the species in question. Given that Bark Lake currently has only one invasive species, Eurasian water milfoil, it is crucial that actions be taken to prevent invasive species introduction, especially with the onset of a public launch. Consequently, invasive species introduction is considered an issue of concern.

In order to prevent the issues of concern related to the new public access site, Chapter III of this report provides several recommendations.

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[28]NR 1.91*(4)(a) Public boating access standards—Minimum Public Boating Access to Qualify Waters for Resource Enhancement Services;* http://docs.legis.wisconsin.gov/code/admin_code/nr/001/1/91.

[29]*No navigable lake is truly "private" due to the fact that the State owns navigable waters below the "ordinary high water mark" as determined by the WDNR. Lakes are, however, often considered "private" by homeowners when the land surrounding the Lake is all privately owned (thereby eliminating the public access to the shorelines).*

[30]*When zebra mussels enter a lake they tend to breed quickly (due to lack of natural predators), leading to high volumes of shells on the plants and shorelines of a Lake. This tends to be a nuisance for recreational use as well as an issue when the shells clog pipes entering the Lake. Another side effect of zebra mussels is that they essentially eat the particles located in the water column, thereby leading to clearer waters. This effect, while sometimes making the Lake "more beautiful" can also lead to sunlight being able to penetrate the Lake at greater depths, thereby increasing the ability of plants to grow at those depths. This process can lead to more aquatic plant growth, which, though often good for fisheries due to increased habitat, can be considered a nuisance for boaters and swimmers.*

Figure 6

AQUATIC INVASIVE SPECIES WATCH LIST

CURLY-LEAF PONDWEED
(*Potamogeton crispus*)

- Leaf edges are wavy and finely toothed; leaf has an overall crispy texture
- Produces flower spikes in the spring that stick up above the water surface

ZEBRA MUSSELS
(*Dreissena polymorpha*)

- Shell has distinct dark stripes
- Hitches rides to lakes on boats and in water buckets
- Infestations are often followed by abnormally clear waters

Source: Wisconsin Department of Natural Resources, Vic Ramey, University of Florida, Minnesota Sea Grant, Ohio Sea Grant, and SEWRPC.

WATER QUANTITY

There is a consensus within the scientific community that the climate has been changing in Wisconsin and the rest of the world. One of the changes occurring worldwide as a result of climate change is the timing and volume of precipitation on a regional basis. For example, on a Statewide basis, there is a relatively high probability that Wisconsin would have higher amounts of annual precipitation, although there may be regional departures from this prediction. Overall, it is also predicted that there will be more “extreme rain events.”[31] Such events will be characterized by heavy rains over a relatively short period of time, rather than rains spread out over a season through many smaller rainfall events.

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

This is an issue of concern in southeastern Wisconsin lakes because the runoff from these high-impact rain events will be moving faster through the surface water systems, particularly where there are large areas of impervious surfaces like rooftops and driveways (see Figure 7 for an illustration of the effects of impervious surfaces on runoff). Water moving faster through the system could have several effects, including: 1) higher rates of erosion of soils and streambanks, further emphasizing the need to maintain natural vegetation and/or to provide green infrastructure (e.g., stormwater management facilities to infiltrate or evapotranspire rainfall and snowmelt), within the watershed for the purpose of holding soils in place or reducing erosion (as discussed in the Sedimentation section above); 2) flooding; and 3) wider variation in the timing and volume of runoff from rain resulting in more fluctuation in streamflows and lake levels. Consequently, each of these issues is considered a potential issue of concern.

Potential Flooding

Flooding events have yet to be reported in the Bark Lake watershed. This is likely because: 1) Bark Lake has a relatively small watershed to surface water ratio (meaning that less water is caught within the watershed draining to the Lake); 2) Bark Lake has a large wetland directly adjacent to the Lake, which naturally slows water and stores it over a large surface area, thereby preventing the water from quickly entering the lake all at one time and causing sporadic water level rises; and 3) there are few low-lying buildings along the Lake shore. Consequently, there is no need to directly recommend measures to mitigate flooding. However, certain recommendations set forth in Chapter III, which are meant address other issues, would manage runoff in a way that could have a positive effect on the factors that contribute to flooding.

Lake Levels

Lake levels became an issue of concern in Bark Lake during the drought of 2012, when the inlet to Bark Lake stopped flowing. This event demonstrated how vulnerable the Lake can be if surface and groundwater sources of inflow are inconsistent or lost over a season. As mentioned above, climate patterns are changing within Wisconsin. These changes could potentially cause changes in lake levels for Bark Lake. However, the extent and nature of these changes is difficult to predict on a local level without a comprehensive local climate analysis (which was not included in the scope of this study). In general, however, climate model projections predict that climate change is likely to cause changes in hydrologic budgets (i.e., changes in water levels or flows) or cause water levels to fluctuate more with the onset of larger fluctuations in precipitation.[32] Consequently, precautions to stabilize lake levels are advised.

Due to the inability to control climate and precipitation on a local scale, the best way to modulate the supply of surface and groundwater to a drainage lake with an outlet is to ensure that water “stays within” the watershed for a relatively long period. In the Bark Lake watershed, where much of the water supplied to the Lake comes from groundwater, one of the best ways to modulate the supply of water to the Lake is to maintain, and possibly improve, groundwater recharge. This can be accomplished by locating new development outside areas of high groundwater recharge potential and by providing stormwater practices that promote infiltration of rainfall.

In the interest of maintaining and potentially improving groundwater recharge in the Bark Lake watershed, Chapter III of this report includes a number of recommendations focused on the high groundwater recharge areas in the Bark Lake watershed (as shown on Map 6). Additionally, recommendations are also provided to mitigate the effects of development planned to take place by the year 2035, as such development involves an increase in impervious cover (e.g., driveways, parking lots, roadways, and roof tops).

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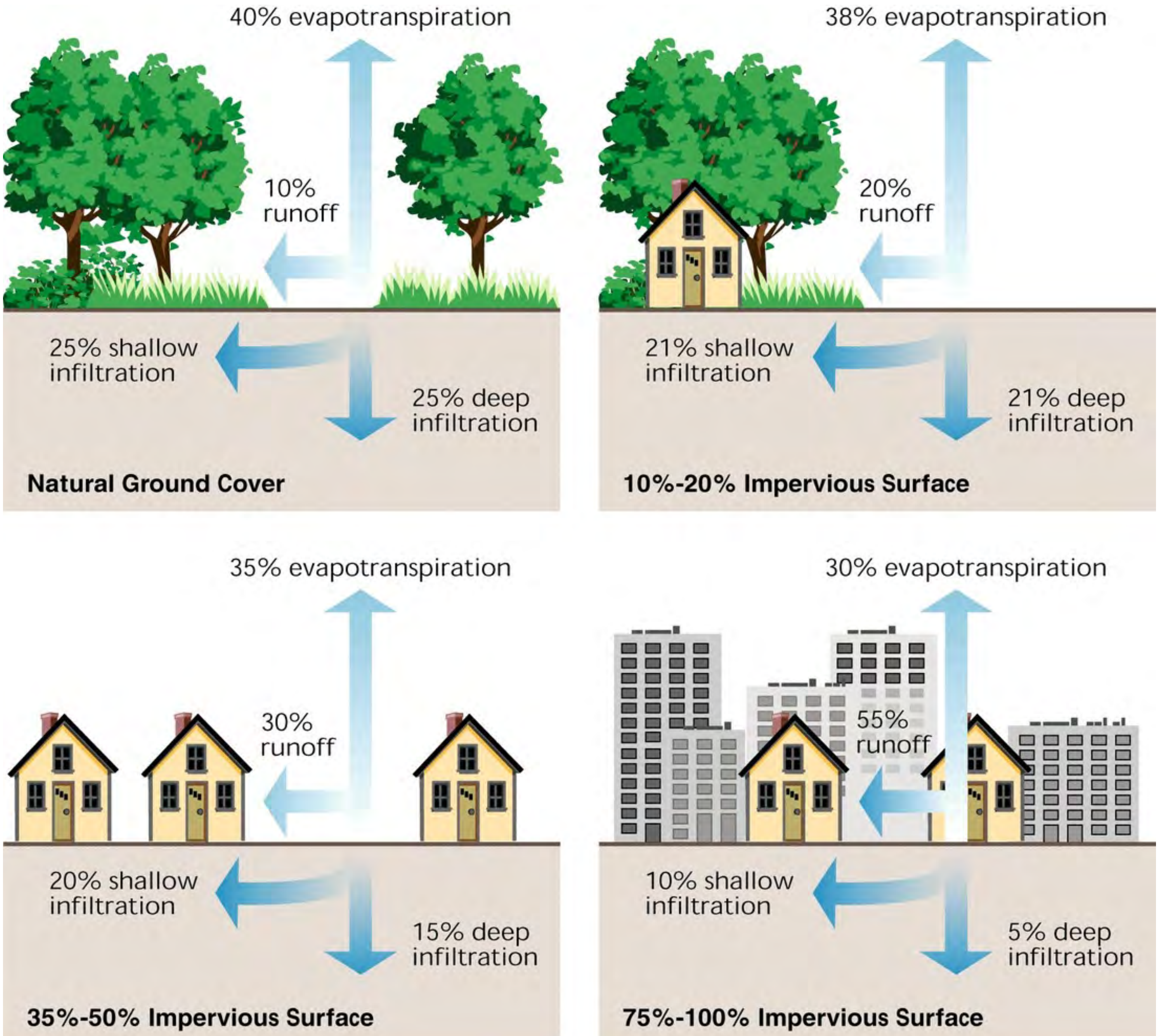
[32]Ibid.

Figure 7

EFFECT OF IMPERVIOUS SURFACE ON GROUNDWATER INFILTRATION AND STORMWATER RUNOFF



Source: Federal Interagency Stream Restoration Working Group.

WILDLIFE

A healthy wildlife population, including deer, amphibians, birds and small mammals, is the ultimate indication of a healthy watershed due to the fact that wildlife requires large well-connected natural areas to thrive. Additionally, the presence of a healthy wildlife population also presents a variety of recreational opportunities, including bird watching, hunting, and nature trekking. Therefore, SEWRPC staff identified wildlife population enhancement as an issue of concern in this watershed, particularly given the limited buffered areas along the Bark Lake shoreline. Chapter III provides recommendations to address this issue.

WETLANDS

The upstream wetland areas in the Bark Lake watershed to the east and north of the Lake provide significant protection to the Lake from nonpoint source pollution. A large portion of the watershed—the whole northern side of the Lake for example, which includes residential and agricultural areas as well as the Kettle Hills golf course—drains into the wetland prior to entering the Lake, as can be seen on Map 3. Wetlands also play a significant role in lowering current and future flooding potential (as discussed in the Water Quantity/Supply section). Finally, since wetlands are capable of slowing and storing water, removing sediments pollutants like pesticides and nutrients,[33] the wetlands are important factors in sustaining a fairly healthy aquatic plant and fish population in the Lake, despite potential significant pollution loading from the watershed.

It is crucial that wetland losses are prevented in critical areas of the Bark Lake watershed in order to prevent future pollution and future large rain events from significantly altering the nature of the Lake. Consequently, recommendations related to this issue of concern are included in Chapter III of this report.

LAKE MONITORING DATA

As mentioned in the water quality section of this chapter, lack of water chemistry data during the development of this report prevented SEWRPC staff from conclusively determining the extent of the current eutrophication in Bark Lake and the extent that upstream pollutants are affecting the Lake. Additionally, this lack of data prevented SEWRPC from being able to make targeted recommendations based on scientific evidence. Nutrient samples upstream from the Lake and long-term phosphorous levels in the deep hole of the Lake, for example, may have been able to indicate where to target pollution reduction measures, if such data had been available. Given that additional data could provide future planners with the tools necessary for making more specific recommendations than those included in this report, lack of lake monitoring data is a major issue of concern. Chapter III of this report, therefore, sets forth several monitoring and data collection recommendations.

SUMMARY

All of the issues of concern expressed by Bark Lake residents during the development of this report have some merit. Additionally, as discussed in Chapter III of this report, addressing these issues will contribute significantly to effectively managing the aquatic plant population within Bark Lake. Therefore, each issue will have associated recommendations in Chapter III. It is important to note that, despite the issues of concern in Bark Lake, there are also a number of opportunities to help ensure the sustainable use of Bark Lake and its watershed. The implementation of the recommendations of this report will capitalize on those opportunities.

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[33]*U.S. Environmental Protection Agency,* Wetlands and People, *2012;* http://water.epa.gov/type/wetlands/people.cfm.

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Chapter III

LAKE MANAGEMENT ALTERNATIVES AND RECOMMENDATIONS

INTRODUCTION

Bark Lake is a precious commodity to its shoreline residents and to the larger Bark River watershed due to its role as a headwater lake. Consequently, it is important to maintain and enhance the health of the Lake to encourage its continued enjoyment. This chapter, therefore, highlights alternatives and recommendations that seek to contribute to this cause by addressing the issues of concern in Chapter II. Accordingly, the chapter is organized by the thematic areas discussed in Chapter II, namely: aquatic invasive species, sedimentation, water quality, lake outflow and blockages, WDNR public access, water chemistry, water quantity, and wildlife enhancement. For each thematic area, management alternatives to address the issues of concern are developed and recommendations are set forth. A summary is provided of the recommendations, which combine to form an overall management plan. The plan identifies priority areas to begin targeting and assigns an overall priority level to each recommendation.

The measures discussed in this chapter are primarily focused on those which can be implemented by the Bark Lake Association, in collaboration with WDNR, the Village of Richfield, and Bark Lake residents. However, partnerships with, developers, landowners, other downstream municipalities may be necessary to ensure the achievement of long-term ecological health in Bark Lake. Therefore, the Bark Lake Association is encouraged to continuously seek out projects and partnerships which will further aid in achieving the recommendations of the plan.

Though the logistics for implementing each recommendation may not be laid out, this chapter does provide some suggestions for potential projects. It is important to know, however, that these project suggestions do not necessarily constitute recommendations. They are presented to provide the implementing entities with ideas about the types of projects they may want to pursue. In short, this chapter is meant to provide a context for understanding what needs to be done, as well as to help the reader picture what those efforts might look like.

AQUATIC INVASIVE SPECIES

As discussed in Chapter II of this plan, Bark Lake generally contains a diverse aquatic plant community capable of supporting a warmwater fishery. However, many of the native species (i.e., beneficial plants) found in the Lake were located in only one or two areas (e.g., fern pondweed, clasping pondweed, water stargrass, and others, as detailed in Appendix C). Additionally, in the 2012 survey (as described in Appendix A), Eurasian water milfoil was the only plant found in every area where aquatic plants were identified within the Lake (see Appendix C for the distributions of all aquatic plants in the Lake). This observation, coupled with reported impairment of recreational boating opportunities and other lake-oriented activities, indicates that an aquatic plant management program should be considered a priority. Consequently, the Bark Lake Association engages in aquatic plant management activities, which are presently limited to chemical applications although manual removal has occurred in the vicinities of piers and docks.

It is important to note that all lakes have plants. In fact, in Bark Lake, which has a high nutrient content (i.e., is a eutrophic lake), it is actually impossible to eliminate plant growth without causing unintended consequences such as high algal growth and fish kills. Thus, in any aquatic plant management plan, the goal is to ensure access to the Lake while increasing the abundance of native plants in general (i.e., limiting the growth of Eurasian water milfoil, which tends to take over aquatic plant communities and create a monoculture). Additionally, it is also important to note that it is unlikely that Eurasian water milfoil will be eliminated in the future. The goal, instead, is to manage the population so that it is reduced to nonnuisance levels.

This report section provides the necessary information and recommendations to manage nuisance aquatic plant growth in and around Bark Lake. Accordingly, it presents the range of alternatives that could be used, and it indicates which alternatives are recommended. The recommendations seek to monitor and control aquatic plant growth that has already occurred in the Lake. There are many other activities, however, which can contribute to *preventing* aquatic plant growth in the Lake. A brief summary of these measures is included at the end of this section, and they are discussed in detail in the sections below.

Aquatic Plant Management Alternatives

Aquatic plant management measures can be classed into four groups: 1) *physical measures*, which include lake bottom coverings and water level management; 2) *biological measures*, which include the use of various organisms, including herbivorous insects and plantings of aquatic plants; 3) *manual measures,* which involve the manual removal of plants by individuals; 4) *mechanical measures*, which include harvesting and removal of aquatic plants with a machine known as a harvester or the use of what is known as suction harvesting; and, 5) *chemical measures*, which include the use of aquatic herbicides. All of these control measures are stringently regulated and most require a State of Wisconsin permit. For example, chemical controls require a permit and are regulated under Chapter NR 107 of the *Wisconsin Administrative Code*; placement of bottom covers, a physical measure, require a WDNR permit under Chapter 30 of the *Wisconsin Statutes*; and all other aquatic plant management practices are regulated under Chapter NR 109 of the *Wisconsin Administrative Code*. Costs for these measures range from minimal, for manual removal of plants using rakes and hand-pulling, to upwards of $60,000 per year for mechanical harvesting, not including the purchase of a harvester, depending on staffing and operation policies. A lake the size of Bark Lake would cost about $7,000 to $10,000 a visit from a contract harvester; however, a lake harvesting program, like the one implemented by Pewaukee, Delavan, Okauchee, Whitewater, and Little Muskego lakes, would run about $60,000 to $120,000[1].

The aquatic plant management elements presented in this plan consider alternative management measures consistent with the provisions of Chapters NR 103, 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 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 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 the sunlight available to the plants. They are often used to create swimming beaches on muddy shores, to improve the appearance of lakefront property, and to open channels for motorboating. Various

[1]*Cost estimates provided by WDNR staff.*

materials can be used with varied success rates. For example, sand and gravel, which are usually widely available and relatively inexpensive, are often used as cover materials despite the fact that plants readily recolonize areas where they are used. Other options include synthetic materials, such as polyethylene, polypropylene, fiberglass, and nylon, which can provide relief from rooted plants for several years. These materials, known as bottom screens or barriers, generally have to be placed and removed annually, as they are susceptible to disturbance by watercraft propellers and to the build-up of gasses from decaying plant biomass trapped under the barriers. In the case of Bark Lake, the need to encourage native aquatic plant growth while simultaneously controlling the growth of exotic species, often in the same location, suggests that the placement of lake bottom covers as a method to control for aquatic plant growth does not appear to be warranted. Thus, such measures are not considered viable.

Biological Measures
Biological controls offer an alternative approach to controlling nuisance plants. Classical biological control techniques, which use herbivorous insects to control nuisance plants, have been shown to be successful.[2] However, studies on the most commonly discussed of these methods, the utilization of *Eurhychiopsis lecontei*, an aquatic weevil species, to control Eurasian water milfoil, indicate variable levels of success, with little control being achieved on those lakes having motorized boating traffic. Thus, the use of *Eurhychiopsis lecontei* as a means of aquatic plant management control is not considered a viable option for use on Bark Lake at this time.

Manual Measures
The physical removal of specific types of vegetation by manual harvesting provides a highly selective means of controlling the growth of nuisance aquatic plant species, including Eurasian water milfoil. There are two common manual removal methods—raking and hand-pulling.

The first of these methods is conducted in nearshore areas with specially designed rakes. The use of such rakes provides an opportunity to remove nonnative plants in shallow nearshore areas and also provides a safe and convenient method for controlling aquatic plants in deeper nearshore waters around piers and docks. The advantage of the rakes is that 1) they are relatively inexpensive (costing between $100 and $150 each), 2) they are easy and generate immediate results, and 3) they immediately remove the plant material from the lake without a waiting period, thereby preventing sedimentation from decomposing plant material. Should the Bark Lake Association decide to implement this method of control, it could acquire a number of these specially designed rakes for use by the riparian owners on a trial basis.

The second 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 nonnative plants in the high growth season, when native and nonnative species often coexist. This is because this method allows for higher selectivity than rakes, mechanical harvesting, and chemical treatments, and therefore results in fewer losses of native plants. Additionally, the physical removal of the plants also prevents sedimentation, which could help maintain water depths in the Lake. Given these advantages, manual removal of Eurasian water milfoil through hand-pulling is considered a viable option in Bark Lake where practical. It could be employed by volunteers or homeowners, as long as they are trained on proper identification of Eurasian water milfoil. WDNR provides a multitude of guidance materials, including an instructional video, on the manual removal of plants.

Pursuant to Chapter NR 109 of the *Wisconsin Administrative Code*, both raking and hand-pulling of aquatic plants along a 100-foot length of shoreline is allowed within a 30-foot-wide corridor without a WDNR permit, provided that the harvested plant material is removed from the lake. Any other manual harvesting would require a State

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[2]*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.*

permit, unless employed in the control of designated nonnative invasive species, such as Eurasian water milfoil. In general, all State permitting requirements for manual aquatic plant harvesting call for all harvested material to be removed from the lake being harvested.

Mechanical Measures

Aquatic plants can also be harvested mechanically with specialized equipment known as harvesters. This equipment consists of a cutting apparatus that cuts up to about five feet below the water surface and a conveyor system that picks up the cut plants. Mechanical harvesting can be a practical and efficient means of controlling sedimentation as well as plant growth, as it removes both the plant biomass, which can decompose, and the associated nutrients from a lake. Mechanical harvesting is particularly effective as a measure to control large-scale growths of aquatic plants. Narrow channels can, however, be harvested to provide navigational access and "cruising lanes" for predator fish to migrate into the macrophyte beds to feed on smaller fish.

An advantage of mechanical aquatic plant harvesting is that the harvester, when properly operated, typically leaves enough plant material in the lake to provide shelter for aquatic wildlife and to stabilize the lake bottom sediments. Aquatic plant harvesting also has been shown to facilitate the growth of native aquatic plants by allowing light penetration to the lakebed.

A disadvantage of mechanical harvesting is that the harvesting operations may cause fragmentation of plants and, thus, unintentionally facilitate the spread of Eurasian water milfoil, which utilizes fragmentation as a means of propagation. Harvesting may also disturb bottom sediments in shallow areas, thereby increasing turbidity and resulting in deleterious effects, including the smothering of fish breeding habitat and nesting sites. Disrupting the bottom sediments also could increase the risk of nonnative species recolonization, as these species tend to thrive under disturbed bottom conditions. To this end, most WDNR-issued permits do not allow harvesting in areas having a water depth of less than three feet, which would limit the utility of this alternative in some littoral areas of the Lake and especially in the inlet and outlet. Nevertheless, if done correctly and carefully, harvesting has been shown to be of benefit in ultimately reducing the regrowth of nuisance plants while increasing the prevalence of native plants, when accomplished under suitable conditions.

Given the expense associated with mechanical harvesting, as well as the fact that the aquatic plant species occur in areas along the shorelines (which are often at depths of three feet or less), this method would only be considered viable if the Bark Lake Association were to purchase or share a small-scale harvester, as shown in Figure 8, and use it only for the major areas of concern and for cutting access lanes from piers and docks. Mechanical harvesting as recommended would have the added advantage of preventing sedimentation. This measure should be considered by the Bark Lake Association as a possible alternative to current methods of aquatic plant control.

In addition to harvesting with a harvester, there is an emerging harvesting method called Diver Assisted Suction Harvesting (DASH). DASH, also known as suction harvesting, is a mechanical process where divers pick aquatic plants, by their roots at the bottom of the lake, and then insert the whole plant into a suction device which takes the plant up to the surface of the lake for disposal. The process is essentially a more efficient method for hand-pulling plants within a lake. This year (2014) is the first year this method has been widely implemented within Wisconsin. Long term evaluations will take place over time to determine the efficacy of the technique, however, intuitively there are many advantages to the method, 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 harvesting with a harvester, thereby reducing the loss of native plants, and 3) lower frequency of fish habitat disturbances. DASH is considered a viable option for the shallower areas and in areas where Eurasian water milfoil is present amongst native plants, subjected to permit requirement and provisions.

Figure 8

SMALL-SCALE HARVESTER

NOTE: This photo shows a harvester which is used on another southeastern Wisconsin lake. This picture is being used solely to show the technology. No particular brand is being advocated.

Source: SEWRPC.

Chemical Measures

Chemical treatment with herbicides is a short-term method for controlling heavy growths 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 are the 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 on fish, fish food sources, and humans—The chemicals that are 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 are also conducted to determine the long-term (chronic) effects of the chemical on animals (e.g., the effects of being exposed to these herbicides on an annual basis). However, it is often impossible to conclusively state that there will be no effects on a long-term basis, due to the constraints of animal testing, time restraints, and other issues. Additionally, long-term studies have not been completed on all of the species, including humans, at each of the Lakes.[3] This factor needs to be considered when choosing to apply chemicals in a lake. Conflicting studies/ opinions regarding the role of the chemical 2-4D as a carcinogen in humans, for example, do exist.[4] For some lake property owners, the risk of using chemicals may be considered too great, despite the legality of the measure. Consequently, the concerns of lakefront owners should be taken into consideration whenever chemicals are used.

2. A risk of increased algal blooms due to the eradication of macrophyte competitors—When nutrients exist in the Lake water, as is the case in Bark Lake, something will grow. Generally, if plants are not the primary user of the nutrients, algae (see Figure 9) has a tendency to take over. Overall, the loss of native plants and excessive use of chemicals must be avoided, particularly if fish populations are to be maintained at a healthy level.

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

[4]*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.*

Figure 9

EXAMPLES OF HIGH ALGAL CONTENT IN LAKES

Source: University of Minnesota, College of Natural Resources, 2003, and SEWRPC.

3. A potential increase in organic sediments, as well as associated anoxic conditions that can cause fish kills—When chemicals are used on 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 sediments (i.e., increased sedimentation), and can lead to a loss of oxygen in the deep areas of a lake (particularly in stratified lakes like Bark Lake). Extensive loss of oxygen can then potentially create conditions that no longer support fish, causing fish kills. This process emphasizes the need to limit chemical control to early spring, when Eurasian water milfoil has yet to form dense mats.

4. Adverse effects on desirable aquatic organisms due to loss of native species—Native plants, such as pondweeds, provide food and spawning habitat for fish and other wildlife. Consequently, if native plants are lost due to chemical application, the fish and wildlife populations often suffer.

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 the plants are not specifically removed from the lake increases the possibility for seeds to remain in the lake after treatment, thereby allowing for a resurgence of the species in the next year. Additionally, if large areas are left void of plants (both native and invasive) this leaves an area of disturbance (i.e., an area without an established plant community), which tends to be where Eurasian water milfoil thrive. In short, chemically treating large areas can sometimes leave opportunities for Eurasian water milfoil reinfestation.

As discussed in Chapter II, there also are complicating factors associated with the application of chemicals to lakes, namely the coincidence of Eurasian water milfoil with native species, the physical similarities between Northern (native) and Eurasian water milfoils, and the presence of hybrid Eurasian water milfoil. However, due to the early growth period of Eurasian water milfoil, there is an effective way to target it while minimizing the first two of these factors, namely chemical treatment in the early spring only. Early spring treatments have the advantage of being more effective due to the colder water temperatures enhancing the herbicidal effects and reducing the concentrations needed. They also reduce human exposure (swimming does not generally happen in very early spring) and limit the potential for collateral damage to native species, as most native aquatic plants species are still dormant in the early spring.

Given the historical aquatic plant management methods in Bark Lake (which were primarily through use of chemical controls), use of *early spring* chemical controls are considered a viable option for Bark Lake. Use of chemical herbicides in aquatic environments is stringently regulated and requires a WDNR permit and WDNR staff oversight during applications. Therefore, preparation for these treatments should begin as early in the year as possible. Additionally, chemical treatment should only be done in areas where Eurasian water milfoil can be found during treatment, in order to prevent loss of native species.

It is important to note that if Eurasian water milfoil beds become very dense, a whole lake treatment, which involves the distribution of a low concentration of chemicals throughout the Lake in the early spring, is an option to be considered. However, for this to be a viable option, an aquatic plant survey from the previous year must indicate that the Lake has 75 percent frequency of occurrence, along with a rake fullness density value of 2 to 3 over the majority of the sample sites (see Figure A-8 in Appendix A of this report for rake fullness schematic). If these conditions are present, the WDNR will consider granting a permit for a whole lake treatment.

Plant Management Recommendations

The most effective plans for managing nuisance aquatic plants rely on a combination of methods and techniques. Therefore, to enhance the recreational uses of Bark Lake while maintaining the quality and diversity of the biological communities, six recommendations are made:

1. **Chemical treatment of Eurasian water milfoil in the nearshore areas of the Lake in the early spring only**, as shown on Map 8. Only herbicides that somewhat selectively control Eurasian water milfoil, such as 2,4-D and endothall,[5] should be used and extra precautions should be taken to prevent the loss of native aquatic species. A WDNR permit, as well as WDNR staff supervision, is required to implement this alternative. Additionally, lakeshore property owners need to be informed of the permit prior to application. Map 8 was developed using the Eurasian water milfoil distribution found in Bark Lake during the 2012 aquatic plant survey; however, changes in communities are possible from year to year. Consequently, the abundance of Eurasian water milfoil in the Lake, along with its coincidence with native plant species, will need to be re-evaluated on an annual basis if this recommendation is implemented.

2. **Manual removal, i.e., hand-pulling and raking, in those areas which require further maintenance after the chemical treatments are completed** as described above (i.e., in the early spring). These efforts should seek to reduce nuisance invasive plants that impede navigation as well as to control Eurasian water milfoil along the shoreline. To this end, the Bark Lake Association should consider educating Lake residents on Eurasian water milfoil identification and hand-pulling and should consider purchasing specially designed rakes for use by the riparian owners on a trial basis. A permit is not required for these activities within a 30-foot distance of a segment of shoreline that does not exceed a 100-foot width, as long as all the resulting plant materials are removed from the Lake. A permit is also not required if the hand-pulling targets Eurasian water milfoil only. It is also recommended that residents be educated on the need to prevent extensive loss of native plants and general plant identification prior to the implementation of this campaign. This will ensure that this measure does not harm (or adversely affect) local wildlife and plant communities.

3. **Consideration of harvesting Eurasian water milfoil in areas where sedimentation is considered an issue of concern**, as well as in areas where access to the Lake is inhibited, as shown in Map 8. This would require the purchase of a small harvester as discussed above. If this recommendation is implemented, harvesting activities will need to avoid fish spawning periods (i.e., early spring), be

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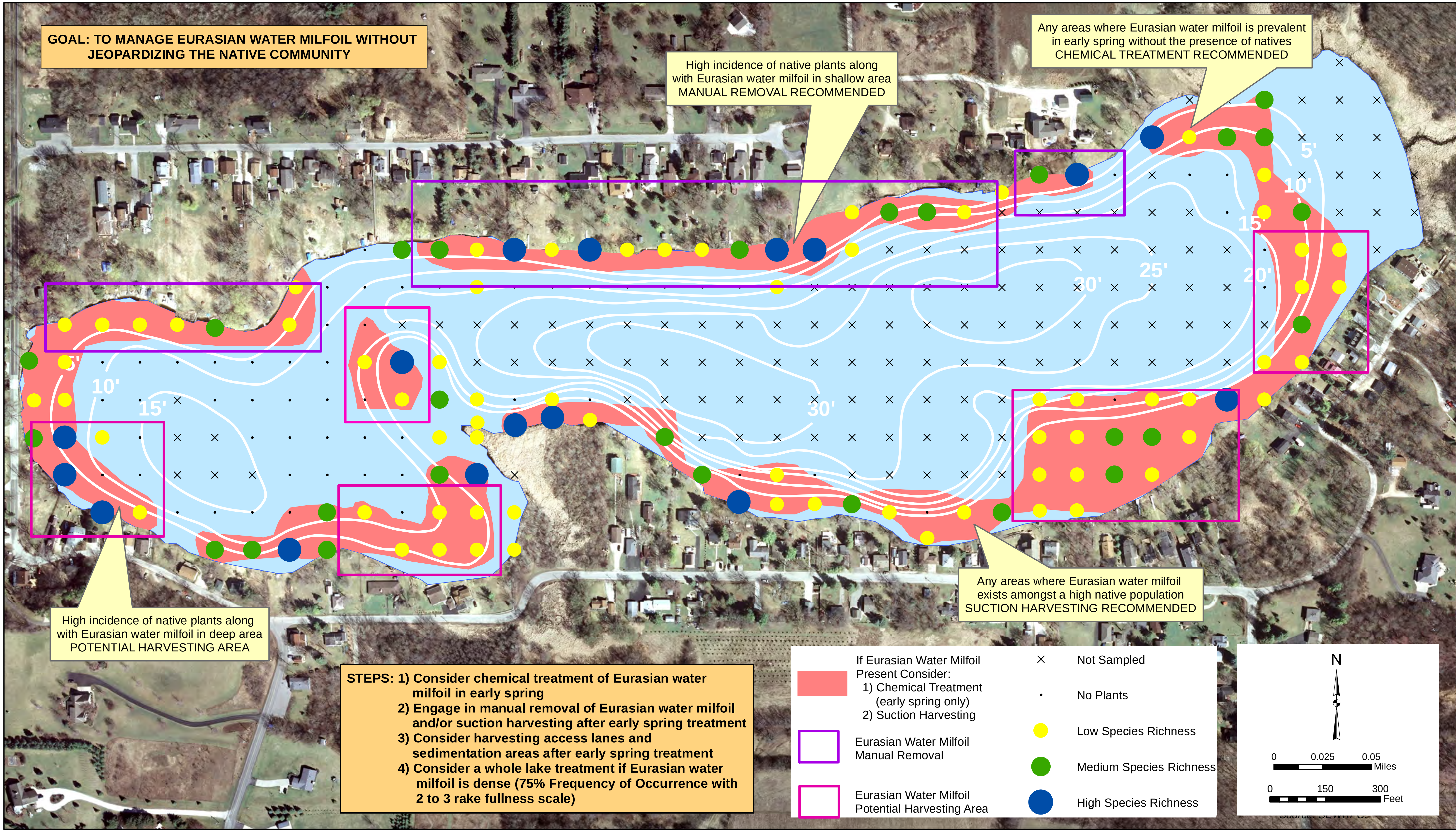
[5]*Wisconsin Department of Natural Resources PUBL-WR-236 90,* Chemical Fact Sheet: 2,4-D, *May 1990; Wisconsin Department of Natural Resources PUBL-WR-237 90*, Chemical Fact Sheet: Endothall, *May 1990.*

Map 8

RECOMMENDED AQUATIC PLANT MANAGEMENT PLAN FOR BARK LAKE



limited to areas greater than three feet deep, use "top cutting" wherever possible,[6] maintain a minimum of one foot of rooted plant material on the bottom of the Lake, be used to maintain 50-foot access lanes and 10-foot navigation lanes, include activities that remove cut plant material from the Lake after cutting activities, and be permitted by the WDNR through a five-year permit.

4. **Consideration of suction harvesting (DASH), upon consultation with WDNR, for controlling nuisance growths of invasive species in areas where mechanical harvesting is not viable**; in areas shallower than three feet and in areas with high native plant populations: around the shorelines, the inlet and the outlet (see Map 8). Due to the change in plant communities year-to-year the abundance of Eurasian water milfoil will need to be re-evaluated annually to determine if this recommendation is viable. In general, suction harvesting can be used for both sparse and large mats of Eurasian water milfoil; however, large mats may become very costly to harvest using this method. Consequently, if dense mats occur, it may be more viable to use chemical controls, as discussed above.

5. **Consideration of whole lake chemical treatment for controlling excessive growth of invasive species.** If the Eurasian water milfoil beds become large and dense, an aquatic plant survey should be done to confirm the frequency of occurrence, along with the density of rake fullness (as discussed above). If these values meet WDNR requirements, a permit will be considered for whole lake treatment.

6. **Reevaluation of this aquatic plant management plan in five years**, including conducting a comprehensive aquatic plant survey. This will help the Bark Lake Association evaluate the effectiveness of the aquatic plant management plan and make appropriate changes to the plan.

As mentioned previously, Map 8 is an aquatic plant management plan map provided to help future aquatic plant managers implement the plan recommendations. However, aquatic plant management must be conducted based on what is occurring at the time of treatment. Consequently, though this recommendation map may indicate a large Eurasian water milfoil treatment area, this whole area may not need to be treated on a year-to-year basis (as was evident by the reduced amount of Eurasian water milfoil in 2013). All efforts to manage the Lake should therefore be completed on a case-by-case basis, with an emphasis on maintaining native plants. Pictures and distribution maps of all the aquatic plants, including the five most abundant, as well as guidance on their identification, is provided in Appendix C.

Other Recommendations

As previously discussed, aquatic plant growth is natural in healthy lakes and provides a host of benefits to a lake. However, a number of conditions can cause excessive plant growth, leading to the onset of aquatic plants at nuisance levels. Accordingly, efforts to improve these nuisance conditions—which often go hand-in-hand with improving the overall quality of the lake and its watershed—can also reduce the amount of plant growth in general. The improvement of water quality, for example, leads to a lake with lower amounts of nutrients, which limits the amount of plants that have the ability to grow.[7] In fact, most of the other recommendations made within this chapter have the added benefit of helping control aquatic plants, as shown in Table 3 Consequently, implementation of the recommendations highlighted below should also be considered a priority.

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[6]*Top cutting refers to cutting only a foot or two below the surface of the Lake to allow native plants to maintain their biomass and, therefore, still support a healthy fishery. This is in contrast to "deep cutting," which cuts all but one foot of plant material.*

[7]*Aquatic plant growth is limited by the amount of nutrients (specifically phosphorus) present in a lake. Lakes are often classified as "biologically rich" based on the concentrations of nutrients they contain. See the Trophic Status and Nutrients sections in Appendix A for further details.*

Table 3

WATERSHED MANAGEMENT EFFORTS AND ASSOCIATED BENEFITS TO AQUATIC PLANT COMMUNITIES

Measure	Goal	Benefit
Nutrient Management	Prevents phosphorous from entering the Lake	Lower amount of nutrients available to support aquatic plant and algal growth
Sediment Reduction	Prevents loss of water depth	Will prevent growth of plants further into the Lake (as plants grow in shallow areas of lakes)
Invasive Species Prevention	To prevent plants like curly-leaf pondweed from entering the Lake	Prevents the introduction of another species which could overtake the aquatic plant community
	To prevent zebra mussels from entering the Lake	Zebra mussels increase water clarity by filtering sediments out of the water column, thereby allowing light to penetrate farther into the lake and increasing plant growth. Preventing this situation, therefore, prevent future aquatic plant growth issues
Buffer Development and Wetland Enhancement	To increase filtration of pollutants and sediments	See benefits associated with Nutrient Management and Sediment Reduction

Source: SEWRPC.

SEDIMENTATION

As discussed in Chapter II of this report, sedimentation was considered an issue of concern in the area surrounding the sandbar located on the southern shore of the Lake. Mitigation efforts meant to deal with sedimentation may be categorized into two types of projects: 1) those that deal with the source of the issue; and 2) those that deal with the symptom. The first of these categories are management efforts which seek to reduce sediment loadings at their source, thereby reducing the amount of sediments entering the Lake. These kinds of projects are ideal, long-term solutions which are often cost effective. The second category generally involves in-lake or in-stream solutions, which either attempt to remove the already deposited sediments or seek to cover them up. These kinds of projects are almost always temporary solutions that require permanent maintenance, due to the fact that the problem almost always persists.

In general, management of sedimentation should seek to reduce sediment loads at the source whenever possible, and then use in-lake solutions only when the symptoms of sedimentation, e.g., loss of water depth or mucky soils, become unmanageable or a danger to the Lake's health or use. This strategy generally prevents the need for constant maintenance of the symptoms of sedimentation. Therefore, this section highlights the types of projects, from both of these categories, which could be implemented to address sedimentation in Bark Lake.

Sediment and Pollution Reduction

As mentioned in the Sedimentation section of Chapter II, there are two major sources of sedimentation: 1) sediments that form on the bottom of the Lake due to excessive plant death; and 2) sediments that enter the Lake from the surrounding watershed through sources of erosion. Reducing each of these at the source of the problem requires different management alternatives, as discussed below.

Plant-Based Sedimentation

Plant-based sedimentation is the result of excessive plant growth and the subsequent biomass accumulation. Though this process could potentially have multiple causes, high phosphorus loads are the most likely cause of this process in Bark Lake, given the phosphorus concentration most recently recorded.[8] Consequently, the imple-

[8]*The last phosphorus recording in 1997, indicated a value above the State's recommended levels of 0.4mg/l.*

mentation of the recommendations included in the Water Quality section of this chapter, which seek to reduce phosphorus loads, would be an effective way to prevent excessive plant growth, and in turn, prevent the growth of the plants that result in this kind of plant growth. Additionally, due to its likely contribution of sediments[9] to Bark Lake, chemical treatment of Eurasian water milfoil early in the growth season (when its biomass has not yet accumulated) and removal of plants (through harvesting, DASH, and manual methods), if growth occurs, are recommended.

Runoff-Based Sedimentation

The second major source of sedimentation is sediments that enter the Lake from erosion and runoff within the watershed. In Bark Lake, given the presence of the upstream wetland (which likely plays a role in preventing sediments from entering the Lake), the most likely sources of sediments are:

- Along the shorelines where shoreline protections such as buffers or riprap[10] do not exist, thereby allowing wave action (often caused by boaters) to erode the shorelines, causing sediment to be directly deposited into the Lake. A survey was conducted to locate these areas around the Lake. The results of the survey are set forth on Map 7 in Chapter II of this report.

- From the properties adjacent to the Lake, particularly on steep slopes which are at high risk for erosion.

In terms of preventing shoreline erosion, it is possible to place a man-made "hard" structure to protect the shoreline. However, natural vegetative buffers (see Figure 10), provide the most ideal solution because they also mitigate pollution by filtering pollutants from runoff which enters the Lake from the adjacent property, reducing erosion caused by runoff (rather than wave action), and providing natural habitat for fish and wildlife. In general, riparian buffers can be valuable in providing wildlife enhancement, pollution reduction, and erosion control. Consequently, outreach efforts and potential financial incentives to encourage natural buffer installation on Bark Lake shorelines are recommended.

In addition to the shoreline areas, it is also recommended that natural vegetation, which often has deep roots that can hold soils in place and act as a buffer, be planted on any steep land area within the properties adjacent to Bark Lake. This will help prevent erosion from occurring and the associated sediments from draining into the Lake. This recommendation will play a large role in preventing the process of sedimentation overall.

Finally, as mentioned in Chapter II of this report, development of properties adjacent to the Lake is planned under year 2035 conditions. The Village of Richfield should stringently enforce the construction erosion control requirements under Village ordinances. [11]

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[9]*Eurasian water milfoil often grows quickly and heavily above the water line, causing dense mats on the surface. When these mats die, they decompose and contribute sediment. While native plants also die and decompose, they generally only grow to the surface of the water and do not cause as large a biomass as Eurasian water milfoil.*

[10]*A description of the different kinds of shoreline protection is included in Appendix A in the Shoreline Protection and Erosion Control section.*

[11]*Erosion control and stormwater plans must be developed and completed before a landowner files for a construction permit (i.e., at least 14 working days before construction begins). Because every site is unique, erosion control and stormwater management plans must be customized to site-specific conditions. The plans must meet the construction and post-construction performance standards and the format identified in Chapter NR 216 of the* Wisconsin Administrative Code, *and local municipal ordinances and regulations.*

Figure 10

EXAMPLE OF A SHORELINE BUFFER IN WISCONSIN

Source: Washington County Planning and Parks Department.

In-Lake Sediment Reduction

As mentioned above, in-lake sedimentation projects address sediments that have been deposited into the Lake. These solutions should be used as temporary fixes to buy time until watershed management measures to reduce sediment can be implemented. In Bark Lake, the only relevant alternative would be to dredge the areas of concern (specifically, the mucky sediments located around the sandbar area on the southern shore). As was discussed in Chapter II, this may be a viable option, subject to WDNR permitting requirements, if a dredging feasibility study is completed. Consequently, further investigation of this option, beginning with an initial consultation with WDNR staff, is recommended. It is important to note, however, that the sandbar itself cannot be dredged due to it being made of parent materials[12] (as was determined by a WDNR staff investigation). This is because a dredging permit requires sediments to be mucky.

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[12]*Parent materials refer to sand and gravel, which cannot be removed due to their value in terms of fishing habitat.*

Overall Sediment Recommendations

To ensure that the sedimentation issue is addressed on a long-term and sustainable basis, the following recommendations are made, as highlighted on Map 9:

1. **Reduction of phosphorus loadings** through the implementation of the recommendations included in the Water Quality section of this chapter.

2. **Implementation of in-lake sedimentation reduction measures**. These efforts should include:

    a. **Implementation of harvesting or manual removal measures**, as described in the Aquatic Invasive Species section of this chapter, for the purpose of preventing plant-based sedimentation.

    b. **Rehabilitation of the shorelines that are unprotected** (see Map 7 in Chapter II of this report) **or exhibit signs of erosion around the Lake**. To this end, educational outreach efforts and partnerships with riparian landowners should be established for the purpose of creating natural vegetative buffers along the shoreline. This could potentially include financial incentives.

3. **Implementation of sediment wash-off reduction measures within the watershed**. These efforts should include identifying and monitoring of sources of erosion within the watershed with a particular emphasis on sediments entering the Lake. This study should then be followed with efforts to reduce sediments through vegetation establishment or best management practices.

4. **Establish educational outreach and partnerships with developers and stringently enforce construction erosion control requirements to ensure the implementation of legally mandated best management practices during construction.**

5. **Consider dredging of the soft sediments surrounding the sandbar**. This consideration should be initiated through a consultation with WDNR staff and the completion of a dredging feasibility study.

Implementation of the recommendations related to sedimentation will require more detailed, second-level planning and should be considered a priority for the continued maintenance and improvement of Bark Lake. Additionally, it is necessary to monitor the success of projects over time and to assess overall progress. Therefore, it is also recommended that sediment depths be monitored every five years. Additionally, Lake levels should be systematically monitored on a more frequent basis, as described below. This will allow for the creation of a record over time that can be evaluated to determine sedimentation rates and document any future changes.

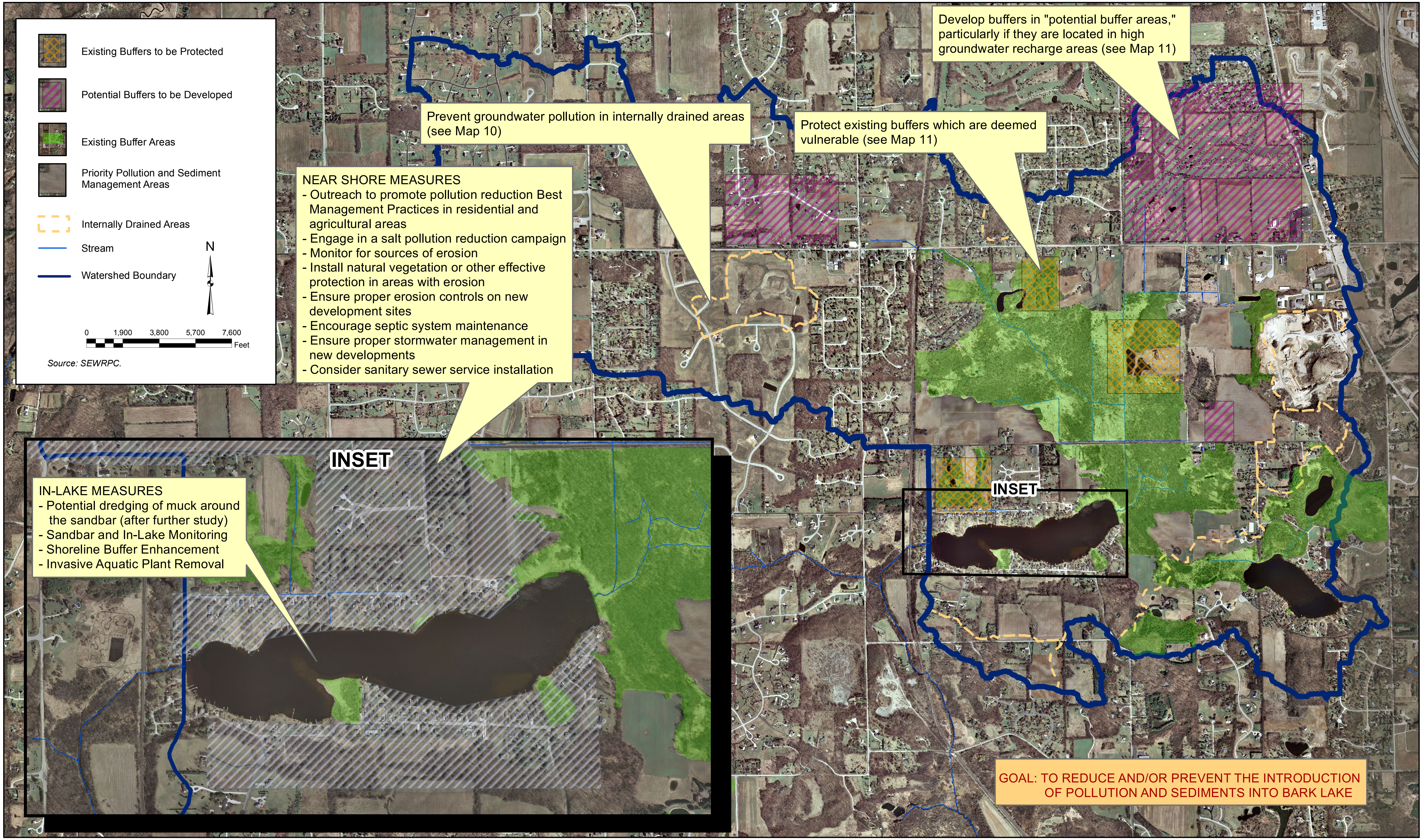
WATER QUALITY

As described in Chapter II and highlighted in Appendix A, limited water quality data is available for Bark Lake. The few data that exist indicate that Bark Lake is a nutrient-rich (i.e., eutrophic) lake. Additionally, many lake residents have concerns about sources of pollution in the watershed as well as the volume of aquatic plant growth, which generally is driven by nutrient pollution. Consequently, recommendations related to the reduction of pollution loads to the Lake are included below.

As with sedimentation, mitigation efforts to improve the water quality of a lake may be categorized into two types of projects: 1) those that address the source of the issue; and 2) those that address the symptoms. The first of these categories are management efforts that seek to reduce or filter pollution at their source, thereby reducing the amount of pollutants entering the lake. These kinds of projects are ideal, cost-effective, long-term solutions to address water quality issues. The second category generally involves in-lake projects that either attempt to remove the already deposited pollutants or seek to deactivate them (e.g., alum treatments or aeration). These types of projects are often attractive because they are easy to understand and can be implemented within the Lake. However, they are almost always temporary solutions that require permanent maintenance. This is because the source of the problem is not addressed and it almost always persists.

Map 9

RECOMMENDED PLAN FOR POLLUTION AND SEDIMENT REDUCTION



In general, management efforts seeking to improve water quality should attempt to reduce pollutant loads at the source, where possible. In-lake solutions should only be used when the symptoms of pollution, e.g., excessive plant growth, annual fish kills, or toxic algae growth become unmanageable. This strategy will hopefully prevent the need for constant maintenance of the symptoms of pollution. In general, Bark Lake has not reported water quality issues that warrant implementation of in-lake water quality management measures. Consequently, such measures are not recommended, and recommendations are made that seek to reduce or filter pollution at its source. However, if further monitoring reveals events like excessive algal blooms or fish kills, this recommendation may need to be revisited.

Pollution Reduction Measures

As discussed in Chapter II of this report, water quality data does not allow for a conclusive answer to where the pollution source is located in a watershed. However, there are six potential pollutant sources in the watershed:

1. The Kettle Hills golf course located in the Northeast corner of the Bark Lake watershed as a source of nutrients and pesticides (as well as a potential source of invasive species);

2. The northwestern area of the watershed, containing both agricultural and residential pollution sources (nutrients, chemicals, sediments, and heavy metals);

3. The internally drained areas that have potential to pollute the groundwater supplied to Bark Lake (the quarry in the eastern portion of the watershed and the deep internally drained area located northwest of the Lake);

4. Future development anticipated by 2035, particularly in the areas from which runoff directly enters the Lake without filtering through a wetland or buffer;

5. Septic system users throughout the watershed; with an emphasis on those in the high and very high groundwater recharge areas as well as those nearest the Lake; and

6. The shoreline properties, as well as the adjacent properties, which are sources of urban and agricultural pollution (nutrients, heavy metals, sediments, and chemicals) with runoff that is not currently filtered through an efficient pollution reduction area like a wetland or a buffer.

In general—though ideally all of these pollution sources should be addressed—the top priorities are those areas which produce runoff that does not get filtered by wetlands. Therefore, shoreline properties and adjacent lands, the internally drained areas, and the septic system users adjacent to the Lake should be considered top priorities for any management efforts. However, if opportunities to target the other areas of concern were to arise, these should be capitalized on (particularly if water quality in Bark Lake declines).

Projects to reduce pollution at its source can either focus on preventing the pollution from occurring or installing systems that naturally filter the pollutants near their sources prior to their entering the Lake. The first of these options would focus on reducing stormwater runoff pollution and groundwater pollution attributable to agricultural, residential, and recreational land uses within the watershed. The second of these would focus on maintaining and installing natural buffer systems, which includes protecting currently established wetlands, uplands and environmental corridors, for the purpose of encouraging natural filtration of pollutants prior to their entering surface water resources.

Ideally, a combination of each of these management alternatives will provide the highest likelihood of success. However, all efforts that seek to reduce pollutant loads from the watershed are likely to contribute to solving the water quality issues in Bark Lake.

Figure 11

ILLUSTRATIONS OF THE DYNAMICS OF COMPONENTS OF NATURAL, AGRICULTURAL, AND URBAN STREAM ECOSYSTEMS

NATURAL STREAM ECOSYSTEM

AGRICULTURAL STREAM ECOSYSTEM

URBAN STREAM ECOSYSTEM

*Source: Illustrations 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.,* http://pubs.usgs.gov/circ/1391/, *2013, and SEWRPC.*

Urban Runoff Reduction

Urban runoff, which is illustrated in Figure 11 and shown in Figure 12, is water which flows over urban land, picking up pollutants such as oils, metals, bacteria, phosphorus, and chlorides along the way. This water then enters the Lake either directly, in the case of residential runoff which occurs on riparian properties, or indirectly through the tributaries to the Lake.

In Bark Lake, there are two areas of concern with regard to residential property. The first includes the residential areas located in the northwest region of the Lake watershed and the second is the residential pollution that directly enters the Lake from riparian properties and areas adjacent to those properties (as described in Chapter II of this report). However, as discussed above, the pollution coming from the northwest area does drain through a wetland prior to entering the Lake, while the adjacent properties do not. Consequently, pollution reduction efforts should begin by targeting riparian landowners, and then should expand to the rest of the residential areas throughout the watershed once the program is established.

The primary method of reducing pollution from residential sources involves the promotion of good urban land management and housekeeping practices. Some examples of these types of practices include: 1) fertilizer and pesticide use management efforts, preventing phosphorus and chemical pollution; 2) litter and pet waste controls, which reduces bacterial contamination and phosphorus pollution; 3) eliminating improper disposal of engine oils as well as oil accumulation on driveways; and 4) management of leaf litter and yard waste, preventing phosphorus and sediment pollution.

In addition to best management practices that reduce bacteria, phosphorus, sediment, and chemical pollution, efforts to reduce chloride (i.e., salt) contamination should also be considered. Pollution of surface water by chlorides is generally the result of anti-icing and deicing efforts on roads and driveways, Pollution of groundwater, which can lead to surface water pollution through the groundwater baseflow component, can be caused by water softener discharges from septic systems. Practices that could potentially reduce these pollutants include: 1) an evaluation of existing road deicing and anti-icing programs with an

Figure 12

EXAMPLES OF URBAN RUNOFF POLLUTANTS

OIL AND GREASE SEDIMENT

Source: Wisconsin Department of Natural Resources.

emphasis on salt reduction;[13] 2) the establishment of new road deicing and anti-icing practices around the Lake, such as the use of salt brines or sand-salt mixtures; and 3) the use of alternative technologies for softening potable water, such as reverse osmosis filters.

Management of post-construction runoff from new urban development is governed by the standards established under Chapter NR 151, "Runoff Management," of the *Wisconsin Administrative Code*.

Agricultural Runoff Reduction

When large areas of agricultural land are present in a watershed, those areas are generally major sources of phosphorus and sediment loadings to a lake.[14] Additionally, land spreading of manure on fields can be a source of phosphorus and bacteria.[15] Consequently, actions to reduce these loadings would likely have a positive impact on the water quality of Bark Lake.

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[13]*Chloride application could be reduced through implementing practices such as applying salt only at intersections, mixing salt with sand, and calibrating spreaders, and also through substitution of less environmentally damaging substances.*

[14]*Pollutant loadings can be significantly reduced through implementation of conservation practices on agricultural land. Further details about phosphorus and sediment loadings are provided in Appendix A in the Pollutant Loadings section.*

[15]*The effects of manure spreading on pollution of surface waters can be reduced through providing adequate manure storage so that spreading operations can be targeted to times when the ground is not frozen and when heavy rains are not anticipated.*

In Bark Lake, there are two areas of concern with regard to agricultural land use. The first involves the agricultural areas located in the area northwest region of the Lake's watershed and the second is the agricultural areas located just north and south of the Lake that drain directly to the Lake (as discussed in Chapter II of this report). As mentioned previously, the pollution coming from the northwest area does drain through a wetland prior to entering the Lake, while the adjacent properties do not. Consequently, pollution reduction efforts targeting agriculture should begin by targeting riparian landowners, and then should expand to the rest of the agricultural areas throughout the watershed once the program is established.

Measures to reduce agricultural runoff are often limited to voluntary or incentive-based programs and partnerships. These measures generally seek to encourage and influence agricultural landowners to: 1) implement best management practices, such as reduced fertilizer and pesticide use, no tillage farming, and good manure management and 2) install pollution reduction measures such as buffers and grassed waterways, as shown in Figure 13. In general, if these outreach and partnership-based measures are implemented, they should focus on appealing to farmers in terms of productivity and profits wherever possible. Agricultural producers can obtain funding through U.S. Department of Agriculture cost-share programs such as the Conservation Reserve Program (CRP), the Conservation Reserve Enhancement Program (CREP), and the Environmental Quality Improvement Program (EQIP).

As with urban runoff, management of agricultural runoff should at a minimum be designed to meet the agricultural standards established under Chapter NR 151, "Runoff Management," of the *Wisconsin Administrative Code*.

Recreational Pollution Reduction

The quality of runoff from recreational land uses is related to the land management techniques in recreational areas, such as parks and golf courses. These areas can sometimes be the source of nutrient pollution through fertilizers, invasive species through landscaping practices, and chemicals through pesticide application. In the Bark Lake watershed, the recreational area of concern is the golf course located in the northeastern part of the watershed (as discussed in Chapter II). Although runoff from this golf course does flow through a wetland, it may still be worthwhile to engage in a partnership with the golf course to ensure that stormwater runoff pollution is managed by implementing practices that reduce sources of such pollution (particularly given the concern that residents had about its effects). In general, implementation of best management practices such as limited pesticide and fertilizer use is the best way to prevent pollution from golf courses, while still allowing for recreational use to continue. Therefore, encouragement of this policy through a partnership or a certification[16] is recommended.

Groundwater Pollution Reduction

Though surface water runoff is the easiest to explain and manage in terms of pollution reduction measures, it is also important to note that groundwater pollution can affect the quality of the Lake's baseflow, i.e., water that supplies the Lake year-round through groundwater. Though infiltration into soils does provide some level of natural pollution filtration, high groundwater recharge potential areas[17] are still vulnerable to pollution. Consequently, identification of areas of high or very high groundwater recharge potential should be used to target areas where actions should be taken to reduce groundwater pollution.

In the Bark Lake watershed there are several areas of concern with relation to groundwater pollution, as shown on Map 10, including: 1) the high and very high groundwater recharge areas located adjacent to the Lake, 2) the internally drained areas from which groundwater flows towards the Lake (i.e., the areas located in the north

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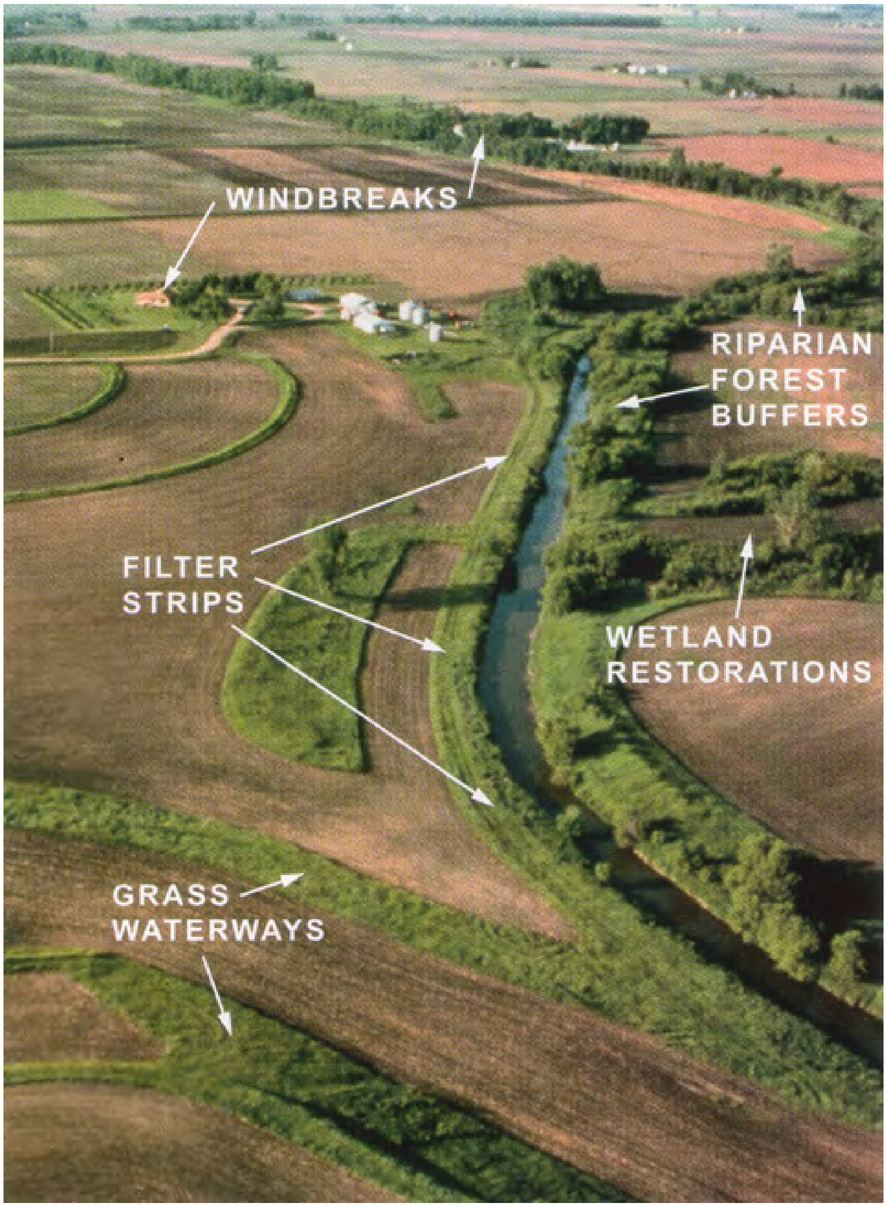
[16]*One such certification is the "Audubon International Certification Program" run by the United States Golf Association (USGA); however, other programs also exist.*

[17]*High groundwater recharge potential areas are further discussed in Appendix A in the Groundwater Recharge subsection.*

Figure 13

EXAMPLES OF RIPARIAN BUFFER AND AGRICULTURAL BEST MANAGEMENT PRACTICES



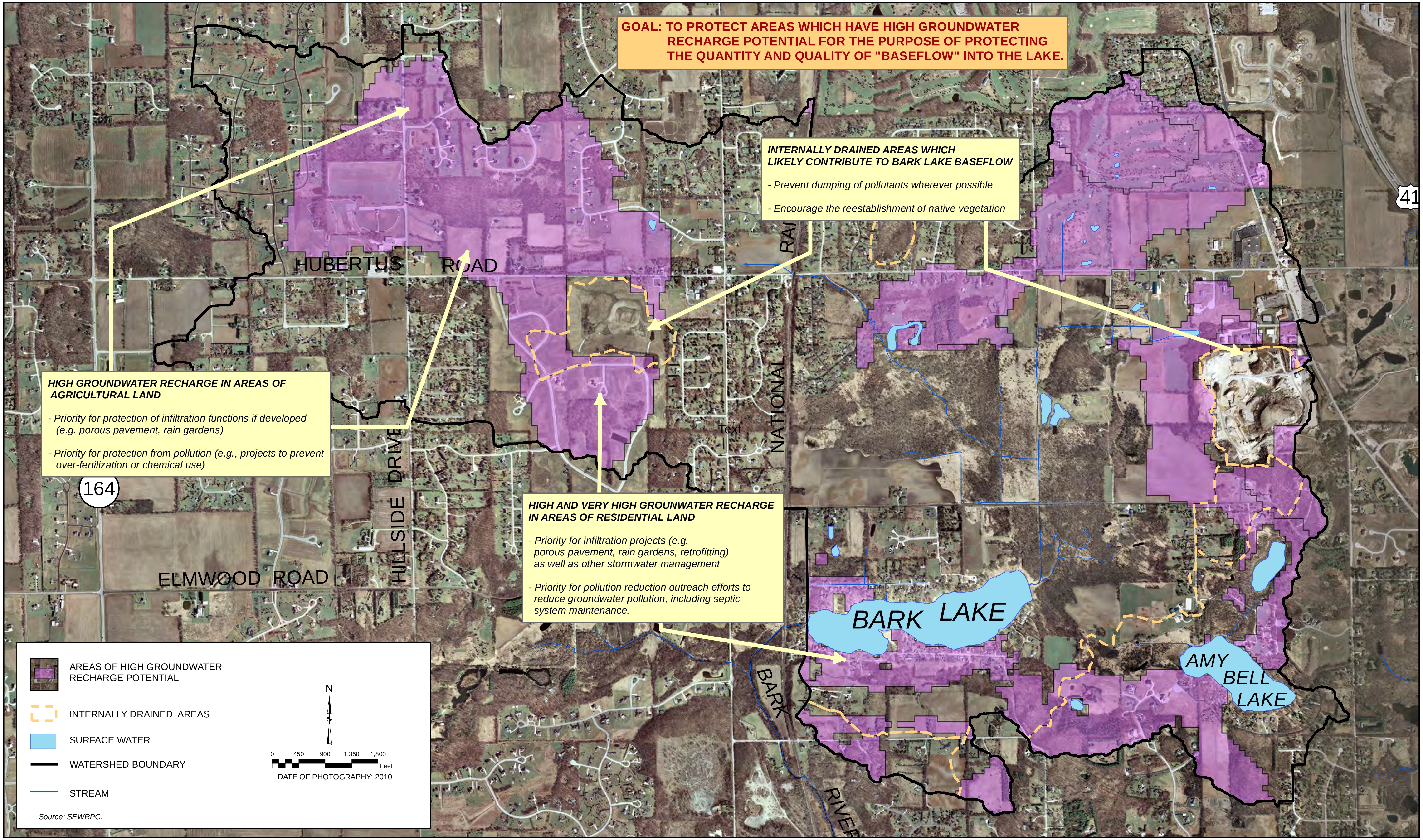
Source: U.S. Department of Agriculture, Natural Resource Conservation Service.

central part of the watershed and the extractive area, or quarry, located in the northeastern portion of the watershed) which contribute solely to groundwater, i.e., they have no surface water connections; and 3) the high and very high groundwater recharge area located in the northwest part of the watershed, which contains both agricultural and residential land use.

Groundwater pollution reduction measures generally focus on three areas: 1) the use of best management practices in the urban and agricultural areas throughout the watershed, 2) septic system maintenance (when applicable), and 3) preventing dumping or direct inflow of pollution into groundwater recharge areas. All of these measures are discussed below.

Map 10

RECOMMENDED PLAN FOR PROMOTING GROUNDWATER RECHARGE AND ABATING GROUNDWATER POLLUTION



Best Management Practices
Within the Bark Lake watershed, the specific areas of concern within the high and very high groundwater recharge areas are agricultural lands and residential areas. These areas produce runoff which could infiltrate the groundwater, as illustrated in Figure 14. Consequently, in order to reduce groundwater pollution, outreach and partnership efforts that increase the implementation of best management practices in urban and agricultural areas, similar to those described in the urban and agricultural runoff sections above, should be considered a priority. These efforts should target agricultural and residential areas located within high and very groundwater recharge potential zones adjacent to the Lake and in the northwestern area of the watershed. In addition, these efforts should target homeowners and developers in new residential developments within high and very high groundwater recharge potential areas in the watershed (as shown on Map 6 in Chapter II of this report).

Septic System Maintenance
In addition to urban and agricultural sources of pollution, groundwater pollution could also occur from mismanagement of septic systems. Generally, when these systems are not properly maintained, the resulting untreated or partially treated leaks and overflows, which contain phosphorus and bacteria, can reach the groundwater and contaminate the baseflow to the Lake, as is also illustrated in Figure 14.[18]

Given that urban development in the Bark Lake watershed is currently served by septic systems only, septic system maintenance within the watershed should be considered a priority. Such maintenance is regulated by Washington County.[19] Outreach to educate septic system owners on the maintenance of their systems could potentially have a positive impact on the Lake with minimal effort. This effort, for example, could include a program where septic users sign up to be automatically reminded of when they should maintain their septic tanks. Washington County provides information on the operation and maintenance of "Private Onsite Wastewater Treatment Systems" (i.e., septic systems) on its website and an educational poster.[20] This guidance states that septic systems should be pumped at recommended intervals of two years for mound systems and three years for all other systems.

In the Bark Lake watershed, septic system maintenance is particularly important in the locations adjacent to the Lake, which are high and very high groundwater recharge potential areas (as shown on Map 10). Consequently, outreach efforts should seek to target these areas first, and then continue on throughout the watershed, once the program has been established.

Finally, if phosphorus concentrations are detected as very high after monitoring occurs (as discussed in the Lake Monitoring Data section), it may also be necessary to consider the installation of sanitary sewer service installation. However, this recommendation will need to be reevaluated once data is available.

Dumping Prevention
Dumping garbage or other pollutants into internally drained areas may contribute to pollution of the groundwater. Extractive areas are generally internally drained. They usually pump groundwater, and, therefore, do not contribute to recharge; however, these areas may pose a groundwater pollution risk once extraction has ceased. Consequently, dumping of potentially polluting material, if found to occur now or in the future, should be prevented.

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[18]*S.R. Carpenter, N.F. Caraco, D.L. Correll, R.W. Howarth, A.N. Sharpley, and V.H. Smith, "Nonpoint Pollution of Surface Waters with Phosphorus and Nitrogen,* Ecological Applications,*" 1998, pg. 559-568.*

[19]*Chapter SPS 383, "Private Onsite Wastewater Treatment Systems," of the* Wisconsin Administrative Code *sets forth regulations related to administration and enforcement, design and installation, management, and monitoring of septic systems.*

[20]http://www.co.washington.wi.us/uploads/docs/powtsposter.pdf.

Figure 14

SCHEMATIC OF GROUNDWATER POLLUTION SOURCES

Source: Hongqi Wang, Shuyuan Liu and Shasha Du. "The Investigation and Assessment on Groundwater Organic Pollution, Organic Pollutants," 2013.

In-Lake Best Management Practices

In addition to the watershed management projects discussed above, there are also best management practices that can be implemented by lake users and managers to prevent water quality issues such as low water clarity and phosphorus accumulation. The first of these relate to motor boating activities in shallow regions. This practice disturbs the sediments in these areas, thereby causing murky waters or low water clarity. This process also leaves the disturbed area vulnerable to invasion of nonnative species, such as Eurasian water milfoil, and it releases phosphorus into the water column, potentially causing algal or plant growth. Consequently, encouraging lake users to avoid such practices could quickly reduce some of the water quality problems in Bark Lake.

Another in-lake measure is the physical removal of phosphorus from the Lake, through aquatic plant harvesting or manual removal. Since aquatic plants use and hold phosphorus during their lifecycle and release that phosphorus into the Lake when they die, this approach removes the phosphorus from the water column through the removal of biomass. Accordingly, implementation of the manual removal and/or harvesting recommendations provided in the Aquatic Invasive Species section of this chapter is recommended.

Riparian Buffers

Natural systems, specifically riparian buffers (see Figure 10), i.e., linear natural vegetation features located along streams and pond and lake shorelines, can be effective in reducing pollution that would otherwise be deposited into a lake or its tributaries, either through surface water runoff or groundwater. Properly located and designed buffer systems distribute runoff; slow water down; and remove pollutants through filtering, infiltration and treatment in the soil column, and uptake by the vegetation that comprises the buffer.

Based upon the summary of the best available science, the preservation and development of buffers, which often include wetland and upland areas, can play a key role in reducing pollution and also in reducing soil erosion, while enhancing wildlife and recreational opportunities. Consequently, the protection of existing buffers, as well as the establishment of new buffers, will help address many of the issues of concern identified in Chapter II of this report.

Factors Affecting Buffer Effectiveness

Buffer width and buffer continuity affect the ability of buffers to filter pollutants. Both are discussed below.

Buffer Width

The ability of buffers to reduce pollution and provide habitat is directly related to their size. As illustrated in Figure 15, effective buffer widths vary with the intended function of the buffer. Based on a compilation of information from numerous sources in the technical literature, a 75-foot-wide buffer, measured from the shoreline, can remove from 70 to 75 percent of total suspended solids, total phosphorus, and total nitrogen from runoff passing through the buffer.[21] A 75-foot-wide buffer can also provide bank stabilization and some in-stream and terrestrial habitat benefits. In general, greater buffer widths of 100 feet or more are needed to protect the quality and health of the aquatic food web. The protection of a 400-foot minimum and 900-foot optimum riparian buffer width provides significant terrestrial and aquatic habitat for wildlife populations.

Even buffers of much shorter widths, such as five feet along lake shorelines, can provide some reduction in shoreline erosion and pollution from runoff, and can provide limited habitat for both aquatic and terrestrial organisms. Consequently, future efforts to reduce pollution loads to the Lake should seek to protect and establish buffers along the shoreline and within the watershed. Further details on buffers are provided in Appendix D.

Buffer Continuity

The continuity and interconnectedness of buffers is an important factor in their effectiveness. In general, when buffers are continuous, i.e., have no gaps along the shoreline, runoff moves through them as opposed to going around them, thereby increasing their ability to trap sediments and remove pollutants. Additionally, fragmentation of riparian buffers, even by roads, combined with encroachment by development, impacts the buffers' ability to provide adequate wildlife habitat. Therefore, it is important to reduce the fragmentation of the existing riparian buffers by 1) establishing connections through planting natural vegetation, i.e., green pathways through lawns and fields between natural areas and 2) limiting new road crossings where feasible, as well as eliminating unnecessary ones, where practical. It is recognized, however, that police, fire protection, and emergency medical service access is an overriding consideration that must be applied in determining whether the objective of removing a crossing is feasible.

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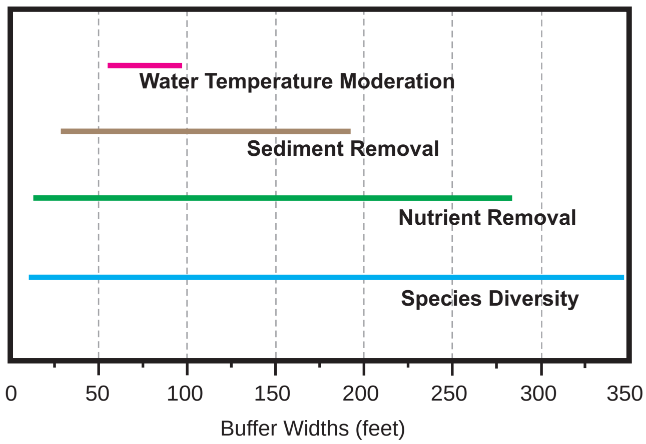
[21]*SEWRPC Planning Report No. 50,* A Regional Water Quality Management Plan Update for the Greater Milwaukee Watersheds, Appendix O, *December 2007.*

Figure 15

RANGE OF BUFFER WIDTHS FOR
PROVIDING SPECIFIC BUFFER FUNCTIONS



NOTE: Site-specific evaluations are required to determine the need for buffers and specific buffer characteristics.

Source: Adapted from A. J. Castelle and others, "Wetland and Stream Buffer Size Requirements-A Review," Journal of Environmental Quality, *Vol. 23.*

The presence of a buffer is always better for water quality and habitat considerations than the absence of one. Therefore, efforts to develop buffers, regardless of width or continuity, are recommended within this report. Efforts to establish buffer vegetation could be developed in accordance with WDNR and Natural Resources Conservation Service (NRCS) technical standards as may be applicable. Additionally, SEWRPC Riparian Buffer Guide No. 1, "Managing the Water's Edge," (Appendix D) provides valuable information related to buffers.

Buffer Protection and Enhancement

In general, the Bark Lake watershed has a fairly extensive buffer system, with the exception of the shoreline properties. In fact, as mentioned previously, these buffers (largely contained within wetlands) are likely responsible for the generally good water quality and wildlife populations which currently exist in the Lake. Thus, efforts to protect these already established buffers are recommended. A buffer analysis was completed by SEWRPC staff indicating the existing and potential buffers as well as which of these areas are currently considered "vulnerable."[22] The results of this analysis are shown on Map 11. These unprotected areas, particularly when located in a high groundwater recharge area (also shown on Map 11), should be considered high priority for purchase, or should be the targets of partnerships, in the interest of protection.

In addition to protecting existing buffers, it is also beneficial to enhance buffers. Map 11 also shows the areas where buffers could potentially be installed in the watershed when opportunities present themselves. However, a focus on shoreline properties would provide a good starting point, as this would provide protection from the sources of pollution that drain directly to the Lake.

Finally, as is also pointed out on Map 10, it should be a priority to establish natural vegetation in the internally drained areas that contribute to the groundwater draining to Bark Lake. This type of buffer will potentially aid in the uptake of pollutants and nutrients that have the potential of contaminating groundwater, and will also play a role in enhancing wildlife habitat, as discussed in the Wildlife section below. It is therefore recommended that partnerships be formed with the owners of these lands to reestablish natural vegetation, when deemed practical.

Overall Water Quality Recommendations

To ensure that water quality issues are addressed on a long-term and sustainable basis, the following recommendations are made:

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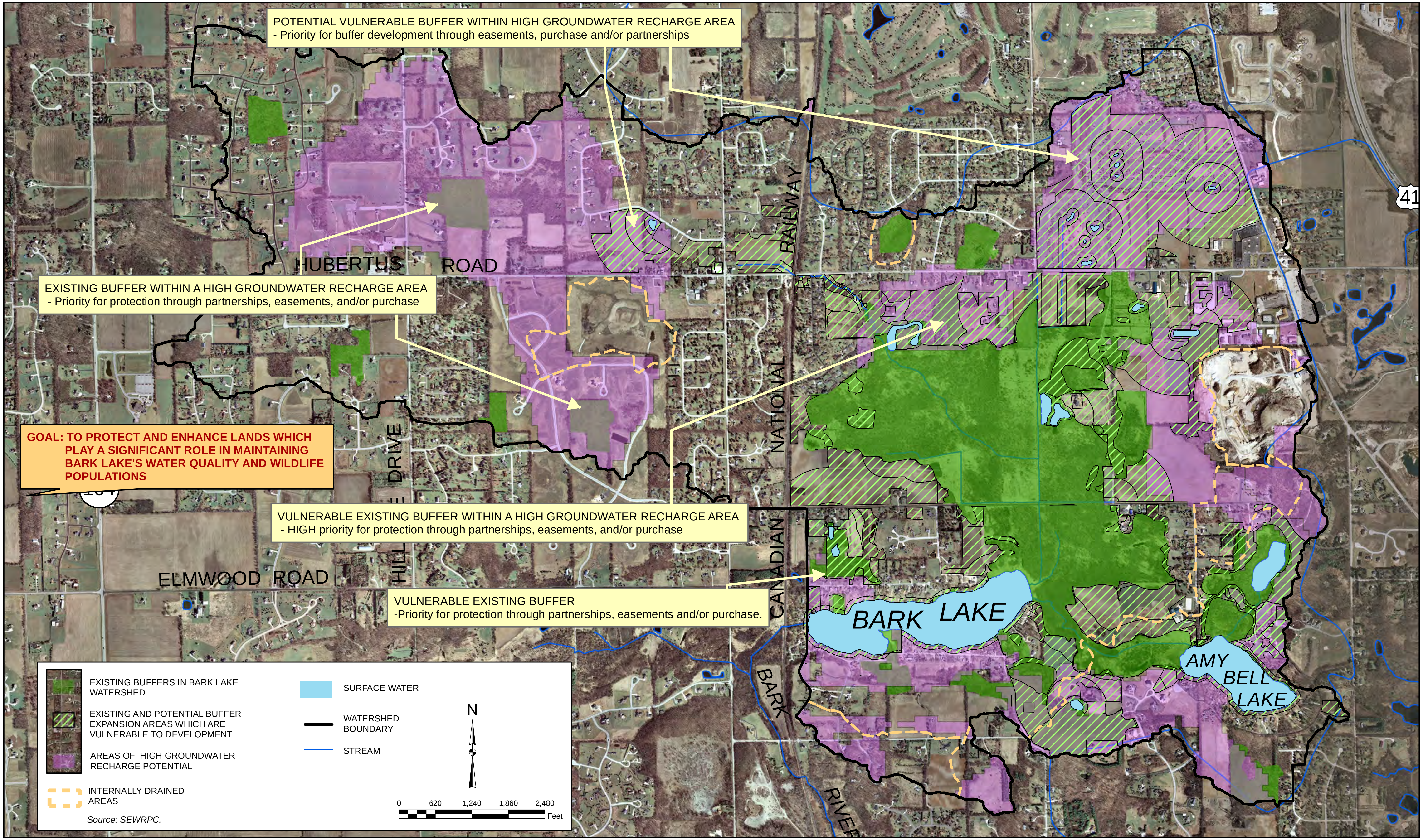
[22]*Vulnerable areas include current or potential buffer areas that do not have some form of protection through location within SEWRPC-designated environmental corridors or natural resource areas, SEWRPC-designated natural areas or critical habitats, floodplains as delineated by the Federal Emergency Management Agency, or privately/publicly protected areas. More details on these designated areas can be found in Appendix A in the Important Natural Areas section as well as the Floodplain Zoning subsection.*

Map 11

LANDS TO BE CONSIDERED FOR PROTECTION WITHIN THE BARK LAKE WATERSHED



1. **Implementation of urban runoff reduction measures** targeting the areas indicated on Map 9, i.e., along the Lake shoreline and in properties that directly run into the Lake. The implementation of this recommendation could involve educational efforts or incentive programs to encourage best management practices.

2. **Implementation of agricultural reduction measures** targeting the areas also indicated on Map 9. A particular emphasis should be placed on the agricultural areas which create runoff that drains directly into the Lake. The implementation of this recommendation could involve educational outreach; partnerships; and incentive-based programs to encourage the implementation of best management practices and of buffers, grassed waterways, and naturalized detention basins.

3. **Implementation of groundwater pollution reduction measures**, as indicated on Map 10. This recommendation addresses the following components:

    a. Groundwater pollution from urban and agricultural sources. This could be addressed through educational outreach and incentive-based programs similar to those described above. These efforts should focus on the urban and agricultural land uses located within high groundwater recharge areas as indicated on Map 10.

    b. Septic system maintenance. This could include educational and outreach programs to encourage septic system maintenance. These efforts should first target shoreline property owners and then expand to the entire watershed, particularly in areas with high groundwater recharge indicated on Map 10.

4. **Prevention of dumping of materials that could cause groundwater pollution** in the internally drained areas indicated on Map 10. This could be addressed through signs and through the enforcement of Village ordinances.

5. **Development and protection of buffers**. These efforts should begin by targeting direct residential inflow sources, i.e., the Lake shoreline properties as well as the adjacent properties, and existing "vulnerable" buffers. To aid in the implementation of this recommendation, Map 11 shows the existing and potential riparian buffers, as well as "vulnerable" buffers, i.e., existing and potential buffer regions which are not currently protected from development. The implementation of this recommendation could involve:

    a. Continued application of limits on development in SEWRPC-delineated primary environmental corridors. This will help protect existing natural buffer systems.

    b. Continued enforcement of shoreland setback requirements (i.e., 75 feet from the ordinary high water mark)[23] in the watershed and continuation of active enforcement of construction site erosion control and stormwater management ordinances.

    c. Provision of informational materials to shoreland property owners on the benefits of buffers to encourage their installation around the Lake. These materials could include instructions on installation. Such programs would be most productive if accompanied by an incentive program.

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[23]*Details related to the requirements of shoreland homeowners in Washington County have been compiled in guidance document called the "Shoreland Property Owner Handbook." Information related to the current ordinances in the Bark Lake watershed can be found in this document at:*
http://www.co.washington.wi.us/uploads/docs/LU_ShlndPropOwnerBook_Copy.pdf

d. Consideration of 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.

e. Conservation easements and land purchases, particularly in areas deemed “vulnerable,” followed by subsequent buffer maintenance and/or installation.

6. **Reestablishment of natural vegetation, or “buffers,” in the internally drained areas** highlighted in Map 10, to mitigate groundwater pollution that could occur in these areas. This should be done through partnerships with the landowners. It is possible that this re-establishment of natural vegetation may be mandated in the extractive area.

Implementation of these recommendations should improve the water quality within Bark Lake. To gauge the success of these recommendations, it is also recommended that a comprehensive, long-term water quality monitoring program be initiated in Bark Lake, with regular phosphorus, Secchi depth, and chlorophyll-*a* monitoring, and periodic chloride measurements and phosphorus measurements in the deeper parts of the Lake. Additionally, tracking best management practice installation, such as number of acres of buffers established, or number of farmers who installed grassed waterways, should also be made a priority. These records will help evaluate the success of the implemented measures, even before they translate into water quality improvements.

LAKE OUTFLOW AND BLOCKAGES

As discussed in Chapter II, blockages in the outflow culvert of Bark Lake have been reported. These debris jams have, thus far, been cleared by the Village of Richfield. **The continued maintenance of the outlet is recommended**. However, as also discussed in Chapter II, it is recommended that the Bark Lake Association or the Village of Richfield **investigate whether the culverts located under the Canadian National Railway downstream from the outflow site are at a higher elevation than the Lake outlet under Bark Lake Drive**. This will help determine if reconstruction of the Railway culverts are needed to lower lake stages and to improve fish passage. A surveying benchmark established at the Lake outlet on the Bark Lake Drive bridge under the SEWRPC vertical control program can be used to measure the elevations of the Railway and Bark Lake Drive culvert inverts in feet above National Geodetic Vertical Datum, 1929 adjustment (NGVD 29). Details on this benchmark are included in Appendix E.

WDNR PUBLIC ACCESS SITE

As discussed in Chapter II, the WDNR is currently constructing a public access site on the southern shoreline of the Lake. This has spurred concern about 1) overcrowding and loss of tranquility; 2) overfishing; and 3) invasive species introduction. In reference to the first concern, the number of parking spots provided is in full compliance with guidance given by the *Wisconsin Administrative Code.* Consequently, recommendations related to reducing the number of boats allowed to come in from the public access site (which is currently four boats considering that only four trailer parking spots are being constructed), have not been included. However, there is a boating ordinance for the Lake (see Appendix B). Consequently, **it is recommended that key components of the relevant ordinances be communicated through signs at the boat landing, and that the ordinance be enforced**. It may be advantageous to establish a protocol for communicating complaints to the appropriate authorities and then making this protocol know to lakeshore property owners.

With respect to overfishing, again, there are legal designations related to bag limits. However, when the public access site is established, Bark Lake will be eligible for fishery population studies and fish stocking. Therefore if, after the public access site is established, it appears that the fish population is adversely affected, it may be possible to change bag limits or qualify for fish stocking. **It is recommended that fishery population studies be conducted soon after the access site is established and once again after the site has been in operation for at least one year**.

Finally, with respect to the introduction of invasive species, **it is recommended to employ signage that communicates the legal expectations of boaters who use the Lake**. Additionally, through the WDNR "Clean Lakes, Clean Boats" program, it may be possible to acquire funding to support staff at the boat launch for the purpose of preventing invasive species introduction. Additionally, **it is recommended that citizens monitor the Lake for new invasive species**, such as curly leaf pondweed, and if new species are identified, seek funding through the WDNR for quick response control measures.[24]

WATER QUANTITY

As discussed in the Water Quantity section of Chapter II, the maintenance of water levels can be crucial to the health of the Lake. Because there is some anecdotal evidence that water levels in Bark Lake may be subject to elevation differences over time (see Sedimentation section in Chapter II), it is a priority to ensure that water levels remain consistent, while allowing natural fluctuations to occur. To maintain water levels, two major types of strategies can be implemented. The first is the implementation of projects which seek to increase the Lake's "resilience," i.e., the Lake's ability to remain healthy with reasonable fluctuations in water levels. These kinds of projects act to prevent the need for the second strategy, namely: the introduction of water into the Lake through man-made efforts. The types of measures involved with both of these strategies are represented below.

Building Resilience

The resilience of a watershed, in terms of modulating fluctuations in runoff and establishing adequate baseflows, is to encourage groundwater recharge (as discussed in Chapter II). Such actions essentially increase the ability of the watershed to soak up the precipitation that occurs, leading to long-term supplies for baseflow and potable water supply from groundwater.

The presence of impervious surfaces such as roads, driveways, and rooftops, and compacted soils that are normally associated with residential lawns, are major factors that reduce infiltration of precipitation and groundwater recharge. These surfaces 1) cover or replace soils and plants which previously would have helped promote infiltration and 2) cause water to move quickly, thereby reducing the potential for infiltration as runoff passes over impervious surfaces (see Figure 7 in Chapter II of this report).

Efforts to build water quantity resilience in the Lake could focus on improving groundwater recharge rates in the watershed and/or on maintaining current levels. Projects associated with these focuses are discussed below.

Groundwater Recharge Improvement

Mitigation efforts and infrastructure changes can be implemented to increase groundwater recharge in areas with impervious surfaces. These include 1) the implementation of infiltration best management practices (green infrastructure) to collect and infiltrate runoff from impervious surfaces in residential areas and 2) retrofitting impervious surfaces. The first of these includes efforts such as the installation of rain gardens (see Figure 16) or infiltration basins. These could be encouraged using incentive programs or educational efforts that provide details on their benefits and installation. The second generally involves the installation of infiltration infrastructure in place of existing impervious surfaces. Some examples of these projects include bioretention cells, modifying curb and gutter street cross sections to promote infiltration, green parking designs, infiltration trenches, permeable or porous pavement, rain barrels and cisterns, riparian buffers, stormwater planters, tree box filters, and vegetated filter strips,. These types of projects may be most successfully promoted as options to be considered when current impervious infrastructure needs to be upgraded or replaced.

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[24]*WDNR has grant programs for Aquatic Invasive Species Education, Prevention, and Planning, as well as for Early Detection and Response. Applying for these grant dollars may aide in reassuring lake residents that new invasive species are being prevented to the greatest extent possible.*

Figure 16

EXAMPLE OF A RAIN GARDEN

NOTE: Further details are provided on Natural Resource Conservation Service and Wisconsin Department of Natural Resources websites at:
http://www.nrcs.usda.gov/Internet/FSE_PLANTMATERIALS/publications/ndpmctn7278.pdf; and
http://dnr.wi.gov/topic/Stormwater/raingarden/

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

In general, implementation of these efforts should focus on residential areas within high groundwater recharge areas. The aforementioned "Healthy Lakes" grant program provides funding for these kinds of projects, such as rain gardens, on shoreline properties. Applying for this funding as a financial incentive to homeowners should therefore be considered in the application of this recommendation. The design of infiltration practices should be accomplished in accordance with WDNR technical standards.[25]

Maintenance of Groundwater Recharge

Maintenance of groundwater recharge refers to the prevention of recharge losses associated with the conversion of agricultural lands and other rural lands to urban development. The 2035 planned land use data for the Bark Lake watershed indicates that the majority of land use changes in the watershed will be located in areas with high and very high groundwater recharge potential. This suggests that the groundwater supply to the Lake could be reduced in the future.

To prevent this loss of resilience, urban development within high groundwater recharge areas should be accomplished with the goal of maintaining as much groundwater recharge capacity as possible, through implementation of stormwater infiltration practices. This effort will also have the added benefit of abating future urban nonpoint source pollution.

Water Introduction

Another measure for increasing or maintaining water levels in a lake is through man-made measures that literally inject water into the lake system. The most common water injection method is interbasin transfers, which involve taking water out of a neighboring watershed and pumping it to a lake. This type of measure is often used as a last resort because it 1) may require construction of a complicated, expensive system of pipes, pumps, and channels; 2) requires substantial maintenance; and 4) often causes environmental problems in the region from which the source water is obtained. Considering that Bark Lake is not currently suffering from major water level issues, and therefore has time to implement groundwater recharge measures, these measures are not considered necessary or viable at this time.

Overall Water Quantity Recommendations

To ensure that water quantity issues are addressed on a long-term and sustainable basis, the following recommendations are made:

1. **Encourage implementation of measures to promote infiltration in areas of existing urban development**. These efforts should focus on residential areas within high groundwater recharge areas as indicated on Map 10. Implementation of this recommendation could involve:

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[25]See http://dnr.wi.gov/topic/stormwater/standards/postconst_standards.html.

a. Improving infiltration of rainfall and snowmelt through installation of innovative BMPs that are associated with low-impact development, including bioretention and rain garden projects[26] and installation of rain barrels; and

b. Retrofitting current urban development (e.g., disconnection of downspouts; installation of permeable pavement).

2. **Reducing the impacts of future urban development within groundwater recharge areas** (see Map 6 in Chapter II of this report) by:

   a. Encouraging the review, update and/or implementation, as necessary, of local land use regulations to encourage conservation development practices in new developments;

   b. Encouraging low-impact design standards in accordance with the regional water supply plan;[27,28]

   c. Purchasing land or obtaining conservation easements in agricultural areas within high groundwater recharge potential; and

   d. Promoting the consideration of groundwater conditions when designing new developments. This could include encouraging developers to incorporate infiltration considerations in site designs and local government consideration of groundwater recharge during review of development proposals.

As with the other recommendations made in this chapter, the logistics related to the implementation of the above recommendations will need to be further developed. However, if even just a few of these recommendations are applied to the watershed, they could greatly contribute to future water quality and quantity within the Bark Lake watershed and the Lake itself. To monitor the effects on the Lake of such measures, and to gauge water level fluctuations in Bark Lake, monitoring of Lake levels is also recommended. To systematically monitor Lake levels, it is recommended that the Lake Association 1) install a staff gage (referenced to NGVD 29) which can be used to regularly record Lake levels and 2) designate a Lake resident to record weekly lake level readings.

WILDLIFE

Because wildlife populations are interconnected with water quality, water quantity, and habitat availability, the implementation of the recommendations made thus far in this chapter would each lead to the enhancement of both aquatic and terrestrial wildlife. Therefore, the implementation of these aforementioned measures is further recommended in this section. However, of these previously described recommendations, a specific emphasis should be placed on the enhancement and protection of buffers and natural areas, as discussed in the Water

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[26]*Roger Bannerman, WDNR, and partners, Menasha biofiltration retention research project, Middleton, Wisconsin, 2008; N.J. LeFevre, J.D. Davidson, and G.L. Oberts, Bioretention of Simulated Snowmelt: Cold Climate Performance and Design Criteria, Water Environment Research Foundation (WERF), 2008; William R. Selbig and Nicholas Balster, Evaluation of Turf Grass and Prairie Vegetated Rain Gardens in a Clay and Sand Soil, Madison, Wisconsin, Water Years 2004-2008, in cooperation with the City of Madison and Wisconsin Department of Natural Resources, USGS Scientific Investigations Report, in draft.*

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

[28]*SEWRPC Technical Report No. 48,* Shallow Groundwater Quantity Sustainability Analysis Demonstration for the Southeastern Wisconsin Region*, November 2009.*

Figure 17

EXAMPLES OF COMPLETED "FISH STICKS" PROJECTS

Source: Wisconsin Department of Natural Resources.

Quality section of this chapter. This is because the primary reason for terrestrial wildlife loss is habitat loss and fragmentation.[29] Therefore, projects that protect and increase habitat availability will likely have the largest impact.

There are however, measures beyond the improvement of terrestrial habitat, water quality, and water quantity that can further enhance the ability of terrestrial and aquatic wildlife to survive and reproduce. These measures include 1) in-lake measures which relate to fish habitat and best management practices and 2) best management practices by residential and agricultural landowners. Each of these measures is discussed below.

In-Lake Measures

Some things can be done within a lake to enhance aquatic- and terrestrial-based wildlife. One of these measures is the improvement of aquatic habitat through aquatic plant management techniques that allow for native plant species to thrive. These measures, such as targeted manual removal of invasive species while sparing native plants, as discussed in the Aquatic Invasive Species section of this report, allow for fish habitat to be preserved in the Lake, while reducing the potential for anoxic conditions[30] which can lead to fish kills. Consequently, the implementation of the measures as recommended in the Aquatic Invasive Species section of this report should be considered a high priority to accomplish multiple objectives.

Two additional recommended measures that improve fish habitat are 1) the introduction or maintenance of woody debris along the shorelines of the Lake and 2) the installation of natural buffer systems. The first measure could take the form of allowing fallen trees to stay in the Lake, or can be implemented in the form of man-made wood structures known as "fish sticks," as shown in Figure 17. The second involves the installation of natural plants along the shoreline as a habitat source (see Figure 10). This recommendation has the added benefit of reducing erosion and pollution that enters the Lake, as discussed in the Water Quality section of this chapter. In general, efforts to improve fish habitat can greatly increase the general wildlife populations in the Lake.

Finally, in addition to habitat enhancement best management practices can be implemented in a lake that will prevent loss of fish populations. **The most feasible of these measures in Bark Lake is the implementation of catch-and-release practices. Encouraging this practice is, therefore, recommended.**

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[29]http://www.nwf.org/wildlife/threats-to-wildlife/habitat-loss.aspx.

[30]*Anoxia refers to lack of oxygen in the water column. More details on this process are provided in Appendix A in the Dissolved Oxygen Levels subsection.*

Best Management Practices

The way people manage their land and treat animals can also have a significant impact on terrestrial wildlife populations. Turtles, for example, need to travel a fair distance from their home to lay their eggs. If pathways to acceptable habitats are not available, or are dangerous, due to pets, fences, cars, etc., the turtles will not have the opportunity to increase their population. Given these effects that humans have on wildlife, many conservation organizations have developed best management practices to increase wildlife populations.

Though some of these practices are species or animal-type specific, e.g., spaying or neutering cats to reduce their desire to kill birds, many of these recommendations relate to general practices that can benefit all wildlife. It may, however, also be desirable to target specific animals as well, depending on the animals that people want to protect. If wildlife enhancement of a specific species is deemed a priority, best management practices aimed at that particular species should be encouraged.

In general, best management practices for wildlife enhancement can be targeted to specific agricultural and residential land uses. Agricultural measures tend to focus on encouraging land management that allows for habitat enhancement, such as allowing fallen trees to naturally decompose or allowing for uneven landscapes. Alternatively, residential measures tend to focus on things that landowners can install to provide habitat, such as installing a pool garden, as well as preventing conditions that deteriorate habitat, such as the introduction of nonnative plants and insects. There are also, however, recommendations common to both types of landowners. Killing wildlife, for example, particularly amphibians, reptiles, and birds, is generally not advised.

Communication of these best management practices may provide a venue for encouraging wildlife populations without having to implement extensive infrastructure changes, such as converting agricultural lands to natural areas. Consequently, the implementation of these best management practices to promote wildlife is recommended.

Overall Wildlife Recommendations

To enhance wildlife within the Bark Lake watershed, the following recommendations are made:

1. **Preserve and expand terrestrial wildlife habitat while making efforts to ensure connectivity between natural areas**. This could be achieved through the implementation of the buffer installation recommendations in the Natural Pollution Filtration section of this chapter. These recommendations are summarized on Map 11. Implementation of this recommendation should also include efforts to protect environmental corridors, wetlands, and uplands throughout the watershed through land purchases or easements.

2. **Improve water quality in the Lake** through the implementation of the recommendations in the Water Quality section of this chapter, as shown on Maps 9 and 10.

3. **Ensure that Lake water levels are modulated** through the implementation of the water quantity recommendations made in the Water Quantity section of this chapter, as shown on Map 10.

4. **Improve aquatic habitat in the Lake by allowing or installing woody debris along the Lake's edge, or by installing natural shoreline buffers.** Implementation of this recommendation could take the form of educational or incentive-based programs to encourage riparian landowners to install these habitats. WDNR grant money is available through the "Healthy Lakes" program on a competitive basis for the implementation of these kinds of projects. These efforts should target all areas that do not currently have a buffer, as shown on Map 7 in Chapter II of this report.

5. **Encourage best management practices in the Lake** such as "catch-and-release" fishing. The need for these practices could be communicated to lake residents and users through outreach efforts and proper signage.

6. **Ensure proper implementation of the aquatic plant management plan** described in the Aquatic Invasive Species section of this chapter, specifically as it relates to avoiding inadvertent damage to native species while attempting to control Eurasian water milfoil.

7. **Encourage the adoption of best management practices to reduce nonpoint source pollution from, and improve habitat on, agricultural and residential land** through voluntary, educational, or incentive-based programs, as well as directly implementing these practices on public and protected lands. If this recommendation is implemented, a complete list of best management practices should be compiled and provided to landowners. Implementation of this recommendation in agricultural areas could also be furthered by:

    a. **Encourage agricultural landowners to enroll in Federal agricultural incentive programs** such as the Conservation Reserve Program, the Wetland Reserve Program, the Wildlife Habitat Incentives Program, or the Landowner Incentive Program, which provide financial incentives to restore habitats.

    b. **Encourage landowners to investigate and consider the establishment of a Priority Amphibian and Reptile Conservation Area (PARCA).**[31]

As with many of the other recommendations made in this chapter, the logistics related to the implementation of the above recommendations will need to be further developed; however, the implementation of any one of these recommendations could significantly enhance wildlife populations within the Bark Lake watershed, now and in the future.

WETLANDS

As discussed in Chapter II of this report, wetlands are currently protected by a series of zoning ordinances. However, there are still wetland maintenance measures which should be taken in order to ensure that the current functions of the wetlands are protected and maintained. The major recommendation with regard to this is to **monitor and control any purple loosestrife that may occur in wetlands**. This species, with a characteristic purple flower, as shown in Figure 18, spreads quickly and replaces the plants in the wetland that are useful for pollution reduction purposes and for habitat. Consequently, it is recommended that a visual survey of appropriate locations in the watershed be made to determine whether purple loosestrife is a problem. Then, if it is found to be an issue removal should be a priority.

Removal of purple loosestrife can take the form of manual removal, chemical treatment, or biological controls (through the release of a specialized herbivorous insect). If purple loosestrife is found in small populations, manual removal should be implemented (with extra precautions taken to ensure no seed dispersal during

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[31] *"The Priority Amphibian and Reptile Conservation Area (PARCA) project is an initiative of PARC-National to develop a network of focus areas designed specifically for the conservation of reptiles and amphibians. Areas are nominated using scientific criteria and expert review, drawing on the concepts of species rarity, richness, regional responsibility, and landscape integrity. PARCAs are a nonregulatory designation whose purpose is to raise public awareness and spark voluntary protection by landowners and conservation partners. PARCAs are not designed to compete with existing landscape biodiversity initiatives, but to complement them by providing an additional spatially explicit layer for conservation consideration."* http://www.northeastparc.org/workinggroups/herpareas.htm

Figure 18

EXAMPLE OF PURPLE LOOSESTRIFE ON A LAKE SHORE

Source: The Nature Conservancy.

removal), whereas chemical or biological controls should be employed if dense populations are found. This campaign could be completed using volunteers or through partnering with other organizations.[32]

LAKE MONITORING DATA

As has been discussed throughout this chapter and in Chapter II of this report, monitoring of Bark Lake and of the management efforts within the Lake is crucial to ensuring the Lake's health. Thus far there is limited data available about the Lake. Consequently, it is recommended that a monitoring plan be put into place to gauge the health of the Lake, and to provide a baseline condition of the Lake to which future conditions can be compared.

[32]*Several lakes within the Southeastern Wisconsin Region, including Lac La Belle, have partnered with the Girl Scouts for the management of purple loosestrife. This is an example of a partnership that may be beneficial in the Bark Lake watershed if purple loosestrife is found to be an issue.*

Recommendations as to what should be monitored have been dispersed throughout this report. They include:

1. **Water quality monitoring**—This is the most basic of the monitoring needs in a lake and should be considered a top priority. This monitoring generally would occur at the deep hole site as chosen by WDNR (see Map 2 in Chapter II of this report) and should include measurements of water clarity (i.e., Secchi depth), total phosphorus concentrations at the surface, chlorophyll-*a* concentrations at the surface, temperature profiles throughout the water column, and dissolved oxygen concentrations at the surface.[33] Wisconsin has the Citizen Lake Monitoring Network (CLMN), which provides training and guidance on monitoring the health of lakes. Volunteers monitor water clarity and dissolved oxygen throughout the open water season (preferably every 10 to14 days) and to monitor water chemistry (i.e., phosphorus and chlorophyll-*a* concentrations) four times per year (two weeks after ice off and during the last two weeks of June, July, and August). In addition, chlorides should also be monitored on an annual basis to gauge if concentrations are increasing over time to levels that could cause damage to the lake ecosystem.[34]

2. **Aquatic plant monitoring**—Monitoring for invasive species should be conducted early in the spring every year that chemical treatment for Eurasian water milfoil is taking place. Additionally, a comprehensive aquatic plant survey to determine all of the plants present in the Lake should be completed every five years during the months of July and August (peak growth season). It may also be advantageous for volunteers to monitor general aquatic plant presence and absence, and relative abundance, on an annual basis. The CLMN provides training and guidance on completing this kind of monitoring.

3. **Water level and sediment depth monitoring**—Considering the concern surrounding water levels and sedimentation in Bark Lake, a water level gage should be established in the Lake and reading should be recorded weekly to monitor water levels. Additionally, it may be advantageous to engage in sediment depth measurement activities that could be completed every five years while completing the aquatic plant survey (as was done in 2012).[35] These depths could then be compared to the sediment depths found in 2012 in order to gauge the extent of sedimentation and sandbar growth in the Lake over time.

4. **General monitoring**—Several things in Bark Lake and its watershed should be monitored for their presence or absence. For example, if the inlet to the Lake ever stops flowing, as was reported once before, the date of this occurrence as well as the duration the inlet remained dry should be recorded. Additionally, any sources of erosion contributing sediment to the Lake should be identified and the erosion site location and characteristics should be documented.

5. **New invasive species monitoring**—As discussed previously in the WDNR Public Access Site section, several invasive plants common in Wisconsin have yet to be reported in the Lake. This includes curly leaf pondweed and zebra mussels (see Chapter II of this report). Consequently, a monitoring plan for early detection of these species is recommended, particularly given the new

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[33]*More details regarding the importance and meaning of water quality parameters are included in Appendix A in the Water Clarity subsection.*

[34]*More details on chlorides in lakes are provided in Appendix A in the Major Anions subsection.*

[35]*Aquatic plant surveys are currently completed using a grid point method which surveys all of the aquatic plants present at various points across the Lake. Details about the survey completed in 2012 are included in Appendix A in the Aquatic Plants section.*

public access site. Again, as discussed above, if a new species is detected, the WDNR has funding that can aid in early eradication, particularly as it pertains to aquatic plants. Monitoring efforts should also include recording the occurrence of purple loosestrife in the watershed, as discussed in the Wetlands section above, to inform management efforts.

6. **Monitoring watershed management actions**—A special effort should be made to record and document the management efforts undertaken within the watershed. This will help in systematically implementing plan recommendations, assuring people that efforts are being made to improve the Lake, and providing an indication of progress before the efforts translate into visible changes in the Lake.

SUMMARY OF RECOMMENDATIONS AND IMPLEMENTATION

Table 4 provides a brief summary of all of the recommendations made under this plan. To facilitate the overall understanding of these recommendations, the table indicates the general type of recommendation, describes the recommendation, indicates the initial target areas, and lists resources available to help with the implementation of the recommendation (including resources included within this plan, funding sources, and other guidance documents). Additionally, the table highlights the recommendations that should be considered high priority.

The recommendations made under this plan cover a wide range of programs, and they seek to address every aspect that influences the health and recreational use of Bark Lake. Consequently, it may not be feasible to implement every one of these recommendations in the immediate future. Priority recommendations are, therefore, indicated, and the Bark Lake Association should begin the program of Lake improvement by implementing those recommendations. It should then also take advantage of opportunities that may arise to implement other recommendations in the short-term. Eventually, all of the recommendations should be addressed, subject to possible modification based on possible changed conditions and the findings of future aquatic plant surveys and water quality monitoring.

It should also be noted that, though not included in the overall recommendations, **the creation of an action plan which highlights action items and responsible parties is highly recommended**. This document, which can be created with the guidance of the SEWRPC staff, will help ensure that the recommendations made under this plan are implemented in a timely and effective manner. Additionally, this document can help ensure that all responsible parties are held accountable for their portion of the plan's implementation.

Finally, though not discussed in this report, the cost of some of the potentially necessary management recommendations, such as dredging, aquatic plant management, sanitary service installation, and land purchases, are likely beyond the fiscal ability of the Bark Lake Association. Consequently, it may be necessary to consider financial partnerships with other organizations, as well as the potential formation of a taxing body such as a Lake District, if the need for these management efforts becomes even more evident with monitoring.

CONCLUSIONS

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 that have been identified in Bark Lake and its watershed. Successful implementation of the plan will require vigilance, cooperation, and enthusiasm, not only from the Bark Lake Association, but also from State and regional agencies, counties, municipalities, and lake residents. The recommended measures will provide the water quality and habitat protection necessary to maintain and establish conditions in the watershed that are suitable for the maintenance and improvement of the natural beauty and ambience of Bark Lake and its ecosystems, and the enjoyment of its human population today and in the future.

Table 4

RECOMMENDED PROTECTION PLAN ELEMENTS FOR BARK LAKE

Goal/Issue Addressed	Recommendation[a]	Initial Focus Area	Implementation Resources[b]
Aquatic Invasive Species Control	**Manage Eurasian water milfoil through chemicals in early spring ONLY**	Areas where Eurasian water milfoil can be targeted without risking native plants	Chapter III “Aquatic Invasive Species” Section; Map 8
	Consider manual and/or mechanical removal of plants for growth which occurs after chemical treatment	- Areas where Eurasian water milfoil is found - Navigation Lanes - Area of concern at the sandbar	Chapter III “Aquatic Invasive Species” Section; Map 8
	Consider a whole lake chemical treatment if Eurasian water milfoil is found to have 75% frequency of occurrence and 2 to 3 rake fullness	Whole Lake	Chapter III “Aquatic Invasive Species” Section; Map 8
	Prevent the introduction of new invasive species through signs and volunteers	WDNR Public Boat Launch	Chapter III “WDNR Public Access Site” Section; WDNR Clean Boats Clean Lakes; WDNR AIS Control Grant
	Monitor for new aquatic invasive species and take prompt action if found	Whole Lake	Chapter III “WDNR Public Access Site” and “Lake Monitoring Data” Sections; Citizen Lake Monitoring Network; WDNR AIS Control Grant
	Monitor Eurasian water milfoil annually and the entire plant community every five years	Whole Lake	Chapter III “Aquatic Invasive Species” and “Lake Monitoring Data” Sections; Citizen Lake Monitoring Network; WDNR Lake Planning Grant
Prevention and Management of In-Lake Sedimentation	Consider harvesting using a harvesting contractor or using suction harvesting in order to prevent plant based sedimentation	Whole Lake with emphasis on areas near the sandbar	Chapter III “Sedimentation” and “Aquatic Invasive Species” Sections; Map 8
	Consider dredging project in the areas adjacent to the sand bar, subject to WDNR permit requirements	Areas adjacent to sandbar	Chapter III “Sedimentation” Section; Map 9; WDNR staff for Consultation
Protection and Enhancement of Fish Populations through In-lake Measures	Promote “catch and release” practices	WDNR Access Site	Chapter III “Wildlife” Section; Village of Richfield (site operator)
	Consider habitat improvement projects along the shoreline	Shoreline properties around the Lake	Chapter III “Wildlife” Section WDNR Website; WDNR Lake Protection Grant
	Monitor fish population once WDNR access site is established	Whole Lake	Chapter III “WDNR Public Access Site” Section; WDNR Staff (Fisheries Biologist)
	Consider fish stocking if populations decline	Whole Lake	Chapter III “WDNR Public Access Site” Section; WDNR Website
Outlet Blockage	**Continue clearing blockages from outlet**	Outlet of Lake	Chapter III “Lake Outflow and Blockages” Section
	Investigate the elevation of the Railway culvert in relation to the Lake outlet and consider reconstruction if an issue is found	Culvert at Canadian National Railway	Chapter III “Lake Outflow and Blockages” Section; Appendix E
Lake Use	Communicate boating ordinances to new Lake users	WDNR Access Site	Chapter III “WDNR Public Access Site” Section; Village of Richfield (Site operator)
	Establish and communicate a protocol for complaints and incompliance issues	Shoreline lakefront property owners	Chapter III “WDNR Public Access Site” Section; Appendix B
Buffer Protection and Enhancement	**Rehabilitate shoreline with natural buffers**	Lake shoreline properties	Chapter III “Water Quality” Section; Map 7; Appendix D; WDNR Lake Protection Grant
	Protect existing buffers from development	Vulnerable existing buffers, particularly in areas with high and very high groundwater recharge	Chapter III “Water Quality” Section; Map 9; Map 11; WDNR Lake Protection Grant
	Further develop buffers where possible	- Vulnerable potential buffer areas - In current extractive area once operations have ceased	Chapter III “Water Quality” Section; Map 9; Map 11; Appendix D; WDNR Lake Protection Grant
	Monitor and remove purple loosestrife	Wetlands east of the Lake	Chapter III “Wetlands” Section and “Lake Monitoring Data” Sections; Figure 18; WDNR Website

Table 4 (continued)

Goal/Issue Addressed	Recommendation[a]	Initial Focus Area	Implementation Resources[b]
Best Management Practices related to Pollution Reduction (with relation to groundwater and surface water), Wildlife Enhancement, and Infiltration Practices	Encourage watershed residents to protect the Lake's water quality from pollutants such as oils, grease, salts, fertilizers, and pesticides, through use of BMPs	- Residential and agricultural areas located in areas adjacent to the Lake - Areas with high groundwater recharge (Kettle Hills Golf Course and northwest area of watershed)	Chapter III "Water Quality" Section; Map 9; Map 10; WDNR Lake Protection Grant
	Encourage watershed residents to protect and enhance wildlife through use of BMPs	Residential and agricultural areas located in areas adjacent to the Lake	Chapter III "Wildlife" Section; Various available guides
	Encourage watershed residents to enhance the Lakes water supply through infiltration technologies	Residential and agricultural areas within high groundwater recharge areas	Chapter III "Water Quantity" Section; Map 10; WDNR Lake Protection Grant; WDNR Website
	Recruit CLMN volunteer for the purpose of implementing a water quality monitoring program so that success can be gauged	Whole Lake	Chapter III "Water Quality" and "Lake Monitoring Data" Sections; Citizen Lake Monitoring Network
Reduction of Direct Groundwater Pollution	Encouraging stormwater pollution reduction best management practices (see above)	High groundwater recharge area adjacent to the Lake	Chapter III "Water Quality" Section; Map 10
	Promote education regarding the maintenance of septic systems	High groundwater recharge area adjacent to the Lake	Chapter III "Water Quality" Section; Map 10
	Prevent dumping of pollutants in internally drained groundwater recharge areas	- Internally drained area in the northwest - Extractive site after operations cease	Chapter III "Water Quality" Section; Map 10; Village Zoning Ordinances
Prevention of Erosion and Loss of Groundwater Recharge through Best Management Practices and Stormwater Management	Monitor and document sources of erosion and install natural vegetation to stabilize any known erosion sites	Areas which drain directly to the Lake	Chapter III "Sedimentation" and "Lake Monitoring Data" Sections; Map 9; Village Stormwater Management Ordinance
	Create educational outreach partnerships with developers and stringently enforce compliance with the village construction erosion ordinance	Areas where new development is planned which drain directly to the Lake	Chapter III "Sedimentation" Section; Map 9; Map 6; WDNR Website; Village Construction and Erosion Control Ordinance
	Encourage the use of infiltration practices and stormwater management in new developments through partnerships or zoning ordinances	- Areas where new development is planned which drain directly to the Lake - Planned development within high groundwater recharge areas	Chapter III "Water Quantity" Section; Map 6; Map 9; WDNR Website; Village Stormwater Management Ordinance
	Monitor lake levels and sediment depths	Whole Lake	Chapter III "Lake Monitoring Data" Section; SEWRPC; WDNR Website

[a]*Red font indicates high-priority actions.*

[b]*Resources provided are limited to materials and grants provided by Wisconsin Department of Natural Resources, Village ordinances, and information provided in this report. Other available resources should be investigated prior to the development of an action plan.*

Source: SEWRPC.

APPENDICES

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Appendix A

INVENTORY FINDINGS

INTRODUCTION

The physical characteristics of a lake and the lands that drain to it, commonly referred to as a lake's "watershed," or "tributary area," are important factors in any evaluation of existing and likely future water quality conditions and lake uses, including recreational uses. Characteristics such as watershed topography, lake morphometry (external shape and dimensions), and local hydrology (water-related features), for example, ultimately influence water quality conditions and the composition of plant and fish communities within a lake. Consequently, the characteristics of a lake and its watershed must be thoroughly evaluated in the lake protection planning process.

This appendix sets forth pertinent information that is available for Bark Lake and its watershed and is divided into subsections in order to help the reader navigate the large amount of information provided. These subsections include:

1. Waterbody Characteristics—This section provides general information about Bark Lake's hydrology and physical characteristics, and can be used to understand general conditions in the Lake, as well as the nature of water flows within the Lake, i.e., residence time.

2. Tributary Area and Land Use Characteristics—This section covers a large breadth of information about the watershed draining to Bark Lake, covering topography, groundwater, soils, existing and planned land use, urban growth, population data, and the amount of the watershed that utilizes septic systems. This section should be used to: understand the conditions within the watershed; identify potential sources of pollution; and determine target areas for watershed management efforts. This section can also provide a context for understanding water quality data within the Lake.

3. Shoreline Protection and Erosion Control—This section presents a survey completed on the Bark Lake's shoreline structures and identifies potential opportunities for shoreline rehabilitation and enhanced erosion control.

4. Water Quality—This section presents and summarizes all relevant water quality data available for Bark Lake and attempts to identify trends, potential causes of issues, and monitoring gaps. This section should be used to understand the general condition of Bark Lake water quality and can be used to identify priority watershed management efforts, e.g., nonpoint source pollution reduction efforts to reduce phosphorous loads.

5. Pollutant Loadings—This section presents pollution loads and in-lake phosphorous concentrations that were calculated using Unit Area Loading and WiLMS models. This data should be used to identify likely sources of sediment, phosphorous, and heavy metal loads, as well as to guide outreach efforts seeking to reduce loadings to the Lake.

6. Aquatic Plants—This section presents the aquatic plant survey completed by the Southeastern Wisconsin Regional Planning Commission (SEWRPC) staff in 2012, and it compares the data found in this survey to previous aquatic plant surveys completed for the Lake. This section should be used to understand the plant communities within the Lake; guide aquatic plant management efforts, particularly as they relate to invasive species; and to understand how the Lake's plant communities have changed over time.

7. Fish and Wildlife—This section provides a brief summary of the fish and wildlife populations within the Bark Lake watershed. This section should be used to better understand fish habitat, populations, and fish management in Bark Lake, as well as to better understand the value of enhancing wildlife populations.

8. Important Natural Areas—This section identifies and describes the relevant natural areas located within the Lake's watershed, including wetlands, woodlands, uplands, environmental corridors, designated natural areas, and lands under legal protection. The section highlights the importance of these lands to the Lake, particularly in terms of water quality and wildlife, and should be used to understand the natural conditions within the watershed, as well as to guide natural land protection and enhancement efforts.

9. Local Ordinances—This final section highlights pertinent local and regional legal structures that exist within the watershed and affect the Lake. This section should be used to understand the legal protections that exist for the Lake, the legal tools that can be used to maintain and enhance the Lake, and the legal and political constraints that need to be adhered to when developing watershed management efforts.

In general, this appendix covers all relevant information that could be collected on Bark Lake, and it explains the importance and application of this information. The information presented in this chapter forms the basis upon which recommendations can be made. However, considering the breadth of data that is presented, it should be noted that this appendix should not necessarily be read in the order it is written, but, instead, should be used as a tool for understanding the many factors that affect Bark Lake.

WATERBODY CHARACTERISTICS

Bark Lake is located in the Village of Richfield in Washington County, Wisconsin, as shown on Map A-1. The Wisconsin Department of Natural Resources (WDNR) has classified the Lake as a drained, or headwater, lake, meaning that the Lake has a defined outflow, and the inflow to the Lake is dependent largely on direct precipitation onto the Lake's surface together with surface runoff from its surrounding watershed. Water is discharged from Bark Lake mainly through the outflow channel at the west end of the Lake.

The hydrologic and morphologic characteristics of Bark Lake, as obtained in part from the most recent survey completed on Bark Lake in 1970,[1] are set forth in Table A-1. Bark Lake is a natural body with two basins, has a length of about 0.7 mile, a width of about 0.2 mile, and a shoreline length of about 1.8 miles. Additionally, the Lake is aligned in an east-west orientation and has a surface area of about 62 acres, a volume of about 844 acre-feet, a maximum depth of 34 feet, and a mean depth of about 14 feet. The bathymetry of the Lake, as it was recorded in 1970, is shown on Map A-2.

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[1]*Wisconsin Department of Natural Resources lake survey, 1970.*

Map A-1

LOCATION OF BARK LAKE AND ITS WATERSHED

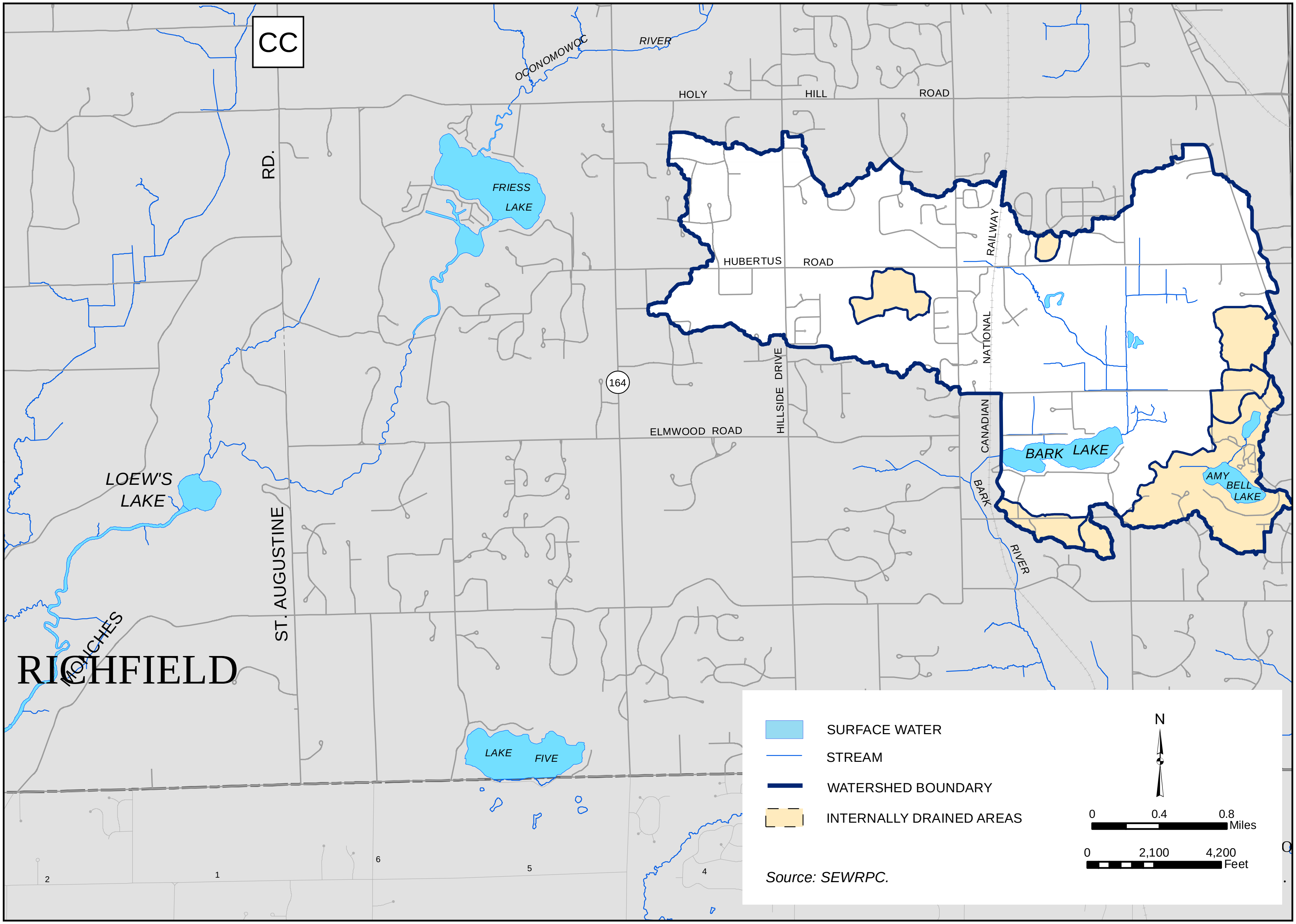


Table A-1

HYDROLOGY AND MORPHOMETRY OF BARK LAKE

Parameter	Measurement
Size	
Surface Area of Lake	62 acres
Total Tributary Area	3,400 acres
Lake Volume	843.7 acre-feet
Residence Time[a]	136 days
Shape	
Length of Lake	0.7 mile
Width of Lake	0.2 mile
Length of Shoreline	1.82 miles
Shoreline Development Factor[b]	1.6
General Lake Orientation	East-west
Depth	
Maximum Depth	34.0 feet
Mean Depth	14.0 feet
Under Three Feet	15.9 percent
Over 20 Feet	31.0 percent

[a] *Residence time is estimated as the time period required for a volume of water equivalent to the volume of the lake to enter the lake during years of normal precipitation.*

[b] *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.

Shoreline Development Factor and Biological Activity

Shoreline development factor is a rating scale which illustrates the irregularity of a lake's shoreline. The rating compares the shoreline length of the lake in question to the shoreline length of a lake of the same area that forms a perfect circle. This is an important factor in understanding the workings of a lake's ecosystems due to the fact that the shoreline development factor is often related to the level of biological activity (the amount of plant and animal life) in a lake. The greater a lake's shoreline development factor (i.e., the more irregular its shoreline), the greater the likelihood that the lake will contain the shallow, nearshore areas (i.e., a littoral zone) suitable habitat for plant and animal life. Bark Lake has a shoreline development factor of 1.6, indicating that the shoreline length is about 1.6 times greater than that of a perfectly circular lake of the same area. Bark Lake is similar to neighboring Friess Lake, which has a shoreline development factor of 1.5, but is more circular than nearby Okauchee Lake, which has a shoreline development factor of 3.1 (which reflects that lake's highly irregular shoreline composed of bays and points).

Biological activity in a lake also can be influenced by other physical factors, such as lake-basin contour and bottom sediment composition. The combination of large shallow areas of nearly flat bottom contours, together with soft bottom sediments, generally produces conditions that support high levels of biological activity. As shown on Map A-2, Bark Lake has several large shallow water areas with low bottom contours located in the western one-third of the Lake, along the south shoreline in the eastern two-thirds of the Lake, and at the extreme east end of the Lake. In addition, as shown on Map A-3, these same areas have relatively deep levels of presumably soft sediment (six to 11 feet thick). Given these factors, Bark Lake likely has moderately high biological activity, relatively nutrient rich water, and the ability to support abundant aquatic plant growth and a productive warmwater fishery.

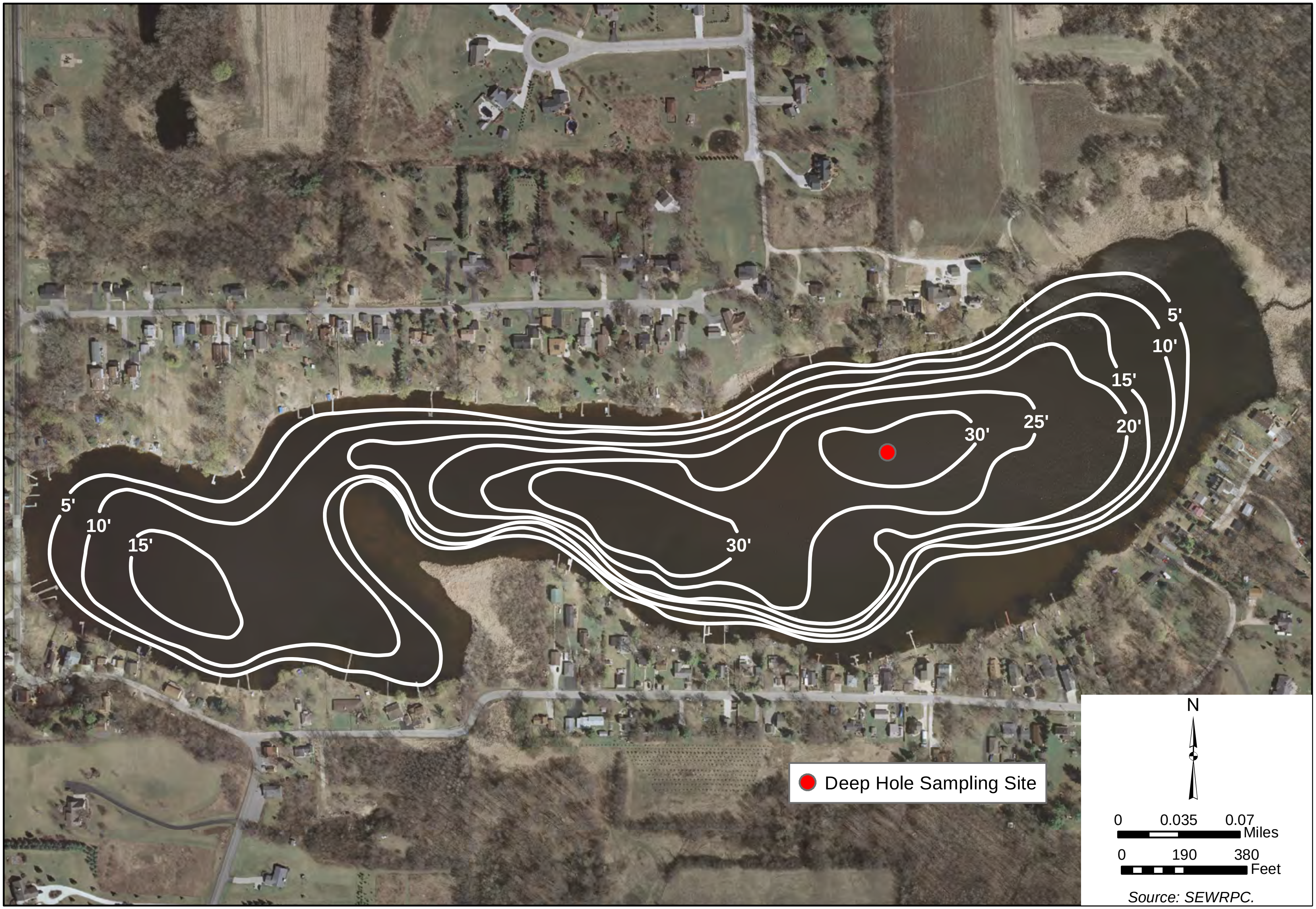
Residence Time

Residence time, also known as *retention time* or *flushing rate*, refers to the average length of time that water remains in a lake. This can be a significant factor in determining the impact of pollutants and nutrients on a lake's water quality. Lakes with short retention times, such as flow-through lakes that are part of a river system, will flush nutrients and pollutants out of the lake fairly quickly. Lakes with long retention times, such as seepage lakes which have no defined outflow, tend to accumulate nutrients that can eventually become concentrated in their bottom sediments. The average retention time for a lake can be as brief as a few days or as long as many years; Lake Superior, for example, has a retention time of 500 years, the longest retention time of any Wisconsin lake.

From a lake management perspective, efforts to control nutrient levels in a lake with a short retention time will usually focus on limiting nutrient inflow to the lake as the rapid flushing time will lead to apparent water quality improvement in a relatively short period of time. In contrast, lakes with slower flushing rates usually respond to watershed protection at a much slower rate, with apparent improvement in water quality sometimes taking years

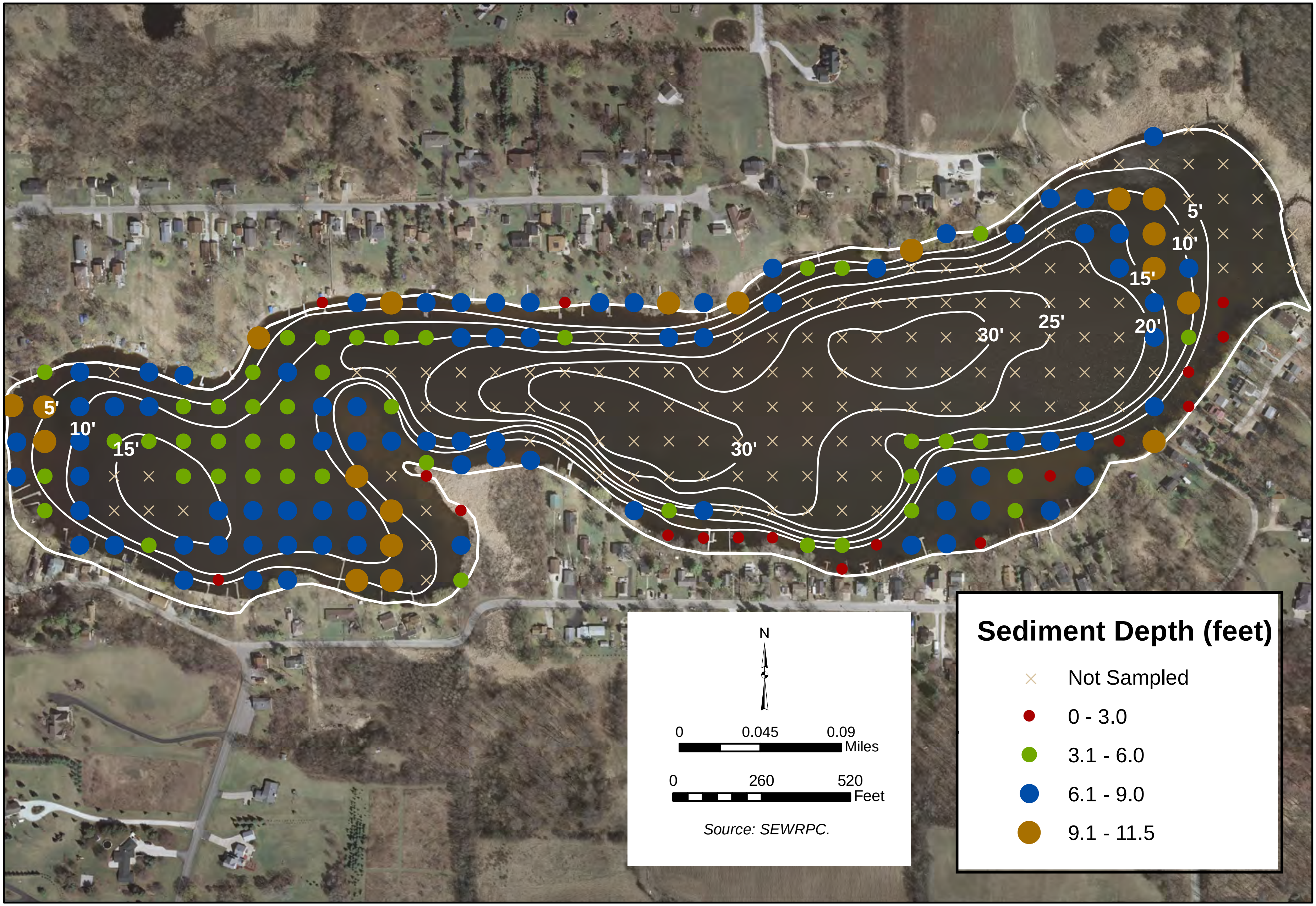
Map A-2

BATHYMETRIC MAP OF BARK LAKE



Map A-3

SOFT SEDIMENT DEPTHS IN BARK LAKE



to occur. With a retention time of 136 days, Bark Lake's flushing rate is moderate (due, in part, to the presence of a defined outflow, the Bark River). Therefore, the degree of nutrient inflow may hold the key to managing water quality conditions within the Lake. The importance of this factor in the management of Bark Lake's water quality cannot be underestimated, as will be described later in this report.

TRIBUTARY AREA AND LAND USE CHARACTERISTICS

Soil erosion, water pollution, recreational use conflicts and wetland losses, as well as the ultimate means for abatement of these problems, are often a function of the human activities within a lake's watershed and the ability of the underlying natural resource base to sustain those activities. This becomes especially significant in areas that are in close proximity to lakes, wetlands, and streams. It is, therefore, crucial to understand the conditions within Bark Lake's watershed in order to properly develop recommendations. This section presents all of the relevant data SEWRPC staff could collect about Bark Lake's watershed and explains how that information can be used. This information will provide a more thorough understanding of the Bark Lake watershed, and in turn, a better understanding of how to address identified issues.

Watershed Characteristics and Hydrology

As shown on Map A-1, the Bark Lake watershed is situated within the Village of Richfield, in the south-central part of Washington County. The total land area that drains to Bark Lake is approximately 3,400 acres, or a little more than five square miles, in areal extent. The watershed is bisected roughly into a western half and an eastern half by the presence of a railway right-of-way that runs north-south through the watershed area. Surface waters in the western half of the watershed that are draining eastward to the Lake must pass through a large culvert under the railway right-of way where it crosses Hubertus Road.

Topography

A watershed's *topographic* features, such as land elevations and slopes, play an integral role in determining a lake's water quality by influencing the amount and composition of runoff to a lake. As shown on Map A-4, land surface elevations in the Bark Lake watershed range from approximately 900 feet above National Geodetic Vertical Datum, 1929 adjustment (NGVD 29) along the southeastern portion of the watershed, to over 1,200 feet above NGVD 29 in the northwestern lobe of the watershed. Runoff to Bark Lake flows from the higher elevations in the northwest to the lower elevations in the southeast. Field surveys of the Bark Lake watershed conducted by Commission staff in 2013 verified this general pattern of surface water flow to the Lake.

Internally Drained Areas

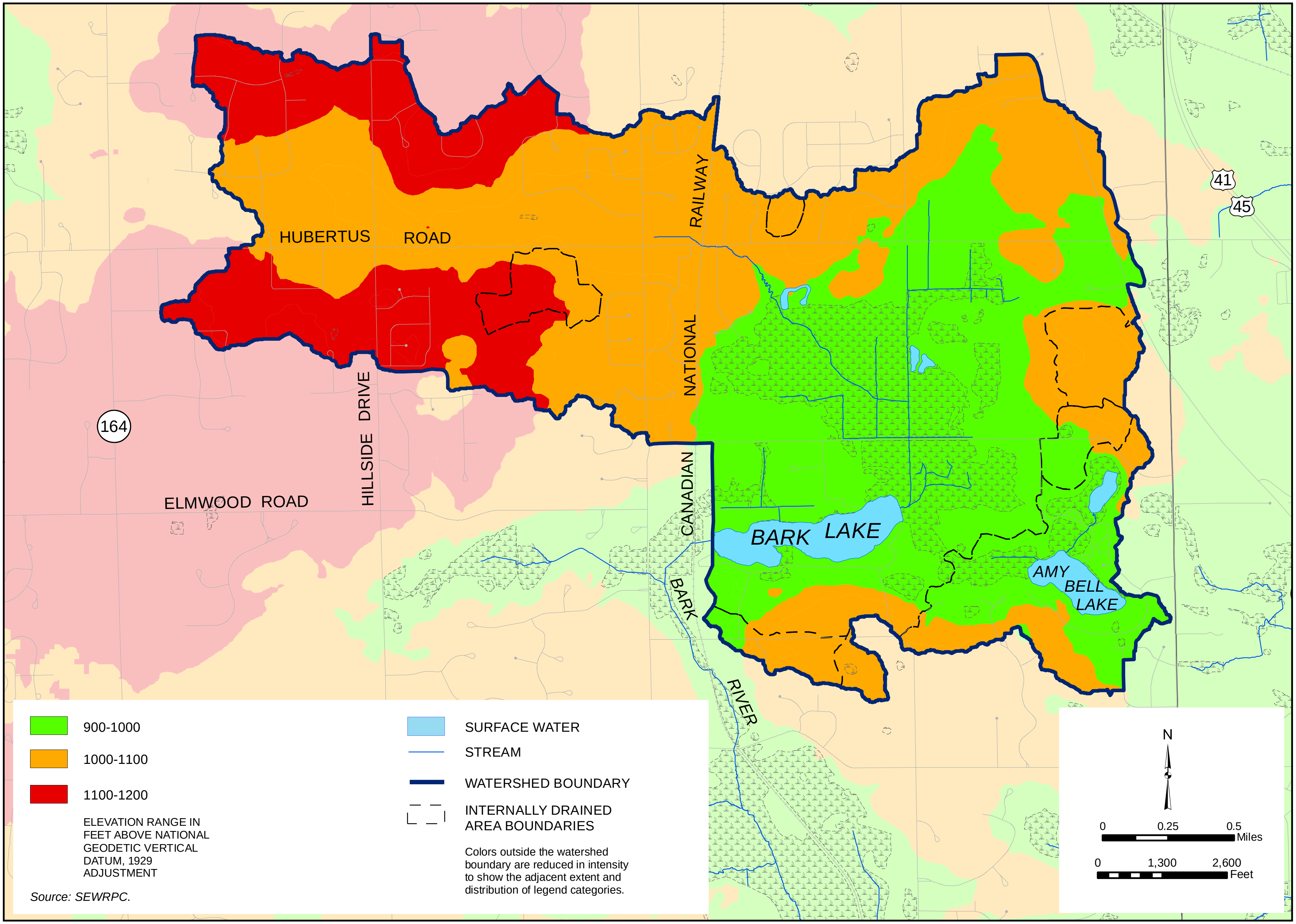
Shown on Map A-5 are the locations of several *internally drained* areas within the Bark Lake watershed. Such areas, as a result of their surface topography, trap surface waters and prevent them from entering Bark Lake via surface runoff (although the water which enters these areas may still drain to the Lake through a groundwater connection). The size, number, and locations of such areas can have a significant impact on the quality and quantity of surface water that drains to a lake. As shown on the map, there are seven such areas in the Bark Lake watershed: one located more-or-less centrally in the northwestern lobe of the watershed, a smaller one located along the northern boundary of the watershed, and five areas along the southeastern boundary of the watershed, one of which drains to Amy Belle Lake.

Slopes

Land slopes within a lake's watershed are an important consideration in determining amounts and types of runoff to a lake that can be expected. Poorly planned hillside development in areas of steep slopes can lead to severe construction and post-construction erosion problems, and high maintenance costs associated with infrastructure to remediate the effects of such erosion. Steeply sloped agricultural lands may make the operation of agricultural equipment difficult, or even hazardous, while development or cultivation of steeply sloped lands is likely to result in erosion and sedimentation that negatively impact surface water quality. Slope maps can therefore guide construction and erosion control efforts to prevent inadvertent damage to the Lake

Map A-4

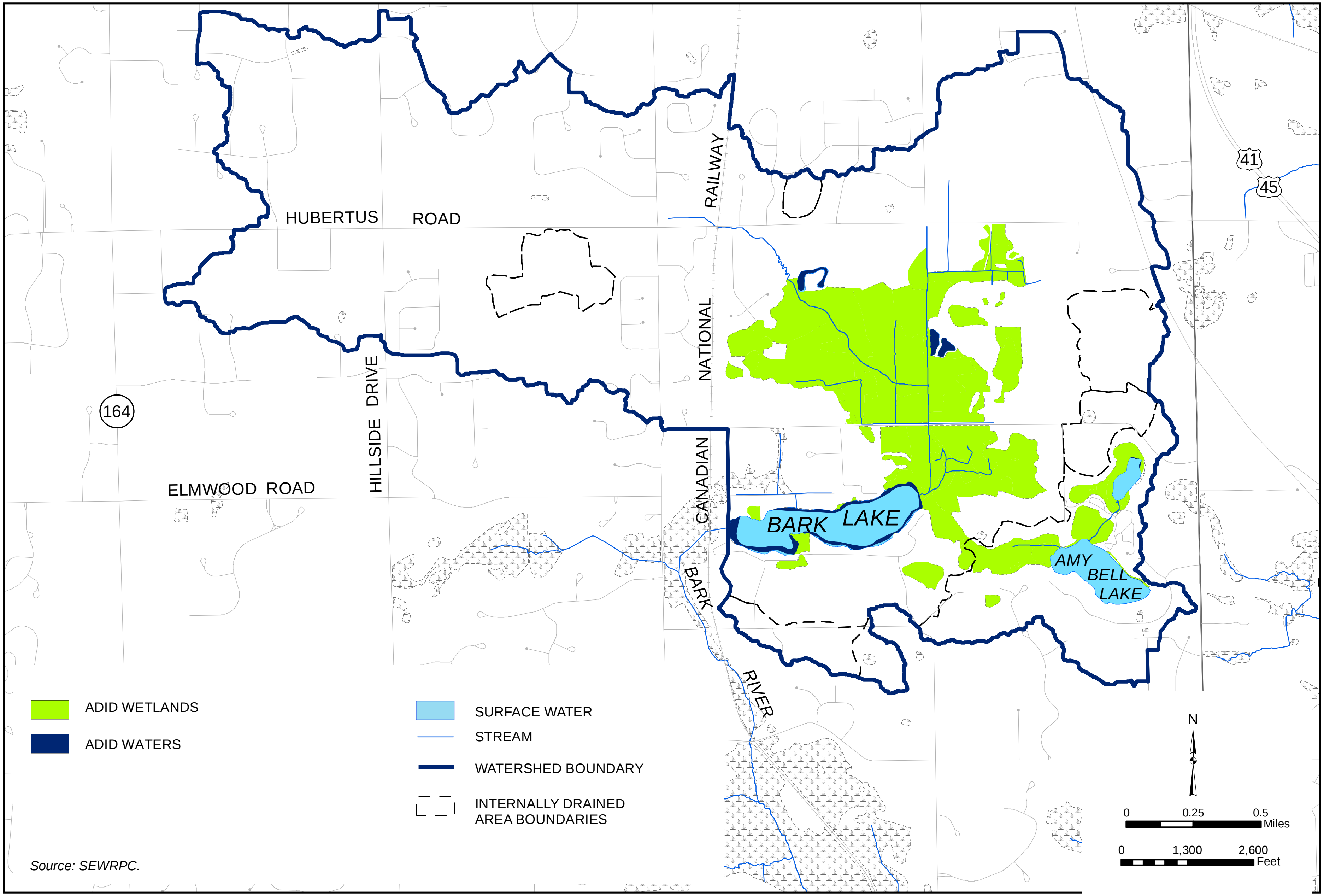
TOPOGRAPHIC AND PHYSIOGRAPHIC CHARACTERISTICS WITHIN THE BARK LAKE WATERSHED



Source: SEWRPC.

Map A-5

SURFACE WATER RESOURCES WITHIN THE BARK LAKE WATERSHED: 2010



Source: SEWRPC.

As shown on Map A-6, slopes in the Bark Lake watershed range from less than 1 percent to greater than 20 percent. Bark Lake generally sits in an area where surface slope is in the 0 to 6 percent range, although immediately to the south of the Lake is a relatively small portion of the watershed containing some of the steepest slopes to be found in the watershed at greater than 20 percent. Much of the watershed to the north and northeast of the Lake has relatively low slopes of less than 6 percent, and the northwestern portion of the watershed contains the majority of steeper sloped lands ranging anywhere from 7 to over 20 percent.

Groundwater

Groundwater within the Bark Lake watershed is crucial to sustaining water levels within the Lake, and flows and/or water levels within the upstream tributaries and wetlands. This is because the groundwater provides baseflow to the streams and wetlands of the watershed. Given that Bark Lake is a headwater lake, these groundwater inputs could potentially be a major reason why the Lake was able to maintain fairly steady water levels, and avoid fish kills, during the drought period in 2012. Additionally, groundwater is also a major source of water supply, with all of the communities within the Bark Lake watershed being dependent on groundwater for a potable water supply and for other urban and rural land uses. Groundwater resources thus constitute an extremely valuable element of the natural resource base within the Bark Lake watershed and need to be protected.

Groundwater Table Elevations

Whereas the boundaries of surface water watersheds are generally determined from topographic maps based on land elevations, the boundaries of groundwatersheds do not necessarily coincide with their surface water counterparts. While it is true that water—whether on the surface or moving through aquifers located below the surface, does flow overall from higher to lower elevations, the movement of groundwater in below-ground aquifer—systems is subject to a variety of additional factors, including geological formations that can block or redirect the flow of water. Map A-7 shows the general water table elevations, in feet above NGVD 29, in the Bark Lake watershed area based on water levels measured in wells. As indicated on the map, these groundwater table elevations generally follow the northwest to southeast downward slope reflected in the surface elevations in the surface watershed of Bark Lake.

Groundwater Recharge

As described above, groundwater plays an important role in sustaining lake levels and maintaining an adequate supply of potable water. Groundwater recharge, therefore, which depends almost entirely on precipitation, is also of great importance, as it maintains the aquifer levels. The amount of precipitation and snowmelt that infiltrates at any location and reaches the groundwater (i.e., groundwater recharge) depends mainly on the permeability of the soils located between the land surface and the groundwater table. Therefore, if soil characteristics are known, it is possible to determine which areas have the highest recharge potential. As shown on Map A-8, while the rates of groundwater recharge within the Bark Lake watershed range from *moderate* to *very high*, the majority of the watershed falls within the moderate category. There are also a few areas identified as having *undefined* rates of recharge, but these are mostly confined to the internally drained areas, as well as the large wetland area directly north of the Lake.

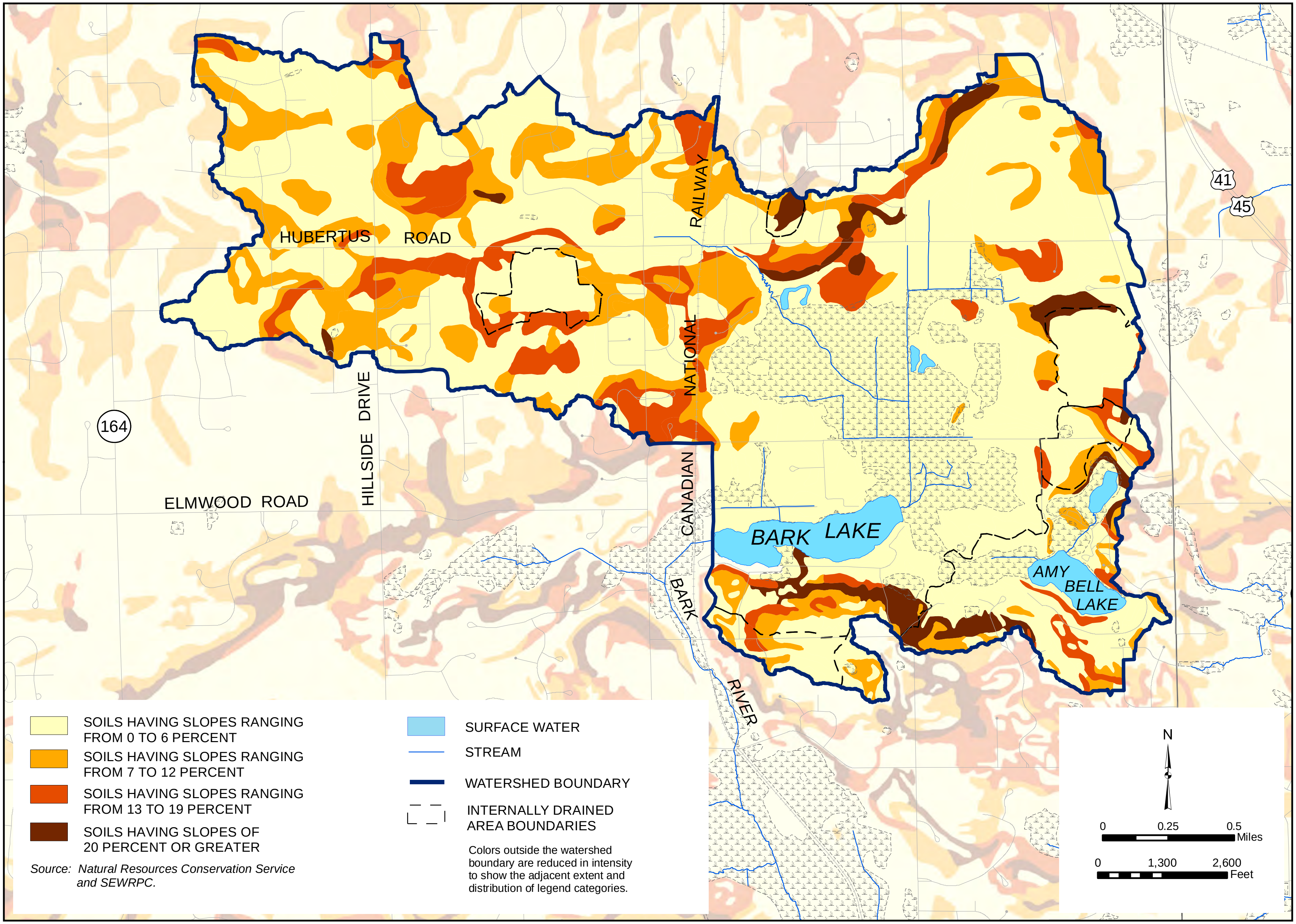
Knowing where the groundwater recharge takes place within the watershed is a crucial step toward protecting lake levels and water supply within the Bark Lake watershed. This is due to the fact that there are activities and land uses that can both reduce and encourage recharge to the groundwater supply, particularly if there are undertaken within the high and very high recharge regions. If development occurs, for example, the area of impervious surfaces may increase, thereby preventing groundwater recharge from continuing to occur in those areas. However, stormwater management practices can be installed to encourage infiltration of runoff. Such mitigating measures should, therefore, be seen as a priority in high groundwater recharge areas.

Depth to Groundwater

When groundwater recharge occurs it can also bring pollution such as pesticides, heavy metals, and nutrients with it. It is therefore important to target any infiltration efforts at areas where there is an adequate depth to groundwater (i.e., the distance between the ground surface, or the bottom of an engineered groundwater

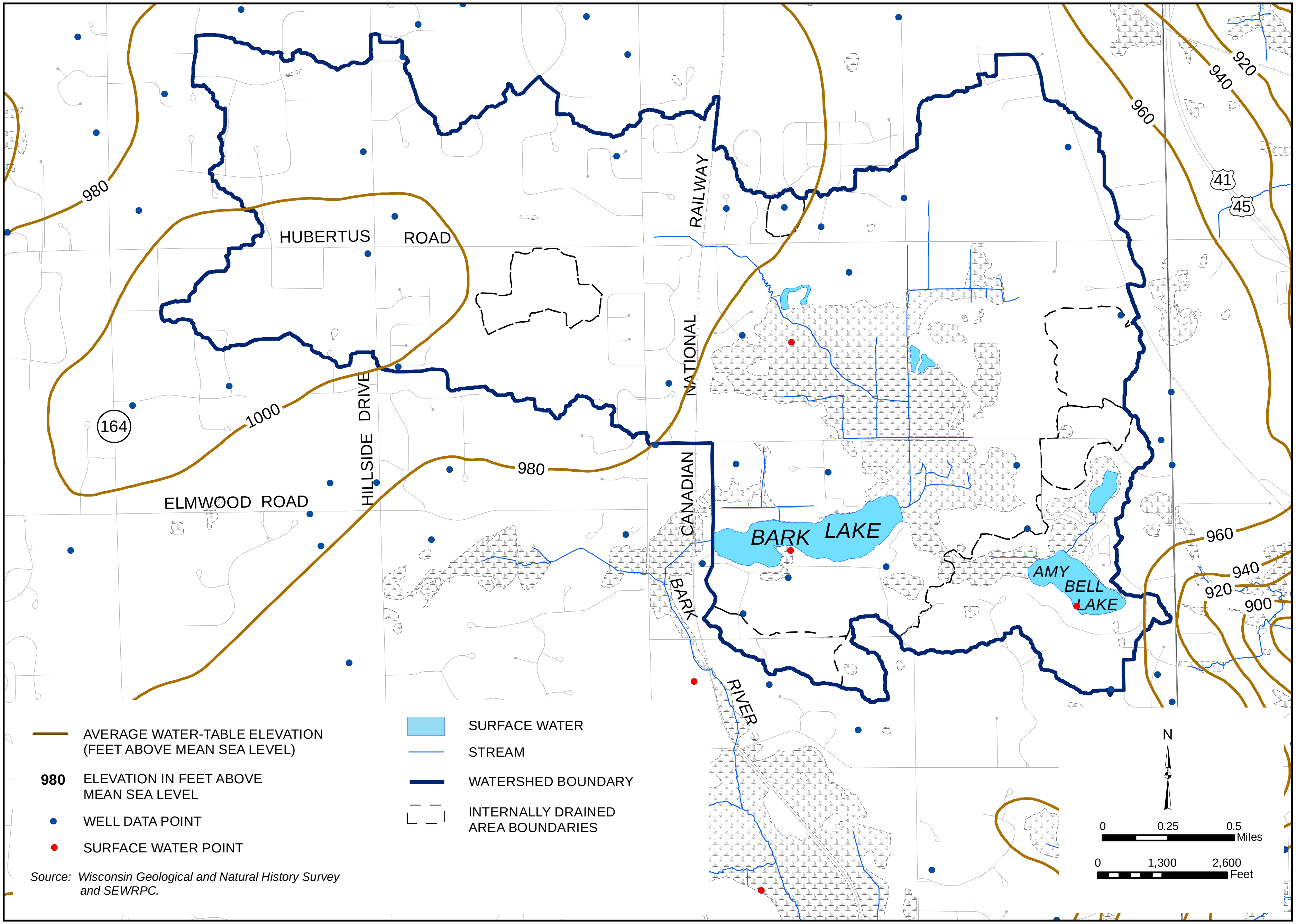
Map A-6

STEEP SLOPES WITHIN THE BARK LAKE WATERSHED



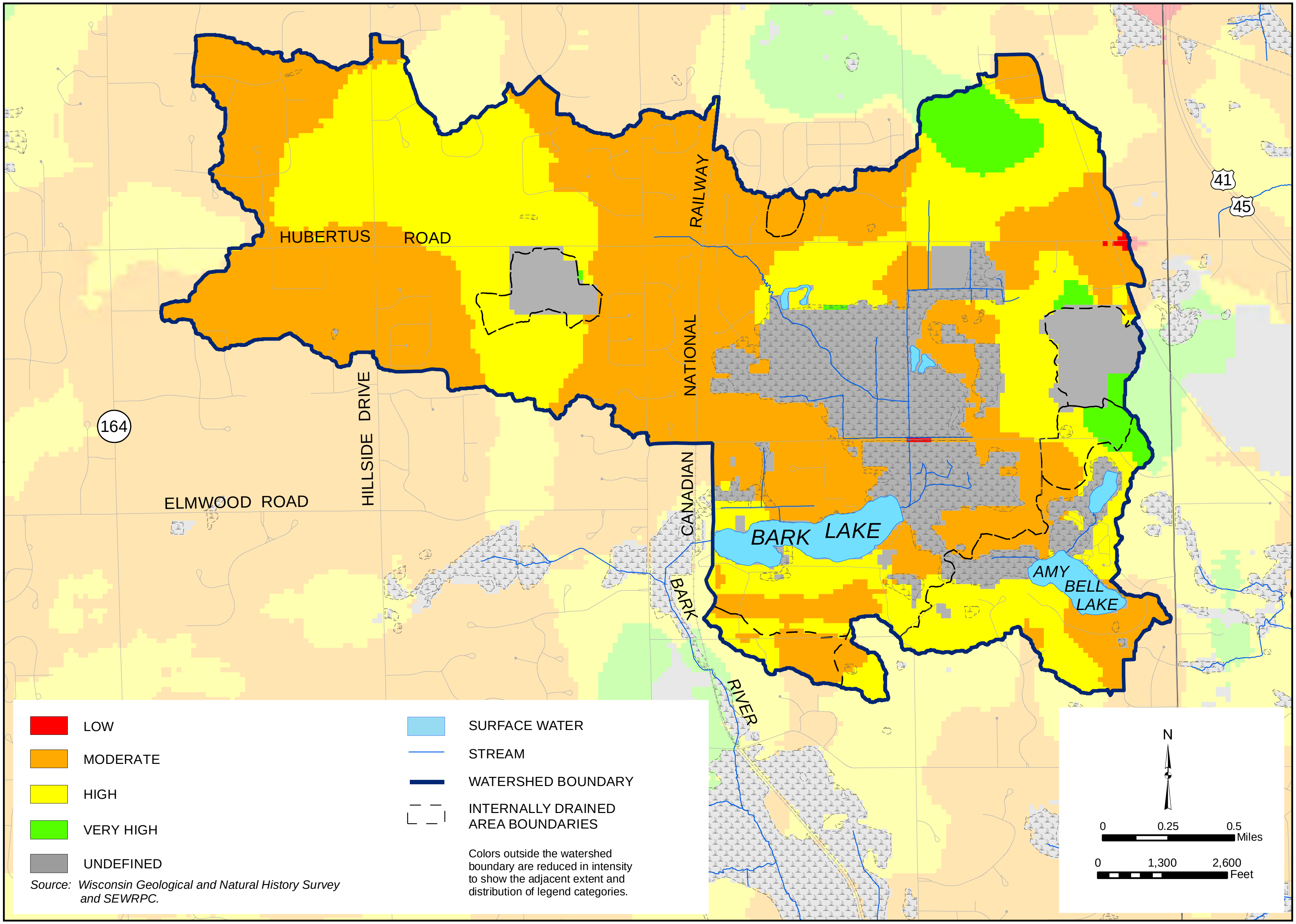
Map A-7

GROUNDWATER TABLE ELEVATIONS BASED ON WELL DATA WITHIN THE BARK LAKE WATERSHED



Map A-8

ESTIMATES OF GROUNDWATER RECHARGE POTENTIAL WITHIN THE BARK LAKE WATERSHED



infiltration facility, and the groundwater surface is found) so as to encourage natural pollution filtration within the soils. Depth to seasonal high groundwater levels for the Bark Lake watershed, which provide a context for understanding groundwater pollution potential, are shown on Map A-9. As expected, the depths to seasonal high groundwater levels in the watershed are generally consistent with the surface topography of the area, e.g., the areas of highest elevation in the watershed generally are those areas with the greatest depths to groundwater.

Soils

The glaciers that once covered southeastern Wisconsin deposited a wide variety of soil-forming materials and sculpted many different landforms that influence soil type and lake hydrology in the Southeastern Wisconsin Region. Soil type, land slope, land use, and vegetative cover are important factors for determining the rate, amount, and quality of stormwater runoff and, consequently, stream and lake water quality. Soil texture and soil particle structure can also influence the permeability, infiltration rate, and erodibility of soils. Additionally, the agricultural value of soils can be useful when determining agricultural areas that should be preserved and/or agricultural areas that should be priorities for conversion to natural areas (i.e., valuable soils stay as agricultural while other soils get priority for conversion to natural areas).

Soil Associations

The soils in the Bark Lake watershed, which are glacial in origin, are shown on Map A-10, and can be classified into three main soil associations, based upon the U.S. Department of Agriculture Natural Resources Conservation Service Soil Survey Geographic Database (SSURGO):[2]

- Hochheim-Theresa association—comprised of well-drained soils that have a subsoil of clay loam and silty clay loam that was formed in thin loess and loam glacial till, on ground moraines; and

- Houghton Palms Adrian—very poorly drained organic soils found in old drainageways, in old lakebeds, and in depressions and floodplains.

These soils generally range from poorly drained, organic soils to well-drained, mineral soils. The Hochheim-Theresa Association, a well-drained soil, blankets the vast majority of the watershed. The Houghton Palms Adrian poorly drained soils cover most of the remaining watershed, including the bulk of the soils in the wetland complex immediately to the north of the Lake.

Using the SSURGO data, these soils can be further subdivided into four main hydrologic groups; well-drained soils, moderately drained soils, poorly drained soils, and very poorly drained soils, as shown on Map A-11. A large proportion of the Bark Lake watershed is comprised of the well-drained Hochheim-Theresa soil association. This result is consistent with the high- to very-high permeability along with moderate to high groundwater recharge potential rankings of soils within this watershed.[3]

Agricultural and Open Lands within Federal and State Soil Classifications

The NRCS, formerly the U.S. Soil Conservation Service, has classified soil groups on the basis of their agricultural qualities and value. Map A-12 shows the locations of NRCS prime agricultural soil groups, as well as other soils of statewide importance (not in the NRCS prime group) and other agricultural lands not meeting State or Federal categories, found within the Bark Lake watershed. As shown on this map, although NRCS prime agricultural lands are generally scattered over the entire watershed, the largest single tracts are more common in

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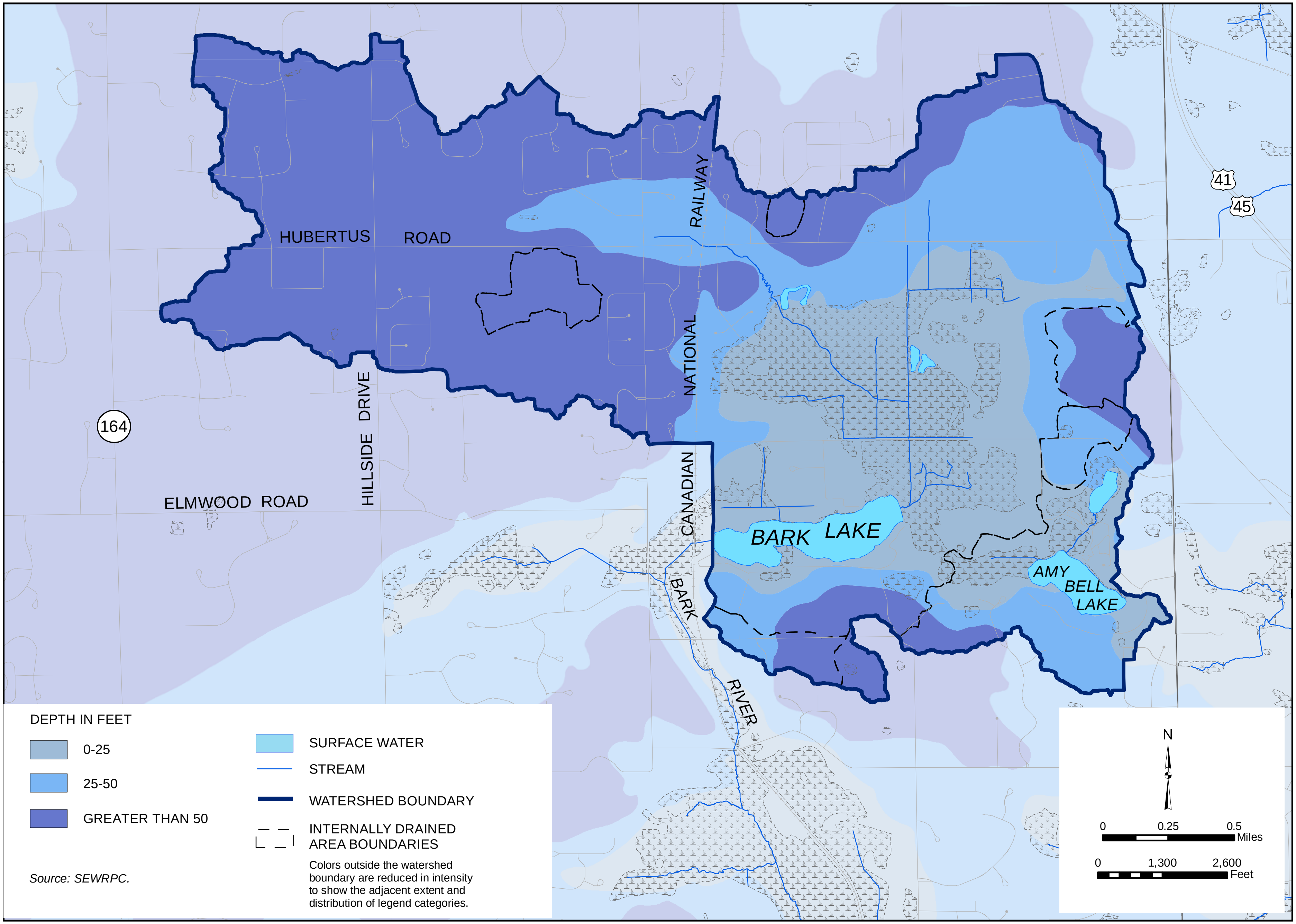
[2]*Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture,* Web Soil Survey. *Available online at:* http://websoilsurvey.nrcs.usda.gov/, *June 2012.*

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

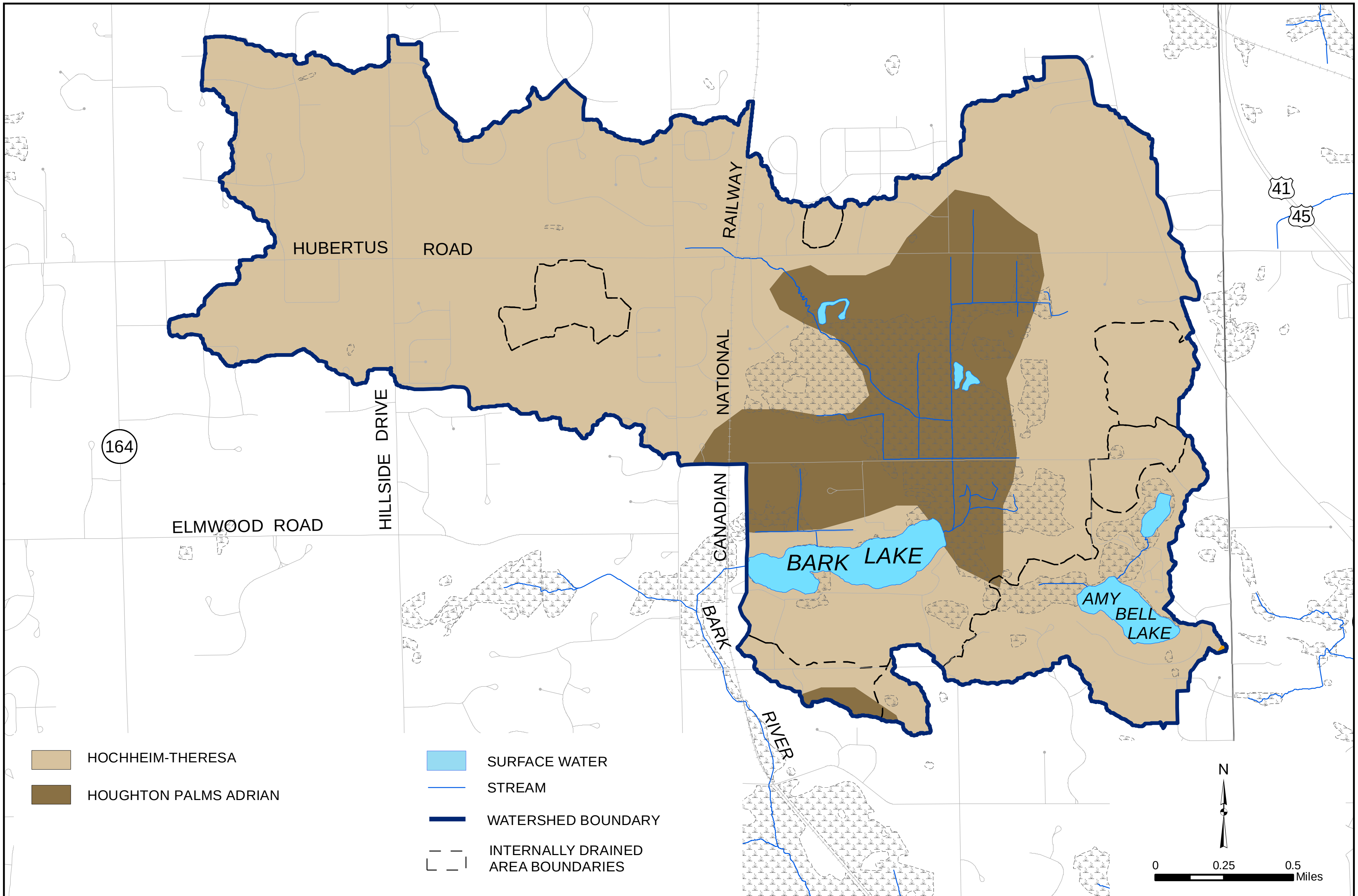
Map A-9

DEPTH TO SEASONAL HIGH GROUNDWATER LEVELS WITHIN THE BARK LAKE WATERSHED



Map A-10

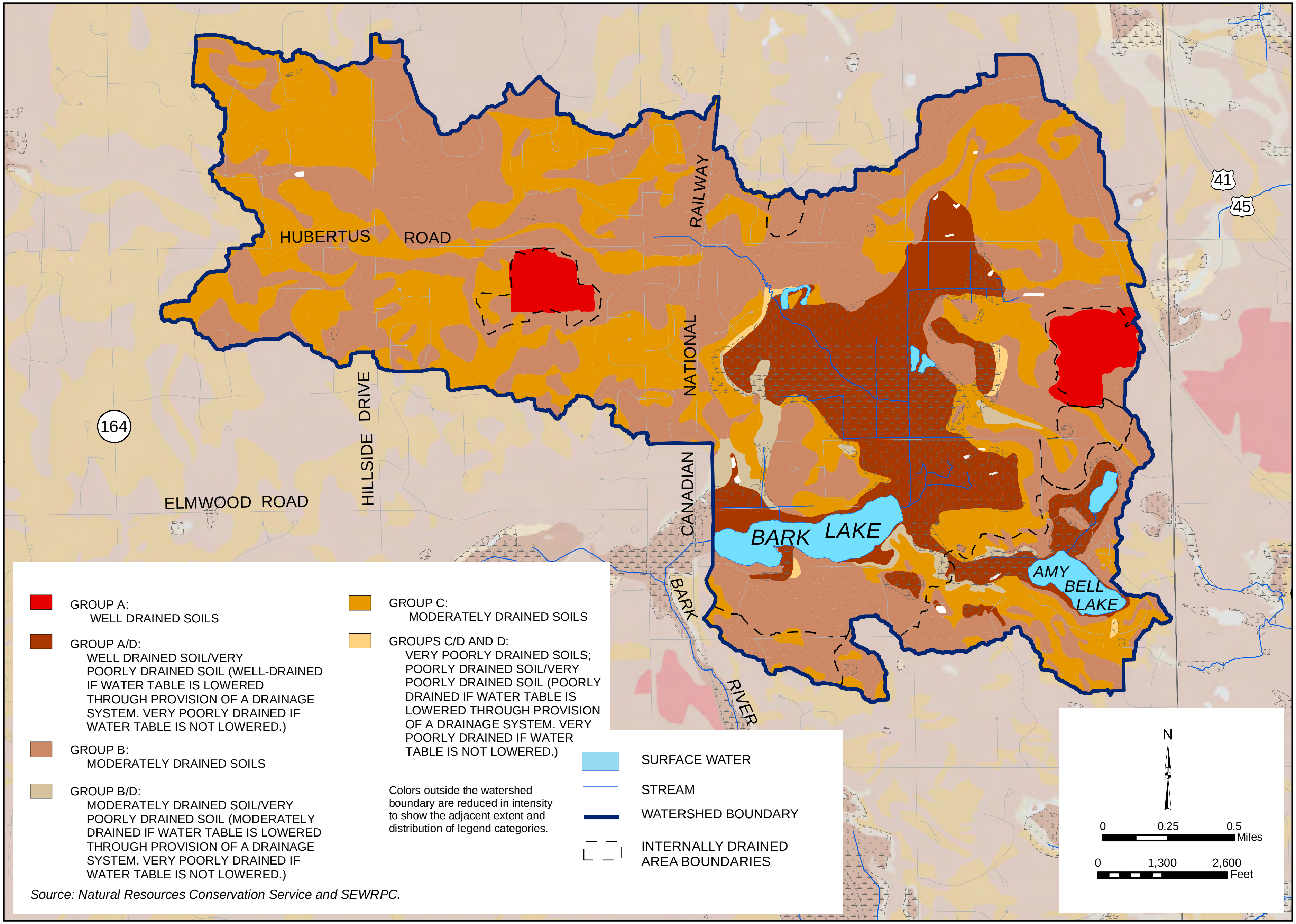
SOIL ASSOCIATIONS WITHIN THE BARK LAKE WATERSHED



Source: Natural Resources Conservation Service and SEWRPC.

Map A-11

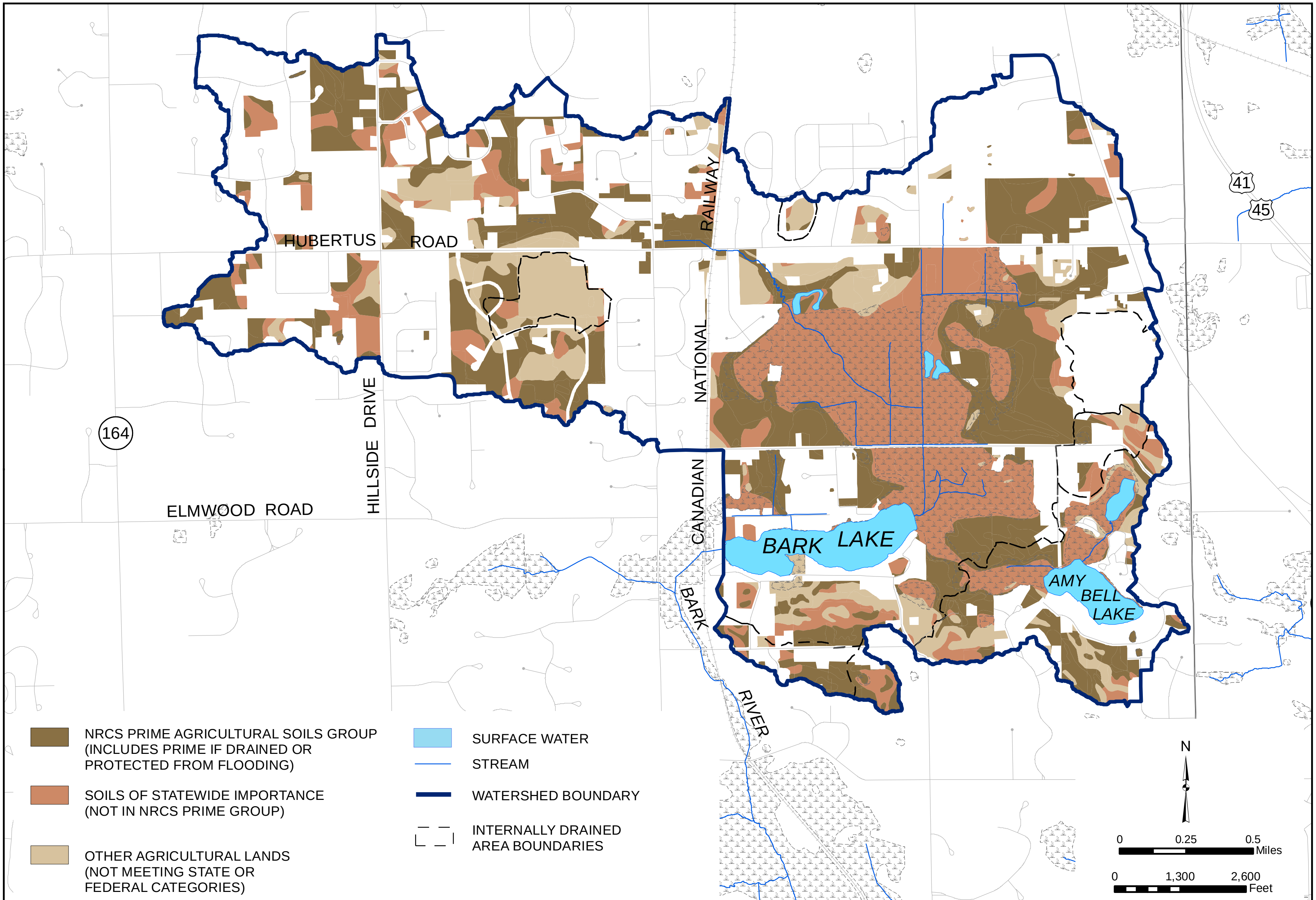
HYDROLOGIC SOIL GROUPS WITHIN THE BARK LAKE WATERSHED



Source: Natural Resources Conservation Service and SEWRPC.

Map A-12

2010 AGRICULTURAL AND OPEN LANDS WITHIN FEDERAL AND STATE SOIL CLASSIFICATIONS FOR AGRICULTURAL USES WITHIN THE BARK LAKE WATERSHED



Source: Natural Resources Conservation Service and SEWRPC.

Table A-2

EXISTING AND PLANNED LAND USE WITHIN THE TOTAL AREA TRIBUTARY TO BARK LAKE: 2010 AND 2035

Land Use Categories[a]	2010 Acres	2010 Percent of Total	2035 Acres	2035 Percent of Total
Urban				
Residential				
Single-Family, Suburban-Density	449	13.2	961	28.3
Single-Family, Low-Density	549	16.1	626	18.4
Single-Family, Medium-Density	- -	- -	- -	- -
Single-Family, High-Density	- -	- -	- -	- -
Multi-Family	- -	- -	23	0.7
Commercial	35	1.0	63	1.9
Industrial	10	0.3	12	0.3
Governmental and Institutional	29	0.9	36	1.0
Transportation, Communication, and Utilities	241	7.1	343	10.1
Recreational	200	5.9	202	5.9
Subtotal	1,513	44.5	2,266	66.6
Rural				
Agricultural and Other Open Lands	1,023	30.1	268	7.9
Wetlands	428	12.6	428	12.6
Woodlands	246	7.2	245	7.2
Water	114	3.4	114	3.4
Extractive	76	2.2	79	2.3
Landfill	- -	- -	- -	- -
Subtotal	1,887	55.5	1,134	33.4
Total	3,400	100.0	3,400	100.0

[a]*Parking included in associated use.*

Source: SEWRPC.

the eastern portion of the watershed with smaller, more fragmented pieces distributed over the northwestern lobe. It is noteworthy that the large wetland complex immediately north of the Lake contains the largest concentration of soils of statewide importance in the watershed, thereby further emphasizing the importance of the wetland to the Bark Lake watershed.

Existing and Planned Land Use

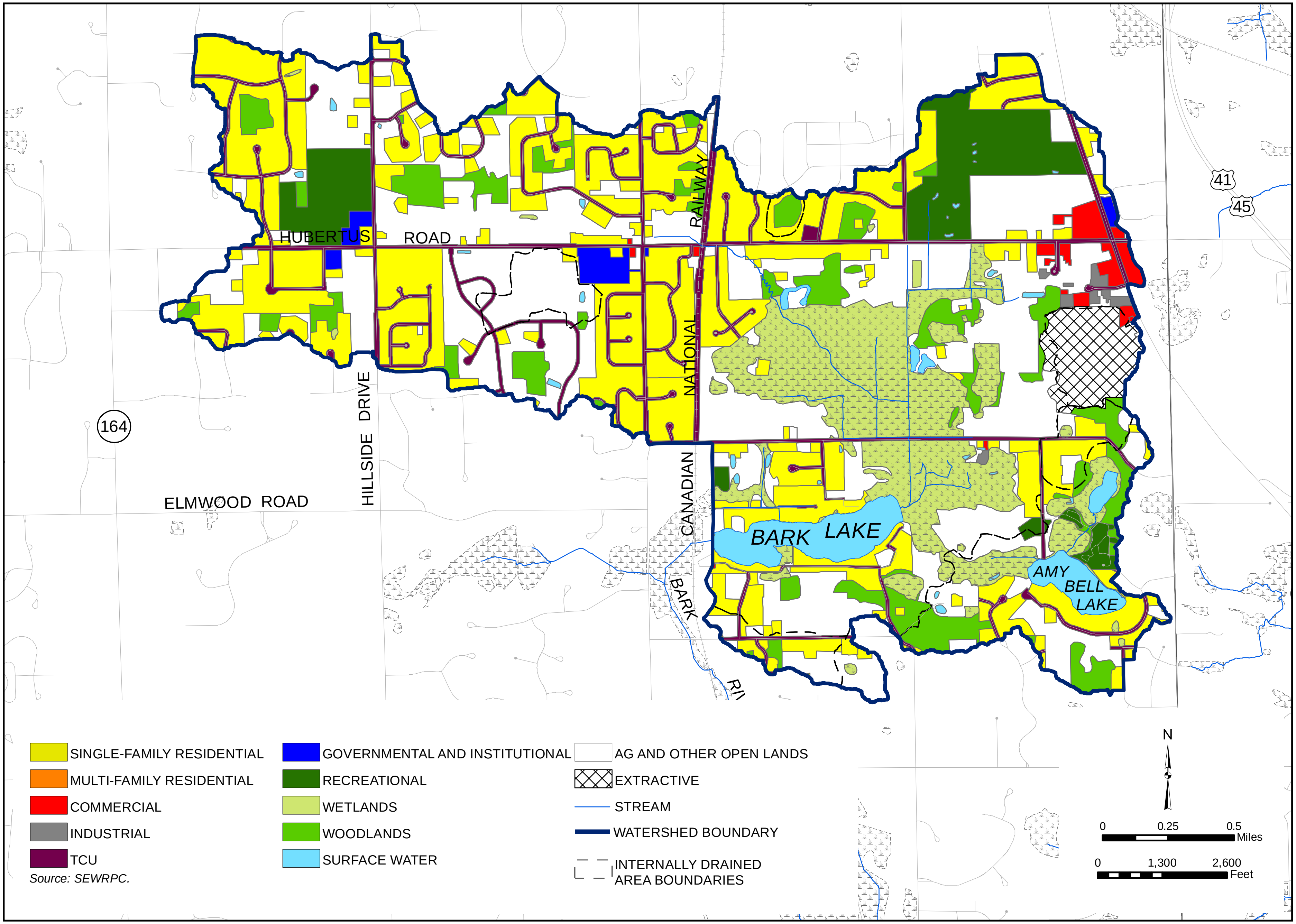
The types, intensity, and spatial distribution of land uses within the Bark Lake watershed are important elements in natural resource management. Land uses can generally be divided into urban uses and rural uses. Table A-2 shows the total acres of Bark Lake watershed being utilized for various rural and urban uses in 2010 compared to the number of acres planned to be in those uses. Map A-13 shows the distribution of those various land uses as they existed in 2010, and Map A-14 indicates the planned distribution of land uses for 2035.

Urban Land Uses

Urban land uses include residential; commercial; industrial; governmental and institutional; transportation, communication, utilities; and recreational lands. As indicated in Table A-2 and displayed on Map A-13, the various urban land uses together accounted for nearly 45 percent of the total Bark Lake watershed area in 2010. Single-family, low-density residential land use comprised the largest urban land use, covering about 549 acres, or about 16 percent, of the total watershed.

Map A-13

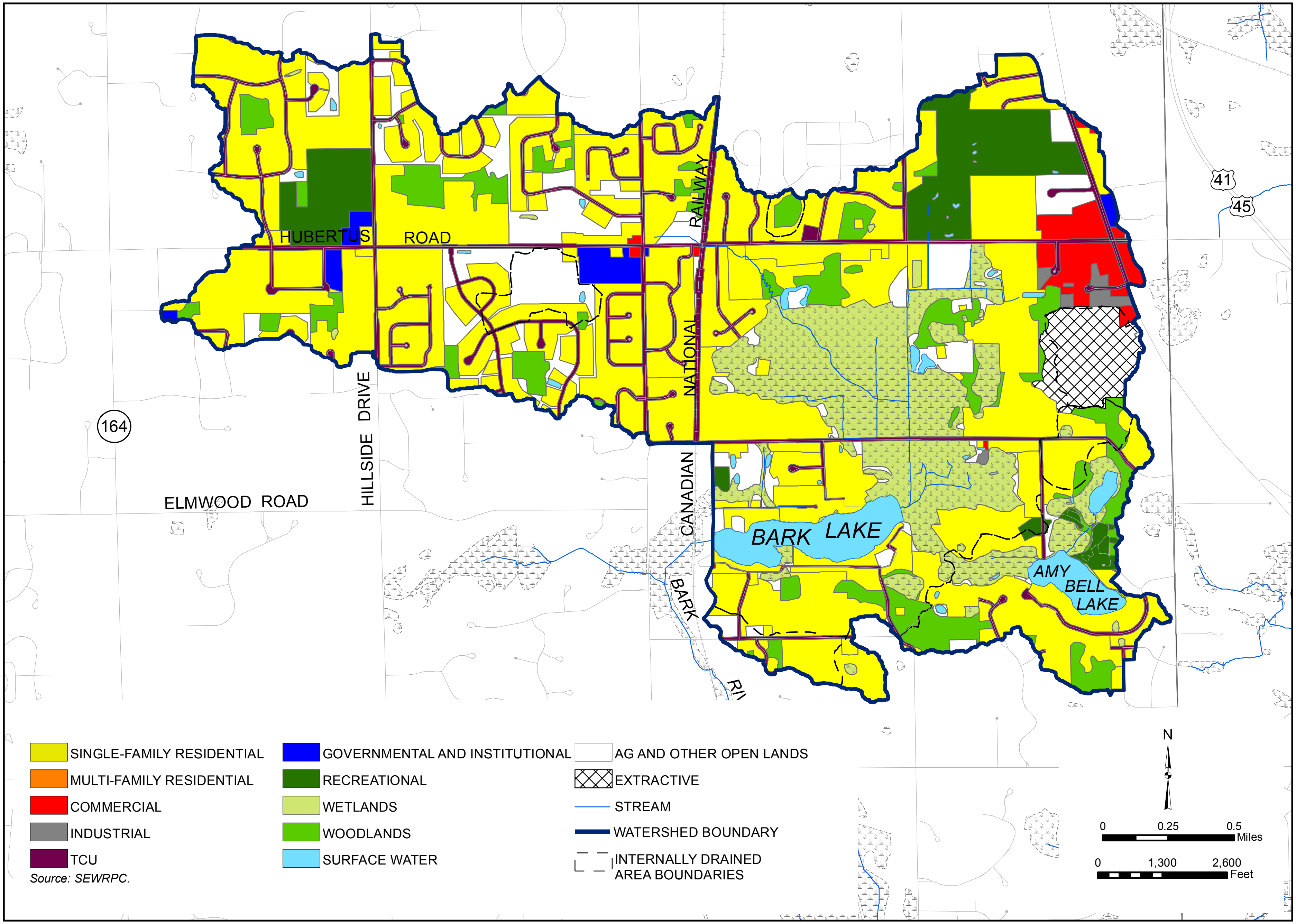
EXISTING 2010 LAND USES WITHIN THE BARK LAKE WATERSHED



Source: SEWRPC.

Map A-14

PLANNED 2035 LAND USES WITHIN THE BARK LAKE WATERSHED



Source: SEWRPC.

Table A-3

HISTORICAL URBAN GROWTH IN THE BARK LAKE TRIBUTARY AREA

Year	Incremental Land in Urban Use (acres)[a]
1920	15.9
1950	60.0
1963	75.3
1970	233.9
1975	92.9
1980	221.3
1985	34.2
1990	20.3
1995	77.6
2000	181.6
2010	148.6

[a]The additional land area in urban use since the preceding year in the table is indicated (e.g., from 2000 to 2010, 148.6 acres of urban land was added).

Source: SEWRPC.

Future changes in land use within the area tributary to the Lake's watershed may include further urban development, infilling of already platted lots, and possible redevelopment of existing properties. Under proposed year 2035 conditions,[4] as shown on Map A-14 and summarized in Table A-2, urban land uses are expected to increase significantly to about 67 percent of the land area in 2035. The area developed in residential uses alone is predicted to increase from about 30 percent of the watershed in 2010, to about 47 percent of the area in 2035. Such land use changes have the potential to significantly modify the nature and delivery of non-point source contaminants to the Lake, with concomitant impacts on the aquatic plant communities and aquatic organisms.

Rural Land Use

Rural lands in the watershed are comprised of woodlands, wetlands, surface water, agricultural lands, other open lands, and extractive uses. As shown on Map A-13 and Table A-2, these various rural land uses together accounted for about 56 percent of the total land area of the Bark Lake watershed in 2010. Agricultural and other open land uses were the largest rural land use in the watershed, encompassing about 30 percent of the total land area. Agricultural land use is divided between active cropland and other open lands, which includes farm buildings, pastures, grasslands that have not succeeded to wetland or woodland communities, and lands adjacent to cropland, such as treelines and hedgerows.

Under proposed year 2035 conditions,[5] as shown on Map A-14 and summarized in Table A-2, rural land uses, especially agricultural use, are expected to decrease significantly from about 30 percent of the land area in 2010, to about 8 percent of the land area in 2035. Most of this land will be converted to residential use.

Historical Urban Growth

The current and planned land use patterns, placed in the context of the historical development of the area, can help the Bark Lake community evaluate what has taken place within the watershed throughout the past 100 years and provide context to any historical water quality data that is obtained on Bark Lake. Historical urban growth within the Bark Lake watershed is presented in Table A-3. As shown in the table, the greatest increases in urban land use in the Bark Lake watershed occurred between 1963 and 1970 and between 1975 and 1980.

Pre- and post-1990 growth is summarized on Map A-15. This map shows that the lands around the shoreline of Bark Lake were developed prior to 1990. Most of the rest of the pre-1990 development in the watershed took place in a north-south corridor in proximity to the railroad right-of-way that runs through the center of the watershed, and in a relatively large tract of land in the western half of the watershed. The majority of post-1990 development has occurred in the western half of the watershed.

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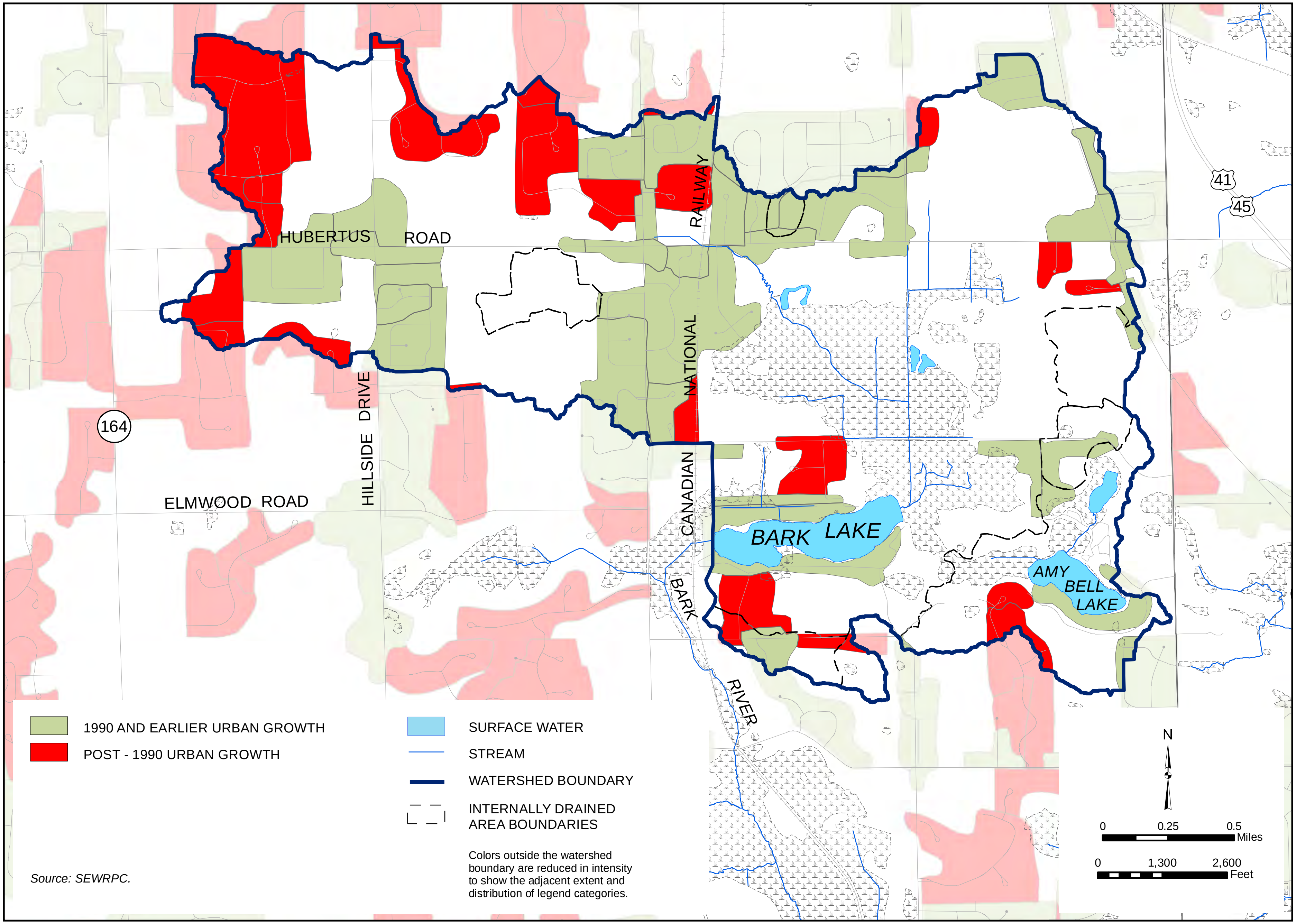
[4]*See SEWRPC Planning Report No. 48,* A Regional Land Use Plan for Southeastern Wisconsin: 2035*, June 2006; see also SEWRPC Community Assistance Planning Report No. 299,* A Multi-Jurisdictional Comprehensive Plan for Washington County: 2035*, April 2010.*

[5]Ibid.

Map A-15

HISTORICAL URBAN GROWTH WITHIN THE BARK LAKE WATERSHED: BEFORE AND AFTER 1990



Source: SEWRPC.

Map A-16 reveals the pattern of historic urban growth in the Bark Lake watershed in more detail over the past century. During the first half of the century (from 1900 to 1950), development in the watershed occurred primarily in the lakeshore areas around Bark Lake (and Amy Bell Lake) and in the settlement of Hubertus along Hubertus Road in the area of Scenic Road. During the 20-year period from 1950 to 1970, development occurred mainly in the central portion of the watershed in the vicinity of the railway right-of-way, in the western portion of the watershed, and in the extreme northeast corner. The decade from 1970 to 1980 witnessed moderate expansion of development adjacent to many of the areas settled during the previous era (1950 to 1970). Then, during the period from 1980 to 1990, the rate of development in the watershed slowed considerably, limited to two relatively small areas, one in the extreme eastern part of the watershed, the other in the western part. The decades from 1990 to 2000 and 2000 to 2010 saw a return of more robust rates of development occurring in the watershed, the majority of which took place in the western half of the watershed, especially along the northern boundary and northwest corner, although there was also a modest level of development in the southern parts of the eastern half of the watershed.

Population and Households

Growth in population and numbers of households from 1960 to 2010 in the Bark Lake watershed is shown in Table A-4. The number of households within the area tributary to Bark Lake has generally shown an increase in each decade since 1960. Population increased from 1960 through 1980, but it has generally decreased, or levelled off since that time. The greatest increase in population occurred during the decade from 1960 to 1970 when the number of people increased by about 152 percent. The greatest increase in the number of households also occurred during that period, when the number of households increased by about 161 percent. During the most recent decade from 2000 to 2010, population decreased by about 2 percent and the number of households increased by about 6 percent.

Septic Service

The presence or absence of septic tank sewerage systems can greatly influence the water quality of a lake and its tributaries, particularly if septic tanks are not being properly maintained. Leaking septic systems can lead to raw sewage and associated bacteria and nutrients draining into the lake and its tributaries. Sanitary sewerage systems can sometimes mitigate these issues by conveying and/or pumping wastewater to a centralized facility where it is treated However, the entire Bark Lake watershed is served by septic systems thus adequate monitoring and maintenance of these systems is important, particularly in areas with shallow depth to groundwater (see Map A-9) and high groundwater recharge (see Map A-8).

SHORELINE PROTECTION AND EROSION CONTROL

Erosion of shorelines results in the loss of land, damage to shoreline infrastructure, and interference with lake access and use. Wind-wave action, ice movement, and wave action produced by motorized boat traffic and activities are usually the primary causes of such erosion along unprotected or under-protected shoreline.

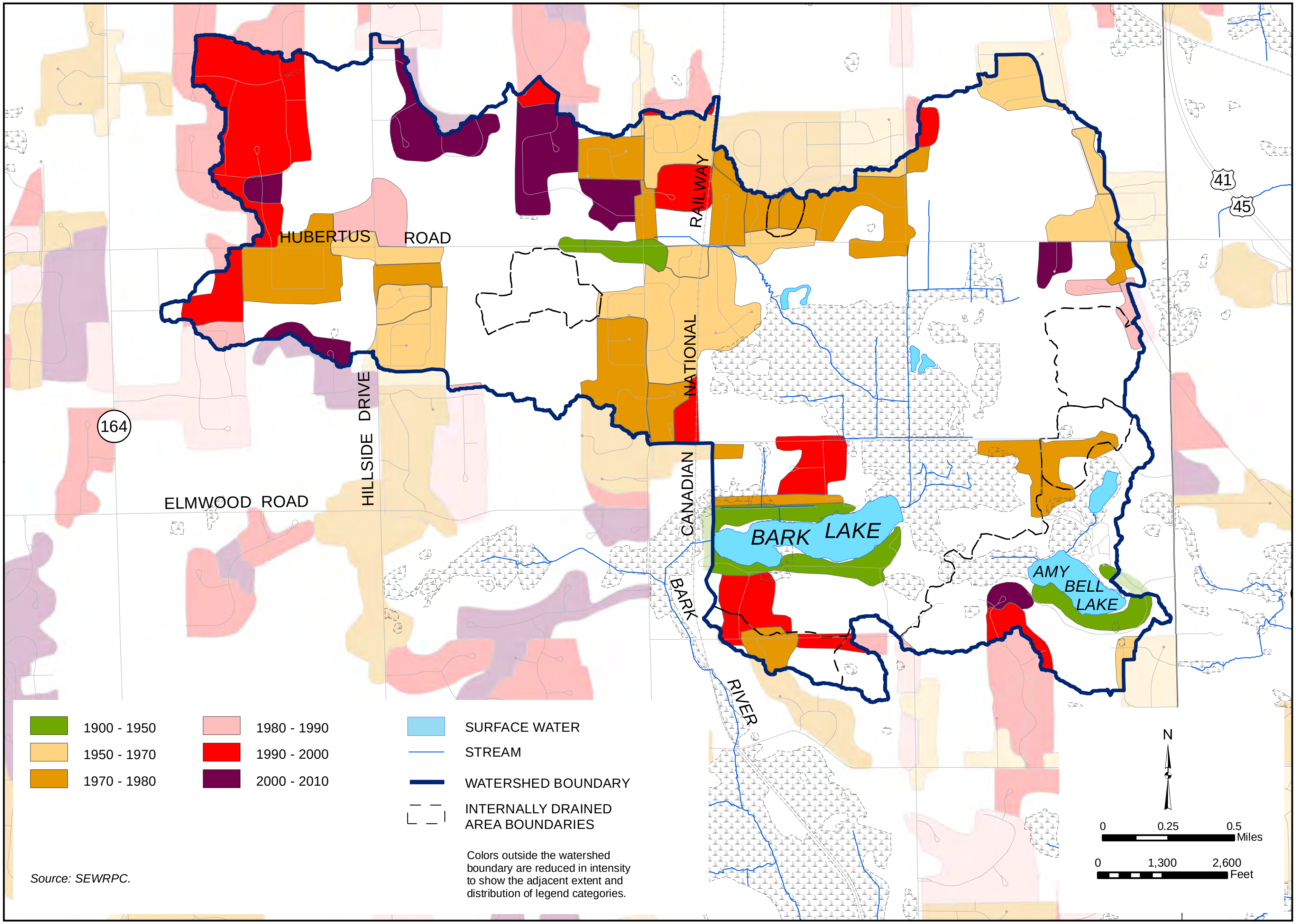
Constructed and Natural Shoreline Protection

Most riparian owners recognize the value of protecting their shorelines from erosion. Often some kind of man-made structure or material has been installed in an attempt to provide protection from erosive forces. Most such structures generally fall into one of three categories, including: 1) "bulkhead," where a solid, *vertical* wall of some material, such as poured concrete, steel, or timber, is erected; 2) "revetment," where a solid, *sloping* wall, usually asphalt, as in the case of a roadway, or poured concrete, is used; and 3) "riprap," where a barrier of rocks and/or stones is placed along the shoreline. Beach areas are considered as a separate category.

However, shoreline protection does not always depend on the installation of man-made structures. Many different kinds of natural shorelines offer substantial protection against erosive forces. The rock boulders and cliffs found along Lake Superior, for example, are natural barriers that serve to protect against shoreline erosion. Additionally, marshlands, such as those found at the east end of Bark Lake and large areas of exposed cattail stalks are a very effective mitigator of shoreline erosive forces, as they act to disperse and dampen waves by dissipating their energy against the plant rather than the shoreline.

Map A-16

HISTORICAL URBAN GROWTH WITHIN THE BARK LAKE WATERSHED: 1900-2010



Colors outside the watershed boundary are reduced in intensity to show the adjacent extent and distribution of legend categories.

Source: SEWRPC.

Table A-4

POPULATION AND HOUSEHOLDS IN THE BARK LAKE TRIBUTARY AREA: 1960-2010

Year	Population	Change from Previous Decade		Households	Change from Previous Decade	
		Number	Percent		Number	Percent
1960	802	- -	- -	191	- -	- -
1970	2,025	1,223	152	499	308	161
1980	2,506	481	24	701	202	40
1990	2,409	-97	-4	767	66	9
2000	2,444	35	1	881	114	15
2010	2,392	-52	-2	930	49	6

Source: U.S. Bureau of Census and SEWRPC.

In fact, the "hard" man-made seawalls of stone, riprap, concrete, timbers, and steel, once considered state-of-the-art in shoreline protection, are now recognized as only part of the solution in protecting and restoring a lake's water quality, wildlife, recreational opportunities, and scenic beauty. More recently, "soft" shoreline protection techniques, referred to as "vegetative shoreline protection," involving a combination of materials including native plantings, are increasingly required pursuant to Chapter NR 328 of the *Wisconsin Administrative Code.* They are also increasingly popular as riparian owners have become aware of the value of protecting their shorelines and improving the viewshed and natural habitat for wildlife.

A survey of the types of shoreline protection found around Bark Lake was conducted by SEWRPC staff during summers of 2012 and 2013. The results of that survey are shown on Map A-17. As with most lakes in the Region, the shoreline of Bark Lake was found to be comprised of stretches of protected shoreline, either man-made or natural, as well as some areas of unprotected shoreline, such as where a riparian owner has mowed a lawn to water's edge or where the shoreline of a wooded lot has been left unprotected. Of the three main types of man-made protection structures observed, riprap was the most commonly occurring type and revetment was the least common type. Figure A-1 shows the various types of shoreline protection observed on Bark Lake during the 2012/2013 surveys. A more comprehensive shoreline assessment was also completed in 2013 for the purpose of guiding management efforts. Map 6 in Chapter II of this report depicts the results of this assessment.

Onshore Buffer Zones

Buffer zones are those onshore areas adjacent to the shorelines of waterbodies, such as lakes, rivers, and wetlands, consisting of a band of vegetation populated with those plant species that help stabilize shorelines against erosion, filter pollutants from runoff, and, when located along streambanks, can lessen downstream flooding and help maintain stream baseflows. Onshore buffers are a proven means of effectively reducing nonpoint source pollution loads to surface waters. Buffers can function to remove sediment, phosphorus, agrichemicals, urban pollutants (metals), and pathogens. When planted with native species, such buffers offer the additional advantage of improving the viewshed and attracting native wildlife.

The use of onshore buffer zones to enhance shoreline and water quality protection has been gaining support among those individuals and organizations charged with the protection of lakes and streams. Although neatly trimmed grass lawns along shorelines are popular, they offer limited benefits for water quality or wildlife habitat, and the cumulative effects of many houses with such shorelines can negatively impact streams, lakes, and wetlands.[6] When combined with stormwater management best practices, environmentally friendly yard care,

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[6]*SEWRPC Riparian Buffer Management Guide No. 1,* Managing the Water's Edge: Making Natural Connections, *May 2010.*

Map A-17

SHORELINE STRUCTURES ON BARK LAKE: 2012/2013

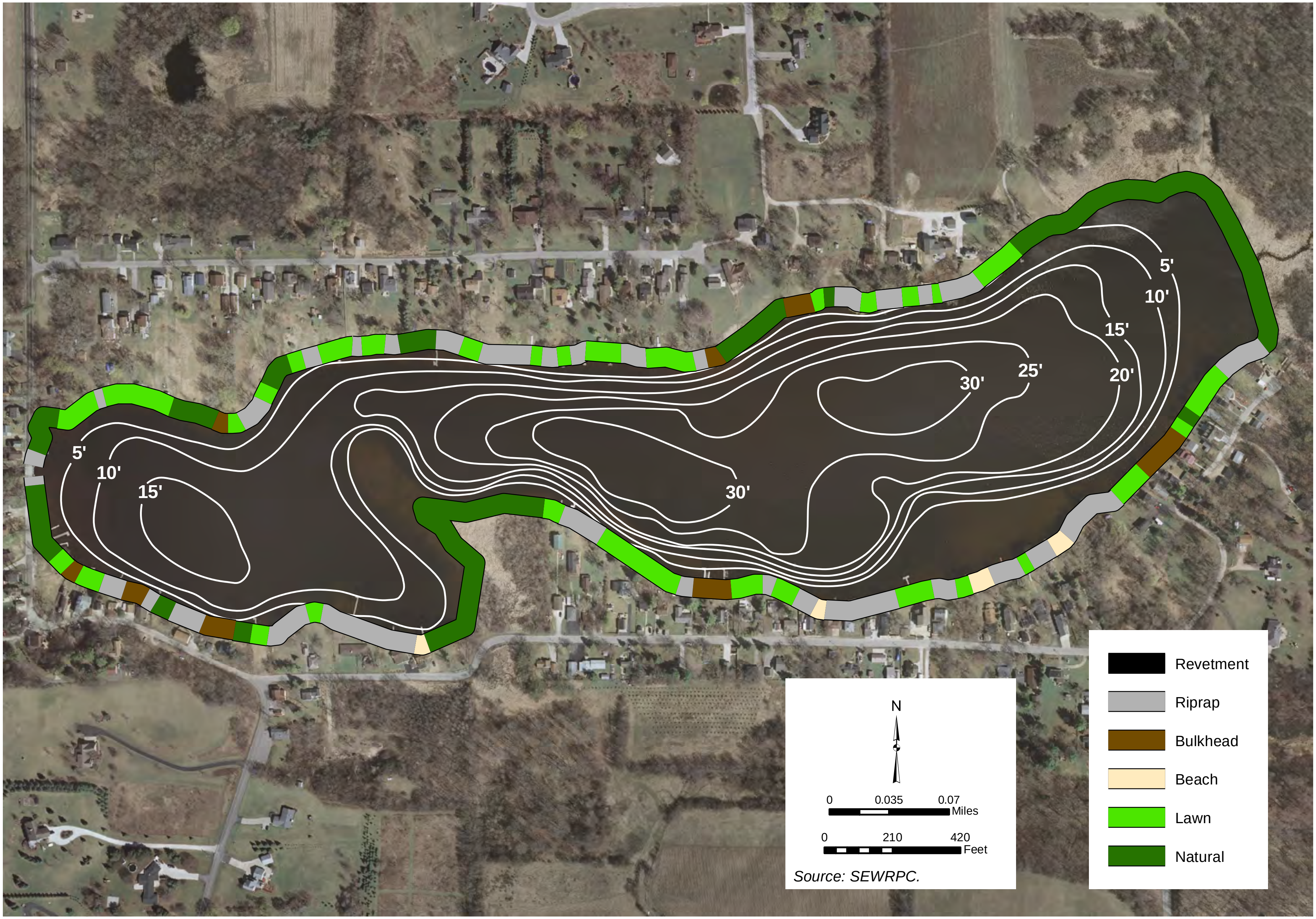

Figure A-1

SHORELINE PROTECTION TECHNIQUES ON BARK LAKE: 2012-2013

RIPRAP

NATURAL VEGETATION

BULKHEAD

REVETMENT

Source: SEWRPC.

effective wastewater treatment, conservation farm methods, and appropriate use of fertilizers and other agri-chemicals, vegetative buffer zones complete the set of actions that can minimize impacts to our shared water resources.[7]

The comprehensive shoreline assessment completed by SEWRPC staff indicated that, in general, there were no significant man-made buffer zones on Bark Lake, which is not unusual for lakes in the Region. This is something that will need to be addressed over time to improve water quality and wildlife habitat in the Bark Lake watershed.

[7]Ibid.

Table A-5

SECCHI-DISK MEASUREMENTS FOR BARK LAKE: 1979-2010

Date	Water Clarity Measurement (feet)	Source of Data
09/06/1979	5.5	STORET Legacy
09/18/1980	9.5	WDNR Baseline
06/25/1992	4.9	WDNR Baseline
07/13/1992	7.9	WDNR Baseline
09/02/1992	5.7	WDNR Baseline
07/09/2001	3.6	Landsat
09/17/2003	6.3	Landsat
07/25/2004	4.8	Landsat
08/03/2007	8.5	Landsat
08/28/2008	6.6	Landsat
07/07/2009	4.0	Landsat
08/24/2009	2.9	Landsat
07/10/2010	4.9	Landsat
08/27/2010	4.7	Landsat
09/12/2010	5.2	Landsat
09/28/2010	5.2	Landsat

Source: Wisconsin Department of Natural Resources and SEWRPC.

WATER QUALITY IN BARK LAKE

Historical water quality data for Bark Lake includes water clarity measurements, based on Secchi-disk readings dating from 1979 through 2010, and a few scattered water chemistry measurements, based on water samples taken in 1979, 1980, 1981, 1992, and 1997. The primary sampling station used for the water chemistry measurements was located at the deepest portion of Bark Lake in the eastern basin of the Lake, as shown on Map A-2. Overall, historical water quality data for Bark Lake is extremely limited in amount and somewhat outdated. Water clarity data, for example, consists of less than a half dozen in-lake measurements, none more recent than 1992, and less than a dozen estimates made from satellite observations during the time period from 2001 through 2010. Water chemistry data is also sparse, consisting of one fairly comprehensive set of measurements taken in 1979, and only about half a dozen incomplete and intermittent sets of measurements, with the most recent being made in 1997.

Principal Water Quality Factors

Water Clarity

Water clarity, or transparency, is often used as an indication of a lake's water quality. It can be affected by physical factors, such as suspended particles, and by various biologic factors, including seasonal variations in planktonic algal populations living in a lake. Water clarity is typically measured with a Secchi disk, a black-and-white, eight-inch-diameter disk, which is lowered into the water until a depth is reached at which the disk is no longer visible. This depth is known as the "Secchi-disk measurement." Such measurements provide a ready means of assessing water quality, and, hence, comprise an important part of lake water quality monitoring efforts. In a study of 54 lakes in southeastern Wisconsin, the mean Secchi-disk measurement was about five feet.[8]

Secchi-disk measurements collected by the WDNR for Bark Lake are presented in Table A-5. As shown in the table, measurements for Bark Lake have been taken at somewhat sporadic intervals since 1979. There were five recorded measurements between 1979 and 1992 that ranged from 5.5 feet to 9.5 feet, with the average measurement being 6.7 feet. With only five measurements over such a long time span (13 years), it is difficult to identify any definite trends. However, a measurement of 5.5 feet would be considered indicative of poor water quality, while a measurement of 9.5 feet would be considered good water quality. It may be worthy to note that of the five measurements recorded over this time period, the last three were all taken in 1992. These 1992 measurements alone ranged from 4.9 feet to 7.9 feet and averaged a little over six feet, indicative of water quality at the upper end of the poor range and close to the fair range. Because of the closeness in time of the three 1992 measurements, they should be considered a more accurate representation of Bark Lake's water quality at that time.

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[8]*R.A. Lillie and J.W. Mason, Wisconsin Department of Natural Resources Technical Bulletin No. 138,* Limnological Characteristics of Wisconsin Lakes, *1983.*

Table A-6

KEY WATER CHEMISTRY PARAMETERS IN BARK LAKE AND OTHER REGIONAL LAKES

Key Water Quality Parameters[a]	Regional Averages[b]	Bark Lake[c] (1979-1992)	Friess Lake[d] (1986-1994)	Pike Lake[e] (1999-2012)	George Lake[f] (1976-1989)
Secchi Disk/Clarity (feet)	4.9	6.7	4.3	6.9	2.0
Lake Thermally Stratifies	- -	Likely[g]	Yes	Yes	Yes
History of Hypolimnetic Anoxia	- -	Yes	Yes	Yes	No
Surface Total Phosphorus	0.079	0.022	0.029	0.023	0.100
Internal Loading of Phosphorus	- -	Possible[g]	Minimal	Possible	Unlikely
Chlorophyll-*a* (μg/l)	43	9.45	14	6	36.0
Surface Total Nitrogen	1.43	1.68	1.30	0.86	1.40
Turbidity	6.70	1.63	1.98	N/A	12.9
TSI/Secchi	N/A	50.0	53.2	50.1	61.0
TSI/Phosphorus	N/A	51.8	53.9	51.6	57.9
TSI/Chlor-*a*	N/A	51.7	51.7	47.1	52.3
Trophic State	N/A	Meso-eutrophic	Meso-eutrophic	Mesotrophic	Eutrophic

[a]*All values in mg/l unless otherwise specified.*

[b]*Data based on a 14-year study (1966-1980) conducted by the Water Resources Research Section, Bureau of Research, as presented* in *R.A. Lillie and J.W. Mason, Wisconsin Department of Natural Resources Technical Bulletin No. 138,* Limnological Characteristics of Wisconsin Lakes, *1983.*

[c]*Bark Lake data is based on the average for summer and fall, 1979-1992.*

[d]*Friess Lake is a 119-acre drainage, or flow-through, lake in Washington County within proximity to Bark Lake. Data is based on the average of summer and fall measurements from 1986 to 1994 (spring overturn 1986-94 for total nitrogen and turbidity); see SEWRPC Memorandum Report No.169,* An Aquatic Plant Management Plan for Friess Lake, Washington County, Wisconsin, *June 2008.*

[e]*Pike Lake is a 461-acre drained lake in Washington County within a few miles of Bark Lake. Data is based on all measurements from 1999 through 2012.*

[f]*George Lake, Kenosha County, is a 59-acre drained lake similar in bathymetry and morphometry to Bark Lake. Data is based on the average of summer measurements from 1976 to 1989. See SEWRPC Community Assistance Planning Report No. 300,* A Lake Management Plan for George Lake, Kenosha County, Wisconsin, *August 2007.*

[g]*Insufficient data to determine positively.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table A-5 also includes Secchi-disk measurements recorded from 2001 through 2010 by the Environmental Remote Sensing Center (ERSC).[9] Measurements ranged from 3.6 feet to 8.5 feet with four remote satellite estimates averaging five feet in 2010, indicative of poor water quality. At the time of this report, there were no current recorded in-lake measurements with which to compare to the satellite data. In order to help interpret the data, Table A-6 shows how Bark Lake compares to other regional lakes in terms of water clarity.

[9]*The Environmental Remote Sensing Center (ERSC), established in 1970 at the University of Wisconsin-Madison campus, was one of the first remote sensing facilities in the United States. Using data gathered by satellite remote sensing over a three-year period, the ERSC generated a map based on a mosaic of satellite images showing the estimated water clarity of the largest 8,000 lakes in Wisconsin. The WDNR, through its volunteer Self-Help Monitoring Program (now the CLMN), was able to gather water clarity measurements from about 800 lakes, or about 10 percent of Wisconsin's largest lakes. Of these, the satellite remote sensing technology utilized by ERSC was able to accurately estimate clarity, providing a basis for extrapolating water clarity estimates to the remaining 90 percent of lakes.*

Color and Turbidity

Two important characteristics affecting water transparency (i.e., water clarity) are color and turbidity. The perceived color of lake waters is often described as "green" or "brown," or some combination of these colors, and is influenced by dissolved and suspended materials in the water, phytoplankton population levels, as well as various physical factors. The actual, or true, color of lake waters is the result of substances dissolved in the water. For example, the brown-stained color of lakes in the northern part of the State is the result of organic acids from certain dissolved humic materials present in those waters which essentially "dye" the lake water in a similar fashion to tea. Consequently, the dark color of water does not necessarily coincide with polluted water. Several color scales have been developed over the years to measure and compare true color of lake water. In the United States, the most commonly used standard of measure is the platinum unit ("units") and the values range from 0 units for very clear lakes to 300 units for heavily stained bog water. The average for lakes in the Southeastern Wisconsin Region is 46 units.[10] Water color for Bark Lake was found to be 55 units during fall of 1980 and 1981, as shown in Table A-7, which is somewhat higher (less clear) than the regional average of 46 units.

Turbidity from suspended particles in the lake water is another factor affecting water transparency. Turbidity in a lake's waters usually results from erosion of soil that is washed into the lake (runoff) and from the disturbance and re-suspension of the lake's bottom sediments. Turbidity for lakes in the Southeastern Wisconsin Region averages about 6.7; Bark Lake averaged 1.2 in shallow waters in 1980 and 1981 and measured 2.5 in deep waters in 1979; these are the only turbidity measurements for Bark Lake that have been documented. Table A-6 shows a comparison of turbidity in several lakes in the Region, including Bark Lake.

Dissolved Oxygen Levels

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 about 5.0 milligrams per liter (mg/l) is considered the minimum level below which oxygen-consuming organisms, such as fish, become stressed, while fish are unlikely to survive when dissolved oxygen concentrations drop below 2.0 mg/l. Oxygen levels near a lake's surface are commonly in the 10 to 12 mg/l range in lakes in the Southeastern Wisconsin Region, but can reach levels approaching 0 mg/l in the bottom waters near the end of summer.

As shown on Table A-7, limited dissolved oxygen data that has been collected on Bark Lake, with samples (at different depths) having been taken on only four different occasions from September 1979 through June 1997. Of the values that were obtained, oxygen levels were between 7.8 and 11.8 at the surface and between 0 and 3.1 at the bottom of the Lake. The surface water measurements indicated good oxygen levels for fish populations; the deep water measurements indicate that *thermal stratification* (as discussed below) is likely occurring.

Thermal Stratification

Low oxygen levels can occur as the result of a number of factors, primary among them being the natural process of *thermal stratification*. Thermal stratification is the result of the differential heating of the lake water and the resulting water temperature-density relationships at various depths within the water column. The process is illustrated in Figure A-2. The development of thermal stratification typically begins in early summer, although stratification may also occur during winter under ice. As shown in Figure A-2, with the start of summer, the surface waters of a lake are warmed by a combination of increasing solar energy from the sun and warmer summer air. As the upper waters continue to be heated, a physical barrier created by the differing water densities between warmer upper waters and cooler deeper waters may begin to form. A lake is said to be "stratified" when this physical barrier, created by a thermal gradient, called a "thermocline," develops to such an extent that it acts

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[10]*R.A. Lillie and J.W. Mason, Wisconsin Department of Natural Resources Technical Bulletin No. 138,* op cit.

Table A-7

WATER CHEMISTRY VALUES FOR BARK LAKE: 1979-1997

Water Quality Parameters[a]	September 6, 1979		September 18,1980		September 13, 1981		June 25, 1992		July 13, 1992		September 2, 1992		June 9, 1997	
	0 Foot	25 Feet	One Foot	Deep[b]	0 Feet	Deep[b]	One Foot	35 Feet	One Foot	25 Feet	One Foot	Deep[b]	One Foot	Deep[b]
N, NH3	0.07	2.76											0.111	
N, Kjeldahl/organic	1.56	0.68											1.9	
N, NO2 + NO3													0.082	
N, NO2.	0.004	0.016												
N, NO3	0.07	0.13												
N, Total	1.68	3.58												
P, Total	0.016	0.020					0.021	0.043	0.020	0.037	0.016	0.097	0.038	
Chlor-a (μg/l)	13.1		8		5.4		15		8		7.2			
Conductivity	822	795					710	700	605	605	629	636		
Dis. Oxy	7.8	0					11.8	1.9	8.2	1	10.3	3.1		
pH	8.1	8.4	8.2				8.2	8.1	8.2	7.9	7.3	7.3		
Turbidity	2.5	74[c]	1.4		1									
Color			55		55									
Ca	71	80												
Mg	38	46												
Na	17	10												
K	1.2	1.9												
Fe	0.08	0.38												
Mn	80	390												
SO4														
Cl	37	47												
Alkalinity	208	204												
Hardness	334	389												
Fluoride														
Silica														
Solids														

[a]*All values in mg/l unless otherwise specified.*

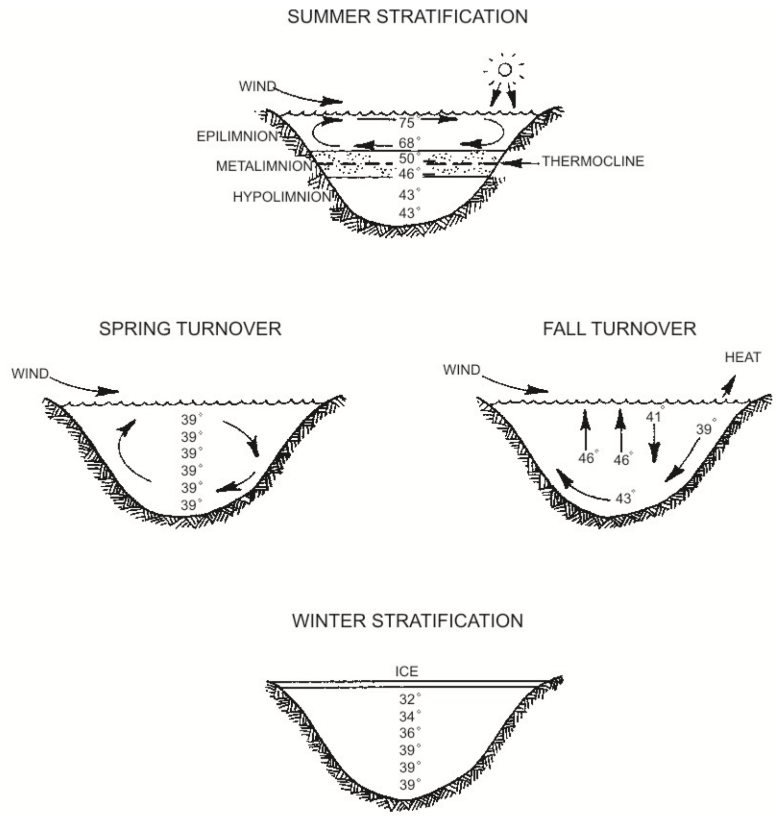
[b]*Unspecified depths*

[c]*This data suspected of being in error and, therefore, not used in the calculation of average turbidity.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

Figure A-2

THERMAL STRATIFICATION OF LAKES



Source: University of Wisconsin-Extension and SEWRPC.

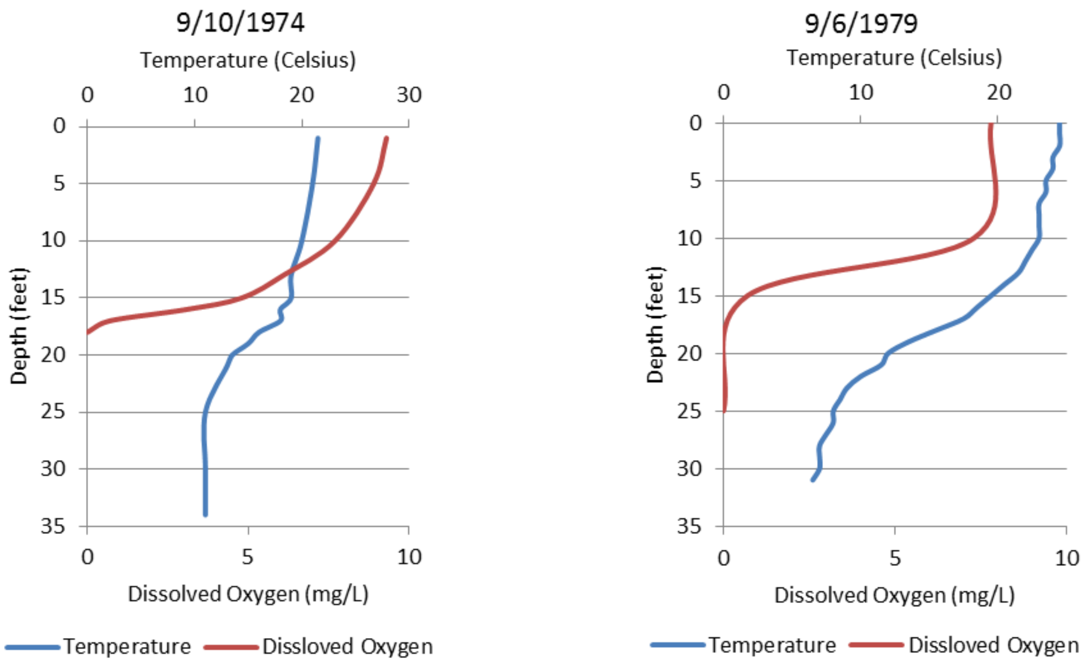
as a barrier separating the upper waters, or "epilimnion," of the lake from the lower waters, or "hypolimnion," sometimes to the extent of preventing the two layers from mixing. Although this barrier is readily crossed by fish, provided sufficient oxygen exists, it essentially prohibits the exchange of water between the upper and lower layers.

To determine if a lake stratifies, data is gathered to look for evidence of the formation of a thermocline. The presence of a thermocline in a lake is generally detectable as a pronounced drop in water temperature over a relatively small change in depth, usually about a 2.0 degrees Fahrenheit (°F) drop in temperature for each three feet of depth. To detect a thermocline, measurements of water temperature are taken at regular depth intervals at the deepest part of a lake. This temperature-depth data can then be depicted graphically in what is known as a "profile." A thermocline, if present, will usually appear as a characteristic "S"-shaped portion of the profile curve, indicative of the rapid drop in temperature over a relatively narrow depth range. Temperature profiles based on data collected in 1974 and 1979, as shown in Figure A-3, indicate that at those times, Bark Lake did stratify, with the thermocline located approximately between the 10- and 15-foot depths.

As a consequence of thermal stratification, a lake's bottom waters are prevented from circulating to the surface to be replenished with oxygen that is continually diffusing into surface waters at the air-water interface. Because of the importance of adequate oxygen in a lake's waters, often when water temperature-depth profile measurements are made, dissolved oxygen measurements are also taken so that profiles for both water temperature and dissolved oxygen can be generated. In this way, the interplay between water depth, water temperature, and dissolved oxygen

Figure A-3

OXYGEN AND TEMPERATURE PROFILES IN BARK LAKE: 1974 AND 1979



Source: SEWRPC.

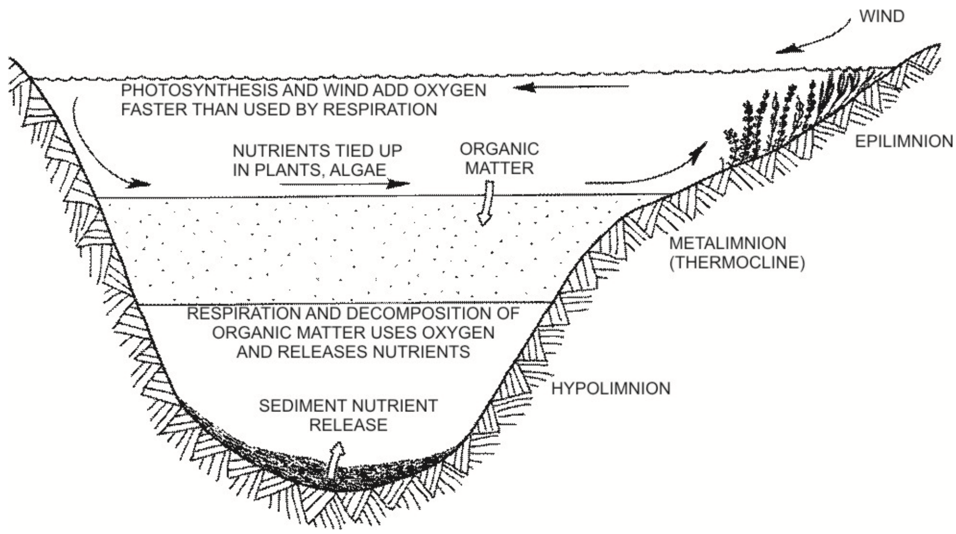
concentration can be more clearly seen and the characteristic S-curve in the water temperature profile will be reinforced with a similar S-curve in the oxygen profile at about the same depth, a clear indication of lake stratification. Figure A-3 also shows the oxygen profiles overlaid with the temperature profiles thereby confirming stratification did occur at about a 15-foot depth in 1974 and 1979. Additionally, in the historical data available for the Lake as presented in Table A-7, a comparison of oxygen levels at the surface to those in the bottom waters, indicate the strong likelihood that stratification occurred in Bark Lake in the years after the 1974 and 1979 profiles were obtained. It is, however, not possible to confirm this determination without the examination of temperature/oxygen-depth profiles. Table A-6 shows how Bark Lake compares to other lakes in the Region in terms of thermal stratification.

Anoxia

When the surface supply of oxygen is cut off from the bottom waters through stratification, if there is not enough dissolved oxygen in the lower waters to meet the demands of bottom-dwelling aquatic life and decaying organic material, eventually the dissolved oxygen levels in the bottom waters may be reduced to zero, a condition known as *anoxia*, or anaerobiosis. This process, which is shown graphically on Figure A-4, can have a number of negative impacts on the organisms, especially fish, living in a lake. For example, where this *hypolimnetic anoxia* (lack of oxygen at deep depths) develops in a lake, fish tend to move upward, nearer to the surface of a lake, where higher dissolved oxygen concentrations exist. This upward migration, when combined with the warmer water temperatures found near a lake's surface, can select against some fish species that prefer the cooler water temperatures and their competitive success may be severely impaired. Additionally, when there is insufficient oxygen in the deeper waters, fish can be susceptible to summerkills. Such is a condition common in many of the lakes in southeastern Wisconsin. When this condition occurs during winter months (when ice cover prevents oxygen from diffusing into surface waters and extended periods of heavy snow cover may effectively block sunlight from reaching oxygen-producing plants under the surface of a lake) it can also lead to winter fish kills, as dissolved oxygen stores are not sufficient to meet the total demand for oxygen.

Figure A-4

LAKE PROCESSING DURING SUMMER STRATIFICATION



Source: University of Wisconsin-Extension and SEWRPC.

As shown in Table A-7, Bark Lake has a history of very low oxygen measurements at its lake bottom, including: an oxygen level of 0 mg/l in September of 1979 and 1.9 mg/l and 1.0 mg/l in June and July of 1992. Fortunately, despite these values neither summer nor winterkills have been reported as an issue in Bark Lake. The lack of data regarding dissolved oxygen measurements for the deeper waters of the Lake since 1992 make it impossible to determine whether anoxic conditions continue to exist in the bottom waters of Bark Lake. However, based on past history of the Lake, as well as observations of other lakes in the Region with similar hydrologic and morphometric characteristics, it is likely that the Lake does continue to stratify and exhibit at least near-anoxic conditions in its bottom waters at certain times of the year. Table A-6 shows how Bark Lake compares to other regional lakes in terms of anoxic conditions.

Fall and Spring Turnover

Continuing with the process of lake stratification, Figure A-2 shows how the interactions between water temperature, depth, and oxygen concentration, play out through the annual progression of the seasons. As summer leads into fall, concurrent cooling air temperatures and the stirring action brought about by wind act together to degrade the thermocline in a lake. As surface waters cool, they become denser, eventually sinking and displacing the now warmer water below. Water is unique among liquids, in that it reaches its maximum density at about 39.2°F, about 7°F *above* its freezing point. Eventually, the entire water column is of uniform temperature. When this state is achieved, wind action will thoroughly mix all the waters in a lake, a process known as “fall turnover.” It is at this point that the hypolimnion can again be replenished with dissolved oxygen.

Once the water temperature at the surface drops to the point of maximum density, 39.2°F, these surface waters “sink” to the bottom. Eventually, the water at the surface cools past the point of maximum density, and, as it attains freezing temperature at 32°F, being less dense than the water below, still at 39.2°F, it remains at the surface and changes into the layer of ice that will remain until spring thaw. As shown in Figure A-2, it is possible for a state of weak winter stratification to occur as the colder, lighter water and ice remain at the surface, separated from the relatively warmer, heavier water near the bottom of a lake.

Spring brings a reversal of the process. With the melting of the layer of ice, the upper layer of water warms past the 32°F point. Eventually, it warms to its maximum density at 39.2°F, the same temperature as the waters below, at which point the entire water column is again at uniform temperature, and, with the aid of the stirring action of wind, is thoroughly mixed. This is referred to as “spring overturn.” Spring overturn usually occurs within weeks after the ice goes out, and is illustrated in Figure A-2. After spring turnover, the water at the surface again warms and becomes less dense, causing it to “float” on the colder, denser water below. Thus begins the eventual formation of a thermocline and another period of summer stratification.

There are no historical records taken during the spring or fall turnover in Bark Lake; however, as a part of this study, SEWRPC staff did collect temperature data which indicated that fall and spring turnover occurred in early October 2012 and mid-April 2013, respectively. This data is further discussed below in the “Water Temperature” subsection of this appendix. This evidence of fall and spring turnover is further supported by the fact that Bark Lake is a very healthy lake with a seemingly thriving fish population, which would require that the Lake have some redistribution of dissolved oxygen throughout the year.

Water Temperature Data

To gain some insight into the natural temperature patterns found in Bark Lake (e.g., the presence or absence of stratification), SEWRPC staff installed eight temperature loggers (see Map A-18)—seven to record water temperature and one to record air temperature. Water temperature loggers were installed at the inlet; the outlet; the edge and inner portion of the sandbar; at the deep hole site at the surface, 21 feet and 30 feet deep. The eighth logger was installed along the shoreline to record air temperature for comparative purposes. All of the loggers, with the exception of the outlet logger, were retrieved at the conclusion of the study period.

Water temperature data was recorded, on an hourly basis from September 21, 2012, at 6:00 a.m. until October 16, 2013, at 12:00 p.m., resulting in 48,264 data points. This data was then analyzed and compiled in order to form conclusions about the stratification patterns of the Lake and to develop a picture of how a lake works in general for the purposes of illustration.

Upon evaluation of the data, it was concluded that the differences between the data for the edge of the sandbar, inner sandbar, and the surface waters of the deep hole were insignificant. If there had been a significant difference between these sites, it might have been possible to draw conclusions about the nature of land surface runoff entering the Lake and contributing to formation of the sandbar; however, this was not the case. Consequently, the data from the two sandbar sites were eliminated from this evaluation.

Figure A-5 illustrates the recorded data from the deep hole and inlet surface water locations in comparison to the air temperature location. As can be expected, the Lake’s surface, as well as the inlet, is highly dependent on air temperature; however, what is more interesting is the fact that the inlet temperature data is actually cooler than the Lake surface throughout most of the summer. As many species of fish actually require waters to remain cool throughout the summer, this influx of cooler waters may have a significant impact on the health of the Lake, further emphasizing the need to maintain flow at the inlet to the greatest extent possible.

Figure A-6 illustrates the recorded temperature data from the “deep hole” site at each of the recorded depths (i.e., surface, 21 feet, and 30 feet) in comparison to air temperatures. In this figure, it is possible to see the process of stratification, as well as fall and spring turnover, as discussed above. The figure begins by demonstrating a clear thermal stratification in the summer/fall 2012 between the surface and deeper locations. The figure then demonstrates how the cooling air temperature and wind led to the lake mixing as the cool, dense water near the surface sank, thereby forcing the cooler, less dense bottom waters upward. Over time it is possible to see this process creating a uniform temperature throughout the Lake (i.e., fall turnover), which began with mixing of the top two depths at the end of September and ended with complete mixing in October. Bark Lake then showed a weak winter stratification from December to January, where the heavier, warmer water remained at the bottom while the lighter, colder water and ice separated to the top. By the end of April 2013, the ice melted off and the surface warmed until the water column reached a uniform temperature, causing the spring overturn. Following the overturn, the waters stratified once again in the summer 2013.

This data shows a textbook example of the four stages illustrated in Figure A-2 and provides conclusive evidence that Bark Lake does stratify periodically, if not annually.

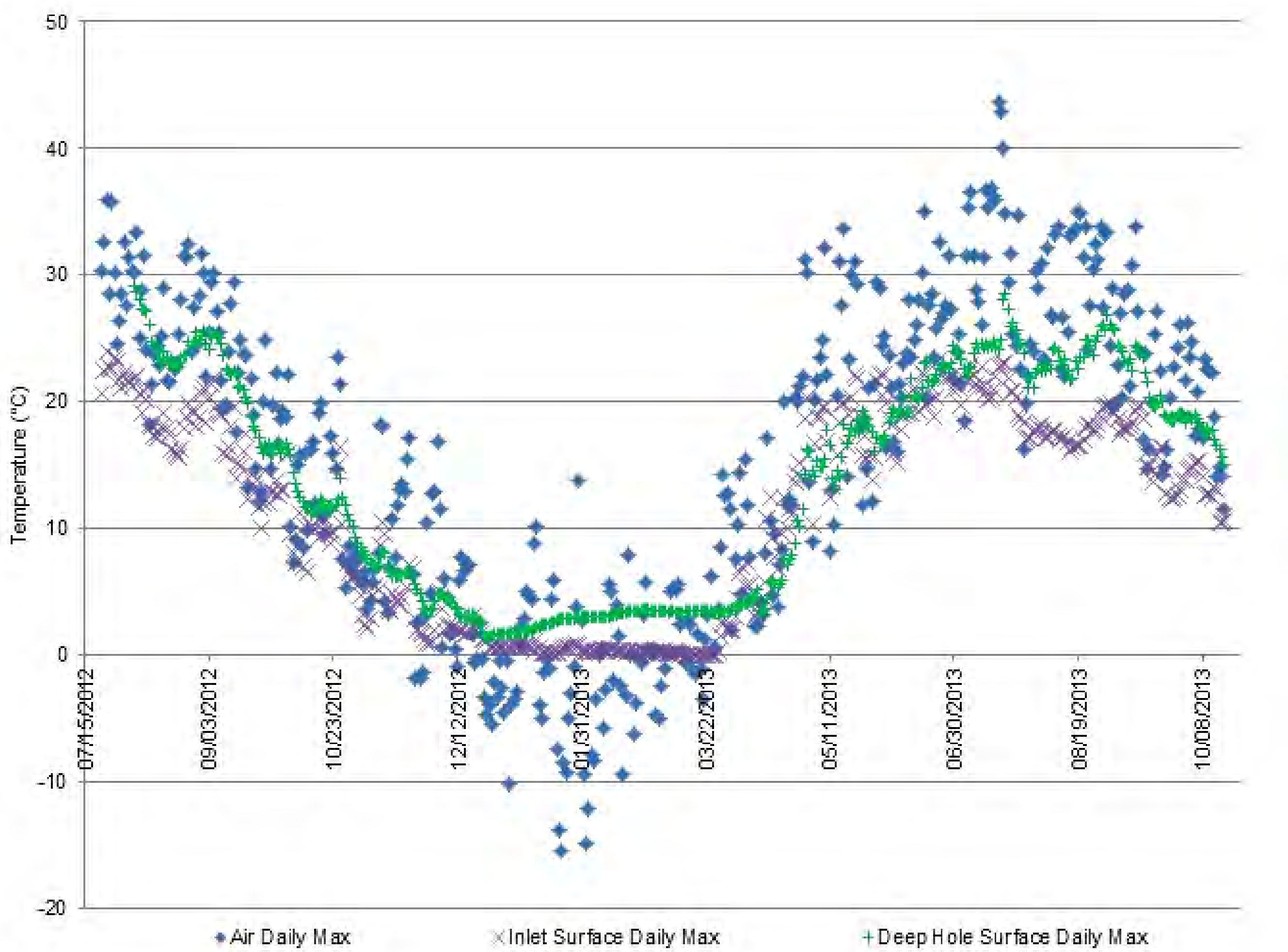
Map A-18

TEMPERATURE LOGGER LOCATIONS WITHIN BARK LAKE

Source: SEWRPC.

Figure A-5

SURFACE WATER AND AIR TEMPERATURE VALUES FOR BARK LAKE: 2012-2013



NOTE: Each color represents a different sample location: air temperature (blue), water temperature at the surface of the inlet (purple), and water temperature at the surface of the deep hole location (green). In this figure, it can be seen that water temperatures are constant and dependent on air temperature. The figure also shows the green line being above the purple line through most of the sample dates, depicting that surface water temperatures at the deep hole are warmer than the surface waters at the inlet.

Source: SEWRPC.

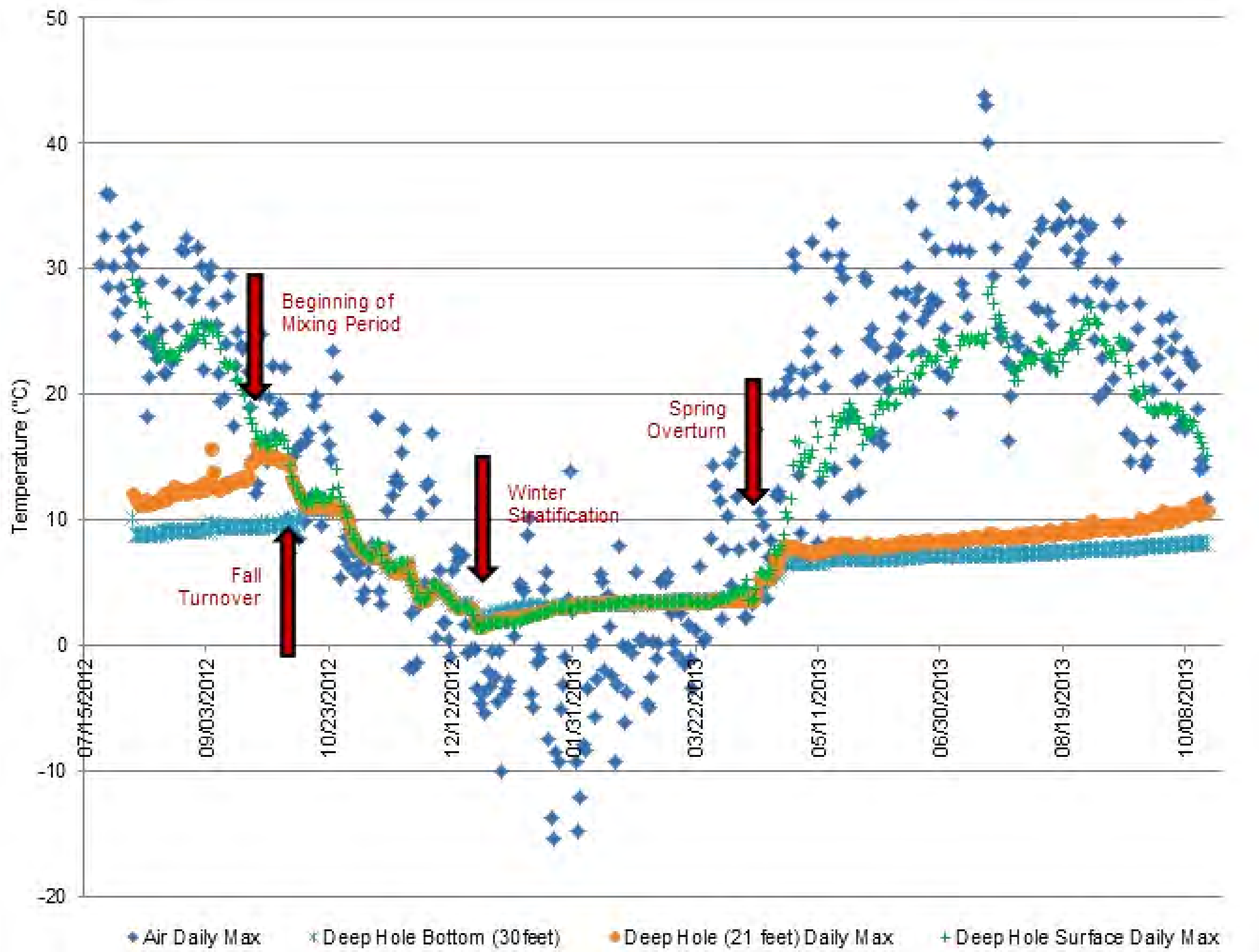
Total Phosphorus

Phosphorus is an element of fundamental importance to living things, both as a nutrient and as a major cellular constituent. Consequently, phosphorous is especially important to plant growth. However, excessive levels of phosphorus in lakes can lead to nuisance levels of plant growth, unsightly algae blooms, decreased water clarity, and oxygen depletion that can stress or kill fish and other aquatic life. Phosphorus occurs naturally in soils and bedrock. It also occurs in fertilizer, soaps, and detergents, which can reach streams and lakes through rural and urban nonpoint source runoff, wastewater treatment plant discharges, and through groundwater that receives treated effluent from private onsite wastewater systems (e.g., septic tanks or mound systems). In response to increased loads of phosphorus to surface waters and the subsequent negative impacts on the State's surface waters, Wisconsin is one of 11 states that have banned the use of phosphorus fertilizers in the past 10 years.

Phosphorus may be found in any of four major fractions, or forms. One form, "ortho," or "dissolved," phosphorus (PO4), is the principle form of phosphorus and, being dissolved in the water column, is readily available for plant

Figure A-6

SURFACE AND DEEP WATER TEMPERATURES IN COMPARISON TO AIR TEMPERATURE FOR BARK LAKE: 2012-2013



NOTE: This figure shows the water temperature data that was collected at 3 depths at the deep hole location: surface waters, 21 feet down and 30 feet down, the air temperature is also reported here. Where these water temperature lines merge (green, orange and aqua blue) illustrates the beginning of turnover and the end of stratification; conversely, where the lines separate illustrates the beginning of stratification.

Source: SEWRPC.

growth. However, its concentration can vary widely over short periods of time as plants take up and release this nutrient. Therefore, *total phosphorus* is usually considered a better indicator of nutrient status. Total phosphorus concentrations include the phosphorus contained in plant and animal fragments suspended in the lake water, phosphorus bound to sediment particles, and phosphorus dissolved in the water column. In lakes, where wastewater and stormwater discharges from an urban or agricultural landscape dominate the inflow, dissolved or orthophosphate phosphorus can comprise the major form of phosphorus. Hence, these lakes tend to be characterized by high levels of biological production, as the nutrient is present in a form that is most suitable for uptake by the aquatic plants. Conversely, in lakes whose inflows are dominated by runoff from an undisturbed watershed, dissolved phosphorus is present in much lower concentrations, and in-lake productivity is less.[11]

Statewide standards for phosphorus concentrations in lakes were adopted in November 2010. The statewide phosphorus standard supersedes the regional guideline value of 20 micrograms per liter (μg/l) or less during spring turnover established by the regional water quality management plan.[12] Pursuant to Section NR 102.06, "Phosphorus," of the *Wisconsin Administrative Code*, Bark Lake would be considered to be a stratified drainage lake, and, as such, subject to a 0.030 mg/l (30 μg/l) total phosphorus criterion, above which value a lake would be considered to be impaired with respect to phosphorus. A concentration of less than 30 μg/l is the level considered necessary to limit algal and aquatic plant growths to levels consistent with recreational water use objectives, as well as water use objectives for maintaining a warmwater fishery and other aquatic life.

Total phosphorus concentrations in Bark Lake were recorded by WDNR staff during 1979, and again in 1992 and 1997. As shown in Table A-7, these measurements indicated a surface, or shallow, concentration of 16 μg/l in 1979, and averaged 19 μg/l in 1992. Both of these values are within the acceptable range under the current Statewide standard. In 1997, however the average surface water phosphorous concentration was 38 μg/l, a level indicative of only "fair" water quality. This level is also above the acceptable statewide standard as well as in excess of recommended concentrations given in the regional water quality management plan. There are no total phosphorus data for Bark Lake after 1997. Table A-6 shows how Bark Lake compares to other regional lakes in terms of total phosphorus concentration in the surface waters of the Lake.

Internal Loading

When aquatic organisms die, they usually sink to the bottom of a lake, where they decompose. Phosphorus from these organisms is then either stored in the bottom sediments or released into the water column. Because phosphorus is not highly soluble in water, it readily forms insoluble precipitates with calcium, iron, and aluminum under aerobic conditions and accumulates predominantly in a lake's bottom sediments. However, if the bottom waters become depleted of oxygen during stratification, as described above, the lack of dissolved oxygen at depth can enhance the development of chemoclines, or chemical gradients, with an inverse relationship to the dissolved oxygen concentration. The effect of these chemical changes along with anaerobic conditions is that phosphorus becomes soluble and is more readily released from the iron and manganese complexes to which it was bound under aerobic conditions in a process known as "internal loading." This process also occurs under aerobic conditions, but generally at a slower rate than under anaerobic conditions. As the waters mix, this phosphorus may be widely dispersed throughout a lake waterbody and become available for algal growth.

Internal loading can affect water quality significantly if these nutrients and salts are then mixed into the epilimnion, especially during early summer, when they can become available for algal and rooted aquatic plant growth. As shown in Table A-7, the amount of phosphorus present in the bottom waters of Bark Lake in 1992, when compared to the amount in the surface waters, indicates that internal loading could be occurring in Bark Lake, particularly since Bark Lake does stratify and also experiences, at least historically, periods of anoxia in its bottom waters. It is, however, difficult to determine with any certainty if this is the case, due to the minimal water chemistry data available for Bark Lake. This possibility should, therefore, be examined in the future.

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[11]*Sven-Olof Ryding and Walter Rast,* "The Control of Eutrophication of Lakes and Reservoirs*," Unesco Man and the Biosphere Series, Volume 1, Parthenon Press, Carnforth, 1988; Jeffrey A. Thornton, Walter Rast, Marjorie M. Holland, Geza Jolankai, and Sven-Olof Ryding,* "*The Assessment and Control of Nonpoint Source Pollution of Aquatic Ecosystems,*" Unesco Man and the Biosphere Series*, Volume 23, Parthenon Press, Carnforth, 1999.*

[12]*See SEWRPC Planning Report No. 30,* A Regional Water Quality Management Plan for Southeastern Wisconsin—2000, *Volume One,* Inventory Findings, *September 1978; Volume Two,* Alternative Plans, *February 1979; and Volume Three,* Recommended Plan, *June 1979.*

***Chlorophyll*-a**

Chlorophyll-*a* is the major photosynthetic, "green," pigment in algae. The amount of chlorophyll-*a* present in the water is an indication of the biomass, or amount of algae, in the water. The mean chlorophyll-*a* concentration for lakes in the Southeastern Wisconsin Region is 43 μg/l, with a median concentration of 10 μg/l.[13] 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.[14]

As shown in Table A-7, chlorophyll-*a* levels were measured in Bark Lake in each of three successive years from 1979 to 1981, and three times in 1992. There are no data since 1992. The earlier 1979 to 1981 data averaged 8.8 μg/l, and the 1992 data averaged 10.1 μg/l. Such measurements indicate water quality in the fair-to-good range. Table A-6 shows how Bark Lake compares to other lakes in the Southeastern Wisconsin Region regarding chlorophyll-*a* surface water concentration.

Other Water Quality Factors

Nitrogen

Nitrogen, especially in its reactive, or "organic," form, is an element second in importance only to phosphorus as essential to the growth of plants, terrestrial or aquatic. Most organic nitrogen is the result of a process known as "nitrogen fixation," which occurs in certain symbiotic microbes found in the roots of some plants, especially legumes and rice. Primary natural sources of nitrogen in lakes include precipitation falling directly onto a lake's surface, nitrogen fixation processes occurring both in a lake's water and its sediments, and groundwater input and surface runoff. Man-made sources of organic nitrogen include livestock wastes; agricultural fertilizers, including lawn fertilizers; and human sewage. Because of its association with plant growth, nitrogen level in a lake is considered a key chemical parameter in monitoring the chemical makeup of lake ecosystems.

Lakes in the Southeastern Wisconsin Region have an average total nitrogen level of 1.43 mg/l, the highest level of any region in the State.[15]As shown in Table A-7, total nitrogen in the surface waters of Bark Lake has only been measured one time, in September of 1979. At that time, the total nitrogen at the surface was 1.68 mg/l. Table A-6 shows how Bark Lake compares to other lakes in southeastern Wisconsin regarding total nitrogen concentrations.

Nitrogen-to-Phosphorus Ratios

Aquatic plants and algae require nutrients such as phosphorus and nitrogen for growth. In hard-water alkaline lakes, most of these nutrients are generally found in concentrations that exceed the needs of growing plants. However, in lakes where the supply of one or more of these nutrients is limited, plant growth is limited by the amount of the nutrient that is available in the least quantity relative to all of the others. The ratio (N:P) of total nitrogen (N) to total phosphorus (P) in lake water indicates which nutrient is the factor most likely to be limiting aquatic plant growth in a lake.[16] Where the N:P ratio is greater than 14:1, phosphorus is most likely to be the limiting nutrient. If the ratio is less than 10:1, nitrogen is most likely to be the limiting nutrient. Any time the ratio is in the middle (i.e., between 10:1 and 14:1), this indicates that either nutrient could be limiting, depending on conditions. Due to the scarcity of data, the N:P ratio in Bark Lake can only be determined from the data dating back to 1979, at which time the ratio was well above 14:1, at 105:1, indicating that, at that time at least, phosphorus was likely the limiting factor for plant production.

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[13]*R.A. Lillie and J.W. Mason, Wisconsin Department of Natural Resources Technical Bulletin No. 138,* op. cit.

[14]*J.R. Vallentyne, "The Process of Eutrophication and Criteria for Trophic State Determination,"* Modeling the Eutrophication Process—Proceedings of a Workshop at St. Petersburg, Florida, *November 19-21, 1969, pages 57-67.*

[15]*R.A. Lillie and J.W. Mason, Wisconsin Department of Natural Resources Technical Bulletin No. 138,* op. cit.

[16]*M.O. Allum, R.E. Gessner, and T.H. Gakstatter, U.S. Environmental Protection Agency Working Paper No. 900,* An Evaluation of the National Eutrophication Data, *1976.*

Alkalinity and Hardness

Alkalinity is a measure of a lake's ability to absorb and neutralize acidic loadings, or "buffering." For example, lakes having a low alkalinity and, therefore, a low buffering capacity, may be more susceptible to the effects of acidic atmospheric deposition. A lake's alkalinity is often closely associated with the soils and bedrock of the lake's watershed. Lakes in the southeastern part of the State traditionally have high alkalinity, averaging about 173 mg/l, reflective of the limestone and dolomite deposits that make up much of the underlying bedrock in this Region. Low-alkalinity lakes are mostly confined to the northern regions of the State.[17] Alkalinity is generally reported as mg/l $CaCO_3$ equivalents. As shown in Table A-7, alkalinity has been measured only one time in Bark Lake, in 1979, at which time the average measurement was 206 mg/l.

In contrast to alkalinity, water hardness is a measure of the multivalent metallic ion concentrations, such as those of calcium and magnesium, present in a lake. Generally, lakes with high levels of hardness produce more fish and aquatic plants than lakes whose water is soft.[18] Hardness is usually reported as an equivalent concentration of calcium carbonate (CaCO3). Hardness measurements for Bark Lake have been documented one time, in 1979. At that time, the shallow water and bottom water measurements were 334 mg/l and 389 mg/l, respectively, which are slightly higher than some of the other lakes in the Southeastern Wisconsin.

pH

The pH of lake water influences many of the chemical and biological processes that occur there. For example, pH can influence how much of certain nutrients, such as phosphorus, nitrogen, and carbon, can be utilized by aquatic life. It can also affect what form of phosphorus is most abundant in water. Additionally, pH can determine solubility, and therefore the toxicity, of such heavy metals as lead, copper, and cadmium.

The pH is a logarithmic measure of hydrogen ion concentration on a scale of 0 to 14 standard units, with 7 indicating neutrality. A pH above 7 indicates basic (or alkaline) water, and a pH below 7 indicates acidic water. Even though moderately low/high pH may not directly harm fish or other organisms, pH near the ends of the scale can have adverse effects on the organisms living in a lake. Additionally, under conditions of very low (acidic) pH, certain metals, such as aluminum, zinc, and mercury, can become soluble if present in a lake's bedrock or watershed soils, leading to an increase in concentrations of such metals in a lake's waters with subsequent potentially harmful effects to the fish and also to the organisms, including humans, who eat them.[19]

As in the case of alkalinity, the chemical makeup of the underlying bedrock has a great influence on the pH of lake waters. In the case of lakes in the Southeastern Wisconsin Region, where the bedrock is comprised largely of limestone and dolomite, the pH typically is in the alkaline range above a pH of 7. In general, the pH for most natural waterbodies is within the range of about 6.0 to about 8.5.[20] Other factors influencing pH include precipitation, as well as biological, algal, activity within the Lake. Natural buffering of rainfall by carbon dioxide in the atmosphere and the carbonate system in Bark Lake, its tributary streams and drainage area, all tend to moderate the pH level in other lakes in the Region.

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[17]*R.A. Lillie and J.W. Mason, Wisconsin Department of Natural Resources Technical Bulletin No. 138,* op. cit.

[18]*Byron Shaw, Lowell Klessig, Christine Mechenich,* Understanding Lake Data, *University of Wisconsin-Extension Publication No. G3582, 2004.*

[19]Ibid.

[20]*Deborah Chapman,* Water Quality Assessments, *2nd Edition, E&FN Spon, 1996.*

Measurements of pH from lakes in southeastern Wisconsin averaged 8.1, which, due to the underlying geology of the Region, was the highest recorded from any region in the State. By contrast, lakes in northeastern Wisconsin are slightly acidic, with an average pH of 6.9.[21] As shown in Table A-7, Bark Lake's pH values in 1979 ranged from 8.1 to 8.4 and from 7.3 to 8.2 during the 1992 study. There have been no pH measurements for Bark Lake since 1992.

Conductivity

The electrical conductivity, or *EC*, of a lake's waters is a measure of how much resistance to electrical flow exists in the water. As the concentration of charged particles, "ions," in water increases, its resistance to electrical flow diminishes, i.e., as the concentration of ions increases, conductivity increases. Therefore, conductivity indirectly estimates the amount of dissolved ions in the water. Since many pollutants that affect a lake's water quality are associated with various ions, abnormally high levels of conductivity in a lake's waters often signal a potential pollution problem. Such pollutants include wastewater from sewage treatment plants and onsite septic systems; urban runoff from roads, especially road salt used to clear road surfaces of ice and snow; animal wastes; and agricultural/lawn/garden runoff, primarily chemical fertilizers and pesticides. Generally, conductivity measurements are expected to fall within a range of about two times a lake's hardness values.[22]

Natural influences also affect a lake's conductivity. For example, just as in the cases of alkalinity and pH, high concentrations of limestone in the soils of a lake's watershed and basin can lead to higher conductivity in the lake's waters due to the dissolution of carbonate minerals in the limestone. In addition, top versus bottom measurements of conductivity generally reveal increased levels of conductivity at depth due to decomposition of bottom sediments and acidic conditions that allow certain materials to become more soluble. Another natural influencing factor of conductivity is the proportion of watershed size to lake size. The larger the watershed, the more soil that's available for water to be in contact with as the water drains to a lake. Other natural influences include such things as atmospheric deposition (in ocean coastal areas, ocean water increases the salt content of strong onshore winds and precipitation) and the concentration of dissolved salts through the process of evaporation of water from a lake's surface.

Until the late 1970s, conductivity was typically measured in units known as micromhos per centimeter (μmhos/cm); after that time, the standard unit was changed to microSiemens/cm (μS/cm).[23] Since increasing temperature creates an increase in electrical flow in an ionic solution, conductivity measurements are automatically compensated to a standard temperature of 25 degrees Celsius (°C), such measurements being referred to as *specific conductivity.*

Conductivity measurements can vary widely from lake to lake. For example, average conductivity for Lake Superior is around 97 μS/cm, while for Lake Mead it is about 850 μS/cm. Freshwater lakes commonly have a specific conductance in the range of 10 to 1,000 μS/cm, although measurements in polluted waters or in lakes receiving large amounts of land runoff can sometimes exceed 1,000 μS/cm.[24] Lakes in the Southeastern Wisconsin Region exhibit moderate levels of conductivity, usually within the 500 to 600 μS/cm range. As shown in Table A-7, a conductivity measurement taken in the surface waters of Bark Lake during 1979 was 822 μS/cm, while conductivity measured in the bottom waters of Bark Lake at the same time period was 795 μS/cm.

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[21]*R.A. Lillie and J.W. Mason, Wisconsin Department of Natural Resources Technical Bulletin No. 138,* op. cit.

[22]*Byron Shaw, Lowell Klessig, Christine Mechenich,* Understanding Lake Data, *University of Wisconsin-Extension. RP-6/2000-1M-350, 2000.*

[23]*1 μmhos/cm = 1 μS/cm.*

[24]*Deborah Chapan,* Water Quality Assessments, *2nd Edition,* op. cit.

Conductivity was, again, measured in the surface and bottom waters of Bark Lake in 1992. At that time, both surface measurements and bottom measurements ranged from 605 to 710 μS/cm. These data are not greatly different from those collected at other regional lakes during a similar time period, as described above. No conductivity data have been collected for Bark Lake since the 1992 study.

Major Anions (ions with a "–" charge): Chlorine (Cl), Sulfates (SO_4), Fluoride (F)

Chlorides

Just as the presence of high concentrations of ions in a lake's waters often are an indication of possible pollution, the *types* of ions present can sometimes give clues as to the possible sources of these pollutants. For example, chloride ions (Cl) are found in small quantities in nearly every lake due to the natural weathering from bedrock and soils in a lake's watershed. But, in large concentrations, chlorides are usually associated with human activities, in particular the application of road salts during winter deicing operations, and in effluents from wastewater treatment plants and onsite septic systems.

The observed increase in chloride concentration in southern Wisconsin lakes, particularly since the 1960s, seems to be closely aligned with a concomitant increase in the use of road salts for winter deicing. Such alignment is particularly noteworthy when viewed in the context of most lakes in Vilas County in northern Wisconsin, where chloride concentrations in lakes has been mostly constant over the years, except for a few cases in which lakes lying adjacent to major roadways and populated areas have begun to exhibit a rise in chloride concentrations.

Figure A-7 shows chloride concentration trends for a several lakes in the Southeastern Wisconsin Region. As shown in this figure, the concentrations of chloride in the Region's lakes have been rising since 1960. How such an increase might be impacting lake ecosystems is not fully known, however, rather than being a significant pollutant in itself, at least at present concentrations, chloride might serve as an "indicator" element due to the fact that chlorides do not naturally occur in high concentrations within Wisconsin. This essentially means that, as chloride concentrations rise (say, as a result of urban road salt runoff), other, more harmful pollutants that are not as easily measured may also be rising (e.g., heavy metals, pharmaceuticals, etc.). Regionwide concentration of chlorides averages 19 mg/l, the highest in the State. As shown in Table A-7, in 1979, chloride concentrations in Bark Lake averaged 42 mg/l. There are no data more recent than the 1979 data.

Sulfates

Besides chlorides, sulfates are another significant water quality parameter. Sulfates are just one of several forms of sulfur, an important nutrient for many forms of aquatic life. Sulfur is a naturally occurring substance that can enter a lake through dissolving from rocks and from fertilizers, although in heavily industrialized areas, such as southeastern Wisconsin, sulfur input from atmospheric sources related to human activities, such as burning of fossil fuels, dominate all other sources.[25] The dominant form of sulfur in lakes is sulfate. Sulfates play a role in a lake's eutrophication process and can, in high concentrations, have a deleterious effect on certain aquatic plants.

Due to their stability when dissolved in water, sulfates tend to accumulate in a lake's bottom sediments unless removed. Like magnesium and calcium, to be discussed below, the highest concentrations of sulfates are found in lakes in the southeastern part of the State where high densities of population and industrialization occur. Generally, lakes in this part of Wisconsin experience sulfate levels in the 20 to 40 mg/l range, with some lakes in southeastern Wisconsin having sulfate levels above 40 mg/l.[26] There are no recorded measurements of sulfates in Bark Lake, indicating that these measurements should be included in future monitoring efforts.

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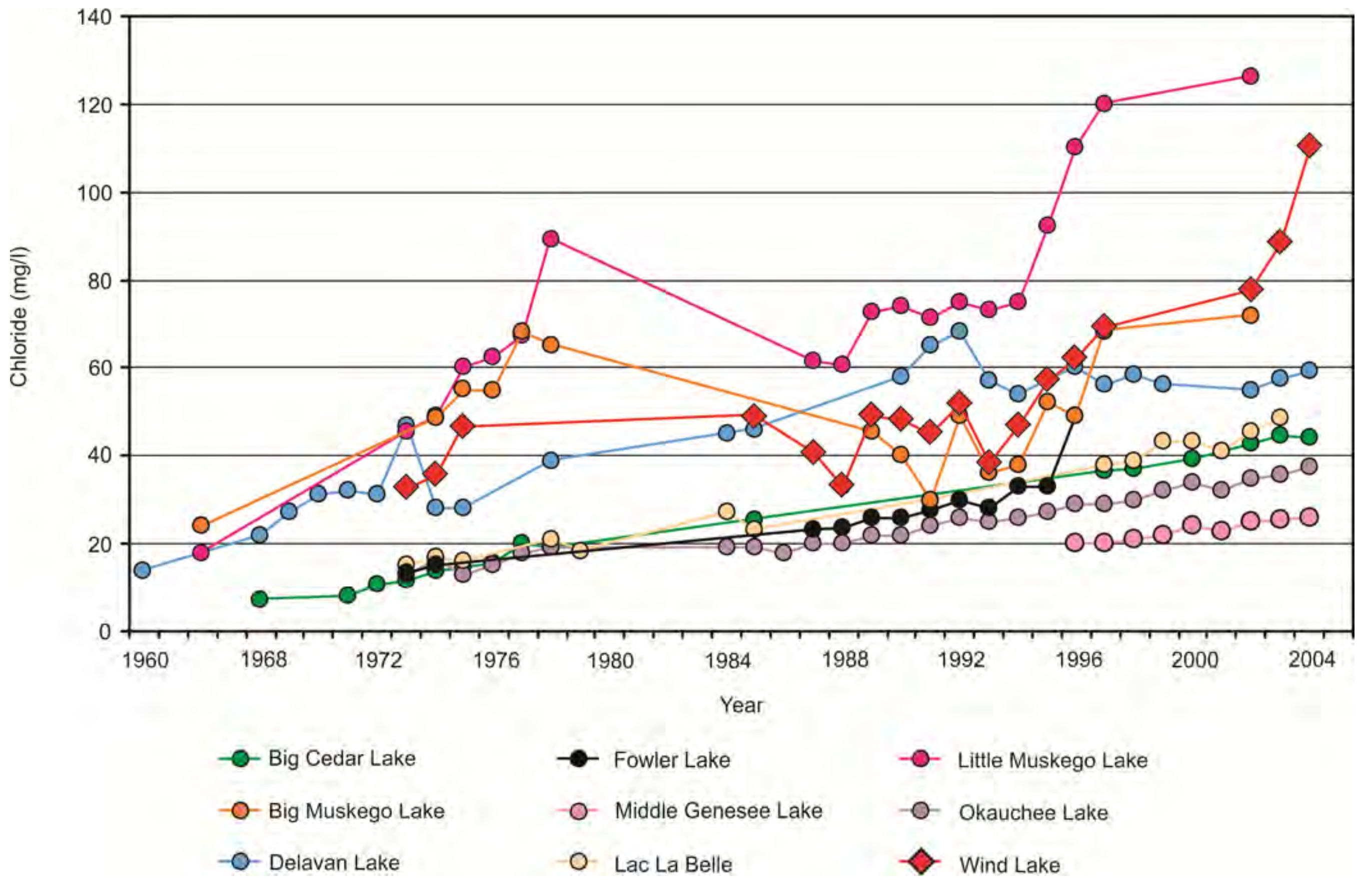
[25]*Robert G. Wetzel,* Limnology: Lake and River Ecosystems, *Third Edition, Academic Press, 2001.*

[26]*R.A. Lillie and J.W. Mason, Wisconsin Department of Natural Resources Technical Bulletin No. 138,* op. cit.

Figure A-7

CHLORIDE CONCENTRATION TRENDS FOR SELECTED LAKES IN SOUTHEASTERN WISCONSIN: 1960-2004



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

Fluoride

Fluoride is probably most widely associated with being added to domestic water supplies to harden teeth and fight tooth decay in humans. Usually present in only small amounts naturally in lakes, Wisconsin lakes usually contain between 0.08 to 0.51 mg/l. Fluoride has not been measured in Bark Lake.

Major Cations (ions with a "+" charge)

Magnesium and Calcium

Calcium (Ca), due to its reactive nature with phosphorus, is often related to the growth of phytoplankton It is also a required nutrient of metabolism in higher plants. Magnesium (Mg) is a fundamental building block of chlorophyll and, as such, is a vital nutrient to all green plants. The limestone and dolomite deposits in the bedrock of much of the Southeastern Wisconsin Region affect not only the alkalinity of the Region's lakes, as described above, but also result in elevated calcium and magnesium levels. Lakes in the Region, therefore, average about 36 and 32 mg/l for calcium and magnesium, respectively—the highest levels in the State.[27] As shown in Table A-7, calcium values in Bark Lake averaged 76 mg/l in 1979, while magnesium levels averaged 42 mg/l in the same year. No other values were obtained.

[27]Ibid.

Sodium and Potassium

Sodium (Na) and potassium (K) have strong links to the growth of cyanobacteria, or blue-green algae, which are among the most studied of all planktonic groups and whose toxic byproducts have been well-documented for their adverse effects on freshwater lakes, especially those with enriched, or eutrophic, conditions. Concentrations of sodium and potassium in a lake are usually fairly uniform regardless of the depth or time of year. In Bark Lake, as shown in Table A-7, concentrations of sodium measured in 1979 at both shallow and deep depths showed a range of variation from a low of 10 mg/l to a high of 17 mg/l. This was the only time sodium has been measured in Bark Lake. The 1979 measurements of potassium ranged from 1.2 mg/l in the shallow waters to 1.9 mg/l in the deeper waters. The 1979 data for sodium and potassium are the only data recorded for these two parameters in Bark Lake.

Silica

Although it is relatively inert regarding its chemical properties, silica plays a significant role in the production of many algal forms in freshwater lakes, especially the diatoms which depend on the substance for the production of their characteristic silicone casing. Therefore, the amount of dissolved silica available in a lake's waters can influence the composition of the phytoplankton population. Insufficient levels of silica in a lake's waters can shift algal population dominance from beneficial species, such as diatoms, to less desirable species, such as blue-green algae. The lowest amounts of silica are found in lakes associated with carbonate rocks, as is commonly the case in the Southeastern Wisconsin Region, where limestone and dolomite deposits make up much of the underlying bedrock. Silica measurements have not been recorded in Bark Lake.

Solids

There are two measurements of solids. The first is total suspended solids (TSS), which refers to the amount of suspended solids, such as soils and sands found suspended or floating within a sample of water. This amount is highly related to the previously discussed turbidity measurements, which can increase when water is disturbed or affected by high amounts of erosion. TSS has not been measured in Bark Lake.

The second measure is total dissolved solids (TDS), which is an estimation of the total amount of inorganic solids dissolved in the water. The abundance of these dissolved solids is influenced by several factors, including:

- The *geologic nature* of a lake's basin—The limestone and dolomite bedrock predominant in southeastern Wisconsin results in higher amounts of carbonates and bicarbonates in the lakes;

- The *topography* of a lake's watershed—As local topography increases in steepness, overrunning water (runoff) spends less time in contact with it and, therefore, reacts less with it;

- *Climate*—Warm, moist climates can greatly increase the rate at which material dissolves in water; and

- *Time*—The longer the time water sits in a lake basin, the more it can react with the basin materials.

Probably the most significant source of dissolved solids in a lake's waters is geologic weathering, e.g., erosion and runoff, although atmospheric precipitation and human activities can also be contributors. Total dissolved solids have not been measured thus far in Bark Lake.

Overall Water Quality Assessment

Historic water quality data for Bark Lake is limited in amount and somewhat dated: Water clarity data consists of less than a half dozen in-lake measurements, none more recent than 1992, and water chemistry data is sparse, consisting of one fairly comprehensive set of measurements taken in 1979, and only about half a dozen incomplete and sporadic sets of measurements taken thereafter, the most recent in 1997. As a result, it is somewhat difficult to assess Bark Lake's current water quality with any degree of certainty. Historical data from 1992 suggests that at that time the Lake was within the range of values expected for regional lakes with similar morphometric and bathymetric features. Current data needs to be collected on a regular basis to establish water quality baselines for the Lake before accurate assessments can be made.

POLLUTANT LOADINGS

Pollutant loading of sediments, phosphorous and metals to a lake are generated by various natural processes and human activities that take place in the area tributary to a lake. These loads are transported through various means, including through the atmosphere as dry fallout and direct precipitation, across the land surface directly as surface runoff and indirectly as groundwater inflows, and by way of inflowing streams as surface water inflows. Calculation of these loads within a watershed can be helpful in determining the potential issues that may occur within a lake. Additionally, the calculations can help target efforts toward reducing pollutant inputs to lakes.

In drained lakes with no identifiable point source discharges (e.g., discharges from wastewater treatment facilities or industries), like Bark Lake, the principal routes for pollutant loadings are: 1) precipitation that falls directly onto the lake's surface; and 2) nonpoint source runoff from the watershed.[28] Although groundwater can, in some cases, contribute a significant amount of water to a lake, groundwater is not usually a source of pollution to a lake. For this reason, the loading calculations and discussions that follow focus on nonpoint source pollutant loadings to the lake, which include urban sources including runoff from residential, commercial, industrial, transportation, and recreational land uses, and rural sources, including runoff from agricultural lands.

All of the calculations for nonpoint sourced phosphorus, suspended solids, and urban-derived metal inputs to Bark Lake were estimated using the Wisconsin Lake Model Spreadsheet (WiLMS version 3.0),[29] and the unit area load-based (UAL) models developed for use within the Southeastern Wisconsin Region. These two models operate on the general principal that, depending on land use (agricultural, residential, etc.), a given area of land within a lake's watershed will deliver a typical mass of pollutants to the lake. Values predicted by these two models can then be used to compute in-lake phosphorus concentrations that can be compared to those observed at monitoring stations in a lake, when such data is available. This comparison serves two purposes: 1) the identification of potential water quality issues of concern and 2) the indication of potential sources of water pollution not accounted for on the basis of land use.[30]

Phosphorus Loadings

Table A-8 sets forth the year 2010 phosphorus load to Bark Lake from its watershed, which was estimated using land use inventory data set forth in the regional land use plan.[31] Under year 2010 conditions, the total phosphorus load to Bark Lake from its watershed was estimated to be 1,120 pounds. Of the annual total phosphorus load, it was estimated that 777 pounds per year, or about 69 percent of the total loading, were contributed by runoff from rural lands, mostly from agricultural uses, and 344 pounds per year, or about 31 percent, were contributed by runoff from urban lands, mostly from residential sources.

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[28]*Sven-Olof Ryding, et al.,* op. cit.*; Jeffrey A. Thornton, et al.,* op. cit.

[29]*John C. Panuska and Jeff C. Kreider, Wisconsin Department of Natural Resources Publication No. PUBL-WR-363-94,* Wisconsin Lake Modeling Suite: Program Documentation and User's Manual, Version 3.3 for Windows, *October 2003.*

[30]*The forecast total phosphorus load to a lake, generated through the WiLMS and UAL models, allows calculation of the likely in-lake average annual total phosphorus concentration that can be compared with the observed values reported in the USGS TSI or Level 2 CLMN datasets. Significant differences between forecast and observed values generally indicates the presence of an unidentified source; occasionally, such a difference can be ascribed to the fact that a lake may fall outside the range of typical lakes used to derive the mathematical relationships used in the WiLMS and UAL models.*

[31]*SEWRPC Planning Report No. 48,* op. cit.

Table A-8

ESTIMATED ANNUAL POLLUTANT LOADINGS BY LAND USE CATEGORY WITHIN THE AREA TRIBUTARY TO BARK LAKE: 2010 AND 2035

Land Use Category	Pollutant Loads: 2010				Pollutant Loads: 2035			
	Sediment (tons)	Phosphorus (pounds)	Copper (pounds)	Zinc (pounds)	Sediment (tons)	Phosphorus (pounds)	Copper (pounds)	Zinc (pounds)
Urban								
Residential[a]	8.7	177.6	- -	8.9	16.0	291.8	2.8	32.2
Commercial	13.3	40.8	7.5	50.7	24.3	74.4	13.6	92.4
Industrial	3.8	11.7	2.2	14.9	4.5	14.0	2.6	17.9
Governmental	7.4	39.2	2.0	23.2	9.2	48.6	2.5	28.8
Transportation	12.0	24.0	52.3	187.5	17.6	35.2	76.8	275.2
Recreational	2.2	50.2	- -	- -	2.3	50.8	- -	- -
Subtotal	47.4	343.5	64.0	285.2	73.9	514.8	98.3	446.5
Rural								
Agricultural	193.0	737.9	- -	- -	49.3	188.3	- -	- -
Wetlands	0.7	15.1	- -	- -	0.7	15.1	- -	- -
Woodlands	0.3	6.8	- -	- -	0.3	6.8	- -	- -
Water	7.2	10.0	- -	- -	7.2	10.0	- -	- -
Extractive	1.8	6.9	- -	- -	2.5	9.5	- -	- -
Subtotal	203.0	776.7	- -	- -	60.0	229.7	- -	- -
Total	250.4	1,120.2	64.0	285.2	133.9	744.5	98.3	446.5

Source: SEWRPC.

Table A-8 also shows the estimated phosphorus loads to Bark Lake from its watershed under planned year 2035 conditions.[32] As a result of anticipated land use changes expected to occur through 2035, the annual total phosphorus load to the Lake is estimated to diminish as agricultural activities within the area tributary to Bark Lake are replaced by urban residential land uses. The annual total phosphorus load to the Lake under the planned conditions is estimated to be 745 pounds. Of the total annual planned condition phosphorus load, 230 pounds per year, or about 31 percent of the total loading, are estimated to be contributed by runoff from rural land, and 515 pounds per year, or about 69 percent of the total loading, are estimated to be contributed by runoff from urban land. Thus, it may be anticipated that, not only will the amount of the phosphorus load decrease, but the distribution of the sources of the phosphorus load to the Lake may change—with the amount of phosphorus being contributed from urban sources experiencing an increase from about one-third of the total in 2000 to about two-thirds of the total in 2035, while the amount of phosphorus from agricultural sources will decrease from over two thirds of the total in 2000 to about a third of the total in 2035.

In-Lake Phosphorus Concentration Predictors

Using the estimated phosphorus load and the hydrographical characteristics of the Lake as inputs to the Organization for Economic Cooperation and Development (OECD) phosphorus loading model, in-lake surface water total phosphorus concentration can be estimated.[33] The results of this model indicated an in-lake value of 73 μg/l, which is above the range of observed in-lake total phosphorus concentrations reported from Bark Lake.

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[32]Ibid.

[33]*Organization for Economic Cooperation and Development,* Eutrophication of Waters: Monitoring, Assessment and Control, *OECD, 1982.*

This disagreement between observed and predicted concentrations suggests either that the phosphorus loads entering the Bark Lake system are being filtered through natural processes (e.g., through the wetlands upstream of Bark Lake), thereby reducing loads to the Lake, or that conservation methods aimed at reducing phosphorous loads within the watershed are working. Given that there have not been reported targeted efforts at nutrient loading reduction within the Bark Lake watershed, the former of these options is most likely. This, however, cannot be confirmed given that the last water quality sample tested for phosphorous was taken in 1997, precluding a definitive conclusion.

Comparison to Regional Water Quality Management Plan

The 1979 regional water quality management plan[34] recommended that phosphorus loads to Bark Lake, particularly from agricultural land uses, be reduced by 80 percent from the then-estimated total phosphorus load to the Lake of 2,200 pounds per year in order to protect and maintain good water quality in the Lake and ensure compliance with WDNR water quality standards. Full implementation of the regional water quality management plan, therefore, would have been expected to reduce the estimated 2,200 pounds of phosphorus entering the Lake per year to about 440 pounds of phosphorus per year. Given that the current load of 1,120 pounds is estimated as more than double this recommended value of 440 pounds, it can be concluded that the Bark Lake community has not likely achieved the targeted reduction in total phosphorus loading to the Lake. This conclusion, however, cannot be substantiated due to lack of in-lake phosphorous data beyond 1997.

Sediment Loadings

The estimated sediment loadings to Bark Lake from its watershed under existing year 2000 and planned year 2035 conditions and as set forth in the adopted regional land use plan[35] are shown in Table A-8. A total annual sediment loading of 250 tons was estimated to be contributed to Bark Lake from its watershed under year 2000 conditions, as shown in Table A-8. Of the likely annual sediment load, it was estimated that 203 tons per year, or about 81 percent of the total loading, were contributed by runoff from rural lands, mostly from agricultural sources, and 47 tons, or 19 percent, were contributed by urban lands.

Under 2035 conditions, the annual sediment load to the Lake from its watershed is anticipated to diminish. The annual sediment load to the Lake under 2035 land use conditions is estimated to be 134 tons. Of this forecast sediment load anticipated for Bark Lake, 60 tons of sediment are estimated to be contributed to the Lake from rural sources and 74 tons from urban sources.

Urban Heavy Metals Loadings

Urbanization brings with it increased use of metals and other materials that contribute pollutants to aquatic systems.[36] The majority of these metals become associated with sediment particles,[37] and are, consequently, likely to be encapsulated into the bottom sediments of a lake.

The estimated loadings of copper and zinc contributed to Bark Lake from its watershed under existing year 2000 land use conditions and forecast year 2035 conditions are shown in Table A-8. Under year 2000 land use conditions, 64 pounds of copper and 285 pounds of zinc were estimated to be contributed annually to Bark Lake,

[34]*SEWRPC Planning Report No. 30, Volume Two,* op. cit.

[35]*SEWRPC Planning Report No. 48,* op. cit.

[36]*Jeffrey A. Thornton, et al.,* op. cit.

[37]*Werner Stumm and James J. Morgan,* Aquatic Chemistry: An Introduction Emphasizing Chemical Equilibria in Natural Waters, *Wiley-Interscience, New York, 1970.*

all from urban lands. Under planned year 2035 conditions, as set forth in the adopted regional land use plan,[38] the annual heavy metal loads to the Lake are anticipated to increase to about 98 pounds of copper and 447 pounds of zinc per year.

TROPHIC STATUS

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 to the degree of nutrient enrichment that has occurred. Three terms are generally used to describe the trophic status of a lake: oligotrophic, mesotrophic, and eutrophic.

Oligotrophic lakes are nutrient-poor lakes. These lakes characteristically support relatively few aquatic plants and often do not contain very productive fisheries. Oligotrophic lakes may provide excellent opportunities for swimming, boating, and waterskiing. Because of the Region's naturally fertile soils and the intensive land use activities, there are relatively few oligotrophic lakes in southeastern Wisconsin.

Mesotrophic lakes are moderately fertile lakes which may support abundant aquatic plant growths and productive fisheries. However, nuisance growths of algae and macrophytes are usually not exhibited by mesotrophic lakes. These lakes may provide opportunities for all types of recreational activities, including boating, swimming, fishing, and waterskiing. Many lakes in southeastern Wisconsin are mesotrophic.

Eutrophic lakes are nutrient-rich lakes. These lakes often exhibit excessive aquatic macrophyte growths and/or experience frequent algae blooms. If the lakes are shallow, fish winterkills may be common. While portions of such lakes are not ideal for swimming and boating, eutrophic lakes may support very productive fisheries. Although some eutrophic lakes are present in the Region, highly eutrophic lakes are rare, especially since the implementation of recommendations put forth under the regional water quality management plan. Highly enriched lakes are sometimes referred to as being hypertrophic.

Several numeric "scales," based on one or more water quality indicators (usually Secchi-disk measurements, total phosphorus, and/or chlorophyll-*a* levels), have been developed to define the trophic condition of a lake. Because trophic state is actually a continuum from very nutrient poor to very nutrient rich, a numeric scale is useful for comparing lakes and for evaluating trends in water quality conditions. Care must be taken, however, that the particular scale used is appropriate for the lake to which it is applied. In this case, two indices appropriate for Wisconsin lakes have been used; namely, the Vollenweider-OECD open-boundary trophic classification system,[39] and the Wisconsin Trophic State Index value (WTSI).[40] The WTSI is a refinement of the Carlson TSI,[41] and is designed to account for the greater humic acid content, or brown water color, present in Wisconsin lakes, and has been adopted by the WDNR for use in lake management investigations.

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[38]*SEWRPC Planning Report No. 48,* op. cit.

[39]*H. Olem and G. Flock, U.S. Environmental Protection Agency Report EPA-440/4-90-006,* The Lake and Reservoir Restoration Guidance Manual, *2nd Edition, Washington, D.C., August 1990.*

[40]*See R.A. Lillie, S. Graham, and P. Rasmussen, "Trophic State Index Equations and Regional Predictive Equations for Wisconsin Lakes,"* Research and Management Findings*, No. 35, Wisconsin Department of Natural Resources Publication No. PUBL-RS-735 93, May 1993.*

[41]*R.E. Carlson, "A Trophic State Index for Lakes,"* Limnology and Oceanography*, Vol. 22, No. 2, 1977.*

WTSI numeric scales are based, over time, on average total phosphorus and chlorophyll-*a* levels and Secchi-disk depths. Using the WTSI numeric scales, lakes with WTSI values in the range of 30 to 40 would be considered oligotrophic, values in the 40 to 50 range would be mesotrophic, and values above 50 would be considered eutrophic. As shown in Table A-6, during 1992, WTSI calculations for Bark Lake based on Secchi-disk measurements averaged 50; based on total phosphorus measurements, averaged 52; and based on chlorophyll-*a* measurements, averaged 52. Such values would classify Bark Lake as a slightly eutrophic, or "meso-eutrophic," lake. This is a typical condition observed in many lakes in southeastern Wisconsin.[42] These values are slightly less than those estimated during the aforementioned ERSC satellite remote sensing study in which 11 estimates of water clarity were taken by satellite between July of 2001 and September of 2010. Under that study, Bark Lake was estimated to have an average Secchi measurement of 1.6 meters, which equates to a WTSI value of 53.2, indicating slightly more enriched conditions than the in-lake measurements. Based upon both the remote sensing and volunteer monitoring data, Bark Lake can be classified as a slightly eutrophic waterbody.

AQUATIC PLANTS

Aquatic plants include larger plants, or macrophytes, and microscopic algae, or phytoplankton. These plants form an integral part of the aquatic food web, converting inorganic nutrients present in the water and sediments into organic compounds that are directly available as food to other aquatic organisms. In this process, known as photosynthesis, plants utilize energy from sunlight and release the oxygen required by many other aquatic life forms into the water. Aquatic plants also serve a number of other valuable functions in a lake ecosystem, including improving water quality by filtering excess nutrients from the water, providing habitat for invertebrates and fish, stabilizing lake bottom substrates, and supplying food for waterfowl and various lake-dwelling animals.

Aquatic plants are often described using the terms *submerged*, *floating,* and *emergent,* depending on where the plant is found in the lake ecosystem. *Submerged* plants are found in the main lake basin and, although most are rooted in the bottom substrate, some forms, such as coontail (*Ceratophylum demersum*) are free-floating. *Floating* plants, such as water lilies, generally have large, floating leaves and are usually found in shallow water areas of a few feet in depth or less that contain loose bottom sediments. Floating plants may also be either rooted (water lily) or free-floating (duckweed, *Lemna* spp.). *Emergent* plants are those that grow along the shoreline areas of a lake, such as the bulrushes and cattails. All three types have significant roles to play in the overall working of a lake's ecosystem.

Aquatic Plant Surveys

To document the types, distribution, and relative abundance of aquatic macrophytes in Bark Lake, an aquatic plant survey was conducted by SEWRPC staff during the summer of 2012. This survey utilized a point intercept methodology[43] in which predetermined points arranged in a grid pattern across the entire lake surface are used as sampling sites. The staff located each point using global positioning system (GPS) technology. At each sampling site, a single rake haul is taken and a quantitative assessment of the rake fullness, on a scale of zero to three, is made for each species identified. Map A-19 shows the locations of the survey sampling sites on Bark Lake, while Figure A-8 includes pictorial representations of the relative rake fullness amounts used to determine the quantitative assessments. Of the 167 sites sampled in Bark Lake, 117 sites had vegetation.

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[42]*SEWRPC Memorandum Report No. 93,* op. cit.

[43]*Wisconsin Department of Natural Resources, Publication No. PUB-SS-1068 2010,* Recommended Baseline Monitoring of Aquatic Plants in Wisconsin: Sampling Design, Field and Laboratory Procedures, Data Entry and Analysis, and Applications, *March 2010.*

Map A-19

AQUATIC PLANT SURVEY SAMPLING POINTS ON BARK LAKE

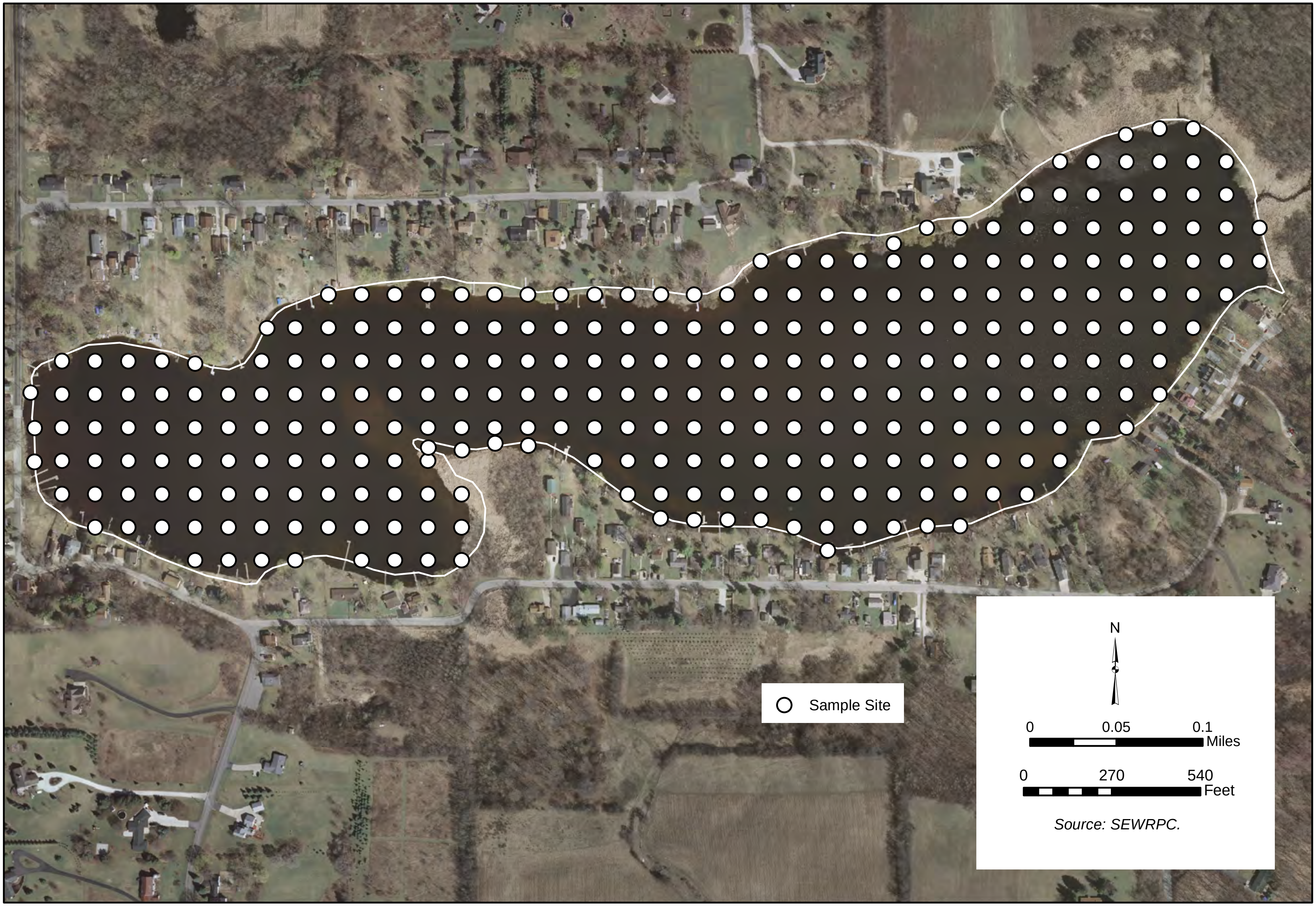

Figure A-8

SCHEMATIC REPRESENTATION OF RAKE FULLNESS RATINGS

0 **1** **2** **3**

NO VEGETATION

Source: Wisconsin Department of Natural Resources and SEWRPC.

A list of aquatic plant species observed during the 2012 survey of Bark Lake, along with various statistical parameters describing the abundance factors of those plants, is presented in Table A-9. Individual species maps showing the relative abundances and distributions of each species in Bark Lake, along with comments regarding the ecological significance of each plant, how to identify it and a photograph of it, can be found in Appendix C.

Aquatic Plant Diversity in Bark Lake

A key aspect of the ability of an ecosystem, such as a lake, to maintain its ecological integrity is through biological diversity, or species richness. Overall, with 16 different native submerged and floating species of aquatic plants identified in the 2012 survey, Bark Lake contains a very good diversity of aquatic species, especially for a lake its size. By way of comparison, nearby Friess Lake contained 15 species of submerged aquatic plants in a 2005 survey[44] and Pike Lake contained 25 native submerged, floating, and emergent species in a 2012 survey. Map A-20 shows degrees of biodiversity, or *species richness*, as it applies to native plant species found in Bark Lake during the 2012 survey.

Dominant Aquatic Plants in Bark Lake

As shown in Table A-9, during the 2012 survey, the overall most dominant species in the Lake, as determined by the "importance value" of each species, was Eurasian water milfoil (*Myriophyllum spicatum*), a nonnative plant. The five most dominant *native* species, in descending order, were: muskgrass (*Chara* spp.), white water lily (*Nuphar* odorata), Illinois pondweed (*Potemogeton illinoensis*), coontail (*Ceratophyllum demersum*), and bladderwort (*Utricularia vulgaris*). As noted above, informative distribution maps for these five species, plus all other species observed in Bark Lake in 2012, are located in Appendix C.

Other Aquatic Plant Species of Special Significance in Bark Lake

Native Plants

Aquatic plants, in much the same way as their terrestrial counterparts live in community with one another. They develop complex interactions and mutual dependencies that are of great significance in how these dynamic communities function within a lake. *Native* aquatic plant species are specifically adapted to local aquatic environments and many kinds of wildlife depend exclusively on the presence of specific plant species for survival. Of the 18 aquatic plants found in Bark Lake, 16 of them were native.

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[44]*SEWRPC Memorandum Report No. 169,* An Aquatic Plant Management Plan for Friess Lake, Washington County, Wisconsin, *June 2008.*

Table A-9

ABUNDANCE DATA FOR SUBMERGED AQUATIC PLANT SPECIES IN BARK LAKE: 2012

Aquatic Plant Species	Number of Sites Found	Frequency of Occurrence[a] (percent)	Relative Density[b]	Importance Value[c]
Floating Plants				
Nymphaea odorata (white water lily)	54	46.20	3.90	177.80
Nuphar variegata (spatterdock)	4	3.40	2.50	8.60
Nelumbo lutea (American lotus)	1	0.90	3.00	2.60
Submerged Plants				
Myriophyllum spicatum (Eurasian water milfoil)	100	85.47	3.59	306.84
Chara spp. (muskgrass)	51	43.59	4.29	187.18
Potamogeton illinoensis (Illinois pondweed)	33	28.21	3.15	88.89
Ceratophyllum demersum (coontail)	37	32.62	2.51	79.49
Utricularia vulgaris (bladderwort)	21	17.95	1.86	33.33
Stuckenia pectinata (Sago pondweed)	15	12.82	2.33	29.91
Potamogeton gramineus (variable pondweed)	9	7.69	3.22	24.79
Potamogeton praelongus (white-stem pondweed)	9	7.69	2.67	20.51
Myriophyllum sibiricum (native milfoil)	8	6.84	2.50	17.09
Najas marina (spiny, or brittle, naiad)	5	4.27	2.00	8.55
Potamogeton richardsonii (clasping-leaf pondweed)	2	1.71	2.00	3.42
Elodea canadensis (waterweed)	1	0.85	3.00	2.56
Najas flexilis (bushy pondweed)	2	1.71	1.00	1.71
Potamogeton robinsii (Robbins pondweed)	1	0.85	2.00	1.71
Zosterella dubia (water stargrass)	1	0.85	1.00	0.85

NOTE: Sampling occurred at 167 sampling sites; 117 had vegetation.

[a]*The percent frequency of occurrence is the number of occurrences of a species divided by the number of samplings with vegetation, expressed as a percentage. It is the percentage of times a particular species occurred when there was aquatic vegetation present.*

[b]*The relative density is the sum of the abundance scores—the field assessment of the abundance, on a scale of 1 to 5, of a particular species at each sampling site—for a species divided by the number of sampling points where that species was found. It is an indication of how abundant a particular plant is throughout a lake.*

[c]*The importance value is the product of the frequency of occurrence and the relative density, expressed as a percentage. It provides an indication of the dominance of a species within a community.*

Source: SEWRPC.

Pondweeds

The presence of native pondweeds is generally considered to be indicative of a healthy lake and good habitat for fishes and aquatic life. Pondweeds, as a group, tend to occur at very specific times during the year; hence, though pondweeds may not be present when the plant survey is conducted, they may still be present within the aquatic plant community. Pondweeds provide good habitat and serve as food and shelter for a variety of aquatic organisms and waterfowl. The 2012 survey identified six native pondweed species in Bark Lake.

Of the pondweeds that occur in the Region, white-stem pondweed (*Potamogeton praelongus*) is of special importance because of its sensitivity to changes in water quality and intolerance of turbidity. It is considered a valuable water quality indicator species, since its disappearance from a lake is usually an indication of deteriorating water quality. Conversely, its presence in a lake is usually an indicator of good water quality.[45] Of the 117 sampling sites that contained vegetation, nine sites contained white-stem pondweed. This species should be given special attention in future aquatic plant surveys in Bark Lake to determine if its population is increasing or decreasing.

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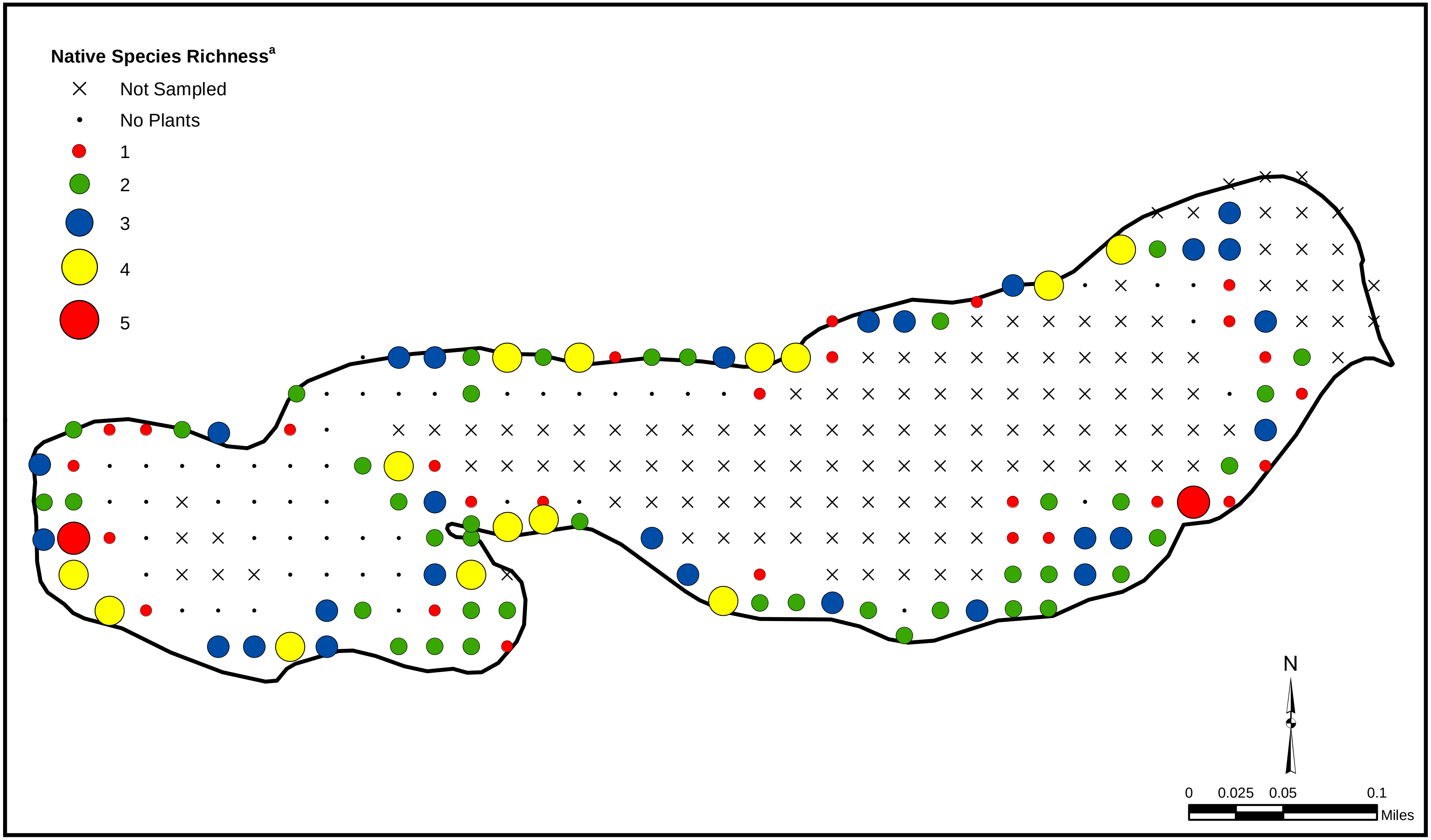
[45]*Wisconsin Lakes Partnership,* Through the Looking Glass...A Field Guide to Aquatic Plants, *University of Wisconsin-Extension.*

Map A-20

AQUATIC PLANT SURVEY SITES AND SPECIES RICHNESS IN BARK LAKE: 2012



[a] *Native species richness refers to the number of native plants present at each sampling site.*

Source: SEWRPC.

Aquatic Invasive Species (AIS)

The introduction of nonnative (invasive) plant and animal species into an area can cause great disruption to both terrestrial and aquatic natural systems. This is because many invasive species have no natural predators to keep their numbers in control and often reproduce explosively, outcompeting native species for necessary resources. This can have devastating effects on native wildlife species that have developed dependencies on the availability of specific native plants. The most common and destructive invasive species in Wisconsin lakes are Eurasian water milfoil and curly-leaf pondweed.

Two invasive species were found in Bark Lake, including spiny naiad and Eurasian water milfoil. The discussion below focuses on the latter because this species is considered detrimental to the ecological health of the Lake and is a declared nuisance species identified in Chapters NR 40 and NR 109 of the *Wisconsin Administrative Code* (while spiny naiad is not).

Eurasian Water Milfoil

Eurasian water milfoil is one of eight milfoil species found in Wisconsin, the only one of which is known to be exotic or nonnative. As mentioned above, because of its nonnative nature, Eurasian water milfoil has few natural enemies that can inhibit its growth, which can be explosive under suitable conditions. The plant exhibits this characteristic growth pattern in lakes with organic-rich sediments, or where the lake bottom has been disturbed, e.g., it frequently has been reported as a colonizing species following dredging. Unless its growth is anticipated and controlled, Eurasian water milfoil populations can displace native plant species and interfere with the aesthetic and recreational use of waterbodies, as was evidenced by the overgrowth that occurred in Bark Lake over the past decade. This plant has also been known to cause severe recreational use problems in lakes within the Southeastern Wisconsin Region.

Eurasian water milfoil reproduces by the rooting of plant fragments. Consequently, some recreational uses of lakes can result in the expansion of Eurasian water milfoil communities. For example, when boat propellers fragment Eurasian water milfoil plants, these fragments, as well as fragments that occur for other reasons, such as wind-induced turbulence or fragmentation of the plant by fishes, are able to generate new root systems, allowing the plant to colonize new sites. The fragments also can cling to boats, trailers, motors, and/or bait buckets, and can stay alive for weeks, contributing to the transfer of milfoil to other lakes. For this reason, it is very important to remove all vegetation from boats, trailers, and other equipment after removing them from the water and prior to launching in other waterbodies.

Of the 117 sampling sites in Bark Lake that contained vegetation, Eurasian water milfoil was found in 100, or 85 percent. Map A-21 shows the distribution and relative densities of Eurasian water milfoil infestations around Bark Lake. Future aquatic plant surveys in Bark Lake will be necessary to monitor whether this species in increasing or decreasing in abundance.

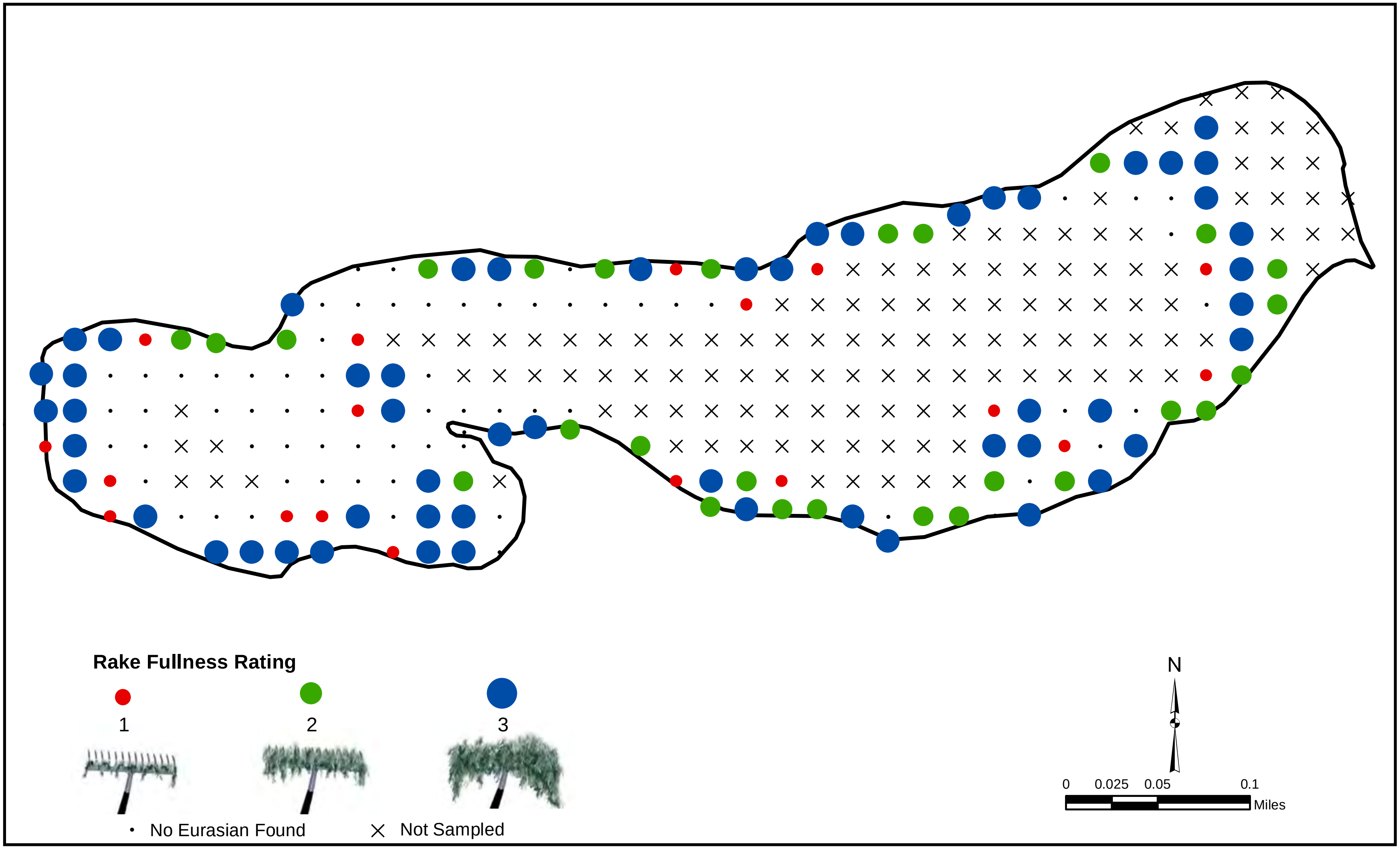
Past and Present Aquatic Plant Management Practices in Bark Lake

Records of aquatic plant management efforts on Wisconsin lakes were first maintained by the WDNR beginning in 1950. Prior to 1950, aquatic plant management interventions are likely, but were not recorded. Currently, all forms of aquatic plant management are subject to permitting by the WDNR pursuant to authorities granted the Department under Chapters NR 107 and NR 109 of the *Wisconsin Administrative Code*.

Past aquatic plant management practices on Bark Lake are not well documented. Table A-10 shows the records of chemical applications in 1997, 2002, 2003, 2012, and 2013. The aquatic plant management activities in Bark Lake could be characterized as primarily a chemical control program designed to minimize nuisance growths of aquatic macrophytes. Unlike many waterbodies in southeastern Wisconsin, there are no records of the use of sodium

Map A-21

EURASIAN WATER MILFOIL OCCURENCE IN BARK LAKE: 2012



Source: SEWRPC.

Table A-10

CHEMICAL CONTROLS ON BARK LAKE: 1979-2003

Year	Algae Control		Macrophyte Control					
	Cutrine Plus	Copper Sulfate	Sodium Arsenite	2,4-D	Hydrothol	Diquat	Glyphosate	Endothall/ Aquathol
1997	- -	- -	- -	100 lbs.	- -	- -	- -	- -
2002	- -	- -	- -	20 gallons	- -	- -	- -	- -
2003	- -	- -	- -	7 gallons	- -	- -	- -	- -
2012	- -	25 lbs.	- -	- -	- -	- -	- -	- -
2013	- -	- -	- -	5 lbs.[a]	- -	- -	- -	- -
Total	- -	- -	- -	27 gallons + 105 lbs.	- -	- -	- -	- -

[a]*In 2013, only a very small area (0.05 acres) was treated due to Eurasian water milfoil no longer being the dominant species.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

arsenite as an aquatic herbicide on Bark Lake[46] and annual chemical treatments have been the primary method of aquatic plant management, focusing on Eurasian water milfoil (2,4-D). These treatments have been aimed at minimizing nuisance growths of the designated nuisance species, Eurasian water milfoil, to the benefit of native aquatic plant flora in Bark Lake.

FISH AND WILDLIFE

Fish and Fisheries

Bark Lake has been recommended for the maintenance of a warmwater sportfishery and full recreational use.[47] The WDNR reports that, in Bark Lake, northern pike, largemouth bass, and panfish are considered to be "common," while walleye are listed as "present."[48] Records of stocking of Bark Lake are few. There was one documented stocking of 2,593 large fingerling walleye stocked from a private hatchery in 2008. The WDNR has no record of any fish surveys being done on Bark Lake, thus no fishery management recommendations can be made at this time. However, when WDNR completes installation of a boat access site,[49] Bark Lake will be eligible for WDNR-led fishery studies and stocking, thereby ensuring that recommendations can be made in the future.

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[46]*Sodium arsenite was typically sprayed onto the surface of a lake, within an area of up to 200 feet from the shoreline, between mid-June and mid-July in a volume sufficient to result in a concentration of about 10 mg/l sodium arsenite (about 5.0 mg/l arsenic) in the treated lake water. The sodium arsenite typically remained in the water column for less than 120 days, during which period the arsenic residue was naturally converted from a highly toxic form to a less toxic, less biologically active form that subsequently was deposited in the lake sediments. By 1969, it became apparent that arsenic was accumulating in the sediments of treated lakes, so the use of sodium arsenite was discontinued in the State.*

[47]*SEWRPC Memorandum Report No. 93,* op. cit.

[48]*Wisconsin Department of Natural Resources Publication No. PUB-FH-800 2005,* Wisconsin Lakes, *2005.*

[49]*A State of Wisconsin-owned property at the southeast end of Bark Lake is under development for use as a public boat access site.*

Bark Lake does not currently contain any State-listed species of special concern, however the Bark River within Washington County is known to provide habitat for the least darter (*Etheostoma microperca*), which is listed.

Habitat Conditions

Despite the absence of fisheries studies of Bark Lake, there has been anecdotal evidence of a healthy fish population. This anecdotal evidence has been further supported by the observed presence of good fishery habitat conditions, in particular fallen trees that are partially submerged under the lake surface, native plant communities, and a sandbar formed of sand and gravel materials. Each of these features is well known for providing good aquatic habitat due to its ability to provide food, oxygen, and spawning grounds, respectively.

Other Wildlife

Amphibians and reptiles are vital components of the Bark Lake ecosystem, and include frogs, toads, salamanders, turtles, and snakes. About 14 species of amphibians and 16 species of reptiles would normally be expected to be present in the Lake's watershed.[50] The watershed would also be expected to support a significant population of waterfowl, including mallards, wood duck, and blue-winged teal. During the migration seasons a greater variety of waterfowl would likely be present and in greater numbers.

With respect to wildlife, most of the wildlife remaining in and around the shorelands of the Lake would be expected to be urban-tolerant species such as muskrats, beaver, smaller animals (shrews, mice), and waterfowl in the lakeshore areas and grey and fox squirrels and cottontail rabbits more widely distributed throughout the immediate riparian areas. Larger mammals, such as the whitetail deer, are likely to be confined to the larger wooded areas and the open meadows found within the watershed of the Lake. The remaining undeveloped areas provide the best-quality cover for many wildlife species.

IMPORTANT NATURAL AREAS

Many important interlocking and interacting relationships occur between living organisms and their environment. The destruction or deterioration of any one element of a natural environment may lead to a chain reaction of deterioration and destruction among the others. The drainage of wetlands, for example, may have far-reaching effects. Such drainage may destroy fish spawning grounds, wildlife habitat, groundwater recharge areas, and natural filtration and floodwater storage areas. The resulting deterioration of surface water quality may, in turn, lead to a deterioration of the quality of the groundwater. Groundwater serves as a source of domestic, municipal, and industrial water supply and provides low flows in rivers and streams. Although the effects of any one environmental change in isolation may not be overwhelming, the combined effects may lead eventually to the deterioration of the underlying and supporting natural resource base, and of the overall quality of the environment for life. The need to protect and preserve the wetlands, uplands, environmental corridors, and other natural areas within the watershed is, therefore, crucial if Bark Lake is to be maintained as a healthy lake system.

Wetlands

Historically, wetlands were largely viewed as wastelands, presenting obstacles to agricultural production and development. Private interests, as well as governmental institutions, supported the transformation of wetlands into desired uses through large-scale draining and filling. This misunderstanding of the importance of wetlands led to dramatic wetland losses until scientific research revealed the value of wetlands as extremely productive and biologically diverse ecosystems that provide natural pollution reduction.[51]

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[50]*SEWRPC Community Assistance Planning Report No. 196,* A Management Plan for Powers Lake, Kenosha and Walworth Counties, Wisconsin*, November 1991.*

[51]*J.A. Cherry, "Ecology of Wetland Ecosystems: Water, Substrate, and Life," Nature Education Knowledge, Volume 3, No. 10, 2012, p. 16. Available online at:* http://www.nature.com/scitable/knowledge/library/ecology-of-wetland-ecosystems-water-substrate-and-17059765.

In terms of diversity, wetlands are most known for their variety of plant life from *submergent* species, including algae; floating species, such as pond lilies; *emergent* species, such as cattails and bulrush; and *woody* species, such as tamarack trees and various species of shrubs. Species of both aquatic and terrestrial wildlife communities that have been found to rely on, or are associated with, wetlands for at least part of their lives include crustaceans, mollusks, and other aquatic insect larvae and adults; fishes, including forage fish and important gamefish species such as trout, northern pike, and largemouth bass; amphibians; reptiles; mammals, including deer, muskrat, and beaver; resident bird species, such as turkey; and migrant species such as sandhill and whooping cranes. Thus, wetlands help maintain biologically diverse communities of ecological and economic value.

In addition to maintaining biodiversity, wetlands provide a host of additional services that include storing flood-waters; improving water quality by filtering pollutants; protecting groundwater aquifers; serving as sinks, sources, or transformers of materials; and providing recreation sites for boating and fishing.[52] This recognition of the value and importance of wetlands has led to the creation of rules and regulations to protect wetlands around the world, as well as nationally (i.e., the Federal Clean Water Act of 1972), statewide, and locally. Most recently, the U.S. Army Corp of Engineers and U.S. Environmental Protection Agency, in coordination with the U.S. Fish and Wildlife Service, WDNR, and SEWRPC have updated the delineation of wetlands in areas of special natural resource interest for the entire Region to protect these areas and their associated critical species habitats through Advanced Delineation and Identification (ADID).[53] These efforts are designed to protect or conserve wetlands and the ecosystem services they provide.

Wetlands in the Bark Lake watershed are distributed as shown on Map A-22. They are located primarily at the inlet to Bark Lake, providing the Lake with a degree of pollution and sediment reduction from surface water runoff that enters the lake from the northern half of the watershed. The provision of this level of protection, in combination with the many other benefits provided by wetlands, illustrates how crucial the maintenance of these wetlands are for Bark Lake.

Woodlands

Woodland areas in the Bark Lake watershed are also shown on Map A-22. The remaining woodland areas in the Lake's watershed are comprised of a number of small, fragmented parcels. Such fragmentation greatly diminishes the ability of a woodland to provide adequate habitat for many wildlife species, thereby indicating that the remediation and connection of woodlands should be encouraged to increase their ability to support wildlife. As can be seen on the map, these areas may be located within or outside of wetland areas.

Uplands

Upland habitats (see Map A-23) are basically natural areas that are not defined as wetland. These areas are usually higher in elevation than wetlands and are located outside wetlands farther away from open water, so they are drier in character. Upland can sometimes be very difficult to distinguish from wetland, because these features form

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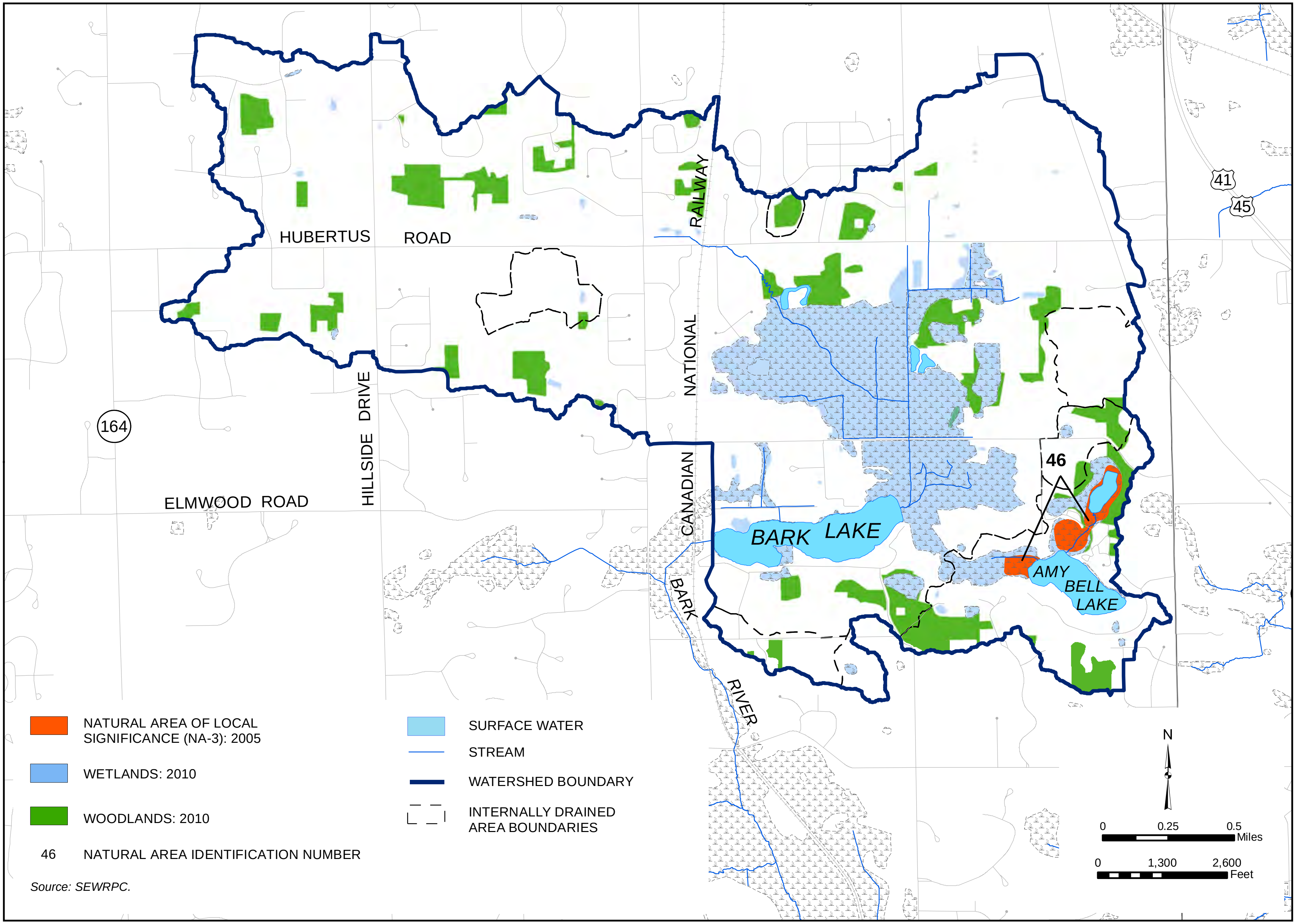
[52] *Marsden Jacob Associates,* Literature Review of the Economic Value of Ecosystem Services that Wetlands Provide, *Final Report prepared for the Department of Sustainability, Environment, Water, Population and Communities, September 2012; The Ramsar Convention on Wetlands. Available online at:* http://www.ramsar.org/cda/en/ramsar-july13-homeindex/main/ramsar/1%5E26239_4000_0__.

[53] *Pursuant to Section NR 103.04(4) of the* Wisconsin Administrative Code, *wetlands in areas of special natural resources interest includes those wetlands both within the boundary of designated areas of special natural resource interest and those wetlands which are in proximity to or have a direct hydrologic connection to such designated areas, which include Advanced Delineation and Identification study (ADID) areas. See SEWRPC Planning Report No 42,* Amendment to the Natural Areas and Critical Species Habitat Protection and Management Plan for the Southeastern Wisconsin Region, *December 2010. Available online at:* http://www.sewrpc.org/SEWRPCFiles/Publications/pr/pr-042-natural-areas-crit-species-habitat-amendment.pdf?

Map A-22

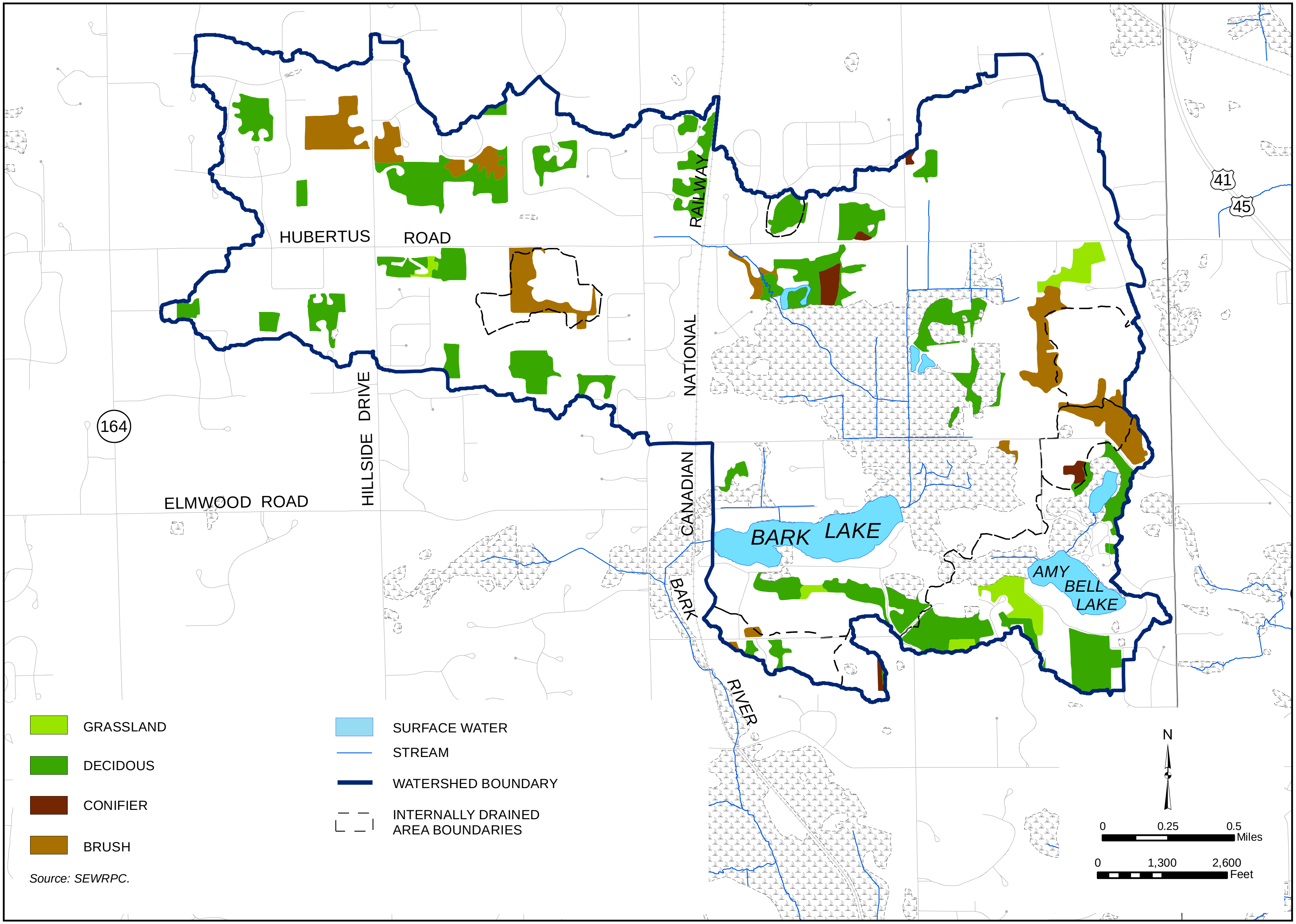
NATURAL AREAS, WOODLANDS, AND WETLANDS WITHIN THE BARK LAKE WATERSHED



Source: SEWRPC.

Map A-23

UPLAND COVER TYPES WITHIN THE BARK LAKE WATERSHED: 2005



Source: SEWRPC.

broad and complex mosaics or combinations across the landscape. It is precisely this combination and linkages between these unique community types that provides the critical habitats to sustain healthy and diverse aquatic and terrestrial wildlife.

Like wetland ecosystems, as described above, upland habitats also provide many critical functions to an ecosystem, including production of food, livestock and crops; groundwater recharge and water quality; air quality; soil conservation; wildlife management potential through provision of critical breeding, nesting, resting, and feeding grounds, and refuge from predators for many species of upland game and nongame species; recreation; tourism; and education.

Another important contrast between upland and wetland is that the upland soils generally pose much fewer limitations for urban development. In general, uplands have a lower water table than wetlands. Also, relative to wetland soils, upland soils have lower compressibility, greater stability, greater bearing capacity, and lower shrink-swell potential. These conditions usually result in less flooding, dry basements, more stable foundations, more stable pavements, and less failure of sanitary sewer and water lines. Therefore, there are significantly lower costs associated with onsite preparation and maintenance for development on upland soils, particularly in connection with roads, foundations, and public utilities, which makes these areas desirable for urban development. Thus, development is often undertaken within upland areas, thereby reducing or eliminating the benefits uplands provide to a watershed. It is, therefore, important to communicate the benefits of uplands and promote protection of their ecological benefits when development occurs.

SEWRPC-Designated Environmental Corridors

The environmental corridor concept is an essential planning tool for protecting the most important remaining natural resource features in the Southeastern Wisconsin Region and elsewhere. It is a planning 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. The process provides a framework for the designation and protection of environmental corridors to guide future growth, land development, and land conservation decisions in appropriate areas to protect both community and natural resource assets.[54]

"Environmental corridors" refer to interconnected green space networks of natural areas and features, public lands, and other open spaces that provide natural resource value. They are divided into the following three categories:

- ***Primary environmental corridors*** (PEC), which contain concentrations of the most significant natural resource features. They are at least 400 acres in size, at least two miles in length, and at least 200 feet wide.

- ***Secondary environmental corridors*** (SEC), which contain significant, but smaller, concentrations of natural resources. They are at least 100 acres in size and at least one mile in length, unless serving to link primary corridors.

- ***Isolated natural resource areas*** (INR), which are isolated "pockets" of natural resources that have been designated significant. They are at least five acres in size and 200 feet wide.

Primary Environmental Corridors

PECs encompassed about 660 acres, or about 19 percent, of the Bark Lake watershed in 2005, including Bark Lake itself (see Map A-24). These PECs represent a composite of the best remaining elements of the natural resource base, and contain almost all of the best remaining woodlands, wetlands, and wildlife habitat areas in the

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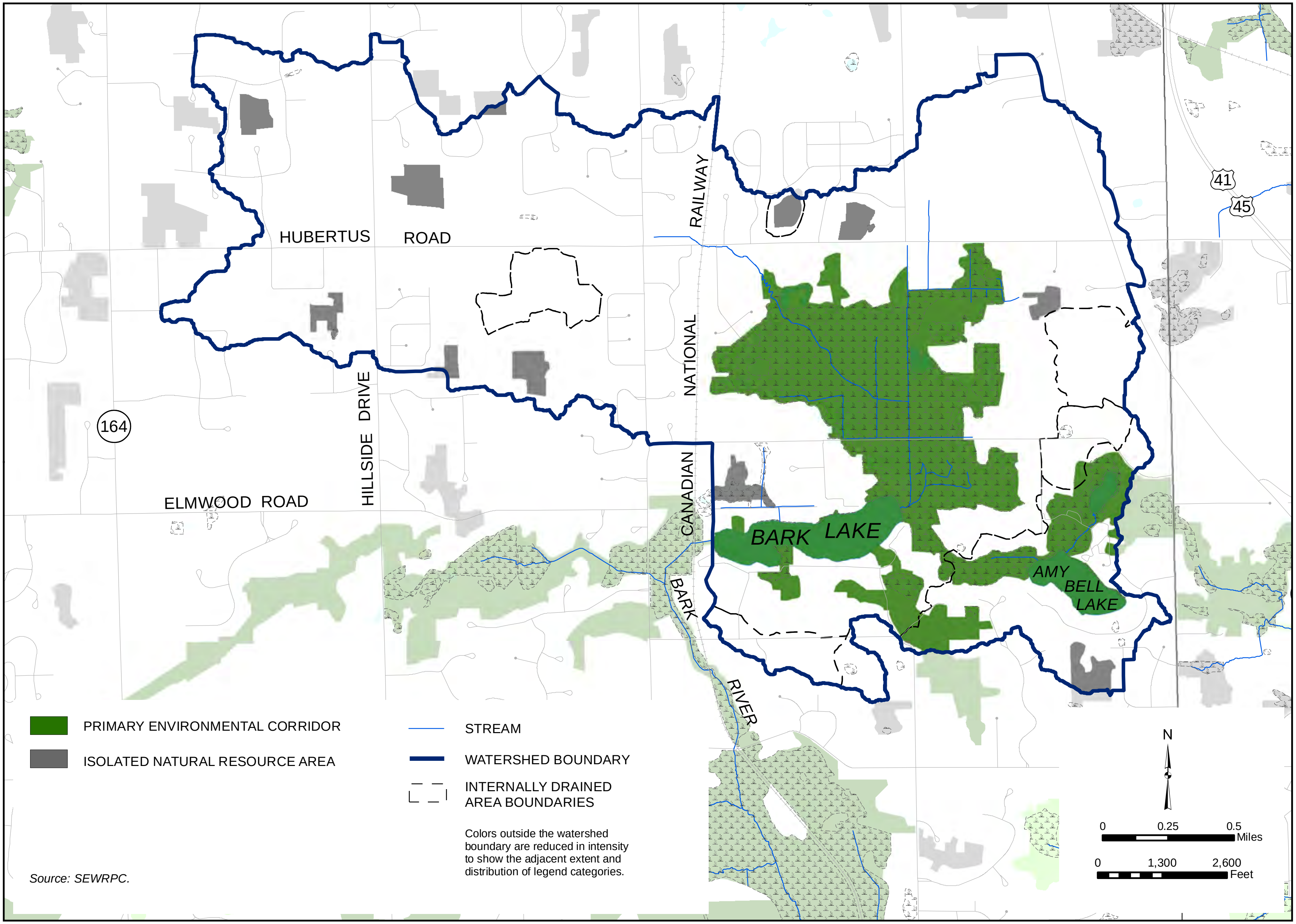
[54]*SEWRPC Riparian Buffer Management Guide No. 1,* op. cit.

Map A-24

ENVIRONMENTAL CORRIDORS AND ISOLATED NATURAL RESOURCE AREAS WITHIN THE BARK LAKE WATERSHED: 2005



watershed. Although Bark Lake is typically shown as open water, it is also important to note that the lakes, rivers, and streams and their associated shoreland areas, including Bark Lake, are, in fact, PECs. In other words, the Lake and its associated shoreland areas are part of the highest quality natural resources within the Bark Lake watershed, thereby providing further evidence that these nearshore areas are vitally important to protect and maintain the quality and integrity of Bark Lake.

Secondary Environmental Corridors

Secondary environmental corridors (SECs) facilitate surface water drainage, maintain pockets of natural resource features, and provide corridors for the movement of wildlife, as well as for the movement and dispersal of seeds for a variety of plant species. There were no SECs within the Bark Lake watershed as of 2005.

Isolated Natural Resource Areas

Smaller concentrations of natural resource features that have been separated physically from the environmental corridors by intensive urban or agricultural land uses, called isolated natural resource areas, have also been identified. Widely scattered throughout the Bark Lake watershed, isolated natural resource areas included about 100 acres, or about 3 percent, of the total study area in 2005. Isolated natural resource areas in the Bark Lake watershed are also shown on Map A-24.

Other Considerations

Since development of the environmental corridor concept, significant advancements in landscape ecology have furthered the 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 these new technologies in combination with protecting environmental corridors and further developing riparian buffers.[55]

SEWRPC-Designated Natural Areas and Critical Species Habitat

Natural areas, as defined by the Wisconsin Natural Areas Preservation Council, are tracts of land or water that have been so minimally modified by human activity, or have sufficiently recovered from the effects of such activity, that they contain intact native plant and animal communities believed to be representative of the pre-European settlement. Natural areas are generally comprised of wetland or upland vegetation communities and/or complex combinations of both these fundamental ecosystem units (see the Wetlands and Uplands subsections). In fact, some of the highest quality natural areas within the Southeastern Wisconsin Region are wetland complexes that have maintained adequate or undisturbed linkages (i.e., landscape connectivity) between the upland/wetland habitats. These findings are consistent with research findings in other areas of the Midwest.[56]

As part of its regional planning program, and as a logical extension of its environmental corridor concept expounded through the regional-, county-, and local-level land use plans for southeastern Wisconsin,[57] SEWRPC has identified natural areas and critical species habitat areas within the Southeastern Wisconsin Region in SEWRPC Planning Report No. 42, "*A Regional Natural Areas and Critical Species Habitat Protection and Management Plan for Southeastern Wisconsin,*" published in September 1997, and amended in 2010. This plan

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[55]Ibid.

[56]*O. Attum, Y.M. Lee, J.H., Roe, and B.A. Kingsbury, "Wetland Complexes and Upland-Wetland Linkages: Landscape Effects on the Distribution of Rare and Common Wetland Reptiles,"* Journal of Zoology, *Volume 275, 2008, pp. 245-251.*

[57]*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.*

was developed to assist Federal, State, and local units and agencies of government, and nongovernmental organizations, in making environmentally sound land use decisions, including acquisition of priority properties, management of public lands, and location of development in appropriate locations that will protect and preserve the natural resource base of the Region.

The identified natural areas were classified into three categories based upon consideration of several factors, including the diversity of plant and animal species and community types present; the structure and integrity of the native plant or animal community; the extent of disturbance by human activity, such as logging, grazing, water level changes, and pollution; the frequency of occurrence within the Region of the plant and animal communities present; the occurrence of unique natural features within the area; the size of the area; and the educational value. These categories are as follows:

1. Natural area of statewide or greater significance (NA-1);

2. Natural area of countywide or regional significance (NA-2); or

3. Natural area of local significance (NA-3).

The natural areas and critical species habitats identified in the Bark Lake watershed, including Bark Lake, are shown on Map A-24. These include Amy Bell Lake and Lowlands, a small lake and bog comprised of 20 acres of tamarack relict and shrub-carr habitat, designated NA-3; and Bark Lake, designated AQ-3 (a lake of local significance).[58] These areas should be protected from development and maintained to the greatest extent possible.

Lands in Public and Private Protection
Within, and immediately adjacent to, the Bark Lake watershed are several land areas that are under public (i.e., State of Wisconsin or Village of Richfield) and private ownership/protection. Those areas are shown on Map A-25. Of note is the small parcel of State of Wisconsin-owned property at the southeast end of Bark Lake that is currently under development for use as a public boat access site.

WDNR-Designated Sensitive Areas
Within or immediately adjacent to bodies of water, the WDNR, pursuant to authorities granted under Chapter 30 of the *Wisconsin Statutes* and Chapter NR 107 of the *Wisconsin Administrative Code*, can designate environmentally sensitive areas on lakes that have special biological, historical, geological, ecological, or archaeological significance, “offering critical or unique fish and wildlife habitat, including seasonal or life-stage requirements, or offering water quality or erosion control benefits of the body of water.” Bark Lake is not listed by the WDNR as containing any officially designated sensitive areas.

RECREATIONAL USES

Bark Lake is used year-round for a variety of active recreational purposes, as well as a visual amenity. As set forth in the regional water quality management plan,[59] Bark Lake is considered to have water quality capable of supporting a full range of active and passive recreational uses. Active recreational uses include fishing, powerboating, waterskiing, tubing, canoeing, kayaking, and swimming during the summer months and ice fishing, snowmobiling, ice skating, cross-country skiing, and snowshoeing during the winter. Popular passive recreational uses include walking, bird watching and picnicking. Like many of the lakes in the Region, Bark Lake experiences occasional intense recreational boating use on weekends and holidays during the summer.

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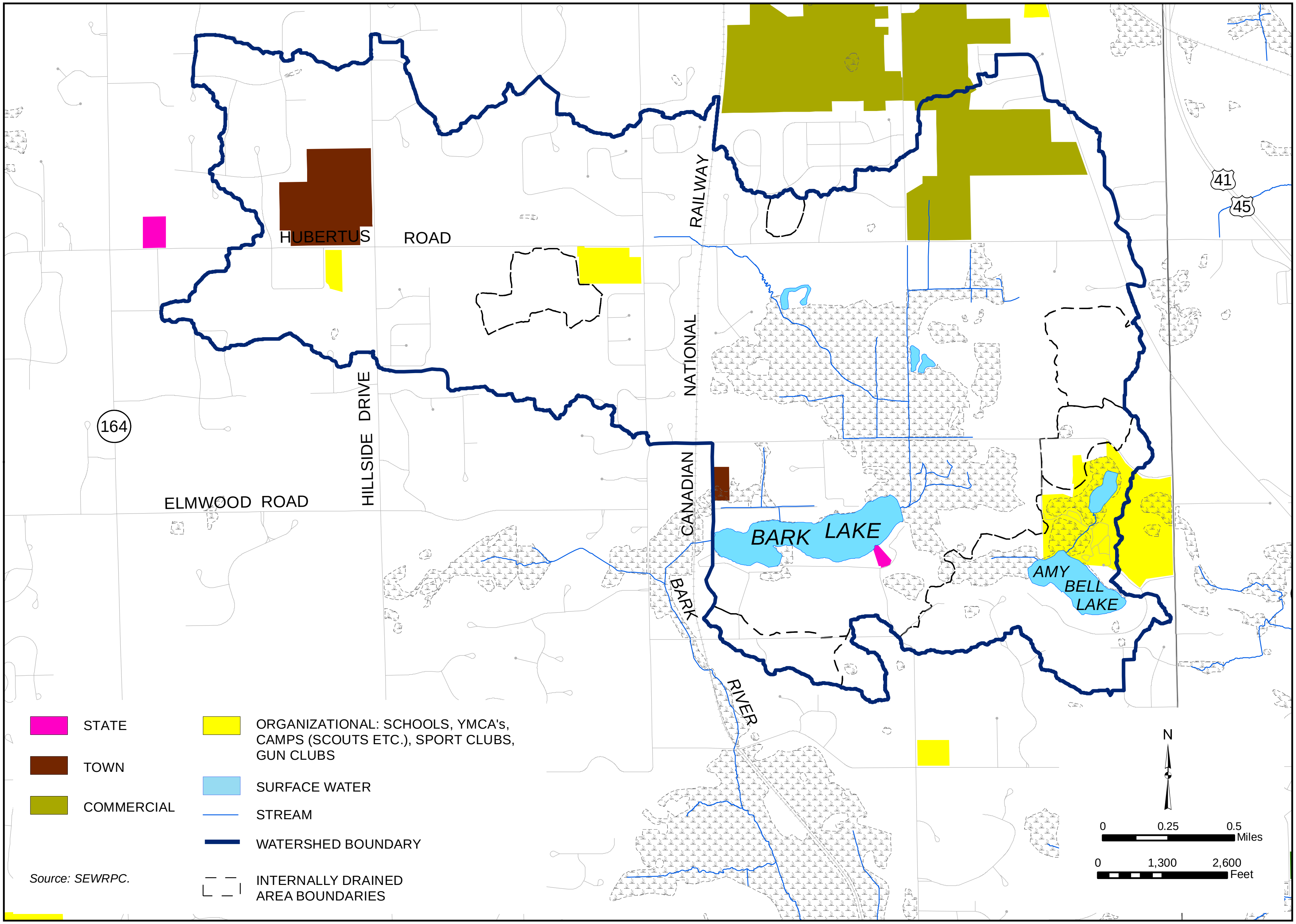
[58]*SEWRPC Planning Report No. 42,* op. cit.

[59]*SEWRPC Planning Report No. 30,* op. cit. *See also SEWRPC Memorandum Report No. 93,* op. cit.

Map A-25

LANDS IN PUBLIC AND PRIVATE PROTECED OWNERSHIP WITHIN AND ADJACENT TO THE BARK LAKE WATERSHED



Source: SEWRPC.

Table A-11

WATERCRAFT DOCKED OR MOORED ON BARK LAKE: 2012[a]

Type of Watercraft									
Powerboat	Fishing Boat	Pontoon Boat	Personal Watercraft	Canoe	Sailboat	Kayak	Pedalboat	Rowboat	Total
13	29	26	4	26	3	7	38	24	170

[a]*Including trailered watercraft and watercraft on land observable during survey.*

Source: SEWRPC.

Watercraft Census

The types of watercraft docked or moored on a lake, as well as the relative proportion of nonmotorized to motorized watercraft, reflect the attitudes of the primary users of the lake, the lake residents. A census of watercraft docked or moored on Bark Lake was conducted by SEWRPC staff during 2012. At that time, a total of the census 170 watercraft were observed, either moored in the water or stored on land in the shoreland areas around the Lake, as shown in Table A-11. About 42 percent of all docked or moored boats were motorized, with fishing boats and pontoon boats comprising the most common types, while 58 percent of all docked or moored boats were nonmotorized, with pedal-boats/paddleboats, rowboats, and canoes being the most common. The five most numerous types of watercraft observed were, in descending order: pedalboats/paddleboats, fishing boats, pontoon boats, canoes, and rowboats. The remaining types of watercraft, in descending order, were: powerboats, kayaks, personal watercraft (PWC), and sailboats.

In a similar survey conducted on nearby Friess Lake in 2005, just over 57 percent of watercraft docked or moored were motorized, with pontoon boats and powerboats comprising the two largest categories, while on Pike Lake, in 2012, motorized watercraft accounted for about 56 percent of all watercraft, with pontoon boats comprising the single-largest category of motorized watercraft.

To assess the degree of recreational boat use on a lake, it has been estimated that, in southeastern Wisconsin, the total number of watercraft of all kinds operating on a lake at any given time is between about 2 percent and 5 percent of the total number of watercraft docked and moored. On Bark Lake, this would equal from about three to nine watercraft. These numbers would produce watercraft densities on Bark Lake that would range from about one watercraft per seven acres down to about one watercraft per 21 acres. If only watercraft of high-speed capability[60] are used in these determinations, the watercraft densities diminish to an estimated one per 16 acres down to one per 41 acres.

"Slow boating" activities, such as canoeing, kayaking, pedalboating, and rowboating, are generally distinguished from "fast boating" activities, such as sailing, waterskiing/tubing, motorboating, or "fast cruising." With regard to this, there is a range of opinions on the issue of what constitutes optimal boating density, or the optimal number of acres of open water available on which to operate a boat. During the mid-1970s and 1980s, for example, an average area of about 16 acres per powerboat or sailboat was considered suitable for the safe and enjoyable use of such watercraft on a lake.[61] However, as motorized watercrafts of all kinds have steadily increased in power and

[60]*For the purpose of this analysis high-speed capabilities include powerboats, fishing boats, pontoon boats, personal watercrafts, and sailboats. The number associated in each is shown in Table A-11.*

[61]*See SEWRPC Planning Report No. 27,* A Regional Park and Open Space Plan for Southeastern Wisconsin: 2000, *November 1977.*

speed, this density has become less accurate. As a result, since 1995, Chapter NR 1 of the *Wisconsin Administrative Code* established standards for recreational boating access on public inland lakes in the State. For a lake with the surface area of Bark Lake, 62 acres, these standards impose a minimum requirement for provision of car-trailer unit parking at one or more access sites which, in total, provide a combination of five vehicle and car-trailer units—which would equate to about one high-speed boat for each 12 acres of water. Based on this standard, Bark Lake would likely be well within the range of having adequate surface area in which to safely operate high-speed watercraft under most normal and nonholiday conditions.

Recreational Use Surveys
Another way to assess the degree of recreational watercraft use on a lake is through direct counts of boats in use on a lake at a given time. During 2012, surveys of the types of watercraft in use and how they were being used on typical summer weekdays and typical summer weekend days were conducted by SEWRPC staff. The results of these surveys are shown in Tables A-12 and A-13. As indicated in Table A-12, during typical summer weekdays there is very little boating activity on Bark Lake. Consequently, it is unlikely that high-speed boating traffic on Bark Lake during weekdays would constitute a safety issue from overcrowding. Weekend boating activities, as shown in Table A-13, generally exceed those on weekdays, as would be expected. Fishing; high-speed cruising, mainly person water crafts (PWCs); waterskiing/tubing; and low-speed cruising, mainly pontoons, are the most popular weekend boating activities on Bark Lake. During the weekend days when the surveys were conducted, boating densities were always less than one watercraft per 12 acres.

Tables A-14 and A-15 show the various types of recreational activities engaged in by people using Bark Lake during typical summer weekdays and weekend days in 2012. The most popular weekday recreational activities on the Lake were personal watercraft operation, waterskiing/tubing, and swimming. On weekend days, the most popular activities were swimming, high-speed cruising, waterskiing/tubing, and fishing from boats.

Overall, during the summer months, the Lake receives a moderate amount of use primarily by boaters and tubers during the week, while on weekends fishermen are the primary users until late morning, at which time local boating ordinances (see Appendix B) allow for high-speed boating traffic to commence.

LOCAL ORDINANCES

Civil Divisions
Superimposed on the watershed boundary is a pattern of local political boundaries. The entire Bark Lake watershed is located within the boundaries of the Village of Richfield in the south central part of Washington County. Geographic boundaries of the civil divisions must be considered in the lake protection plan since civil divisions, including lake management districts and lake protection and rehabilitation districts, form the basic foundation of the public decision-making framework within which intergovernmental, environmental, and developmental problems must be addressed.

Civil Division Zoning Ordinances
Zoning is used to regulate the use of land in a manner that promotes the general welfare of citizens, the quality of the environment and the conservation of resources, and to implement land use plans. Local zoning regulations include general, or comprehensive, zoning regulations and special-purpose regulations, such as those governing floodland areas, shoreland and shoreland-wetland areas, subdivisions, construction erosion control, and stormwater management. General zoning and special-purpose zoning regulations may be adopted as a single ordinance or as separate ordinances, and they may or may not be contained in the same document. Any analysis of locally proposed land uses must take into consideration the provisions of both general and special-purpose zoning. Table A-16 shows the general- and special-purpose zoning ordinances for the civil divisions that are part of the Bark Lake watershed.

General Zoning
Villages in Wisconsin are granted comprehensive, or general, zoning powers under Section 61.35 of the *Wisconsin Statutes.*

Table A-12

ACTIVE RECREATIONAL WATERCRAFT AND RELATED ACTIVITIES ON BARK LAKE—WEEKDAYS: SUMMER 2012

		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.		4:00 p.m. to 5:00 p.m.
Category	Observation	June 29	August 8	August 15	June 21	July 31	August 8	August 23
Type of Watercraft (number in use)	Power/ski boat	0	0	0	0	0	1	0
	Pontoon boat	0	0	0	0	0	0	0
	Fishing boat	0	0	0	0	0	0	1
	Personal watercraft	0	0	0	0	0	0	0
	Kayak/canoe	0	0	0	0	0	0	0
	Rowboat	0	0	0	0	0	0	0
	Sailboat	0	0	0	0	0	0	0
	Wind board/paddle board	0	0	0	0	0	0	0
	Paddleboat (pedalboat)	0	0	0	0	0	0	0
	Other	0	0	0	0	0	0	0
Activity of Watercraft (number engaged)	Motorized cruise/pleasure							
	Low speed	0	0	0	0	0	0	1
	High speed	0	0	0	0	0	0	0
	Fishing	0	0	0	0	0	0	0
	Skiing/tubing	0	0	0	0	0	1	0
	Sailing/windsurfing	0	0	0	0	0	0	0
	Rowing/paddling/pedaling	0	0	0	0	0	0	0
	Other	0	0	0	0	0	0	0
Total	On water	0	0	0	0	0	1	1
	In high-speed use	0	0	0	0	0	1	0

NOTE: Shaded column denotes local no-wake ordinance in effect from 5:00 p.m. to 10:00 a.m. on Bark Lake.

Source: SEWRPC.

Table A-13

ACTIVE RECREATIONAL WATERCRAFT AND RELATED ACTIVITIES ON BARK LAKE—WEEKENDS: SUMMER 2012

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.		4:00 p.m. to 5:00 p.m.
		August 19	July 21	August 11	August 19	July 21	August 11	August 25	August 25
Type of Watercraft (number in use)	Power/ski boat	0	0	0	0	0	2	0	0
	Pontoon boat	0	0	0	2	0	0	0	0
	Fishing boat	0	1	0	2	1	1	0	0
	Personal watercraft	0	0	2	0	0	2	0	0
	Kayak/canoe	0	0	0	0	1	0	0	0
	Rowboat	0	0	0	0	0	0	0	0
	Sailboat	0	0	0	0	0	0	0	0
	Wind board/paddle board	0	0	0	0	0	0	0	0
	Paddleboat (pedalboat)	0	0	0	0	0	0	0	0
	Other	0	0	0	0	0	0	0	0
Activity of Watercraft (number engaged)	Motorized cruise/pleasure								
	Low speed	0	0	0	0	0	0	0	0
	High speed	0	0	2	0	0	0	0	0
	Fishing	0	1	0	4	2	0	0	0
	Skiing/tubing	0	0	0	0	0	2	0	0
	Sailing/windsurfing	0	0	0	0	0	0	0	0
	Rowing/paddling/pedaling	0	0	0	0	0	0	0	0
	Other	0	0	0	0	0	0	0	0
Total	On water	0	1	2	4	2	5	0	0
	In high-speed use	0	0	2	0	0	4	0	0

NOTE: Shaded column denotes local no-wake ordinance in effect from 5:00 p.m. to 10:00 a.m. on Bark Lake.

Source: SEWRPC.

Table A-14

RECREATIONAL ACTIVITIES OBSERVED ON BARK LAKE—WEEKDAYS: SUMMER 2012

Activity Observed (average number of people)	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.		4:00 p.m. to 5:00 p.m.
	June 29	August 8	August 15	June 21	July 31	August 8	August 23
Park Goer	0	0	0	0	0	0	0
Beach Swimming[a]	0	0	0	0	0	3	0
Boat/Raft Swimming	0	0	0	0	0	0	1
Canoeing/Kayaking	0	0	0	0	0	0	0
Sailboating	0	0	0	0	0	0	0
Wind Surfing/Paddle Boarding	0	0	0	0	0	0	0
Rowing	0	0	0	0	0	0	0
Paddleboating	0	0	0	0	0	0	0
Fishing from Boats	0	0	0	0	0	0	0
Fishing from Shore	1	0	0	0	0	0	0
Low-Speed Cruising	0	0	0	0	0	0	2
High-Speed Cruising	0	0	0	0	0	0	0
Skiing/Tubing	0	0	0	0	0	6	0
Personal Watercraft Operation	0	0	0	0	0	9	0
Other	0	0	0	0	0	6	0

NOTE: Shaded column denotes local no-wake ordinance in effect from 5:00 p.m. to 10:00 a.m. on Bark Lake.

[a]*There are no public parks or beaches on Bark Lake; beach swimming would refer to people swimming on beaches located on riparian properties*

Source: SEWRPC.

In 1986, Washington County rescinded its general zoning ordinance, and all nine towns that were subject to the general County zoning ordinance have since adopted their own general zoning ordinance. The Town of Richfield, incorporated as a Village on February 13, 2008, has adopted its own ordinances in regard to general zoning, as shown in Table A-16.

Floodplain Zoning

Flooding is a natural occurrence associated with many lakes and streams. It becomes a problem when it occurs in areas where human development exists. *Floodplains* are those lands that may become flooded during a flooding event. Map A-26 shows the extent of floodplains within the Bark Lake watershed based on a one percent probability (100-year recurrence interval), which is the regulatory standard applied for local zoning and Federal flood insurance purposes.

Section 87.30 of the *Wisconsin Statutes* requires that villages and counties, with respect to their unincorporated areas, adopt floodplain zoning to preserve the floodwater conveyance and storage capacity of floodplain areas and to prevent the location of new flood-damage-prone development in flood hazard areas. The minimum standards which such ordinances must meet are set forth in Chapter NR 116, "Wisconsin's Floodplain Management Program," of the *Wisconsin Administrative Code*. As shown in Table A-16, the Village of Richfield has adopted, with minor revisions, the Washington County floodland zoning ordinances.

Table A-15

RECREATIONAL ACTIVITIES OBSERVED ON BARK LAKE—WEEKENDS: SUMMER 2012

Activity Observed (average number of people)	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.		4:00 p.m. to 5:00 p.m.
	August 19	July 21	August 11	August 19	July 21	August 11	August 25	August 25
Park Goer	0	0	0	0	0	0	0	0
Beach Swimming[a]	0	0	0	0	0	15	0	0
Boat/Raft Swimming	0	0	0	0	0	8	5	0
Canoeing/Kayaking	0	0	0	0	0	0	0	0
Sailboating	0	0	0	0	0	0	0	0
Wind Surfing/Paddle Boarding	0	0	0	0	0	0	0	0
Rowing	0	0	0	0	0	0	0	0
Paddleboating	0	0	0	0	0	0	0	0
Fishing from Boats	0	1	0	8	3	0	0	0
Fishing from Shore	0	0	0	0	0	0	0	1
Low-Speed Cruising	0	0	0	0	0	4	0	0
High-Speed Cruising	0	0	0	0	0	8	0	0
Skiing/Tubing	0	0	0	0	0	6	0	0
Personal Watercraft Operation	0	0	2	0	0	2	0	0
Other	0	0	0	0	0	0	0	0

NOTE: Shaded column denotes local no-wake ordinance in effect from 5:00 p.m. to 10:00 a.m. on Bark Lake.

[a]*There are no public parks or beaches on Bark Lake; beach swimming would refer to people swimming on beaches located on riparian properties*

Source: SEWRPC.

Table A-16

LAND USE REGULATIONS WITHIN THE AREA TRIBUTARY TO BARK LAKE IN WASHINGTON COUNTY BY CIVIL DIVISION

Community	Type of Ordinance				
	General Zoning	Floodland Zoning	Shoreland or Shoreland-Wetland Zoning	Subdivision Control	Construction Site Erosion Control and Stormwater Management
Village of Richfield	Adopted	Washington County ordinance with minor revisions	Washington County ordinance with minor revisions	Adopted	- -[a]

[a]*The Town of Richfield incorporated as a Village on February 13, 2008; Richfield has adopted an Erosion Control and Stormwater Management Ordinance and has entered into an intergovernmental agreement with Washington County for County administration of the ordinances.*

Source: SEWRPC.

Shoreland Zoning

Shoreland zoning regulations play an important role in protecting water resources. Under Section 59.692 of the *Wisconsin Statutes*, counties in Wisconsin (within their unincorporated areas) are required to adopt zoning regulations within statutorily defined shoreland areas, which are defined as those lands within 1,000 feet of a navigable lake, pond, or flowage; 300 feet of a navigable stream; or to the landward side of the floodplain, whichever distance is greater.[62] Shoreland zoning has the goal of protecting water quality, fish and wildlife habitat, recreation, and natural beauty. To accomplish these goals, the statewide minimum standards for county shoreland zoning ordinances in Chapter NR 115, "Wisconsin's Shoreland Management Program," of the *Wisconsin Administrative Code*[63] create a 35-foot vegetated buffer strip and a 75-foot building setback around navigable waters, control the intensity of development around navigable waters, and protect wetlands within shorelands.

The Village of Richfield has adopted, with minor revisions, the County shoreland or shoreland-wetland zoning ordinances, as indicated in Table A-16.

Subdivision Zoning

Chapter 236 of the *Wisconsin Statutes* requires the preparation of a subdivision plat whenever five or more lots of 1.5 acres or less in area are created either at one time or by successive divisions within a period of five years. The *Wisconsin Statutes* set forth requirements for surveying lots and streets, for plat review and approval by State and local agencies and for recording approved plats. Section 236.45 of the *Wisconsin Statutes* allows any city, village, town or county that has established a planning agency to adopt a land division ordinance, provided the local ordinance is at least as restrictive as the State platting requirements. Local land division ordinances may include the review of other land divisions not defined as "subdivisions" under Chapter 236, such as when fewer than five lots are created or when lots larger than 1.5 acres are created. As shown in Table A-16, the Village of Richfield has adopted its own subdivision control ordinance.

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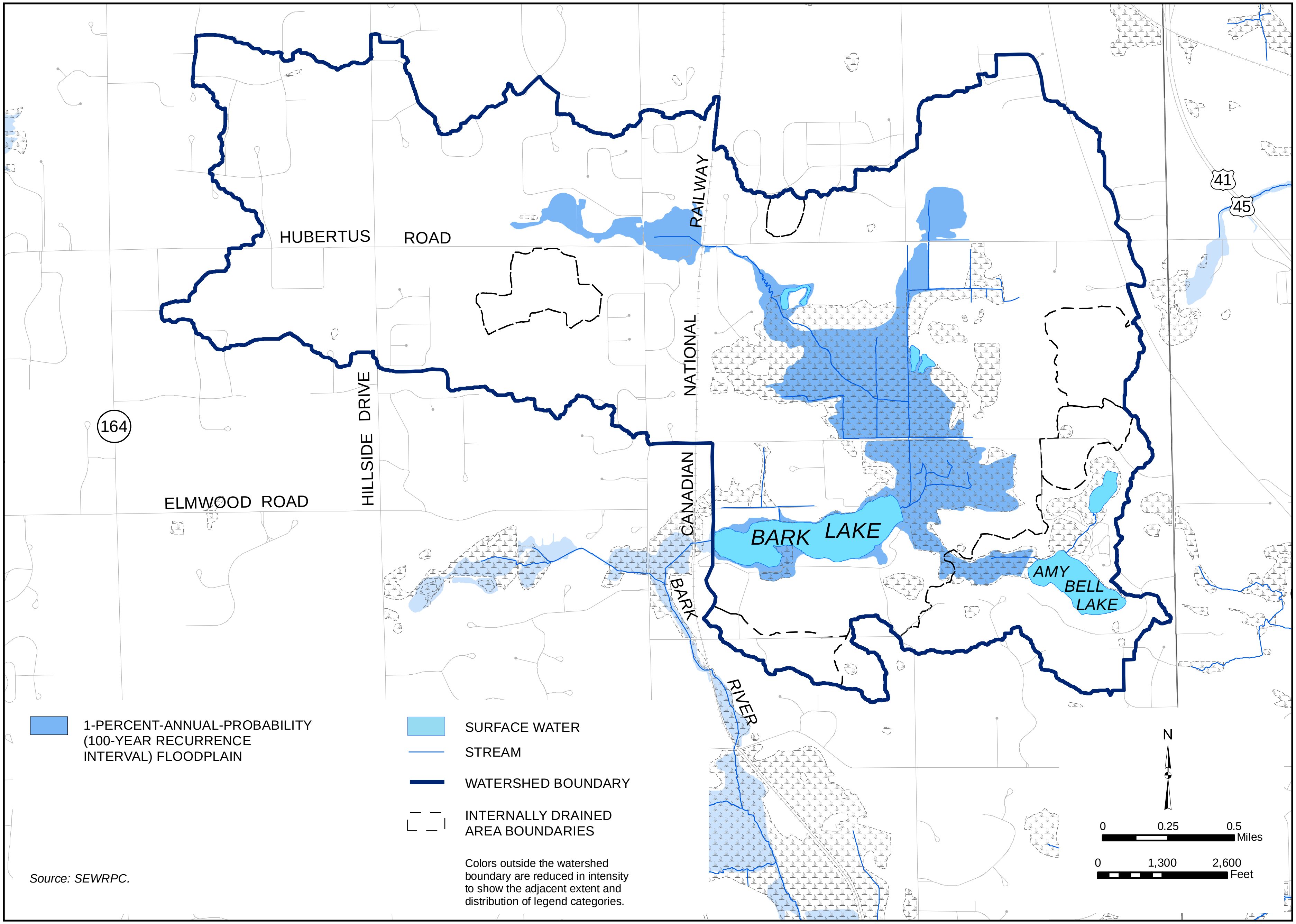
[62]*Definitive determination of navigability and location of the ordinary high water mark on a case-by-case basis is the responsibility of the Wisconsin Department of Natural Resources.*

[63]*The most recent revisions to Chapter NR 115 were promulgated in 2014.*

Map A-26

FLOODPLAINS WITHIN THE BARK LAKE WATERSHED



Source: SEWRPC.

Construction Site Erosion Control and Stormwater Management Zoning

Stormwater management and erosion control ordinances help minimize water pollution, flooding, and other negative impacts of urbanization on water resources (lakes, streams, wetlands, and groundwater) and property owners, both during and after construction activities. These ordinances are an important tool for accomplishing watershed protection goals because they apply to the whole watershed.

The *Wisconsin Statutes* grant authority to counties (Section 59.693), villages (Section 61.653), and towns (Section 60.627) in Wisconsin to adopt ordinances for the prevention of erosion from construction sites and the management of stormwater runoff, which generally apply to new development from lands within their jurisdictions. A county ordinance would apply to all unincorporated areas and newly annexed lands, unless the annexing city or village enforces an ordinance at least as restrictive as the county ordinance.

As shown in Table A-16, the Village of Richfield has adopted a construction site erosion control and stormwater management ordinance and has entered into an intergovernmental agreement with Washington County for County administration of the ordinance.

Appendix B

BOATING ORDINANCE FOR BARK LAKE

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Chapter 42. PARKS AND RECREATION

GENERAL REFERENCES

Definitions, generally — See § 1.12.
Alcohol and nonintoxicating beverages — See Ch. **6**.

42.01. Parks.

A. Definitions. The following words, terms, and phrases, when used in this article, shall have the meanings ascribed to them in this section, except where the context clearly indicates a different meaning:

PUBLIC GROUNDS
All public parks owned or operated by the Village.

VEHICLE
Any bicycle, snowmobile, motorcycle, trailer, wagon, horse, or similar means of travel.

B. Prohibited Acts. It shall be unlawful for any person to commit any of the following acts in or upon any public grounds in the Village:

1. Parking. To park any vehicle, except within the limits of clearly marked parking areas.

2. Vehicles. To operate any vehicle, except upon clearly marked roadways, trails or paths designated for such purposes.

3. Speed. To operate any vehicle upon any roadway within the limits of such public grounds at a speed in excess of 15 miles per hour or a lesser posted speed limit.

4. Closing hours. To enter or remain in or upon such grounds between the hours of 10:30 p.m. and 7:00 a.m. the following morning except as allowed by permit issued by the Park and Recreation Commission.

5. Firearms. To carry, keep or use any firearm, bow and arrow, slingshot, trap gun, or other shooting device.

6. Vandalism. To soil, deface, injure, damage, upset, or destroy any building, fence, fountain, bench, table, receptacle, fireplace, tree, bush, flower, or other object situated, used, or kept upon such grounds.

7. Digging. To dig or break up the ground surface except in areas specifically designated as campgrounds and upon issuance of a permit by the Park and Recreation Commission.

8. Fires. To build any fire, except in fireplaces or other suitable facilities provided for that purpose; or to dispose live embers of any fire. Fires may be permitted in areas specifically designated as a campground and upon issuance of a permit by the park and recreation commission.

9. Litter. To leave, throw or break any bottle, box, refuse, or other object, except in clearly marked refuse receptacles provided for that purpose.

10. Animals. To take, have, or keep any dog or cat, except upon a leash.

11. Fireworks. To set off fireworks of any kind, except when a public display permit has been issued by the Village Board pursuant to section 38-111.

12. Games. To engage in any athletic contest, game or activity, except in areas specifically designated for such activity, whereby large areas of public grounds are usurped by the participants to the exclusion and at the peril of injury to others.

13. Rules. To fail, refuse or neglect to obey the regularly posted rules and regulations for the use or enjoyment of any facilities.

C. Group use of parks; registration or permit required. Any assembly of persons over 20 in number shall register with the Village Clerk before using the facilities, giving the name of a person responsible and the activity planned and pay appropriate fee(s). Any group over 200 in number shall obtain a permit from the park and recreation commission prior to the date of use. The commission shall include in its consideration of any such request the ability of the park facilities to accommodate the proposed activity and compatibility of the proposed activity with other planned activities and uses in the park. The committee may require a damage deposit and/or fee established by the Village board in the fee schedule.

D. Music. Portable music and sound equipment, including radios, record players, etc., may be used in the park only in such a manner which is not a nuisance to other users or park personnel. Live music or musical instrument playing is allowed in the parks only with prior approval of the park and recreation commission.

E. Alcohol use. The only alcoholic beverages to be consumed on such public grounds are those sold on such public grounds by licensees of the Village. The use of alcoholic beverages may be restricted to certain areas of each park by the park and recreation commission to avoid use conflicts. Such restrictions shall be posted in any such designated area.

F. Penalties for violation of article. Any person who shall violate any provision of this article may be punished by a forfeiture of not more than $250, together with the costs of prosecution, and, in case of default of payment of such forfeiture and costs, by imprisonment in the county jail for a term not exceeding 30 days.

42.02. Boating and lake recreational activities.

The intent of this ordinance is to provide safe and healthful conditions for the enjoyment of aquatic recreation in the Village of Richfield consistent with public rights and interests, and the capability of the water resources.

A. Definitions. The following words, terms, and phrases, when used in this article, shall have the meanings ascribed to them in this section, except where the context clearly indicates a different meaning:

MECHANICAL

A way to power a watercraft through electric, gas, or other methods other than human motions.

PUBLIC ACCESS

Any access to the waters by means of public property.

SLOW-NO-WAKE

That speed at which a boat moves as slowly as possible while still maintaining steerage control.

TRAFFIC LANE

The surface of the lake that is more than 150 feet distant from and parallel to the shore, or 100 feet distant from the projecting extremities of any pier, wharf or other structure built in or over the water.

B. Applicability of article provisions. The provisions of this article shall apply to the waters of Amy Belle Lake, Bark Lake, Friess Lake, Little Friess Lake, and Lake Five.

C. Enforcement of article provisions. The provisions of this article shall be enforced by the Washington County Sheriff's Department lake patrol, a contracted law enforcement unit of the Village of Richfield.

D. State boating and safety laws adopted. The statutory provisions describing and defining water traffic, boats, boating and related activities contained in Wis. Stats. §§ 30.50—30.71 and the rules and regulations of the State Department of Natural Resources are adopted and by reference made a part of this article. Any act required or prohibited by the provisions of such statutes or rule or regulation incorporated by reference is required or prohibited by this article.

E. Posting of Village boating regulations required. Signs briefly stating boating regulations, as established in this article, shall be posted at all public and private launch sites where a fee is paid.

F. Speed regulations. In addition to the speed regulations in Wis. Stats. § 30.66, the following restrictions shall apply:

1. No person shall operate a boat powered by mechanical means at any time on Amy Belle Lake.

2. No person shall operate a boat at a speed greater than 25 miles per hour from 10:00 a.m. to 7:00 p.m. on Friess Lake. At all other times the maximum speed shall be slow-no-wake.

3. No person shall operate a boat at a speed greater than 40 miles per hour on Lake Five from 10:00 a.m. to 8:00 p.m. or sunset, whichever comes first. At all other times the maximum speed shall be slow-no-wake.

4. No person shall operate a boat at a speed greater than 25 miles per hour during the hours of 10:00 a.m. to 5:00 p.m. on Bark Lake. At all other times the maximum speed shall be slow-no-wake.

5. No person shall operate a boat at a speed greater than slow-no-wake at all times on Little Friess Lake.

6. No person shall operate a boat outside the traffic lane established in section 42.02 (A) on Friess Lake, Lake Five or Bark Lake at a speed greater than slow-no-wake.

7. No person may operate any vehicle on any icebound lake at a speed greater than 25 miles per hour.

G. Emergency slow no wake.

1. Declaration of emergency. During periods of abnormally high lake levels, the Village President or his/her designee is authorized and directed to declare a high lake water emergency for any and all lakes located in the Village. The Village Administrator, working with the lake associations and the Highway Superintendent, shall establish benchmark(s) on each of the lakes to use as reference point(s) during abnormally high lake levels. These reference point(s) shall be used in the determination to declare an emergency. Additional factors may be considered to declare an emergency, such as weather forecasts, shoreline erosion, neighborhood concerns, historical data, DNR information and other variables.

2. Orders. During high lake water emergencies, the Village president or his/her designee is authorized and directed to issue slow-no-wake orders for any and all lakes located in the Village. Copies of such orders shall be posted at all public and private landings. When lake levels have returned to normal levels the Village president or his/her designee shall declare a cessation of the high level emergency and rescind the slow-no-wake order.

3. Speed limit. During the period that the slow-no-wake order is in effect, no person shall operate a boat at a speed greater than slow-no-wake.

4. Penalty. Any person who violates this section shall be subject to a forfeiture of $50 for the first offense and $100 for the second and subsequent offenses.

H. Prohibited operation. In addition to the requirements and restrictions set forth in Wis. Stats. § 30.68 and 30.62(2):

1. No motor boat shall pass within 100 feet of a swimmer or skindiver's marker unless physical circumstances make compliance impossible.

2. No person shall operate any boat 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 water skier operate or approach closer than 100 feet to any swimmer or skindiver's marker.

3. All boats for rent or hire shall have stenciled or printed on the top side of the rear seat thereof the maximum safe carrying capacity of such boat.

4. No motorboat shall approach or pass another boat in such a manner as to create a hazardous wake or wash.

5. No person shall use wake-enhancing devices, including ballast tanks, wedges, or hydrofoils or other mechanical devices, or un-even loading of persons or gear, to artificially operate bow-high on any lake in the Village.

I. Water skiing. In addition to the requirements and restrictions set forth in Wis. Stats. § 30.68:

1. No person shall operate a motorboat towing a person on water skis, aquaplane, wakeboard, 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 he/she can, in fact, observe the progress of the person being towed.

2. No person shall operate nor shall any boat owner allow a boat to be operated to tow more than two persons on water skis, aquaplanes or other similar devices at any one time, except that on Bark Lake not more than one person may be so towed.

3. Persons waterskiing or using other similar devices shall also conform to all provisions of this article and shall not engage in any activity contrary to the provisions of this article.

J. Rafts, buoys, and markers.

1. All rafts, platforms, buoys, and markers shall be anchored and shall have at least eight inches of freeboard above the waterline so that they will not float or drift in excess of 10 feet in any direction from the position that is directly above their anchor.

2. On Bark Lake no raft or pier shall be located within 100 feet of the traffic lane marked with buoys in accordance with section 42.02(A).

K. Swimming and skindiving. In addition to the requirements and restrictions set forth in Wis. Stats. § 30.70, no person shall swim in the traffic lane unless he is accompanied by a manned boat.

L. Aircraft. It shall be unlawful for any aircraft, whether designed for taking off or landing on water or not, to use any part of the lakes or waters regulated under this article for landing or taking off, except in the case of emergency.

M. Public notification if amended. In addition to following all state and local laws governing public notification when amending this ordinance, the Village will make every effort to notify the Lake Association Presidents or lake residents at least 60 days prior to the proposed modifications.

N. Penalties for violation of this article. Wisconsin state boating penalties as found in Wis. Stat. 30.80, and deposits as established in the Uniform Deposit and Bail Schedule established by the Wisconsin Judicial Conference, are hereby adopted by reference.

Appendix C

BARK LAKE AQUATIC PLANT SPECIES DETAILS

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Figure C-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: *http://wisplants.uwsp.edu*

Skawinkinski, 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: *http://www.michiganflora.net/home.aspx*

Ceratophyllum demersum — Coontail

Native

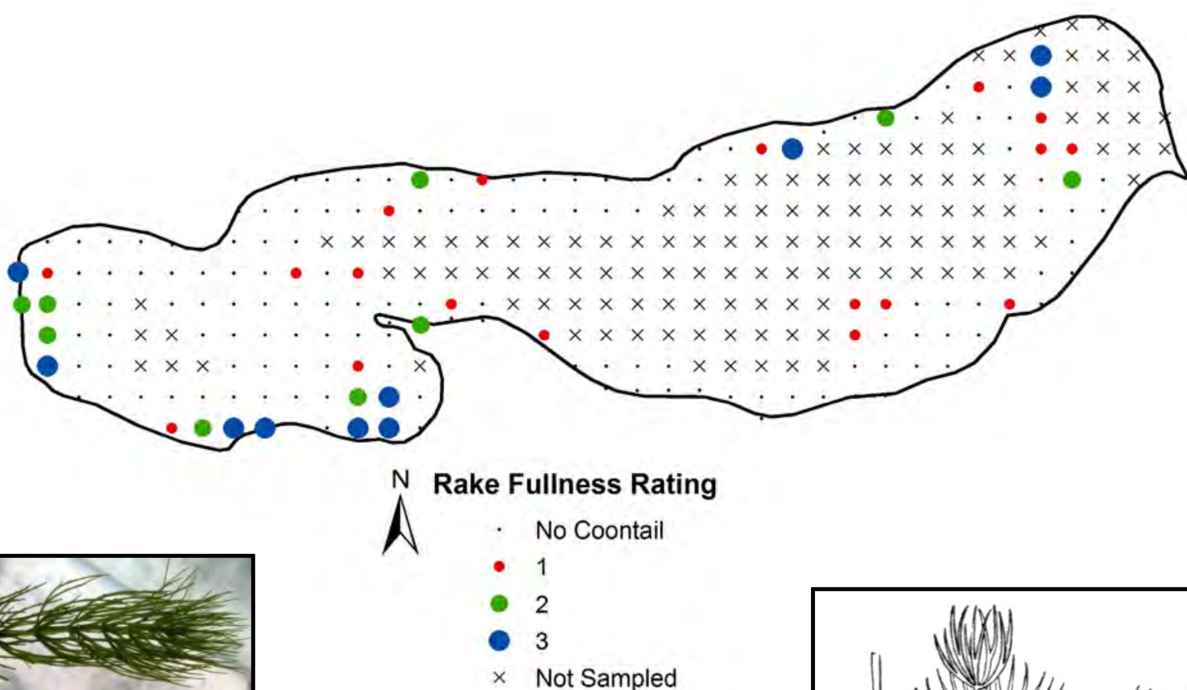
Identifying Features

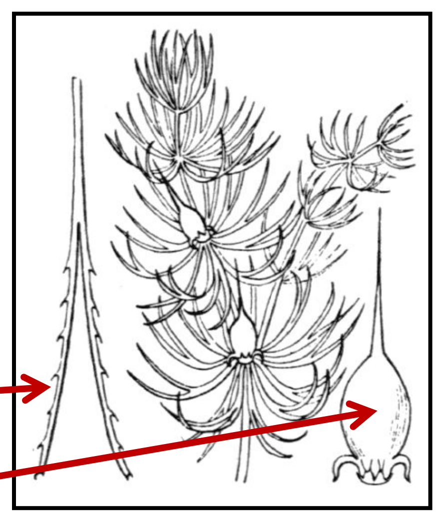
- Often bushy near tips of branches, giving the raccoon tail-like appearance (“coontail”)
- Whorled leaves with one to two orders of branching and small teeth on their margins
- Flowers (rare) small and produced in leaf axils

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)

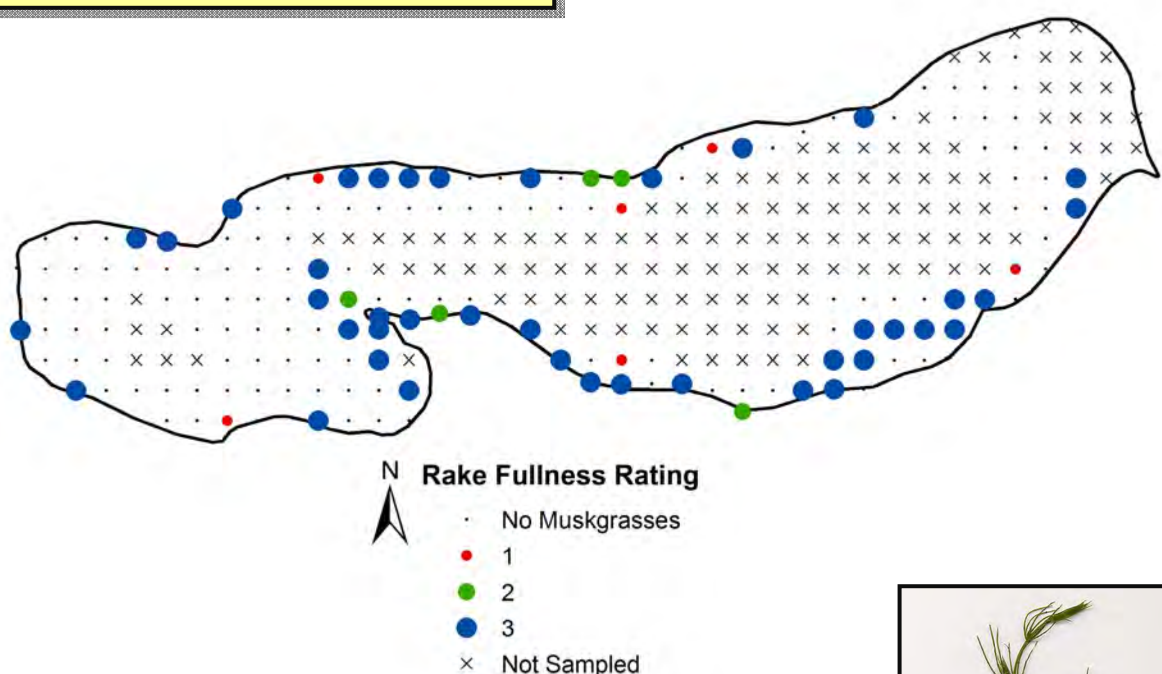
Identifying Features

- 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



Elodea canadensis — **Common Waterweed**

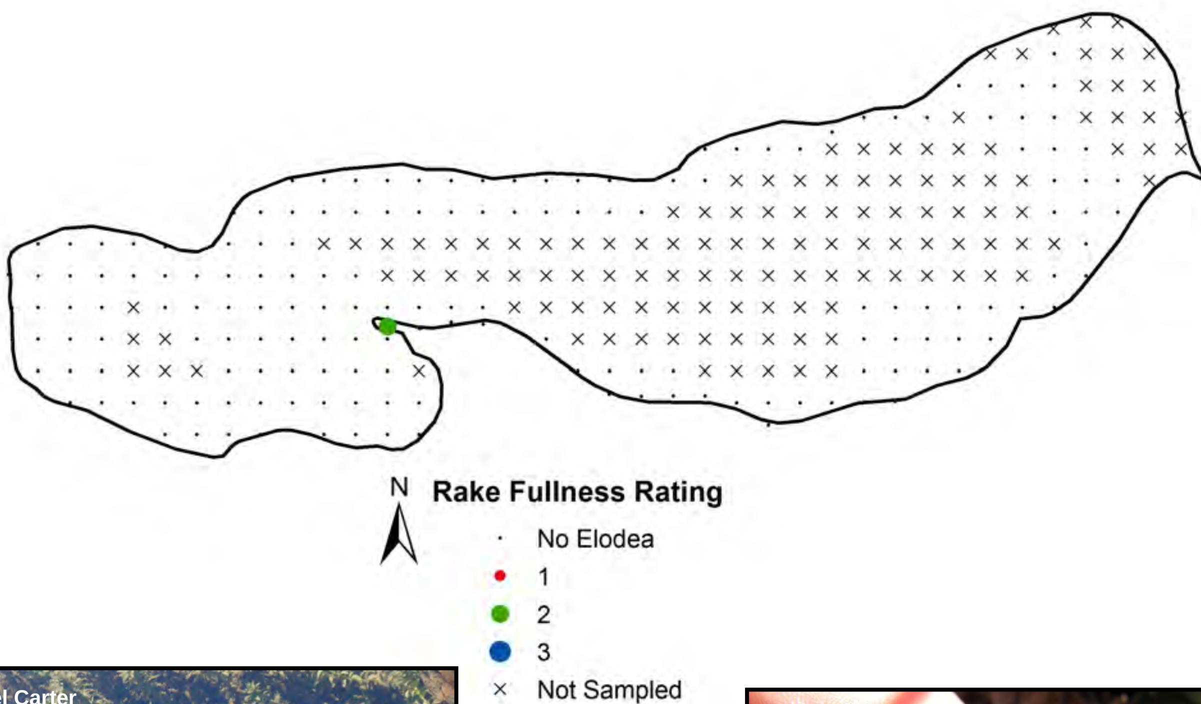
Native

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 sibiricum Northern Water Milfoil

Native

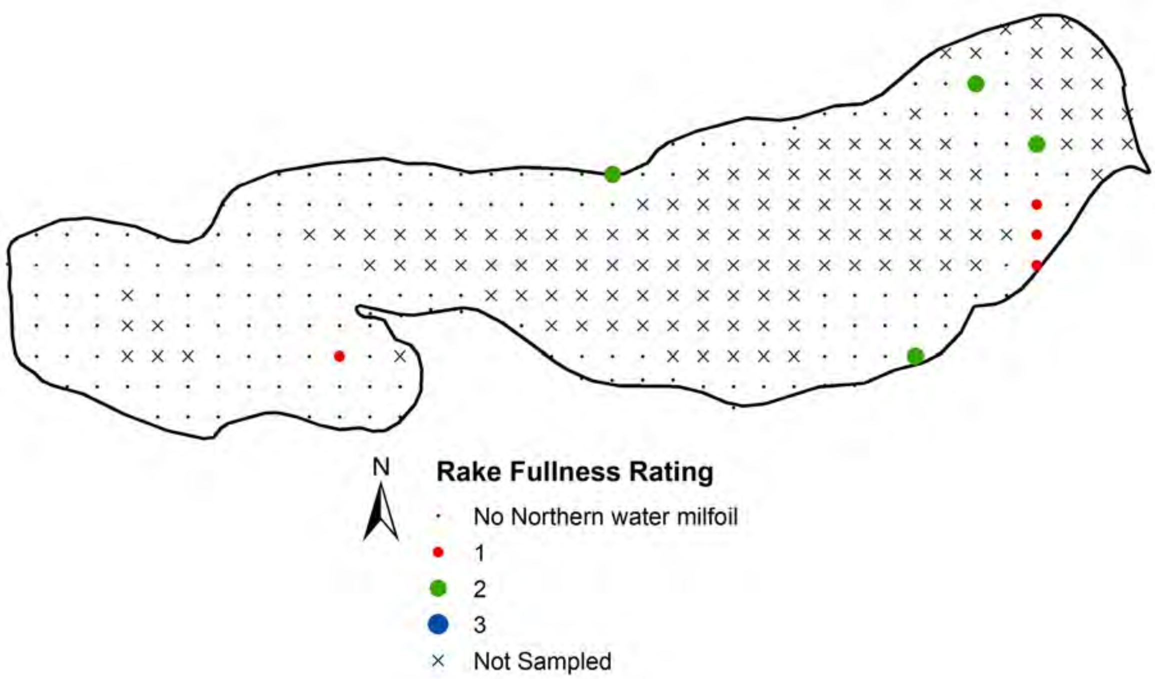
Identifying Features

- Light-colored, stout stems
- Leaves in whorls of four to five, divided into four to 12 pairs of leaflets, lower leaflets longer than the upper ones
- Forms winter buds (turions) in autumn

Northern water milfoil is similar to other water milfoils. Eurasian water milfoil (*M. spicatum*) tends to produce more leaflets per leaf and have more delicate, pinkish stems

Ecology

- Found in lakes and streams, shallow and deep
- Overwinters as winter buds and/or hardy rootstalks
- Consumed by waterfowl
- Habitat for fish and aquatic invertebrates
- Hybridizes with Eurasian water milfoil, resulting in plants with intermediate characteristics



Myriophyllum spicatum — Eurasian Water Milfoil

Nonnative/Exotic

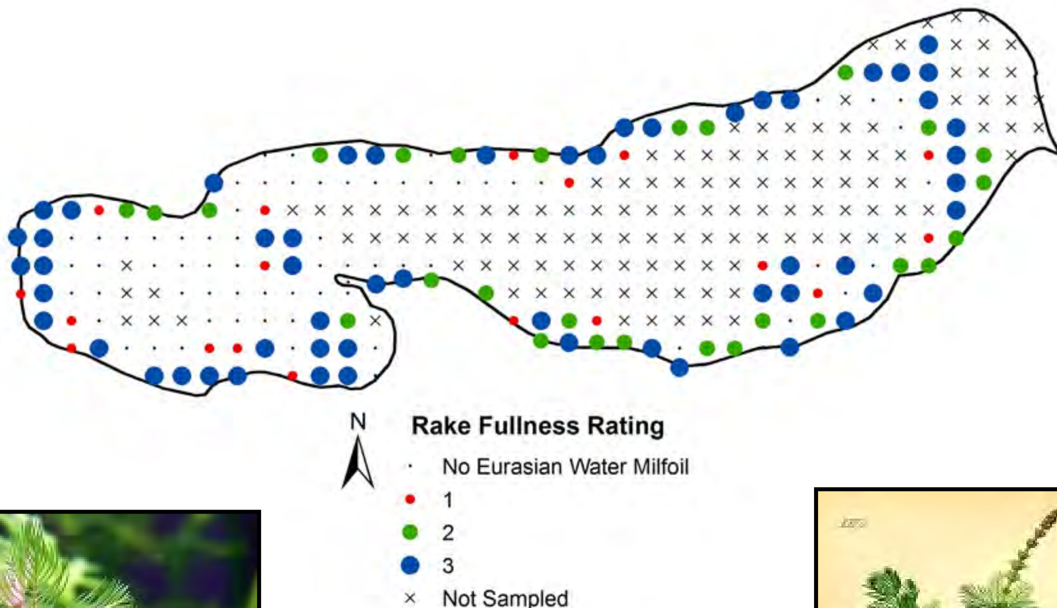
Identifying Features

- 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 Native — Bushy Pondweed or Slender Naiad

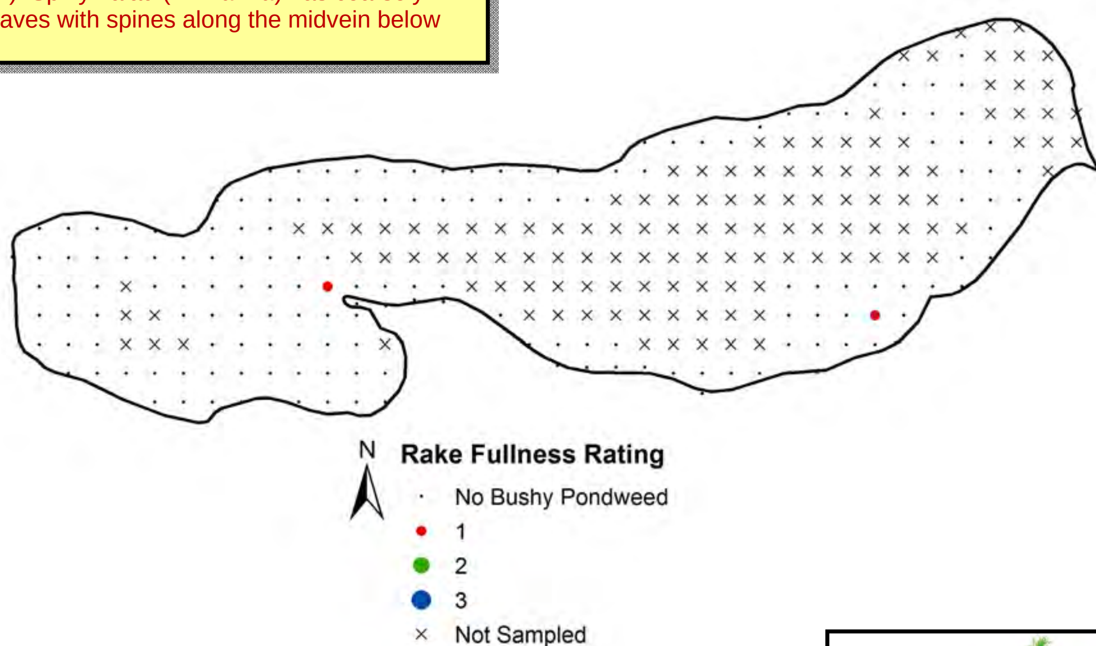
Identifying Features

- 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

Najas marina — Spiny Naiad

Nonnative/Exotic

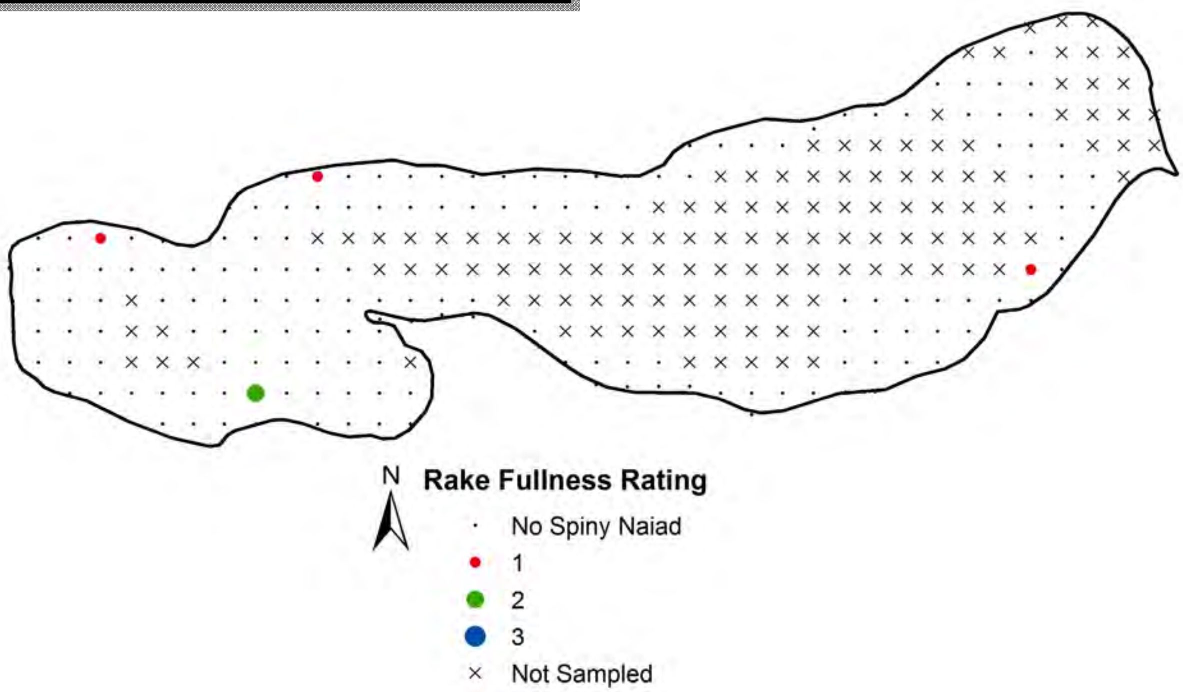
Identifying Features

- Stems stiff and spiny, often branching many times
- Leaves stiff, 1.0 to 4.0 mm thick, with coarse teeth along the margins and midvein on the underside

Spiny naiad is quite distinct from other naiads due to its larger, coarsely toothed leaves and the irregularly pitted surface of its fruits. Spiny naiad is presumably introduced in Wisconsin, but it is considered native in other states, including Minnesota

Ecology

- Alkaline lakes, water quality ranging from good to poor
- An annual, regenerating from seed each year
- Occurs as separate male and female plants
- Capable of growing aggressively



Nelumbo lutea American Lotus

Native

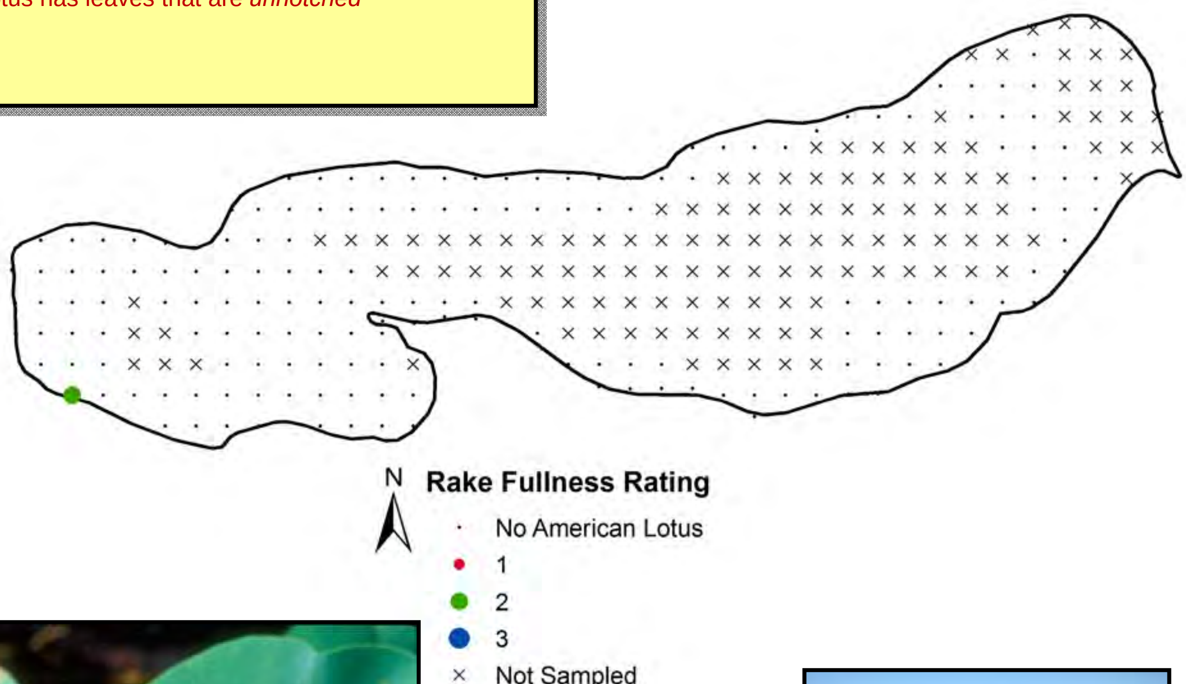
Identifying Features

- Emergent or floating, *unnotched*, large umbrella-like leaves (1.0 to 2.5 feet) in diameter
- Yellow flowers six to 10 inches across; after flowering, enlarged receptacles resemble shower heads
- Produces long rhizomes in the substrate, forming large colonies

American lotus is similar in appearance to water lilies (*Nymphea* spp.) and pond lilies (*Nuphar* spp.), but lotus has leaves that are *unnotched*

Ecology

- Found in shallow backwaters, ponds, inlets and bays of lakes, and margins of slow rivers; requires more natural areas that receive little disturbance
- Fruits eaten by waterfowl and rhizomes eaten by muskrat and beaver
- Leaf surfaces covered in fine, water-repellent hairs that cause water to bead and roll off

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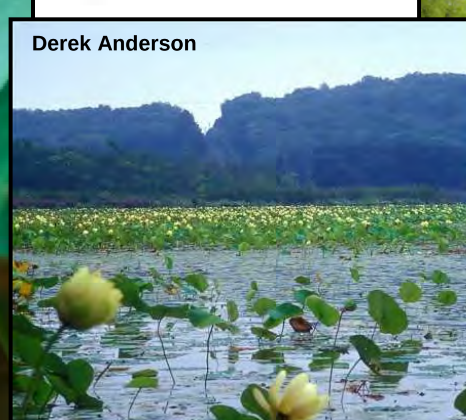

Derek Anderson


Allan Gathman

Nuphar spp. Yellow Water (Pond) Lily and Spatterdock

Native

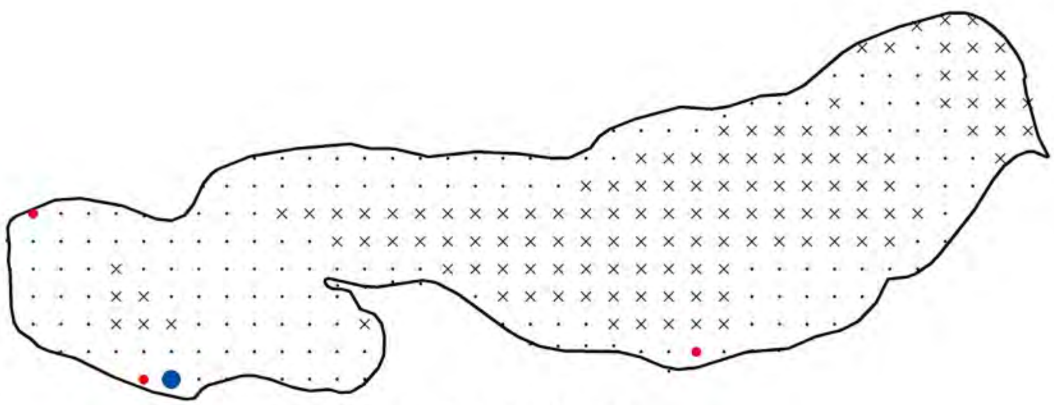
Identifying Features

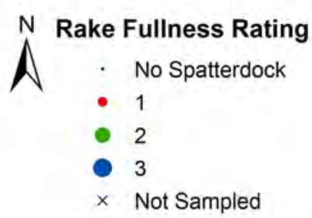
- *Heart-shaped*, *notched leaves* emerging above the water surface or floating
- Yellow flowers about one inch wide (*N. advena*) or yellow, often with dark patches at the base, and one to two inches wide (*N. variegata*)

Pond lilies (*Nuphar* spp.) are superficially similar to water lilies (*Nymphea* spp.), but have yellow versus white flowers and leaves somewhat heart-shaped versus round. American lotus (*Nelumbo lutea*) is also similar, but its leaves are round and unnotched, and its flowers are much larger

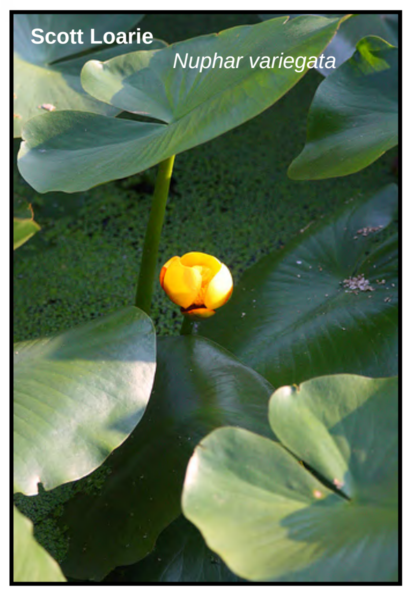
Ecology

- 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





Nuphar advena
Lindley Ashline



Scott Loarie
Nuphar variegata

Nymphaea odorata

Native

White Water Lily

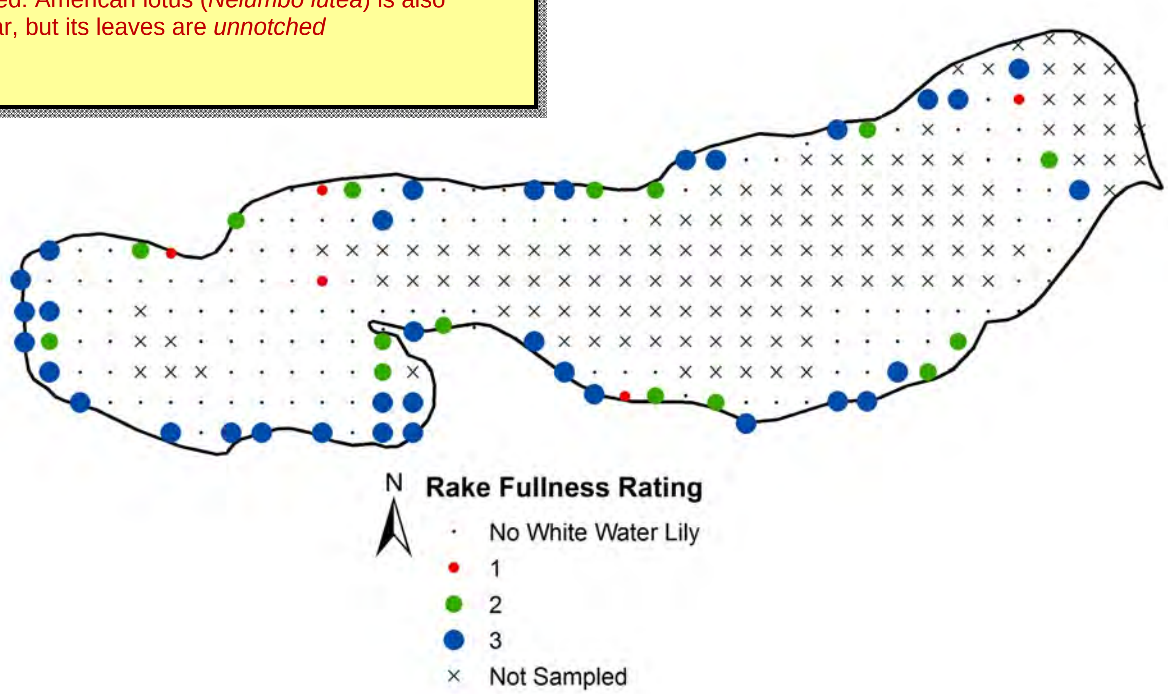
Identifying Features

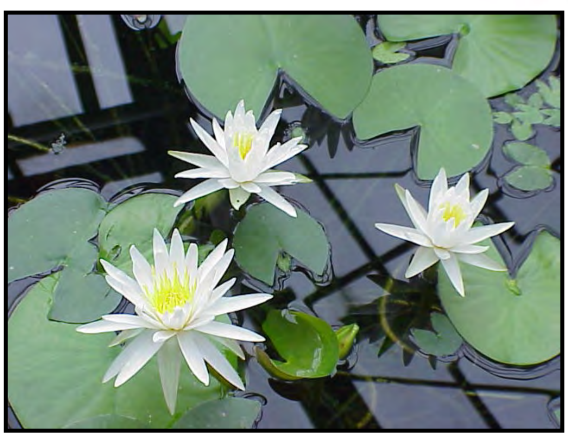
- Leaf stalks round in cross-section with four large air passages
- Floating leaves round (four to 12 inches wide under favorable conditions), *with a notch* from the outside to the center, and reddish-purple underneath
- Flowers white with a yellow center, three to nine inches wide

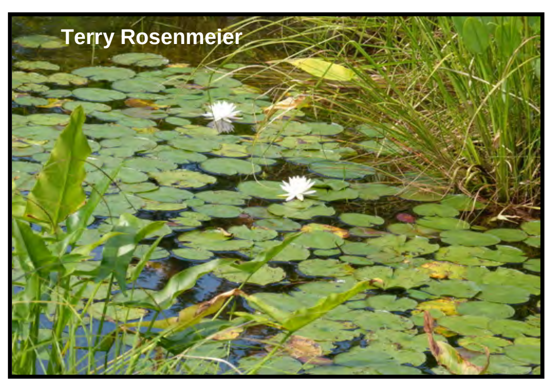
Pond lilies (*Nuphar* spp.) are superficially similar, but have yellow flowers and leaves somewhat heart-shaped. American lotus (*Nelumbo lutea*) is also similar, but its leaves are *unnotched*

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







Potamogeton gramineus — Variable Pondweed

Native

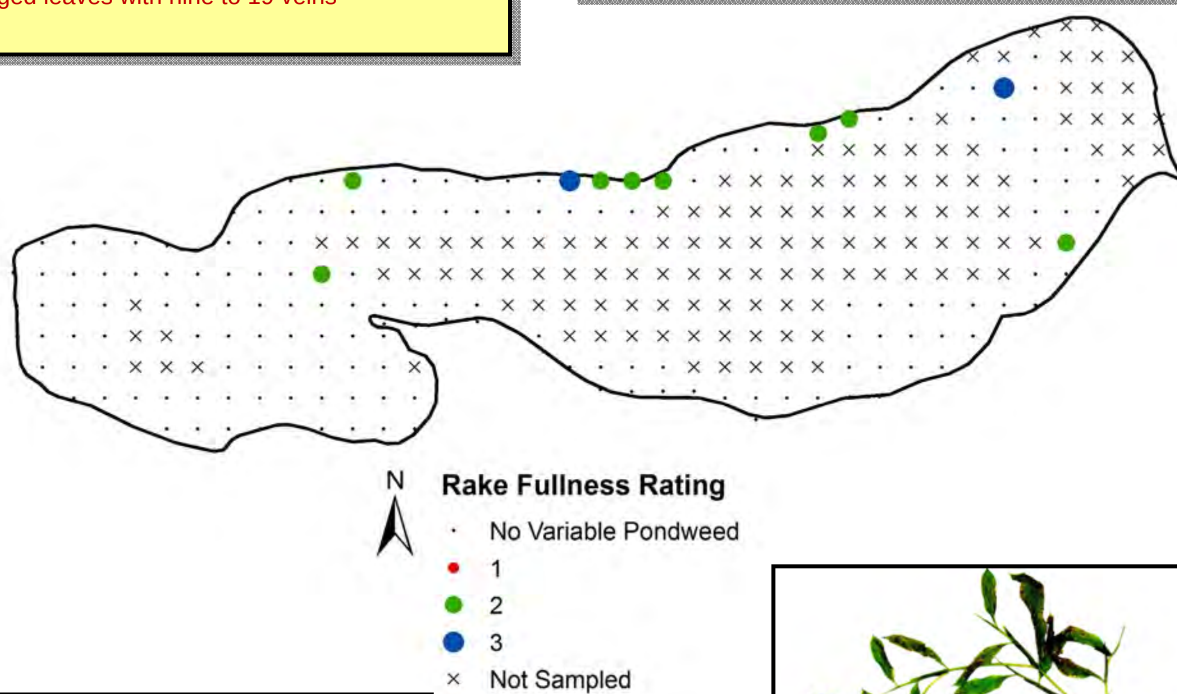
Identifying Features

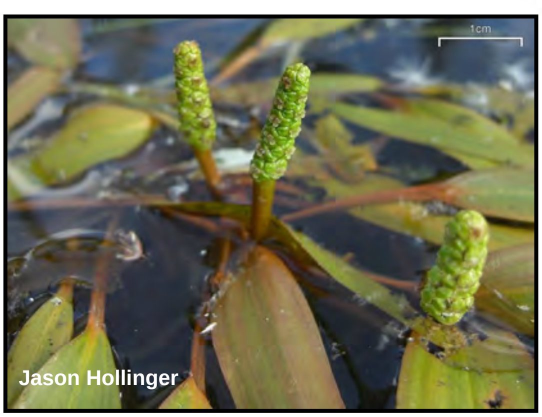
- Often heavily branched
- Submerged leaves narrow to lance-shaped, with three to seven veins, smooth margins, without stalks, but the blade tapering to the stem
- *Floating leaves* with 11 to 19 veins and a slender stalk that is usually longer than the blade
- Often covered with calcium carbonate in hard water

Variable pondweed is similar to Illinois pondweed (*P. illinoensis*), but Illinois pondweed has submerged leaves with nine to 19 veins

Ecology

- Shallow to deep water, often with muskgrass, wild celery, and/or slender naiad; requires more natural areas that receive little disturbance
- Overwinters as rhizomes or winter buds (turions)
- Provides food for waterfowl, muskrat, deer, and beaver
- Provides habitat for fish and aquatic invertebrates





Potamogeton illinoensis Illinois Pondweed

Native

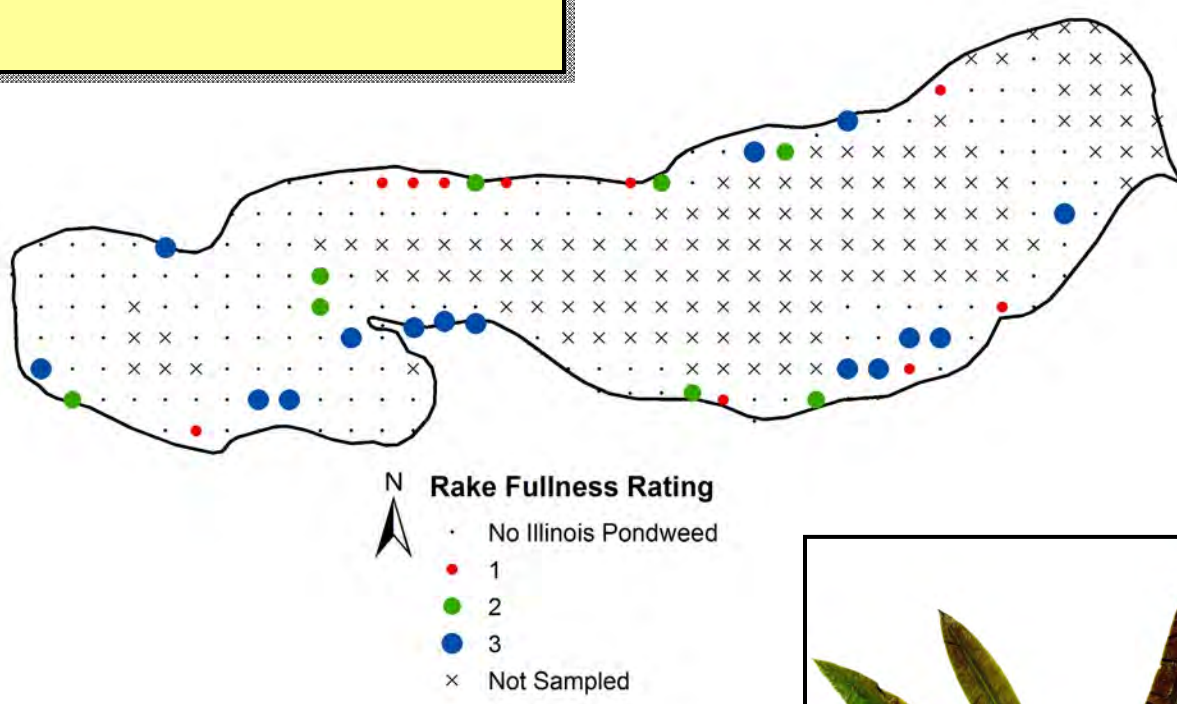
Identifying Features

- Stout stems up to 2.0 m long, often branched
- Submerged leaves with nine to 19 veins (midvein prominent) on short stalks (up to 4.0 cm) or attached directly to the stem
- Floating leaves, if produced, elliptical, with 13 to 29 veins
- Often covered with calcium carbonate in hard water

Variable pondweed (*P. gramineus*) is similar to Illinois pondweed, but differs in having three to seven veins on submerged leaves

Ecology

- Lakes with clear water, shallow or deep, neutral or hard, over soft sediments
- Overwinters as rhizomes or remains green under the ice
- Provides food for waterfowl, muskrat, deer, and beaver
- Provides excellent habitat for fish and aquatic invertebrates



Potamogeton pectinatus
Native

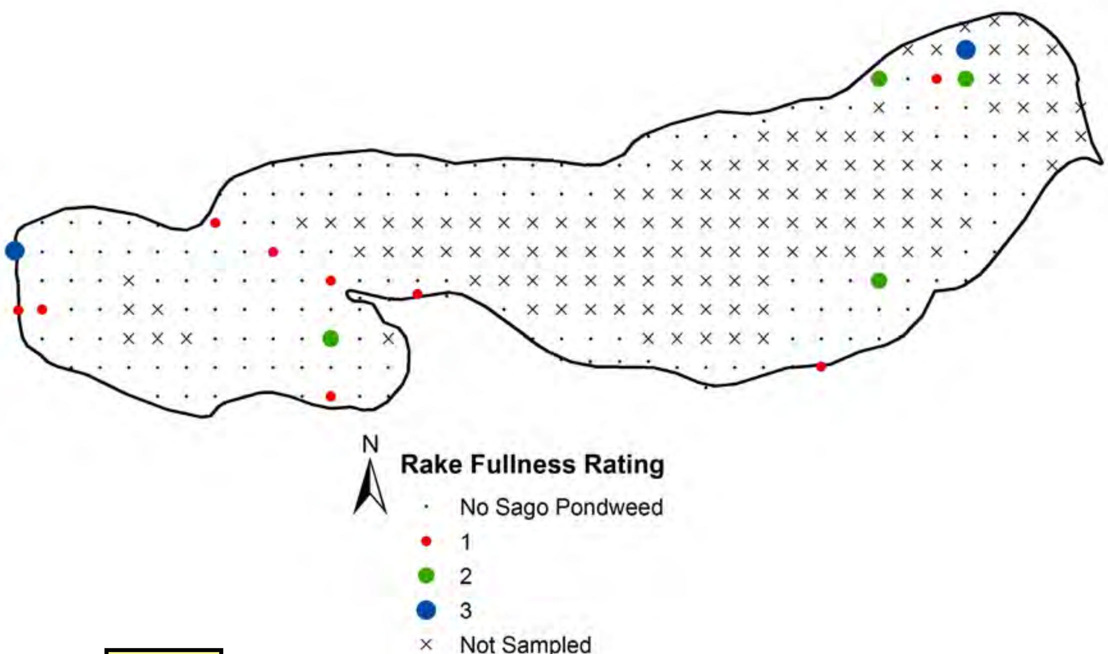
Sago Pondweed

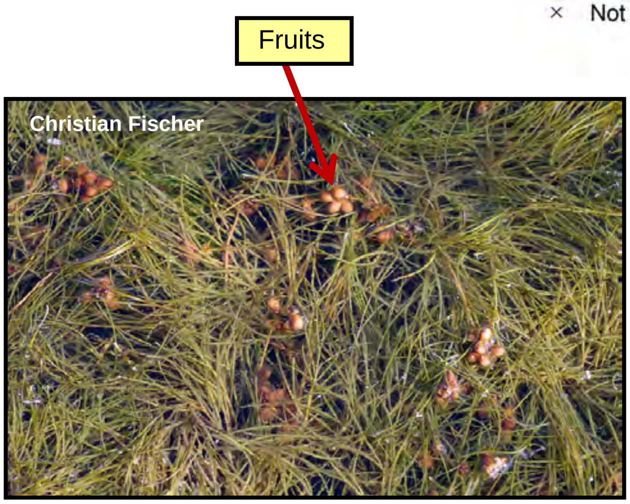
Identifying Features

- 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





Potamogeton praelongus — White-Stem Pondweed

Native

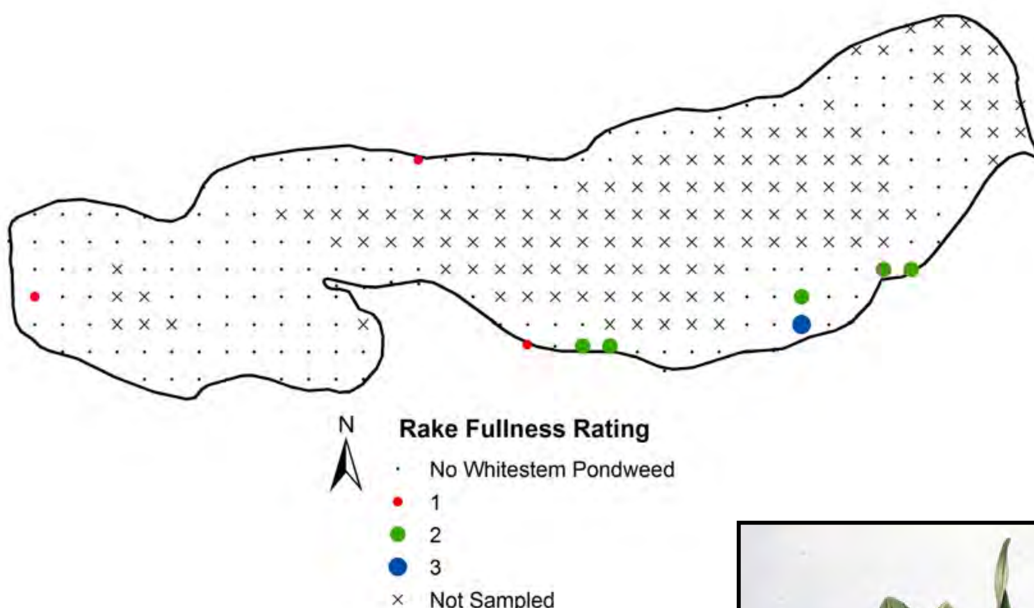
Identifying Features

- Stems usually pale and zig-zagging
- Leaves clasping, alternate, with three to five prominent veins and 11 to 35 smaller ones, with boat-shaped tips that often split when pressed between fingers

White-stem pondweed is similar to clasping pondweed (*P. richardsonii*), but the leaves of clasping pondweed do not have boat-shaped tips that split when pressed

Ecology

- Found in clear lakes in water three to 12 feet deep over soft sediments
- *"Indicator species"* due to its sensitivity to water quality changes; its disappearance indicating degradation; requires more natural areas that receive little disturbance
- Sometimes remains evergreen beneath the ice
- Provides food for waterfowl, muskrat, beaver, and deer
- Provides habitat for trout and muskellunge



Potamogeton richardsonii — Clasping Pondweed

Native

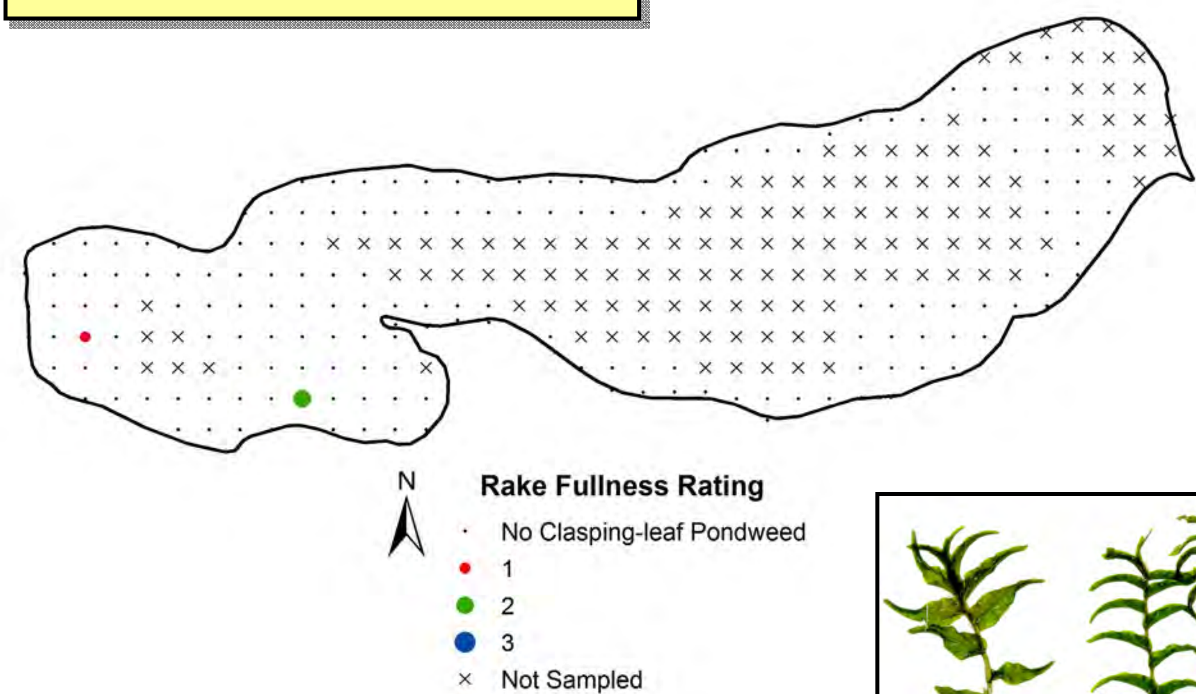
Identifying Features

- Leaves alternating along and clasping the stem, with wavy edges, coming to a point at the tip, and often with three to five veins prominent among many more that are faintly visible
- Produces no floating leaves

Clasping pondweed is similar to white-stem pondweed (*P. praelongus*), but the latter has boat-shaped leaf tips that split when pressed between one's fingers. The exotic curly-leaf pondweed (*P. crispus*) may appear similar, but differs by having serrated leaf margins

Ecology

- In lakes and streams, shallow and deep, often in association with coontail
- Tolerant of disturbance
- Fruits a food source for waterfowl and plants browsed by muskrat, beaver, and deer
- Stems emerging from perennial rhizomes



Potamogeton robbinsii — Robbins Pondweed or Fern Pondweed

Native

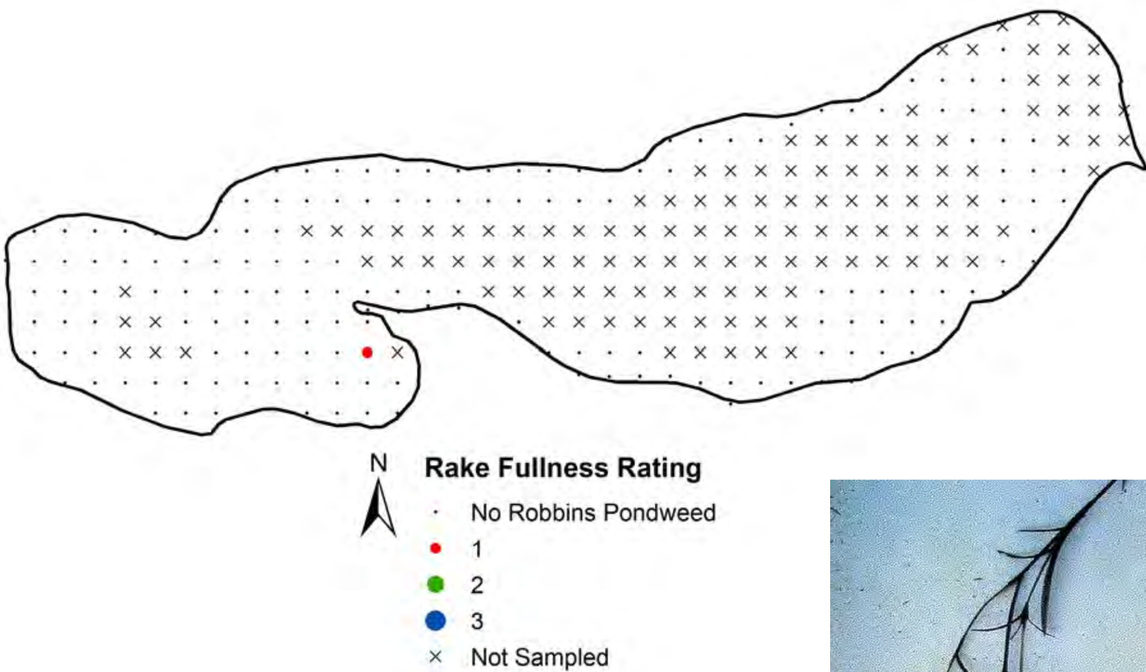
Identifying Features

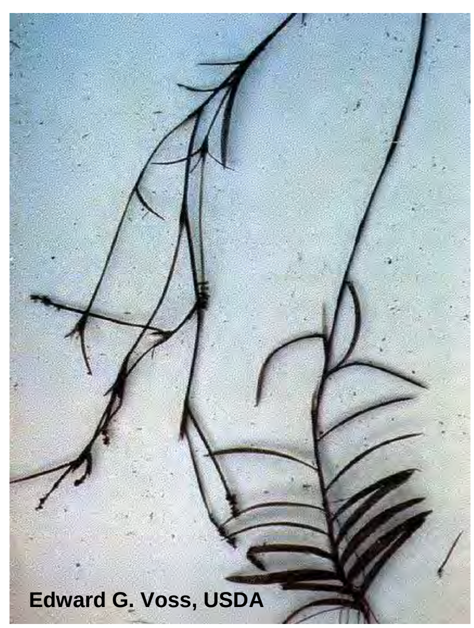
- Robust stems; stems and leaves often dark green to brown
- Leaves two-ranked (in opposite directions) along the stem, long and pointed, wrapping around the stem at the base, with edges finely serrated
- No floating leaves

Robbins pondweed is similar to flat-stem pondweed (*P. zosteriformis*) and water stargrass (*Zosterella dubia*), but is distinguished from both by its round stem

Ecology

- Lakes, often deeper than other pondweeds; requires more natural areas that receive little disturbance
- Plants often remaining green over the winter
- Regenerates from rhizomes and winter buds (turions), fruit only rarely produced
- Provides food for waterfowl
- Provides habitat for invertebrates and fish, particularly pike





Utricularia spp. — Bladderworts

Native

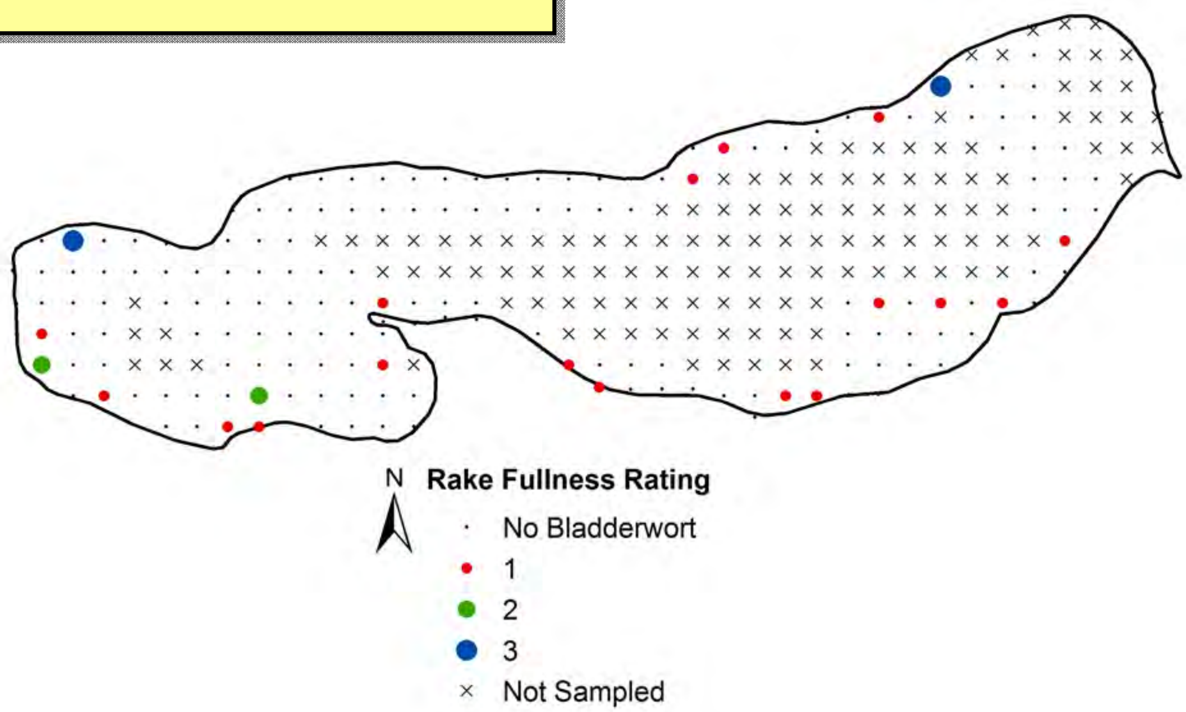
Identifying Features

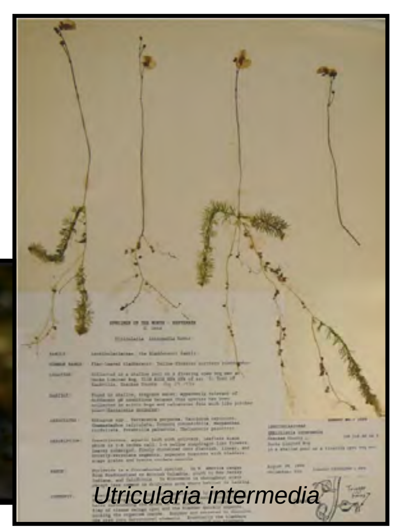
- Flowers snapdragon-like, yellow or purple, held on stalks above the water surface
- *Producing bladders* (small air chambers on the stem) that capture prey and give buoyancy to the stem
- Stems either floating (due to air bladders) or anchored in the substrate; branches finely divided, if floating

Several similar bladderworts occur in southeastern Wisconsin

Ecology

- Most species found in quiet shallows and along shores, but common bladderwort (*Utricularia vulgaris*) sometimes occurring in water several feet deep
- Provides forage and cover for a wide range of aquatic organisms
- Bladders capturing and digesting prey, including small invertebrates and protozoans





Zosterella dubia — Water Stargrass

Native

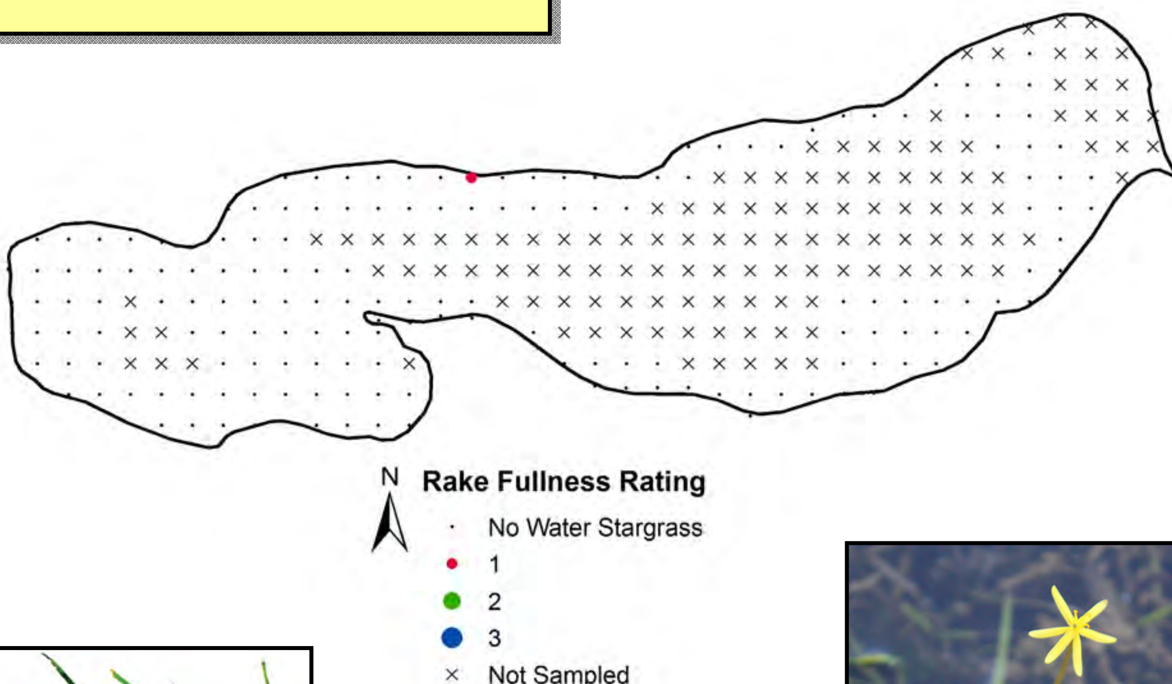
Identifying Features

- 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



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Appendix D

SEWRPC RIPARIAN BUFFER GUIDE NO. 1
“MANAGING THE WATER’S EDGE”

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Managing the Water's Edge

Making Natural Connections

Problem Statement:

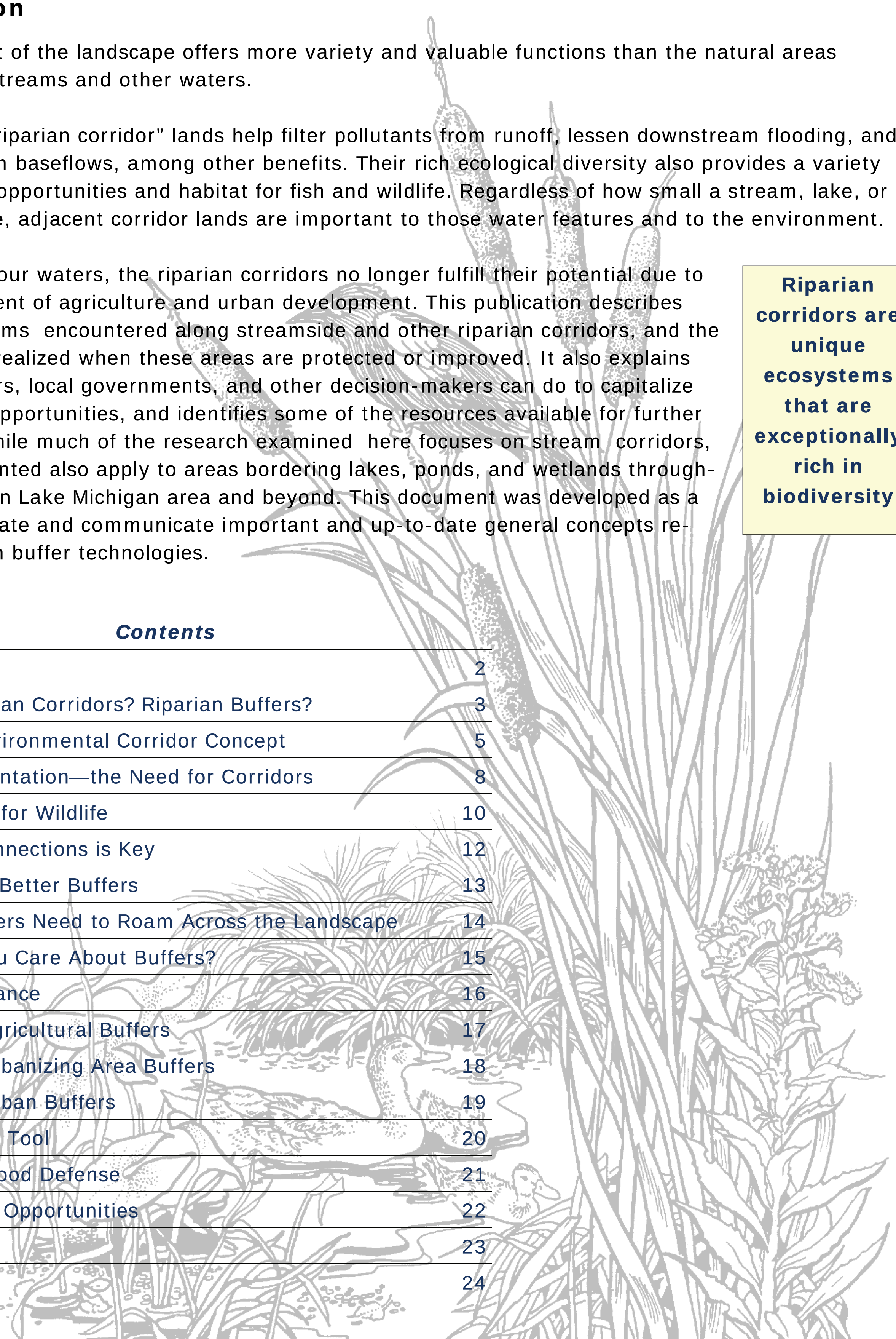
Despite significant research related to buffers, there remains no consensus as to what constitutes optimal riparian buffer design or proper buffer width for effective pollutant removal, water quality protection, prevention of channel erosion, provision of fish and wildlife habitat, enhancement of environmental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

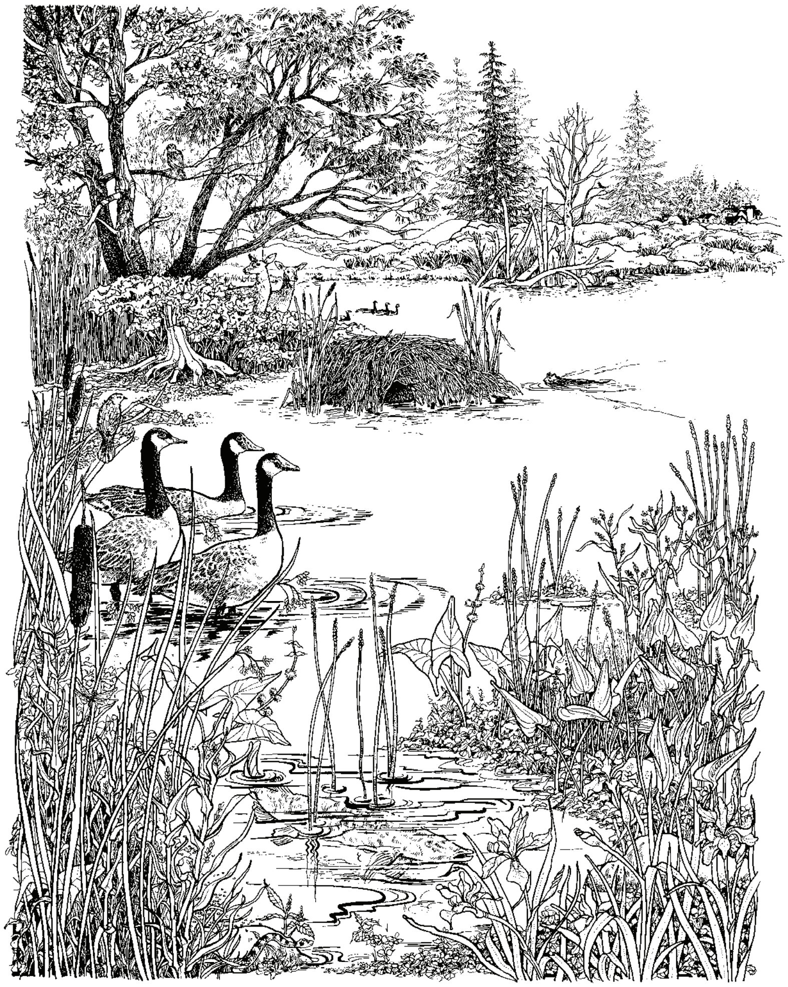
Along many of our waters, the riparian corridors no longer fulfill their potential due to the encroachment of agriculture and urban development. This publication describes common problems encountered along streamside and other riparian corridors, and the many benefits realized when these areas are protected 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

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.**

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.

Beyond the Environmental Corridor Concept

The term "environmental corridors" (also known as "green infrastructure") refers to an interconnected 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.

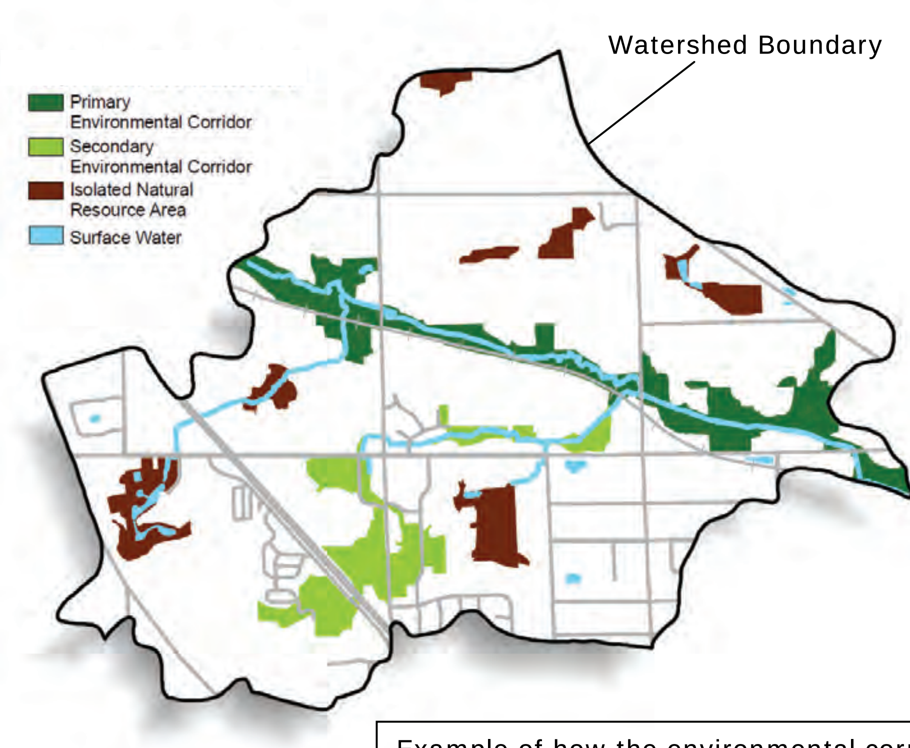
- **Secondary environmental corridors** contain significant but smaller concentrations of natural resources. They are at least 100 acres in size and at least one mile long, unless serving to link primary corridors.

- **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

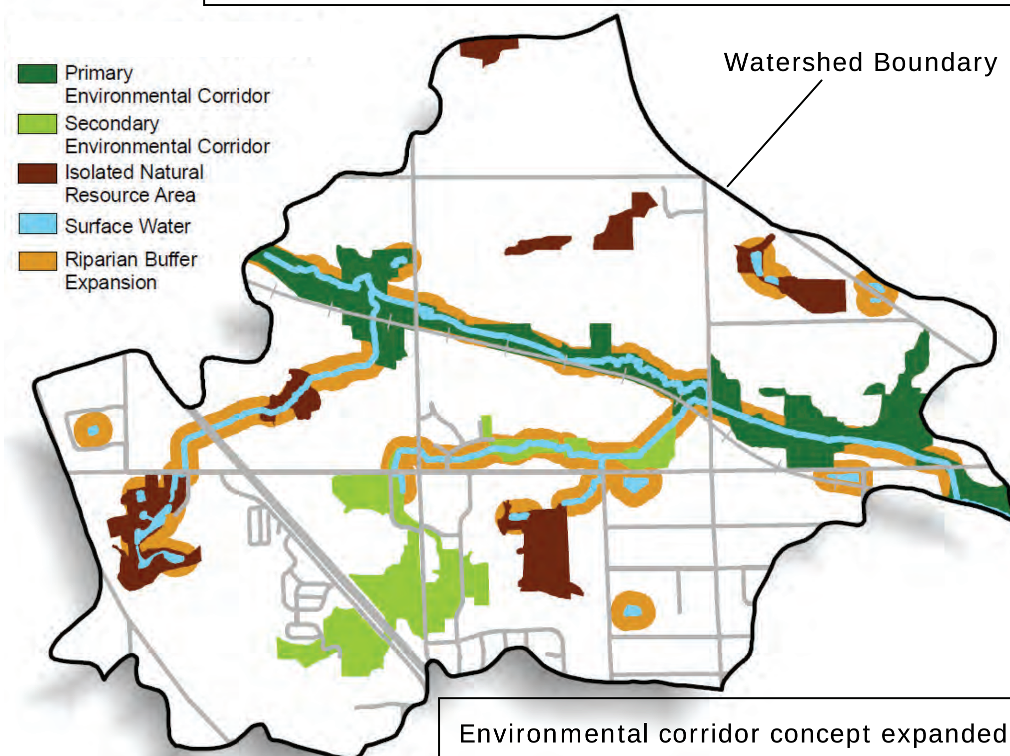


The Minimum Goals of **75** within a Watershed

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 http://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.

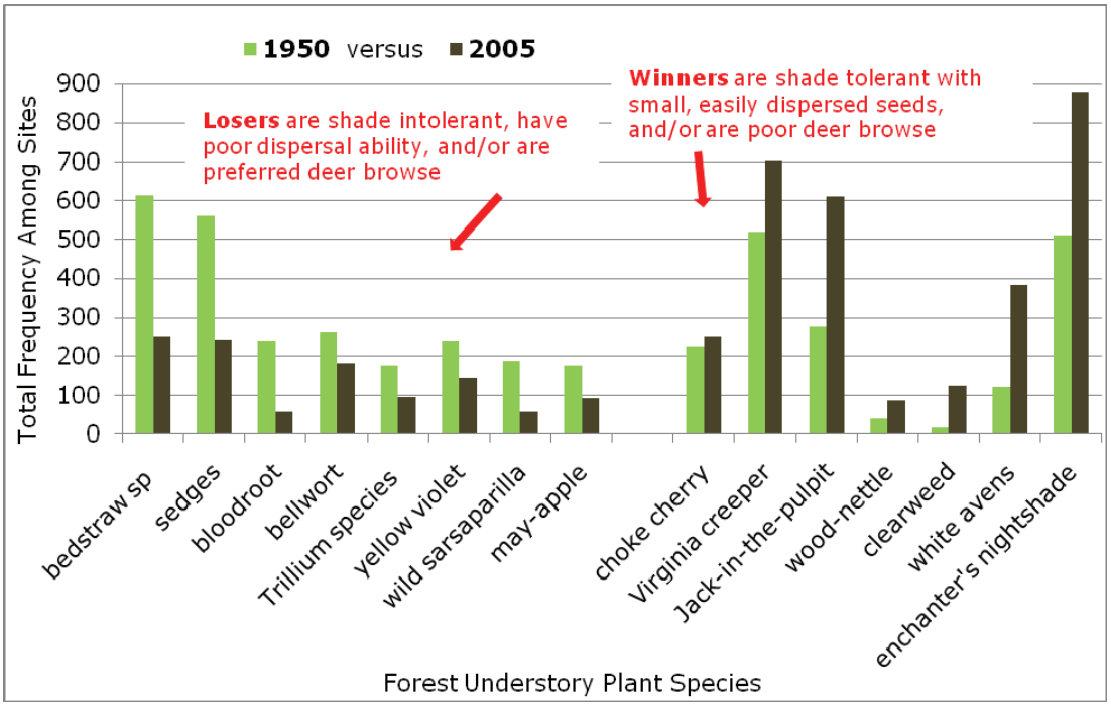
At the time of conversion of agricultural lands to urban uses, there are opportunities to re-create and expand riparian buffers and environmental corridors reconnecting uplands and waterways and restoring ecological integrity and scenic beauty locally and regionally. For example, placement of roads and 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



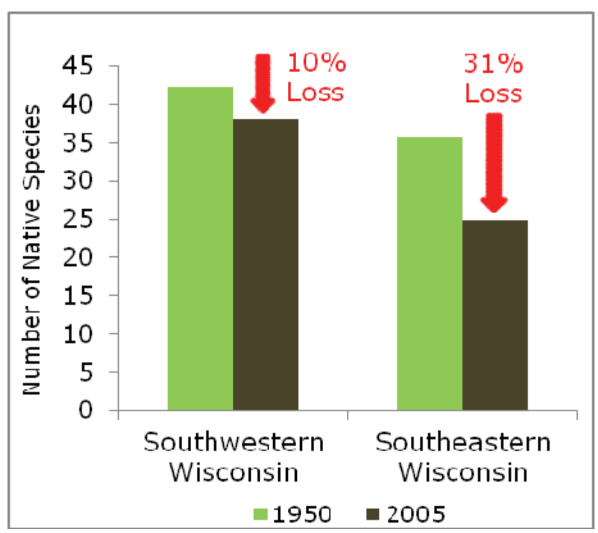
Forest fragmentation has led to significant plant species loss within Southern Wisconsin

(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

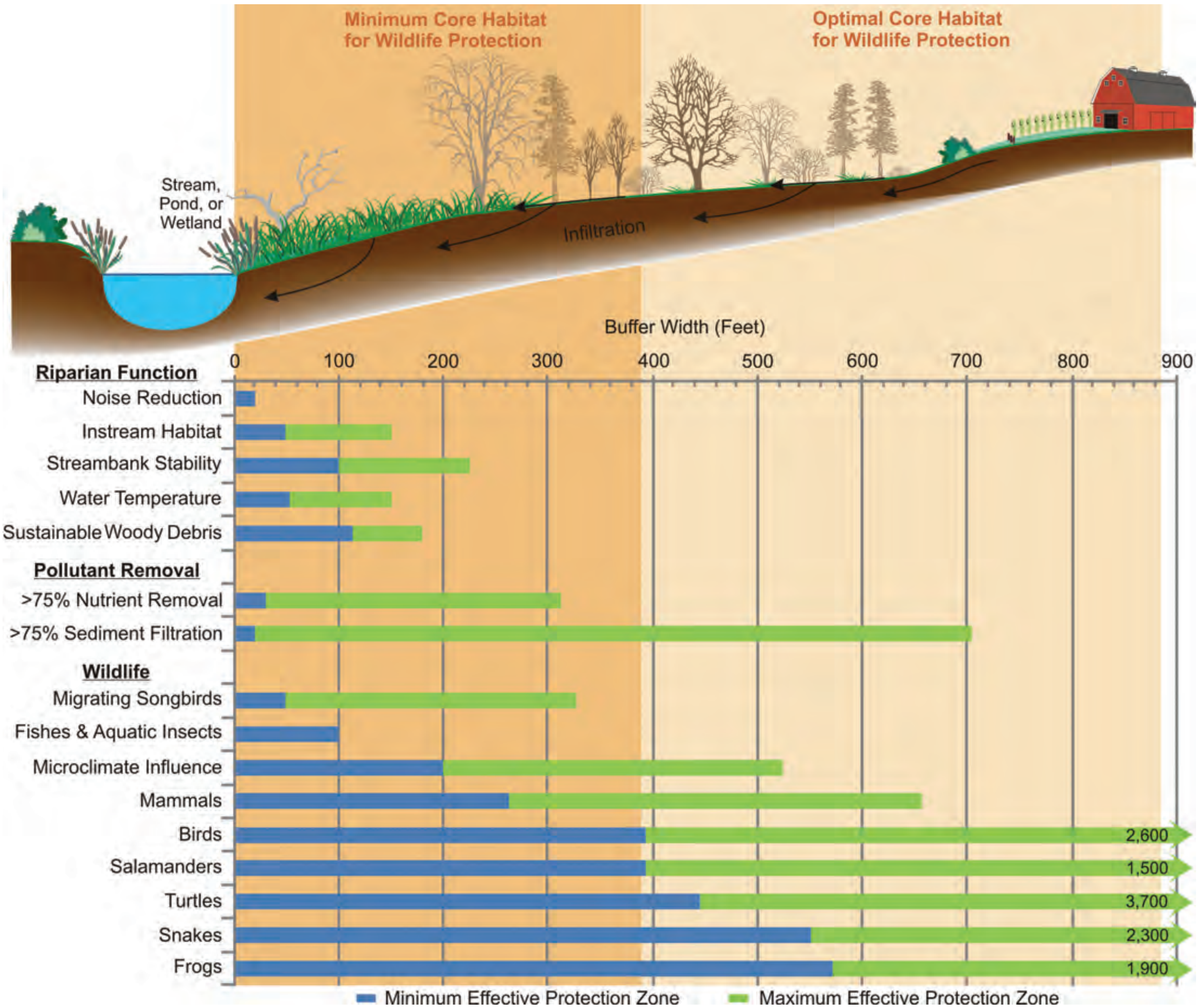
Since the 1950s, forests have increasingly become more fragmented by land development, both agricultural and urban, and associated roads and infrastructure, which have caused these forests to become isolated "islands of green" on the landscape. In particular, there has been significant loss of forest 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.

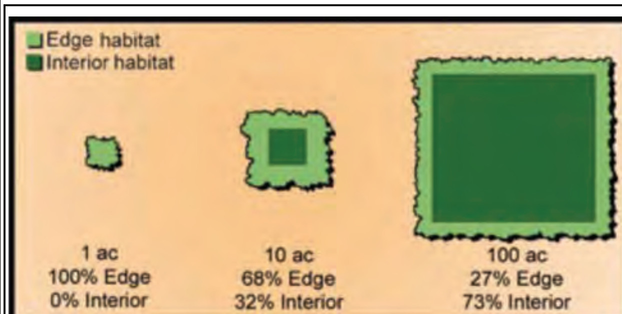
Wider is Better for Wildlife

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.*



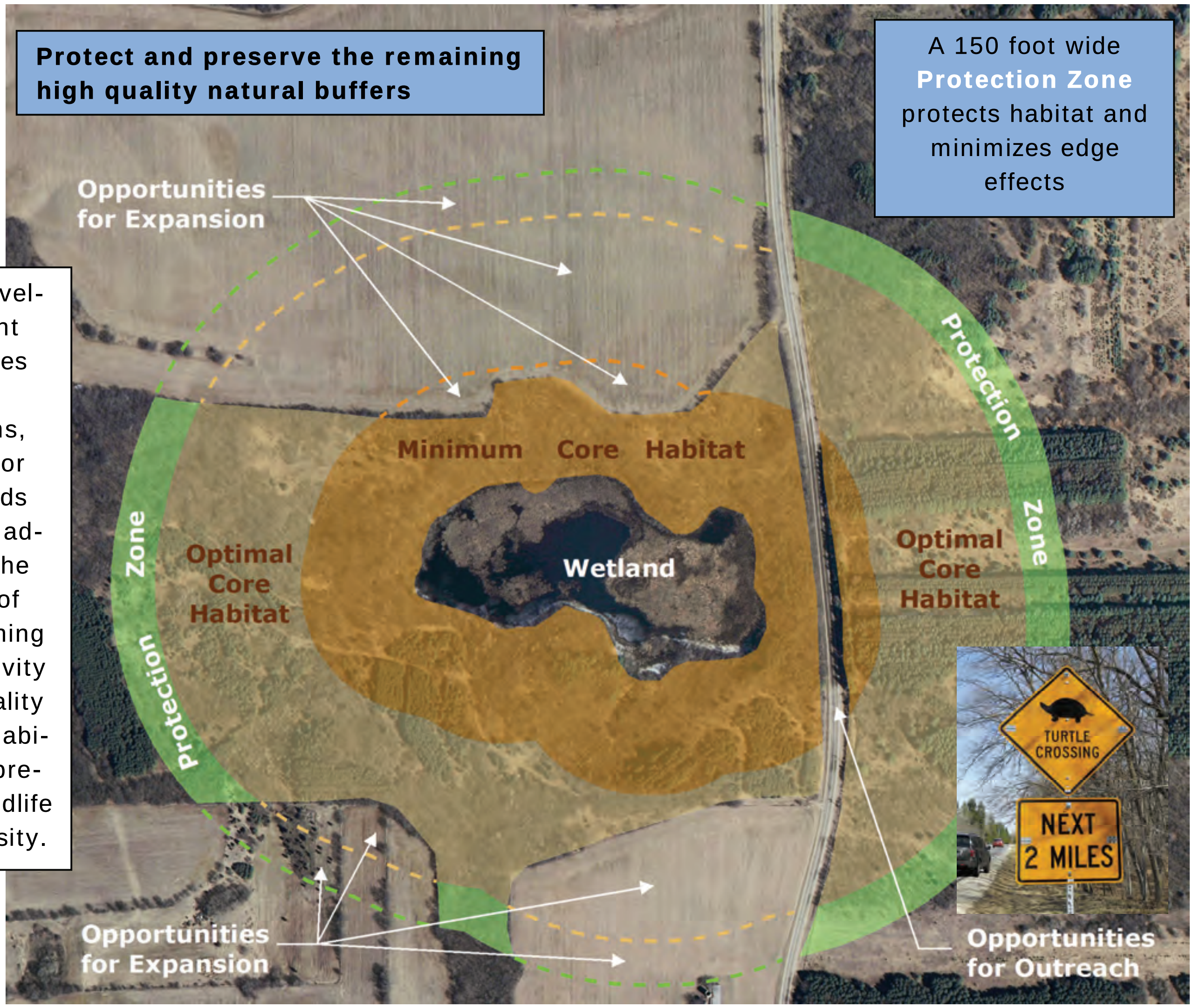
"***Large patches typically conserve a greater variety and quality of habitats, resulting in higher species diversity and abundance."*** *Larger patches contain greater amounts of interior habitat and less edge effects, which benefits interior species, by providing safety from parasitism, disease, and invasive species.*

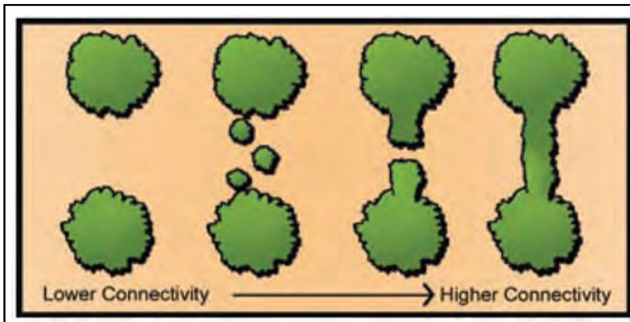
(Bentrup, G. 2008. Conservation buffers: design guidelines for buffers, corridors, and greenways. Gen. Tech. Rep. SRS-109. Asheville, NC: Department of Agriculture, Forest Service, Southern Research Station)

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.

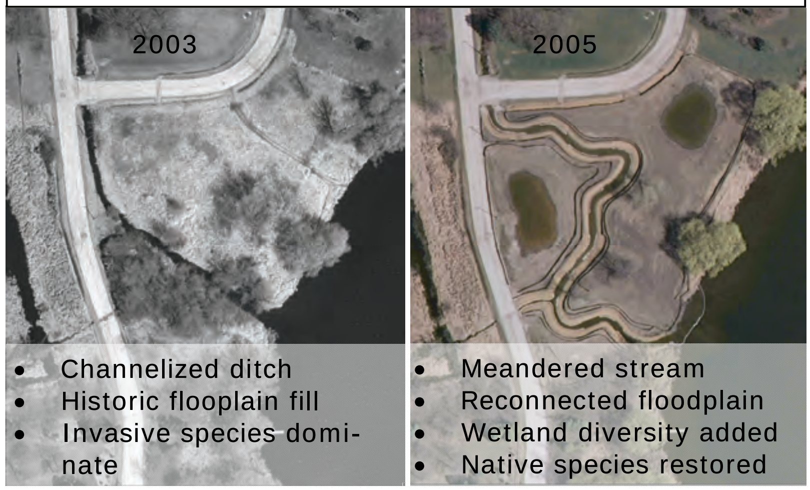




Increasing connectivity among quality natural landscapes (wetlands, woodlands, prairies) can benefit biodiversity by providing access to other areas of habitat, increasing gene flow and population viability, enabling recolonization of patches, and providing habitat (Bentrup 2008).

Basic Rules to Better Buffers

There are opportunities to improve buffer functions to improve water quality and wildlife habitat, even in urban situations



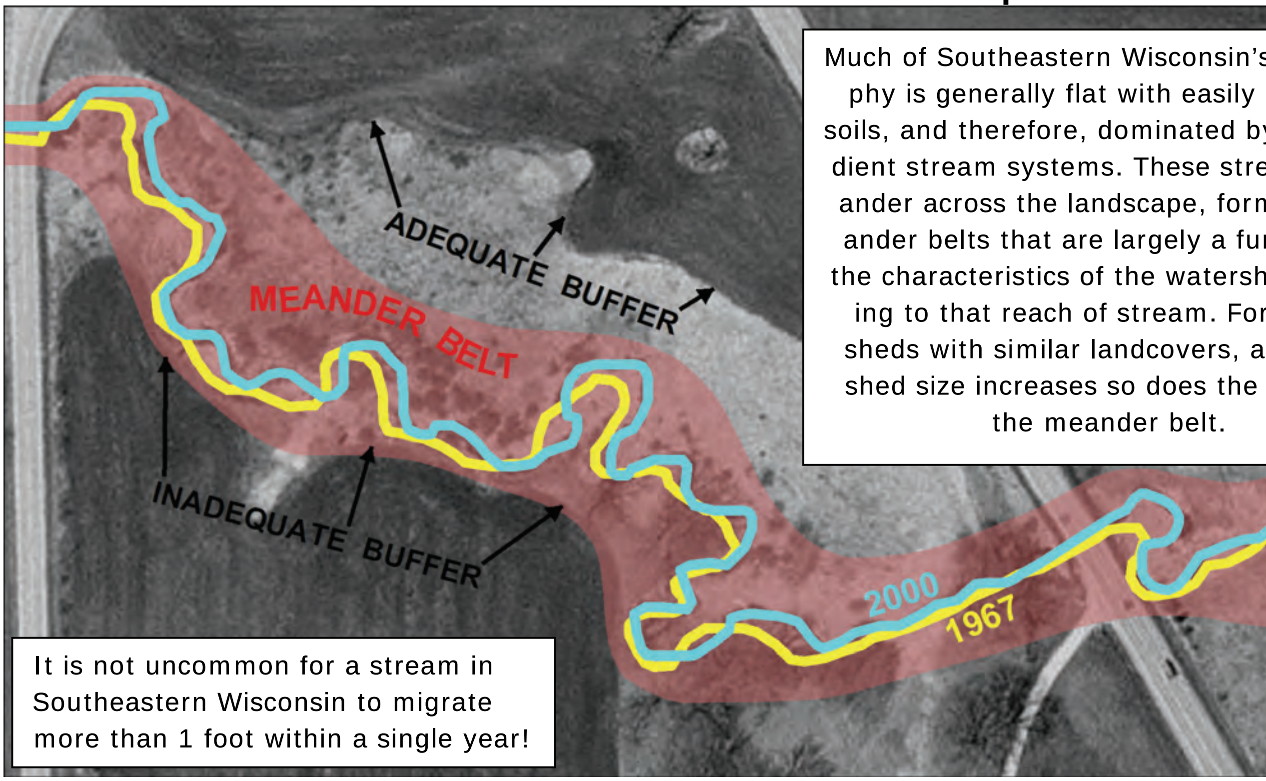
Protecting the integrity of native species in the region is an objective shared by many communities. The natural environment is an essential component of our existence and contributes to defining our communities and neighborhoods. Conservation design and open space development patterns in urbanizing areas and farm conservation programs in rural areas have begun to address the importance of maintaining and restoring riparian buffers and connectivity among corridors.

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:

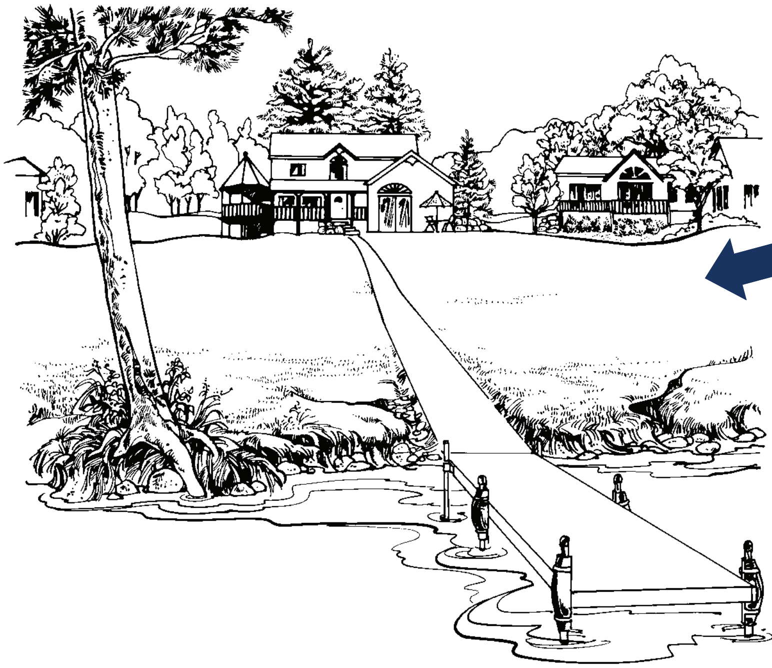
- Increased quality of the canoeing/kayaking experience
- Improved fishing and hunting quality by improving habitat
- Improved bird watching/wildlife viewing quality and opportunities
- Increased potential for expansion of trails for hiking and bicycling
- Opportunities made available for youth and others 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 http://www.soils.wisc.edu/extension/nonpoint/wbi.php).

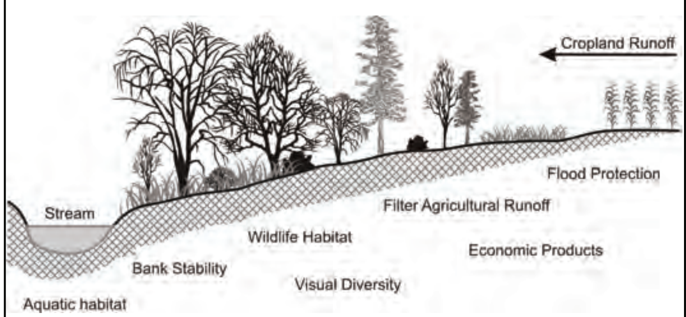
While it is true that riparian buffers alone may not always be able to reduce nutrient and sediment loading from agricultural lands, WBI researchers found that "...***riparian buffers are capable of reducing large percentages of the phosphorus and sediment that are currently being carried by Wisconsin 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.



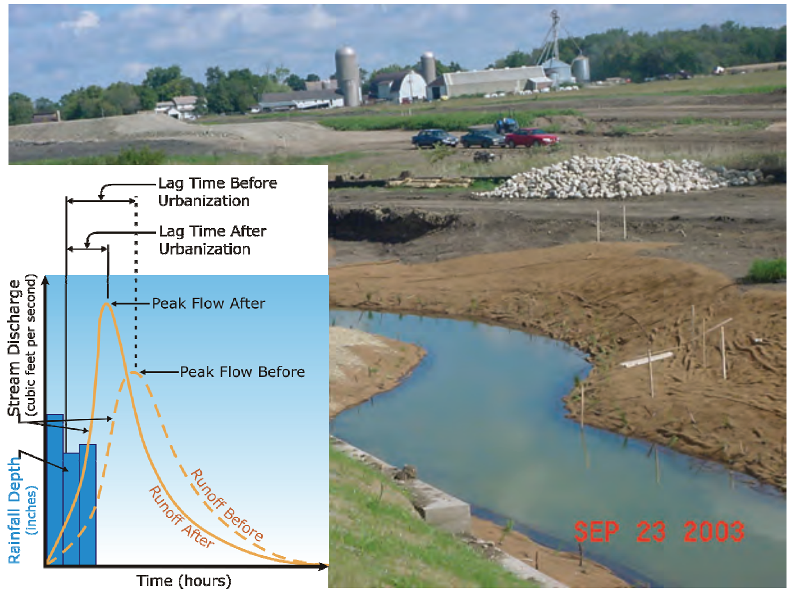
The USDA in *Agroforestry Notes* (AF Note-4, January 1997) outlines a four step process for designing riparian buffers for Agricultural lands:

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.



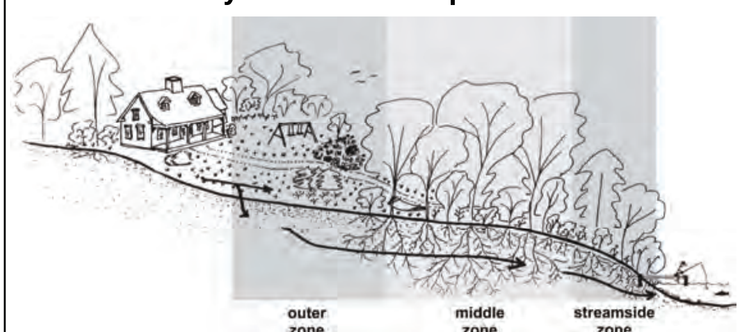
Comparison of hydrographs before and after urbanization. Note the rapid runoff and greater peak streamflow tied to watershed development. (Adapted from Federal Interagency Stream Restoration Working Group (FISRWG), Stream Corridor Restoration: Principles, Processes, and Practices, October 1998)

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.

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.

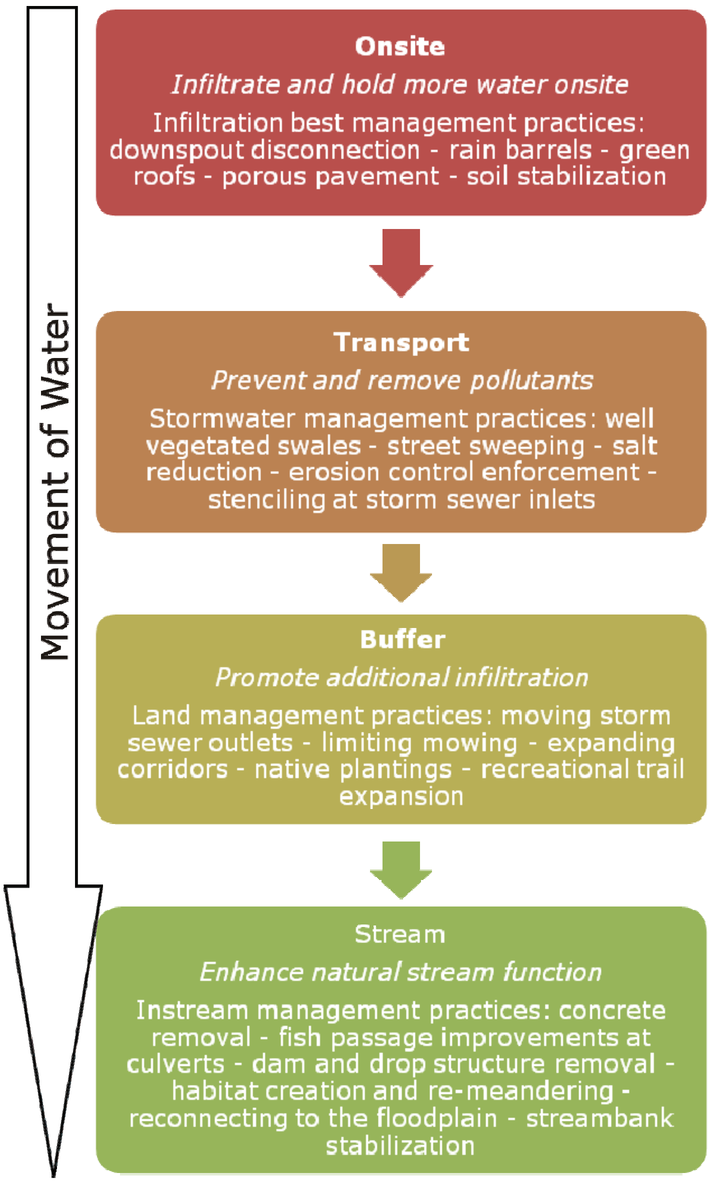
Streamside Zone-Area from the water's edge to the top of the bank or uplands that provides critical connection between water, wetland, and upland habitats for wildlife as well as protect streams from bank erosion

(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.

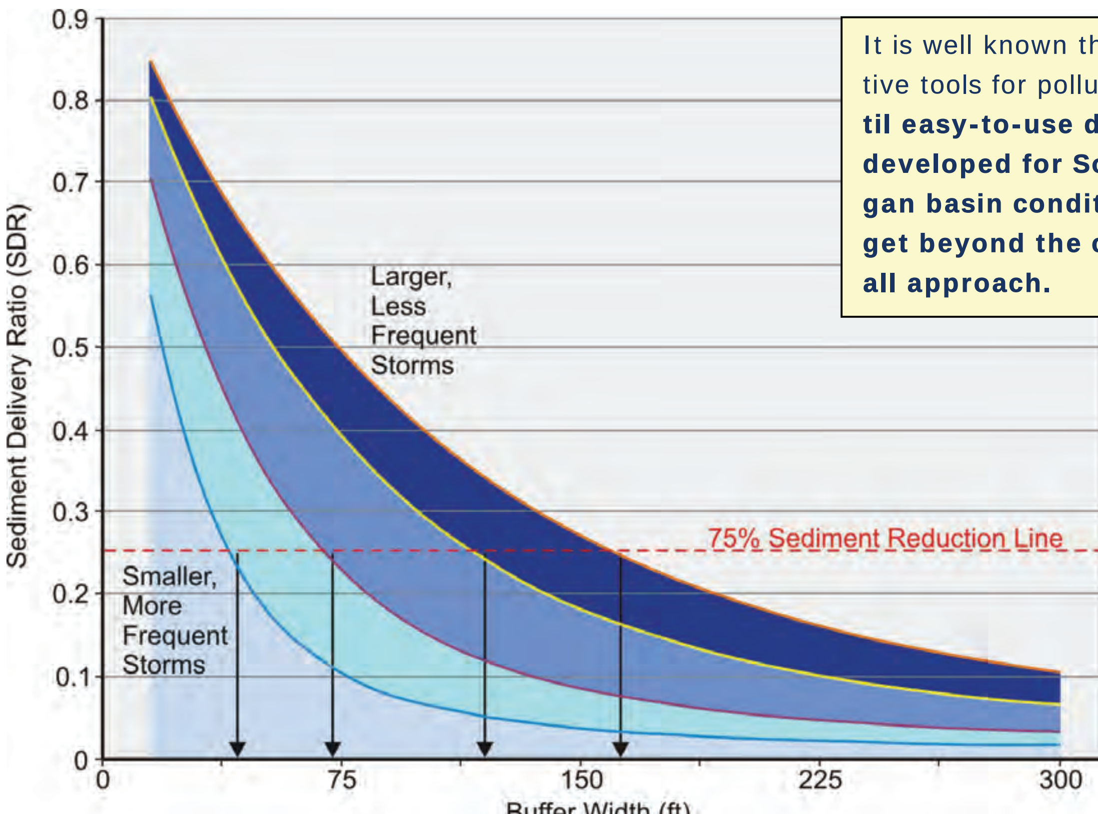
A Buffer Design Tool

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.* *http://carpena.ifas.ufl.edu/vfsmod/citations.shtml)*

Buffers Are A Good Defense

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.

> ***"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)*

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.

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.

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.

* * *

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www.sewrpc.org

May 7, 2010

Appendix E

VERTICAL CONTROL STATION ON BARK LAKE OUTLET

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SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION
RECORD OF VERTICAL CONTROL STATION

SECTION 26, TOWNSHIP 9 N, RANGE 19 E

Washington COUNTY

BENCH MARK NO. MRK-5 ELEVATION 972.919'

REFERENCE BENCH MARK NO. RRK-5 ELEVATION 974.755'

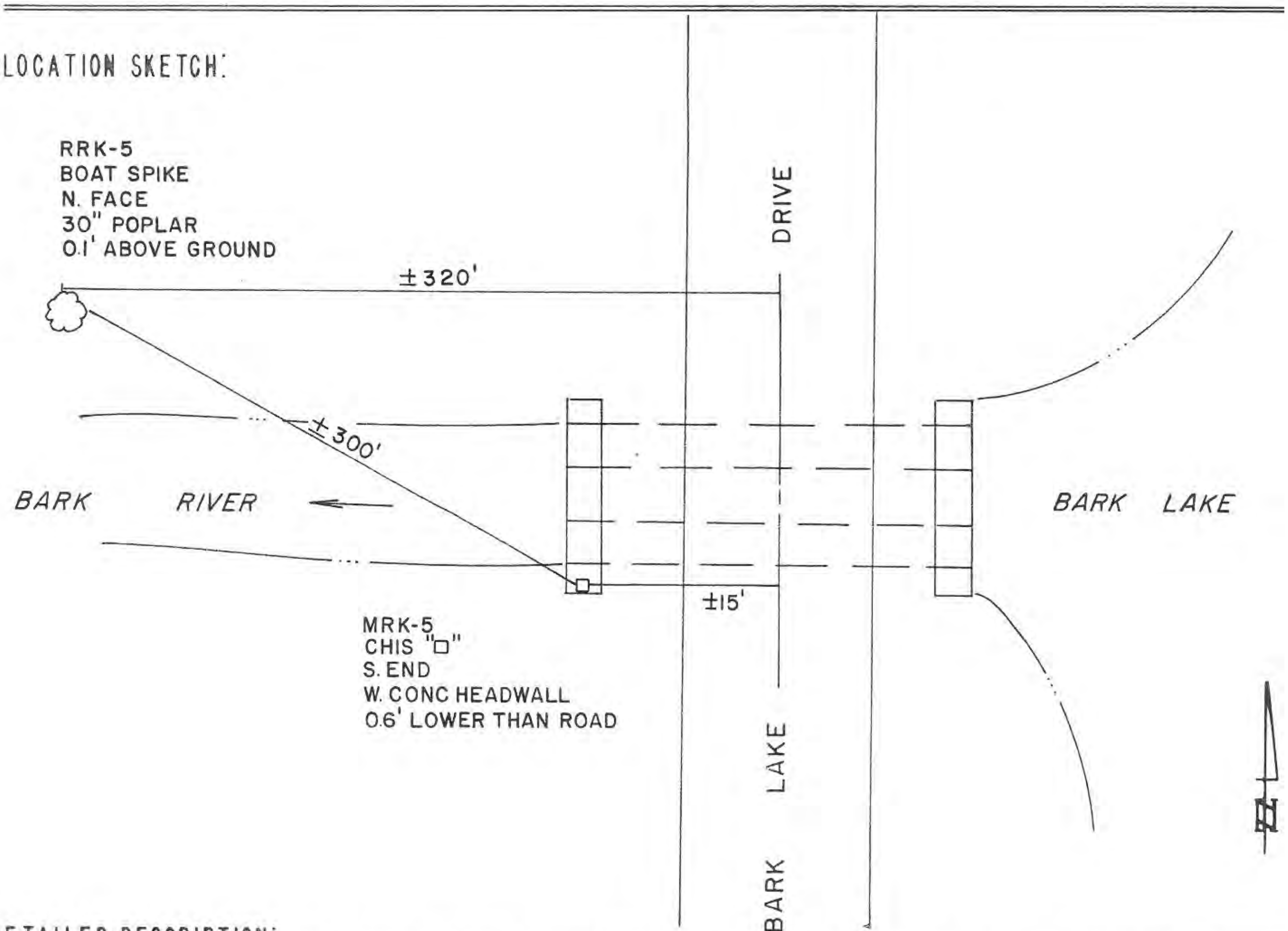
SET BY: ALSTER & ASSOCIATES, INC., ENGINEERS, MADISON, WISCONSIN

VERTICAL DATUM: MEAN SEA LEVEL, 1929 ADJUSTMENT

VERTICAL CONTROL ACCURACY: Third Order Second Order, Class II

DATE OF SURVEY: April 1977 Revised November 1996

LOCATION SKETCH:



DETAILED DESCRIPTION: About 0.11 mile south and 0.25 mile east of the NW corner of section 26, T 9 N, R 19 E;