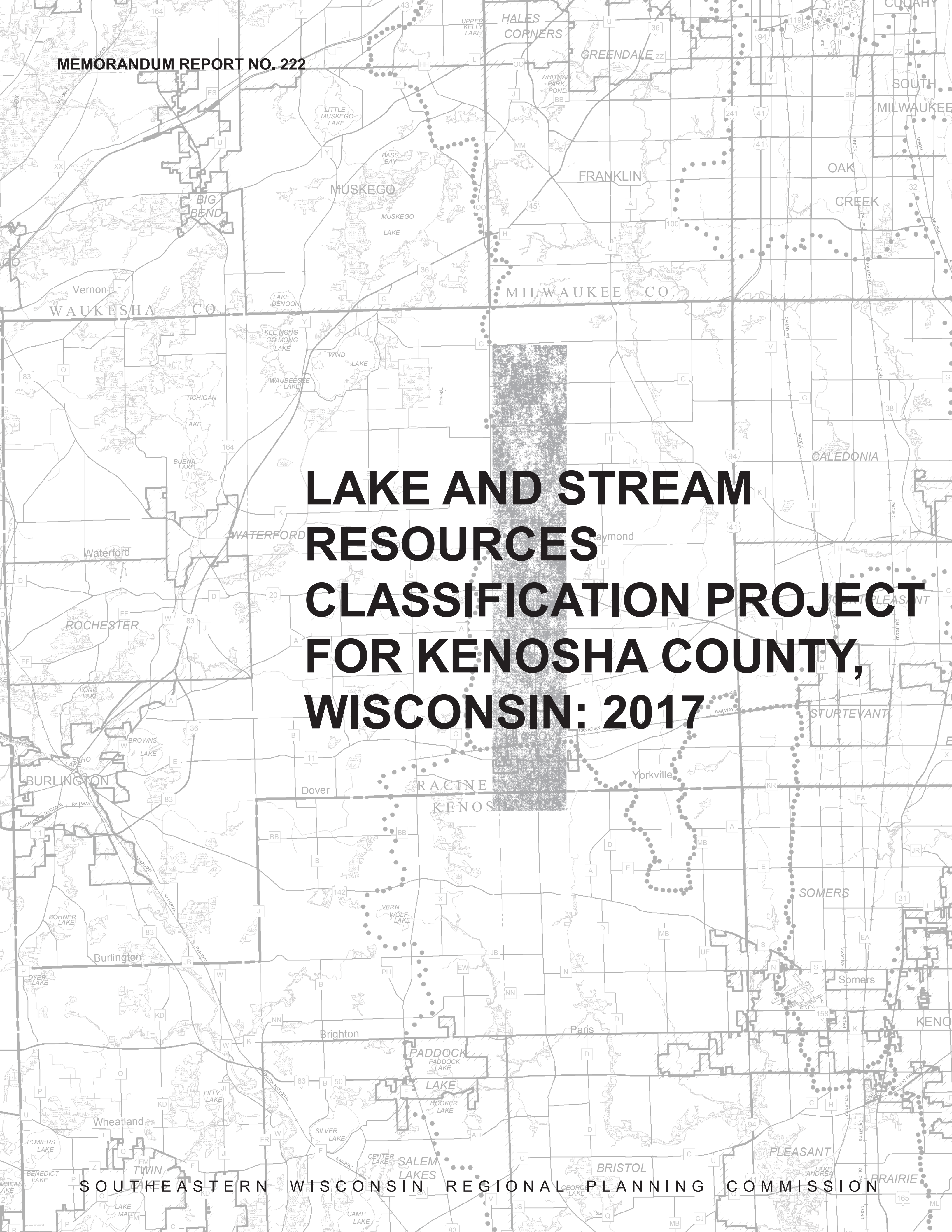
MEMORANDUM REPORT NO. 222



LAKE AND STREAM RESOURCES CLASSIFICATION PROJECT FOR KENOSHA COUNTY, WISCONSIN: 2017

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

KENOSHA COUNTY LAKE AND STREAM CLASSIFICATION PLAN TECHNICAL ASSISTANCE

Special acknowledgment is due to the following individuals for their contributions to this plan:

Daniel Treloar, County Conservationist,
Kenosha County Division of Planning Operations

Andy Buehler, Director of Planning & Development,
Kenosha County Department of Public Works and Development Services

Craig Helker, Water Resources Management Specialist,
Wisconsin Department of Natural Resources

Luke Roffler, Fisheries Biologist,
Wisconsin Department of Natural Resources

Joyce Gramz, Senior GIS Applications Specialist,
GIS Support, Southeastern Wisconsin Regional Planning Commission

Special acknowledgment is due Dale J. Buser PE, PH, Principal Specialist; Dr. Thomas Slawski, Chief Biologlist; Beverly Saunders, Former Senior Specialist; Zofia Noe, Specialist; Anna Cisar, Former Research Analyst; and, Laura Fields-Sommers, Former Research Analyst, for their contribution to the preparation of this report.

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Prepared by the

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

and the
Kenosha County Division of Planning and Development
19600 75th St., Suite 185-3
Bristol, WI 53104
www.co.kenosha.wi.us

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Chapter I

INTRODUCTION

Lakes and streams are coveted natural resource features. Many people favor home sites abutting water bodies. This situation generates high demand for comparatively small land areas, a factor which tends to increase waterfront property values and often causes waterfront areas to be divided into many small parcels with limited frontage. This in turn increases population density along water bodies and focuses ecological pressure on oftentimes fragile natural resource communities. Ordinances help regulate and limit human pressure on waterbodies and other natural areas. Creating and applying such ordinances can be complex. The variability of waterbody and community characteristics yields a complex mosaic of resource vulnerability and cultural pressure, a situation causing the health and vitality of certain waterbodies to be more at risk. While it may be impractical and even untenable to custom-craft rules for every conceivable water body type, existing data can be used to group water bodies into similar classifications. In this way, property owners, lake users, natural resource agencies, and other interested parties can focus energy best matching water body characteristics.

Kenosha County's abundant lakes and streams have highly variable conditions and settings. All are close to major population centers, a situation creating high demand for waterfront property. To better match zoning ordinances with on-the-ground natural resource management limitations and needs, Kenosha County applied for and received a grant under Chapter NR 191, "Lake Protection and Classification Grants," of the *Wisconsin Administrative Code*. The grant project involves collecting information that helps quantify both the sensitivity of water bodies to changing conditions and the degree of human influence in a lake's watershed. Using these factors, an algorithm was developed that assigns sensitivity and human influence values to each water body, and uses this information to suggest future management objectives that can help customize actions and ordinances to better match the relative need for protection.

PROJECT SETTING

Kenosha County (the County) occupies approximately 278 square miles in the extreme southeastern corner of Wisconsin. It is the southern-most coastal county in the State, having boundaries coterminous with Lake and McHenry Counties in Illinois, and Walworth and Racine Counties in Wisconsin. Lake Michigan forms the County's eastern boundary (see Map 1). Most of the County's population resides in the eastern third of the County, with 60 percent living in the City of Kenosha. The County is largely rural, with agriculture being an important and valuable economic resource utilizing nearly half of the County's land area.[1] Inland lakes and streams occupy approximately 4,800

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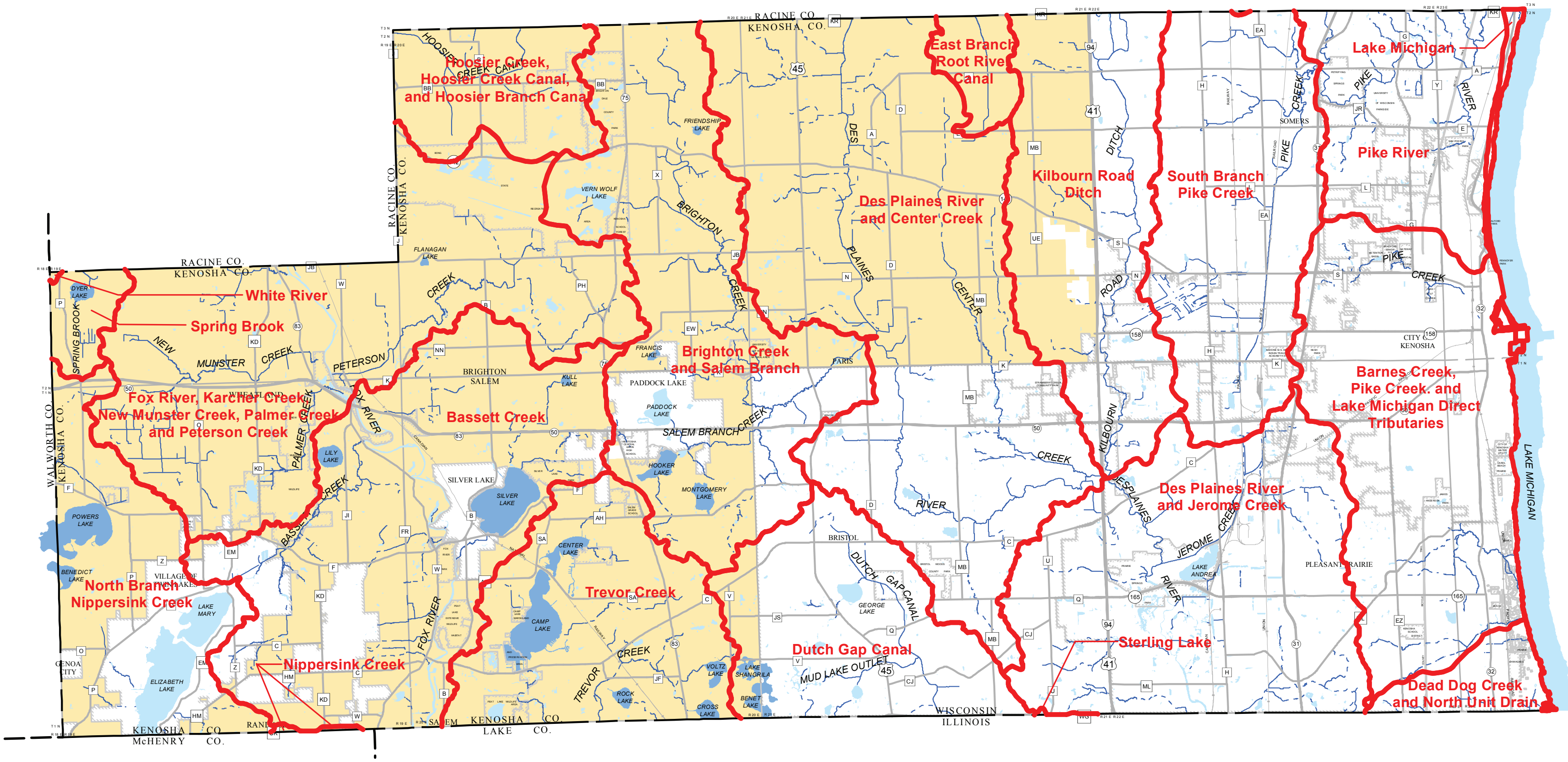
[1] *SEWRPC Community Assistance Planning Report No. 131, 2nd Edition,* A Park and Open Space Plan for Kenosha County, *Second Edition, April 2012.*

Map 1

KENOSHA COUNTY LAKE AND STREAM CLASSIFICATION PROJECT AREA



U.S.G.S. HYDROLOGIC UNIT CODE 12 SUBWATERSHED BOUNDARY AND LOCAL STREAM NAMES WITHIN THE SUBWATERSHED

PROJECT AREA

N

0 1.5 3 Miles

Source: U.S. Geological Survey and SEWRPC.

PROJECT LAKES

FOX RIVER WATERSHED:	DES PLAINES WATERSHED:
BENEDICT	FRANCIS
CAMP	FREINDSHIP
CENTER	HOOKER
CROSS	MOMTGOMERY
DYER	SHANGRI-LA/BENET
FLANNAGAN	
KULL	
LILY	
POWERS	
ROCK	

NAMED PROJECT STREAMS

DES PLAINES RIVER WATERSHED:	FOX RIVER WATERSHED:
BRIGHTON CREEK	BASSET CREEK
CENTER CREEK	HOOSIER CREEK
DES PLAINES RIVER	HOOSIER CREEK CANAL
DUTCH GAP CANAL	HOOSIER BRANCH CANAL
KILBOURNE ROAD DITCH	FOX RIVER
SALEM BRANCH	KARCHER CREEK
	NEW MUNSTER CREEK
DES PLAINES RIVER WATERSHED:	PALMER CREEK
EAST BRANCH ROOT RIVER CANAL	PETERSON CREEK
	SPRING BROOK
	TREVOR CREEK

acres (about 3 percent) of the County's total area.[2] Twenty-seven named lakes are located entirely or partially within the County. These lakes occupy about 3,861 acres. Twenty lakes are considered to be "major lakes" (defined as lakes with surface areas of at least 50 acres).[3] In addition to lakes, approximately 110 miles of named perennial streams and an additional 55 miles of unnamed tributary streams are mapped in the County.

The physiographic and topographic features of Kenosha County are primarily created by glacial action. Glaciers formed the gently rolling plains depositing clay-rich soil (ground moraines) in the eastern part of the County. The sand- and gravel-rich hills and valleys in the western part of the County are also the product of glacial action. Abruptly sloping terminal moraines and meltwater features are intermixed with other fluviolacustrine features.[4] The majority of the County's lakes are found in the areas of irregular topography in the western part of the County. Water bodies in the areas can commonly receive significant groundwater contributions from shallow glacially deposited sand and gravel aquifers. It is also important to note that the subcontinental divide crosses the County. Approximately 78 percent of the County drains to the Gulf of Mexico via the Mississippi River while about 22 percent of the County drains to the Atlantic Ocean through the Great Lakes-St. Lawrence River watershed.[5]

Being located midway between the Chicago and Milwaukee metropolitan areas, Kenosha County has experienced, and continues to experience, significant population growth and development pressure. Its proximity to major population centers and transportation corridors has affected overall land use, fueling urban expansion while simultaneously reducing the number of farms and county-wide acreage devoted to agriculture. Nevertheless, the total value of farm products produced by Kenosha County farms has increased.[6]

Expanding urban areas and changes in farming will likely affect the area's lakes and streams. Change brings opportunity for holistic progress, but can exacerbate or create new management challenges. Examples of past broad problems that commonly accompanied intensified land use include increased point and nonpoint source pollution, decreases of riparian buffer, and overall ecosystem degradation. However, conscientious enforcement of progressive stormwater management practices can allow communities to help resolve long-standing water quality and quantity problems as an integral part of development.

LEGISLATIVE ACTION

In 1959,[7] the Legislature asked the then Wisconsin Conservation Department (now the Wisconsin Department of Natural Resources) to develop a program to evaluate lakes and streams. In pursuit of this mandate, the Wisconsin Conservation Department prepared a series of water resources inventories that reported basic data needed to understand key lake characteristics. These inventories were prepared on a county-by-county basis, with the summary

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[2] *Kenosha County Department of Public Works and Development Services Division of Planning and Development,* A Land and Water Resource Management Plan for Kenosha County: 2017-2026, *February 2016.*

[3] Ibid.

[4] *Fluviolacustrine refers to glacial deposits laid down under alternating or overlapping lacustrine (formed at the bottom or along the shore of lakes) and fluviatile (formed in or near rivers) conditions.*

[5] Ibid.

[6] *United States Department of Agriculture,* 2012 Census of Agriculture, Kenosha County, Wisconsin, *https://www.agcensus.usda.gov/Publications/2012/Online_Resources/County_Profiles/Wisconsin/cp55059.pdf*

[7] *This date precedes establishment of Wisconsin's lake classification grant program.*

of the surface-water resources of Kenosha County being completed in 1961 and updated in 1982.[8, 9] The County has since updated data on their water resources under *A Land and Water Resource Management Plan for Kenosha County: 2008-2012*[10] and more recently under *A Land and Water Resource Management Plan for Kenosha County: 2017-2026*.[11]

The basic motivation behind the 1961, 1982, and current classification programs were similar; namely, the realization that use of, and demand for, surface waters is increasing, and, as uses grow and intensify, use conflicts arise. Use conflicts occur among various user groups, ranging from irrigators to anglers to recreational boaters to riparian homeowners, among others. Occasionally, such use conflicts are destructive to both the inherent fabric of water-focused communities and the water resources themselves. Mechanisms are required to promote future, harmonious coexistence of water resource uses consistent with the capacity of the water resource features' ability to support such uses. The Legislature created the lakes classification program noting that previously mandated State-level mechanisms had been only partially successful in achieving the degree of protection desired for the waterways of the State.[12] The Legislature further commented that additional measures needed to be developed at the local level to adequately protect and rehabilitate the State's surface water resources. The Wisconsin Department of Natural Resources subsequently funded a grants program to foster lake protection and classification.[13]

The overall goal of this lake and stream classification project was to produce a scientific and technical basis to support local ordinance refinement. Such refinement was to be carried out in unincorporated areas of Kenosha County in response to the requirements of Chapter NR 115, "Wisconsin's Shoreland Protection Program," of the *Wisconsin Administrative Code* as it existed prior to July 2015. Based on changes to State law enacted through the State budget under 2015 Wisconsin Act 55, a local shoreland zoning ordinance may no longer regulate a matter more restrictively than it is regulated by a State shoreland-zoning standard unless that matter is not regulated by a standard in Chapter NR 115, "Wisconsin's Shoreland Protection Program," of the *Wisconsin Administrative Code*. Therefore, this project focuses upon providing management guidance and information useful for land and water conservation programs.

In addition to changes to State law, the extent of unincorporated areas in Kenosha County changed over the time period between grant award and project completion. Most final data analysis and report composition occurred during 2016. During November 2016, the Town of Salem (an unincorporated area and therefore under the jurisdiction of the County) and the Village of Silver Lake received notice the Wisconsin Department of Administration approved the merger of these two municipalities and formation of the new Village of Salem Lakes. Since most of the research and report preparation were completed before formation of the Village of Salem Lakes, this report includes analysis of lakes and streams in the former Town of Salem, even though these lakes and streams are no longer located in unincorporated areas.

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[8] *Wisconsin Department of Natural Resources,* Surface Water Resources of Kenosha County, *1961*.

[9] *Wisconsin Department of Natural Resources,* Surface Water Resources of Kenosha County, *2nd Edition, 1982.*

[10] *SEWRPC Community Assistance Planning Report No. 255, 2nd Edition,* A Land and Water Resource Management Plan for Kenosha County: 2008-2012, *October 2007.*

[11] *Kenosha County Department of Public Works and Development Services Division of Planning and Development, op. cit.*

[12] *Wisconsin Statutes Section 281.69,* Lake management and classification grants and contracts, *October 7,* 2016

[13] *Wisconsin Administrative Code Chapter 191,* Lake Protection and Classification Grants, *March 2014.*

PROJECT DESCRIPTION

This Lake and Stream Classification Study uses existing information and custom-collected lake and stream data to examine water resource features in unincorporated or recently incorporated portions of Kenosha County. Water body characteristics are identified and contrasted to aggregate water bodies into groups with similar characteristics and management challenges. Examples of conceptual management strategies and information useful for land and water conservation programs are then provided for each group. Examples of potential management and action strategies are presented in Chapter VI. Possible approaches include implementing State nonagricultural performance standards and prohibitions, reducing construction site erosion, managing stormwater runoff more effectively as discussed in the County's land and water resource management plan,[14] considering setbacks for structures, promoting more sensitive management of shoreline vegetation, and minimizing impervious surface area.

PROJECT GOALS AND OBJECTIVES

As shown on Map 1 and Table 1, this lake and stream classification project addresses major, named inland lakes and streams within the unincorporated areas of Kenosha County.[15] The objectives of this project are to:

1. Review and update data and scientific information pertaining to the subject inland lakes and streams;
2. Describe existing hydrologic and hydraulic conditions within their watersheds, including the rates and routes along which water flows through the lakes and streams;
3. Identify and quantify the extent of existing and potential future water quality problems likely to be experienced in the lakes and streams, and develop estimates of likely water quality under planned year 2035 land use conditions;
4. Quantify impervious surface areas on individual riparian parcels for major lakes. Impervious surfaces are defined as any surfaces which water cannot infiltrate stormwater, and are commonly associated with driveways, parking lots, sidewalks, patios, and building rooftops in the study area.
5. Assess and consider lake and stream water quality using physicochemical monitoring data collected as part of regularly ongoing water quality monitoring programs; and
6. Suggest examples of conceptual management actions, public information and education strategies, ordinance refinements, and other possible responses that help mitigate identified challenges.

Accomplishing these goals will generate a comprehensive knowledge base to support lake and stream classification in Kenosha County in a manner consistent with the objectives of Chapter NR 191 ,"Lake Protection and Classification Grants," *Wisconsin Administrative Code* and as modified by subsequent guidance.[16] The proposed lake and

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[14] *SEWRPC Community Assistance Planning Report No. 255, 2nd Edition, op. cit., p. 94.*

[15] *This area includes the portions of the Village of Salem Lakes that were the Town of Salem before February 14, 2017.*

[16] *The 2015-2017 State Budget (Act 55) changed State laws relative to shoreland zoning. Under Act 55, a shoreland zoning ordinance may not regulate a matter more restrictively than it is regulated by a State shoreland-zoning standard unless the matter is not regulated by a standard in Chapter 115. "Wisconsin's Shoreland Protection Program" of the Wisconsin Administrative Code. Examples of unregulated matters may include wetland setbacks, bluff setbacks, development density, and stormwater standards. In addition, under Act 55, a local shoreland zoning ordinance may not require establishment or expansion of a vegetative buffer on already developed land and may not establish standards for impervious surfaces unless those standards consider a surface to be pervious if its runoff is treated or is discharged to internally drained pervious areas.*

Table 1

STREAMS IN THE CLASSIFICATION PROJECT AREA

Hydrologic Unit Code 12 Digit (HUC 12) Number	HUC 12 Name	HUC 12 Size (Acres)		Key Named Streams in HUC 12 in Kenosha County Project Area	Discharges to
		Watershed Total	Portion In Kenosha County		
040400020202	East Branch Root River Canal	9789	1464	East Branch Root River Canal	Lake Michigan
071200040101	Brighton Creek	17585	14879	Brighton Creek, Salem Branch	Des Plaines River
071200040102	Kilbourn Road Ditch	15071	4850	Kilbourn Road Ditch	Des Plaines River
071200040103	Headwaters Des Plaines River	28195	16303	Des Plaines River, Center Creek (sometimes referred to as the Root River[a])	Des Plaines River
071200040201	North Mill Creek	23174	8569	Dutch Gap Canal, becomes Mill Creek downstream in Illinois	Des Plaines River
071200060604	White River	25427	17	None	Fox River
071200060802	North Branch Nippersink Creek	25505	5149	None	Fox River
071200060907	Nippersink Creek	12024	47	None	Fox River
071200061001	Hoosier Creek	13698	4593	Hoosier Creek, Hoosier Creek Canal, Hoosier Branch Canal	Fox River
071200061002	Spring Brook – Fox River	8503	1203	Spring Brook	Fox River
071200061003	Palmer Creek – Fox River	24212	18808	Fox River, Karcher Creek, New Munster Creek, Palmer Creek, Petersen Creek	Fox River
071200061005	Channel Lake	12444	9478	Trevor Creek	Fox River
071200061006	Bassett Creek – Fox River	22926	14501	Bassett Creek	Fox River

[a]*Not to be confused with the Root River that enters Lake Michigan in Racine, Wisconsin.*

Source: U.S. Geological Survey and SEWRPC.

stream resource classification project and suggested management concepts can become part of an ongoing program of lake/stream-related management actions.[17, 18]

[17] *SEWRPC Community Assistance Planning Report No. 255, 2nd Edition, op. cit.*

[18] *SEWRPC Community Assistance Planning Report No. 299,* A Multi-Jurisdictional Comprehensive Plan for Kenosha County: 2035, *April 2010.*

Chapter II

PROJECT APPROACH

Wisconsin's shoreland zoning standards originated during the late 1960s. Since then, a more holistic understanding of aquatic natural system management has evolved. As part of this evolution, it is now better understood that every lake and stream does not have an equal ability to remain healthy in the face of equal development pressure and recreational use.

A variety of factors influence a lake or stream's ability to remain healthy. Quantifying these factors can help predict the amount of protection a lake or stream needs to remain ecologically vital. A systematic scoring process can simultaneously consider a suite of important variables. The resultant scores help managers understand which lakes and streams are more sensitive to pressure, and allow managers to contrast the amount of pressure already applied (or predicted to be applied at a future point in time) to individual waterbodies.

Although current State law prohibits shoreland regulations more restrictive than published NR 115 standards, conservation initiatives can still be identified and designed that modify human behavior and protect, enhance, or restore important resource elements. The goal of these initiatives is to maintain or improve each waterbody's ecosystem integrity, and its ability to provide human needs (e.g., aesthetics, recreational appeal, and water quality). Problem-targeted prescriptive remedies can be applied to similar water bodies confronted with similar challenges, allowing a systematic regional approach to coalition building, planning, enforcement, budgeting, grant funding requests, and project execution.

A water body classification system groups water bodies based on their inherent vulnerability to human impact and the extent and intensity of surrounding existing human land use/development. The resulting classification does not identify certain water bodies as "more valuable" than others. Instead, the intent is to group water bodies into a manageable number of classes, which helps agencies to efficiently prescribe and prioritize the most appropriate management techniques and strategies. These general techniques and strategies are then custom-tailored to each waterbody's unique physical, chemical, and biological characteristics.

Technical and financial resources targeting agricultural and urban runoff, habitat quality, water quality, outreach and similar projects are typically insufficient to meet demand. Therefore, the projects with the highest "bang for the buck" should be implemented first. With the wide range of factors that must be considered, it can be difficult to systematically prioritize projects. The Water Body Classification System developed in this document provides a framework for identifying and targeting efforts that have the greatest beneficial effect. Consequently, it is an excellent tool for planning studies and documenting efficiency and need for grant applications.

The following paragraphs describe a few of the key issues and principles important to the processes used to compare and contrast individual water bodies and which are integral to the scoring and ranking process.

IMPERVIOUS AREA

Impervious areas are land covers such as roofs, walkways, driveways, patios, tennis courts, and other concrete, asphalt, shingled structures, or extremely compacted soil areas where the surface material itself or soil conditions impede or prevent rain and snowmelt from soaking into the ground. Impervious areas increase the amount and speed of runoff and commonly cause some or all of the following changes to the lakes and streams they feed:

- Widely fluctuating flow rates and/or water levels in lakes and streams. This can express itself as greater flood flow and floodplain elevation, less dry-weather flow, and reduced abundance of perennial stream segments,
- Depressed groundwater elevations and decreased flows to natural groundwater discharge areas (springs and certain reaches of wetlands, lakes, and streams) and human-induced extraction points (wells),
- Increased erosion of natural stream channels and increased sedimentation in still water areas such as lakes and wetlands,
- Diminished natural processes that remove or detain nutrients and sediment from surface water and groundwater. In turn, the amounts of sediment and pollutants delivered to waterways increases,
- Reduced ability for natural processes to attenuate water-borne pollutants,
- Degraded habitat (e.g., gravel spawning areas eroded or covered with fine sediment, loss of instream and riparian vegetation and structure),
- Increased warm-season water temperature and loss of sensitive cool and coldwater fish and colder winter water temperatures, and
- Reduced aquatic organism diversity and populations (e.g., fish, mussels, insects).

As development alters the natural landscape, the percentage of the land covered by impervious surface nearly always increases. Imperviousness has become synonymous with the degree of human presence. Studies show that human population density is positively correlated with the percentage of impervious cover.[1]

Paving over natural landscapes, in the absence of mitigating measures, starts a chain of events that typically results in degraded water resources. The chain begins with altering the hydrologic cycle, or the way that rainwater and snow melt are detained, stored, and transported. Figure 1 illustrates how increases in impervious cover amplify the speed at which water leaves the landscape and the amount of runoff that eventually ends up in lakes and streams. Depending upon the type of soil, land cover, and slope, between 5 and 40 percent of rainfall typically leaves undeveloped areas as surface-water runoff.

When the proportion of land area covered with impervious surfaces increases, less runoff is temporarily detained, evaporated, or infiltrated into the ground and runoff is more quickly conveyed to its ultimate discharge point (see Figure 2). More runoff volume and faster, more efficient water conveyance through road gutters, pipes, and artificially straightened channels results in higher and more rapidly-occurring flood peaks, a situation that can overwhelm natural drainage features and existing drainage infrastructure, resulting in localized flooding and greater and

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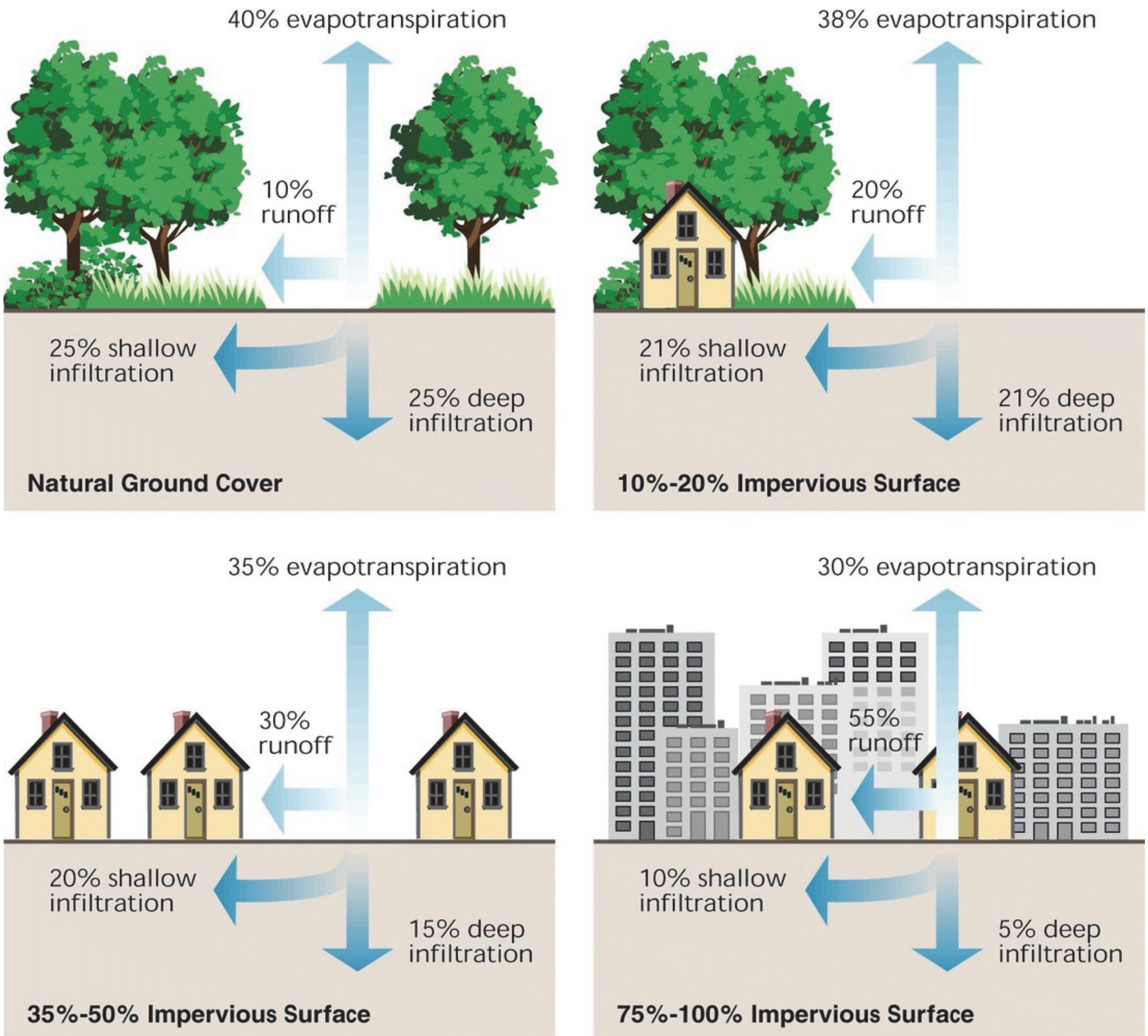
[1] *Arnold, C., and C.J. Gibbons,* Impervious Surface Coverage - The Emergence of a Key Environmental Indicator, *Journal of the American Planning Association 62(2):243-258, 1996; and, Center for Watershed Protection,* Housing Density and Urban Land Use as Stream Quality Indicators, *Watershed Protection Techniques 3(3):735-739, 2000.*

Figure 1

RAINFALL/RUNOFF CHANGES ASSOCIATED WITH URBANIZATION



Source: Federal Interagency Stream Restoration Working Group (FISRWG), Stream Corridor Restoration: Principles, Processes, and Practices, October 1998

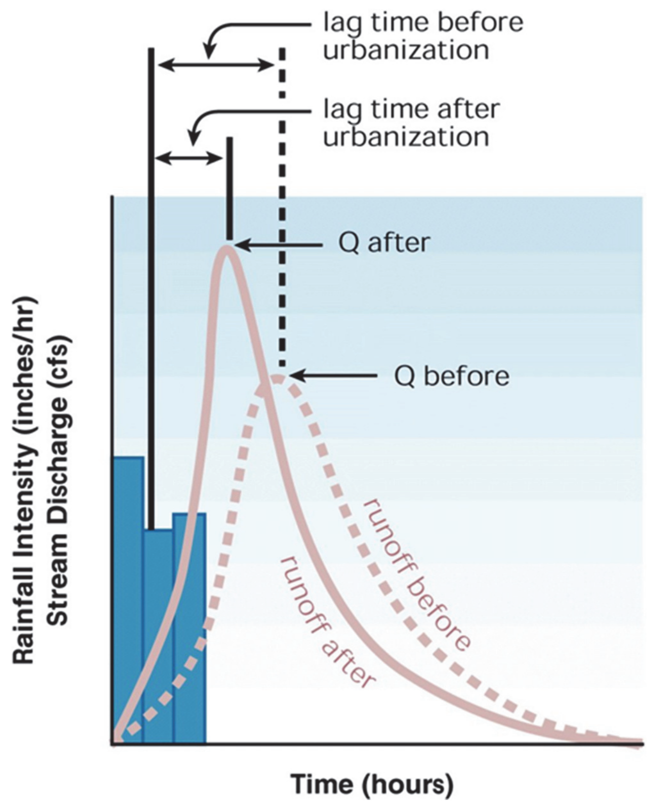
more frequent flooding in downstream areas. These high flows can damage infrastructure and destabilize stream channels. Decreased infiltration can reduce groundwater's contribution to streamflow, leading to lower stream flow during fair and dry-weather periods. Dry-weather flow and attendant positive ecological role and function of formerly reliable perennial streams can cease.

Stream form and ecology are highly dependent on the amount, source, and timing of water entering the stream. Hydrologic disruption perturbs the physical characteristics and ecology of streams. Intensified runoff increases erosion and sediment transport from vulnerable areas such as construction sites and areas of disturbed soils to streams. Intensified runoff also destabilizes stream beds and banks and can lead to stream channels broadening and/or incising themselves into the landscape. The increased volume of water and sediment entering streams, combined with the "flashiness" of these peak discharges, often result in wider, deeper, and straighter stream channels. As the stream entrenches itself, it may no longer be able to access adjacent floodplain areas, further intensifying erosive power on the stream's bed and banks, and further compromising the positive ecological and water quality functions that occur in natural floodplains.

Erosion commonly causes substantial loss of both streamside (riparian) habitat and instream habitat (e.g., woody structure for cover, gravels for spawning) as the natural streambed cover and substrate is eroded during high energy periods and as a uniform blanket of eroded sand and silt blankets the stream bottom during low flow periods. Furthermore, streams form can change, reducing the number of pools, riffles, and other features critical to aquatic organism refuge, breeding, and feeding. Loss of tree cover and reduced groundwater inflow can cause water temperatures to fluctuate more greatly, with water warmer in the summer and colder water in the winter, both of which can be detrimental to native aquatic organisms. Degraded streams are commonly artificially deepened, lined, and/or straightened (ditched) to offset flooding problems, which further reduces a stream's ability to attenuate high flows and detain or retain nutrients and sediment. While approaches such as ditching may temporarily reduce localized flooding, such measures can increase flooding in downstream areas and further compromise the stream's ecological value.

Figure 2

RELATIVE RUNOFF RATE AND INTENSITY BEFORE AND AFTER URBANIZATION



Note: Runoff from urbanized areas typically changes in two ways when contrasted to pre-development conditions. First, flood peaks increase. Second, peak flows occur more quickly. In addition to these two factors, the total volume of stormwater leaving an urbanized area commonly, but not always, increases. In the diagram above, Q refers to stream discharge.

Source: Federal Interagency Stream Restoration Working Group (FISRWG), Stream Corridor Restoration: Principles, Processes, and Practices, *October 1998*

When completing community-level planning studies, or in cases where detailed site-specific data is not available, impervious surface coverage may be the most practical and cost-effective indicator of the overall hydrologic and ecologic impact of development. Impervious land cover can be a surrogate to site-specific measurements, thereby helping avoid unwarranted expense and complexity. Impervious surfaces are proven contributors to hydrologic changes that degrade waterways, and are a major component and indicator of intensive land uses that generate heavy runoff and water-borne pollution.

Connected impervious land cover negatively affects a waterbody's Index of Biotic Integrity (IBI) scores. IBI is a measure of the quality of the aquatic community and combines elements, such as abundance, diversity (number of different species), tolerance (ability of a species to survive with lower water quality), feeding or trophic classifications (e.g., top carnivores, vertebrates, or large aquatic insects), and healthy appearance (e.g., deformities, eroded fins, or lesions). Connected impervious surfaces rapidly convey runoff to waterbodies and hinder or prevent natural pollution attenuation processes such as infiltration, filtering, and biologic degradation.

Research completed during the past 20 years suggests strong correlation between the proportion of a watershed occupied by impervious surface and the health of receiving streams.[2] Sediment and nutrient delivery models predict phosphorus loads to increase between 200 and 700 percent as lots are cleared and developed.[3] A study of pollutants in Wisconsin stormwater revealed that streets were the single most important urban pollution source in residential, commercial, and industrial areas.[4]

A factor favoring use of imperviousness as an environmental indicator is that it can be measured from aerial photography and can be accurately estimated based upon land use characteristics. The percentage of land covered by impervious surfaces varies significantly with land use. A frequently cited source of impervious cover estimates for various land uses is the U.S. Department of Agriculture, Natural Resources Conservation Service (formerly the Soil Conservation Service) Technical Release No. 55 (TR-55).

Sustainable land use and site design begin with analyzing natural and environmental features, assets, and constraints. Applying this principle to water resources protection translates to maintaining natural hydrologic function by retaining natural runoff patterns and vegetation to the maximum extent practicable. Reducing impervious surface area is a key element of the overall strategy, which also includes construction site erosion control practices and stormwater management measures to mitigate or reduce the effects of runoff from new development. For example, large-lot subdivisions generally create more impervious cover and greater water resource impacts on a per-capita basis than cluster-style housing (Figure 3). This is true even though the large lots may have less impervious coverage per lot. Because the traditional design requires longer roads, driveways, and sidewalks, there is still more impervious surface on a per-capita basis.[5] A South Carolina study compared the water quality impact of conventional versus clustered subdivision design.[6] Total water quality impacts were significantly greater with conventional designs - conventional designs generated 43 percent more runoff and three times the amount of sediment loading. Conventional subdivisions also exported more nitrogen, phosphorus, and chemical oxygen demand. Cluster development can reduce site imperviousness by 10-50 percent, depending on the lot size and the road network.[7] Thoughtful planning and design that reduces impervious surface area can save money.[8] Reduced construction footprints, infrastructure needs, and ongoing maintenance demands can save considerable private-equity and public-sector investment.

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[2] *Arnold, C., and C.J. Gibbons,* Impervious Surface Coverage. The Emergence of a Key Environmental Indicator. *Journal of the American Planning Association 62(2):243-258, 1996; Schueler, T., Site* Planning for Urban Stream Protection. *Center for Watershed Protection. Ellicot, MD, 1995; and, Schueler, T.,* The Importance of Imperviousness. *Watershed Protection Techniques 1:100-111, 1994.*

[3] *Bernthal, T.W., and Barrett, J.R.,* Effectiveness of Shoreland Zoning Standards to Meet Statutory Objectives: A Literature Review with Policy Implications, *Wisconsin Department of Natural Resources, PUBL-WT-505-97, 1997.*

[4] *Bannerman, R., D. Owens, R. Dodds, and N. Hornewer. 1993.* Sources of Pollutants in Wisconsin Stormwater, *Water Science & Technology (28)3-5 pp.241-259, 1993.*

[5] *Arendt, Randall,* Designing Open Space Subdivision, a Practical Step by Step Approach. *Natural Lands Trust, Inc. Media, PA, 1994.*

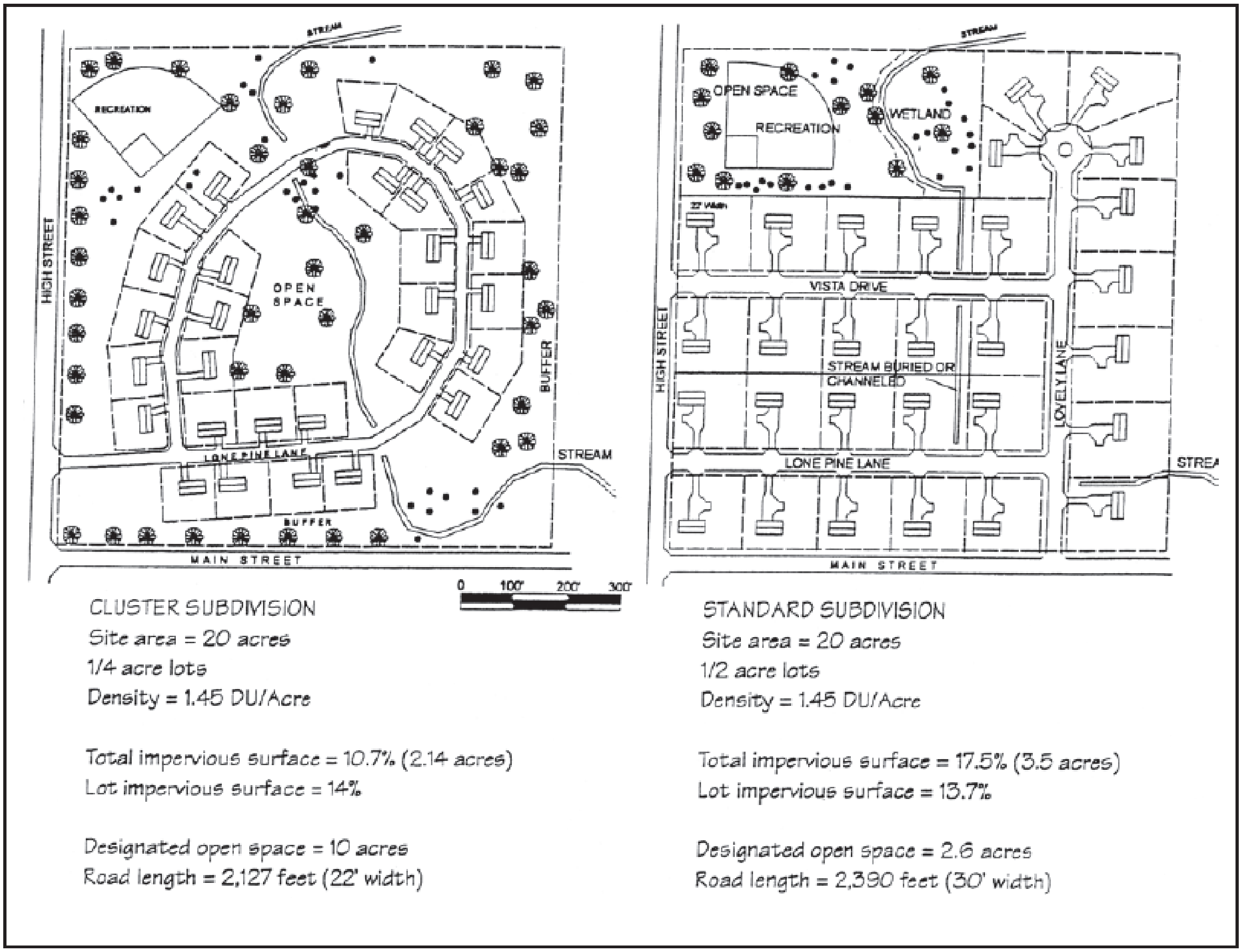
[6] *South Carolina Coastal Conservation League,* Getting a Rein on Runoff: How Sprawl and the Traditional Town Compare, *South Carolina Coastal Conservation League Land Development Bulletin, No. 7, 1995.*

[7] *Schueler, T.R., Use of Cluster Development to Protect Watersheds. Watershed Protection Techniques 1,3:137-40, 1994.*

[8] *Arnold, C., and C.J. Gibbons,* Impervious Surface Coverage: The Emergence of a Key Environmental Indicator, *Journal of the American Planning Association 62(2):243-258, 1996.*

Figure 3

OVERALL SITE IMPERVIOUSNESS ASSOCIATED WITH CLUSTER-STYLE VERSUS TRADITIONAL SUBDIVISIONS



Source: John Alexopoulos, University of Connecticut, in Arnold and Gibbons 1996.

Another less tangible advantage of using imperviousness as an environmental indicator is that it is a parameter that is easily understood by the average citizen. Reducing paved areas is one of the relatively few planning initiatives that resonates at all levels, from suburban driveways to big-box retail parking lots. Impervious cover is characteristic of urban land use, and is an excellent integrative indicator of the extent and intensity of urbanization. Using impervious land cover as an environmental indicator is an important and logical educational tool to help protect and restore a community's aquatic natural resources. Similarly and alternately, the restoration and protection of naturally vegetated areas is an equally important and complementary management strategy.

Imperviousness is especially important with regard to stormwater management. Best management practices (BMPs) include a wide range of onsite options to manage stormwater runoff. BMPs are often divided into two major types: those involving structures such as stormwater detention ponds, swales, or infiltration facilities; and nonstructural practices that usually involve the use of natural vegetated areas to buffer, direct, absorb, detain, and otherwise break

Table 2

BENEFITS PROVIDED BY VARIOUS URBAN STORMWATER BEST MANAGEMENT PRACTICES

	Peak Discharge Control					
BMP	2 Year Storm	10 Year Storm	100 Year Storm	Volume Control	Groundwater Recharge	Streambank Erosion Control
Extended Detention						
Dry	●	●	●	⊘	⊘	●
Dry w/Marsh	●	●	●	○	⊘	●
Wet	●	●	●	⊘	⊘	●
Wet Pond	●	●	●	○	⊘	⊘
Infiltration Trench						
Full Exfiltration	●	○	⊘	●	●	●
Partial Exfiltration	●	●	⊘	●	●	●
Water Quality Trench	⊘	⊘	⊘	●	●	●
Infiltration Basin						
Full Exfiltration	●	○	⊘	●	●	●
Infiltration/Detention	●	●	●	●	●	○
Off-Line Basin	⊘	⊘	⊘	●	●	○
Porous Pavement						
Full Exfiltration	●	○	⊘	●	●	●
Partial Exfiltration	●	●	○	●	●	○
Water Quality	⊘	⊘	⊘	●	●	○
Water Quality Inlet	⊘	⊘	⊘	⊘	⊘	⊘
Grassed Swale	○	⊘	⊘	○	○	⊘
Filter Strip	○	⊘	⊘	○	○	⊘

⊘ Seldom or Never Provided ○ Sometimes Provided w/Careful Design ● Usually Provided

Source: Dane County Waterbody Classification Report Part 1; Derived from Schueler, Thomas R. (1987). Controlling Urban Runoff: A Practical Manual for Plan and Designing Urban BMPs*.*

up large impervious areas.[9] Table 2 compares water quantity and quality benefits provided by urban BMPs. Maintenance activities such as prompt leaf and yard waste collection and/or management, sweeping particulate matter from roadways, and storm drain cleaning are also examples of BMPs. Examples of BMPs applicable to individual home sites include directing downspouts to grassy areas away from pavement, installing rain gardens, limiting fertilizer and pesticide use, and properly disposing leaves and yard waste.

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[9] *Dane County Regional Planning Commission,* Dane County Water Quality Summary Plan, *Madison, Wisconsin, 2004.*

LAND USE

More intensive human land use generally corresponds to increased concentrations and greater numbers of water pollutants. Faster runoff speed and greater runoff volume transports these pollutants more quickly and more efficiently into waterways, which in turn increases "nonpoint source pollution," or diffuse sources of polluted runoff from land surfaces. Major categories of nonpoint source pollutants include nutrients, fertilizers, pesticides, oil and other organic compounds, heavy metals and other toxic contaminants, pathogens (disease-causing microorganisms), sediment, and debris. Overabundant nutrients such as phosphorus and nitrogen can lead to algal "blooms" in surface waters that eventually decay and deplete water bodies of life-sustaining oxygen. Toxic contaminants like heavy metals and pesticides threaten the health of aquatic organisms and human consumers, and can persist for long periods of time in the environment. Chloride, a component of common salt, can rise to levels injurious or even toxic to desirable aquatic plants and animals. Many undesirable aquatic invasive species (e.g., phragmites-common reed, round goby) are very tolerant of saltier environments, while many desirable native organisms are quite sensitive to higher chloride concentrations. Therefore, even if chloride concentrations are not identified as toxic, higher chloride concentrations can cause a gradual shift of aquatic community structure and desirability from a lake-use standpoint. Pathogens can be entrained with runoff and can present possible health hazards for recreational users and other lake users. Sediment is a major nonpoint source pollutant, both for its effects on aquatic ecology and because many of the other pollutants tend to adhere to eroded soil particles. Debris detracts from the visual and aesthetic qualities of surface water bodies and can pose a hazard to wildlife through ingestion and entrapment.

Kenosha County has a longstanding agricultural history, and much of the County's land is devoted to crop and livestock production. While some types of agricultural operations may be more detrimental to water quality than others, agriculture affects most surface waters in Kenosha County to one extent or another. Runoff from tilled fields can release large amounts of sediment and nutrients to water bodies. Artificially drained fields (e.g., fields that are tiled or ditched) can short circuit detention features, increasing runoff intensity, decreasing the efficiency of natural pollutant removal mechanisms, and decreasing groundwater discharge. Streambank erosion from overgrazing and instream livestock watering can be a problem. Also, runoff from barnyards, feedlots, and croplands where manure and other organic waste is spread can contribute significant amounts of nutrients and organic material to water bodies. Excess and/or poor quality agricultural runoff can lead to excess bacteria and high pathogen levels, can foster algal blooms and excess aquatic plant growth, and can deplete dissolved oxygen in receiving streams and lakes. Lastly, pesticides used to control weeds and insects can contribute potentially toxic materials to surface waters.

Many agricultural best management practices (BMPs) have been designed to help address these problems. Table 3 compares the pollutant removal efficiency of several agricultural BMPs commonly used to manage rural nonpoint source runoff. Site-specific cropping and tilling practices; nutrient, pesticide, and barnyard management; stream buffers; streambank fencing; and wetland restoration can also benefit stormwater quality (see Table 4). These measures are typically implemented in cooperation with individual landowners as opportunity and available funds allow.

BUFFERS

In their natural state, southeastern Wisconsin's streams and lakes are typically surrounded by wide bands of profuse vegetation. These vegetated areas slow runoff, capture sediment, and detain or capture nutrients and other pollutants, and are commonly referred to as buffer areas.

When shoreland vegetation is disturbed or removed by humans, aquatic plants and animals generally suffer. Vegetated riparian zones along shorelines help stabilize banks making them more resistant to erosion and slow runoff improving water quality.[10] Trees and brush which topple into nearshore waters are another important part of habitat

[10] *When water slows, water-borne sediment and nutrients can be trapped before entering a water body. This can help maintain water clarity and quality, prevents siltation of streambeds or lakebeds, and helps preserve water depth and valuable shallow water habitat areas.*

Table 3

POLLUTANT REMOVAL EFFICIENCY OF COMMONLY EMPLOYED AGRICULTURAL STORMWATER MANAGEMENT PRACTICES

Comparison of Median Pollutant Removal Efficiencies Among Selected Practice Groups: Conventional Pollutants							
		Median Removal Rate For Stormwater Pollutants (%)					
Practice Groups	N	TSS	TP	Sol P	Total N	Nitrate	Carbon
Detention Pond	2	7	10	2	5	3	(-1)
Dry ED Pond	6	61	19	(-9)	31	9	25
Wet Pond	30	77	47	51	30	24	45
Wet ED Pond	6	60	58	58	35	42	27
Ponds[a]	**36**	**67**	**48**	**52**	**31**	**24**	**41**
Shallow Marsh	14	84	38	37	24	78	21
ED Wetland	5	63	24	32	36	29	ND
Pond/Wetland	11	72	54	39	13	15	4
Wetlands	**35**	**78**	**51**	**39**	**21**	**67**	**28**
Surface Sand Filters	6	83	60	(-37)	32	(-9)	67
Filters[b]	**11**	**87**	**51**	**(-31)**	**44**	**(-13)**	**66**
Channels	**9**	**0**	**(-14)**	**(-15)**	**0**	**2**	**18**
Swales[c]	**9**	**81**	**29**	**34**	**ND**	**38**	**67**

N =Number of performance monitoring studies. The actual number for a given parameter is likely to be slightly less.
Sol P= Soluble phosphorus, as measured as ortho-p, soluble reactive phosphorus or biologically available phosphorus.
Total N = Total Nitrogen. Carbon = Measure of organic carbon (BOD, COD, or TOC).
[a] Excludes conventional and dry ED ponds.
[b] Excludes vertical sand filters and vegetated filter strips.
[c] Includes biofilters, wet swales and dry swales.

Source: Dane County Waterbody Classification Report Part 1.

structure. Exposed and submerged woody structure diversifies nearshore habitat, greatly benefitting a wide variety of insects, fish, birds, and mammals living in nearshore and riparian areas. Woody structure plays an important role in the aquatic food chain by providing colonization sites for insects as well as roosting, resting, and cover areas for a host of other animals. The insects that live upon, and the structure created by, branches and logs provides cover and forage opportunities for juvenile and adult fish. Floating logs, leaning trees, and overhanging branches also provided basking sites for turtles and snakes, as well as perching sites for shorebirds and ambush sites for raccoons and other mammals that prey on aquatic life, thus stimulating a broad and diverse food web. In comparison, much simplified "tidy" shorelines and ecosystems associated with urbanized areas support less biomass, with commonly only the most tolerant species remaining.

Recommended shoreline buffer widths for many critical functions were compiled from multiple studies (Figure 4). Under most circumstances, to adequately protect streams, lakes, and wetlands, buffers should be at least 75 to 100 feet wide. Buffers with widths toward the lower end of the suggested range help maintain physical and chemical characteristics of adjacent aquatic resources. Increasing buffer widths substantially improves pollutant removal efficiency up to a width of about 100 feet. After 100 feet, much greater widths are needed to greatly improve pollutant removal efficiency. In other words, after about 70 to 80 percent removal is obtained, much greater buffer widths are needed to significantly increase pollutant removal efficiency.[11] Nevertheless, buffer widths toward the upper end

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[11] *Desbonnet, A., et. al., Vegetated Buffers in the Coastal Zone: A Summary Review and Bibliography. Coastal Resource Center, Rhode Island Sea Grant, University of Rhode Island, ISBN 0-938-412-37-x, 1994.*

Table 4

THE RELATIVE EFFECTIVENESS, COST, AND BENEFIT OF VARIOUS AGRICULTURAL MANAGEMENT PRACTICES TO REDUCE POLLUTANTS IN STORMWATER

Agricultural Management Practices			
Management Practice	Effectiveness	Capital Cost	On-Site Benefit
Contour Cropping	High	Low	Moderate
Strip Cropping	High	Low	Moderate
Field Diversions	High	Moderate	Moderate
Terraces	High	Moderate	Moderate
Waterways	High	Moderate	Moderate
Reduced Tillage	High	Low	Moderate
Critical-Area Stabilization	High	High	Low
Grade Stabilization Structure	High	High	Low
Shoreline Protection	High	High	Low
Barnyard Runoff Management	High	Moderate	Moderate
Long-term Manure Storage Facilities	High	High	Moderate
Short-term Manure Storage Facilities	High	Moderate	Moderate
Livestock Exclusion from Woodlot	High	Low	Low

Source: Wisconsin Department of Natural Resources, 1986.

of the suggested range appear to be the minimum necessary for maintaining the biological components of many streams, lakes, and wetlands.

Buffers need not be completely retired from agricultural production. Instead, certain cropping systems can yield many of the benefits that buffers provide (i.e., harvestable buffers), yet provide value to the land owner and income to the farmer. For example, substituting pasture or hay land for cultivated row crops in key areas can greatly benefit water quality, yet the crop can be harvested and contribute to farm income. Some Southeastern Wisconsin communities and organizations encourage such practices cash subsidies.

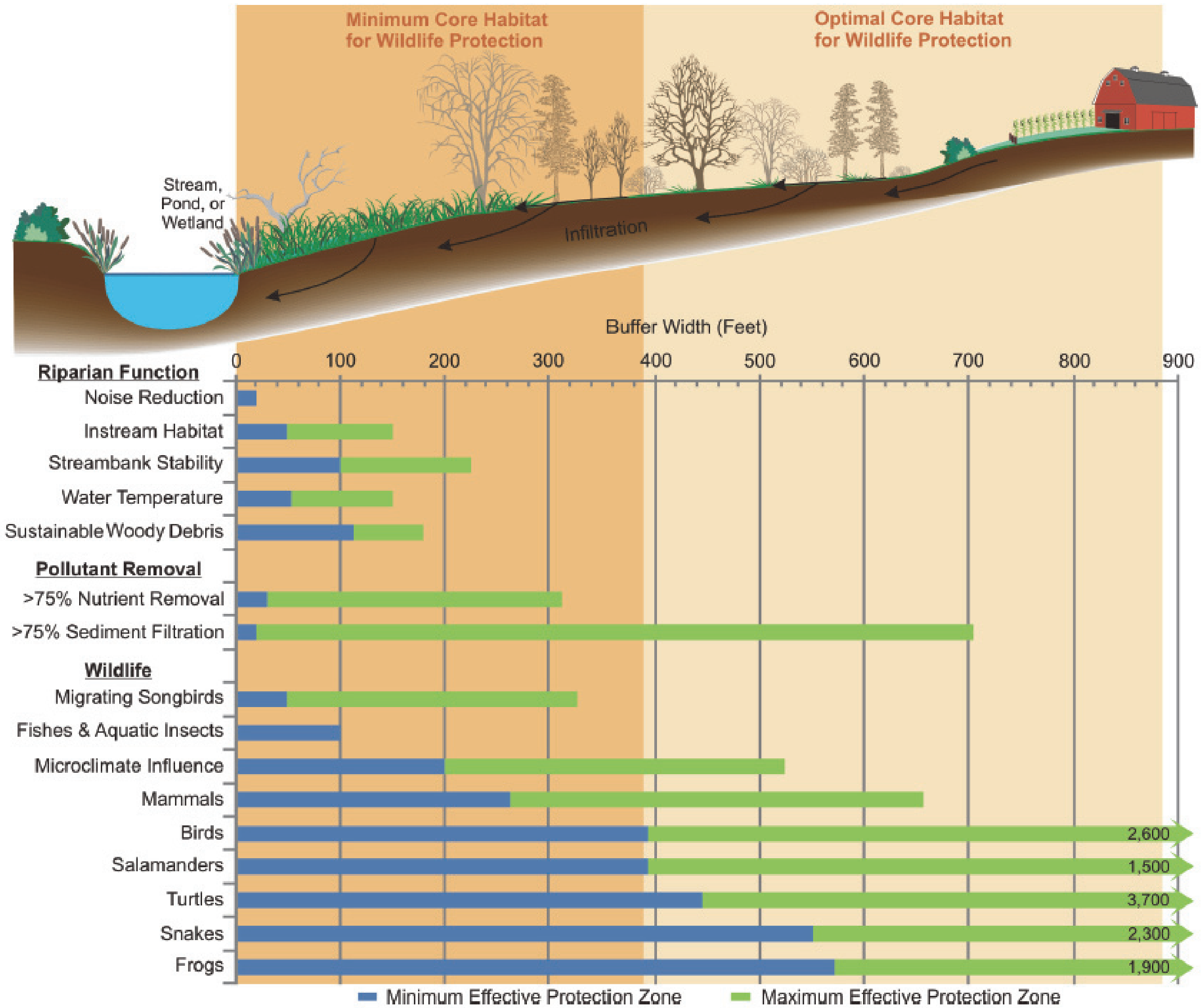
LAKES AND STREAMS ARE INHERENTLY DIFFERENT

Important ecological differences exist between streams and lakes. "Lotic" or flowing water aquatic communities are found in rivers and streams. Lakes and ponds support "lentic" or still water aquatic communities. Differences in retention time and water volume affect the way silt, nutrients, gases (e.g., oxygen and carbon dioxide), and contaminants are distributed through and removed from the water column.

Lakes may or may not be connected to river systems. Certain lakes (e.g., seepage lakes) may form isolated natural communities. In such situations, the lake is somewhat biologically self-contained, and all indigenous fully aquatic life must find suitable habitat types for all life stages (reproduction, rearing, feeding, refuge) in the immediate water body. Similarly, unless intentionally stocked by humans, once a fish is eliminated from such a system, it cannot be easily reintroduced from other connected water bodies.

Figure 4

RECOMMENDED SHORELINE BUFFER WIDTHS



Source: SEWRPC, Riparian Buffer Management Guide No. 1, Managing the Water's Edge, Making Natural Connections.

On the other end of the habitat spectrum, most streams are part of an extensive system of channels that eventually lead to the ocean. Under natural conditions, streams provide corridors through which aquatic organisms disperse and colonize new areas. If local conditions extinguish certain species from a stream or river, these species can commonly migrate from connected streams and river and recolonize the depopulated segment. Unfortunately, humans commonly interrupt stream ecological continuity by constructing infrastructure which cannot be circumvented by migrating organisms or modifying streams to make them inhospitable. A few examples of such infrastructure and inhospitable reaches includes dams, certain culverts and bridges, polluted reaches, thermal barriers, lined channels, artificially low water, and debris.

Many of the human and watershed induced impacts on stream water quality and quantity lead to rapid and direct response by the organisms living in lotic environments. This is in contrast to lakes where human and watershed effects may only lead to gradual and less visible change. The response time for the negative effects of human manipulation to express itself is typically longer in lakes. Similarly, the positive effects of remedial work that aims to reverse negative human influence impacts can commonly be seen quicker in rivers and streams.

Streams are particularly sensitive to changes in water quantity, especially increased peak flows and erosion/scouring associated with high flow events, as well as reductions in "baseflow" or dry weather streamflow. Increased flows result when more water leaves the land surface during storms or snowmelt, when less water is detained in wetlands and other off-channel areas, and when less water infiltrates into the ground. Decreases in baseflow result from reduced groundwater recharge that supplies streams and lakes during dry weather periods. Perennial streams may cease flowing during dry periods, with the attendant loss of fully aquatic species such as fish, mussels, and fully aquatic invertebrates. These impacts can begin to occur at relatively low levels of development and before water quality problems become apparent. By the time water quality impacts become plainly evident, the stream ecosystem has usually already been substantially degraded by hydrologic change.[12]

The effects of changing hydrology are less evident in most lakes, which are not as susceptible to rapid water level changes from an immediate in-lake biological standpoint. However, since many lakes are connected to streams, changing stream conditions can manifest themselves in the lakes they feed. For example, degraded streams commonly deliver greater overall masses of sediment and nutrients to the lakes they feed. Similarly, the streams may provide life-cycle critical ecological functions to the lake (e.g., spawning habitat for lake resident fish). Therefore, changes to the streams entering a lake can manifest into changes in the physical and ecological nature of the lake.

Much of the direct human impact to lakes is related to shoreline development. Developed shorelines typically suffer from of habitat types supporting lake health. Examples of shore area change related to development includes loss of trees, woody shrubs and attendant shading, loss of shoreline shrubs and nearshore aquatic plants, and installation of sandy beaches, seawalls, and piers. All of these changes can lessen the shorelines' ability to resist erosion, can reduce the capacity of buffers to cleanse runoff entering the lake, and compromises or eliminates habitat needed for desirable organisms such as fish. Changes in the near shore area can impact the lake's water quality, habitat, fish, the insects on which fish feed, and on top carnivores which feed on other fish. The cumulative effects of development on the shoreline can affect the ecology of the entire lake.

By recognizing these differences between lakes and streams, they are treated separately in this classification study.

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[12] *Dane County Regional Planning Commission,* Dane County Water Body Classification Study Phase 1, *March 2005.*

Chapter III

LAKE CLASSIFICATION

INTRODUCTION

The lake and stream classification system developed as part of this project creates an easy-to-use tool that allows lake and stream characteristics, opportunities, and threats to be considered when refining water resource management objectives and goals. Each waterbody is assigned to a specific lake and stream management category, and each category prescribes a range of approaches most suitable to the conditions present within each category's lakes and streams. In this way, the protocol recommends semi-customized approaches that are uniquely well suited to protect the current and future health of the diverse conditions in project-area lakes and streams (see Chapter IV for stream information). The lake and stream classification and management tool primarily uses existing natural resource databases, although the Southeastern Wisconsin Regional Planning Commission (SEWRPC) staff did measure the amount of impervious surface on lots and other development around project lakes specifically for this project. The resultant data set allows each water body's sensitivity to human influence to be estimated and the existing and projected future levels of human influence to be scored. These scores are then compared to help identify the relative vulnerability and pressure placed upon the County's unincorporated-area lakes.

An algorithm was developed that scored input data, generating sensitivity and human influence scores for each water body (see Appendix A for input data and information on the scoring process). Sensitivity and human influence scores were each separated into high, medium, and low score groups. Plotting sensitivity and human influence scores on an X-Y plot yields a three-by-three classification matrix. General management strategies for each category are developed (Table 5). This approach follows procedures prescribed in the *Wisconsin Administrative Code*,[1, 2] borrows from concepts developed by Wisconsin Lake Classification Advisory Committee and the Wiscon-

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[1] *Wisconsin Administrative Code Chapter NR 191,* Lake Protection and Classification Grants, *March 2014.*

[2] *Chapter NR 191 requires that lakes be grouped into management categories using the following factors: 1) the size, depth, and shape of the lake; 2) the size of the lake's watershed; 3) the quality of water in the lake; 4) the lake's current use, or potential for he lake to be over used, for recreation purposes; 5) the current patterns of development or the potential for the development of the land surrounding the lake; 6) the potential for the lake to suffer from nonpoint source water pollution; and, 7) the type and size of the fish and wildlife population and the extent of their habitats in and around the lake.*

Table 5

SUGGESTED CLASSIFICATION GROUPS AND MANAGEMENT STRATEGIES

Sensitivity to Development	Current Human Influence		
	Low Level	Medium Level	High Level
High Sensitivity	Protection (I)	Protection (I)	Protection and Restoration (II)
Medium Sensitivity	Protection (I)	Protection and Restoration (II)	Restoration and Enhancement (III)
Low Sensitivity	Protection and Restoration (II)	Restoration and Enhancement (III)	Restoration and Enhancement (III)

NOTES: Roman numeral designations I, II, and III refer to the assigned level of management classification. These categories do not assign certain water bodies higher quality or higher importance – water bodies assigned to the "Protection and Restoration" (yellow) and "Restoration and Enhancement" (red) categories should not be "written off". High value water bodies can be found in all management categories.

Source: Dane County Regional Planning Commission, Dane County Water Body Classification Study Phase I, *March 2007; and SEWRPC.*

sin Association of Lakes,[3] and is similar to that used by a few other Wisconsin counties.[4] The resultant management categories do *not* assign certain lakes higher quality or higher importance – lakes assigned to the Protection and Restoration (yellow) and Restoration and Enhancement (red) categories should not be "written off". Following this approach, the most appropriate management techniques to help protect lake health adapts to actual lake and watershed conditions.

Applying this approach, suggested management techniques may differ between water bodies. For example, preserving existing natural areas is highly recommended to protect high sensitivity/low human influence lakes (e.g., rural seepage lakes - upper left corner of Table 5). Conversely, for less sensitive lakes with high levels of human influence (such as intensively developed drainage lakes), management options focus on strategies that help curb and limit increased human pressure on the lake (e.g., lake and watershed protection) and, if possible, reduce human pressure on the lake and watershed by restoring or naturalizing key areas (i.e., enhancement). For example, naturalizing developed shorelines would be recommended, as well as protecting, enhancing, or actively managing remaining natural areas (lower right on Table 5).

DATA COLLECTION

Published natural resource and land use information was compiled to create databases useful to define in-lake and watershed sensitivity and in-lake and watershed human influence. Key sources of data were gathered from the following organizations:

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[3] *Lake Classification Advisory Committee,* A Guide for County Lake Classification, *June 1999; and, Wisconsin Association of Lakes,* County-Level Water Classification in Wisconsin: An Assessment, *June 2007, online, http://www.uwsp.edu/cnr-ap/UWEXLakes/Documents/ecology/shoreland/nr115/lake_classification_assessment_june_2007_wal.pdf*

[4] *Dane County Regional Planning Commission,* Dane County Water Body Classification Study Phase 1, *March 2005.*

- Wisconsin Department of Natural Resources (WDNR)
    - Surface Water Integrated Monitoring System (SWIMS)
    - Surface Water Data Viewer (SWDV)
    - Lake and AIS Mapping Tool
    - Water Condition Viewer
- U. S. Geologic Survey (USGS)
- Kenosha County Land and Water Resource Management Plans and GIS Website
- U.S. Department of Agriculture
- SEWRPC 2015 digital, color orthophotography and 2010 land use mapping

SEWRPC completed a custom land use survey, on-the-ground shoreline assessments, and an impervious surface/development setback analysis as an integral part of this study. Values were tallied, measured, and mapped by SEWRPC staff.

RANKING CRITERIA

Key sensitivity criteria (left side of the matrix) help determine and describe a water body's assimilative capacity (the ability to dilute, process, or flush pollutants downstream). Human influence criteria (horizontal scale along the top of the matrix) help quantify the amount of human activity and influence on a lake and its watershed. To avoid excessive and irrelevant scoring variation, focus was placed on identifying parameters that do not regularly and predictably fluctuate (e.g., water temperature). This helps reduce scoring process noise and lends greater robustness to the classification system. The following subsections describe sensitivity and human influence criteria used in the lake management scoring algorithm and describe basic rationale for inclusion in the scoring process.

Sensitivity Criteria

Natural Community

Different types of lakes have varying abilities to cope with nutrient loading. On account of this, the WDNR classifies lakes into several categories using factors such as lake surface area, depth, hydrology, and watershed size. Unique maximum acceptable total phosphorus concentrations are assigned to each lake category, standards which can be modified if a two-story fishery exists in a lake.[5] In general, shallow lakes are less sensitive to increased phosphorus loads than deep lakes, and lakes that have appreciable surface-water inflows are less sensitive to increased phosphorus inputs than lakes that rely primarily on groundwater for their water supplies. Overall, lakes with lower phosphorus standards are more sensitive to human disturbance.[6]

Natural community model results are used by regulators to assign acceptable nutrient levels in lakes, and are, therefore, a well-documented and accepted designation. For this reason, natural community models were given more weight in the scoring process. Lakes with two-story fisheries were given additional weight.[7]

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[5] *Two-story fisheries exist in warmwater fishery lakes. Such lakes are home a type of fish that requires well-oxygenated cold water to survive in the summer, water that commonly only occurs in deep water areas. In southern Wisconsin, the presence of ciscoes and sometimes trout is indicative of a two-story fishery.*

[6] *Additional information on lake natural community classifications and assignments may be found on the Wisconsin Department of Natural Resources website at the following link: http://dnr.wi.gov/topic/rivers/naturalcommunities.html#lakes*

[7] *Two-story fisheries are particularly prone to nutrient enrichment, since increased plant and algae growth can deplete oxygen in deep, cold portions of the lake which in turn can eliminate coldwater fish from the lake.*

Shallow Areas

For the purpose of this study, shallow areas were defined as the total acreage with water three feet deep or less. The area of each lake occupied by shallow areas was determined by examining existing bathymetric maps.[8] Shallow areas are more prone to human-induced bottom agitation and sediment resuspension, plant uprooting, fish disturbance, and other disruption. Such disturbance can diminish water clarity and quality, favor conditions that encourage spread of invasive plants, and impede fish reproduction and survival. Shallow lakes are also more susceptible to winterkill, because they have less water volume to store oxygen and tend to be more productive, causing them to have higher oxygen-consumption rates. Therefore, lakes with high proportions of their total areas occupied by shallow areas were considered more sensitive to human disturbance.

Potential for Internal Phosphorus Loading

Many lakes that seasonally stratify develop low oxygen concentrations in deep areas. Low oxygen water catalyzes geochemical reactions in lake-bottom sediment that release otherwise insoluble phosphorus into the water column. This process is called "internal loading". Internal loading can be a significant component of the total phosphorus available to algae in lakes. This process is only significant in lakes classified as "deep" using the WDNR's natural community type tool. Internal loading is generally most significant in smaller nutrient-rich lakes with broad expanses of lake-bottom deeper than 15 or 20 feet. Lakes with broad deep water areas accentuate sensitivity to human-induced phosphorus loads, and therefore are more sensitive.

Shoreline Development Factor

Lakes have infinitely variable shapes. Some lakes are nearly circular while others have intricate shorelines with many irregularly shaped bays and peninsulas. *Shoreline development factor* is a calculated numerical score that expresses the shape of a lake. It is determined by forming a ratio of a lake's total shoreline length divided by the area of a circle with equivalent area. A value of 1.0 signifies a perfectly circular lake, with higher numbers associated with lakes with irregular shapes. Lakes with irregular shapes have a tendency to have more shoreline per acre of open water, and hence have the potential for more lots (potential urban development) for a given size lake. Therefore, lakes with a higher shoreline development factors are considered more sensitive.

Water Clarity

Water clarity, or transparency, is a commonly used indicator of lake water quality, and is often correlated with algal abundance or sediment-derived turbidity. Water clarity for this project was estimated by satellite-derived measurements.[9] Decreased water clarity can disrupt a lake's aquatic plant community and potentially reduce its ability to assimilate nutrients, which in turn creates a self-reinforcing loop further decreasing water clarity. Lakes with higher water clarity tend to be less nutrient rich and are more sensitive as they are more susceptible to changes in both the watershed and the lake.

Stormwater Processing

Runoff leaves the landscape and enters lakes, bringing with it sediment, nutrients, and other pollutants. Wetlands and floodplains capture and detain stormwater pollutants, and can help slow runoff, all of which can improve lake water quality. SEWRPC staff determined the percentage of each lake's watershed occupied by floodplain and wetland areas. Lakes with higher percentages of their watersheds occupied by floodplains and wetlands were considered less sensitive.

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[8] *Three foot depth contours were not available for Montgomery Lake; instead its shallow areas were defined as waters four feet deep or less.*

[9] *Satellite-derived water clarity measurements are available using the WDNR's Lakes and Aquatic Invasive Species Mapping Tool, which can be accessed at the following website: http://dnr.wi.gov/lakes/viewer/*

Groundwater Recharge

Groundwater recharge refers to that portion of precipitation that filters through soil and reaches the water table. Groundwater recharge often sustains lakes, streams, and wetlands (especially during dry periods), as well as provides water to important water-supply aquifers. As water moves through soil, sediment, nutrients, and other pollutants are removed, and the water is cooled. The amount of precipitation that becomes groundwater recharge depends mainly on the permeability and slope of the land surface. Human influence generally decreases groundwater recharge, increasing the volume and speed of stormwater runoff.

As part of its regional water supply planning program, SEWRPC collaborated with the U.S. Geological Survey to estimate groundwater recharge potential for the study area using a soil-water balance model.[10] Areas were identified to have low, medium, high, or very high groundwater recharge potential. Lakes with watersheds occupied by large areas of very high and high groundwater recharge potential produce less runoff and generally have higher groundwater contributions. The percentage of each lake's watershed with low, moderate, high, and very high groundwater recharge potential was determined. Lakes with watersheds occupied by high percentages of high and very high groundwater recharge potential were considered less sensitive than lakes with high percentages of watershed underlain by low or moderate groundwater recharge potential.

Human Influence Criteria

Unprotected Shoreline

This parameter references length of shoreline prone to artificially high erosion rates. Such areas are not protected by in-lake vegetation (e.g., cattails, bulrush, water lilies, and thick beds of aquatic plants), man-made or natural buffers, or engineered shoreline protection elements (e.g., bulkheads, revetments, rip-rap). A lake with a higher percentage of unprotected shoreline has a larger potential for significant shoreline erosion. Such lakes were assigned higher human influence scores.

External Sediment Loading

External sediment loading refers to solids entering a lake from upland areas throughout the lake's watershed. Human activities (especially agriculture and urban land use) greatly increase sediment loads to lakes. External sediment loads decrease water clarity, increase siltation of the lake bottom, and commonly carry heavy loads of plant nutrients (e.g., phosphorus) and pollutants (e.g., heavy metals, pesticides). This can foster nuisance-level aquatic plant growth and/or algal blooms which can generate organic toxins. Commission staff estimated sediment loading using the unit area load-based (UAL) model and SEWRPC land use data. Lakes with higher sediment loading were assigned higher human influence scores.

Public Boat Launches

The presence of public boat launches suggests more intensive and transient use of the lake. This can lead to recreational use conflicts, and contribute to ecological problems (e.g., erosion, turbidity, plant fragmentations, and introduction of non-native species). Lakes with boat access points were assigned a higher human influence ranking.

Buffer

Buffer refers to portions of a lake's shoreline with significant vegetation beginning at the shoreline and extending landward from the water's edge. Shorelines in their natural state are generally considered to be well buffered. Buffers help mitigate the effects of human influence, as these areas slow and detain runoff, as well as reduce and filter pollutants and nutrients from runoff water before it reaches a lake. Buffer areas also provide important breeding, refuge, and feeding area for aquatic and terrestrial animals. Lakes with higher percentages of buffered shoreline

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10 *SEWRPC Technical Report Number 47,* Groundwater Recharge in Southeastern Wisconsin Estimated by a GIS-Based Water Balance Model, *July 2008.*

were assigned lower human influence scores. The quality of buffer areas was estimated using direct observations collected by SEWRPC staff as part of this study.[11] The buffer scoring process considered the quality and density of vegetation. Areas with robust vegetation were considered less influenced by human activity.

Impervious Surface

Impervious surfaces are areas covered by artificial land covers that impede or prevent precipitation and snow melt from soaking into the ground. Such surfaces speed runoff, increase total runoff volume, contribute to higher flood flows and elevations, diminish dry weather flow, and generally negatively influence water quality. Studies show that increasing impervious surface area is directly related to the degradation of aquatic communities.[12] Lakes receiving runoff from areas of higher average imperviousness were considered to have a higher human influence ranking. Imperviousness was subdivided into two categories:

Shoreline

Impervious surfaces on the shoreline refer to the amount of nonporous land cover on each shoreline lot. The percentage of lot imperviousness was calculated using digital color orthophotography. The percent imperviousness was calculated for each lot. Average lot imperviousness was then calculated for each lake.

Watershed

Impervious surfaces in the watershed refer to the amount of nonporous land cover throughout the uplands. Watershed imperiousness was calculated using SEWRPC 2010 land use data and estimates of typical imperviousness for various land use types. In general, more highly developed watersheds were given higher human influence scores.

Number of Lots per Mile of Shoreline

More lots per unit length of shoreline equates to narrower lots. Narrower lots are generally related to more homes and more people per mile of shoreline. Greater human population generally equates to more human activity on a lake shoreland, and greater human influence.

OTHER CRITERIA NOT USED

Many other sensitivity and human influence criteria could be considered to classify lakes. However, many were either incorporated into other factors, could not be adequately characterized due to incomplete coverage or data sets, were highly autocorrelated with other variables (i.e., not independent) which could skew a classification system, and/or were not believed to add significant value to the analysis. Examples of individual sensitivity parameters not used in this classification system include: lake depth to volume ratio, stratification factor, trophic state index, photic zone, volume, maximum depth, critical species, watershed area, hydrologic soil group, soil erodibility, septic suitability, environmental corridors, and historic urban growth. It should be noted that while these factors were not included individually, many of these factors are included as components of the elements actually used for this study. Examples of human influence parameters not included are: parcel lake frontage, boat use, maximum optimal boat density, changes in trophic state index, water quality-chloride, point and nonpoint pollution sources, nonpoint source rating, algal blooms, aquatic invasive species, constructed shoreline protection, portion of shoreline eroding, population, land use, zoning, and protected areas.

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[11] *The data for the buffer parameter are derived from the shoreline assessment surveys done as part of this project. Appendix B explains what the shoreline assessment is and illustrates the survey for each lake. Further discussion on robust and sparse shoreline protection can also be found in Appendix B.*

[12] *Arnold, C., and C.J. Gibbons,* Impervious Surface Coverage. The Emergence of a Key Environmental Indicator, *Journal of the American Planning Association 62(2):243-258, 1996; and, Schueler, T. 1994. The Importance of Imperviousness. Watershed Protection Techniques 1:100-111.*

CONVERTING RAW DATA TO SCORES

Appendix A summarizes measured natural resource values used to ascertain relative sensitivity and human influence for each lake included in the Kenosha County Lake Classification project.[13] The resultant range of individual parameter values were studied to assign relative scores to allow lakes with very different characteristics to be compared. Scores for each variable considered the range of values in the project area and assume that values are normally distributed. The lowest range values were assigned a low numerical score (i.e., typically between one and two), while the upper range scores were typically assigned scores of four or five. Intermediate values were typically scored between two and four. Weights were applied to the scores to either suppress overexpressed variables or emphasize certain factors.

Table 6

LAKE CLASSIFICATION CATEGORY BREAKPOINTS

Rating	Sensitivity Scores	Human Influence Scores
Low (Level I)	< 22	< 22
Medium (Level II)	22 – 28	22 – 28
High (Level III)	> 28	> 28

Source: SEWRPC.

A formula was developed to form a single composite score for both sensitivity and human influence values. The formula uses the numerical individual element scores described in the preceding paragraph. The formula normalizes scores for differing lake areas, and gives higher weight to watershed-based variables for lakes that have greater watershed area to lake surface area ratios. The formula assigns the most sensitive lakes the highest sensitivity numerical scores, and the lakes most influenced by humans are assigned the highest human influence numerical scores. Ranking brackets, weights, formulas, and resultant scores are described in Appendix A.

LAKE CLASSIFICATION

The composite numerical scores from Appendix A were plotted with sensitivity on the vertical axis and human influence on the horizontal axis as shown on Figure 5. In addition, the suggested lake classification strategies and breakpoints illustrated by Tables 5 and 6, respectively, were superimposed upon the plotted scores to generate a three-by-three matrix in Figure 5.

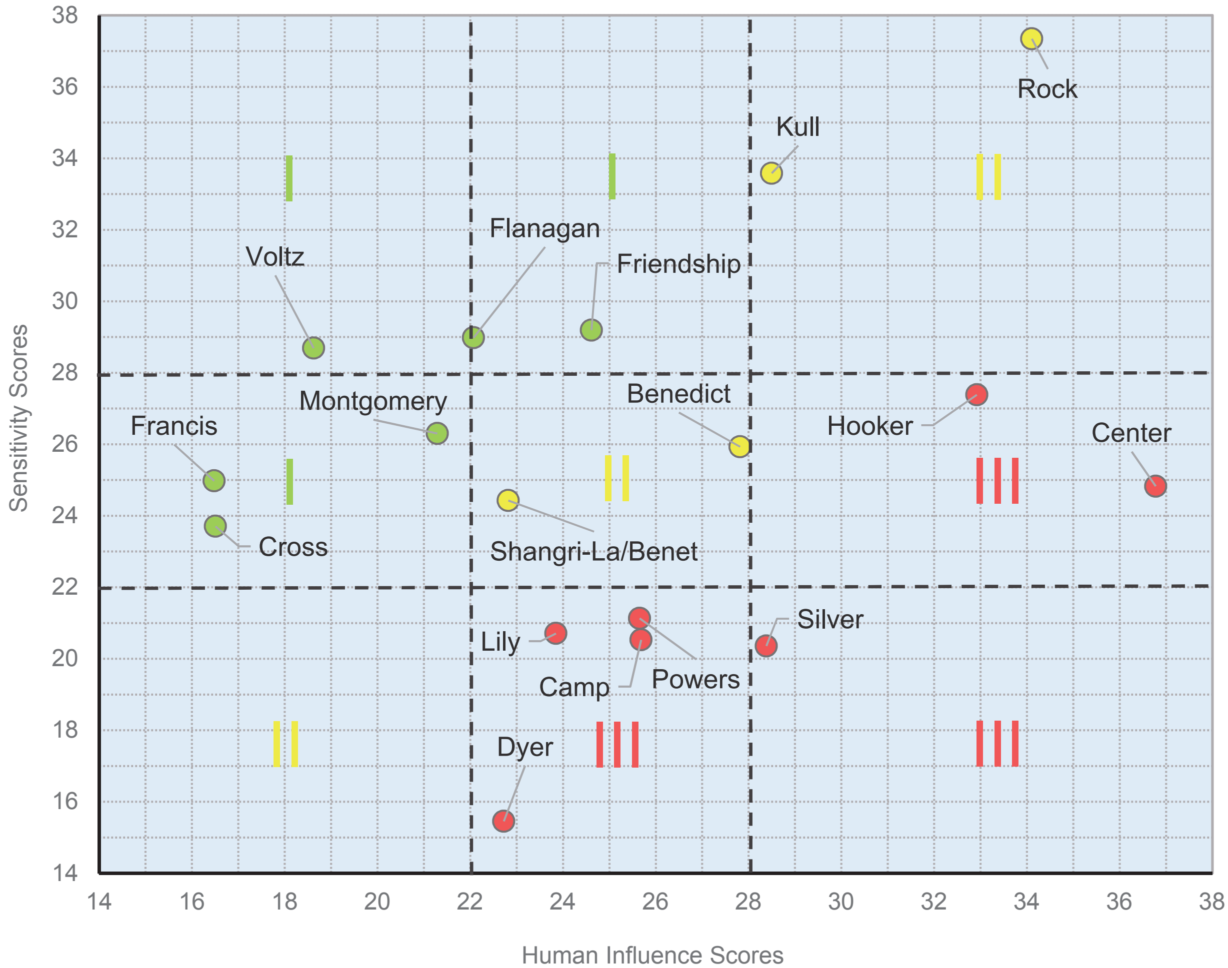
This results in a suggested management strategy for each lake.

- **Class I – Protection** (Cross, Flanagan, Francis, Friendship, Montgomery, and Voltz)
- **Class II – Combined Protection and Restoration** (Benedict, Kull, Rock, and Shangri-La/Benet)
- **Class III – Restoration and Enhancement** (Camp, Center, Dyer, Hooker, Lily, Powers, and Silver)

[13] *The Town of Salem merged with the Village of Silver Lake and officially became the Village of Salem Lakes in February 2017. Therefore, the following lakes or portions of lakes are no longer located in the unincorporated areas of Kenosha County and are no longer under the zoning jurisdiction of Kenosha County: Camp, Center, Cross, Hooker, Montgomery, Rock, Shangri-La/Bennet, Silver, and Voltz Lakes. The Village of Salem Lakes is currently in the process of adopting Chapter 12 General Zoning and Shoreland/Floodplain Ordinance and has contracted with the Kenosha County Division of Planning and Development for the continued administration and regulation of this ordinance.*

Figure 5

LAKE CLASSIFICATION SCORING MATRIX AND MANAGEMENT STRATEGY ASSIGNMENTS FOR SELECTED KENOSHA COUNTY LAKES



Note: Three lake classes and associated management strategies are identified with a Roman numeral in each box:

- Level I – Protection
- Level II – Combined Protection and Restoration
- Level III – Restoration and Enhancement

Source: SEWRPC.

The resultant scores and management strategy for each lake are summarized in Table 7 and graphically illustrated on Map 2. *The resultant management categories do not assign higher quality or higher importance to certain lakes – lakes assigned to the yellow and red categories should not be "written off"*. Following this approach, the most appropriate management techniques to help protect lake health adapts to actual lake and watershed conditions. More detail regarding management strategies is provided in Chapter VI.

Table 7

SUMMARY OF LAKE SENSITIVITY, HUMAN INFLUENCE, AND MANAGEMENT STRATEGY ASSIGNMENTS

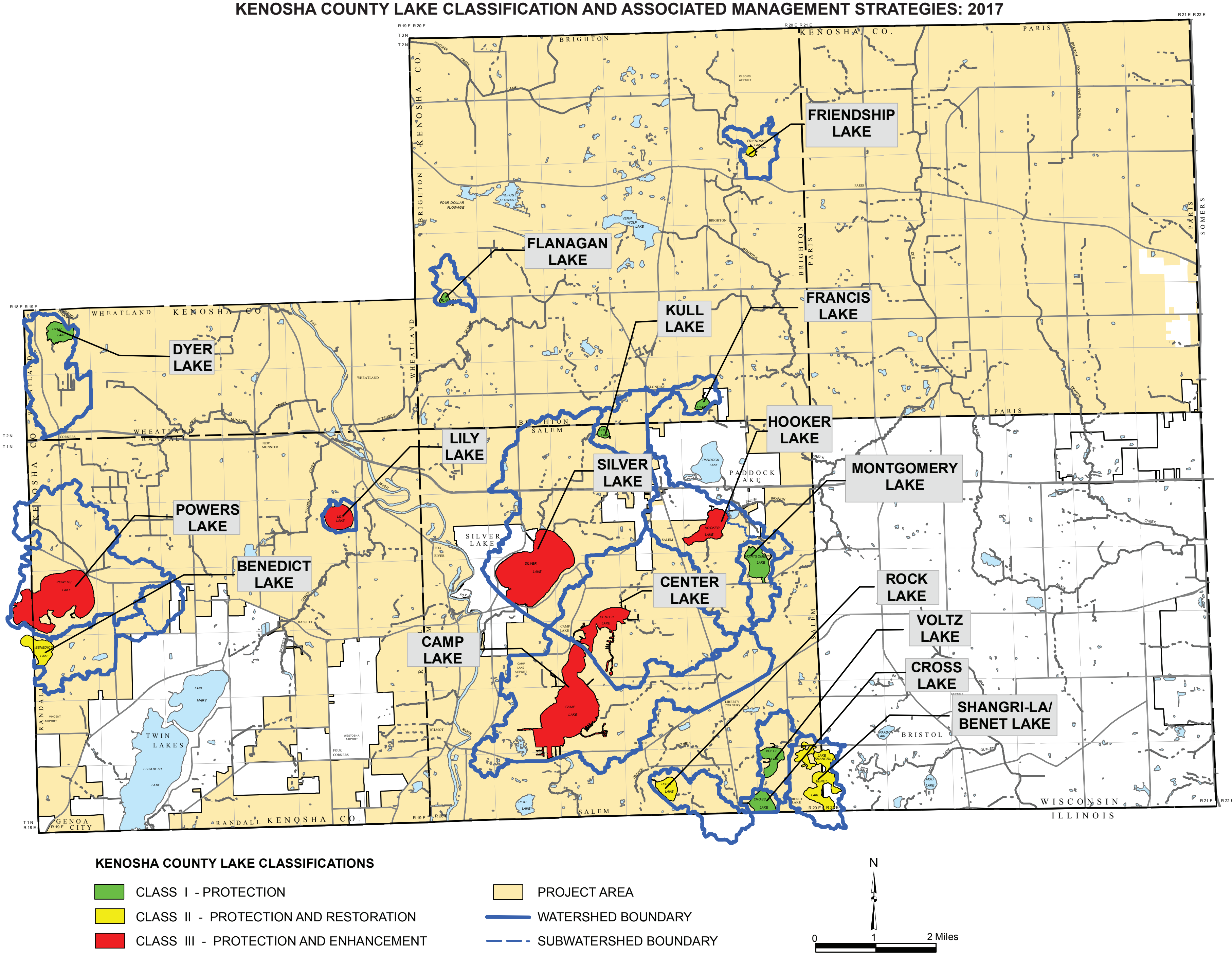
Lake	Sensitivity Classification	Human Influence Classification	Management Strategies	
			Classification	Objective
Benedict	Medium	Medium	II	Combined Protection and Restoration
Camp	Low	Medium	III	Restoration and Enhancement
Center	Medium	High	III	Restoration and Enhancement
Cross	Medium	Low	I	Protection Measures Preferred
Dyer	Low	Medium	III	Restoration and Enhancement
Flanagan	High	Medium	I	Protection Measures Preferred
Francis	Medium	Low	I	Protection Measures Preferred
Friendship	High	Medium	I	Protection Measures Preferred
Hooker	Medium	High	III	Restoration and Enhancement
Kull	High	High	II	Combined Protection and Restoration
Lily	Low	Medium	III	Restoration and Enhancement
Montgomery	Medium	Low	I	Protection Measures Preferred
Powers	Low	Medium	III	Restoration and Enhancement
Rock	High	High	II	Combined Protection and Restoration
Shangri-La/ Benet	Medium	Medium	II	Combined Protection and Restoration
Silver	Low	High	III	Restoration and Enhancement
Voltz	High	Low	I	Protection Measures Preferred

NOTE: The lake classes and associated management strategy categories do not assign certain lakes higher quality or higher importance – lakes assigned to the "Protection and Restoration" (yellow) and "Restoration and Enhancement" (red) categories should not be "written off". High value lakes are found in all management categories.

Source: SEWRPC.

Map 2

KENOSHA COUNTY LAKE CLASSIFICATION AND ASSOCIATED MANAGEMENT STRATEGIES: 2017



Source: Wisconsin Department of Natural Resource and SEWRPC.

Chapter IV

STREAM CLASSIFICATION

INTRODUCTION

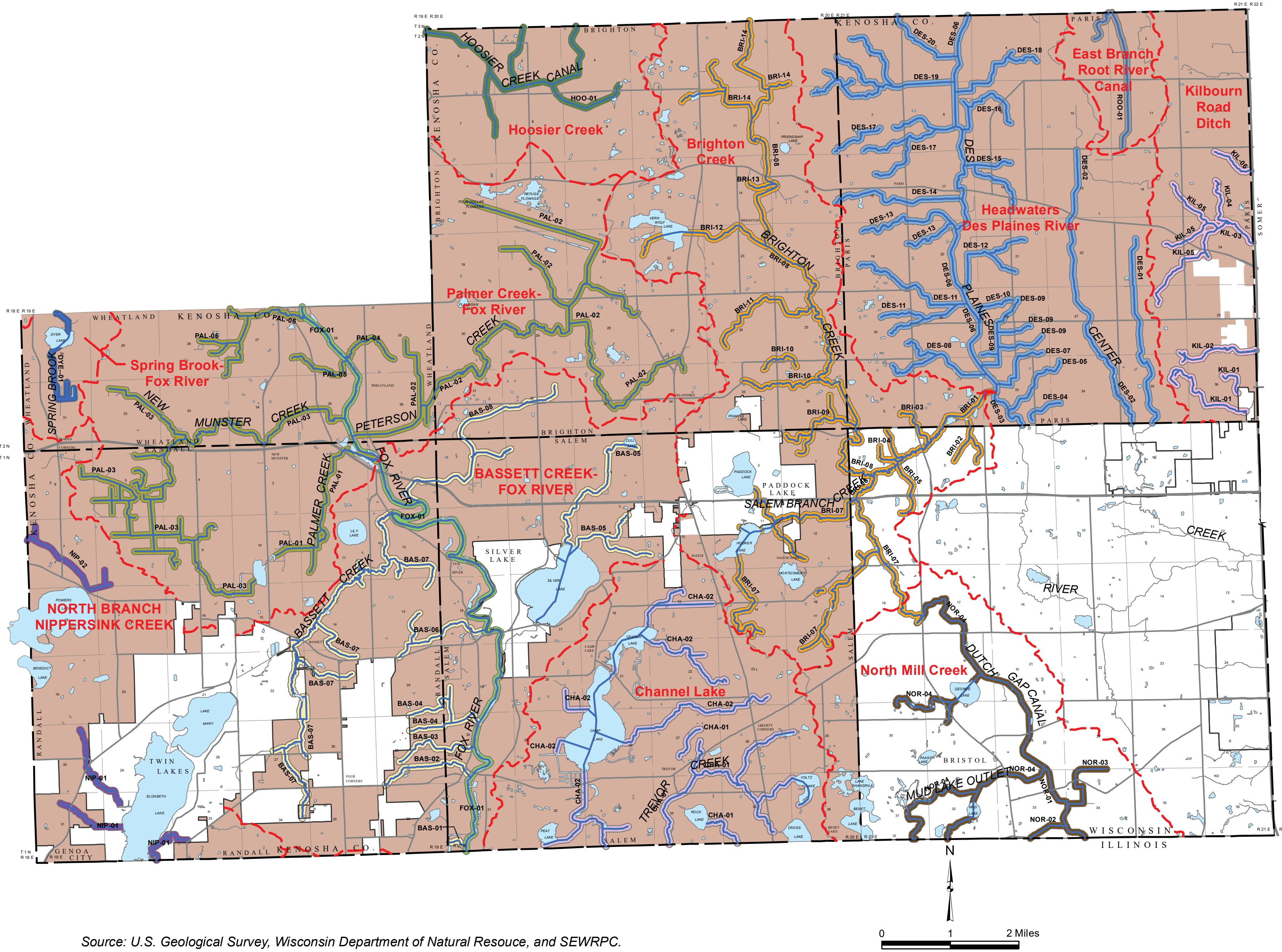
The characteristics of mapped streams were examined throughout the unincorporated portions of Kenosha County. The project area was divided into watersheds using hydrologic unit code 12-digit (HUC-12) boundaries established by the U.S. Geological Survey (see Maps 1 and 3). This helps allow this project to use data sets reported at the HUC-12 watershed level, and provides a convenient method to organize study results. Users of this report should note that multiple named streams occur within many HUC-12 areas, yet many of the HUC-12 watershed borrow the name of only one of the named streams within the subject area. Therefore, one must not confuse the HUC-12 watershed name with the individual stream names. Many of the commonly used stream names within the project area are included in Map 3. Nevertheless, most stream reaches remain unnamed.

The procedure used to identify and manage stream descriptive data is similar to that that used in Chapter III to classify lakes. However, some data sets are unique to streams, while certain lake data sets are irrelevant to streams. Similar to the lake classification effort, this process provides a two-tiered approach accounting for a water body's sensitivity to development as well as the current level of human influence. Data was assembled that helps quantify a variety of factors related to water body sensitivity and human influence. An algorithm combines component scores. These scores are examined to generate three groups of values per axis: high/medium/low sensitivity to development and high/medium/low current human influence. Appendix C describes the data, scoring process, and formulas used to derive these scores. Table 8 presents the breakpoints used to segregates scores into the three categories. The resultant scores and categories allow each stream reach's sensitivity to human influence and the existing and projected future levels of human influence to be compared and contrasted, which in turn helps quantify the relative vulnerability and anthropogenic pressure placed upon each project-area stream reach.

Stream sensitivity and human influence factors are jointly considered to suggest management approaches. The resulting three-by-three classification matrix identifies general management strategies for each category as shown in Table 5. These categories do *not* assign certain stream higher quality or higher importance – *streams assigned to the "Protection and Restoration" (yellow) and "Restoration and Enhancement" (red) categories should not be "written off"*. High value streams can be found in all management categories. Following this approach, the most appropriate management techniques to help protect stream health adapt to actual stream and watershed conditions. For example, the preferred methods to protect highly sensitive/low human influence streams (e.g., rural, cold, headwater streams - upper left corner of Table 5) is preservation of existing natural areas. For less sensitive streams with higher levels of human influence such as intensively developed urbanized streams and watersheds (lower right corner of Table 5), management options usually focus on strategies that help limit increased human pressure on the stream bed, bank, ecology, and water quality. In addition, where practicable, restoring or naturalizing key areas (enhancement) is also promoted to reduce human pressure on less sensitive more urbanized streams and their watersheds.

Map 3

DESIGNATED STREAM REACHES AND NAMES AMONG WATERSHEDS WITHIN KENOSHA COUNTY



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

Examples of techniques to achieve this goal includes restoring developed streambank areas to a more natural condition (e.g., installing buffers), naturalizing human-manipulated stream form and function to increase longitudinal and lateral hydrologic and ecologic connectivity, and enhancing or actively protecting remaining existing natural areas.

DATA COLLECTION

Southeastern Wisconsin Regional Planning Commission (SEWRPC) staff compiled relevant stream and watershed data to create a database on sensitivity and a database on human influence. This primarily relied on using existing data published by various government agencies. Key sources of published data included:

- Wisconsin Department of Natural Resources (WDNR)
  - Surface Water Integrated Monitoring System (SWIMS)
  - Surface Water Data Viewer (SWDV)
  - Water Condition Viewer
- U. S. Geological Survey
- Wisconsin Geological and Natural History Survey
- University Extension-University of Wisconsin
- U. S. Department of Agriculture
- Kenosha Land and Water Resource Management Plans and GIS website
- SEWRPC digital, color orthophotography and land use mapping

METHODOLOGY

HUC-12 watersheds are considered to be local-scale features – approximately 90,000 HUC-12 watersheds are found in the conterminous United States. Much of the available stream-related data is reported by HUC-12, which helps assign such data to individual stream reaches. The eleven HUC-12 watersheds were subdivided into stream reaches using the Strahler stream order system to provide finer detail.[1] First and second order tributary reaches were considered jointly, third and fourth order streams were also considered jointly, while the single fifth order stream (the Fox River) was considered separately. Since most of the project streams are unnamed, all project streams reaches were assigned an identification number. Sixty-six individually scored stream reaches were scored as part of this project. Map 3 illustrates the locations and labels for all the stream reaches examined as part of this study.

SCORING VARIABLES

Sensitivity criteria help estimate a water body's assimilative capacity (the ability to dilute, process, or flush pollutants downstream). Human influence criteria help express the amount of human activity and influence on a stream and its watershed. To avoid excessive and irrelevant score variation, focus was directed to identify parameters that do not regularly and predictably fluctuate (e.g., water temperature). This helps reduce scoring process noise and

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[1] *Stream order is a system where headwater stream are assigned an order of one. When two first order streams merge, the combined stream order is two. When two second order streams converge, a third order stream is created. More information about this system can be found at the following website:* http://usgs-mrs.cr.usgs.gov/NHDHelp/WebHelp/NHD_Help/Introduction_to_the_NHD/Feature_Attribution/Stream_Order.htm

lends greater robustness to the classification system. In addition, most project streams were small unnamed headwater reaches with poorly delineated catchments and little specific data. Therefore, the available land use information at the larger HUC-12 watershed scale was used to approximate average conditions of some parameters for all stream reaches within that HUC-12. This was done for the Stormwater Processing variable within the Sensitive Criteria scoring as well as the Watershed Impervious Surface, Pollutant Load Priority, and Index of Biological Integrity variables with the Human Influence Criteria scoring.

The following subsections briefly describe criteria used in the stream management scoring algorithm and give basic rationale for inclusion. Additional details about input data, scoring criterion, the scoring process, and result and values can be found in Appendix C.

Sensitivity Criteria

Stream Order

Strahler stream order expresses the size and position of a stream within a watershed. First-order streams are small headwater segments with no tributaries, and collect water from diffuse runoff, seepage, or single point sources. Second-order streams are formed where two first-order streams converge, third-order streams are formed where two second-order streams converge, and so on. Small headwater streams are generally more sensitive to human influence in the immediate area. A few examples of why low order streams are more sensitive include: they tend to be smaller and more prone to habitat fragmentation, they are often highly dependent on local groundwater systems for dry-weather flow, they have colder water with lower nutrient and sediment loads in their unaltered state, and they commonly have more sensitive aquatic communities.

Natural Communities

The WDNR developed a stream model to classify stream reaches by aquatic community. This tool considers probable fish occurrence and abundance, as well as the ecological conditions that largely determine the biotic community (i.e., stream flow and water temperature).[2] Although models always have some limitations, it does provide an objective, standardized, and ecologically meaningful framework to classify streams.[3] The natural community classification identifies 11 natural community classes and combinations of macroinvertebrate, cold water, cool water, and warm water, as well as intermittent, headwater, and mainstem designations, all of which have unique physical and biological characteristics.[4] For the purpose of the stream classification study, headwater and colder streams were considered more sensitive, due to limited flow volumes and reach lengths. On the other end of the spectrum, warm mainstem streams were considered least sensitive, due to larger flow volumes and access to variety of refuge and habitat areas.

Geology

The gradation, structure, and layering of sediment underlying a particular location directly affects the area's hydrology. The more porous the watershed's underlying sediment, the more precipitation that can infiltrate the soil and recharge groundwater. More infiltration translates to reduced stormwater runoff volume and intensity, increased dry-weather stream flow, and less severe temperature extremes. Landscapes underlain with thick layers of sand and

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[2] *John Lyons,* "Patterns in the species composition of fish assemblages among Wisconsin streams," Environmental Biology of Fishes *Volume 45, 1996, pages 329-341*.

[3] *John Lyons,* "Wisconsin Department of Natural Resources, An Overview of the Wisconsin Stream Model," *January 2007.*

[4] *John Lyons,* "Proposed temperature and flow criteria for natural communities for flowing waters," *February 2008, updated October 2012.*

gravel are considered the least sensitive because they have the greatest ability to infiltrate precipitation and recharge and store groundwater. Conversely, landscapes underlain by thick layers of clay and silt are considered the most sensitive. Partial ranking were applied, due to combinations of different soil types and sediment depths within the same reach watershed, as appropriate.

Rare Species/ Trout Stream
The presence of rare species or trout strongly suggests that a stream is providing uncommon habitat. Stream habitat degradation would likely harm such species. Therefore, streams with more rare species were designated as more sensitive. Trout streams were designated as the most sensitive, because there is only one remaining documented trout stream in Kenosha County.

Table 8

STREAM CLASSIFICATION CATEGORY BREAKPOINTS

Rating	Sensitivity	Human Influence
Low (Level I)	< 17	< 6.5
Medium (Level II)	17-35	6.5 – 12.5
High (Level III)	> 35	> 12.5

Source: SEWRPC.

Stormwater Processing
Runoff leaves the landscape and enters streams, bringing with it sediment, nutrients, and other pollutants. Wetlands and floodplains help capture and detain stormwater pollutants and can help slow runoff, improving the quality of water entering water bodies. SEWRPC determined the percentage of each stream's watershed consisting of wetland areas. Streams with higher percentages of their watershed occupied by wetlands were considered less sensitive.

Human Influence Criteria
Most of the available human influence data is reported at the each HUC-12 watershed scale, and therefore do not allow small stream reaches to be differentiated. By reviewing aerial photography, SEWRPC staff estimated the degree of channel modification for each stream reach. Functionally, this means that all of the reaches in a HUC-12 watershed use the same basic scores and reach-scale variation is largely defined by the channel modification.

Watershed Impervious Surface
Impervious surfaces are areas covered by artificial land covers that impede or prevent precipitation and snow melt from soaking into the ground. Such surfaces speed runoff, increase total runoff volume, contribute to higher flood flows and elevations, diminish dry-weather flow, and generally negatively influence water quality. Studies show that increasing impervious surface area are directly related to the degradation of aquatic communities.[5]

The amount of impervious surface directly connected to water bodies was estimated using 2010 land use (i.e., existing conditions) and year 2035 planned land use (i.e., future conditions) for each HUC-12 watershed. The estimated percent connected impervious surface for each type of land use was calculated, and the sum of all land use impervious surface estimates yielded overall HUC-12 impervious area. The total connected impervious scoring process considered both 2010 and 2035 land use data. However, 2035 land use was weighted more heavily to account for controllable change.

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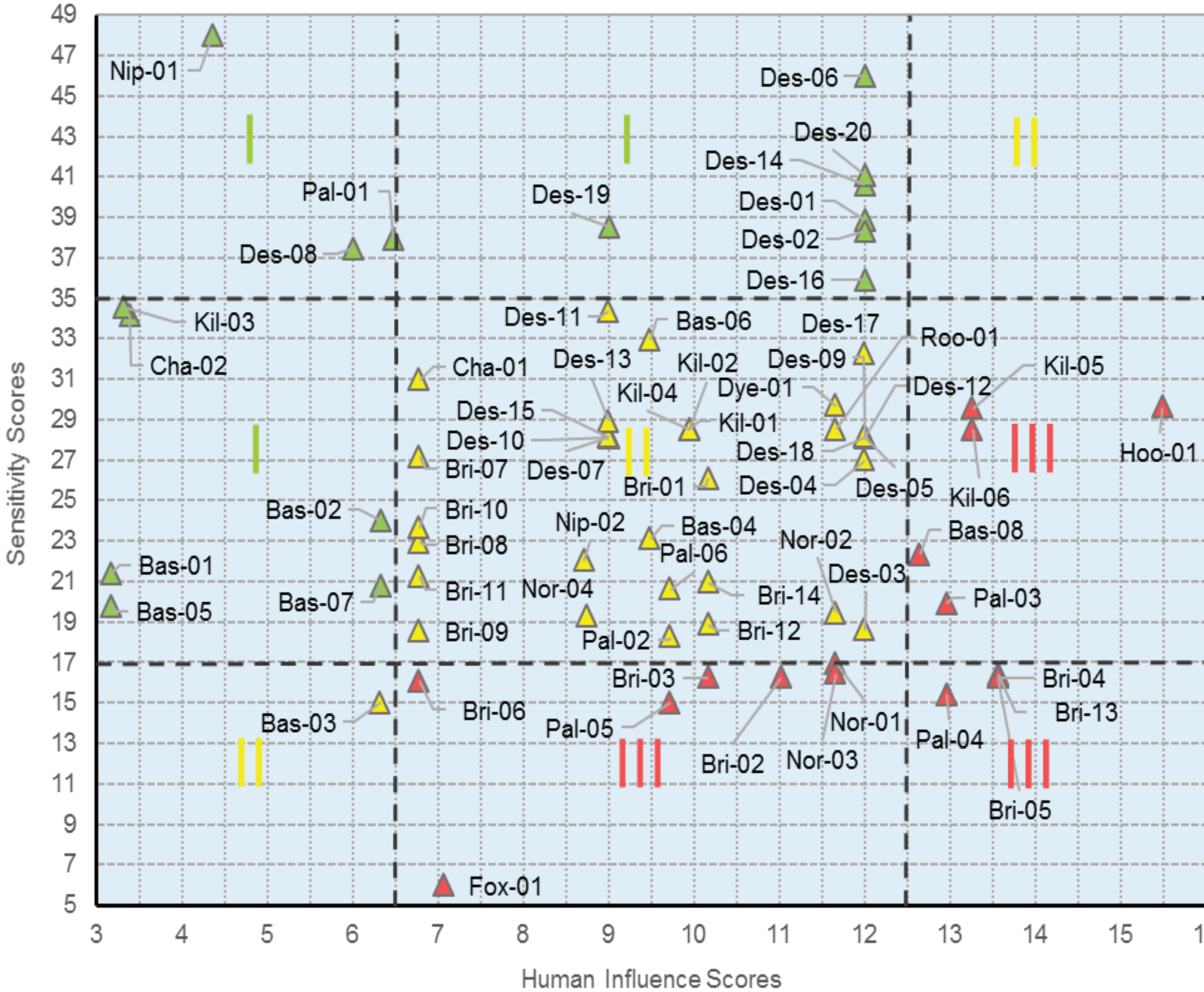
[5] Arno*ld, C., and C.J. Gibbons, Impervious Surface Coverage. The Emergence of a Key Environmental Indicator, Journal of the American Planning Association 62(2):243-258, 1996; and, Schueler, T. 1994. The Importance of Imperviousness. Watershed Protection Techniques 1:100-111.*

Figure 6

CLASSIFICATION SCORING MATRIX AND MANAGEMENT STRATEGY ASSIGNMENTS AMONG SELECTED KENOSHA COUNTY STREAMS



Note: Three stream classes and associated management strategies are identified with a Roman numeral in each box:

- Level I – Protection Measures Preferred
- Level II – Combined Protection and Restoration
- Level III – Restoration and Enhancement

Source: SEWRPC.

Pollutant Load Priority

Streams designated in the 2017 to 2026 Kenosha Land and Water Resource Management Plan[6] as having pollutant load priorities were singled out as a proxy for water quality. In Wisconsin, phosphorus typically has the greatest impact on overall water quality and ecological health. Excess nitrogen and sediment are also common pollutants in Wisconsin streams. Streams with more than one priority were considered to have more human influence.

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[6] *Kenosha County Department of Public Works and Development Services Division of Planning and Development, A Land and Water Resource Management Plan for Kenosha County: 2017-2026, February 2016.*

Index of Biotic Integrity

The index of biotic integrity (IBI) is a measure of overall ecological health of a stream reach based upon organisms actually found in the sampled reach. IBI combines elements such as species diversity, abundance, tolerance (ability of a species to tolerate pollution), and feeding class (e.g., shredders, collectors, and scrapers). The Hilsenhoff Biological Index and the Macroinvertebrate Index of Biological Integrity were considered together to help fill data gaps and provide an overall score. Low IBI values were given the highest human influence scores since low IBI scores suggest excessive human-sourced sediment, high temperatures and other water quality/quantity issues, and/or pollutants. Note that fisheries IBI scores were not used as part of this variable because this was captured as part of the Natural Community element of the sensitivity criteria.

Channel Modification

Humans commonly straighten, deepen, line, and bury streams in pipes to speed runoff, dry wet areas, and increase the amount of useable land area. Such activities shorten streams, which in turn makes them steeper, removes coarse streambed material, and alters streamside vegetation, all of which help protect the stream's bed and banks from eroding. Ditching or channelization generally decrease a stream's ability to detain and cleanse floodwater, which increases downstream flooding and decreases downstream water quality; and commonly diminishes the ecological benefits provided by a stream. Streams that have greater lengths/proportions of ditched, straightened, lined, or buried channel were assigned higher human influence scores.

OTHER CRITERIA NOT USED

Other sensitivity and human influence criteria were considered, but excluded from the classification system due to redundancy as an indicator, coarse resolution, or to incomplete data availability. Sensitivity parameters not used in the classification system include watershed health assessment, fish diversity, endangered species, watershed area, and environmental corridors. Human influence parameters not used included land use, fish biological index, impaired status, species richness, genera richness, family level biotic index, water quality-chloride, non-point source polluters, point source polluters, aquatic invasive species, and protected areas.

BREAKPOINTS AND CLASSIFICATION

The resulting sensitivity and human influence scores for each stream were plotted and examined. Break point scores were assigned to segregate about 25 percent of the scores in the "low" range, 25 percent in the "high" range, with the remaining 50 percent relegated to "medium" scores. Breakpoint values are summarized in Table 8.

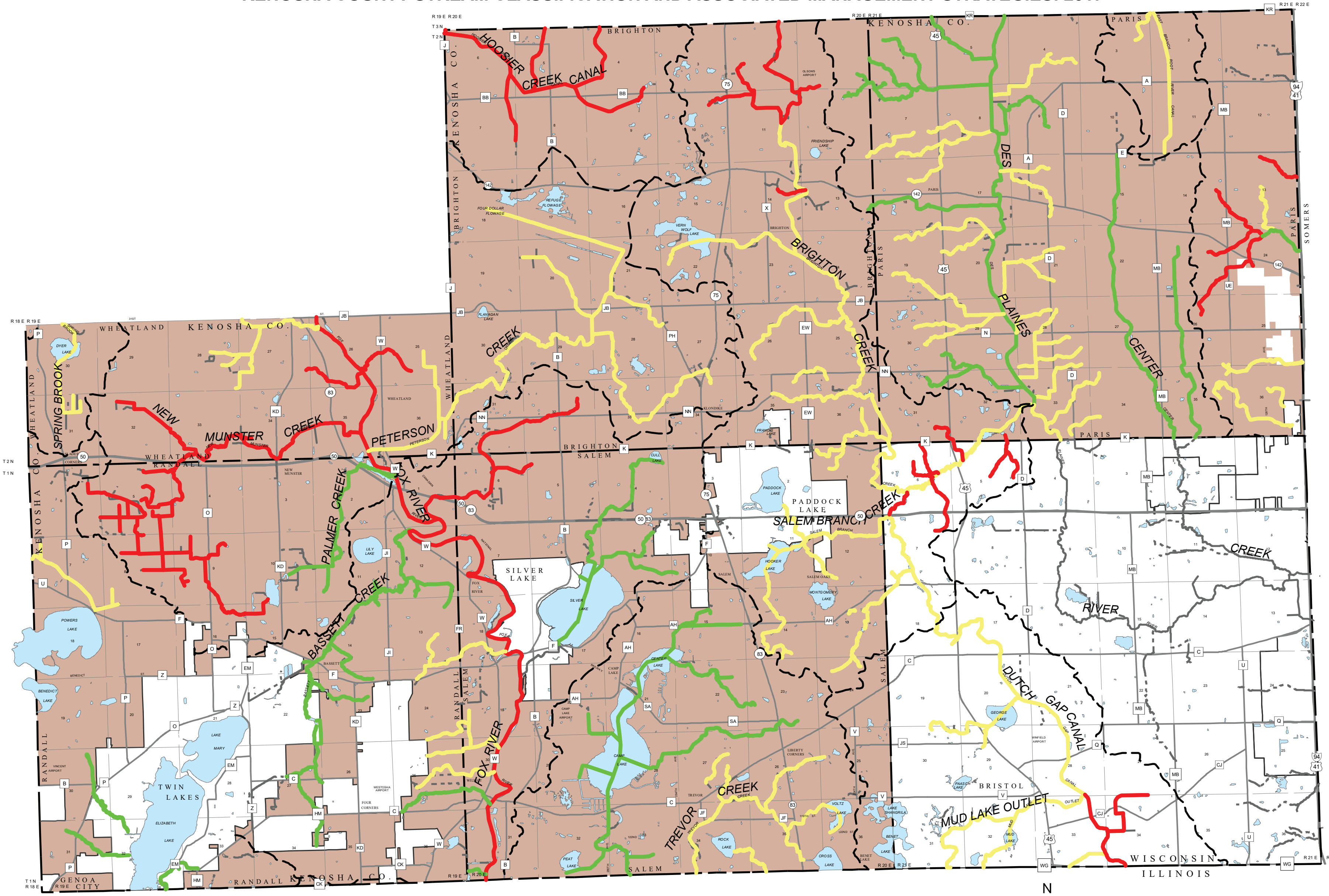
MANAGEMENT STRATEGY ASSIGNMENT

The sensitivity and human influence scores were considered together to assign management strategy categories. The management strategy categories follow the principles used in lake classification (see Table 5). The resulting three-by-three matrix was plotted using sensitivity ranking along the vertical axis and human influence ranking along the horizontal axis (see Figure 6). Each stream falls into one of the nine combinations of sensitivity and human influence scores. Scores, classifications, and management strategy for each project stream reach are presented in Table 9. Map 4 identifies both the stream classification and prescribed management strategies for all project stream reaches.

Streams with seemingly very different morphologies sometimes exhibit similar sensitivity scores. For example, a stream could be considered sensitive based upon biota, or by its location in a clay-rich soil watershed. In highly manipulated landscapes such as Kenosha County, rare species more commonly persist in streams with a greater ability to maintain good water quality and flow in the face of development. Counterintuitively, such streams are commonly less sensitive to human influence. Nevertheless, while many variables would cause such streams to be considered less sensitive, the desire to preserve rare species offsets other watershed-based sensitivity scores and cause the stream to be classified as more sensitive to human influence. Although other streams may have lost rare and sensitive species, innate watershed conditions classify these streams as highly vulnerable to human influence, and generate high sensitivity scores even though rare species are absent.

Map 4

KENOSHA COUNTY STREAM CLASSIFICATION AND ASSOCIATED MANAGEMENT STRATEGIES: 2017



CLASSIFICATION CODE

- CLASS I - PROTECTION
- CLASS II - PROTECTION AND RESTORATION
- CLASS III - PROTECTION AND ENHANCEMENT
- U.S.G.S SUBWATERSHED HYDROLOGIC UNIT CODE 12
- UNINCORPORATED AREAS IN KENOSHA COUNTY

N

0 1 2 Miles

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

Table 9

SUMMARY OF STREAM SENSITIVITY, HUMAN INFLUENCE, AND MANAGEMENT STRATEGY ASSIGNMENTS

Stream Code	Stream Number	U.S. Geological Survey Hydrologic Unit Code (HUC) Name	U.S. Geological Survey Hydrologic Unit Code (HUC) 12-Digit Code	Named Streams[a]	Sensitivity Classification	Human Influence Classification	Management Strategies Classification	Management Strategies Objective
Bas-01	1	Bassett Creek - Fox River	071200061006		M	L	I	Protection
Bas-02	2				M	L	I	Protection
Bas-03	3				L	L	II	Restoration and Enhancement
Bas-04	4				M	M	II	Restoration and Enhancement
Bas-05	5				M	L	I	Protection
Bas-06	6				M	M	II	Restoration and Enhancement
Bas-07	7			Bassett Creek	M	L	I	Protection
Bas-08	8				M	H	III	Combined Protection and Restoration
Bri-01	9	Brighton Creek	071200060101	Brighton Creek (Lower Reaches)	L	M	II	Restoration and Enhancement
Bri-02	10				L	M	III	Combined Protection and Restoration
Bri-03	11				L	M	III	Combined Protection and Restoration
Bri-04	12				L	H	III	Combined Protection and Restoration
Bri-05	13				L	H	III	Combined Protection and Restoration
Bri-06	14			Salem Branch	L	M	III	Combined Protection and Restoration
Bri-07	15			Salem Branch	M	M	II	Restoration and Enhancement
Bri-08	16			Brighton Creek (Upper Reaches)	M	M	II	Restoration and Enhancement

Table 9 (continued)

Stream Code	Stream Number	U.S. Geological Survey Hydrologic Unit Code (HUC)		Named Streams[a]	Sensitivity Classification	Human Influence Classification	Management Strategies	
		Name	12-Digit Code				Classification	Objective
Bri-09	17				M	M	II	Restoration and Enhancement
Bri-10	18				M	M	II	Restoration and Enhancement
Bri-11	19				M	M	II	Restoration and Enhancement
Bri-12	20				M	M	II	Restoration and Enhancement
Bri-13	21				M	H	III	Combined Protection and Restoration
Bri-14	22				M	M	III	Combined Protection and Restoration
Cha-01	23	Channel Lake	071200061005	Trevor Creek	M	M	II	Restoration and Enhancement
Cha-02	24				M	L	I	Protection
Roo-01	25	East Branch Root River Canal	071200060202	East Branch Root River Canal	M	M	II	Restoration and Enhancement
Des-01	26	Head-waters of Des Plaines River	071200060103	Des Plaines River	H	M	I	Protection
Des-02	27			Center Creek	H	M	I	Protection
Des-03	28				M	M	II	Restoration and Enhancement
Des-04	29				M	M	II	Restoration and Enhancement
Des-05	30				M	M	II	Restoration and Enhancement
Des-06	31			Des Plaines River	H	M	I	Protection
Des-07	32				M	M	II	Restoration and Enhancement

Table 9 (continued)

Stream Code	Stream Number	U.S. Geological Survey Hydrologic Unit Code (HUC) Name	12-Digit Code	Named Streams[a]	Sensitivity Classification	Human Influence Classification	Management Strategies Classification	Objective
Des-08	33				H	L	I	Protection
Des-09	34				M	M	II	Restoration and Enhancement
Des-10	35				M	M	II	Restoration and Enhancement
Des-11	36				M	M	II	Restoration and Enhancement
Des-12	37				M	M	II	Restoration and Enhancement
Des-13	38				M	M	II	Restoration and Enhancement
Des-14	39				H	M	I	Protection
Des-15	40				M	M	II	Restoration and Enhancement
Des-16	41				H	M	I	Protection
Des-17	42				M	M	II	Restoration and Enhancement
Des-18	43				M	M	II	Restoration and Enhancement
Des-19	44				H	M	I	Protection
Des-20	45			Des Plaines River	H	M	I	Protection
Hoo-01	46	Hoosier Creek	071200061001	Hoosier Creek Canal	M	H	III	Combined Protection and Restoration
Kil-01	47	Kilbourn Road Ditch	071200060102		M	M	II	Restoration and Enhancement
Kil-02	48				M	M	II	Restoration and Enhancement
Kil-03	49				M	L	I	Protection
Kil-04	50				M	M	II	Restoration and Enhancement

Table 9 (continued)

Stream Code	Stream Number	U.S. Geological Survey Hydrologic Unit Code (HUC)		Named Streams[a]	Sensitivity Classification	Human Influence Classification	Management Strategies	
		Name	12-Digit Code				Classification	Objective
Kil-05	51				M	H	III	Combined Protection and Restoration
Kil-06	52				M	H	III	Combined Protection and Restoration
Nip-01	53	North Branch of Nipper-sink Creek	071200060802		H	L	I	Protection
Nip-02	54				M	M	II	Restoration and Enhancement
Nor-01	55	North Mill Creek	071200060201		L	M	III	Combined Protection and Restoration
Nor-02	56			North Mill Creek	M	M	II	Restoration and Enhancement
Nor-03	57				L	M	III	Combined Protection and Restoration
Nor-04	58			Mud Lake Outlet & Dutch Gap Canal (North Mill Creek)	M	M	II	Restoration and Enhancement
Pal-01	59	Palmer Creek-Fox River	071200061003	Palmer Creek	H	L	I	Protection
Pal-02	60				M	M	II	Restoration and Enhancement
Pal-03	61			Peterson Creek	M	H	III	Combined Protection and Restoration
Pal-04	62			New Munster Creek	L	H	III	Combined Protection and Restoration
Pal-05	63				L	M	II	Restoration and Enhancement

Table 9 (continued)

Stream Code	Stream Number	U.S. Geological Survey Hydrologic Unit Code (HUC) Name	12-Digit Code	Named Streams[a]	Sensitivity Classification	Human Influence Classification	Management Strategies Classification	Objective
Pal-05	63				L	M	II	Restoration and Enhancement
Pal-06	64				M	M	II	Restoration and Enhancement
Dye-01	65	Spring Brook - Fox River	071200061002	Spring Brook (Dyer Creek)	M	M	II	Restoration and Enhancement
Fox-01	66	- -[b]	- -[b]	Fox River	L	M	III	Combined Protection and Restoration

NOTE: The stream classes and associated management strategy categories do not assign certain lakes higher quality or higher importance – lakes assigned to the "Protection and Restoration" (yellow) and "Restoration and Enhancement" (red) categories should not be "written off". High value lakes are found in all management categories.

[a] *Unless otherwise noted, stream reaches are unnamed.*

[b] *The Fox River mainstem crosses multiple USGS HUC-12 watersheds throughout Kenosha County.*

Source: SEWRPC.

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CHAPTER V

DEVELOPMENT AND MANAGEMENT IMPLICATIONS

PURPOSE

The intensity and density of human shoreline use and development can profoundly influence the biological integrity, aesthetics, recreational value, water quality, and overall appeal of lakes. Kenosha County's lake shorelines are not uniformly developed. Some lakes, particularly smaller lakes, have fewer property owners, fewer residences, and lower overall levels of human influence, even when lake size is considered. Conversely, some larger lakes are ringed with small lots, have tightly spaced homes, and have large amounts of impervious cover adjacent to the lake. The suite of management approaches for such widely differing lakes is very different. Protection should be the focus on relatively undeveloped lakes, while active management and restoration may be required to protect the long-term health of intensively developed lakes.

SEWRPC staff used 2015 digital color orthophotography and parcel descriptions to examine development patterns around each study area lake. From this information, the total area of impervious surfaces present on individual riparian parcels could be estimated and lake-wide impervious surface averages developed. Similarly, the width and size of all riparian lots and the distances between lake shorelines and residences were measured and tabulated. State and County laws set requirements for these factors, and the degree to which various lakes conform to existing regulations were examined.

OVERVIEW OF RELEVANT REGULATIONS

The State of Wisconsin has long been interested in measures that protect the State's lakes and rivers. This led the State to enact legislation protecting shoreland areas.[1, 2] The stated intent was to "maintain safe and healthful conditions, prevent and control water pollution, protect spawning grounds, fish and aquatic life; control building sites, placement of structure and land uses, and reserve shore cover and natural beauty." Rules enacted during the late 1960s established minimum standards to achieve these goals in shoreland areas, but allowed counties to customize

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[1] *"Shoreland areas" are lands within 1,000 feet of the ordinary high-water mark of a lake, pond, or flowage, or within 300 feet from a river or stream or to the landward side of the floodplain associated with a river or stream, whichever distance is greater.*

[2] Wisconsin Statutes *Section 59.692,* Zoning of Shorelands on Navigable Waters, *October 7, 2016; and,* Wisconsin Statutes *Section 281.31,* Navigable Waters Protection Law, *October 7, 2016.*

rules based upon local conditions.[3] These rules stipulated that each county shall adopt an ordinance setting standards for vegetation clearing/buffers; impervious surfaces on riparian parcels and within 300 feet of the ordinary high water mark; filling, grading, lagooning, ditching and excavating; building setback distance and height; and minimum lot size for shoreland properties. Many Wisconsin counties enacted zoning regulations with conditions more restrictive than minimum standards, particularly after the 1990s.[4]

The July 2015 Wisconsin State Budget Bill, Legislative Act 55, included provisions modifying statutes and codes controlling shoreland zoning.[5] These changes prevent counties from enforcing shoreline standards more restrictive than the minimum Statewide zoning standards described in Chapter NR 115 of the *Wisconsin Administrative Code* (Wisconsin's Shoreland Protection Program). Furthermore, the act specifically prohibits counties from regulating the following in shoreland areas:

- Requirements for expanded vegetative buffers on previously developed land,
- Outdoor lighting,
- Nonconforming structures that do not expand the building's footprint,
- Inspection before sale/transfer of a property,
- Limits on vertical expansion of structures when less than 35 feet in height, and
- Impervious surface standards that do not allow on- or off-site infiltration alternatives.

Highly Developed Shoreline Regulation

Wisconsin's Shoreland Protection Program recognizes the variable nature of lakes throughout the state, that some lakes are found in urbanized areas, and allows counties to regulate "highly developed shoreline" areas in a manner more consistent with on-the-ground conditions. The highly developed shoreline designation can be assigned to shoreline areas meeting at least one of the following criteria:

1. A shoreline area that is within an area identified as an urbanized area or urban cluster in the 2010 U.S. Census

2. A shoreline area within an area with commercial, industrial, or business land use(s) as of January 31, 2013

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[3] Wisconsin Administrative Code *Chapter NR 115,* Wisconsin's Shoreland Protection Program, *January 2010.*

[4] *Lutze, Kay and Lynn Markham (University of Wisconsin Extension Center for Land Use Education), Shoreland Zoning: Protecting Lakes Through a Partnership Between Citizens, Lake Associations, County Zoning Staff, County Boards, DNR, UW-Extension and More, March 30, 2016, see https://www.uwsp.edu/cnr-ap/UWEXLakes/Documents/programs/convention/2016/WedPMworkshops/LynnMarkhamKayLutze_ShorelandZoning.pdf*

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

3. After conducting a hearing, additional areas not included in 1 and 2 above, provided that the additional length of shoreline must be at least 500 feet long and, as of February 1, 2010, was either served by a public sewerage system or has a majority of its lots developed with more than 30 percent impervious surface area

   If a shoreline qualifies as highly developed, NR 115 allows up to 30 percent impervious area for residential land use and up to 40 percent for commercial, industrial, or business uses (as opposed to the general standard of 15 percent impervious land cover).

   All the following lakes listed below within Kenosha County were determined to meet the highly developed shoreline designation:[6]

Benedict	Hooker	Rock
Benet	Lily	Shangri-La
Camp	Montgomery	Silver
Center	Powers	Voltz
Cross		

Vegetative Buffers

State law requires that land extending at least 35 feet inland from the ordinary high-water mark be designated as vegetative buffer zone. Vegetation may not be removed in such areas except for routine maintenance, or to create an access and viewing corridor on riparian lots. The viewing corridor may not exceed 35 feet of the shoreline frontage per 100 feet of shoreline frontage. The viewing corridor can run uninterrupted for the entire permitted length.[7] Counties can also allow vegetation removal as part of accepted forestry management practices on parcels of 10 acres or more, and may also allow vegetation removal focused on control of exotic or invasive species, removal of damaged or diseased or disease-causing vegetation, which promotes public safety; or other reasons on a case-by-case basis if any removed vegetation is replanted in the same area as soon as practicable.[8] Counties may no longer require existing developments to establish or expand buffers, except as an option for mitigation purposes.[9] For example, if an open structure (e.g., a structure such as a gazebo without solid walls) is planned to be built closer to the ordinary high-water mark than allowed by setback standards, a buffer can be required.

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[6] *Kenosha County Department of Planning and Development,* Kenosha County General Zoning and Shoreland/ Floodplain Zoning Ordinance, Chapter 12, *Municipal Code of Kenosha County, Amended January 17, 2017*.

[7] *Lutze, Kay (Shoreland Zoning Coordinator),* Correspondence/Memorandum 2015 Wisconsin Act 55 and Shoreland Zoning, *State of Wisconsin, October 1, 2015. The Act 55 vegetation removal standard is more liberal than that stipulated in* Wisconsin Administrative Code *Chapter NR 115.05(c)2b, which stipulates that trees and shrubs within the vegetative buffer zone may be removed to create an access/viewing corridor over length of shoreline not greater than 30 percent of the parcel's shoreline frontage or 200 feet, whichever is less. In such a case where a law has been passed and the affected* Administrative Code *has not yet been revised, the requirements imposed under the new law govern.*

[8] Wisconsin Administrative Code Chapter NR 115, Wisconsin's Shoreland Protection Program, S*eptember 2014.*

[9] *Lutze, op cit.*

Lot Size

Lot size standards differ based upon the presence of public sanitary sewer service. Lots not served by public sanitary sewers must be larger, with a minimum lot size of 20,000 square feet and an average width of 100 feet. Lots served by public sanitary sewers must be at least 10,000 square feet in size, and average 65 feet in width.[10] Public sanitary sewer service was not available at the following lakes as of 2010: Benedict, Dyer, Flanagan, Friendship, Kull, Lily, and Powers. Sanitary sewer service is available around portions of Francis and Voltz Lakes, and all residential lots are located in serviced areas. Almost all of the lots on the remaining eight lakes (Camp, Center, Cross, Hooker, Montgomery, Rock, Shangri-La/Benet, and Silver Lakes) were served by public sanitary sewers as of 2010.

Substandard lots are a legally created lot or parcel that met minimum area and width standards when created, but do not meet current standards. Such lots may generally be used as building sites, if construction conforms to other minimum shoreland zoning standards (e.g., setback).[11]

Setback

Chapter NR 115 requires that buildings must be positioned inland at least 75 feet from the ordinary high-water mark (OHWM) of any navigable water.[12] Where an existing development pattern is present, the shoreland setback for the principal structure can be reduced to the average setback of the principal structure on each adjacent lot, but must remain at least 35 feet from the OHWM. Exemptions may be requested and certain types of structures (e.g., boathouses, gazebos, fishing rafts) are exempt from setback regulation under certain conditions.

Non-conforming structures refer to structures that were lawfully placed at the time of construction, but do not meet current standards. Unlimited maintenance and repair is allowed on existing nonconforming structures; however, regulations restrict expansion of non-exempt structures closer than 75 feet, but further than 35 feet from the OHWM. In these cases, property owners are restricted to adding-on vertically, thereby not expanding the structure footprint. Expansion of non-exempt structures closer than 35 feet is generally prohibited. Local ordinances may require property owners expanding the footprint of any non-conforming building to offset the environmental impact of planned expansion.

Impervious Surface

As was discussed in Chapter II, impervious surfaces tributary to lakes and streams are believed to impair fisheries and overall ecological integrity. Studies in Wisconsin reveal an overall decline in the number and diversity of fish in lakes and streams with more runoff (see Figure 7).[13] Therefore, actions that limit expansion and/or mitigate the effect of impervious surfaces are critical to watershed health, and are a focus of attention.

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[10] Wisconsin Administrative *Code NR 115, op. cit.*

[11] *To be used as a building site, the lot must not have been reconfigured or combined with another lot or parcel, and must not have had a portion of a building built upon it and extending to a neighboring parcel.*

[12] *Non-habitable boat houses without plumbing, open-sided or screened structures, fishing rafts on the Wolf and Mississippi Rivers, broadcast signal receivers, utilities, and walkways are wholly or partially exempt from setback requirements.*

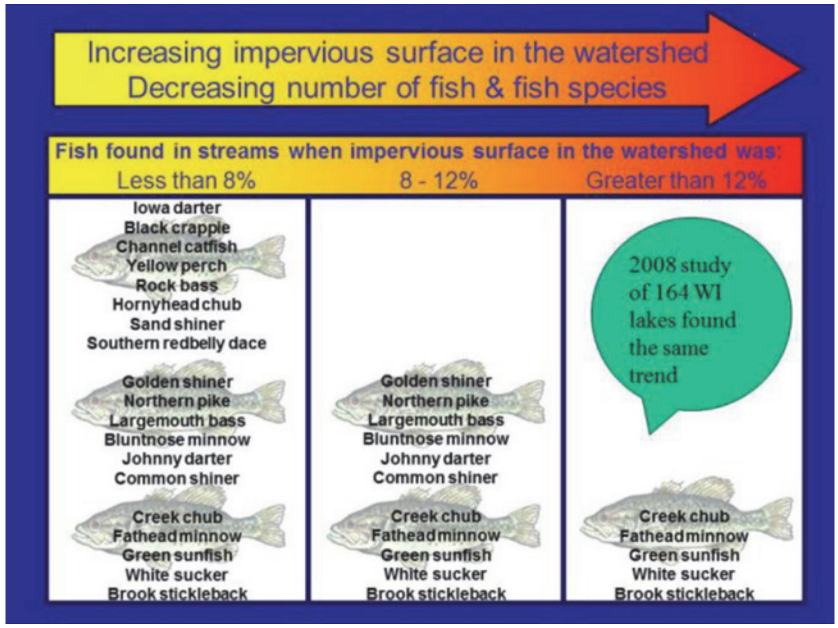
[13] *Markham, Lynn,* Why Does the New Shoreland Zoning Rule Limit Impervious Surfaces Like Rooftops and Driveways?, *University of Wisconsin-Extension, 2011. Available online at: http://dnr.wi.gov/topic/shorelandzoning/documents/impervioussurfacefactsheet7-11.pdf*

Legislative Act 55 states that all property owners may retain their current level of impervious surface. Runoff from impervious surfaces that is subsequently treated is not counted towards the percent imperviousness for a particular lot. Any new construction or expansions are required to meet the following standards:

- Residential land use
    - 15 percent impervious without mitigation
    - 30 percent with mitigation
- Residential land use on "highly developed shorelines" (see the previous section for additional information regarding highly developed shorelines)
    - 30 percent without mitigation
    - 40 percent with mitigation
- Commercial, industrial, or business land use
    - 40 percent without mitigation
    - 60 percent with mitigation

Figure 7

IMPERVIOUS LAND COVER'S EFFECT ON FISHERIES



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Source: University of Wisconsin-Extension.

PROJECT AREA DEVELOPMENT STATISTICS AND CONFORMANCE WITH EXISTING CODES AND GUIDELINES

Vegetative Buffers

The condition and vegetation of the Lakes' shorelines was inventoried in 2014 as part of this study, but the size and extent of individual lot vegetative buffers were not quantified. This qualitative information includes photographs of the entire shoreline around each lake, general descriptions of shoreline conditions, and an overview of plant species in the shoreline area of each lake. Appendix B summarizes shoreline assessment data. Shoreline photographs from all lakes can be viewed at the Kenosha County website. Vegetation is described in the updated lake summary reports prepared under this planning effort.[14]

Comparing vegetative buffers to regulatory standards requires detailed analysis beyond the scope of this study. Nevertheless, the condition of project-area lake shorelines and plant communities was described and photographed, documenting existing conditions to help future planners assess change.

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[14] *See Kenosha County Land and Water Conservation webpage link for copies of Lake Summary reports at http://www.co.kenosha.wi.us/676/Land-Water-Conservation.*

Lakes with many small lots would be expected to have the least vegetative buffer (see lot size section below). Lot size (particularly width) regulations can help maintain existing vegetative buffers.

The major lakes (i.e., greater than 50 acres in surface area) generally have less vegetative buffers remaining than the smaller lakes, with some notable exceptions such as Dyer Lake and Montgomery Lake (see Appendix B for more details). Any amount of riparian buffer is better than having no buffer at all (see Appendix D), but this inventory shows that buffers are generally lacking on more than 70 percent of lakes within the County. Consequently, there is great potential to improve the extent and distribution of buffers and their associated water quality and wildlife benefits on these lakes within the County (see Chapter VI for more details).

Lot Size

Lots abutting lakes are highly coveted, especially in heavily populated areas close to major metropolitan areas. High demand increases the price of lakefront parcels. To make parcels affordable and meet high demand, lake shorelines are commonly divided into many small parcels with limited frontage. This commonly results in lakes ringed with homes on small lots. Zoning ordinances require that buildable lots meet several threshold criteria, one of which is size. However, many homes and lots predate zoning ordinances, creating a situation where lots commonly do not meet current lot-size criteria.

The sizes of tax parcels abutting each study-area lake were compiled, evaluated, and contrasted to the suggested lake management classification. Figure 8 shows the number of lake lots of a particular size within the study area, and identifies how many lots in each category are on management classification I, II, or III lakes (see Chapter III for more details on lake classification). As can be seen in Figure 8, most small (less than one-half acre) lots are found on class III lakes. However, small lots form a significant percentage of the total number of lots in each management class (see Figure 8).

Some small lots may not meet Chapter NR 115 minimum size standards (10,000 square feet for sewered areas, 20,000 square feet for unsewered areas). Large numbers of substandard lots are indicative of great human pressure upon a lake. The ecology of such areas generally suffers, but can be improved by active application of restoration and enhancement practices (see Chapter VI for more details).

Setback

The presence of small lots with limited buildable areas coupled with the desire of lot owners for their homes to be close to the major feature of interest (i.e., the lake) cause many lake homes to be built close to the shoreline and in close proximity to other homes. State regulations require homes to generally be at least 75 feet from the lake shoreline, but in some instances allow this distance to be reduced to as little as 35 feet. As is the case with lot size, many lake homes were built before regulations were enacted, and some homes do not conform to current criteria.

SEWRPC examined digital, color orthophotography and measured the distance between various structures and the adjacent lake's shoreline. These residential setback values were grouped into categories that help illustrate how well each lake conforms to Chapter NR 115 criteria (see Table 10). These data are also summarized graphically on Figure 9, which plots the total number of parcels throughout the study area with setbacks less than, potentially less than, or meeting Chapter NR 115 minimum standards by lake management class. Figure 10 is similar, but presents the proportion of parcels in each management class within the various setback ranges.

The available data shows that 62 residences, or about 4 per cent of all study area lake parcel residences, are situated closer than 35 feet from lake shorelines (a distance closer than allowed by State law), and, therefore, do not conform with NR 115 requirements. Most of these parcels are found on management Classification III lakes. Management Classification III lakes also have a higher proportion of homes less than 35 feet from the shoreline. Management Class II lakes have the highest proportion of homes situated between 35 and 75 feet from the shoreline, which is permissible in certain situations (e.g., homes on either side are also less than 75 feet from the shoreline). About one-quarter of the homes throughout the study area do not, or might not, conform to NR 115 setback criteria.

Figure 8

TOTAL NUMBER, PROPORTION, AND SIZE OF SHORELINE PARCELS BY LAKE MANAGEMENT CLASS FOR SELECT KENOSHA COUNTY LAKES

Source: Kenosha County and SEWRPC.

Impervious Surface

Lakes

SEWRPC estimated riparian parcel imperviousness using 2010 digital color orthophotography. Impervious surface area included features such as building rooftops, patios, decks, driveways, sidewalks, parking areas, and tennis courts. The impervious surface percentage of each lot was calculated by totaling the area of impervious features on a particular lot, and dividing by total lot size. The average percent impervious surface for each lake's shoreland area was calculated by averaging the percent impervious surface of individual lots. Expressing shoreland impervious area in this manner avoids a situation where a few large open parcels (e.g., parks) skew overall lake impervious surface averages. A few large open parcels can mask the amount of impervious surface on the majority of lake

Table 10

RIPARIAN PARCEL RESIDENTIAL STRUCTURE SETBACK DISTANCES AMONG SELECTED KENOSHA COUNTY LAKES: 2010

Lake Management Class	Lake	Total Number of Parcels	Residence Setback (if multiple, closest structure)							
			< 35 Feet		35 - 75 Feet		> 75 Feet			
			Number of Parcels	Percent of Total Parcels	Number of Parcels	Percent of Total Parcels	Number of Parcels	Percent of Total Parcels	Mean Setback (Feet)	Median Setback (Feet)
1	Cross	49	0	0	18	37	31	63	80	67
	Flanagan[a]	7	0	0	2	29	5	71	112	95
	Francis[b]	3	0	0	0	0	3	100	1000	1000
	Kull[a]	3	0	0	0	0	3	100	295	295
	Montgomery	62	0	0	4	6	58	94	154	130
	Voltz[b]	37	1	3	10	27	26	70	93	77
	Subtotal	161	1	1	34	21	126	78	- -	- -
2	Benedict[a]	42	2	5	13	31	27	64	91	74
	Dyer[a]	6	0	0	1	17	5	83	278	230
	Friendship	2	0	0	1	50	1	50	141	141
	Rock	70	0	0	26	37	44	63	86	78
	Shangri-La/Benet	196	9	5	75	38	112	57	68	65
	Subtotal	316	11	3	116	37	189	60	- -	- -
3	Camp	265	3	1	21	8	241	91	116	110
	Center	195	15	8	46	24	134	69	112	73
	Hooker	80	3	4	13	16	64	80	106	91
	Lily[a]	97	1	1	11	11	85	88	72	56
	Powers[a]	226	15	7	49	22	162	72	93	85
	Silver	113	13	12	12	11	88	78	79	80
	Subtotal	976	50	5	152	16	774	79	- -	- -

[a]*Not served by sanitary sewers service as of 2010.*

[b]*Partially served by sanitary sewer service as of 2010.*

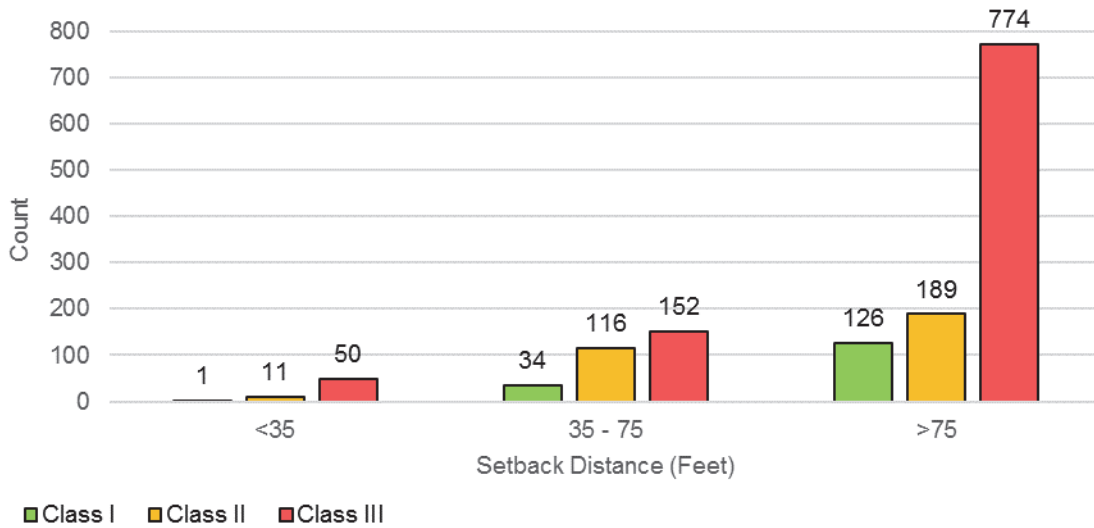
Source: SEWPRC.

frontage, which is most commonly residential lots. Impervious surface values for the shoreline parcels ringing each study area lake are summarized in Table 11. As shown in Figure 11, Class I lake shorelines contain the lowest average percent imperviousness surface and Class III lake shorelines contain the highest average percent impervious surface. In addition to differences in average impervious surface, aside from atypical outliers, Class I lakes have the lowest high-range lot impervious surface values throughout the study area, while Class III lakes have the lots with the greatest proportion of impervious surface throughout the study area.

Figure 12 further illustrates the impervious value statistics for each project-area lake, and identifies each lake by management class. All project area lakes aside from Dyer, Flanagan, Francis, Friendship, and Kull Lakes are considered to be highly developed according to criteria set forth in the Kenosha County General Zoning and Shoreland/Floodplain Ordinance. These five lakes had the lowest average proportion of shoreline area covered with impervious surfaces (see Figure 12). Aside from one parcel located on Flanagan Lake, all parcels around these five lakes meet impervious surface standards by a wide margin.

Figure 9

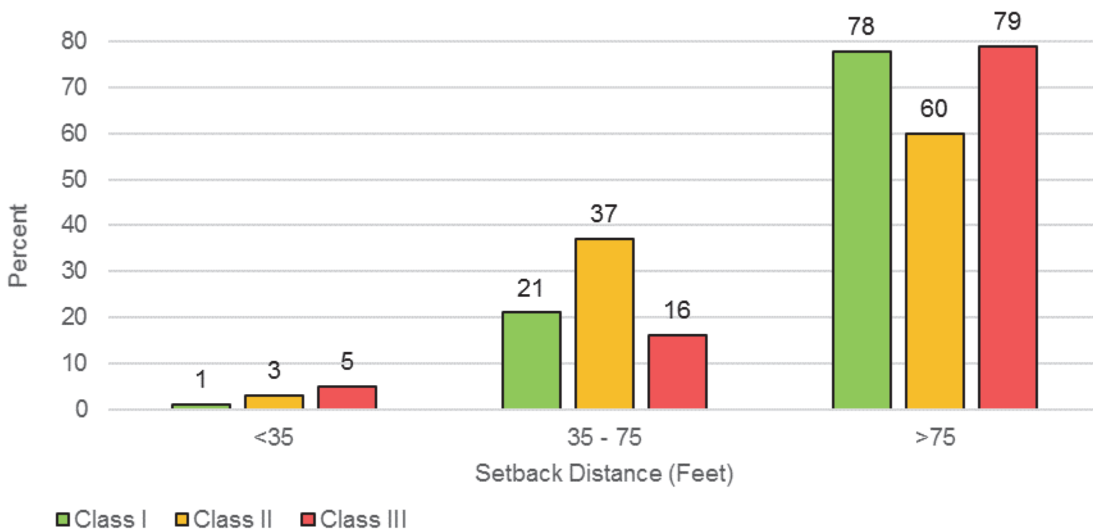
TOTAL NUMBER OF SHORELINE PARCELS BY SETBACK DISTANCE FROM PRIMARY RESIDENCE BY LAKE MANAGEMENT CLASS FOR SELECT KENOSHA COUNTY LAKES: 2010



Source: Kenosha County and SEWRPC.

Figure 10

PROPORTION OF SHORELINE PARCELS BY SETBACK DISTANCES OF PRIMARY RESIDENCE BY LAKE MANAGEMENT CLASS FOR SELECT KENOSHA COUNTY LAKES: 2010



Source: Kenosha County and SEWRPC.

On average, lots around all 12 lakes identified as highly developed by Kenosha County ordinances meet Chapter NR 115 impervious surface standards. However, 326 parcels around Benedict, Camp, Center, Cross, Hooker, Lily, Montgomery, Powers, Rock, Shangri-La/Benet, and Silver Lakes have more than 30 percent impervious surface, and therefore do not meet NR 115 criteria (see Table 11). Two-thirds of all highly impermeable lots are found on management Class III lakes. Sixty-nine lots around six lakes have more than 40 percent impervious cover. These

Table 11

RIPARIAN PARCEL IMPERVIOUS LAND COVER BY LAKE MANAGEMENT CLASS AMONG SELECTED KENOSHA COUNTY LAKES: 2010

Lake Management Class	Lake	Total Number of Parcels	Impervious Surface Category							
			<15 Percent		15-30 Percent		30-40 Percent		>40 Percent	
			Number of Parcels	Percent of Total Parcels	Number of Parcels	Percent of Total Parcels	Number of Parcels	Percent of Total Parcels	Number of Parcels	Percent of Total Parcels
1	Cross	49	20	41	7	14	10	20	12	24
	Flanagan	7	6	86	1	14	0	0	0	0
	Francis	3	3	100	0	0	0	0	0	0
	Kull	3	3	100	0	0	0	0	0	0
	Montgomery	62	29	47	28	45	5	8	0	0
	Voltz	37	19	51	18	49	0	0	0	0
	Subtotal..........	161	80	50	54	34	15	9	12	7
2	Benedict	42	18	43	21	50	3	7	0	0
	Dyer	6	6	100	0	0	0	0	0	0
	Friendship	2	2	100	0	0	0	0	0	0
	Rock	70	23	33	36	51	11	16	0	0
	Shangri-La/Benet	196	41	21	80	41	56	29	19	10
	Subtotal..........	316	90	28	137	43	70	22	19	6
3	Camp	265	163	62	85	32	16	6	1	0
	Center	195	92	47	66	34	21	11	16	8
	Hooker	80	37	46	34	43	6	8	3	4
	Lily	97	30	31	46	47	21	22	0	0
	Powers	226	45	20	88	39	62	27	32	14
	Silver	113	41	36	40	35	15	13	17	15
	Subtotal..........	976	408	42	359	37	141	14	69	7
Total		1453	578	40	550	38	226	16	100	7

Source: SEWPRC.

lakes include Cross Lake (a Class I lake), Shangri-La/Benet (a Class II lake), and Center, Hooker, Powers, and Silver Lakes (Class III lakes).

While it is important to quantify the impervious surfaces present on lakeshore properties, many lakes have watersheds extending far beyond the lakes. Lakes that depend upon surface water for much of their water supply can be drastically affected by events in portions of the watershed far from the lake itself. For this reason, impervious surfaces in the watersheds feeding the lake must be considered. Although it is beyond the scope of this study to provide details for smaller sub-basins feeding each study-area lake, the information in the following section is useful to judge the relevant impact and risk for future water quality and ecological degradation fostered by impervious surfaces in the lakes' watersheds.

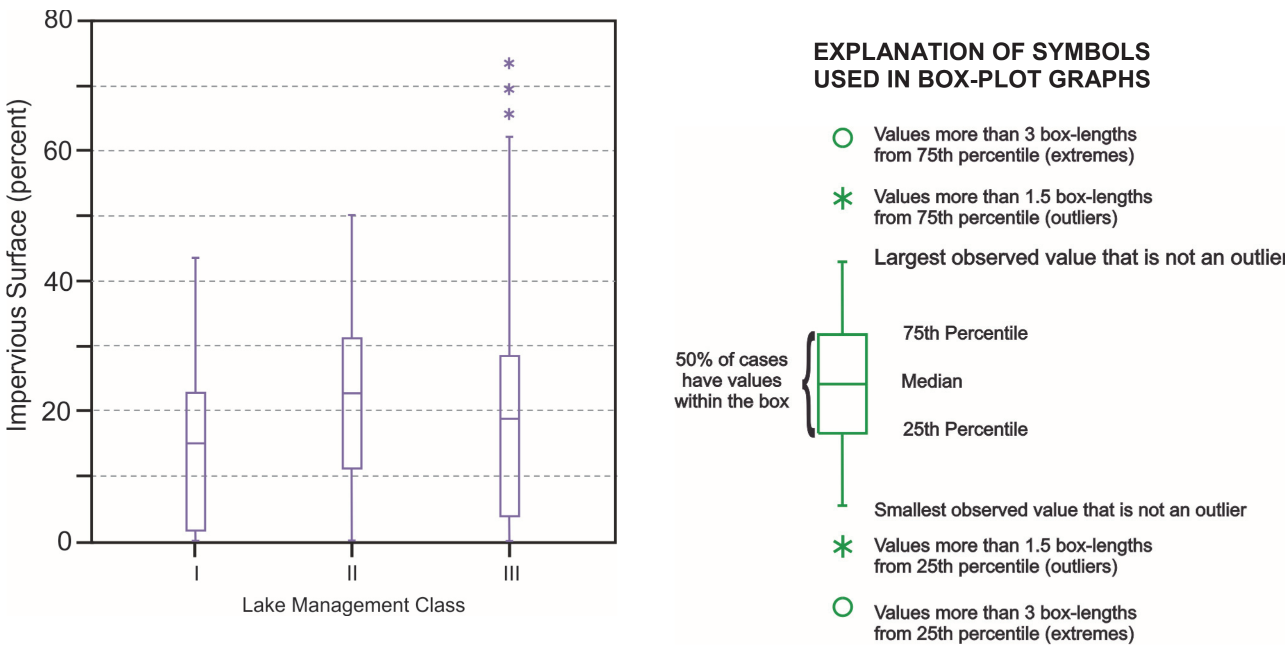
Streams

On a HUC-12 watershed basis,[15] all project streams were found to presently have less than 8 percent connected impervious cover based on year 2010 land use, a condition supportive of healthy and desirable fisheries (see Table

[15] *HUC-12 watersheds are considered to be local-scale features – approximately 90,000 HUC-12 watersheds are found in the conterminous United States. Much of the available stream-related data is reported by HUC-12, which helps assign such data to individual stream reaches.*

Figure 11

PERCENT IMPERVIOUS SURFACE OF SHORELINE PARCELS AMONG LAKE MANAGEMENT CLASSES WITHIN KENOSHA COUNTY



Source: SEWRPC.

12). However, planned 2035 land use suggests that significant change may occur in many watersheds. The amount of impervious surface in over half of the watersheds will approach levels that typically degrade stream fisheries. When watershed impervious surface totals exceed 12 percent, fisheries conditions are consistently poor (see Figure 7). Four watersheds are forecast to exceed 12 percent impervious surface by 2035 (North Branch Nippersink Creek: 25 percent, Channel Lake: 16 percent, Bassett Creek: 14 percent, and Brighton Creek: 12 percent). Additionally, two other watersheds will pass or reach the 8 percent impervious threshold, a value associated with deteriorating

fisheries (Kilbourn Road Ditch: 11 percent and North Mill Creek: 8 percent). All streams within these HUC-12 watersheds should be managed to minimize the impact and expansion of impervious surfaces.

Some project area lakes are located in the watersheds mentioned in the preceding paragraph, and are, therefore, potentially threatened by excessive impervious surfaces. These lakes include the following:

Bassett Creek – Fox River
- Lily
- Silver

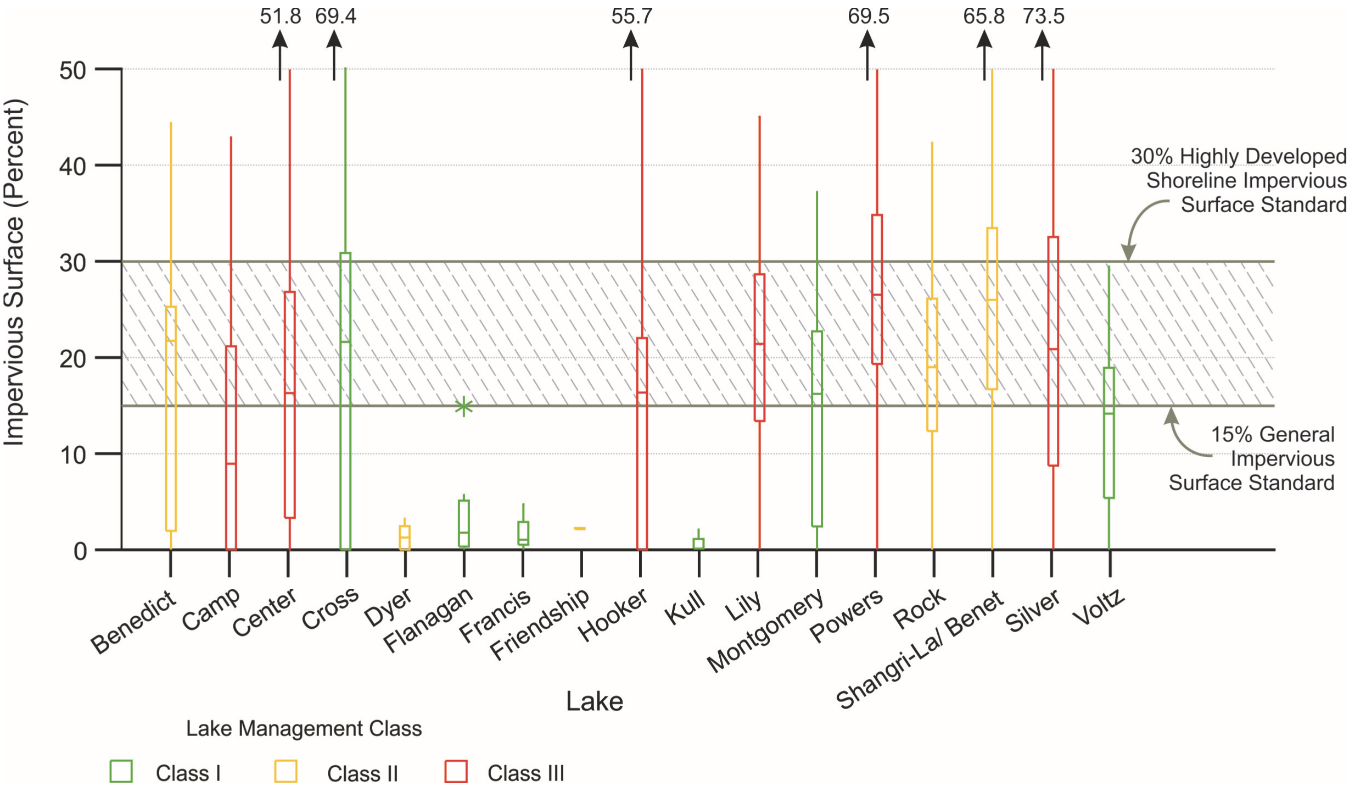
Brighton Creek
- Francis
- Friendship
- Hooker
- Montgomery

Channel Lake
- Camp
- Center
- Cross
- Rock
- Voltz

North Mill Creek
- Shangri-La/Benet

Figure 12

PERCENT IMPERVIOUS SURFACE OF RESIDENTIAL SHORELINE LOTS FOR SELECT KENOSHA COUNTY LAKES



NOTE: See Chapter 12 Kenosha County General Zoning and Shoreland / Floodplain Zoning Ordinance, Section L-Shoreland Regulations, 12.18-2 (Tree Cutting, Shrubbery Clearing, and Impervious Surface), and section (b) – Impervious Surface on pages 48-49 for more details on impervious surface standards. http://www.co.kenosha.wi.us/DocumentCenter/Home/View/80

Source: Kenosha County and SEWRPC.

Water quality, lake ecology, and fisheries may suffer in these lakes if the streams feeding the lakes mirror forecasts for the overall HUC-12 watersheds. Lakes with larger watersheds are comparatively more at risk. To evaluate this threat, the size of the watershed feeding each lake was reviewed and compared to other relevant factors (see Figure 13). From this analysis, the relative threat to each lake is quantified below.

Most Threatened
- Center
- Friendship
- Rock
- Voltz

Threatened
- Cross
- Francis
- Hooker
- Lily
- Silver

Less Threatened
- Camp
- Montgomery
- Shangri-La/Benet

One must remember that these interpretations do not account for planned or potential development in each lake's actual watershed, but instead rely on an evaluation of potential conditions in entire HUC-12 watersheds that contain the actual lake watersheds. As such, specific knowledge about each lake's watershed can greatly modify these interpretations.

Table 12

OVERALL ESTIMATED PERCENT CONNECTED IMPERVIOUS SURFACE VALUES FOR KENOSHA COUNTY HUC-12 WATERSHEDS: 2010

HUC-12 Watershed Name	Overall Percent Impervious Surface	
	Existing 2010	Planned 2035
Bassett Creek-Fox River	4	14
Brighton Creek	3	12
Channel Lake	5	16
East Branch Root River Canal	1	1
Headwaters Des Plaines River	1	2
Hoosier Creek	1	1
Kilbourn Road Ditch	2	11
North Branch Nippersink Creek	5	25
North Mill Creek	3	8
Palmer Creek – Fox River	3	7
Spring Brook – Fox River	2	5

Source: SEWRPC.

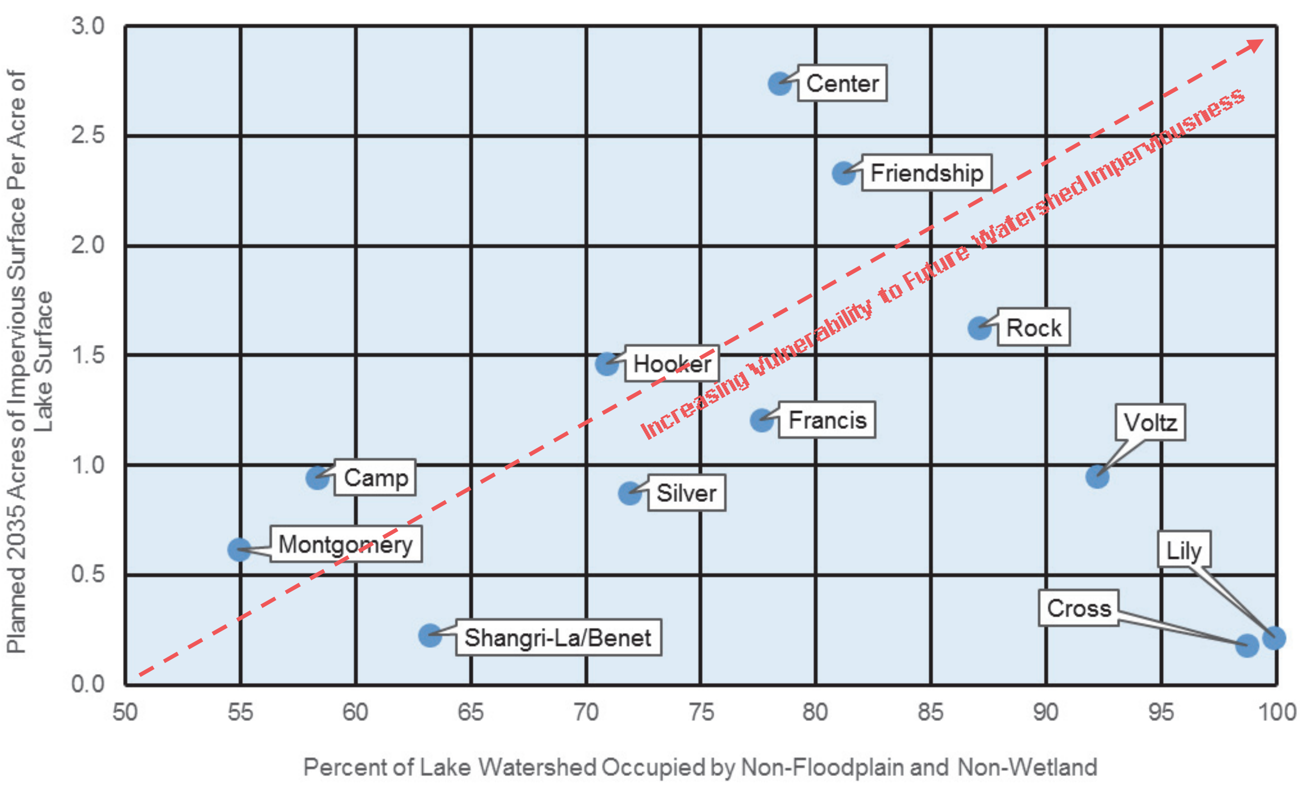
APPLICATION CONSIDERATIONS

Lakes and streams were assigned to management classifications based upon a broad suite of variables. Since each lake and stream is unique, some water bodies score high in one criteria and low in another, while other water bodies may score exactly the opposite. Nevertheless, the composite scores may assign both water bodies to the same management category. Therefore, scores must be considered holistically, with less overall importance attributed to individual factors. This means that management must follow a broader approach that fits many potential issues, and must not focus solely on "silver bullet" answers that relate to one scoring category (e.g., parcel-specific issues like lot size or lot-by-lot imperviousness).

Much of the pollution entering most water bodies does not originate on the lakeshore or from within the channels or banks of streams. Furthermore, pollution control laws enacted in response to the 1972 Federal Clean Water Act greatly reduced the proportion of pollutants entering water bodies from point sources such as wastewater from municipal, industrial, com-

Figure 13

VULNERABILITY TO FUTURE INCREASES IN WATERSHED IMPERVIOUSNESS FOR SELECT KENOSHA COUNTY LAKES



Source: SEWRPC.

mercial, and residential sources. Currently, the broad upland areas feeding waterbodies through surface runoff typically deliver the bulk of the sediment, nutrients, and other pollutants entering lakes and streams. Controlling runoff from these nonpoint sources requires basic changes to the way humans manage and interact with the landscape, and often include difficult changes to cultural attitudes, habits, and expectations.

A good indicator of the overall stress humans place on waterbodies is the amount of impervious surface in a watershed. Impervious surfaces have a negative effect upon all downstream waterbodies. Most water bodies can benefit from activities that reduce the impact of impervious surfaces directly connected to lakes and streams. Therefore, measures that reduce the overall amount and/or impact of new or existing impervious surfaces must be a foundational element of any mitigation strategy. This can include measures that reduce or slow runoff from developed land as well as agricultural parcels. Essentially, any measure that temporarily detains or slows runoff can benefit receiving water quality.

Under most conditions, it is much easier, cheaper, and more sustainable to preserve or enhance natural systems that provide benefits to water bodies as opposed to constructing engineered systems to take the place of natural systems. For this reason, all water resource protection, enhancement, or restoration initiatives must include preservation of features that provide ecological services to the water body in question. Typical examples of beneficial natural features include wetlands and floodplains, both of which help detain floodwater, reduce flood elevations, and help improve water quality. The first steps in any program should be to assure these natural area services are sustained into the future, and are improved to the extent practical. In cases where natural features have been substantially altered or eliminated, or if they are naturally absent, engineered systems can be constructed that mimic natural systems, an approach that commonly reduces long-term cost and increases overall appeal of the installed infrastructure.

Chapter VI

MANAGEMENT ALTERNATIVES

INTRODUCTION

As described in previous chapters, this report provides a scientific basis and rationale for grouping waterbodies into three management classes based on each waterbody's inherent sensitivity to human disturbance and each waterbody's current and projected degree of human influence. This classification scheme is driven by the physical characteristics of the waterbodies and their watersheds as well as present and planned levels of land use and development. These factors, when considered jointly, help quantify current and future environmental sensitivity and resiliency (i.e., ability to withstand impacts) to human-induced stressors such as land use changes, hydrologic alteration, and riparian buffer clearing (see Figure 14), all of which can have complex and compounded negative repercussions on water quality, wildlife, and fisheries.[1] By qualifying the similarities and differences of project waterbodies, this classification scheme provides a logical foundation to focus particular management strategies and program types where they will most efficiently benefit waterbodies of interest.

The management activities discussed in this chapter focus upon buffers and environmental corridors, groundwater recharge, surface hydrology, water quality, wildlife and fisheries, and education and outreach. More specifically, the recommended management strategies are designed to promote landscape connectivity (such as idealized in Figure 14) as well as corridors among habitat types;[2] restore degraded habitats; and remove other threats and stressors such as invasive species, upland erosion, or water quality degradation at scales ranging from the individual sites to entire watersheds. As the recommended management strategies are implemented over time, these steps will help lakes and streams resist ecological and physical degradation, and therefore add to their "resistance" (see Figure 14). These same strategies build the ecological "resilience" of these waterbodies improving their ability to recover from the impact of future development and other stressors. Implementing appropriate and efficient management strategies will help protect, enhance, and restore water quality, habitat, natural scenic beauty, and recreational quality of the surface waters in Kenosha County for future generations.

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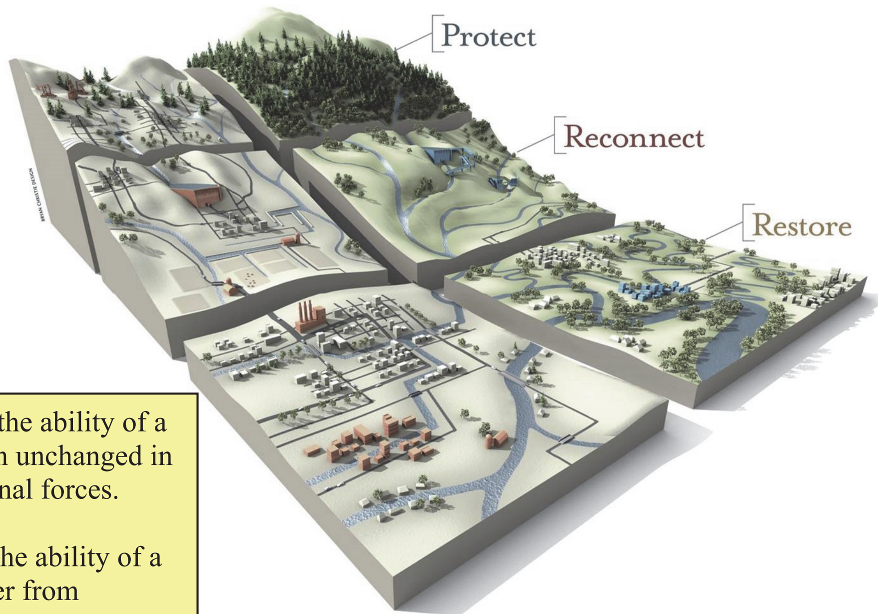
[1] *Abigail J. Lynch, and others, "Climate Change Effects on North American Inland Fish Populations and Assemblages," Fisheries, Volume 41(7), July 2016.*

[2] *Jack E. Williams, and others, Adaptation and Restoration of Western Trout Streams: Opportunities and Strategies, Fisheries, Vol. 40, No. 7, pages 304-317, July 2015; and, James E. Whitney, and others, Physiological Basis of Climate Change Impacts on North American Inland Fisheries, Fisheries, Vol. 41, No. 7, pages 333-345, July 2016.*

Figure 14

WATERSHED-SCALE ADAPTATION STRATEGIES TO PROMOTE ECOLOGICAL RESISTENCE AND RESILIENCE



"***Resistance***" is the ability of a system to remain unchanged in the face of external forces.

"***Resilience***" is the ability of a system to recover from disturbance.

This graphic depicts several strategies that include: protecting the highest quality remaining habitats; increasing landscape connectivity and corridors among occupied habitat patches among water and land features; reconnecting mainstem with tributary reaches through fish passage enhancements and improving instream flows; and, restoring degraded habitats within intensive land use development areas. **This graphic was provided courtesy of Bryan Christie Design and Trout Unlimited.**

Source: Source: Adapted from Jack E. Williams and other, "Climate Change Adaptation and Restoration of Western Trout Streams: Opportunities and Strategies," Fisheries, Volume 40(No. 7), pages 306-317, July 2015; and SEWRPC

This classification scheme is designed to complement other ongoing or planned County and regional programs operating at site and watershed scales, such as agricultural nutrient management, erosion control, urban stormwater, and wastewater management programs. For example, the classification scheme could be used to prioritize action plan elements suggested as part of large-scale grant applications. Another example includes using the classification scheme to focus resources used to enforce existing ordinances to identify areas where stepped up compliance will pay the greatest dividends. In addition, this report also is intended to provide the cities, villages, and towns in which lakes and streams are located with a consistent approach that promotes uniform and coordinated management across governmental boundaries.

Water Classification Strategies

Through the lake and stream classifications discussed in Chapters III and IV, the waterbodies were segregated into one of three categories: protection, protection and restoration, and restoration and enhancement as described below:

1. Protection – These waterbodies currently exhibit desirable characteristics, but may be threatened in the future. Protection tactics vary. Example tactics include managing urban and agricultural runoff, developing and enhancing buffers, and minimizing impervious surfaces associated with new development.

2. Protection and Restoration – These waters display some evidence of ecological or physical degradation, but these waterbodies still retain the ability to return to desirable conditions by undoing damage done in

the past and protecting intact areas. Protection and restoration strategies attempt to improve water quality, attenuate floods and runoff speed/volume, and/or enhance wildlife habitat. Example management tactics include returning functionality to ecological systems by restoring natural vegetation in critical areas throughout the watershed, reducing impacts to groundwater recharge and surface water and groundwater quality in future and existing development, and restoring farmed wetlands.

3. Restoration and Enhancement – These waterbodies generally have degraded conditions, and need intervention to reclaim latent ecological potential. They are commonly found in areas intensively used or modified by humans. Example restoration and enhancement strategies include restoring shoreline vegetation and habitat, naturalizing degraded shorelines and riparian areas, implementing pollution reduction measures, and remeandering ditched stream reaches.

BUFFERS AND ENVIRONMENTAL CORRIDORS

Riparian buffers and a variety of other natural features (e.g., wetlands and floodplains) protect water quality, groundwater supplies, fisheries, and wildlife; enhance the ecological resilience to invasive species, and reduce the potential for flood damage and inundation of structures and the harmful effects of climate change (e.g., increased temperatures and/or periods of drought).[3] Features such as wetlands, floodplains, and vegetative buffers,[4] can significantly decrease the amount of pollution entering a waterbody. Wetlands and floodplains can help reduce downstream flood flows and elevations and can also reduce stream power, thereby reducing erosion by spreading the energy of the flowing water over a broader area and/or by detaining water in a relatively passive manner. Vegetative buffers and vegetation in shallow nearshore areas can have similar effects of slowing water down, and they can help protect shorelines from wave-induced erosion. All can act as sediment, nutrient, and pollution traps. Pollutants can either be absorbed and utilized (in the case of nutrients) or filtered or settled out (in the case of sediment). Certain wetland plants, such as cattails, are particularly effective in this capacity.

The 75-foot regulatory-mandated shoreland setback provides highly productive habitat and significant pollution reduction benefits (as high as 75 percent reduction in some situations). While the 75-foot buffer provides some habitat value, significant wildlife benefits are associated with much broader riparian buffers (400-foot minimum wildlife width and 900-foot optimum wildlife width). Fragmentation of riparian buffers by roads, railways, and utilities, and highly groomed landscapes, combined with encroachment by development, harms the structure and function of riparian corridors and their ability to adequately protect waterways and wildlife habitat. Stream crossings and other more innocuous barriers such as debris jams, fords, and manipulated channels also tend to have a cumulative impact on a stream and associated lands, and they can harm water quality and the sustainability of quality fisheries. Therefore, it is important to reduce fragmentation of existing riparian buffers by modifying features that block aquatic organism migration, removing unnecessary infrastructure such as abandoned dams and unused stream crossings, and designing future infrastructure to be sensitive to waterbody ecology.

Riparian buffers and other natural features provide the broadest value in their natural state, but can still provide valuable ecological services when developed as compatible open space uses. They can be restored or artificially

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[3] *N.E. Seavy and others, "Why Climate Change Makes Riparian Restoration More Important than Ever: Recommendations for Practice and Research,"* Ecological Restoration, *Volume 27(3): pages 330-338, September, 2009; "Association of State Floodplain Managers, Natural and Beneficial Floodplain Functions: Floodplain Management-More than Flood Loss Reduction, 2008," www.flood.org/NewUrgent/Other.asp.*

[4] *Vegetative buffers (e.g., forests, grassed waterways, and manmade vegetative strips) and wetlands have the natural ability to slow runoff. This promotes trapping, storage, and/or consumption of pollutants before they enter adjacent waterbodies.*

Table 13

EXAMPLE BUFFER AND ENVIRONMENTAL CORRIDOR MANAGEMENT STRATEGIES

Management Strategies	Protection Waters	Protection & Restoration Waters	Restoration & Enhancement Waters
Protect existing buffers with emphasis on connections to natural areas and "vulnerable" buffers	Critical need	Moderate need	Limited need
Acquire, protect and restore land adjacent to Kenosha County Waters	Critical need	Moderate need	Critical need
Limit development in SEWRPC-delineated environmental corridors and natural resource areas	Critical need	Critical need	Critical need
Remove or manage invasive species in the waterbody, riparian zone and environmental corridors	Critical need	Critical need	Critical need
Restore natural vegetation in waterbodies, riparian zones, and environmental corridors	Limited need	Critical need	Critical need
Establish buffers along waterways where they currently do not exist	Moderate need	Moderate need	Critical need
Remove abandoned and non-essential roads and trails where appropriate	Limited need	Limited need	Limited need
Limit creation of new roads and installation of new infrastructure crossing waterbodies, buffers and environmental corridors	Moderate need	Moderate need	Moderate need
Preserve small wetlands and woodlands not located in identified environmental corridors, buffers, or natural resource areas	Moderate need	Moderate need	Critical need

Critical need   Moderate need   Limited need

Source: SEWRPC.

enhanced along manipulated drainage ways as part of projects that help stabilize eroding beds and banks. Artificial buffers can take a number of different forms. A few examples include grassed waterways, vegetative strips, and non-row-crop agriculture paralleling shorelines. Such buffers are generally constructed to intercept runoff shortly before it enters a stream or lake. Artificial buffers function in a similar way to natural buffers (e.g., they slow run-off); however, they need to be carefully designed and should use native plants or appropriate crops to ensure long-term function. Artificial buffers can enhance lake water quality without significant adverse effect to residential and agricultural land use purposes. More details regarding artificial buffers and their efficacy are included in Appendix D. Example buffer recommendations by waterbody classification are listed in Table 13.

GROUNDWATER RECHARGE

Groundwater recharge supplies water to aquifers feeding lakes and streams and providing reliable dry-weather flow (i.e., baseflow). Baseflow is an essential component of natural hydrology. Baseflow maintains aquatic life during drought which contributes to the overall health of surface waterbodies. Seepage lakes are especially dependent on groundwater flow. The availability of groundwater can be reduced by increased consumptive water use within the groundwatershed, water export from the groundwatershed, decreased infiltration caused by development (i.e., increased impervious surface), and increased evapotranspiration caused by climatic warming. Groundwater is the dominant source of high quality, cold water to most surface waterbodies during the critical summer months.

Table 14

EXAMPLE GROUNDWATER RECHARGE MANAGEMENT STRATEGIES

Management Strategies	Protection Waters	Protection & Restoration Waters	Restoration & Enhancement Waters
Protect and preserve land with very high and high recharge potential	●	●	●
Consider groundwater conditions when locating buildings - avoid locating buildings in shallow groundwater areas, discharge areas, and recharge areas	◍	●	●
Consider groundwater while burying utilities (e.g., sewers, water lines) and other infrastructure that could intercept and divert groundwater flow	◍	◍	●
Reduce negative impact of future and existing development on groundwater quality and quantity by using best management practices that increase infiltration	●	●	●
Consider the effect of new development and infrastructure (e.g., sewers, wells) on existing groundwater hydrology. Consider adopting a groundwater protection ordinance.	●	●	●
Implement pollution reduction measures in agricultural areas and other areas of potential nonpoint source pollution located in very high/high groundwater recharge areas or infiltration facilities	●	●	●

● Critical need ◍ Moderate need ○ Limited need

Source: SEWRPC.

Infiltration through soils (i.e., groundwater recharge) provides some level of pollution reduction. However, groundwater remains vulnerable to certain types or higher-than-natural pollutant loading. This vulnerability should be particularly considered in high groundwater recharge potential areas since such areas often contribute the bulk of water supplying local groundwater flow systems.[5] A long list of contaminant sources can pollute groundwater supplies. For example, industrial operations, bulk storage areas, and landfills can release contaminants that can degrade groundwater quality. Agricultural product storage facilities, highly groomed landscapes, and agricultural lands can be potential sources of nutrients, pathogens, and pesticides. Residential areas can contribute nutrients, pesticides, salts, heavy metals, and organic contaminants from lawn care, water treatment, vehicle storage and maintenance, and other activities.

Many methods are used to maintain or enhance groundwater recharge. Table 14 highlights example recommendations for each waterbody classification. Reducing impervious surfaces associated with both existing and new

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[5] *SEWRPC studied groundwater potential in the Southeastern Wisconsin Region. More information on groundwater recharge potential can be found in Technical Report Number 47,* Groundwater Recharge in Southeastern Wisconsin Estimated by a GIS-Based Water Balance Model, *SEWRPC, 2008.*

development and locating denser development outside of high groundwater recharge areas increases the soil area that can absorb rainwater and allow recharge of groundwater supplies. Infiltration can also be improved and pollution minimized through best management practices (BMPs) such as:

- Bioretention facilities;
- Rain barrels and cisterns;
- Permeable pavement or pavers;
- Disconnected downspouts from sewers;
- Substituting grassed swales for curb and gutter, where appropriate;
- Active infiltration of detained stormwater, graywater, or highly treated wastewater;[6]
- Green parking design;
- Infiltration basins;
- Riparian buffers;
- Sand and organic filters;
- Soil amendments;
- Stormwater planters;
- Tree box filters; and,
- Vegetated filter strips

SURFACE-WATER HYDROLOGY

Urban development brings significant changes to the landscape. These changes historically include modified drainage patterns, hardened or armored land surfaces, and reduced groundwater infiltration. All of these changes generally increase the volume and speed of runoff leaving the landscape from precipitation events and snowmelt. Historically, managing these increases often involved constructing storm sewers, open channel drainage systems, and/or straightening streams to convey stormwater as quickly as possible to large natural waterbodies. These changes decrease the time needed for water from a storm or snowmelt event to reach a stream or lake, increasing the flashiness of the receiving waterbody.[7] Increased flashiness can cause flooding, water quality impairment, erosion, infrastructure damage, safety concerns, and environmental degradation. These negative effects have driven development of alternative stormwater management approaches. Consequently, current stormwater management practices seek to mitigate runoff using a variety of measures focusing on mimicking natural processes, especially those of detention, retention, infiltration, and filtration (Table 2). Minimizing impervious surfaces can reduce the amount and speed of runoff. Restoring or enhancing natural features such as stream meanders, buffers, and reconnecting floodplains can reduce flashiness. Example recommendations regarding surface hydrology are listed in Table 15 by waterbody classification category.

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[6] *Wisconsin regulations prevent degradation of groundwater quality - a premise of State law is that all groundwater is potentially a source of drinking water. Therefore, groundwater quality standards are based upon potable water standards. Infiltration facilities are subject to these standards, and may require active groundwater quality monitoring to demonstrate compliance. Furthermore, some water sources may not be suitable for infiltration without advanced treatment.*

[7] *The flow volume of "flashy" streams changes rapidly and radically. During fair and dry weather periods, flow may be very low or may cease altogether. However, flows increase extremely rapidly after precipitation or snowmelt events, and runoff during these events is commonly much greater than comparable natural streams. However, the peak flow of flashy streams quickly diminishes after precipitation or snowmelt ceases.*

Table 15

EXAMPLE SURFACE-WATER HYDROLOGY MANAGEMENT STRATEGIES

Management Strategies	Protection Waters	Protection & Restoration Waters	Restoration & Enhancement Waters
Follow recommendations for Buffer and Corridors, Groundwater Recharge, plus the following:			
Minimize impervious surface in new construction	●	●	●
Employ green infrastructure practices whenever practical.	●	●	●
Restore natural landscape elements that reduce flashiness (e.g., floodplains, natural stream channel configurations, wetlands)	○	◍	●
Inspect and properly maintain stormwater management infrastructure	◍	◍	●
Implement agricultural conservation practices (e.g., low and no till cropping)	◍	◍	●

● Critical need ◍ Moderate need ○ Limited need

Source: SEWRPC.

WATER QUALITY

Humans can profoundly affect surface-water and groundwater quality. Therefore, recommendations related to groundwater recharge and surface hydrology are important to maintain and/or improve water quality. Two broad strategies are suggested to protect water quality. The first is to reduce pollution sources while the second is to protect, restore, and enhance naturally occurring pollution removal processes within the watershed and waterbody. A few example water quality recommendations with their inherent suitability for each waterbody classification are presented in Table 16.

Pollution sources can be reduced by applying both agricultural and urban best management practices. Examples of agricultural best management practices include the following:

- Minimize tillage, address soil compaction, and avoid other soil disturbance, which degrades soil structure and infiltration capacity;
- Retain vegetation year-round, employing cover crops;
- Prevent livestock access to waterbodies;
- Avoid excessive use of crop nutrients and pesticides - conscientiously follow nutrient manage plans and label directions;
- Establish cropped/harvestable buffers in areas close to streams and lakes;
- Avoid stream crossings whenever possible; and,
- Implement environmentally sensitive storage and disposal practices for silage, manure, and other high nutrient substances to minimize the potential for runoff or leakage.

Table 16

EXAMPLE WATER QUALITY MANAGEMENT STRATEGIES

Management Strategies	Protection Waters	Protection & Restoration Waters	Restoration & Enhancement Waters
Follow recommendations for Buffer and Corridors, Groundwater Recharge, and Surface Hydrology, plus the following:			
Reduce non-point source pollution from agricultural areas by employing runoff best management practices	Limited need	Moderate need	Critical need
Avoid storing silage, manure, salt, fuel, and other contaminants near water bodies and wetlands	Critical need	Critical need	Critical need
Promote good housekeeping practices such as management of fertilizer, pesticide use, trash, pet waste, lawn watering, leaf litter, and yard waste	Moderate need	Moderate need	Critical need
Minimize salt use for de-icing and water softening	Critical need	Critical need	Critical need
Avoid coal tar-based asphalt sealants	Critical need	Critical need	Critical need
Inspect, maintain, and naturalize/enhance (e.g., riparian vegetation and floating treatment wetlands) stormwater retention basins to improve pollution reduction capabilities	Limited need	Moderate need	Critical need
Minimize connected impervious surfaces. Substitute grassed waterways for lined channels and buried piping	Moderate need	Critical need	Critical need
Identify major stormwater outfalls and the potential benefit of water quality retrofits	Limited need	Moderate need	Critical need
Restore marginal farmed wetlands/floodplains and or degraded wetlands/floodplains. Assure that wetlands and floodplains are well connected to waterbodies.	Moderate need	Critical need	Critical need
Minimize soil disturbance when using heavy equipment	Critical need	Critical need	Critical need

Critical need   Moderate need   Limited need

Source: SEWRPC.

Pollutant loads from developed areas can be lessened by following good housekeeping practices. Examples of such practices include:

- Modify stormwater infrastructure to detain, treat, and infiltrate runoff (as discussed in the *Groundwater Recharge* section above);
- Manage landscaping chemicals- minimize fertilizer and pesticide use;
- Properly dispose of yard waste, trash, and pet waste;
- Minimize lawn watering, especially directly after applying fertilizer or pesticides;
- Remove leaf litter and yard waste from shoreline areas and ensure proper disposal (i.e., pickup or composting in uplands);

- Sweep streets and expeditiously collect leaves;
- Direct downspouts to grassy areas underlain by porous soils and rain gardens – do not discharge downspouts directly to paved areas, storm sewers, or roadside drainage ways;
- Avoid coal-tar based asphalt sealants; and,
- Minimize salt use in the open environment (e.g., chloride-based road deicers, water softener regeneration brine).

The second component of strategic plans that aim to improve water quality involves protecting, restoring, and enhancing natural features that attenuate pollutants. Buffers can reduce pollutant loads to water bodies. As surface water flows through buffers, pollutants are filtered out before water enters lakes and streams. Wetlands and floodplains efficiently improve water quality by slowing water and allowing pollutants to settle out and/or be biologically processed. Enhancements such as preserving infiltration capacity in watersheds, substituting unlined vegetated ditches for curb and gutter systems, and converting dry detention basins to wet basins with permanent ponds or infiltration basins can benefit water quality.

WILDLIFE AND FISHERIES

Healthy wildlife and aquatic organism populations (including but not limited to deer, amphibians, reptiles, birds, small animals, and fish) are the ultimate indication of a healthy watershed. This is largely attributable to the fact that wildlife and aquatic organism populations require diverse, well-connected natural areas, which are also associated with good water quality and aquatic habitat. Aquatic organisms such as fish, mussels, and insects are essential to retaining ecological health. Healthy aquatic, riparian, and upland ecological communities provide the basis for high-demand active recreational pursuits such as hunting, fishing, birdwatching as well as improving overall aesthetic appeal that benefits all human waterbody uses.

For terrestrial wildlife, preserving, restoring, and enhancing buffers and environmental corridors is of paramount importance. These features provide life-cycle critical refuge, foraging, breeding areas, and nursery areas. Environmental corridors also help maintain or create ecological connection between sections of habitat. Habitat fragmentation (i.e., dividing useable wildlife habitat into pieces with intervening inhospitable land use areas) prevents wildlife from moving from one natural area to another. Terrestrial habitat is often fragmented by roads and intensive development, and is a major threat to genetic diversity. Habitat fragmentation limits wildlife access to the variety of potential environments that provide life-cycle critical functions. For example, wildlife's ability to communicate, detect prey, and avoid predators is impeded by mortality hazards (e.g., road hits), noise, light, physical barriers (e.g., fencing, large expanses of pavement, steep slopes), and vibrations created by roads and associated traffic. Fragmented terrestrial habitat also has more edge, a situation encouraging colonization by invasive and nuisance plants and animals, which in turn compromises the habitat's value to many native species limiting the productivity of the habitat block. To survive in the long term, some native species require large uninterrupted blocks of ecologically intact habitat (e.g., forest interior birds).

Fish and other organisms migrate in and around lakes and streams. Aquatic organisms need access to a variety of habitat types to survive and successfully sustain their populations. For example, many popular gamefish ascend small streams feeding larger lakes and rivers to find habitat types suitable for reproduction which are not available in large rivers and lakes. If such habitat is inaccessible, the populations of such fish ultimately decline and may require stocking to maintain, if practicable, or may become locally extinct. Even small intermittent streams provide life-cycle critical habitat for some popular gamefish (e.g., northern pike, perch) and forage fish (e.g., suckers, certain minnow species).

Human influence is particularly pronounced in stream environments where infrastructure is built to benefit people. Much of this infrastructure can impede or block movement of fish and other aquatic organisms. Examples of such infrastructure includes dams, road or railway/stream crossings (e.g., high velocity stretches, perched outlets, and/or shallow water depth culverts), ditched and enclosed stream segments, and fords. Human-induced change can also impede the ability of fish and other aquatic organisms to migrate. Excessive sediment, debris, and dense growth of invasive plants can make stream reaches impassable to fish and other aquatic organisms. The philosophy and comprehensive process used to improve aquatic habitat in the lower rural/urban fringe portion of the Milwaukee River watershed is described in a paper included in Appendix E. This paper's study area (Ozaukee County) has many characteristics similar to Kenosha County.

The first step of any program aiming to maintain and enhance aquatic organism passage is developing a database identifying where viable habitat is isolated by artificial structures and channel conditions, and quantifying the physical nature of each migration impediment. An inventory of migration impediments allows the location, potential cost, and interplay of migration impediments to be quantified, and provides critical planning information and justification for future grant applications.[8] Projects that may benefit fish and aquatic organism passage on smaller streams include the following examples, all of which aim to maintain, and enhance to the extent practical, the physical, biological, sediment and debris transport, chemical, and hydrologic characteristics of streams.

- Control the amount of impervious surface in watersheds and install features that enhance infiltration and detention of runoff
- Protect groundwater supplies
- Preserve riparian buffers and protecting spawning areas and riffles
- Restore natural configuration of streambeds and banks where modified with emphasis on restoring and enhancing floodplain and riparian wetland hydrologic connectivity
- Remove artificial migration impediments (e.g., human-induced debris jams, excessively shallow water reaches, velocity barriers, vertical displacement barriers)
- In modified stream reaches, enhance instream pool and riffle habitats to increase spawning habitat and add deep-water resting places
- Promote alcove environment at the mouths of tributary streams to provide refuge from warm waters during low-flow summer conditions
- Revegetate stream banks/lake shorelines to increase shade, keeping waters cooler in the summer and providing vital nearshore habitats for wildlife
- Promote or install coarse woody structure to increase habitat and protect shorelines

As stream habitat and connectivity improve over time, wildlife and aquatic organism populations will be better able to sustain their numbers and grow to healthy sizes and abundance.

Many human activities can directly impact fish and wildlife. For example, mowing wetlands and shorelines and ditching streams destroys valuable habitat. Conversely, leaving dead trees and other coarse woody material to decompose naturally adds both aquatic and terrestrial habitat. Preventing introduction of invasive species, minimizing disturbance of habitat, and removing trash can benefit fish and wildlife populations. Example management recommendations for each waterbody classification group are listed in Table 17.

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[8] *Ozaukee County has a well-developed aquatic organism passage program, and has a landscape and a level of development similar to much of Kenosha County. Ozaukee County's impediment and habitat inventory process is outlined at the following link: http://www.co.ozaukee.wi.us/2089/Impediment-and-Habitat-Inventories. The website also has considerable information regarding other aspects of aquatic organism passage and habitat prioritization.*

Table 17

EXAMPLE WILDLIFE AND FISHERIES MANAGEMENT STRATEGIES

Management Strategies	Protection Waters	Protection & Restoration Waters	Restoration & Enhancement Waters
Follow recommendations for Buffer and Corridors, Groundwater Recharge, and Surface Hydrology, and Water Quality plus the following:			
Preserve and enhance environmental corridors. Avoid further habitat fragmentation. Endeavor to naturalize corridors between habitat blocks.	Critical need	Critical need	Critical need
Control livestock access to waterbodies or consider alternative watering sources to leave habitat intact.	Moderate need	Moderate need	Moderate need
Allow dead trees and other coarse woody material that falls into waterbodies to decompose naturally.	Moderate need	Moderate need	Critical need
Avoid mowing wetlands, shorelines and ditches.	Moderate need	Critical need	Critical need
Actively manage woodlands and wetlands to maintain ecological function by reducing invasive species populations and taking action to contend with introduced pests (e.g., emerald ash borer).	Critical need	Critical need	Critical need
Avoid introducing non-native species (i.e. fire ants, flatworms, yellow floating heart, rusty crayfish, round goby, goldfish)	Critical need	Critical need	Critical need
Implement riparian and in-water cleanup efforts	Moderate need	Moderate need	Moderate need
Remove human-induced debris jams that impede water, debris, sediment, and/or aquatic organism passage.	Critical need	Critical need	Critical need
Remove or retrofit infrastructure that act as terrestrial passage barriers.	Moderate need	Moderate need	Moderate need
Inventory aquatic organism passage impediments and develop prioritized remedial action plan	Critical need	Critical need	Critical need
Remove or redesign stream crossing and other infrastructure that compromises stream stability and/or impedes water, sediment, debris, and aquatic organism passage.	Critical need	Critical need	Critical need
Protect fishery diversity and aquatic habitat	Critical need	Moderate need	Limited need
Restore and or rehabilitate ditched and otherwise modified stream reaches.	Limited need	Moderate need	Critical need
Remove (preferred), restore, or modify failing shoreline infrastructure	Limited need	Moderate need	Critical need

Critical need   Moderate need   Limited need

Source: SEWRPC.

MONITORING

Beyond the active management activities discussed above, monitoring waterbodies is also advised to allow change, either positive or negative, to be noted and acted upon. Two volunteer groups exist for lake and stream monitoring: the University of Wisconsin-Extension Citizen Lake Monitoring Network (CLMN) and Water Action Volunteers (WAV) for stream monitoring. CLMN volunteers record water clarity readings, determine trophic status, measure temperature and dissolved oxygen profiles, and monitor native and invasive aquatic plants and species.[9] Many of these parameters are also monitored by WAV including dissolved oxygen, temperature, and water clarity, but WAV volunteers also monitor streamflow, habitat, and macroinvertebrates.[10] Monitoring lakes and streams creates baseline water quality data that helps quantify the current health of the system. This data also helps identify trends in water quality over longer periods of time.

Water quality is not the only monitoring activity that provides value to waterbodies. Monitoring extant native and non-native flora and fauna in and around waterbodies helps quantify ecological shifts over time. Non-native species should be monitored to maintain awareness of the presence, growth and nuisance level of non-native species, and to help determine when and to what extent active management methods should be considered. This also helps allow rapid recognition of new non-native species, when the infestation is still limited in extent and most manageable. Monitoring native species is also important, since the native flora and fauna are the foundation of Kenosha County's ecology and define the habitat attributes used to help identify if a system is healthy or not. Therefore, monitoring aquatic plants, fish, and other wildlife can illustrate if the diversity of species in the system is declining, is improving, or is stable.

Certain volunteer groups focus on invasive species monitoring, including Project RED (Riverine Early Detectors) and Clean Boats Clean Waters (CBCW). Project RED is a volunteer group that identifies, reports, and controls invasive species in and along rivers and streams.[11] The CBCW initiative helps slow the spread of invasive species to lakes by conducting boat inspections at boat launches. These volunteers educate boaters on aquatic invasive species and help them properly and efficiently identify and check equipment for undesirable species.[12] Such efforts help maintain the integrity of the existing native community. Any management actions to remove non-native species, and/or to improve native species diversity, helps support healthier and more diverse wildlife within and adjacent to waterbodies within Kenosha County.

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[9] *For more information on CLMN visit http://www.uwsp.edu/cnr-ap/UWEXLakes/Pages/programs/clmn or contact Paul Skawinski at Paul.Skawinski@uwsp.edu*

[10] *For more information on WAV visit http://watermonitoring.uwex.edu/wav/*

[11] *For more information on Project RED visit https://www.wisconsinrivers.org/our-work/project-red*

[12] *For more information on CBCW visit http://www.uwsp.edu/cnr-ap/UWEXLakes/Pages/programs/cbcw/ or contact Erin McFarlane at Erin.McFarlane@uswsp.edu*

IMPLEMENTATION AND EDUCATION

Kenosha County should consider pursuing/developing watershed level plans that are "consistent with" (or approved according to) the Environmental Protection Agency's Nine Key Element standards for watershed restoration.[13] Having a plan consistent with Nine Key Element standards allows watershed stakeholders with specific recommendations in the plan to be eligible for grants using Federal section 319 funds (i.e. Targeted Runoff Management funds for agricultural and urban areas). Projects in the plan may also qualify for Great Lakes Restoration Initiative (GLRI) funding as determined by EPA and GLRI staff. The County would need to work with the Department of Natural Resources, landowners, municipalities and other stakeholders to implement plan recommendations.

Helping property owners, nongovernmental organizations (NGOs), local government agencies, and business owners better understand watershed management, its importance, and how they can actively participate in effective implementation benefits water resource management plans. Community members and waterbody users have the ability to further degrade or improve conditions in Kenosha County's waterbodies. Encouraging widespread landowner and other interested party acceptance and use of common best management practices can measurably improve waterbody health.[14] Example recommendations for community residents and waterbody users include:

- Promoting informational and educational activities that draw attention to Kenosha County's water resources, including:
    - Installing signs visible from highways and other transportation routes that identify the names of the County's lakes and streams. Named waterbodies generally are placed in higher esteem than unnamed "ditches,"
    - Identifying key watershed boundaries (e.g., Fox River, Des Plaines, and Lake Michigan drainage basins). Emphasize locating the subcontinental divide separating water flowing to the Great Lakes from that draining to the Mississippi River),
    - Fostering volunteer water quality monitoring,
    - Distributing information describing household best management pollution prevention practices,
    - Distributing information on invasive species control and prevention,
    - Maintaining the ecological integrity of natural areas by excluding invasive species and managing landscapes to compensate for negative change (e.g., woodland canopy die-off from tree disease such as emerald ash borer),
    - Promoting onsite reuse of composted leaves and grass clippings,
    - Discouraging disposal of leaves and other refuse in shoreline areas,
    - Minimizing pavement and other impermeable land covers,
    - Properly using lawn and garden fertilizers and pesticides, and,
    - Promoting stormwater infiltration practices.

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[13] *More information about Nine Key Element plans is available from many on-line resources, including the Wisconsin DNR. A relevant Wisconsin WDNR website can be found at the following address: http://dnr.wi.gov/topic/nonpoint/9keyelementplans.html.*

[14] *A wealth of excellent educational materials are available free on the internet from a wide variety of local, state, and federal agencies and other organizations. An example with particular relevance to Wisconsin lakes is the Healthy Lakes Program. More information about the Healthy Lakes Program can be found at the following website: http://healthylakeswi.com/. The Healthy Lakes Program distributes information booklets about many of the issues discussed in this report.*

- Encouraging citizen participation in implementation of large-scale project recommendations;
- Encouraging inclusion of water resource-oriented curricula and projects in local schools;
- Identifying activities appropriate to youth and service organizations and sharing these with the leadership of these groups (e.g., Eagle Scout projects, community garden projects); and,
- Promoting synergies with existing community activities and organizations such as recycling and public health.

Example recommendations for business owners, municipalities, developers, and farmers:

- Application of modern soil conservation and water quality practices including the following examples:
  - Cropped/harvestable buffers
  - No-till, strip-till, and mulch-till agriculture
  - Low disturbance manure application
  - Cover crops and interseeding cover crops into corn and soybeans
  - Nutrient management plans
  - Roofed animal lots
  - Retirement of marginal cropland, conversion to less intensive cropping system, or enrollment in conservation programs
- Encouraging installation and use of green infrastructure,
- Encouraging street sweeping in early spring and prompt leaf pickup in fall to reduce phosphorus loads to waterbodies,
- Vigorous enforcement of existing ordinances, particularly those dealing with water quality and riparian areas,
- Adoption of groundwater protection ordinances,[15]
- Encouraging practices that support waterbody health, such as use of natural landscaping and stormwater management in yards and parking areas, and,
- Encouraging participation of builders and developers by:
  - Sponsoring workshops focusing on special and alternative design considerations supporting preservation or enhancement of surface-water ecosystems as part of development,
  - Informing clients about the process of making positive environmental choices with respect to remodeling, rebuilding, and constructing new buildings, and,
  - Preserving green space,
  - Helping developers and speculators appreciate that properties adjoining healthy noteworthy waterbodies demand higher prices, thereby demonstrating that conservation add value.

[15] *The Village of Richfield Wisconsin, located in southern Washington County, promulgated a successful groundwater ordinance over a decade ago. For more information, visit the Village's groundwater protection website: http://www.richfieldwi.gov/index.aspx?NID=300*

SUMMARY

A waterbody classification system is based on the notion that water resource plans, policies, and programs can be tailored and targeted to better meet resource objectives and needs as well as priorities of the community. In other words, a uniform policy approach may not be necessary or even appropriate in many cases. The principle emphasis of this study was to develop a classification system that is intuitive, relatively simple, and is supported by current science and resource information. It also has been designed so that it can be easily updated as new or better information becomes available. The classification system provides the basis and framework for guiding program resources, promoting cost-sharing opportunities, and also partnerships among the various agencies and groups.

This classification system provides a basis for coordinated protection and management of the lakes and streams throughout Kenosha County. Coordinated management among all municipalities, landowners, NGOs, and other interested parties helps assure that the *overall* interests and priorities are the basis for planning, communication, decision making, and implementation. Since grant awards often favor projects with larger-scale focus that appeal to a wide range of stakeholders, this plan can be used to demonstrate the larger scale focus of Kenosha County's water resource related projects. Table 18 provides a list of potential grants to help fund management activities. It must be remembered that many other sources of grant funding are available including Federal agencies, NGOs, in-kind donations, and cash from private charities and donations.

The classification plan is just the beginning. Future efforts may involve public input, discussion of priorities, identification of limitations or gaps in existing programs, and evaluation of how the program may be enhanced or improved. This report provides the necessary background information and basis for community discussions and efforts. For example, a particular management strategy or activity will vary depending on whether it is targeted to a lake or stream; focused on protection, restoration, or enhancement (based on the classification); leaning more toward a regulatory, incentive, or educational approach; or leading to specific urban or rural designs, practices, or activities. Agencies, groups, and individuals can focus their activities on the projects that hold the most promise taking into account their available skills, resources, and support base. The waterbody classification system and suggested management programs are intended to provide a common understanding and framework by which the various partners can work together; combine technical, financial, and volunteer resources; and target activity where it is most needed and would yield the greatest benefit.

Coordinated implementation of recommended measures provides the water quality and habitat protection foundation needed to protect, enhance, and/or restore waterbody health. Healthy waterbodies are intrinsically more valuable from many perspectives, which in turn benefits landowners and resident and nonresident users of Kenosha County's water resources.

Table 18

EXAMPLE WDNR GRANTS AVAILABLE FOR LAKE AND STREAM MANAGEMENT

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

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

Source: Wisconsin Department of Natural Resources and SEWRPC.

APPENDICES

Appendix A

LAKE AND WATERSHED SENSITIVITY AND HUMAN INFLUENCE CRITERIA: VARIABLES; PARAMETER VALUES; SCORING CATEGORIES AND WEIGHTING; AND, CLASSIFICATION RANKING FACTORS

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Table A-1

LAKE AND WATERSHED SENSITIVITY INPUT VARIABLES AND SCORING BRACKETS

Sensitivity Criteria					Scoring		
Criterion	Data Source	Description	Measured Value/Units	Lake Classification Significance	Value Brackets	Score	Formula Weighting
Lake and Shoreline							
Natural Community	WDNR	Lake morphology and watershed conditions are used to predict the ecologic conditions of lakes and their tolerance to enrichment. Certain types of lakes are more sensitive to nutrient enrichment and watershed disruption.	WDNR Natural Community Estimate	Lakes that stratify and that do not have large watersheds are generally identified as more sensitive.	Shallow Lowland	1 (least sensitive)	2.00
					Shallow Headwater	2	
					Deep Lowland	3	
					Deep Headwater	4	
					Deep Seepage	5 (most sensitive)	
Shallow Areas	WDNR	Portions of a lake less than 3 feet deep.	Dimensionless percentage	Shallow areas of lakes are more prone to disturbance by boating and other high-intensity human activities. This can lead to sediment resuspension, cloudier water, detrimental effects to fish spawning and nursery areas, and changes to the aquatic plant community.	<12%	1 (least sensitive)	1.25
					12%-17%	2	
					>17%-40%	3	
					>40%	4 (most sensitive)	
Potential for high Internal Loading	WDNR	Certain lakes are deep enough to stratify. During summer, the water in cold, deep portions of such lakes may be devoid of oxygen, leading to conditions that allow phosphorus from the lake bottom to re-enter the water column. This internal load of phosphorus can become an important source of excess nutrients to the lake.	Percentage of lake bottom more than 20 feet below the water surface.	Lakes that stratify and have large areas of anoxic water in contact with the lake bottom are have the most potential for internal loading. Lakes with significant internal loading of phosphorus are more prone to have excess nutrient levels, which can lead to nuisance plant growth and algal blooms.	0%	1 (least sensitive)	1.00
					0%-20%	2	
					>20%-40%	3	
					>40%	4 (most sensitive)	
					<2 feet	1 (least sensitive)	
					2 - 4 feet	2	
					>4 - 8 feet	3	
					> 8 feet	4 (most sensitive)	
Shoreline Development Factor (SDF)	SEWRPC	Lakes with irregular shapes have more shoreline per acre of lake surface. More shoreline can translate to more lots and homes. The shoreline development factor contrasts the shoreline length of a given lake to the equivalent sized perfect circle. The minimum score is 1.0, which means the lake is a perfect circle.	SDF/Dimen-sionless Ratio.	Higher values are associated with lakes with irregular shorelines. The more irregularly shaped the lake, the more lots can be potentially be developed per acre of open water.	1.0 - 1.1	1 (least sensitive)	1.50
					>1.1 - 1.5	2	
					>1.5- 2.0	3	
					>2.0	4 (most sensitive)	
Two-Story Fishery	WDNR Publica-tions	Certain fish species (e.g., trout, cisco, whitefish) require cold water to survive year round, conditions only found at depth in deep lakes during the summer. The deep water in many lakes does not contain sufficient oxygen to support fish life. However, certain lakes do have cold oxygenated water in deep areas during summer, and are able to support both cold and warm water species. Such lakes are considered to have a two-story fishery.	Presence or Absence of Two-Story Fishery	Lakes with two-story fisheries are sensitive to nutrient enrichment. Excess nutrients can lead to abundant plant and algal growth, which in turn can deplete deep-water oxygen during the summer. When oxygen is depleted in the cold water area, cold-water dependent fish must leave the lake or die.	Absent	1	1.00
					Present	2	

Table A-1 (continued)

Sensitivity Criteria					Scoring		
Criterion	**Data Source**	**Description**	**Measured Value/Units**	**Lake Classification Significance**	**Value Brackets**	**Score**	**Formula Weighting**
Watershed (areas beyond 1,000 feet of lake shoreline)							
Stormflow Processing	SEWRPC	Wetlands and floodplains detain and slow runoff, and can help remove pollutants from runoff improving water quality.	Acres of floodplain plus acres of wetland divided by total watershed area/dimension less percentage	Lakes with watersheds occupied by large amounts of wetlands and floodplains are more able to attenuate pollutants, and are therefore less sensitive to changes in upland areas.	>30%	1 (least sensitive)	1.00
					>20% - 30%	2	
					10% -20%	3	
					<10%	4 (most sensitive)	
Groundwater Recharge Areas	SEWRPC	Proportion of very high and high recharge potential area to total watershed area. Higher percentages commonly correlate with more abundant groundwater supplies to lakes and reduced runoff intensity.	Sum of acres of very high and high recharge potential (based upon SEWRPC studies) divided by total watershed area/dimension less percentage	Permeable soil types (e.g., sands and gravels) and more level areas are more conducive to surface-water infiltration. More infiltration generally provides greater supplies of cool clean water during dry periods and reduces the volume of storm runoff. Reduced stormwater runoff volumes commonly is related to higher stream water quality.	>40%	1 (least sensitive)	1.50
					>20%-40%	2	
					5%-20%	3	
					<5%	4 (most sensitive)	
Watershed Size Weighting Factor	SEWRPC	The relative size of a lake's watershed versus its surface area effects the significance of watershed-based variables. To account for this issue, the watershed size was divided by each lake's size, and the average watershed to lake ratio was determined for the study area. Next, each lake's watershed to lake ratio was normalized by dividing by the study area average watershed to lake ratio, yielding this study's watershed size weighting factor.	Dimensionless numbers less than 1.0 reveal that a lake's watershed to lake ratio is smaller than typical. Lakes with values greater than 1.0 have larger than typical watersheds.	Lakes with large watersheds versus their size will be affected more greatly than lakes that have modest watersheds compared to their size. The watershed size weighting factor gives more importance to watershed-related factors in lakes with large watersheds.	N/A	N/A	N/A

NOTE: The parameters are weighted differently for final scoring.

Source: SEWRPC.

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Table A-2

LAKE AND WATERSHED SENSITIVITY PARAMETERS AND VALUES

	Lake and Shoreline Characteristics								Watershed Characteristics				
Lake	Surface Area-Published Value Range[a]	Surface Area-Value Used in This Study[b]	Water Less Than 3 Feet Deep (Percent)[c,d]	Water Greater Than 15 Feet Deep (Percent)[d]	Shoreline Development Factor	Water Clarity (Feet)	Natural Community Assignment	Two-Story Fishery	Watershed Area (Acres)	Proportion of Watershed Occupied by Mapped Wetlands and Floodplains (Percent)	Proportion of Watershed Very High and High Ground-water Recharge Potential Areas (Percent)	Watershed /Lake Acreage Ratio	Watershed Size Weighting Factor
Benedict	76-81	81	13	41	1.3	8 to 16	Deep Headwater	No	976	9	46	12.1	1.2
Camp	439-523	523	53	3	1.6	4 to 8	Shallow Lowland	No	3,087	42	11	5.9	0.6
Center	126-146	146	16	19	4.0	4 to 8	Deep Lowland	No	2,502	22	29	17.2	1.7
Cross	87-89	88	19	32	1.7	8 to 16	Deep Headwater	No	100	1	1	1.1	0.1
Dyer	51-66	66	23	0	1.1	4 to 8	Shallow Headwater	No	840	23	75	12.7	1.3
Flanagan	11-12	12	14	32	1.1	2 to 4	Deep Seepage	No	185	2	8	15.9	1.6
Francis	16-17	17	13	34	1.7	8 to 16	Deep Headwater	No	171	22	32	10.0	1.0
Friendship	11-13	13	21[e]	0	1.1	1 to 2	Deep Headwater	No	253	19	2	20.1	2.0
Hooker	103-113	113	17	33	1.6	8 to 16	Deep Headwater	No	1,380	29	7	12.2	1.2
Kull	13-17	17	18	0	1.0	4 to 8	Deep Headwater	No	469	12	0	28.0	2.8
Lily	84-86	86	8	26	1.0	8 to 16	Deep Seepage	No	133	0	4	1.5	0.2
Montgomery	57-61	61	44	8	1.7	8 to 16	Deep Headwater	No	314	45	0	5.2	0.5
Powers	451-459	458	10	49	1.8	8 to 16	Deep Headwater	No	1,915	46	45	4.2	0.4
Rock	44-55	53	9	66	1.2	8 to 16	Deep Seepage (presumed)	Yes	540	13	2	10.2	1.0
Shangri-La/Benet	181-200	181	32	3	3.1	2 to 4	Deep Seepage (presumed)	No	518	38	12	2.9	0.3
Silver	464-528	528	22	21	1.2	4 to 8	Deep Lowland	No	3,308	28	31	6.3	0.6
Voltz	55-64	64	20	17	2.1	8 to 16	Deep Headwater	No	381	8	3	5.9	0.6
Averages	- -	*147*	21	23	*1.7*	- -	- -	- -	*1004*	*21*	*18*	*10.1*	*1.0*

[a]Reported lake surface area varies widely by source and over time. Some of the reasons why this may happen includes water elevation changes, differences in vegetation over the years, inclusion or exclusion of fringing marsh, and inclusion or exclusion of channels leading off the main body of the lake, or actual changes in the lake shoreline over the 60-year period of record.

[b]The lake surface area used in this study was believed by SEWRPC to best represent the present ordinary high water mark open water area of the lakes. It generally includes connected channels and sparsely vegetated marsh, and therefore tends toward the larger side of published values.

[c]Lakes with poorly quantified, unmeasured, or very limited areas of less than 3 feet of water depth remain blank in this table.

[d]Most water depths were measured during the 1950's and 1960's by WDNR, and may not fully represent present conditions. Montgomery Lake water depths were measured by SEWRPC.

[e]A bathymetric map was not available for Friendship Lake. Therefore, the average proportion of shallow water area for the other study area lakes was assigned for scoring purposes.

Source: SEWRPC.

Table A-3

LAKE AND WATERSHED SENSITIVITY SCORES

	Lake and Shoreline Factors							Watershed Factors				Sensitivity Scores	
Factor Weights	2.00	1.25	1.00	1.00	1.50	1.00	- -	1.00	1.50	- -	- -	- -	- -
Lake	Natural Community	Shallow Areas	Potential for High Internal Loading	Water Clarity	Shoreline Develop-ment Factor	Two-Story Fishery	Lake-Based Subtotal Score	Stormflow Processing	Ground-water Recharge Areas	Watershed Size Weighting Factor	Watershed-Based Subtotal Score	Total Score	Category
Benedict	3	2	4	4	2	1	19.5	4	1	1.2	6.4	25.9	Medium
Camp	1	4	2	3	3	1	16.5	1	3	0.6	4.0	20.5	Low
Center	2	2	2	3	4	1	17.5	2	2	1.7	7.3	24.8	Medium
Cross	3	3	3	4	3	1	21.3	4	4	0.1	2.5	23.7	Medium
Dyer	1	3	1	3	1	1	11.3	2	1	1.3	4.2	15.5	Low
Flanagan	4	2	3	2	1	1	17.0	4	3	1.6	12.0	29.0	High
Francis	3	2	3	4	3	1	20.0	2	2	1.0	5.0	25.0	Medium
Friendship	3	3	1	1	2	1	14.8	3	4	2.0	14.4	29.2	High
Hooker	3	2	3	4	3	1	20.0	2	3	1.2	7.4	27.4	Medium
Kull	3	3	1	3	1	1	15.3	3	4	2.8	18.3	33.6	High
Lily	4	1	3	4	1	1	17.8	4	4	0.2	3.0	20.7	Low
Montgomery	3	4	2	4	3	1	21.5	1	4	0.5	4.8	26.3	Medium
Powers	3	1	4	4	3	1	19.8	1	1	0.4	1.4	21.1	Low
Rock	4	1	4	4	2	2	28.3	3	4	1.0	9.1	37.3	High
Shangri-La/Benet	4	3	2	2	4	1	21.8	1	3	0.3	2.7	24.4	Medium
Silver	2	3	3	3	2	1	16.8	2	2	0.6	3.6	20.4	Low
Voltz	3	3	2	4	4	1	21.8	4	4	0.6	6.9	28.7	High
Averages	2.9	2.5	2.5	3.3	2.5	1.1	18.9	2.5	2.9	1.0	6.6	25.5	- -

Note: The formulas used to derive scores use the abbreviations below:

NC - Natural Community, SA - Shallow Areas, PHIL - Potential for High Internal Loading, WC - Water Clarity, SDF - Shoreline Development Factor, TSF - Two-Story Fishery, SP - Stormflow Processing, GRA - Groundwater Recharge Areas, WSWF - Watershed Size Weighting Factor

Lake-Based Subtotal = (NC*NC Weight * TSF*TSF Weight)+(SA*SA Weight)+(PHIL*PHIL Weight)+(WC*WC Weight)+(SDF*SDF Weight)

Watershed-Based Subtotal= (SP*SP Weight*WSWF)+(GRA*GRA Weight*Square Root(WSWF))

Sensitivity Score = Lake-Based Subtotal+Watershed-Based Subtotal

Source: SEWRPC.

Table A-4

LAKE AND WATERSHED HUMAN INFLUENCE INPUT VARIABLES AND SCORING BRACKETS

Human Influence Criteria					Scoring		
Criterion	Data Source	Description	Measured Value/Units	Lake Classification Significance	Value Brackets	Score	Formula Weighting
Lake and Shoreline							
Unprotected Shoreline	SEWRPC	Lakeshore are naturally resistant to erosion. When natural protection is removed, landowners commonly install walls, rip-rap, and other structures to protect shorelines from erosion. Some shorelines have no intact shoreline protection, and are prone to erosion.	Proportion of total shoreline length that is unprotected/ dimensionless.	Eroding shorelines contribute sediment and nutrients to lakes, commonly have little habitat values and damage nearby intact riparian and nearshore habitat, and are visually unattractive. Human influence commonly increases unprotected, eroding shoreline.	<3%	1 (least influence)	1.00
					3%-10%	2	
					>10%-50%	3	
					>50%	4 (most influence)	
Boat Access	WDNR	The number and locations where ramps and parking areas enable the public to trailer a boat and set it upon the water.	Number of public boat launches.	Invasive species commonly find their way to new habitat by "hitchhiking" on human equipment. For aquatic invasive species, boats are in important vector. Lakes with public boat launches are more at risk of aquatic invasive species infestations than lakes without public boat launches.	No public boat access	1 (least influence)	1.50
					Public carry-in boat access	2	
					Public power boat access	3 (most influence)	
Buffer	SEWRPC	In a natural setting, shoreland areas are typically profusely vegetated and host a wide variety of plants and animals. Humans commonly eliminate or greatly simplify shoreland areas. The heavy vegetation along shorelines slows runoff flowing towards the adjacent lake, which in turn allows sediment to settle out, nutrients to be absorbed, and water to soak into the ground. Such areas are labelled buffers. Buffers can be naturally occurring or can be restored or enhanced if damaged by human activity.	SEWRPC reviewed the state of nearshore and riparian vegetation around most lakes. When unable to enter certain lakes, similar estimates were made from a distance and from aerial photography. The robustness of nearshore and riparian vegetation were evaluated to produce a dimensionless custom buffer vegetation score.	Lakes that are surrounded by buffers are less sensitive to human influence. Compromised buffers can be restored or enhanced to improve lake water quality.	<120	1 (least influence)	1.00
					120 - 240	2	
					>240 - 340	3	
					>340	4 (most influence)	
Shoreland Impervious Surface	SEWRPC and Calculation	Humans build roads, buildings, patios, walkways, and many other features. Such features cover natural ground with surfaces that repel water (impervious surfaces). Impervious surface increase the amount of runoff and pollution entering a lake and decrease groundwater recharge.	The proportion of total shoreland parcel acreage covered by impervious features using the composite 2010/planned 2035 land use. Dimensionless.	Increasing proportions of impervious surface have been linked to declines in water quality, fisheries, and ecological health.	<1%	1 (least influence)	2.00
					1%-3%	2	
					>3%-10%	3	
					>10%	4 (most influence)	
Shoreland Develop-ment Density	SEWRPC	In general, human population density is directly related to the amount of modification to the landscape and pressure upon natural resource elements. Large numbers of narrow parcels often correlate with higher human population density around a lake.	Parcels per mile of lake shoreline.	Many small parcels ringing a lake are indicative of large numbers of resident lake users, a situation placing heavy pressure on the lake's ecology, available recreational resources, and ability to sustain desirable conditions.	<5	1 (least influence)	1.00
					5-25	2	
					>25-50	3	
					>50	4 (most influence)	

Table A-4 (continued)

Human Influence Criteria					Scoring		
Criterion	Data Source	Description	Measured Value/Units	Lake Classification Significance	Value Brackets	Score	Formula Weighting
Watershed (areas beyond 1,000 feet of lake shoreline)							
Impervious Surface	SEWRPC	Humans build roads, buildings, patios, walkways, and many other features. Such features cover natural ground with surfaces that repel water (impervious surfaces). Impervious surface increase the amount of runoff and pollution entering a lake and decrease groundwater recharge.	The proportion of total watershed acreage covered by impervious features. Both 2010 and 2035 land use data were used, with double weight given to planned land use. Dimensionless.	Increasing proportions of impervious surface have been linked to declines in water quality, fisheries, and ecological health.	<4%	1 (least influence)	2.00
					4%-8%	2	
					>8%-12	3	
					>12%	4 (most influence)	
External Loading	SEWRPC	Sediment, nutrients, and other pollutants leave shoreland areas and enter lakes. While some sediment and nutrients enter all lakes, human activity can greatly increase loading, reaching levels that degrades water quality and lake ecology. Since most phosphorus and many heavy metals are adsorbed to and transported to sediment, the quantity of sediment entering a lake is also a reasonable surrogate for nutrient and pollutant loading.	Tons of sediment per acre per year.	High sediment, nutrient, and pollutant loads reveal lakes highly influenced by human activity.	<0.1	1 (least influence)	2.00
					0.1-<0.9	2	
					0.9-<1.9	3	
					>1.9	4 (most influence)	
Watershed Size Weighting Factor	SEWRPC	The relative size of a lake's watershed versus its surface area effects the significance of watershed-based variables. To account for this issue, the watershed size was divided by each lake's size, and the average watershed to lake ratio was determined for the study area. Next, each lake's watershed to lake ratio was normalized by dividing by the study area average watershed to lake ratio, yielding this study's watershed size weighting factor.	- -	- -	N/A	N/A	N/A

NOTE: The parameters are weighted differently for final scoring.

Source: SEWRPC.

Table A-5

LAKE AND WATERSHED HUMAN INFLUENCE PARAMETERS AND VALUES

Lake	Lake and Shoreline Characteristics							Watershed Characteristics					
	Proportion of Total Shoreline that is Unprotected Shoreline (Percent)	Public Boat Access (Number of facilities)		Buffer	Proportion of Shoreland Parcels Occupied by Impervious Surfaces (Percent)	Shoreline Development Density (Parcels/ Mile of Shoreline)	Watershed Area (Acres)	Proportion of Lake Watershed Occupied by Impervious Surfaces (Percent)			External Loading (tons sediment/ acre of lake surface area/year)	Watershed/ Lake Acreage Ratio	Watershed Size Weighting Factor
		Ramp	Carry-In					2010 Land Use	Planned 2035 Land Use	Composite 2010/2035 Land Use			
Benedict	58.4	0	0	114	3.4	24.7	976	5.4	15.7	12.3	3.00	12.1	1.2
Camp	8.2	3	1	177	4.4	54.6	3,087	4.5	15.7	12.0	2.00	5.9	0.6
Center	14.8	1	0	215	5.8	29.9	2,502	4.9	14.8	11.5	4.00	17.2	1.7
Cross	50.9	0	0	100	9.8	22.3	100	5.4	5.4	5.4	1.00	1.1	0.1
Dyer	4.8	0	0	493	1.5	5.1	840	1.9	6.2	4.8	3.00	12.7	1.3
Flanagan	1.4	0	0	282	0.9	13.5	185	1.2	2.4	2.0	4.00	15.9	1.6
Francis	23.6	0	0	336	1.5	3.7	171	0.9	0.9	0.9	2.00	10.0	1.0
Friendship	5.7	0	0	153	2.2	3.6	253	1.1	3.8	2.9	4.00	20.1	2.0
Hooker	6.5	3	0	498	2.9	33.8	1,380	7.3	20.1	15.8	3.00	12.2	1.2
Kull	0.0	0	0	146	0.2	5.0	469	1.7	11.0	7.9	4.00	28.0	2.8
Lily	80.8	1	0	76	20.7	72.9	133	6.8	6.9	6.9	1.00	1.5	0.2
Montgomery	3.3	0	1	280	5.7	33.5	314	3.2	9.2	7.2	1.00	5.2	0.5
Powers	31.8	2	0	164	22.2	42.6	1,915	3.6	5.8	5.0	2.00	4.2	0.4
Rock	16.0	0	1	148	13.0	56.5	540	9.3	13.9	12.4	3.00	10.2	1.0
Shangri-La/Benet	12.8	1	0	311	4.5	31.6	518	6.5	9.6	8.6	2.00	2.9	0.3
Silver	11.5	2	1	224	10.3	29.0	3,308	4.0	11.1	8.7	2.00	6.3	0.6
Voltz	4.8	0	0	290	2.9	16.1	381	3.8	9.4	7.5	2.00	5.9	0.6
Averages	19.7	0.8	0.2	236	6.6	28.1	1,004	4.2	9.5	7.7	2.53	10.1	1.0

Source: SEWRPC.

Table A-6

LAKE AND WATERSHED HUMAN INFLUENCE SCORES

Lake and Shoreline Factors							Watershed Factors				Human Influence Scores	
Factor Weights	1.00	1.50	1.00	2.00	1.00	- -	2.00	2.00	- -	- -	- -	- -
Lake	Proportion of Total Shoreline that is Unprotected Shoreline	Public Boat Access	Buffer	Proportion of Shoreland Parcels Occupied by Impervious Surfaces	Shoreline Develop-ment Density	Lake-Based Subtotal Score	Proportion of Lake Watershed Occupied by Impervious Surfaces	External Loading	Watershed Size Weighting Factor	Watershed-Based Subtotal Score	Total Score	Category
Benedict	4	1	1	2	2	12.5	4	3	1.2	15.3	27.8	Medium
Camp	2	3	2	2	4	16.5	4	2	0.6	9.2	25.7	Medium
Center	3	3	2	3	3	18.5	3	4	1.7	18.3	36.8	High
Cross	4	1	1	3	2	14.5	2	1	0.1	2.0	16.5	Low
Dyer	2	1	4	1	2	11.5	2	3	1.3	11.2	22.7	Medium
Flanagan	1	1	3	1	2	9.5	1	4	1.6	12.6	22.1	Medium
Francis	3	1	3	1	1	10.5	1	2	1.0	6.0	16.5	Low
Friendship	2	1	2	2	1	10.5	1	4	2.0	14.1	24.6	Medium
Hooker	2	3	4	2	3	17.5	4	3	1.2	15.4	32.9	High
Kull	1	1	2	1	2	8.5	2	4	2.8	20.0	28.5	High
Lily	4	3	1	4	4	21.5	2	1	0.2	2.3	23.8	Medium
Montgomery	2	2	3	3	3	17.0	2	1	0.5	4.3	21.3	Low
Powers	3	3	2	4	3	20.5	2	2	0.4	5.2	25.7	Medium
Rock	3	2	2	4	4	20.0	4	3	1.0	14.1	34.1	High
Shangri-La/Benet	3	3	3	2	3	17.5	3	2	0.3	5.3	22.8	Medium
Silver	3	3	2	4	3	20.5	3	2	0.6	7.9	28.4	High
Voltz	2	1	3	2	2	12.5	2	2	0.6	6.1	18.6	Low
Averages	2.6	1.9	2.4	2.4	2.6	15.3	2.5	2.5	1.0	10.0	25.2	- -

Note: The formulas used to derive scores use the abbreviations below:

NC - Natural Community, SA - Shallow Areas, PHIL - Potential for High Internal Loading, WC - Water Clarity, SDF - Shoreline Development Factor, TSF - Two-Story Fishery, SP - Stormflow Processing, GRA - Groundwater Recharge Areas, WSWF - Watershed Size Weighting Factor

Lake-Based Subtotal = (NC*NC Weight * TSF*TSF Weight)+(SA*SA Weight)+(PHIL*PHIL Weight)+(WC*WC Weight)+(SDF*SDF Weight)
Watershed-Based Subtotal= (SP*SP Weight*WSWF)+(GRA*GRA Weight*Square Root(WSWF))
Sensitivity Score = Lake-Based Subtotal+Watershed-Based Subtotal

Source: SEWRPC.

Appendix B

SHORELINE ASSESSMENTS

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METHODOLOGY

During summer 2014, the distribution and extent of shoreline protection and the potential for shoreland management were assessed around lakes in unincorporated portions of Kenosha County. The assessment defined each lake's shoreline (or riparian area), in-lake areas (the waters immediately contiguous with the water's edge), and near shore area (uplands immediately inland from the water's edge).

The surveys were conducted from the water; accessing water bodies through a public launch, working with shoreline owners to either gain access from a private launch, or working with them for use of personal boats. SEWRPC staff could not gain access to- Flanagan and Kull Lakes. Although property owners around Flanagan Lake denied access to the Lake, the Lake was able to be assessed visually from adjacent roadways. Dense cattail stands covered much of Kull Lake preventing access. Nevertheless, data could be drawn from other data sources. Since Kull Lake could not be observed by any means, no photographs are available.

Once on-water access was gained, SEWRPC staff navigated the periphery of each lake, observing individual properties and documenting shoreline conditions with photographs and noting findings on an aerial orthophotograph. Shorelines were assessed for:

- In-lake emergent vegetation (including lily pads);
- Partially or wholly submerged coarse woody structure (e.g., downed trees) trees;
- Type of shoreline protection (noting if it's failing);
- Erosion;
- Natural or man-made buffers (noting width, using a 1 to 5 scale[1]);
- Steep slopes;
- Purple loosestrife; and,
- Culverts and drainage pipes.

The resultant data was digitized using ArcMap, overlaying point and line shapefiles over an aerial orthophotograph of the lake. The features typically denoted by points include culverts, downed trees, drainage pipes, erosion sites and purple loosestrife. Shoreline features such as buffers, vegetation, rip-rap, and bulkhead were denoted by lines. Buffers and stands of vegetation were identified as thin (1 to 2 on the scale) or robust (3 to 5 on the scale). It should be noted that buffer refers to trees, shrubs, tall grasses and flower gardens while vegetation refers to in-lake emergent plants such as cattails and lily pads. Buffer does not include manicured lawn areas.

To visually represent the degree of the type of protection the features, the features are color coordinated with "cool" colors (i.e., purple, and blue) representing more natural features while "warm" colors (i.e., yellow, orange, red) representing artificial features. To make the results more legible, some of the larger lakes are divided into smaller subsections. Photographs were also taken during the shoreline assessment,[2] the numbers of the photos are also listed on the maps. Individual shoreline maps for each project lake are included below and mapped in alphabetical order as listed below:

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[1] *The scale used for defining both buffers and vegetation was based on a 5-point scale; 1 = 1 to 5 feet wide, 2 = 5 to 15 feet wide, 3 = 15 to 35 feet wide, 4 = 35 to 50 feet wide, and 5 = 50 feet wide or greater.*

[2] *Photographs were not taken on Flanagan Lake and Kull Lake, because staff were not given permission to access the lake. Therefore, neither of the two lakes were surveyed from the water's edge and no shoreline photographs could be taken.*

- Benedict Lake (Maps B-1 to B-3)
- Camp Lake (Maps B-4 to B-10)
- Center Lake (Maps B-11 to B-16)
- Cross Lake (Maps B-17 to B-19)
- Dyer Lake (Maps B-20 to B-22)
- Flanagan Lake (Map B-23)
- Francis Lake (Map B-24)
- Friendship Lake (Map B-25)
- Hooker Lake (Maps B-26 to B-28)
- Kull Lake (Map B-29)
- Lily Lake (Maps B-30 to B-32)
- Montgomery Lake (Map B-33)
- Powers Lake (Maps B-34 to B-39)
- Rock Lake (Maps B-40 to B-42)
- Shangri-La/Benet Lakes (Maps B-43 to B-47)
- Silver Lake (Maps B-48 to B-51)
- Voltz Lake (Maps B-52 to B-54)

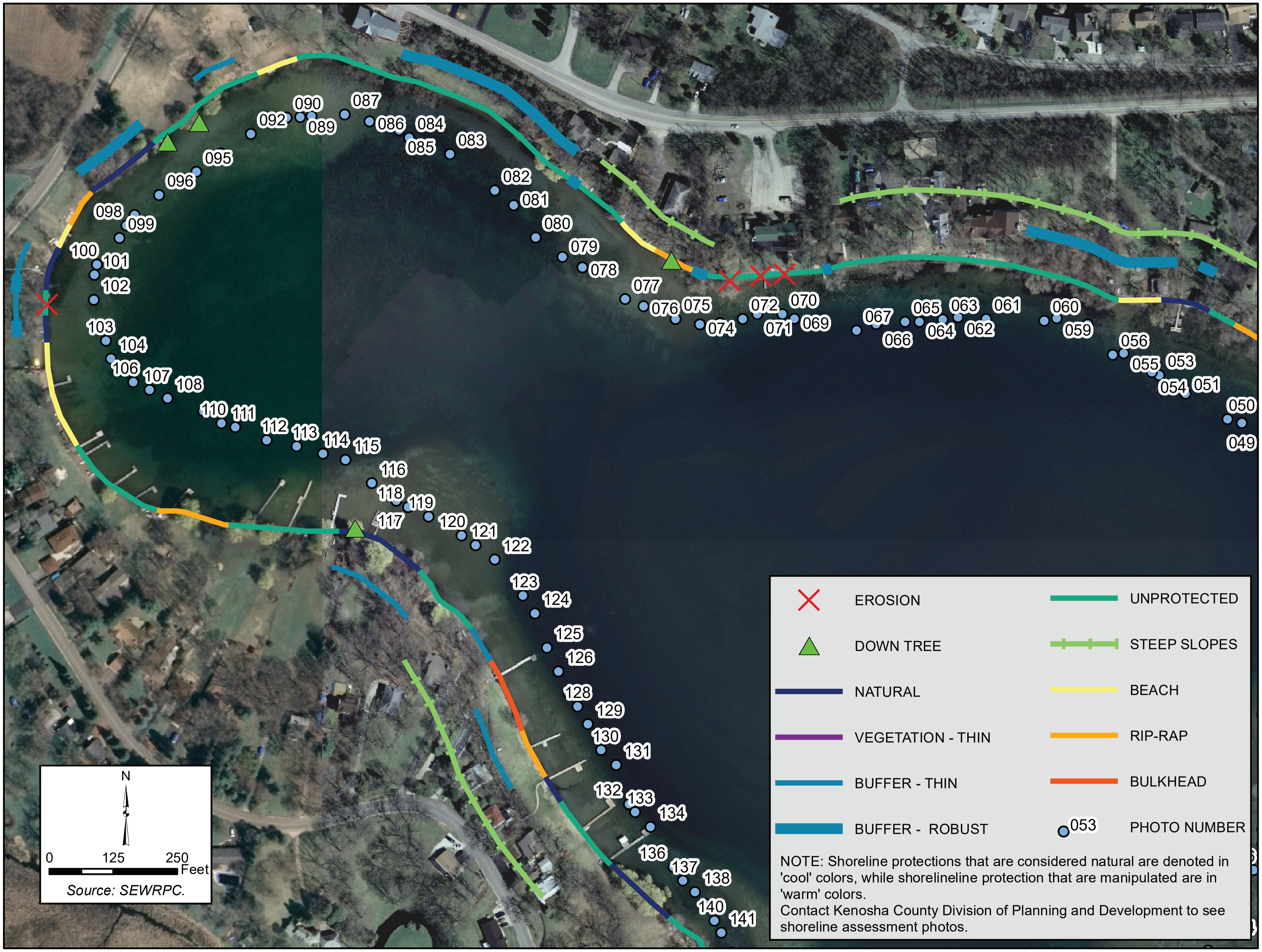
Contact the Kenosha County Division of Planning and Development to view any shoreline photos and/or obtain ArcMap shapefiles of all surveyed information for any of the lakes mapped.

Map B-1

SHORELINE ASSESSMENT FOR BENEDICT LAKE: 2014

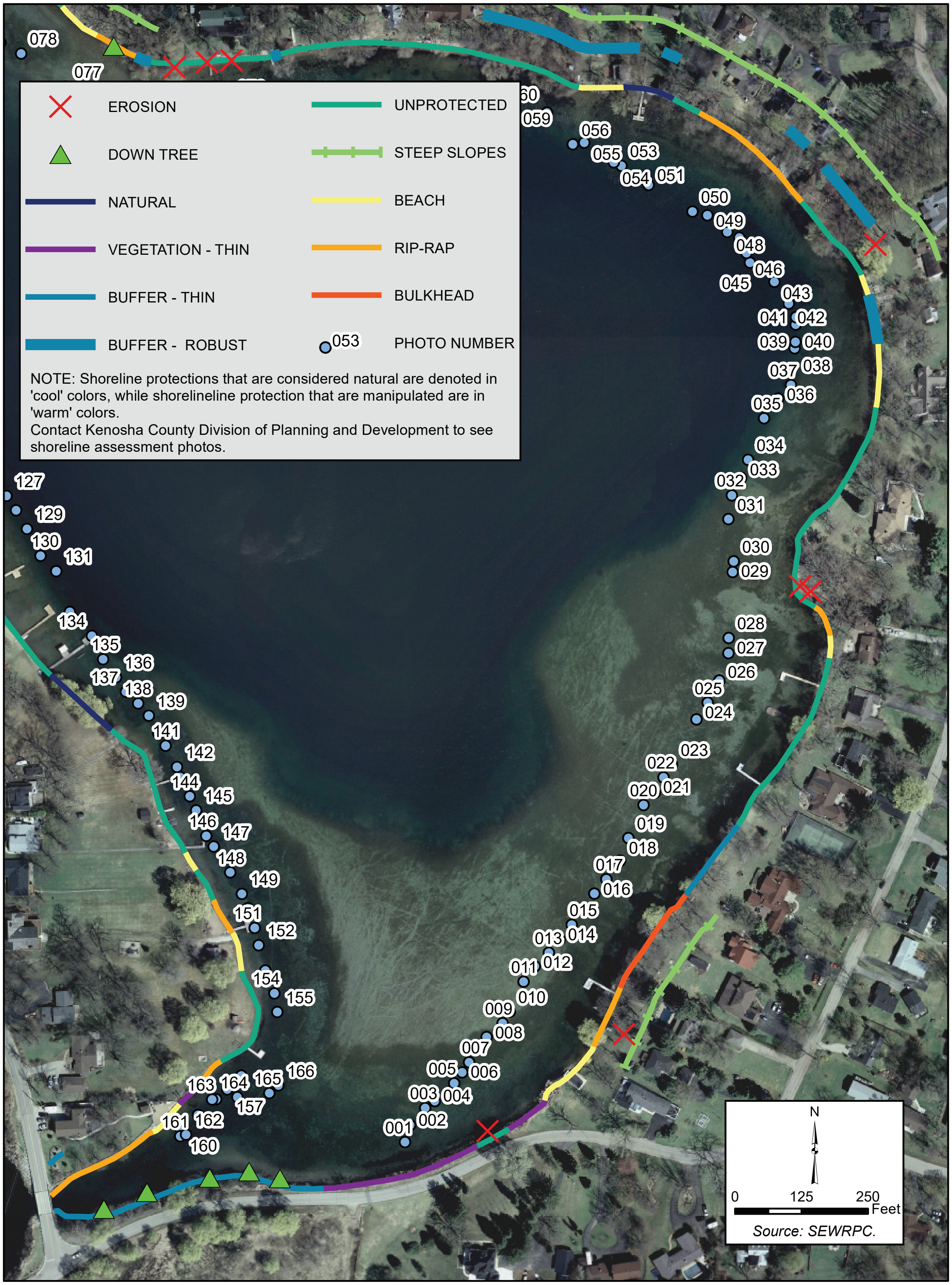
Map B-2

SHORLINE ASSESSMENT FOR NORTH PORTION OF BENEDICT LAKE: 2014



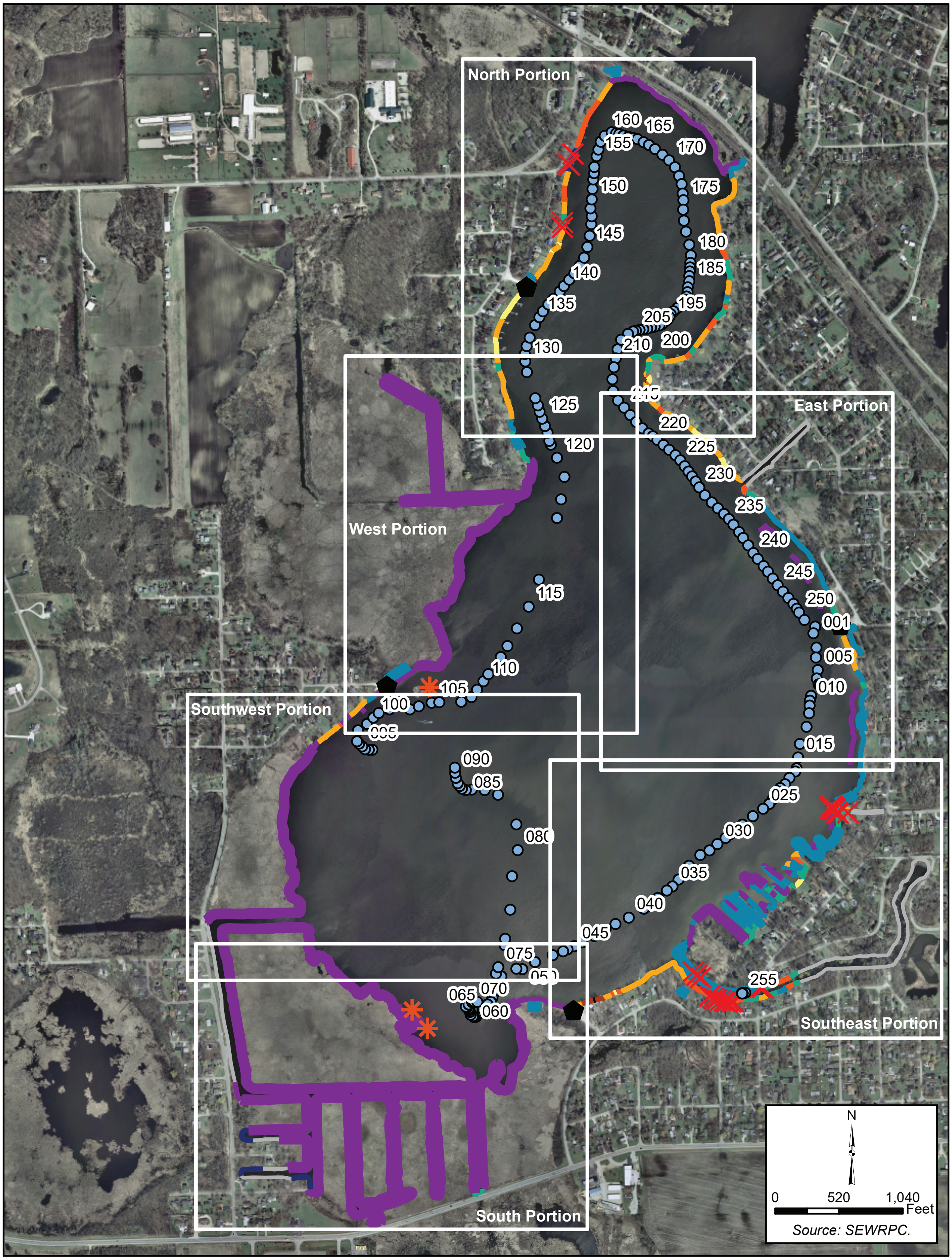
Map B-3

SHORELINE ASSESSMENT FOR SOUTH PORTION OF BENEDICT LAKE: 2014



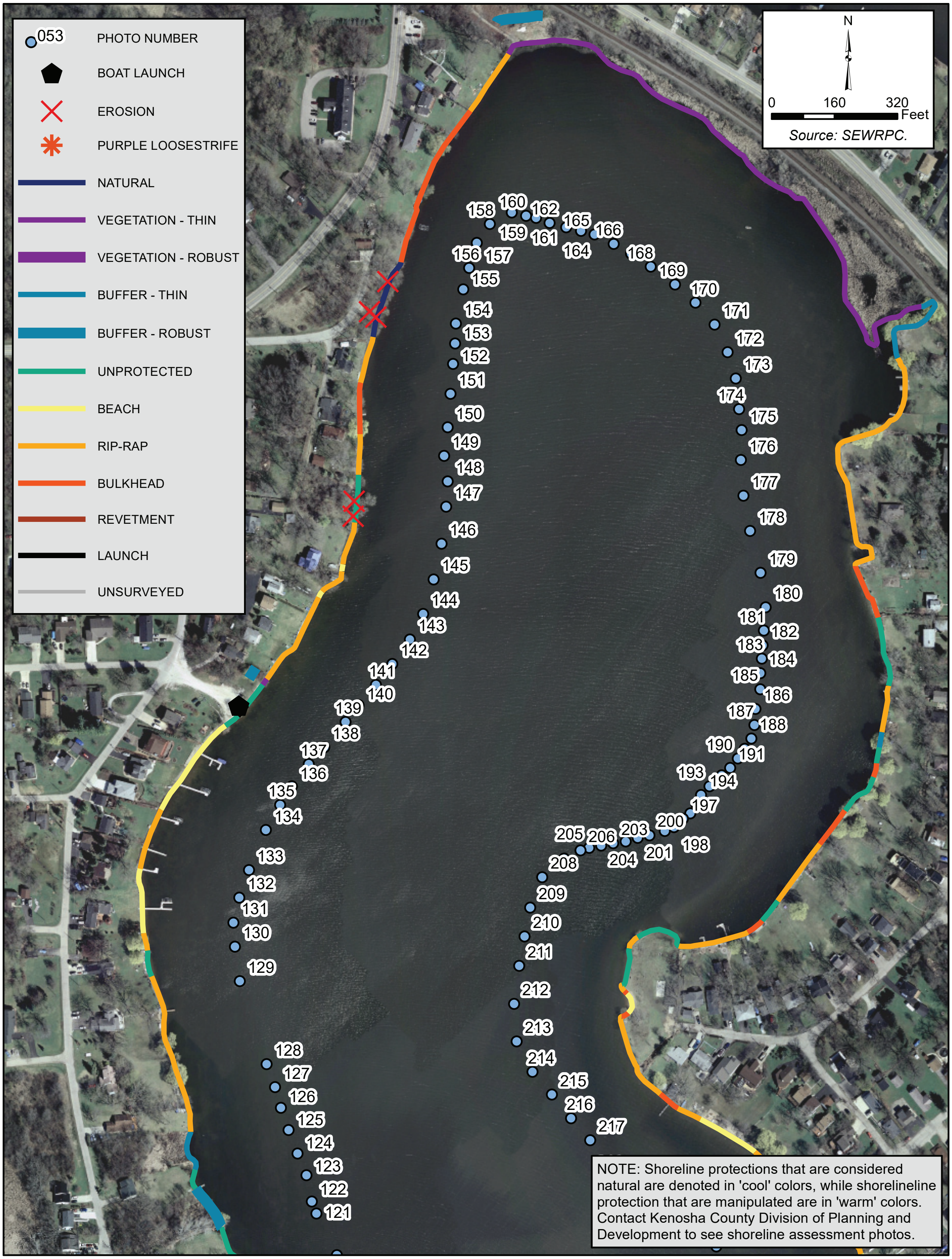
Map B-4

SHORELINE ASSESSMENT FOR CAMP LAKE: 2014



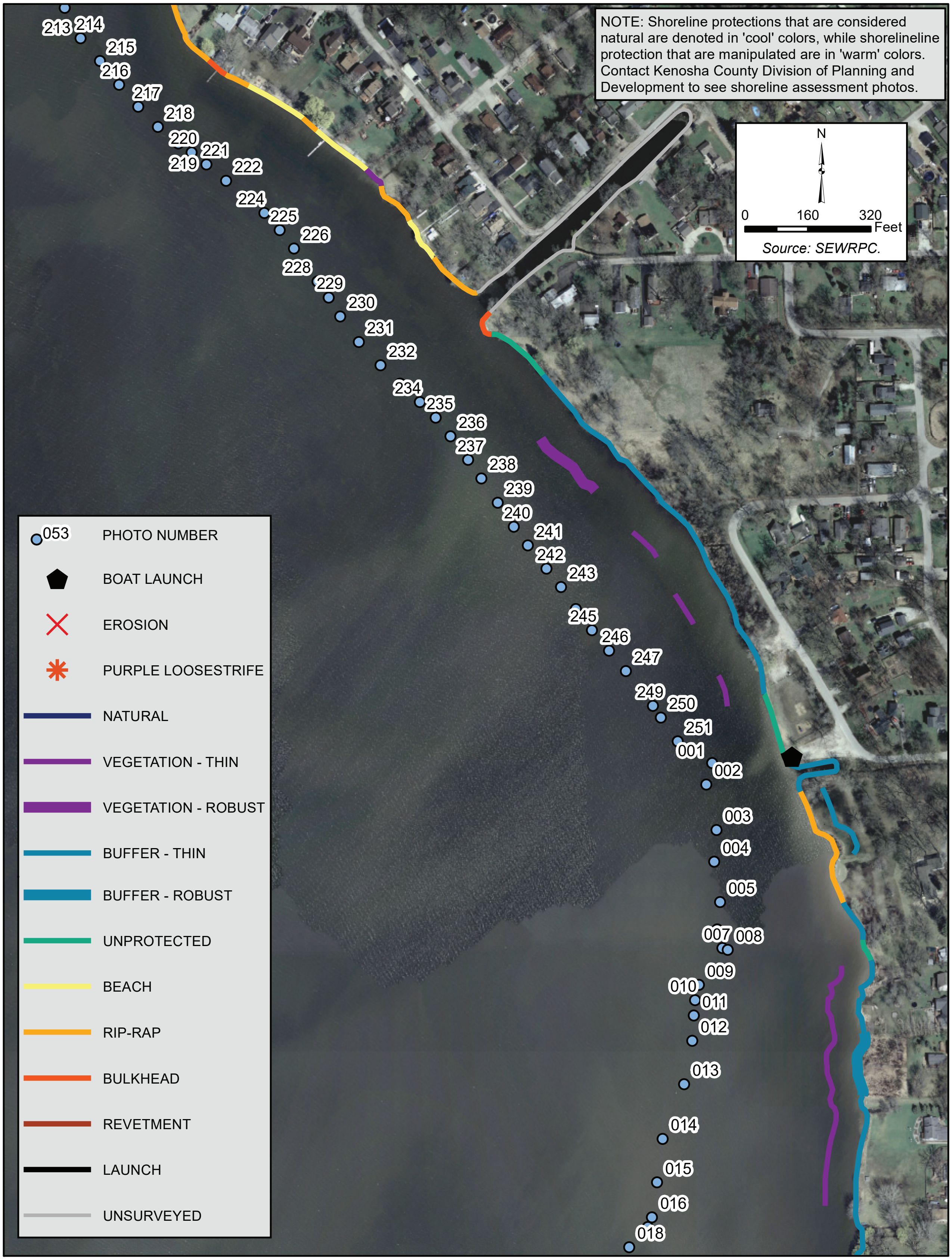
Map B-5

SHORELINE ASSESSMENT FOR NORTH PORTION OF CAMP LAKE: 2014



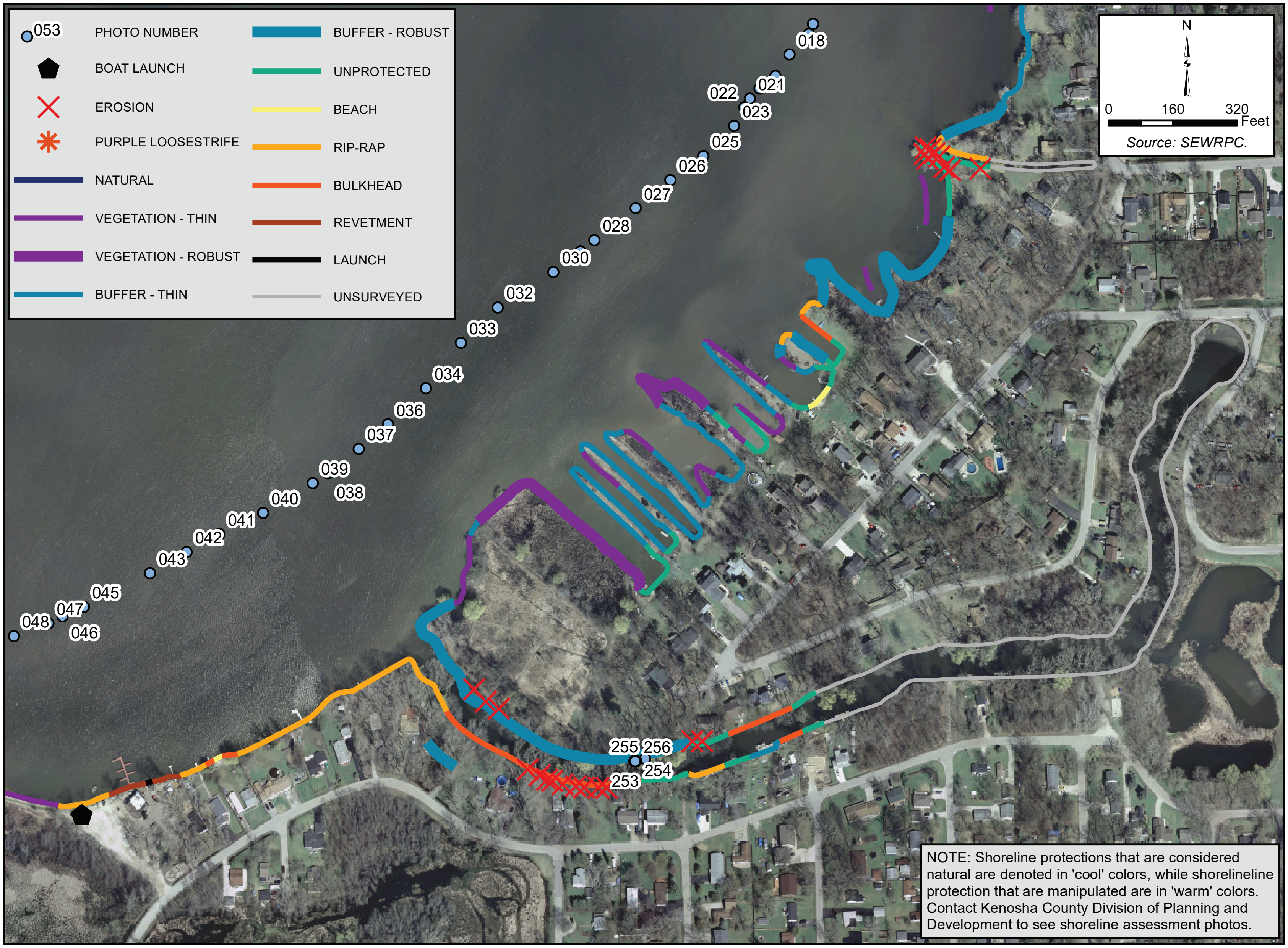
Map B-6

SHORELINE ASSESSMENT FOR EAST PORTION OF CAMP LAKE: 2014



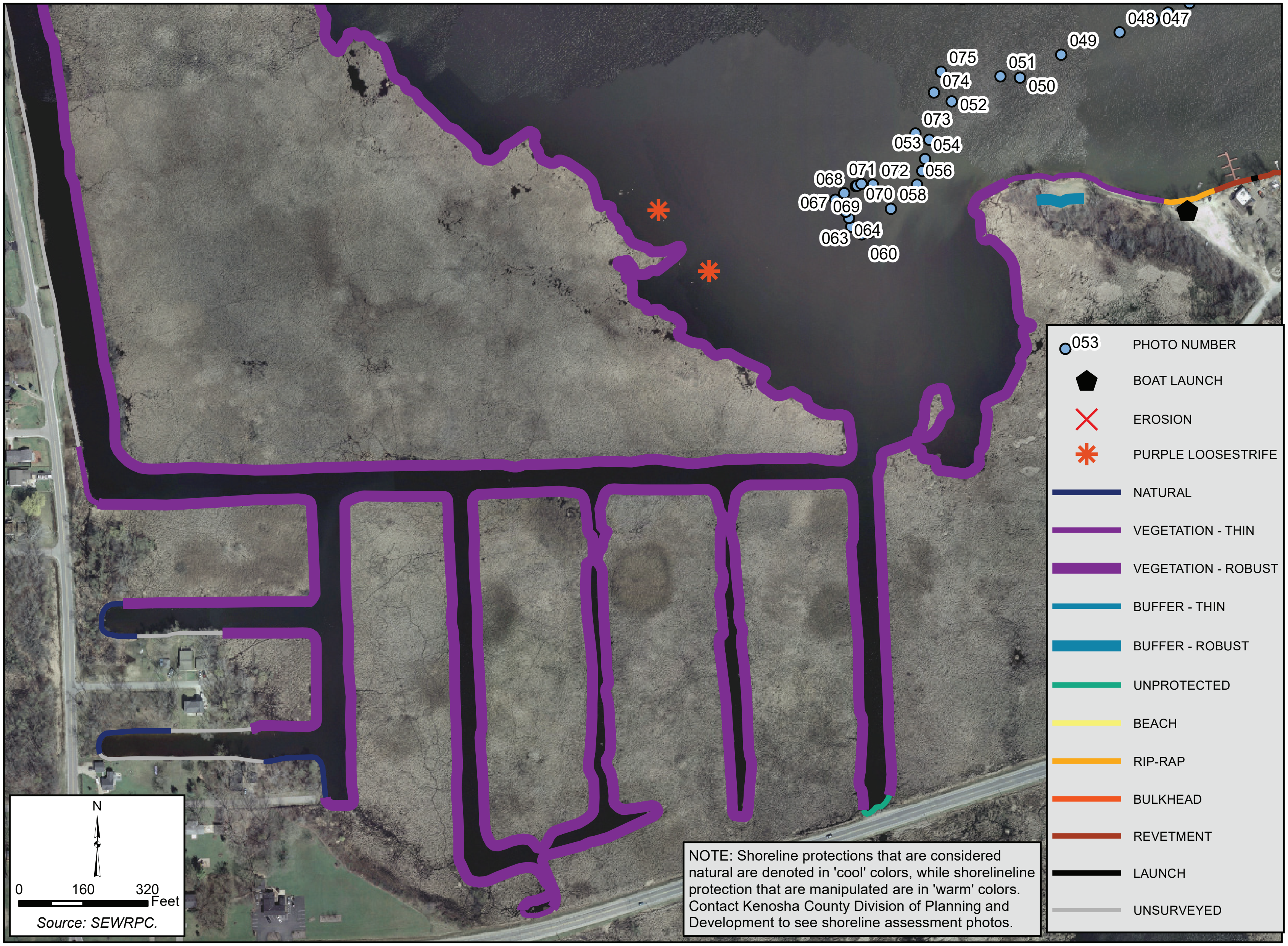
Map B-7

SHORELINE ASSESSMENT FOR SOUTHEAST PORTION OF CAMP LAKE: 2014



Map B-8

SHORELINE ASSESSMENT FOR SOUTH PORTION OF CAMP LAKE: 2014

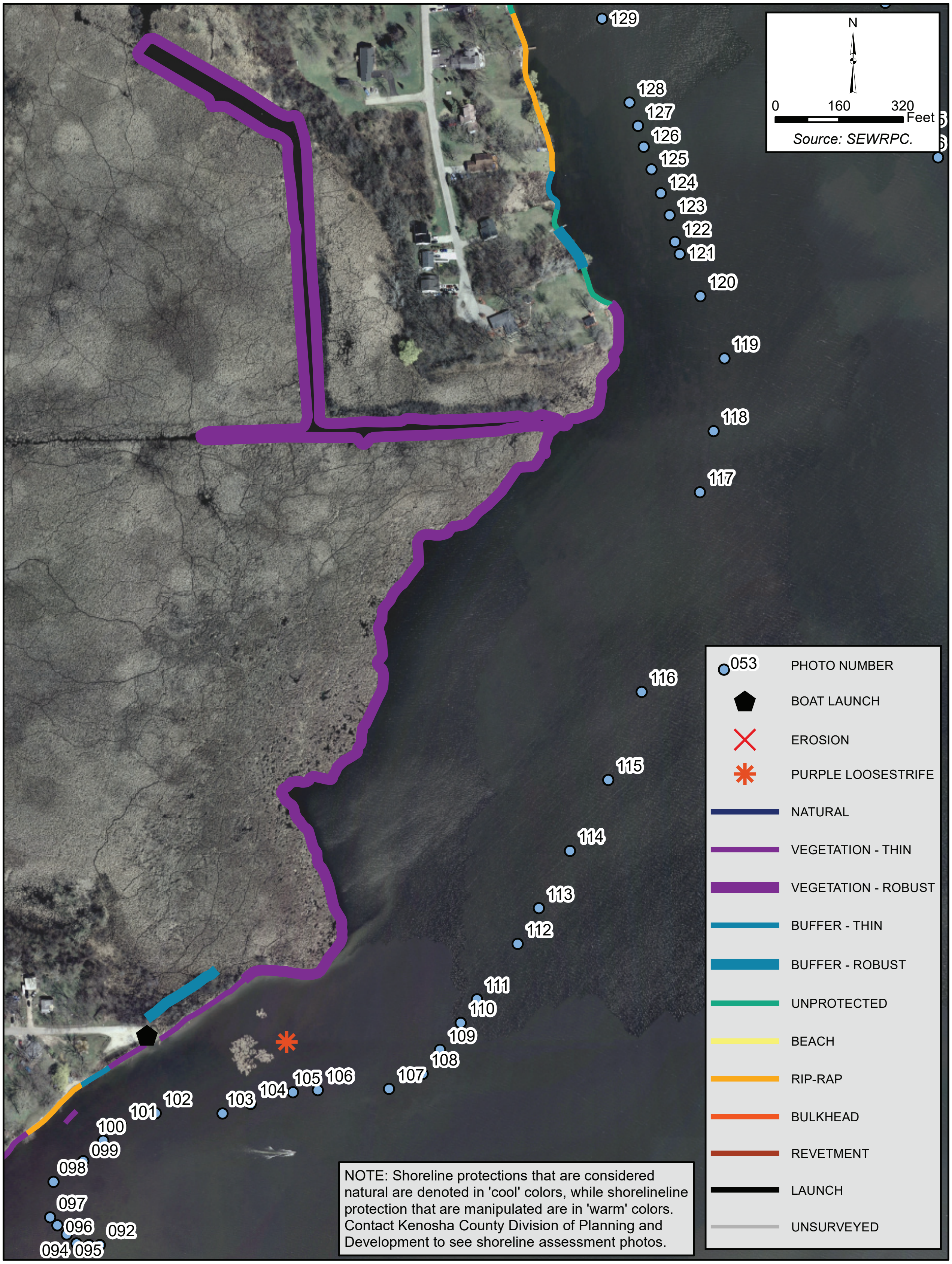


Map B-9

SHORELINE ASSESSMENT FOR SOUTHWEST PORTION OF CAMP LAKE: 2014

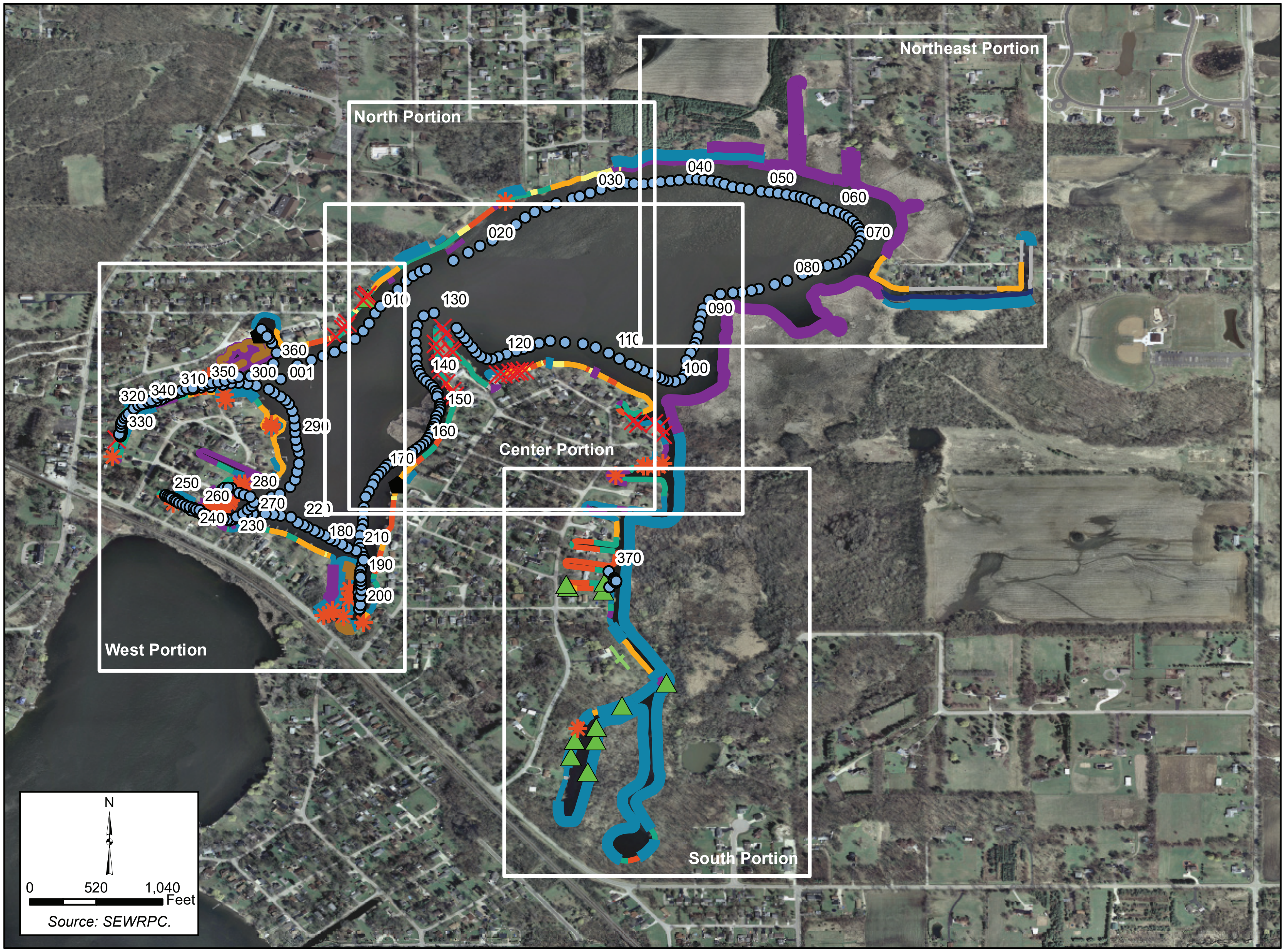
Map B-10

SHORELINE ASSESSMENT FOR WEST PORTION OF CAMP LAKE: 2014



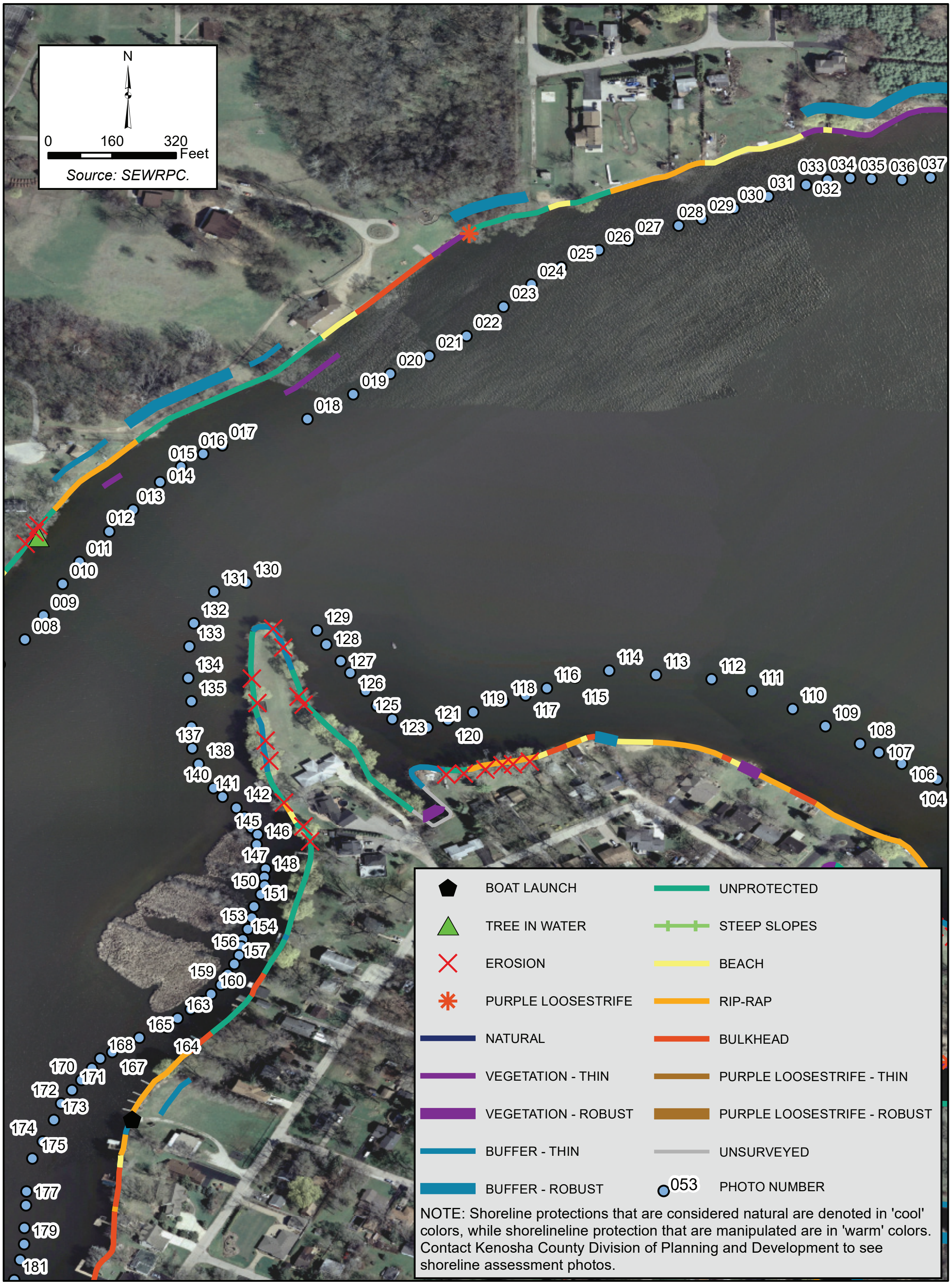
Map B-11

SHORELINE ASSESSMENT FOR CENTER LAKE: 2014



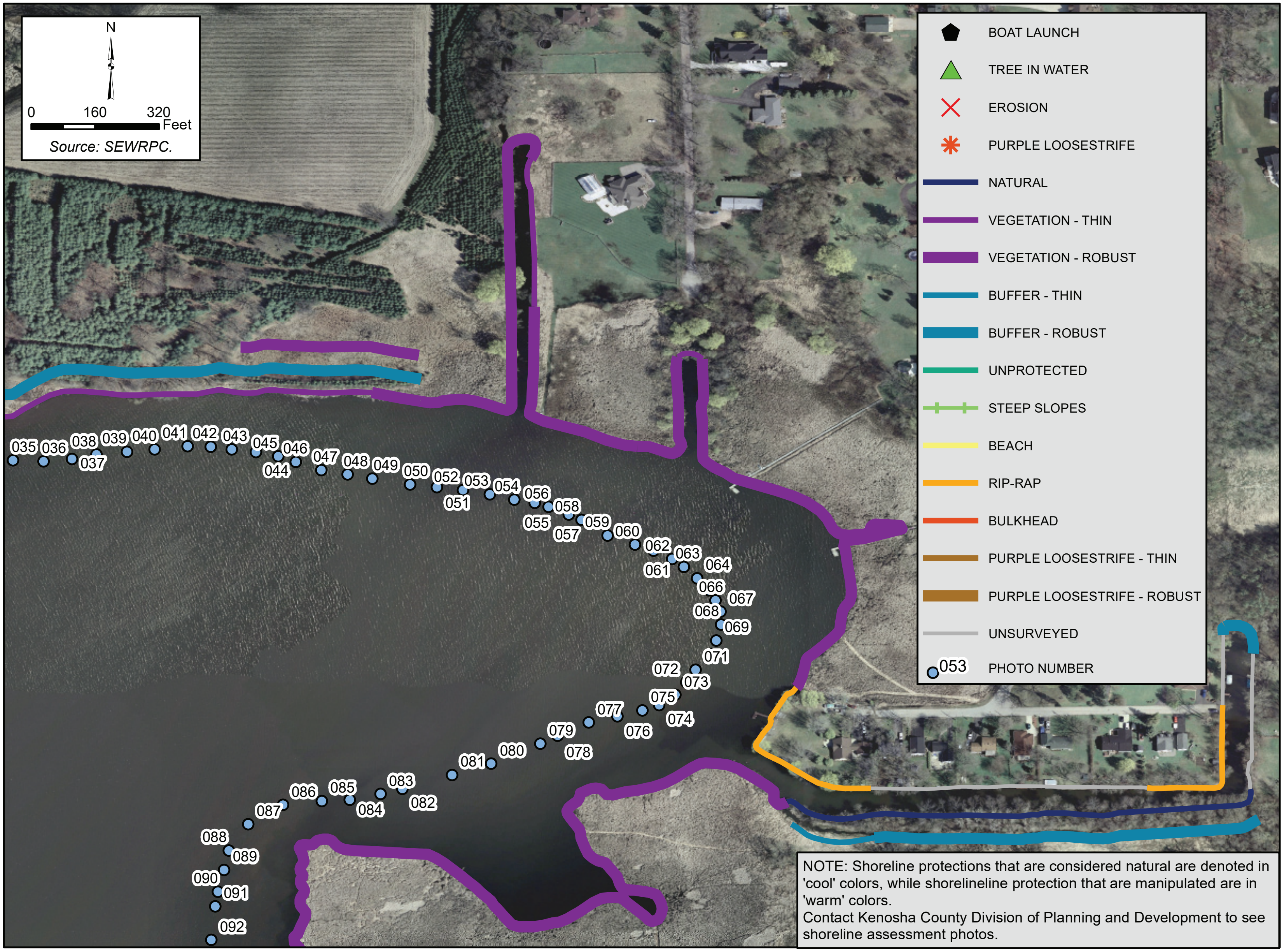
Map B-12

SHORELINE ASSESSMENT FOR NORTH PORTION OF CENTER LAKE: 2014



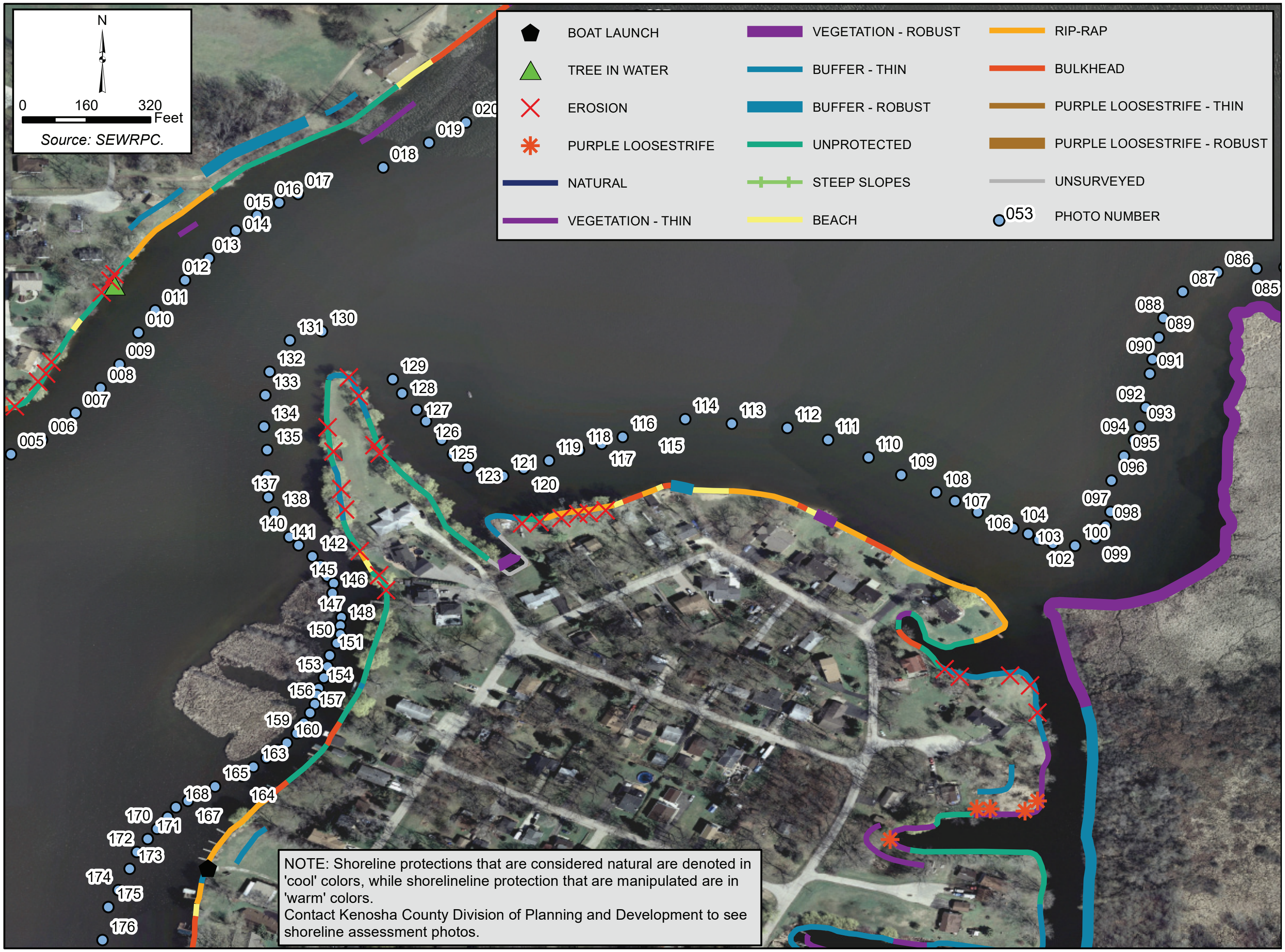
Map B-13

SHORELINE ASSESSMENT FOR NORTHEAST PORTION OF CENTER LAKE: 2014



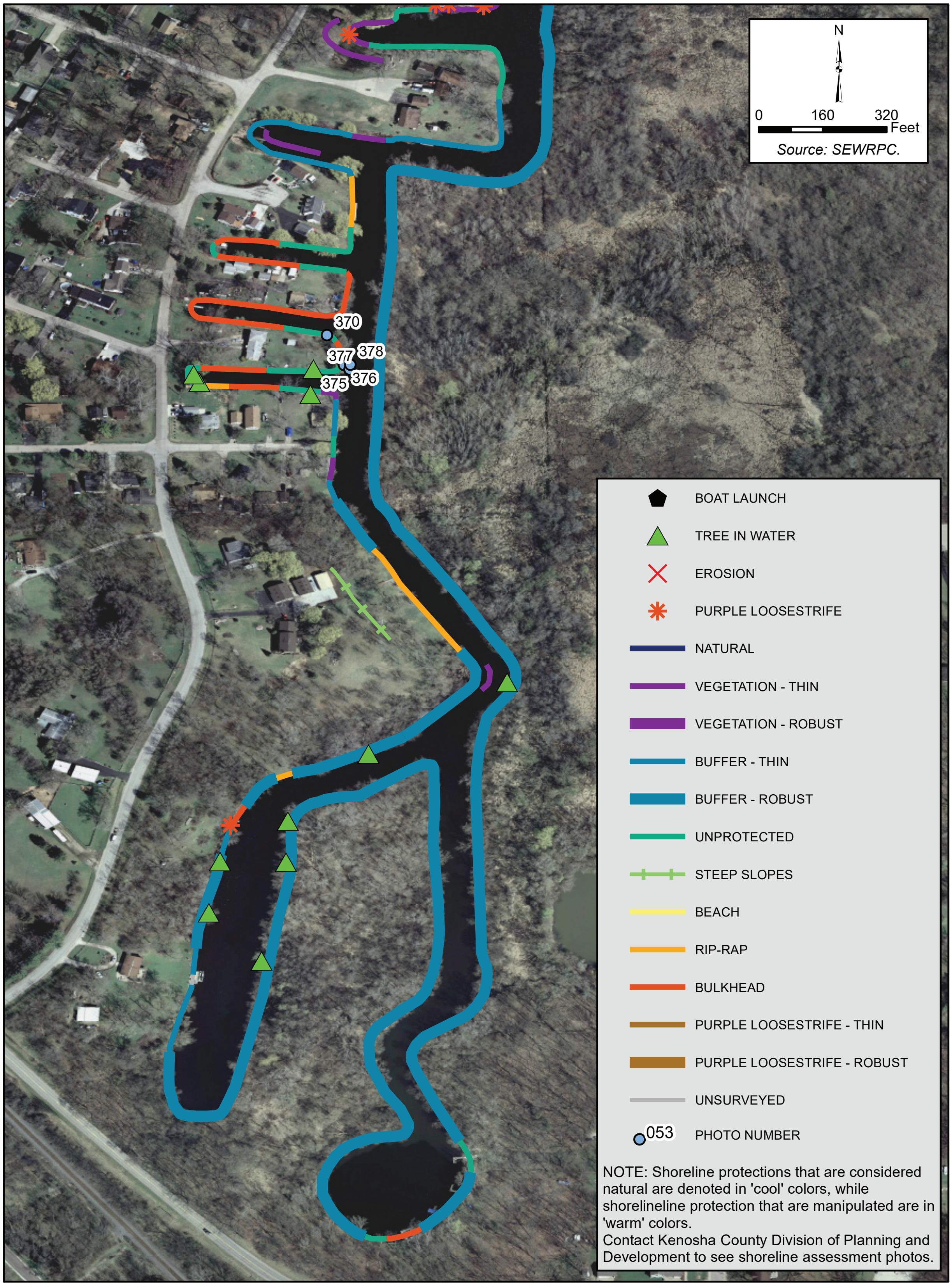
Map B-14

SHORELINE ASSESSMENT FOR CENTER PORTION OF CENTER LAKE: 2014



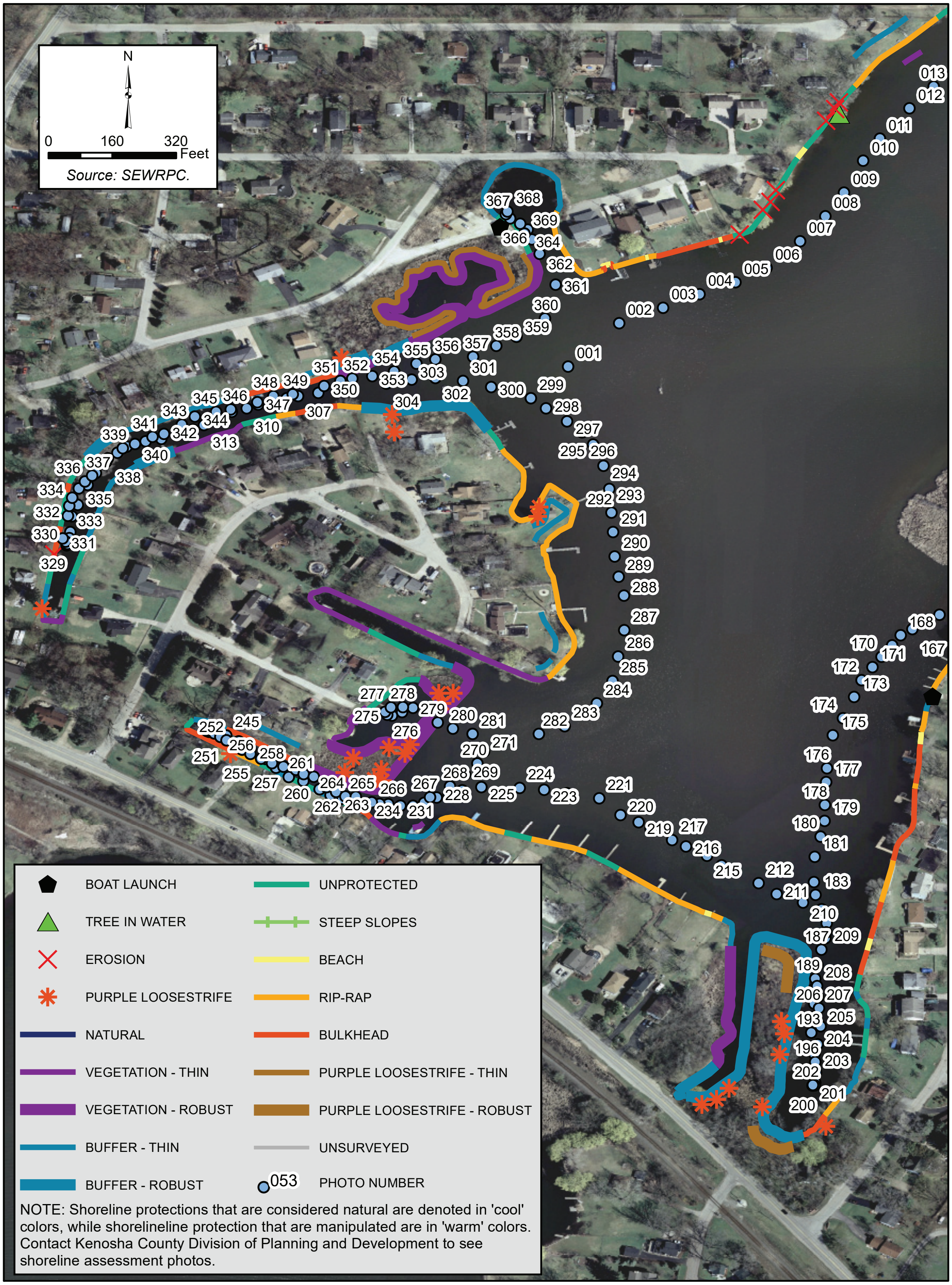
Map B-15

SHORELINE ASSESSMENT FOR SOUTH PORTION OF CENTER LAKE: 2014



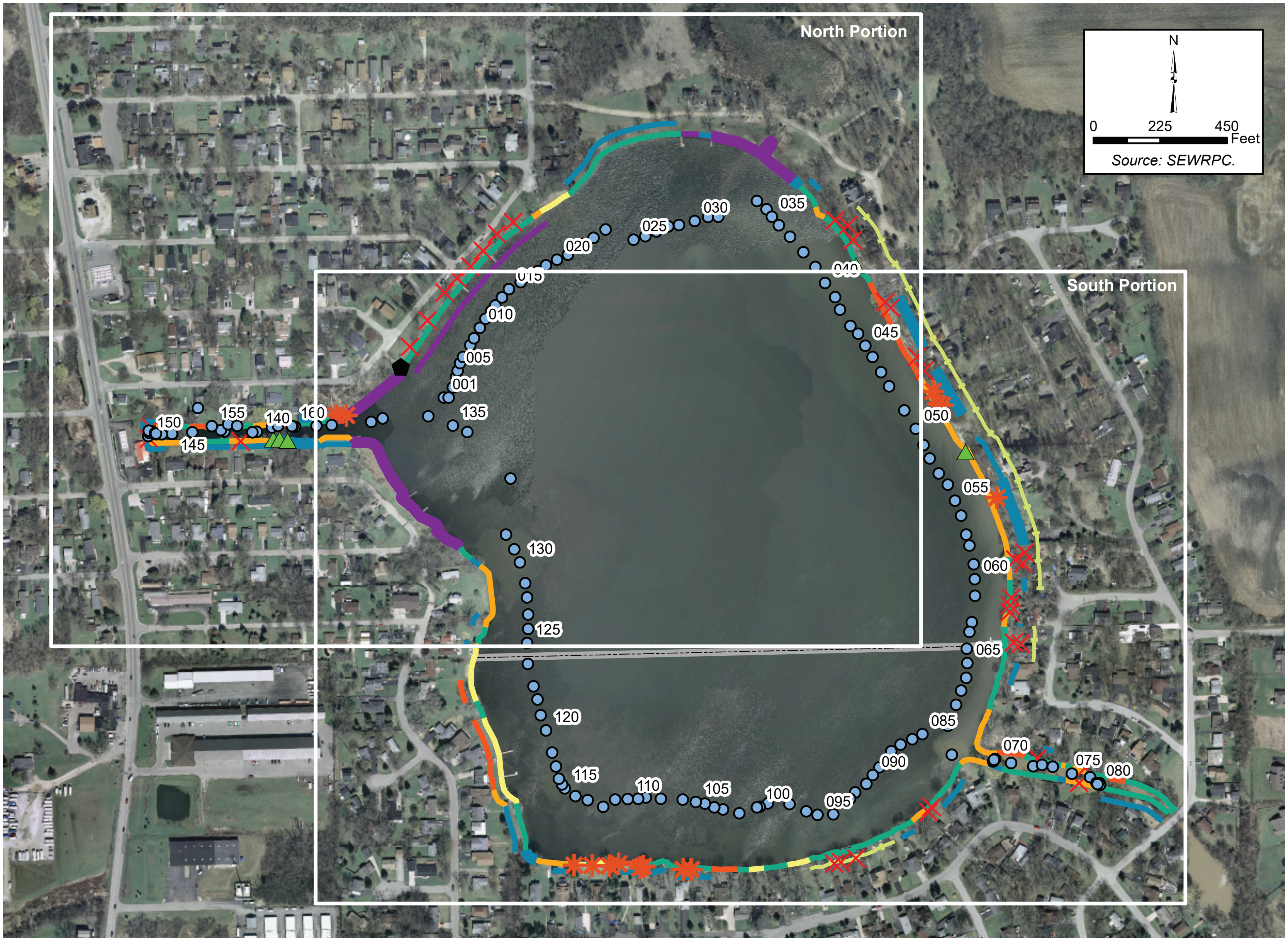
Map B-16

SHORELINE ASSESSMENT FOR WEST PORTION OF CENTER LAKE: 2014



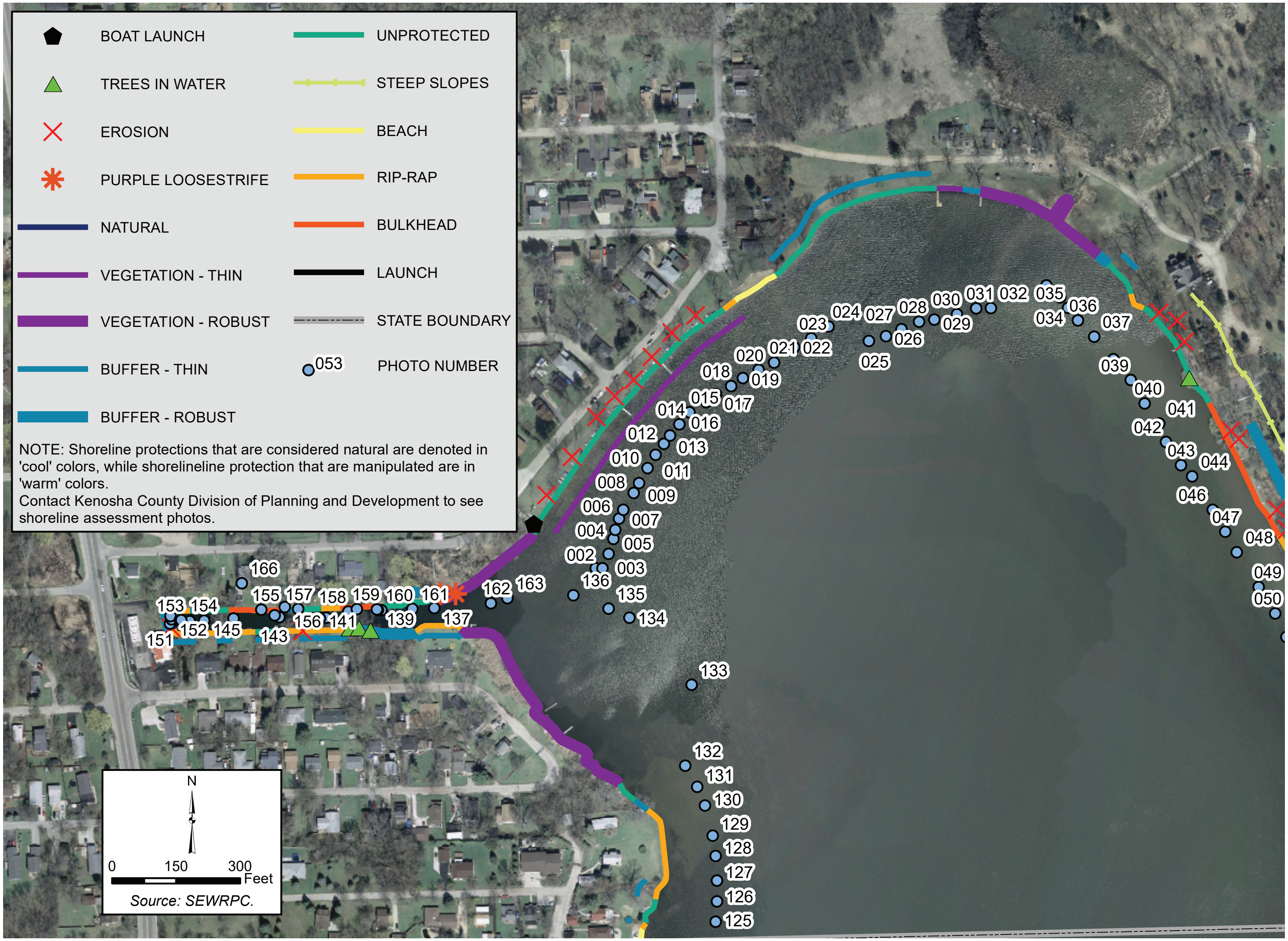
Map B-17

SHORELINE ASSESSMENT FOR CROSS LAKE



Map B-18

SHORELINE ASSESSMENT FOR NORTH PORTION OF CROSS LAKE: 2014

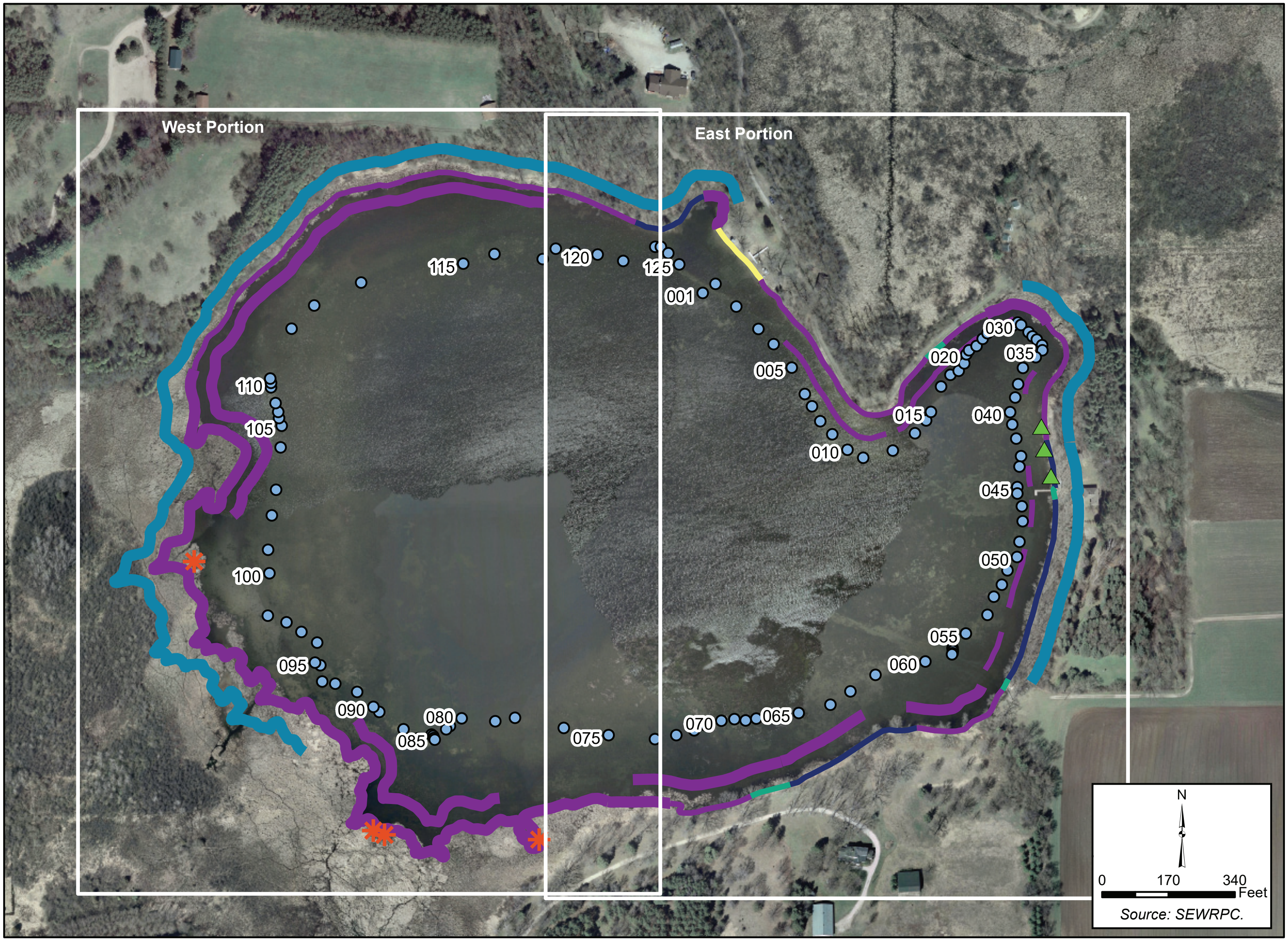


Map B-19

SHORELINE ASSESSMENT FOR SOUTH PORTION OF CROSS LAKE: 2014

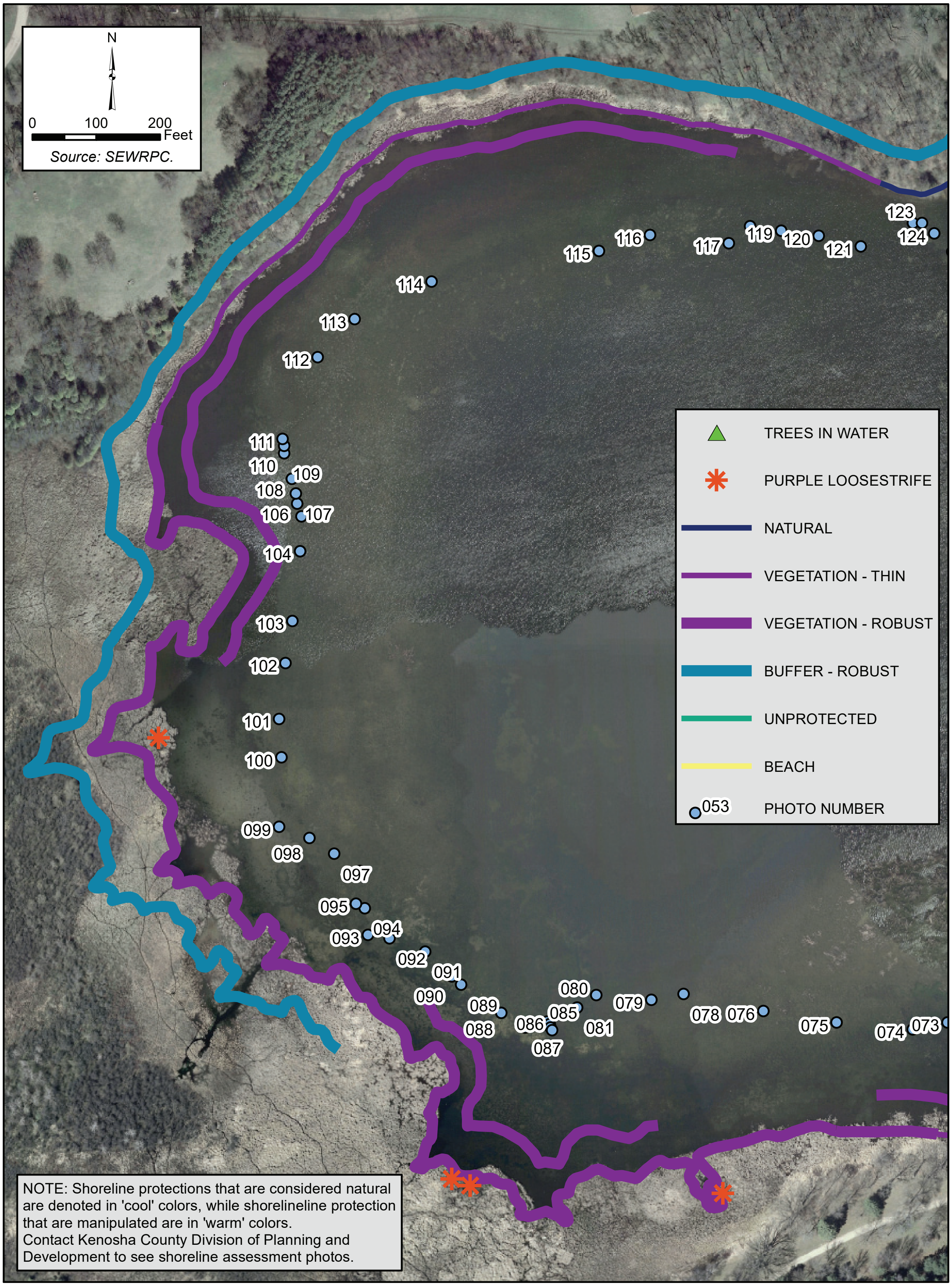
Map B-20

SHORELINE ASSESSMENT FOR DYER LAKE



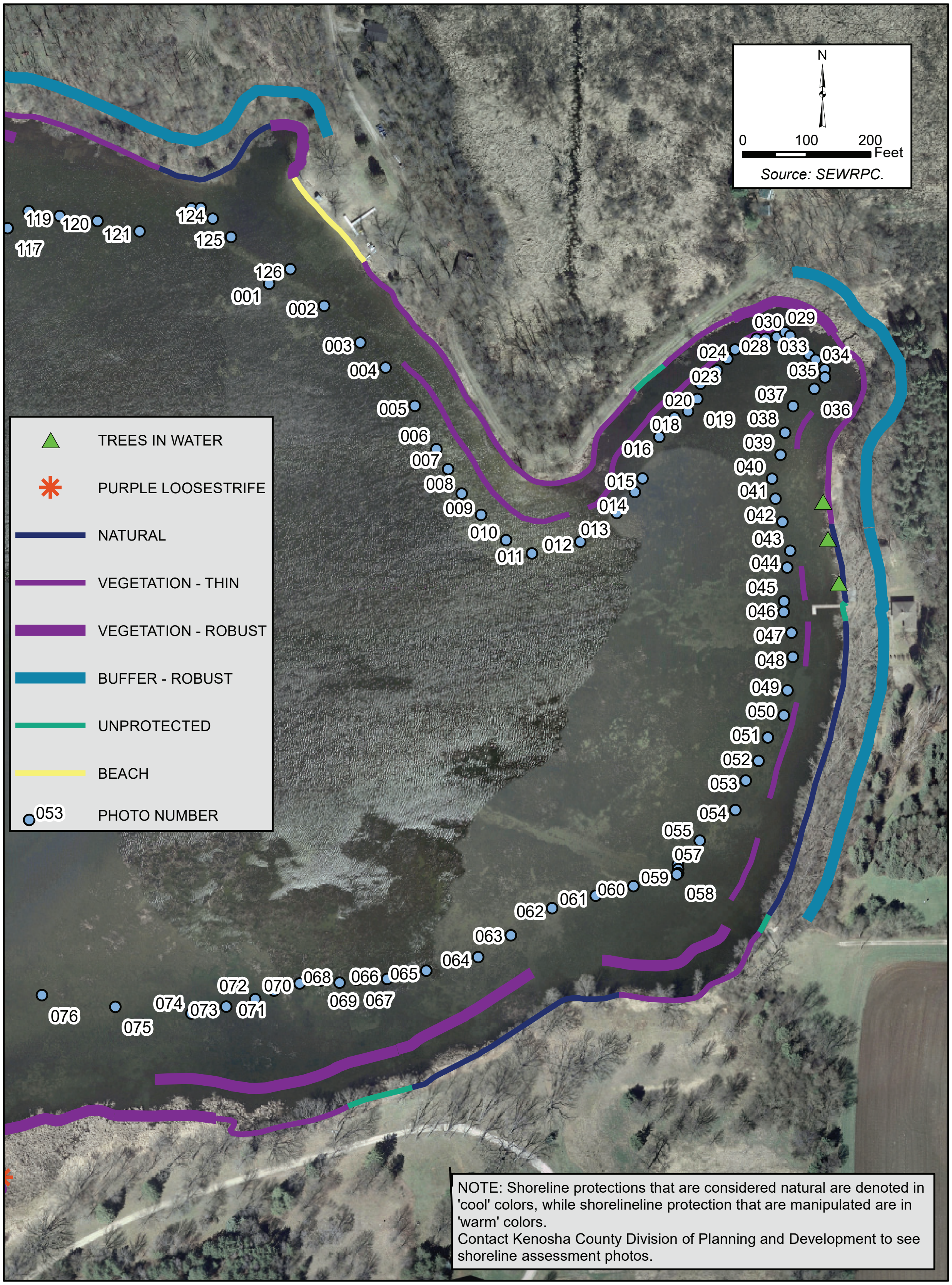
Map B-21

SHORELINE ASSESSMENT FOR WEST PORTION OF DYER LAKE: 2014



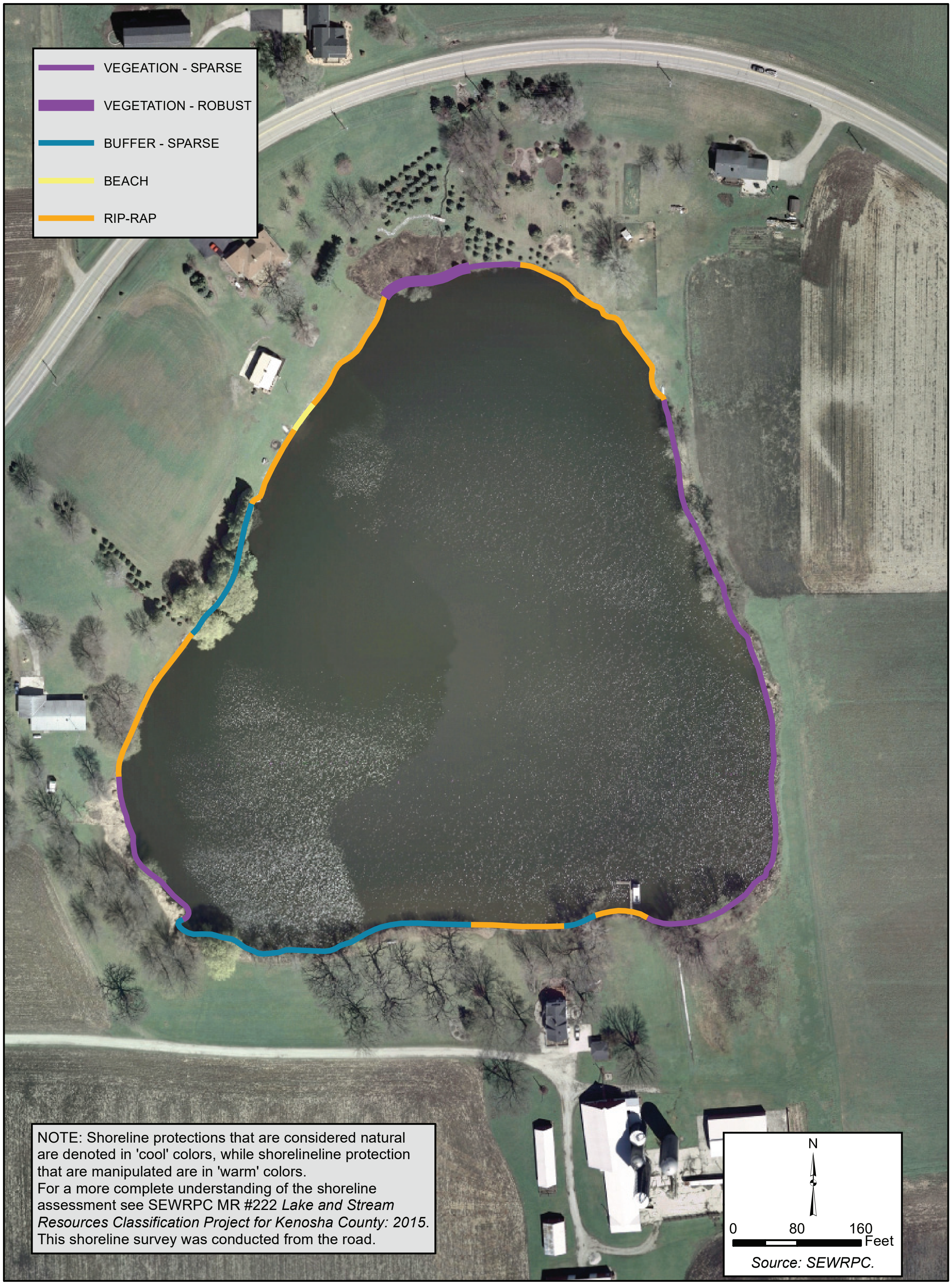
Map B-22

SHORELINE ASSESSMENT FOR EAST PORTION OF DYER LAKE: 2014



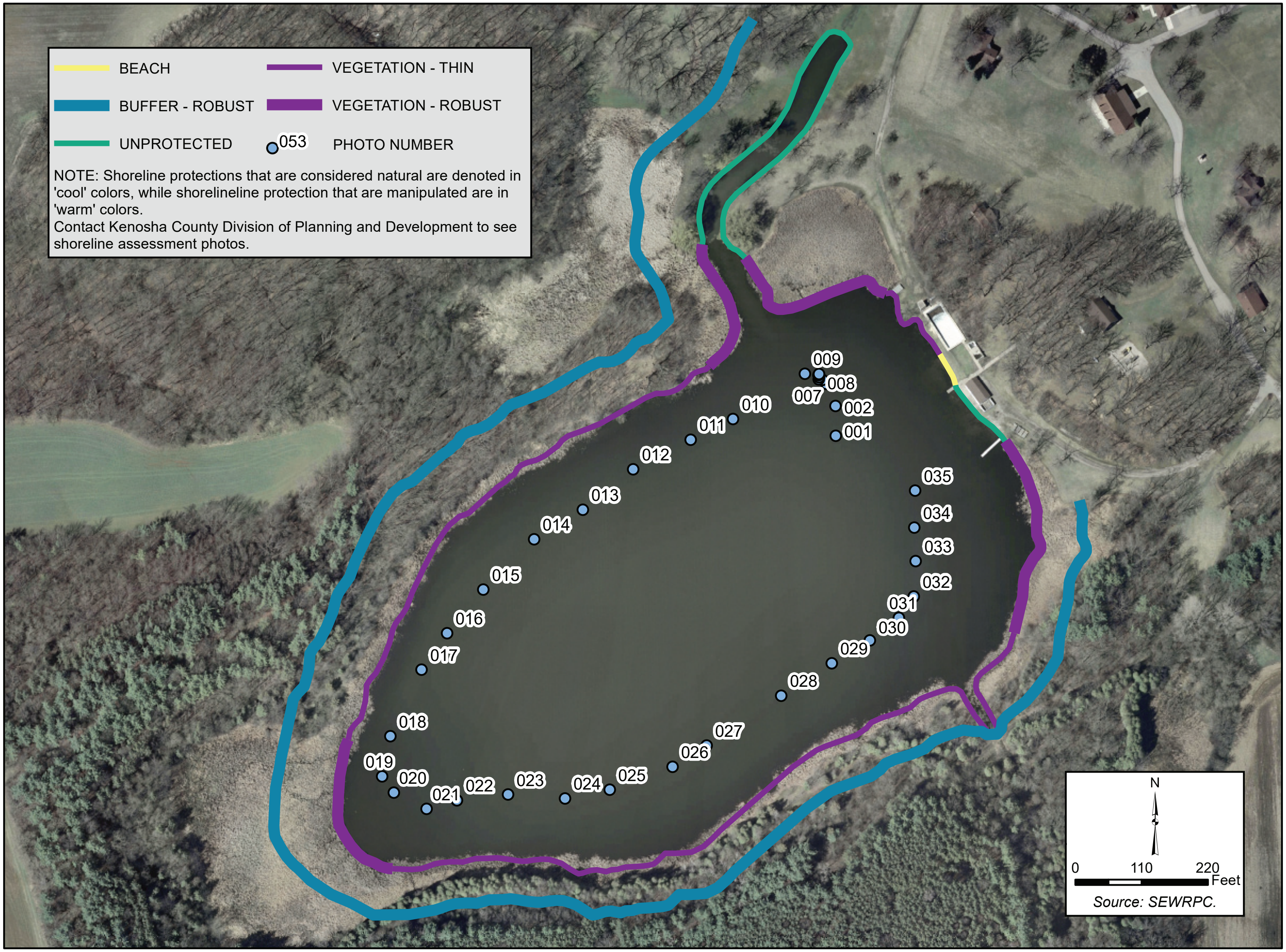
Map B-23

SHORELINE ASSESSMENT OF FLANAGAN LAKE: 2014



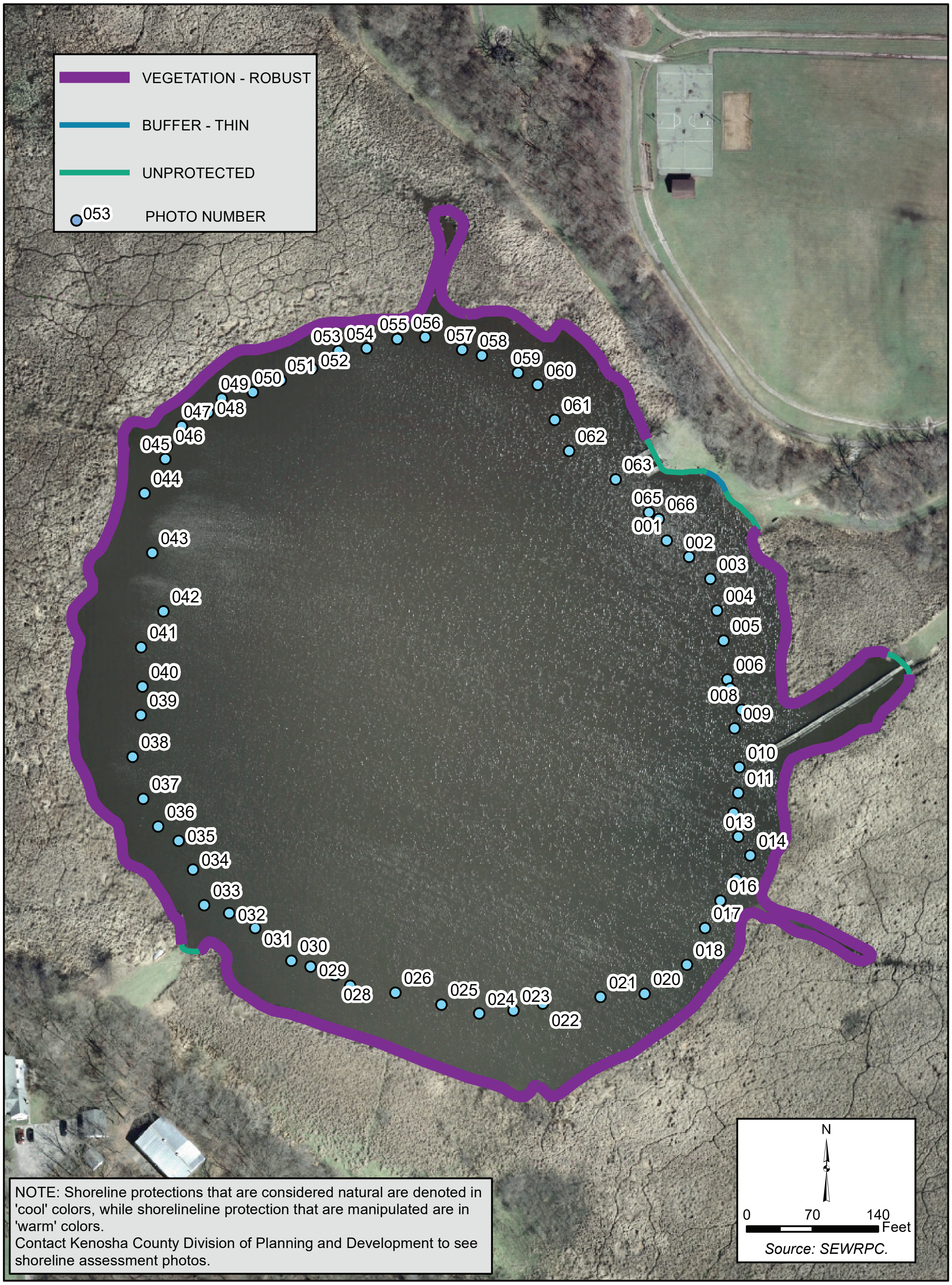
Map B-24

SHORELINE ASSESSMENT OF FRANCIS LAKE: 2014



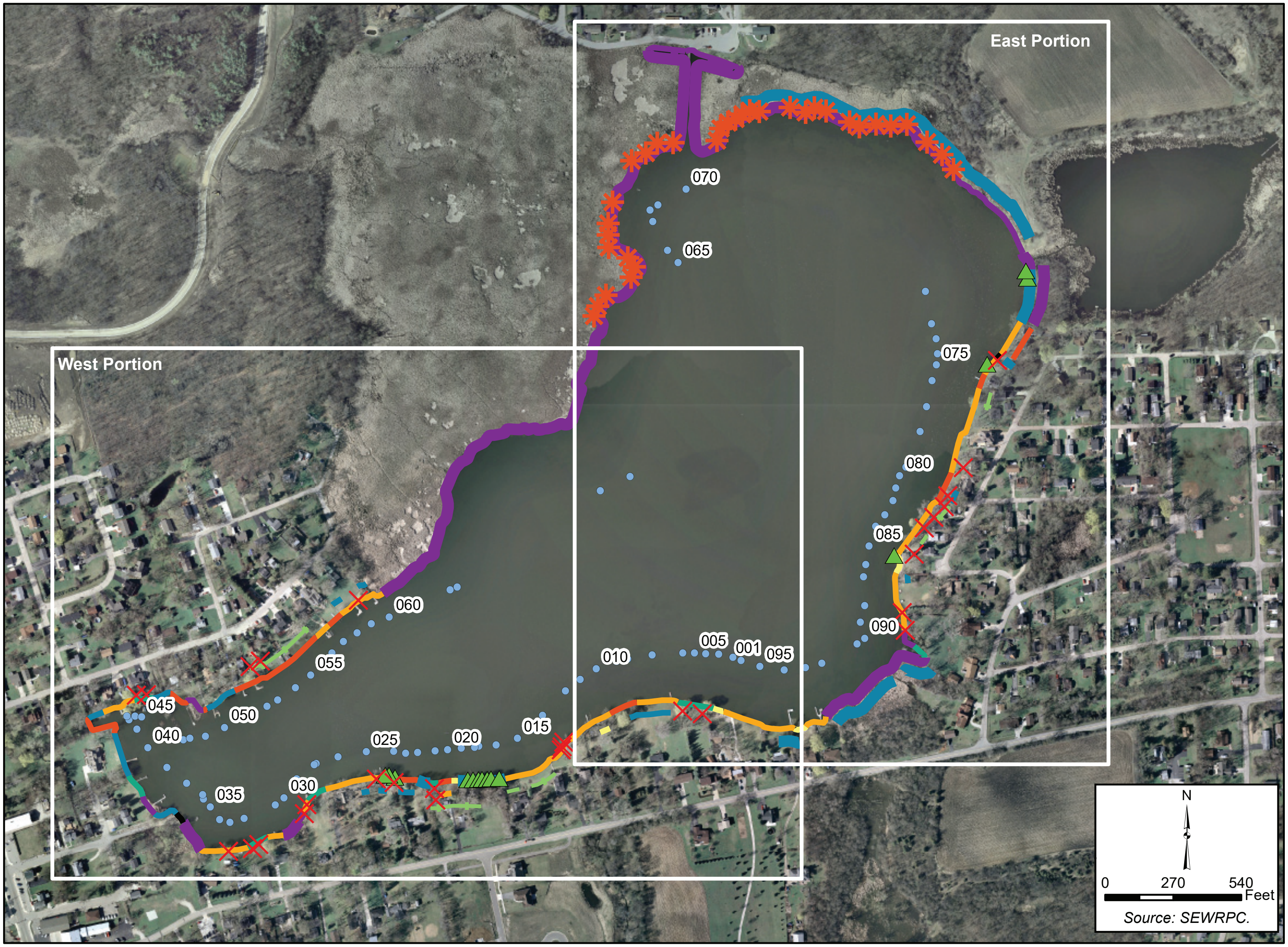
Map B-25

SHORELINE ASSESSMENT OF FRIENDSHIP LAKE: 2014



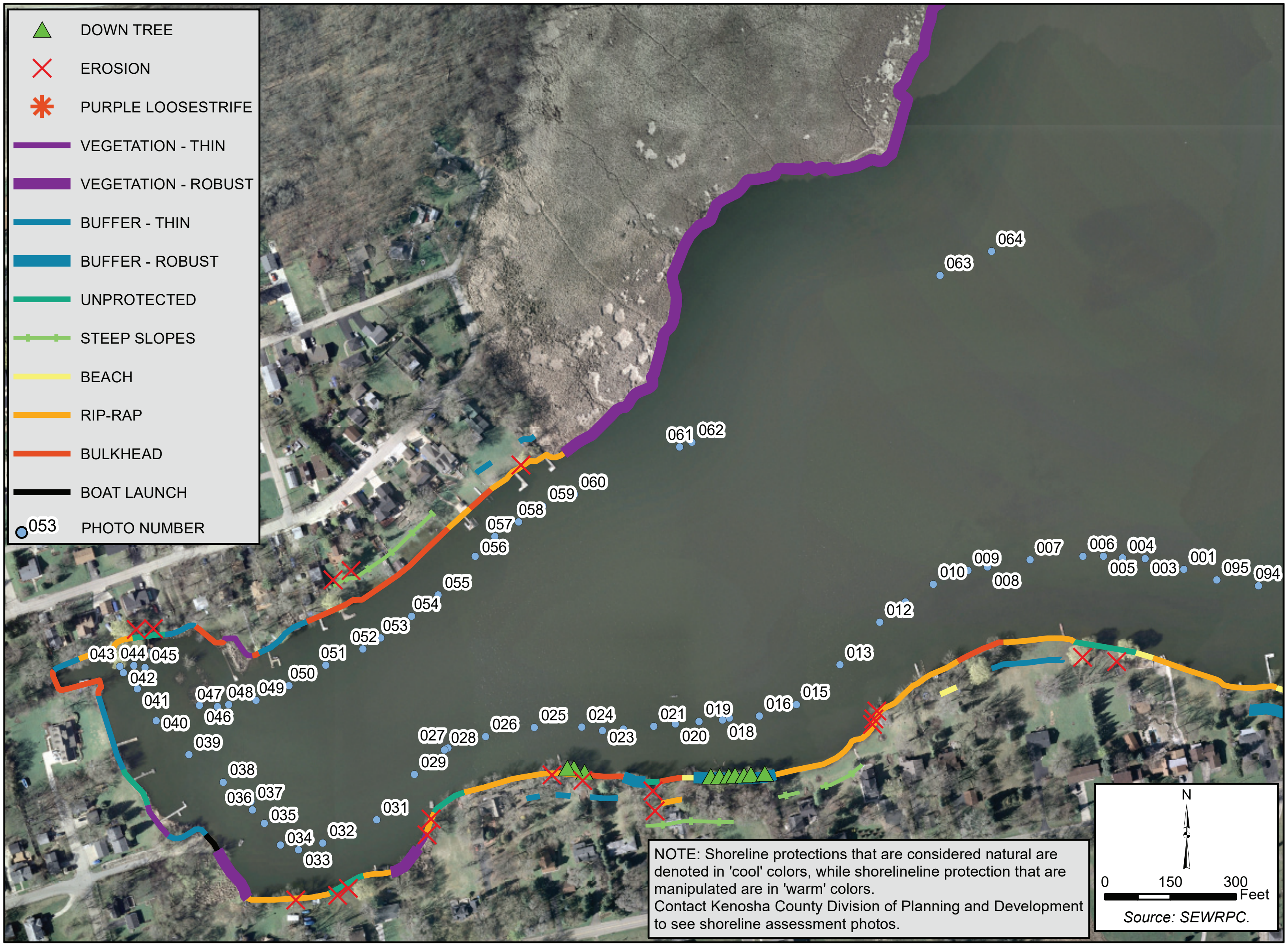
Map B-26

SHORELINE ASSESSMENT FOR HOOKER LAKE



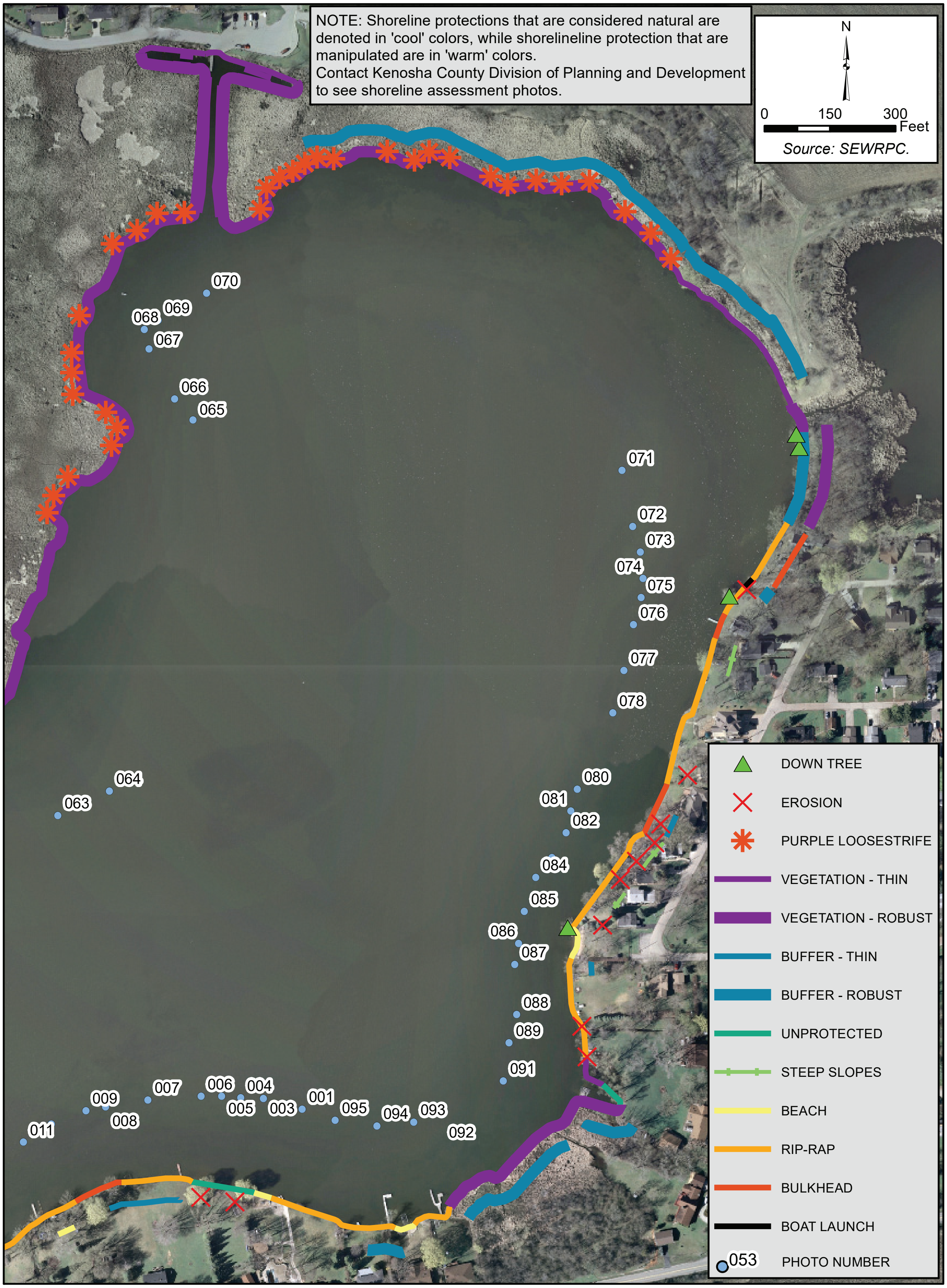
Map B-27

SHORELINE ASSESSMENT FOR WEST PORTION OF HOOKER LAKE: 2014



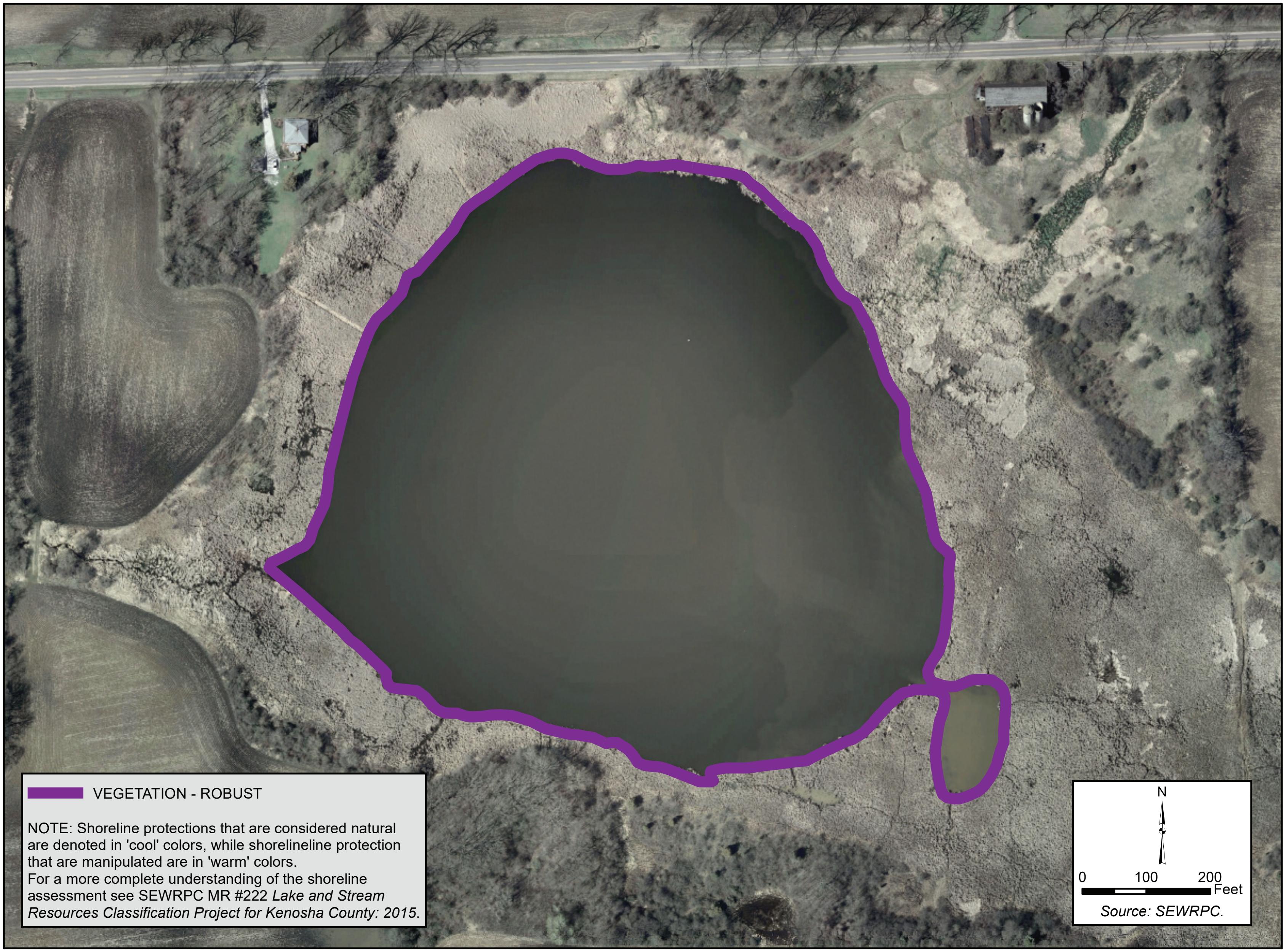
Map B-28

SHORELINE ASSESSMENT FOR EAST PORTION OF HOOKER LAKE: 2014



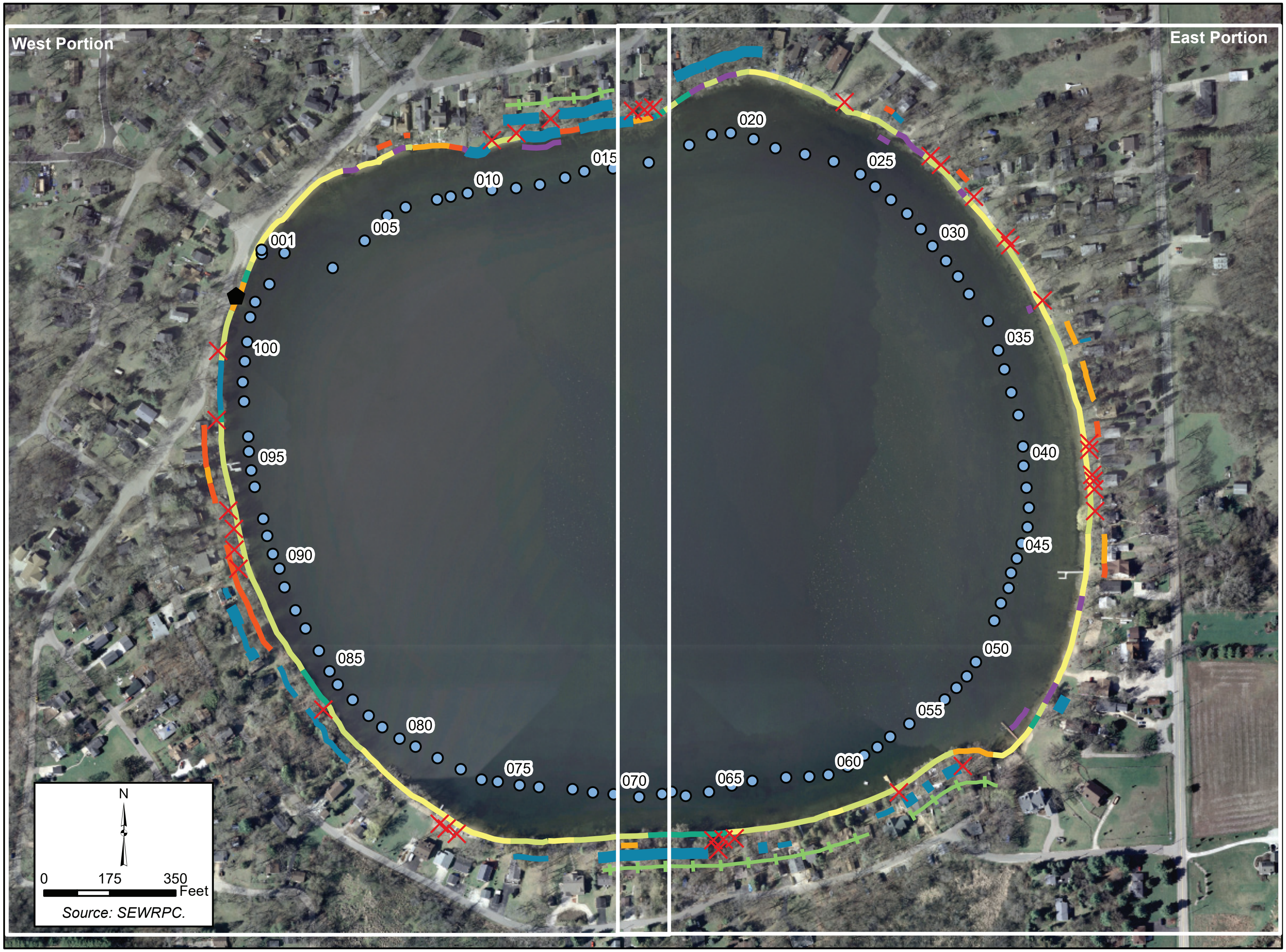
Map B-29

SHORELINE ASSESSMENT OF KULL LAKE: 2014



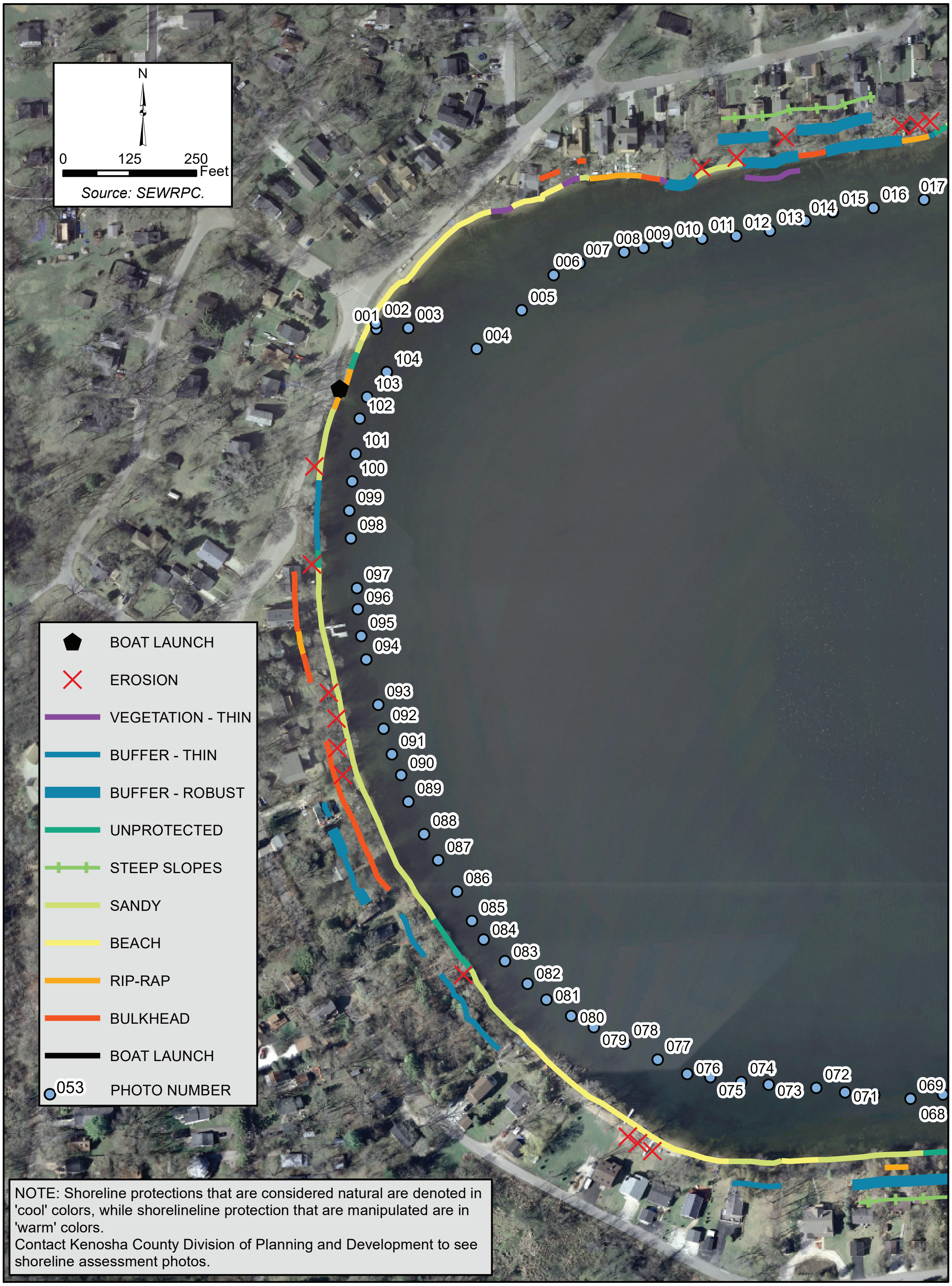
Map B-30

SHORELINE ASSESSMENT FOR LILY LAKE



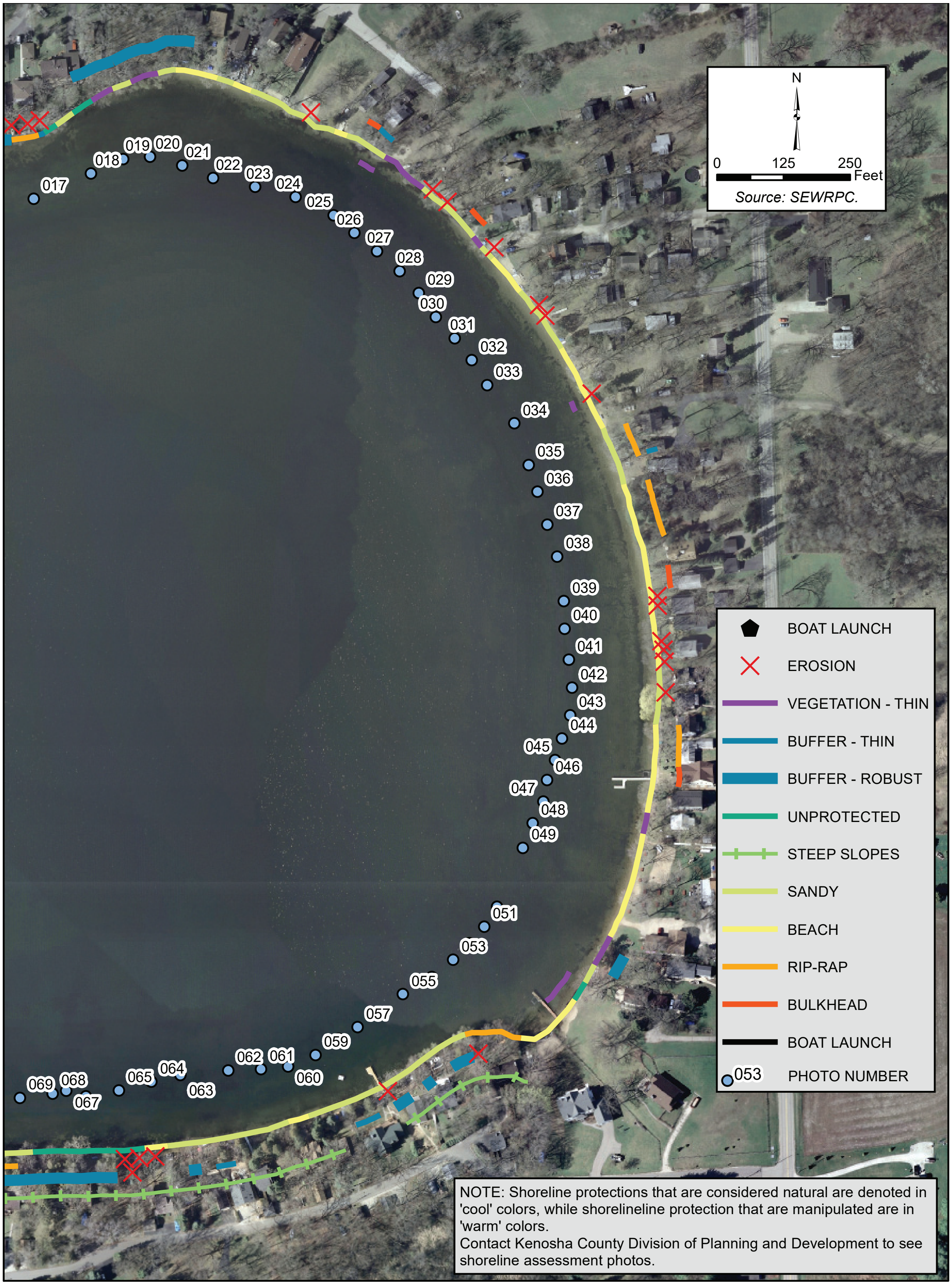
Map B-31

SHORELINE ASSESSMENT FOR WEST PORTION OF LILY LAKE: 2014



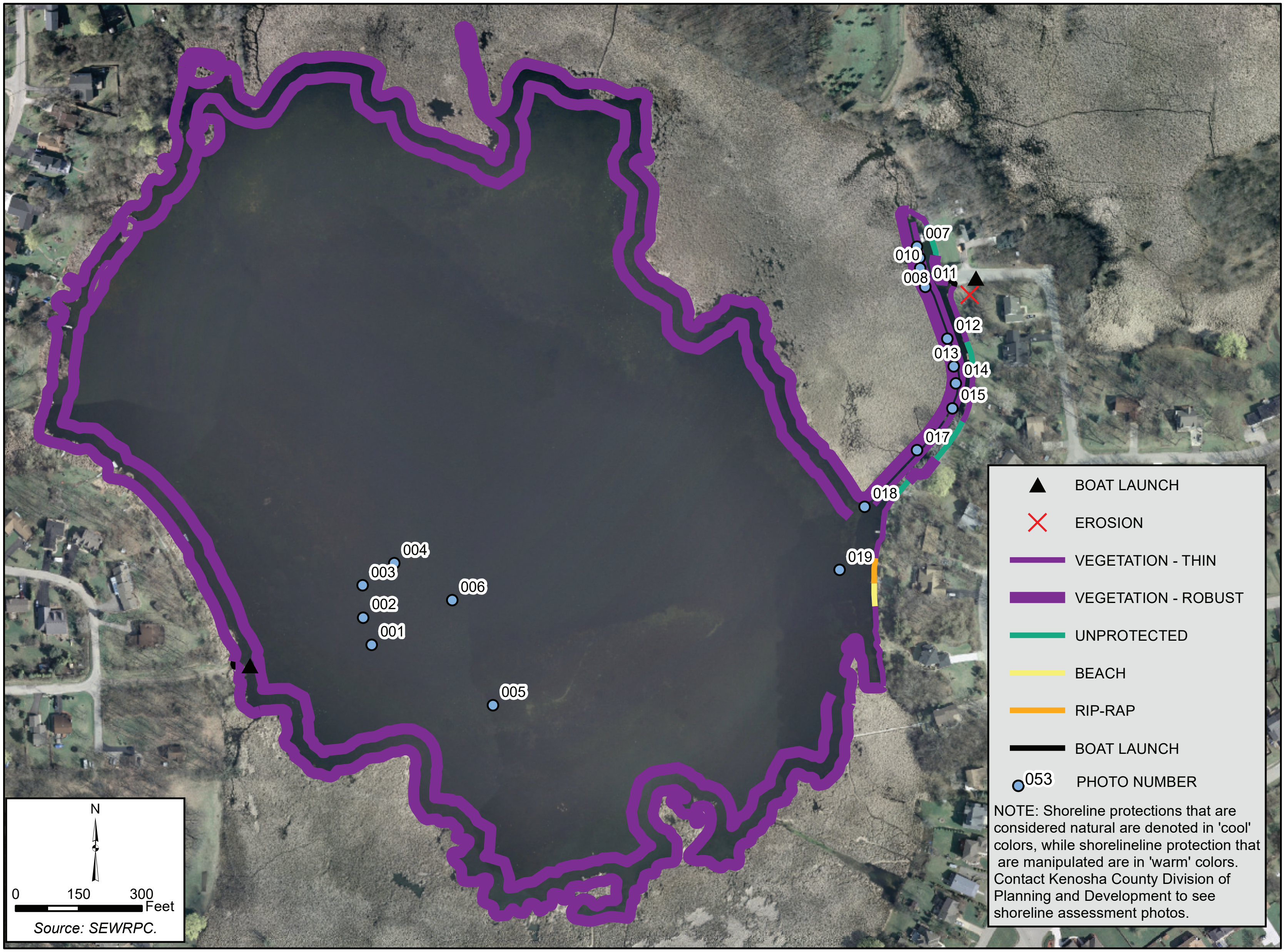
Map B-32

SHORELINE ASSESSMENT FOR EAST PORTION OF LILY LAKE: 2014



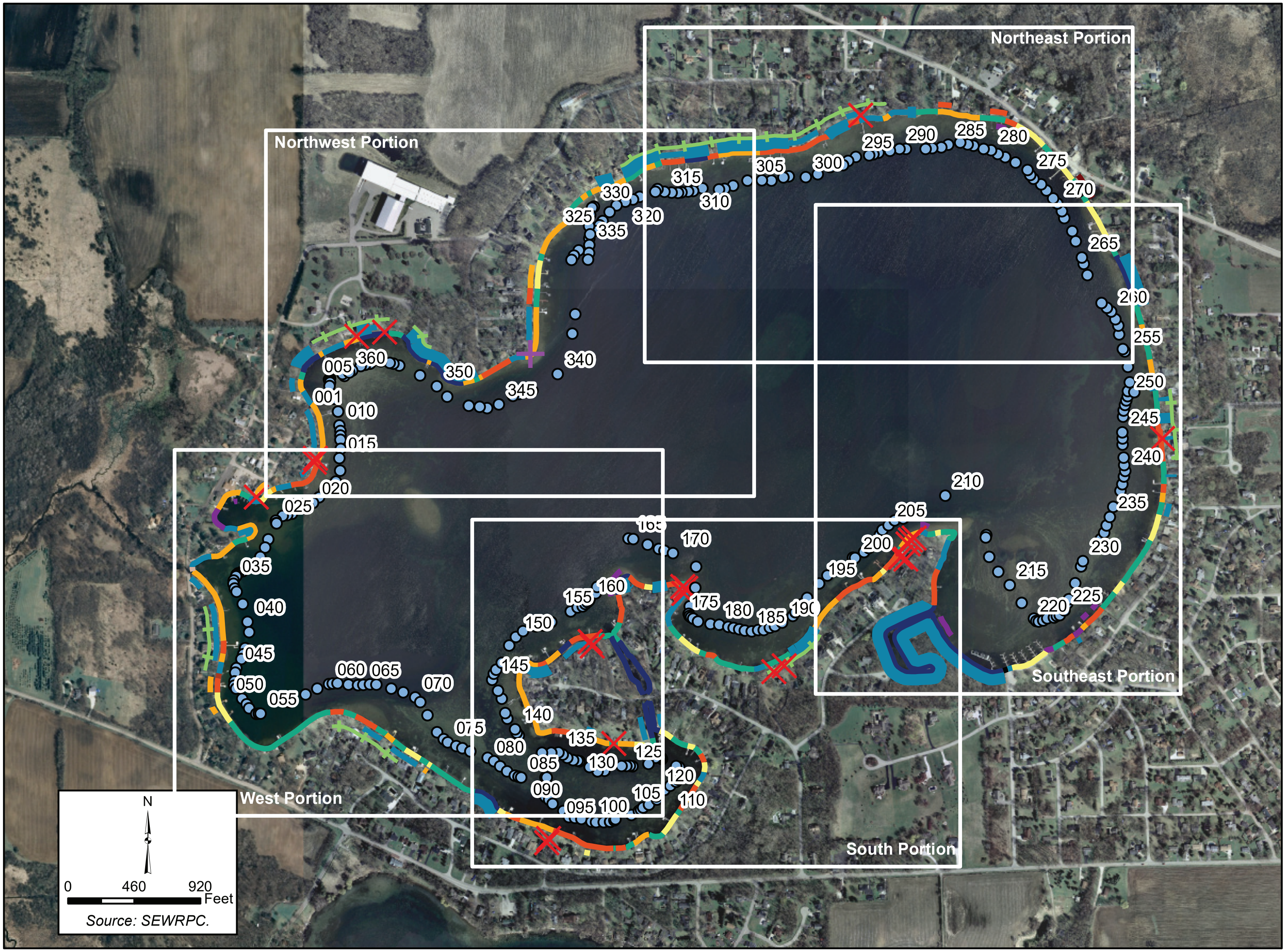
Map B-33

SHORELINE ASSESSMENT OF MONTGOMERY LAKE: 2014



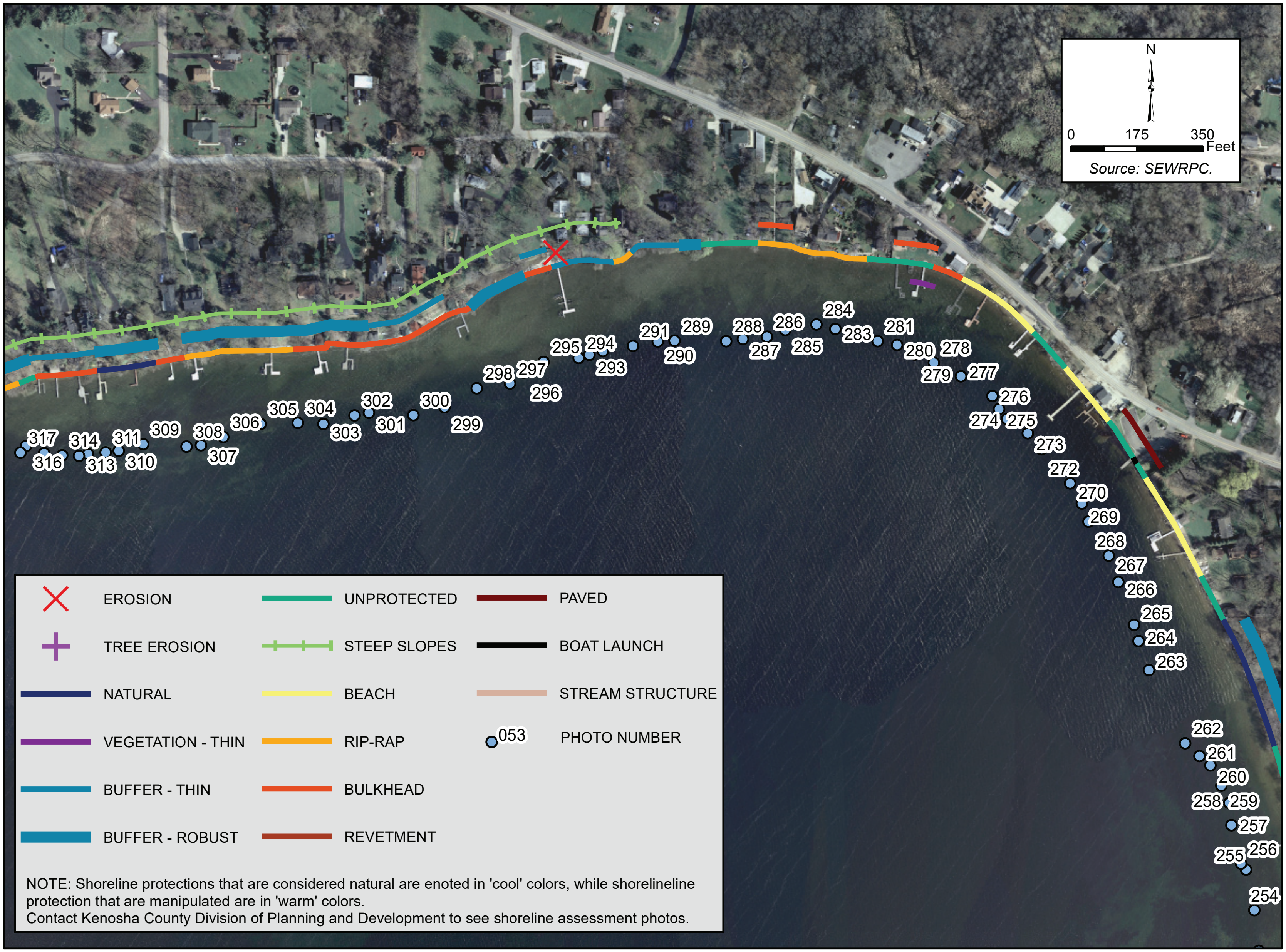
Map B-34

SHORELINE ASSESSMENT FOR POWERS LAKE



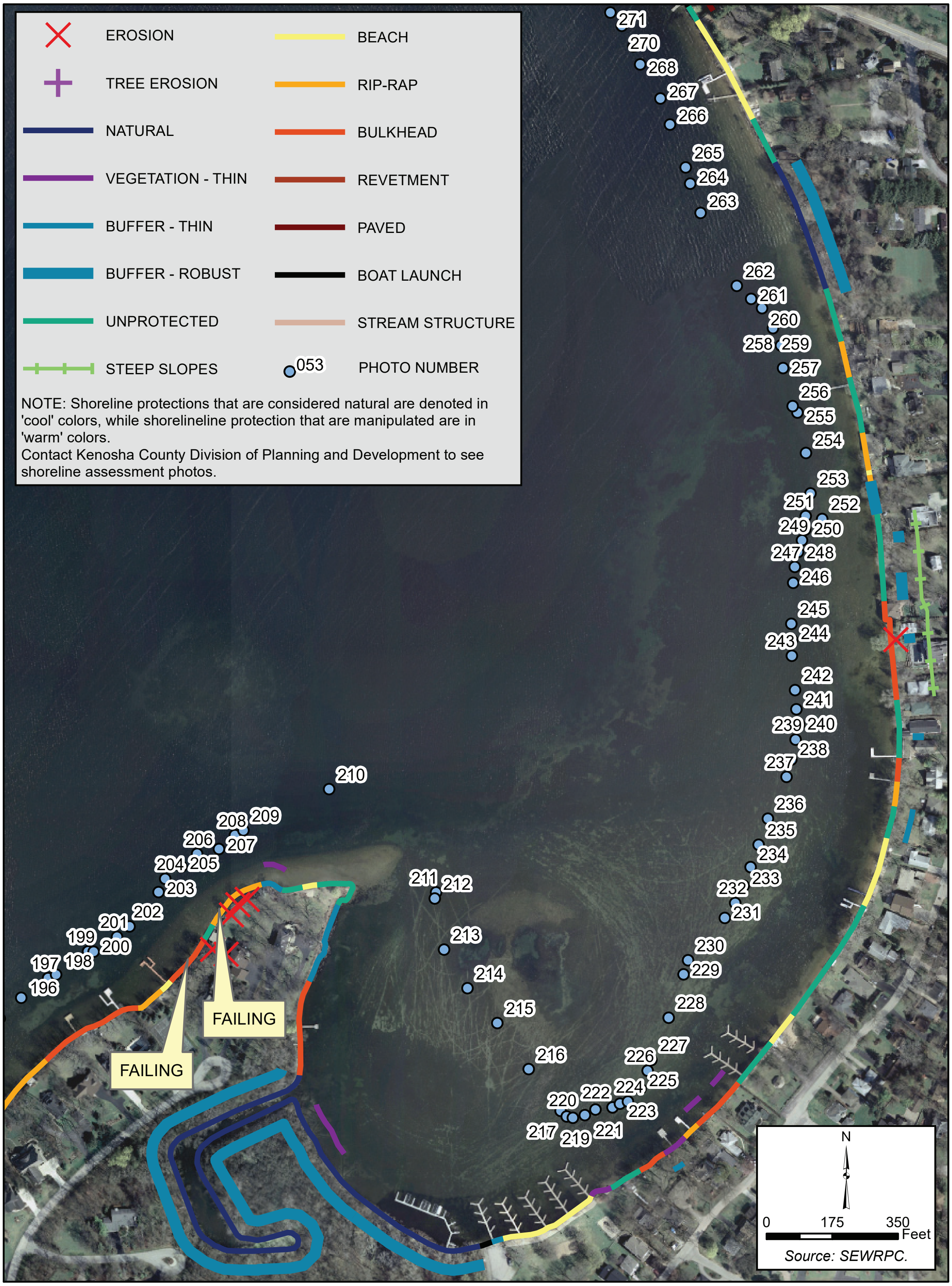
Map B-35

SHORELINE ASSESSMENT FOR NORTHEAST PORTION OF POWERS LAKE: 2014



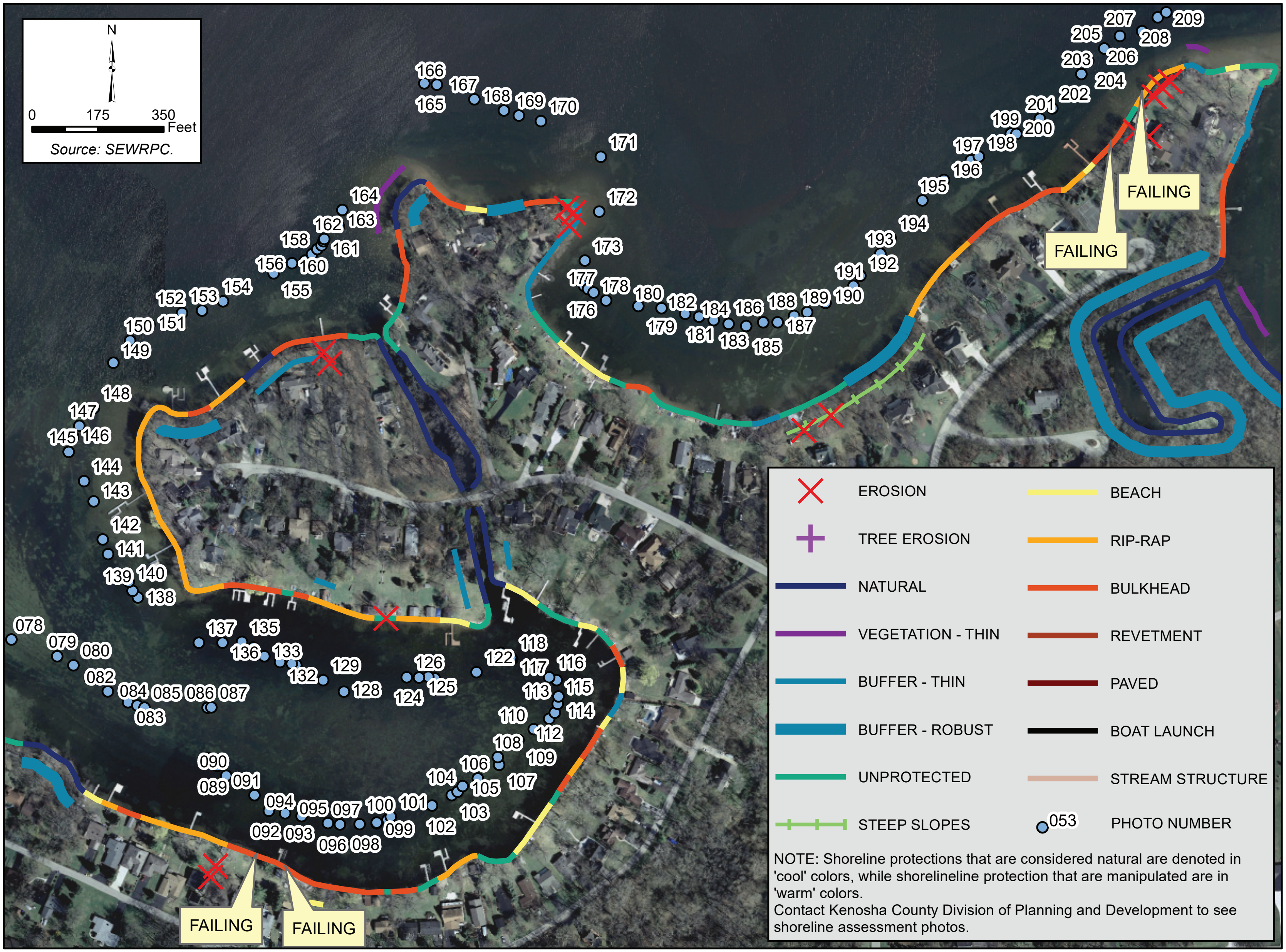
Map B-36

SHORELINE ASSESSMENT FOR SOUTHEAST PORTION OF POWERS LAKE: 2014



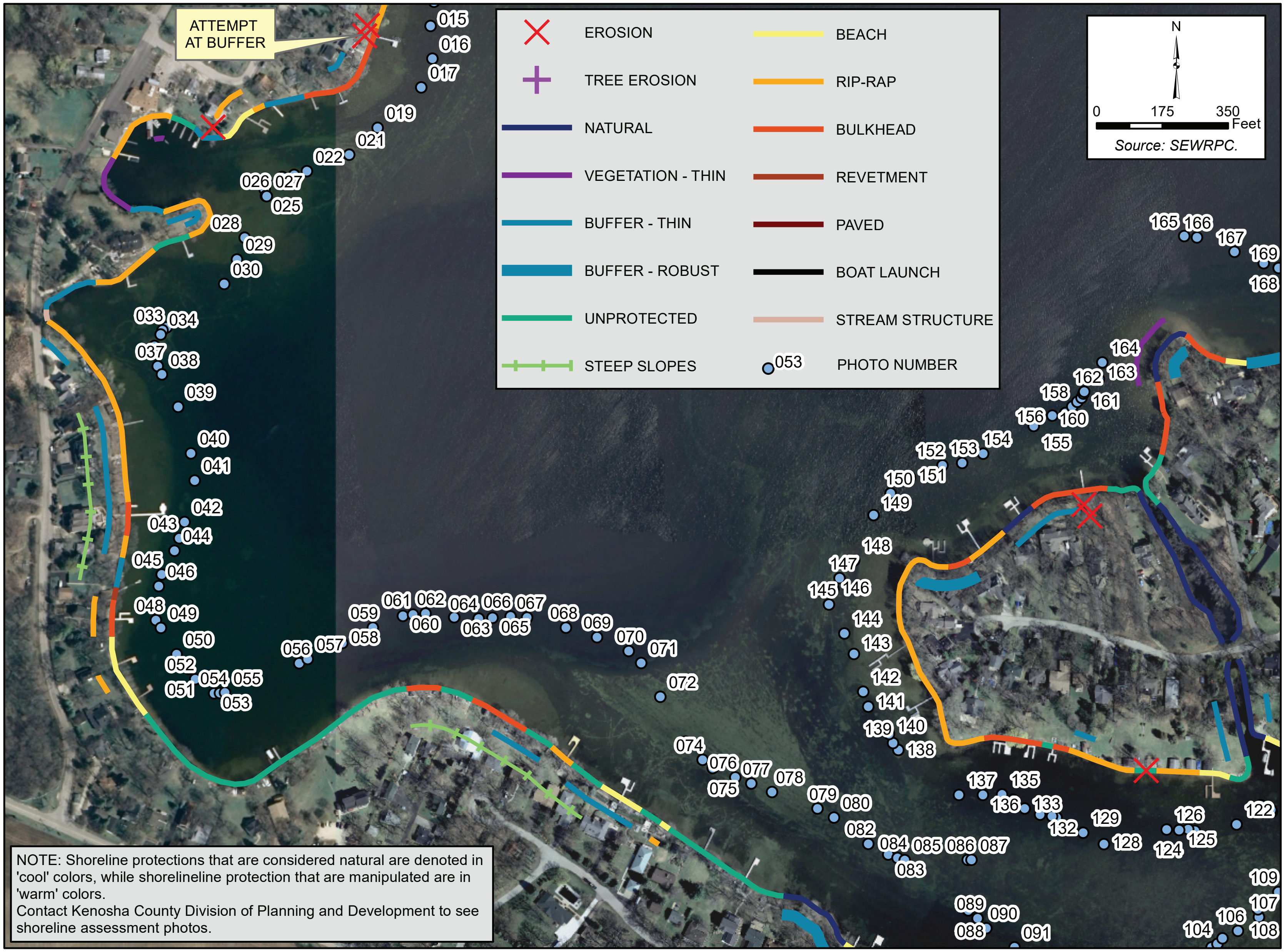
Map B-37

SHORELINE ASSESSMENT FOR SOUTH PORTION OF POWERS LAKE: 2014



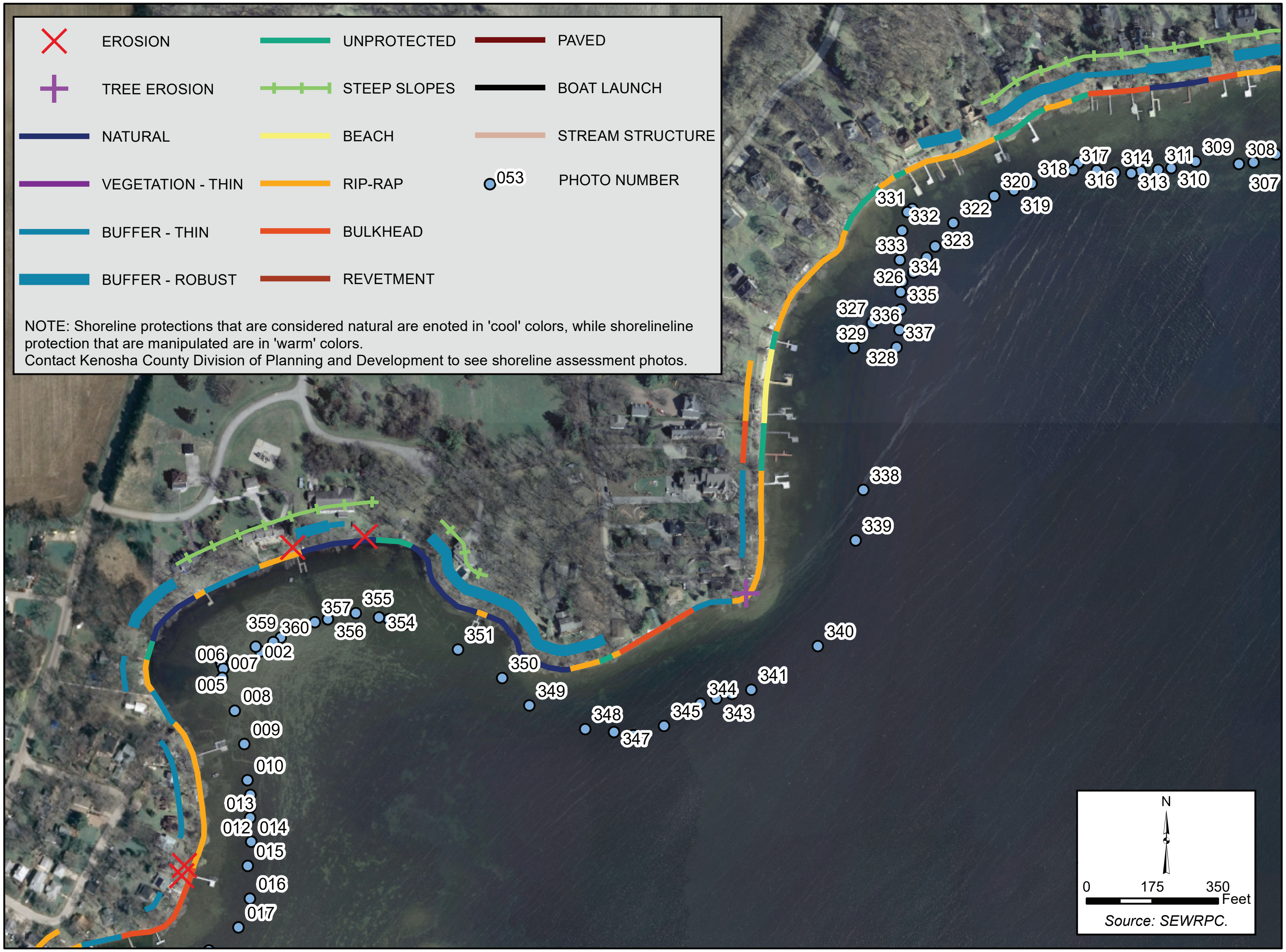
Map B-38

SHORELINE ASSESSMENT FOR WEST PORTION OF POWERS LAKE: 2014



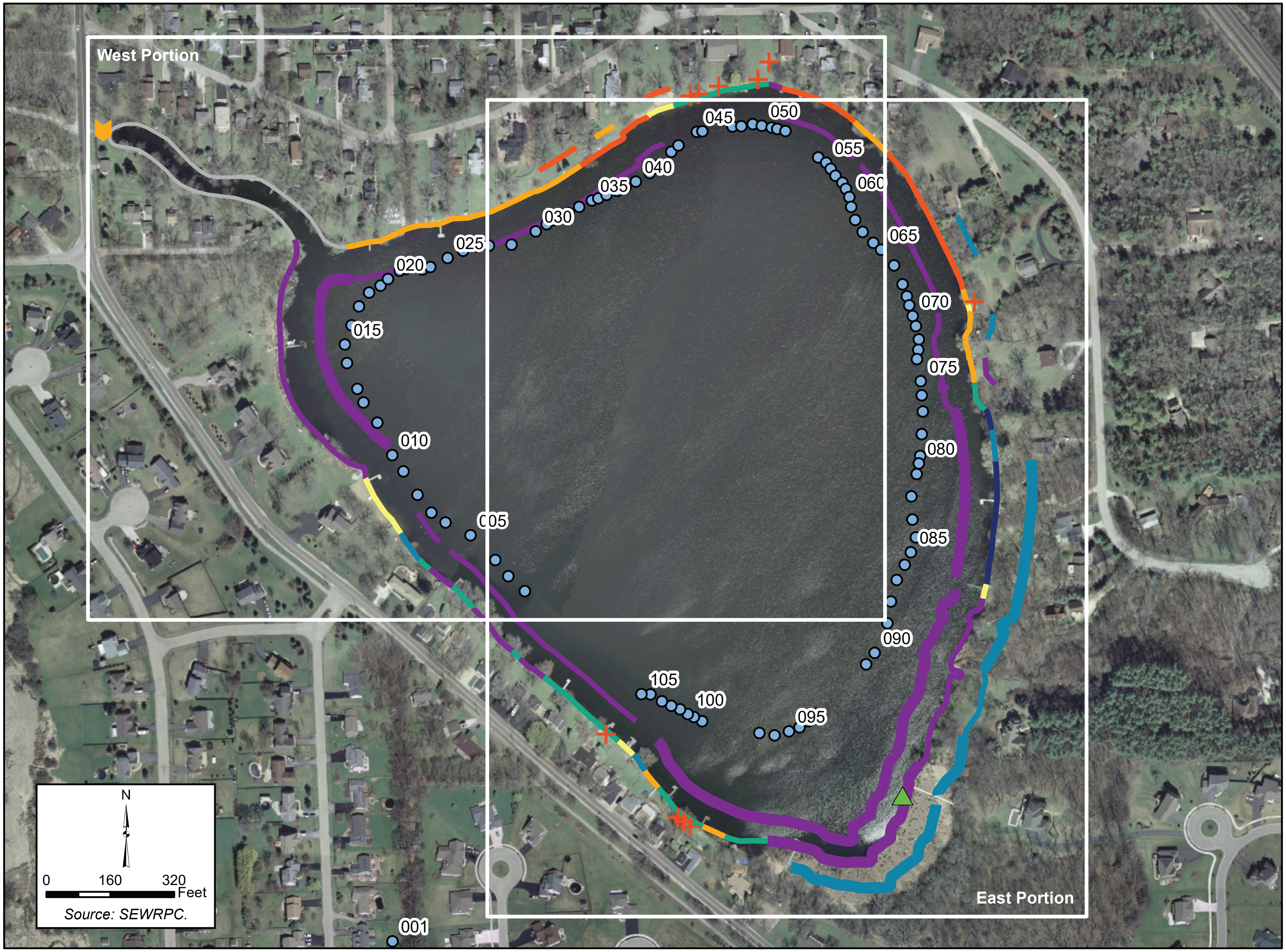
Map B-39

SHORELINE ASSESSMENT FOR NORTHWEST PORTION OF POWERS LAKE: 2014



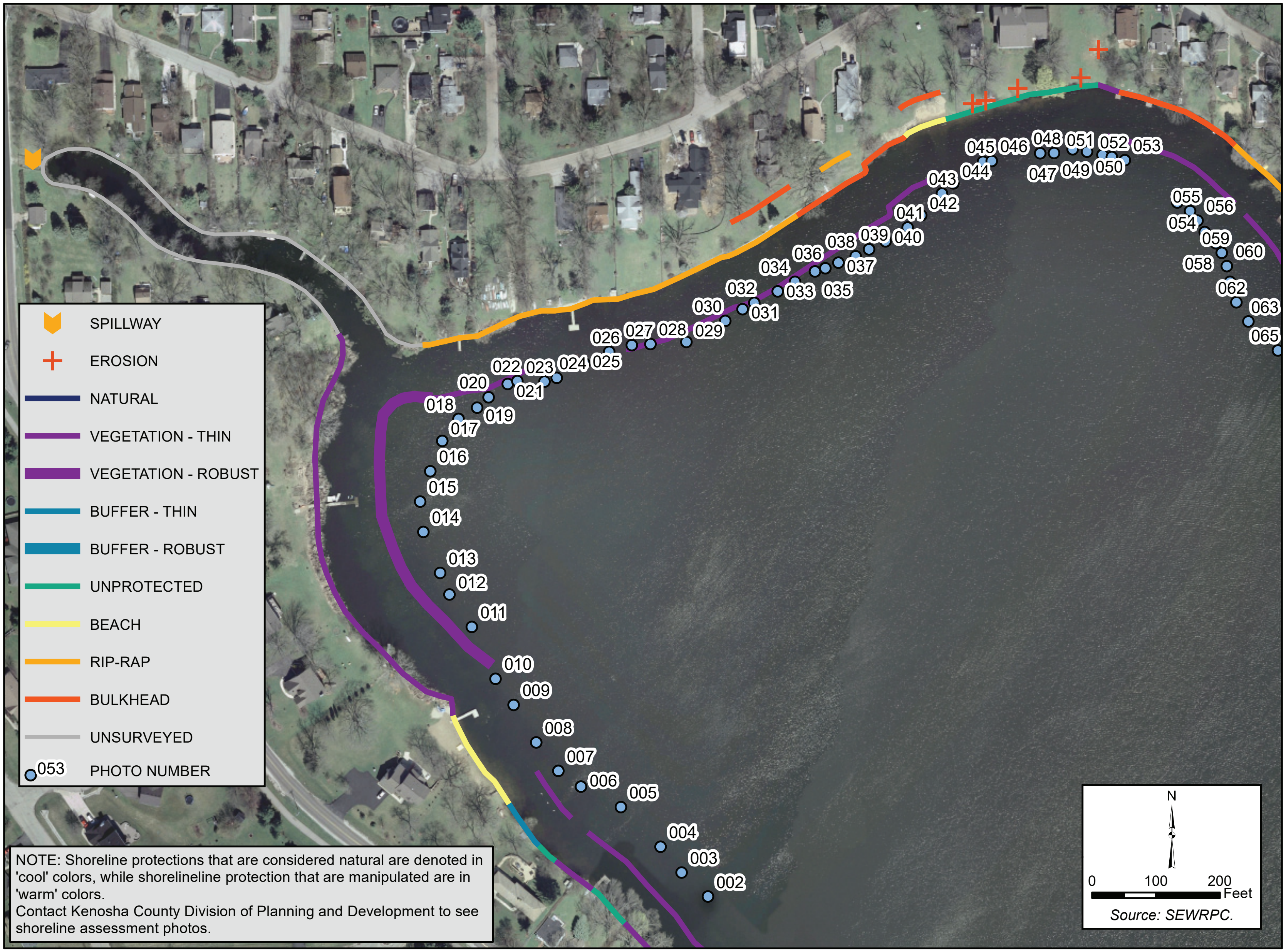
Map B-40

SHORELINE ASSESSMENT FOR ROCK LAKE



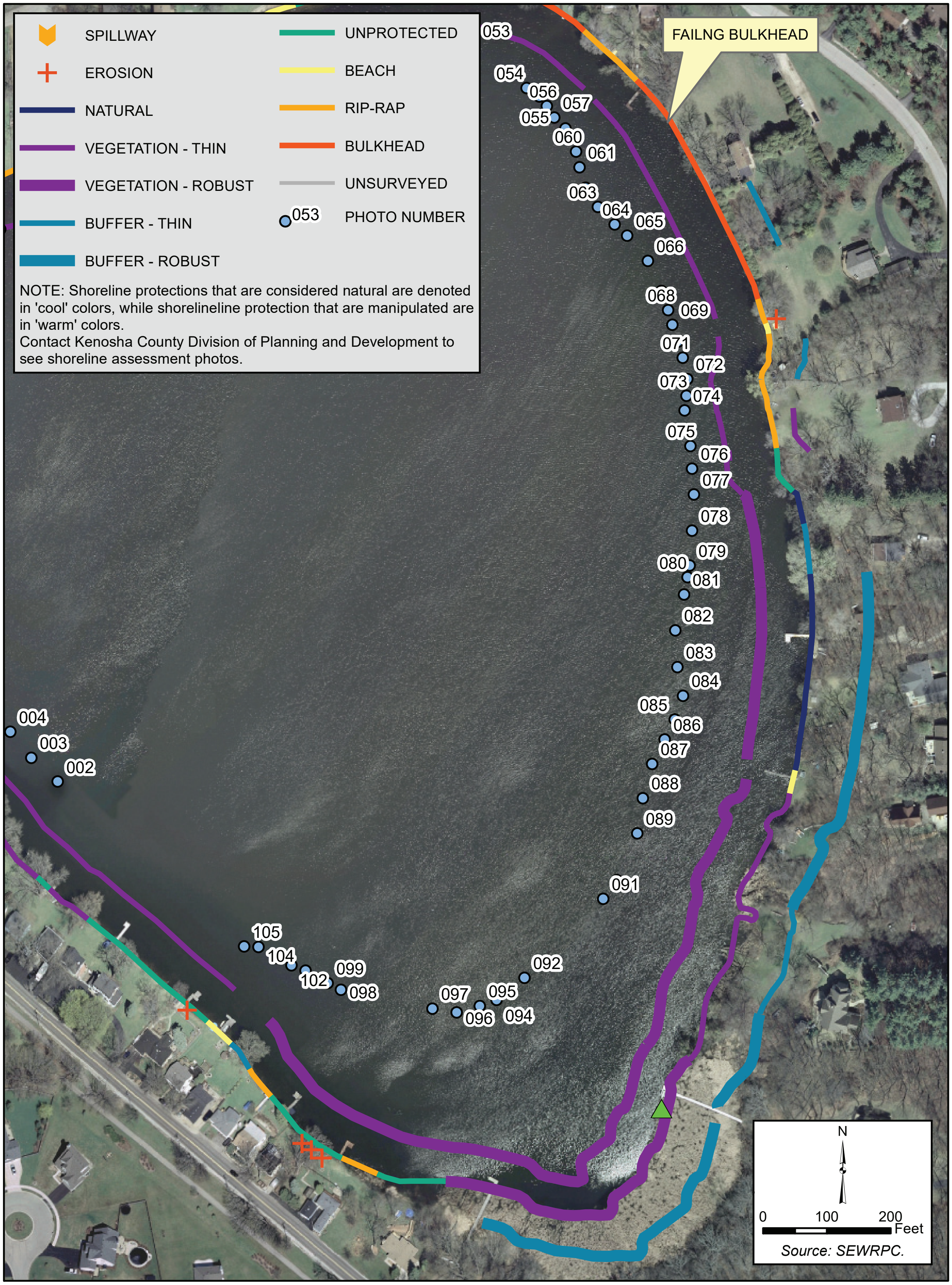
Map B-41

SHORELINE ASSESSMENT FOR WEST PORTION OF ROCK LAKE: 2014



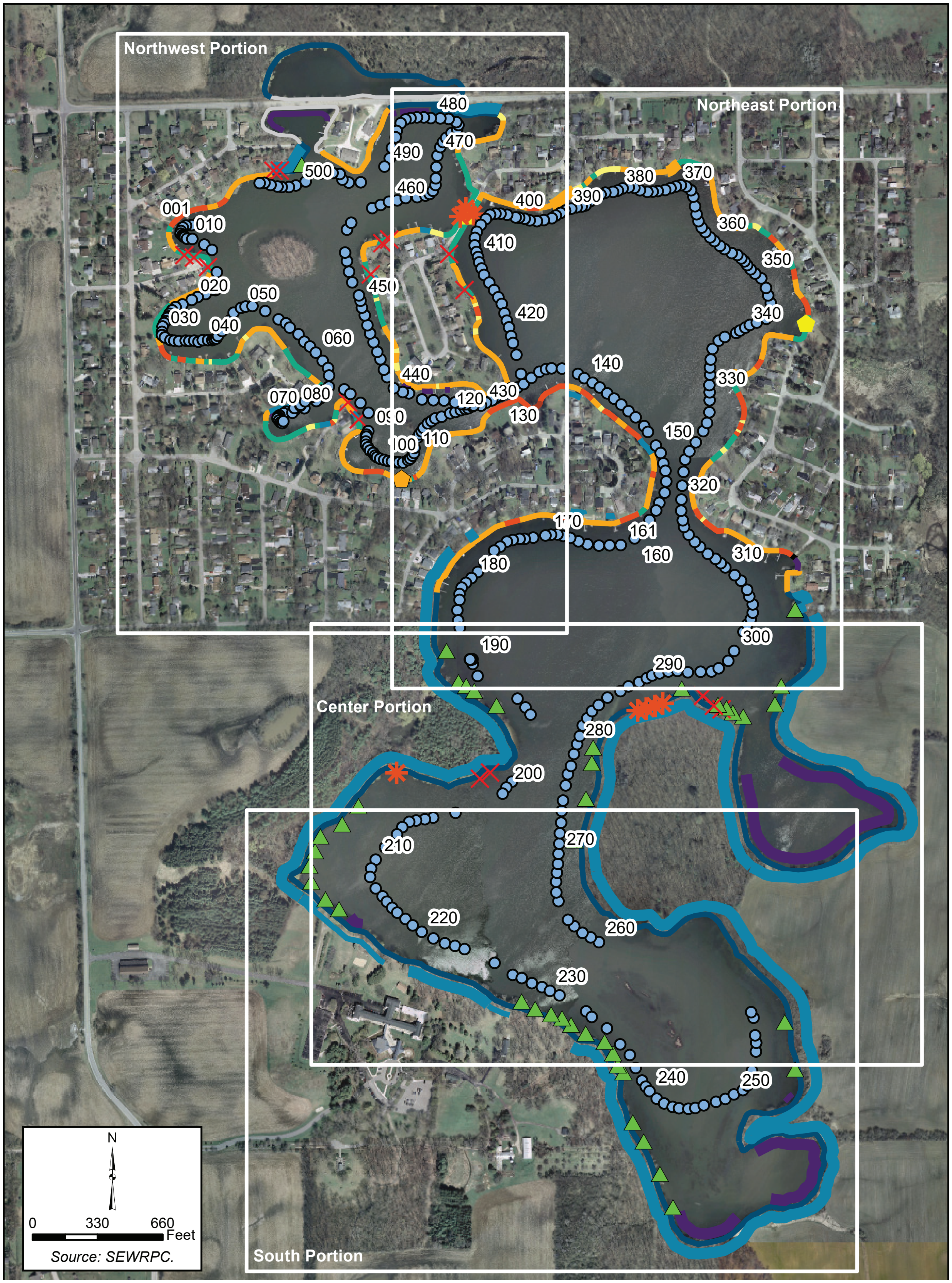
Map B-42

SHORELINE ASSESSMENT FOR EAST PORTION OF ROCK LAKE: 2014



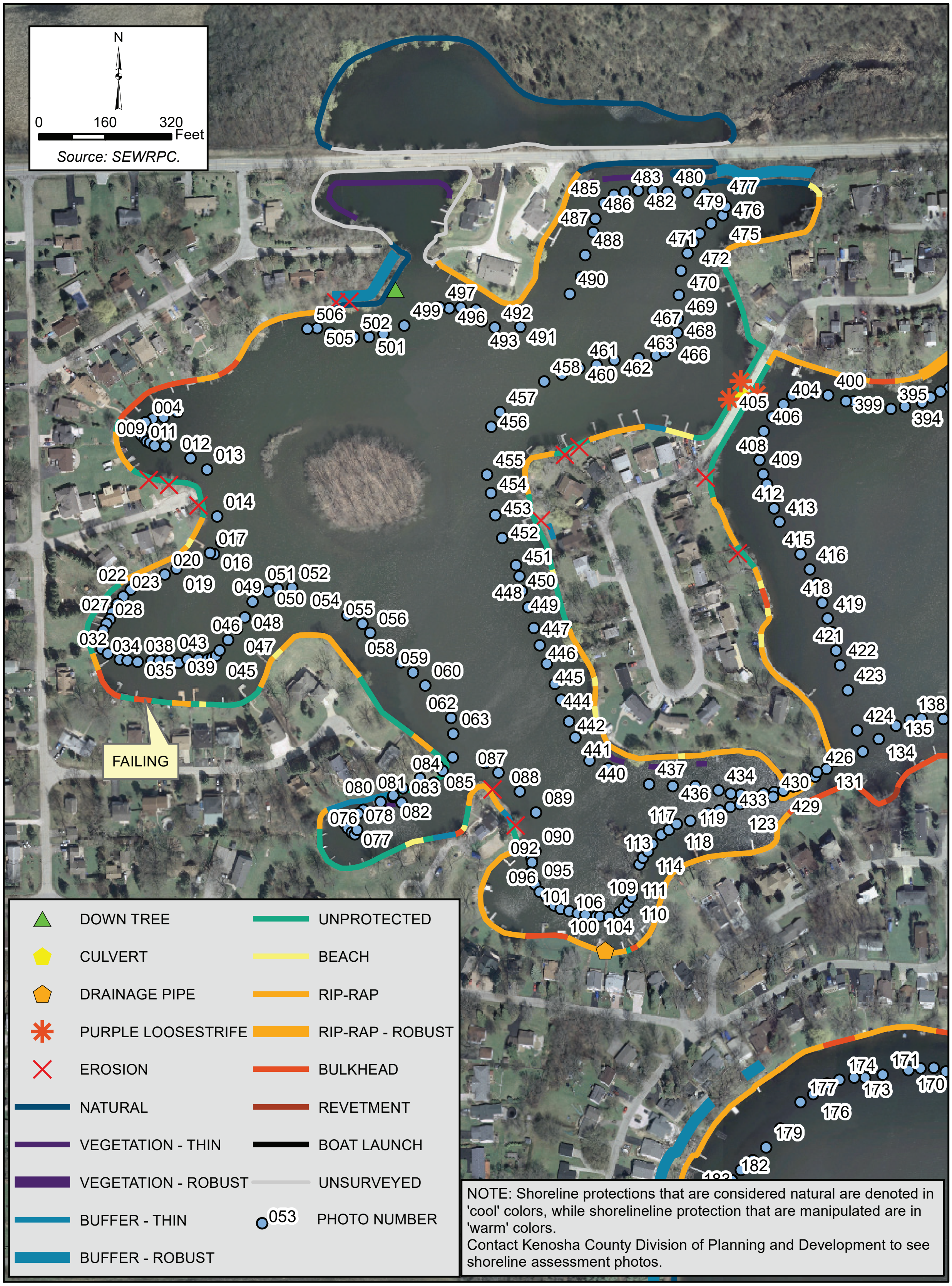
Map B-43

SHANGRI-LA/BENET LAKES



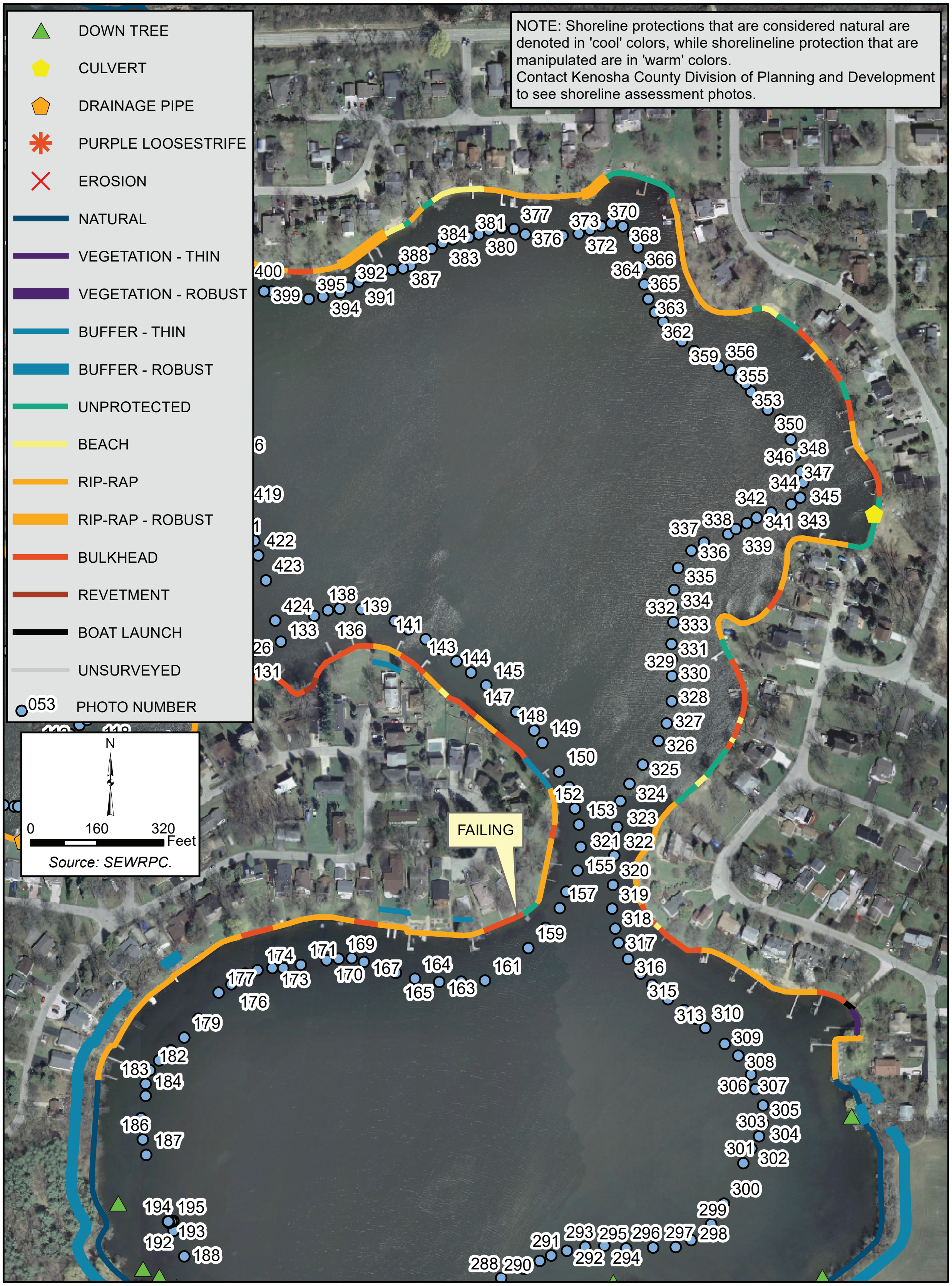
Map B-44

SHORELINE ASSESSMENT FOR NORTHWEST PORTION OF LAKES SHANGRI-LA/BENET: 2014



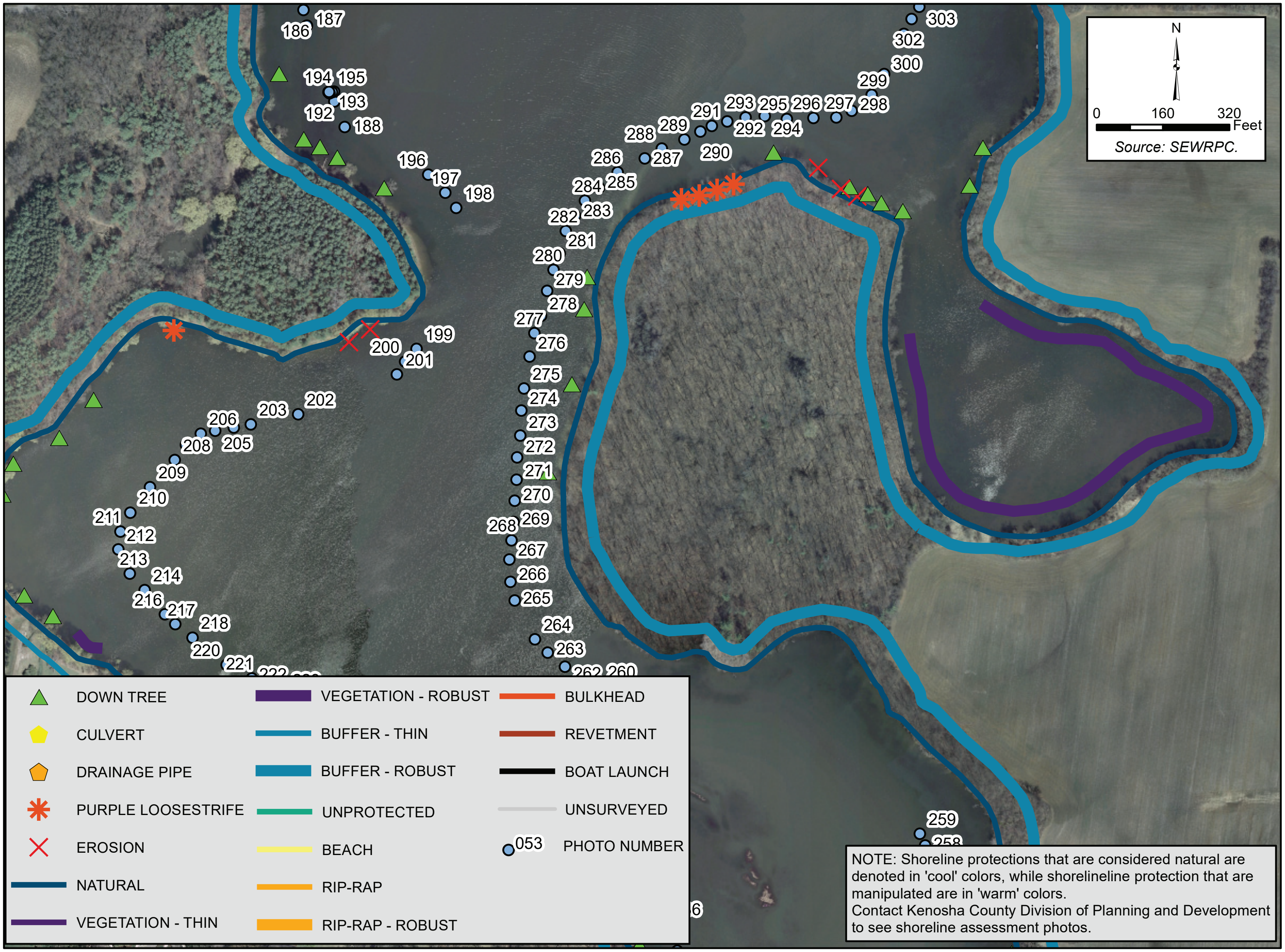
Map B-45

SHORELINE ASSESSMENT FOR NORTHEAST PORTION OF LAKES SHANGRI-LA/BENET: 2014



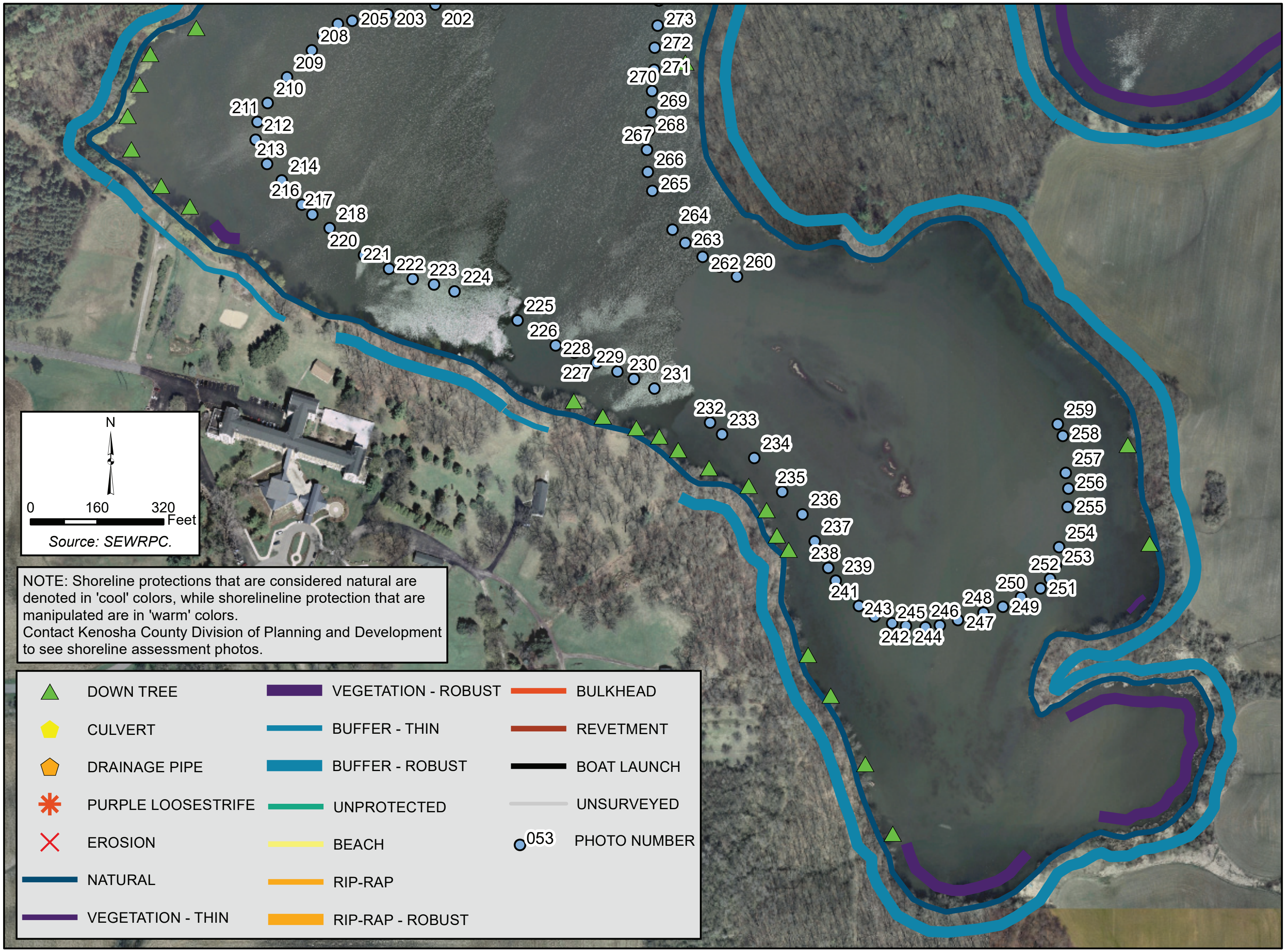
Map B-46

SHORELINE ASSESSMENT FOR CENTER PORTION OF LAKES SHANGRI-LA/BENET: 2014



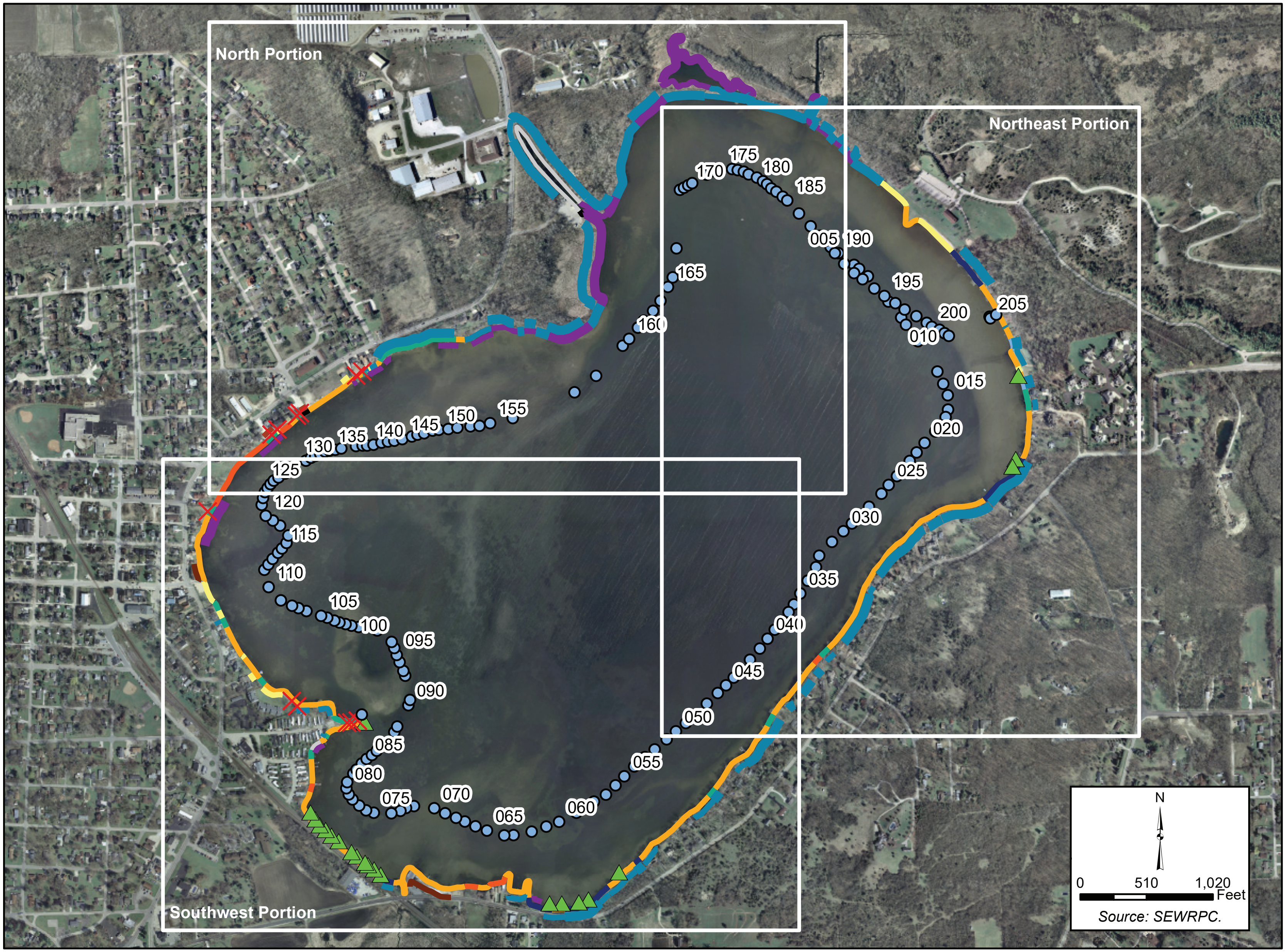
Map B-47

SHORELINE ASSESSMENT FOR SOUTH PORTION OF LAKES SHANGRI-LA/BENET: 2014



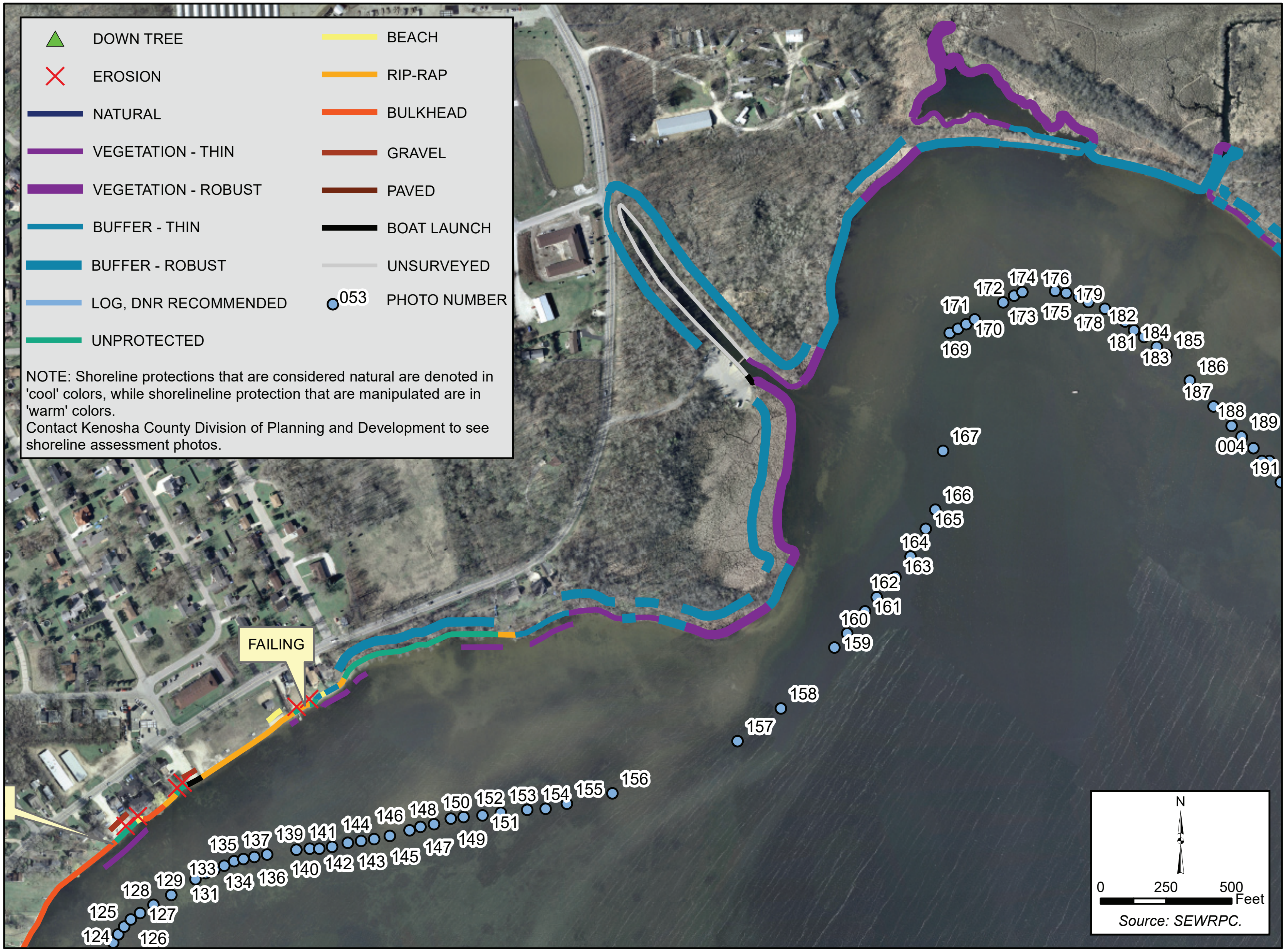
Map B-48

SHORELINE ASSESSMENT FOR SILVER LAKE



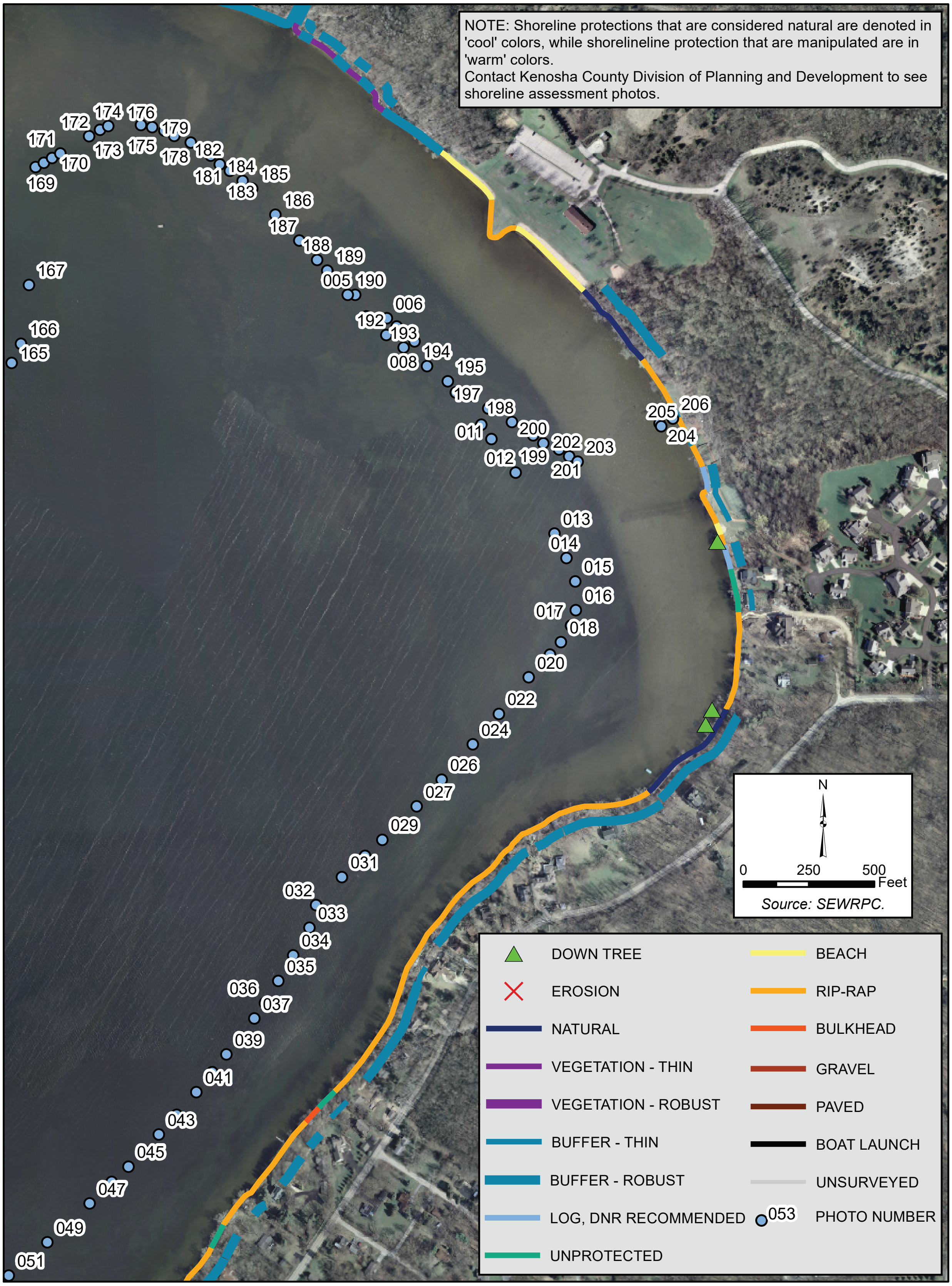
Map B-49

SHORELINE ASSESSMENT FOR NORTH PORTION OF SILVER LAKE: 2014



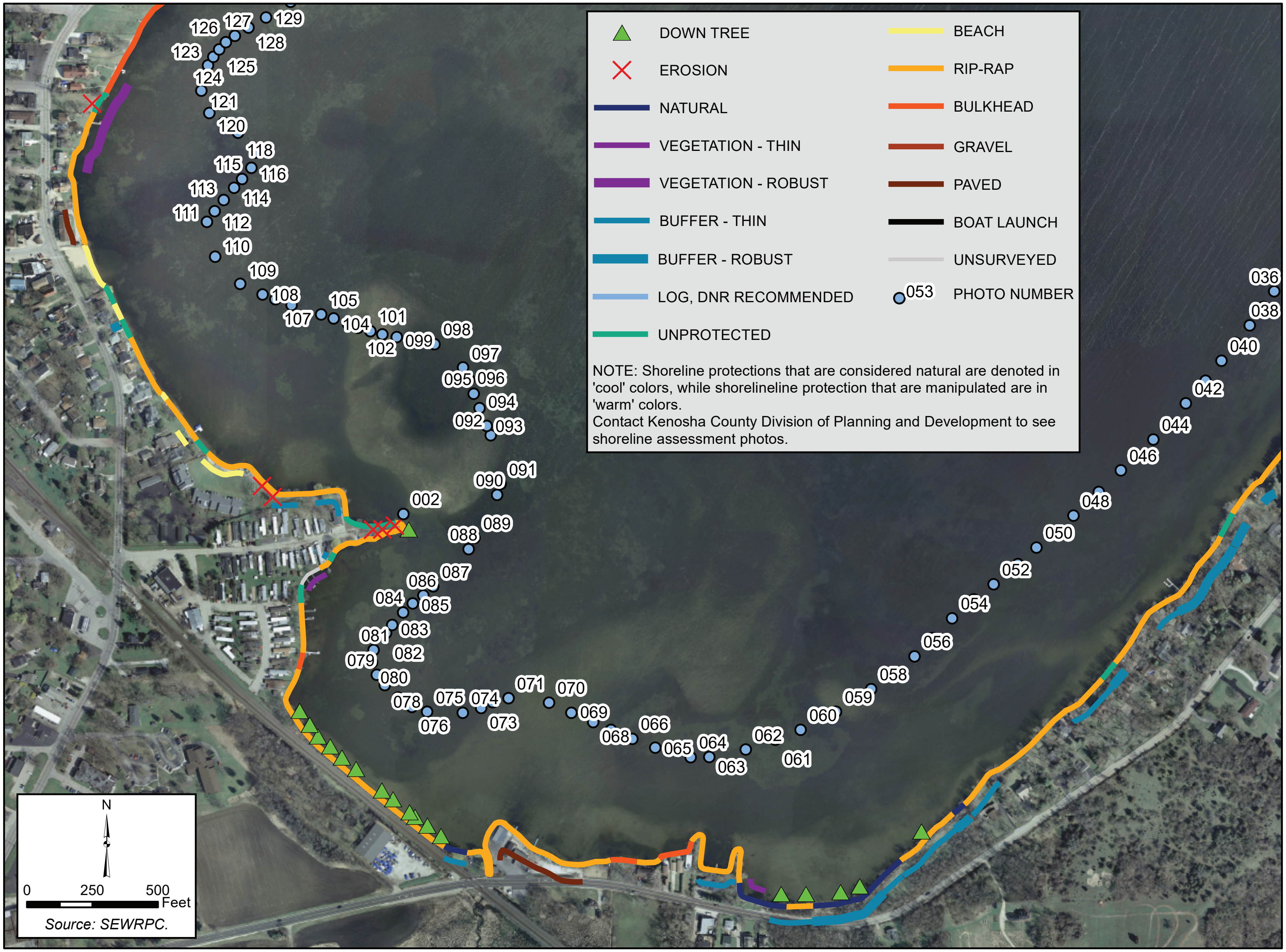
Map B-50

SHORELINE ASSESSMENT FOR NORTHEAST PORTION OF SILVER LAKE: 2014



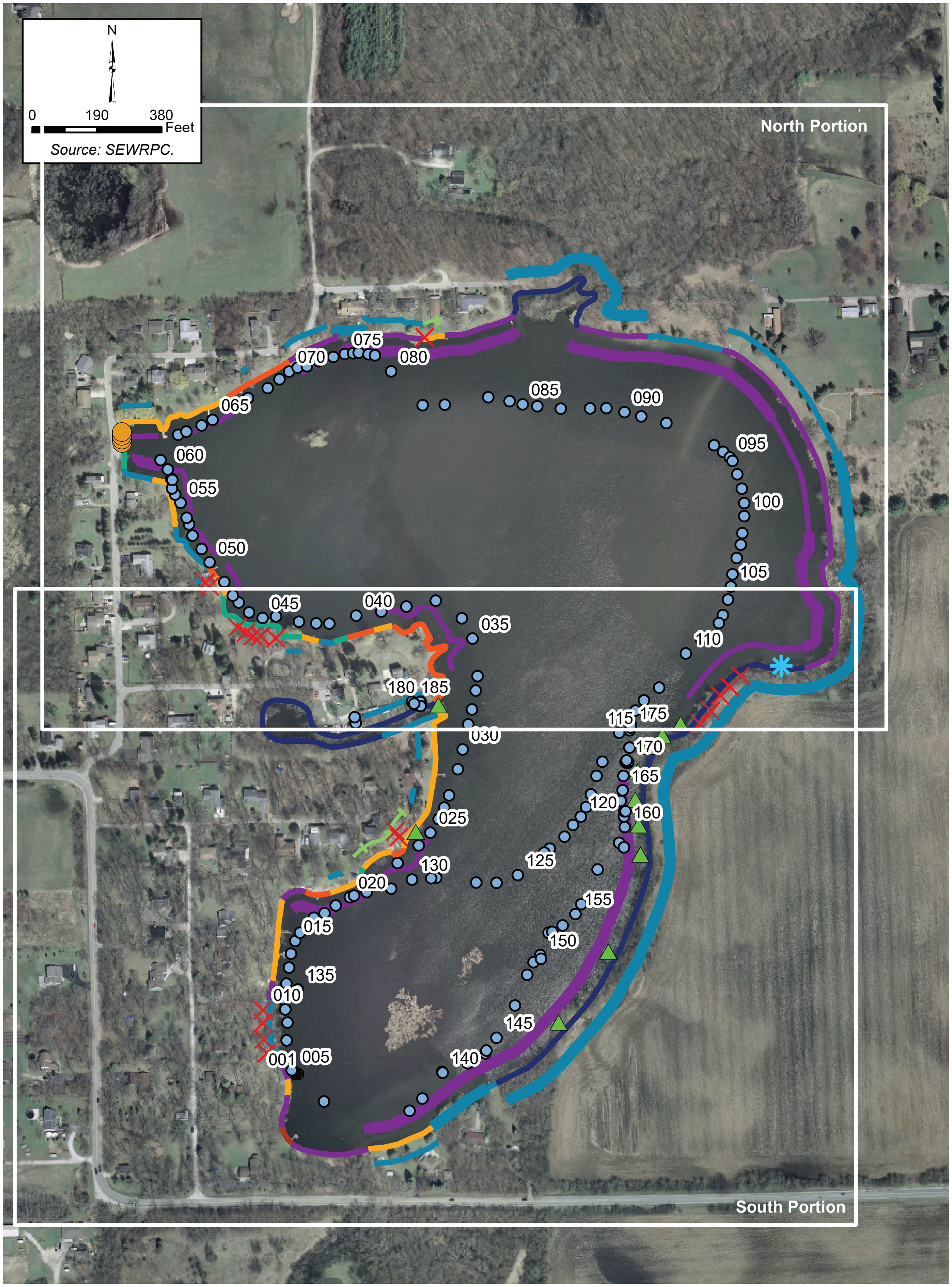
Map B-51

SHORELINE ASSESSMENT FOR SOUTHWEST PORTION OF SILVER LAKE: 2014



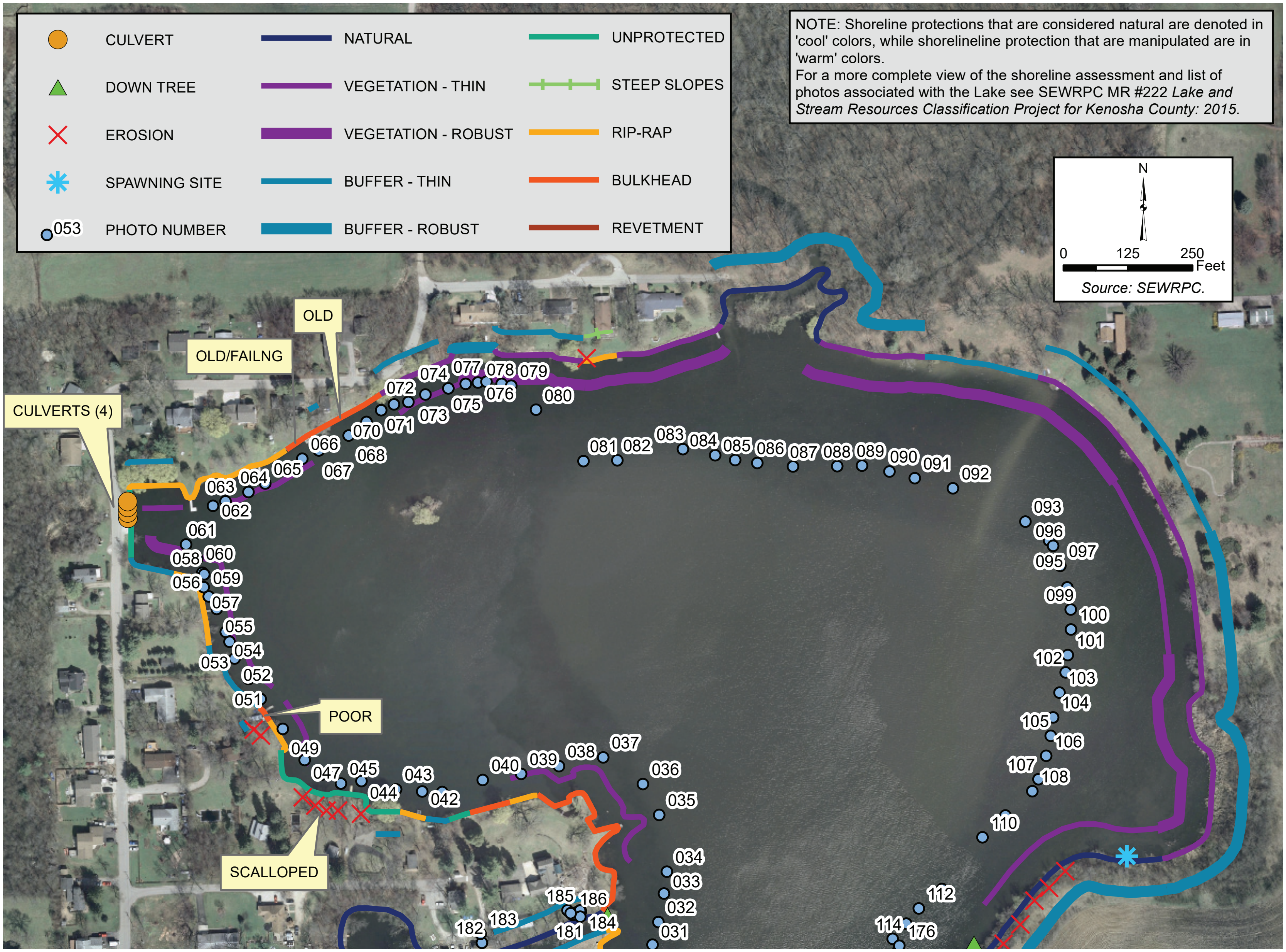
Map B-52

SHORELINE ASSESSMENT FOR VOLTZ LAKE



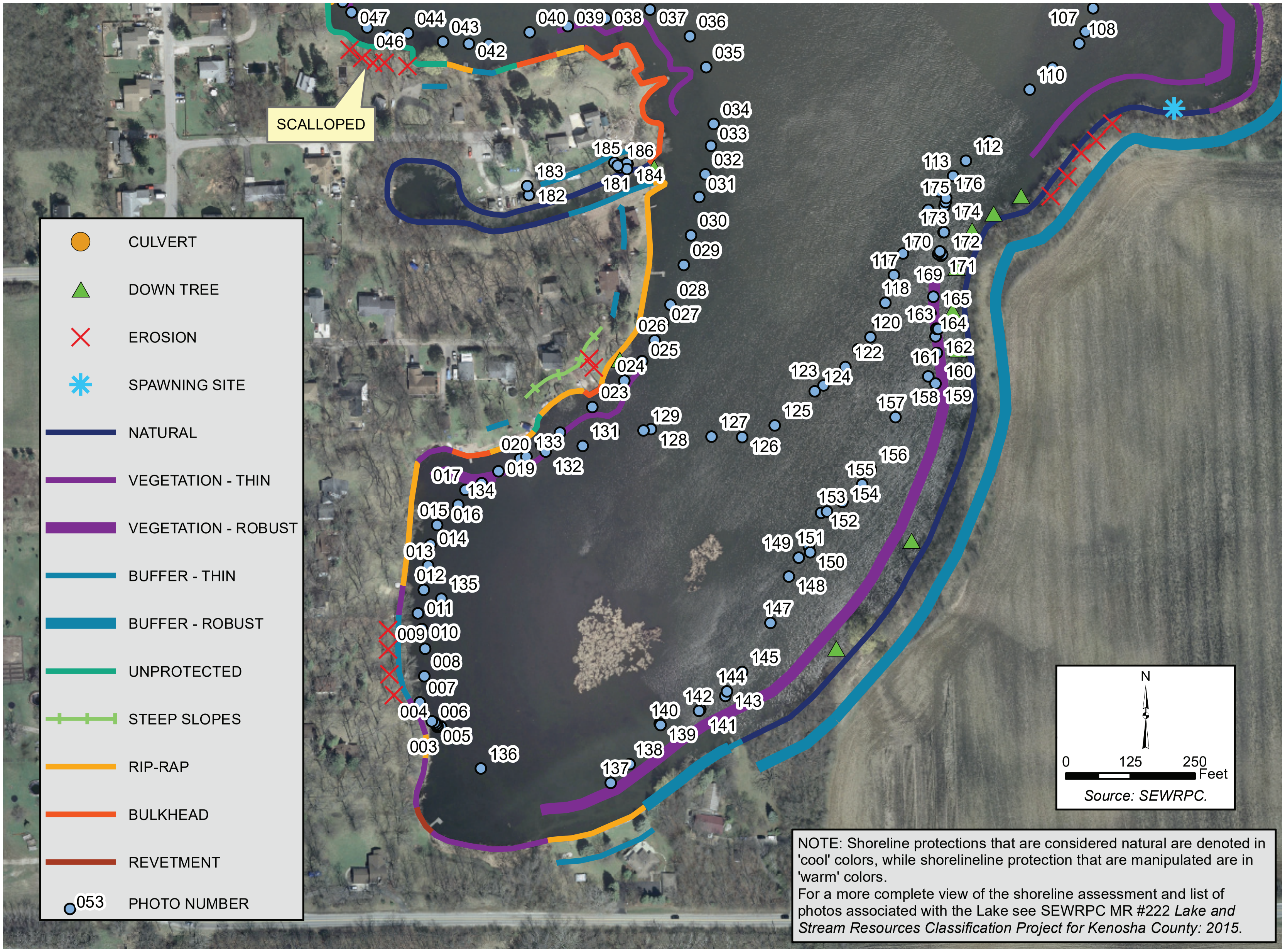
Map B-53

SHORELINE ASSESSMENT FOR NORTH PORTION OF VOLTZ LAKE: 2014



Map B-54

SHORELINE ASSESSMENT FOR SOUTH PORTION OF VOLTZ LAKE: 2014



Appendix C

STREAM REACH AND WATERSHED SENSITIVITY AND HUMAN INFLUENCE CRITERIA: VARIABLES; PARAMETER VALUES; SCORING CATEGORIES AND WEIGHTING; AND, CLASSIFICATION RANKING FACTORS

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Table C-1

STREAM AND WATERSHED SENSITIVITY INPUT VARIABLES AND SCORING BRACKETS

Sensitivity Criteria					Scoring		
Criterion	Data Source	Description	Measured Value/Units	Lake Classification Significance	Value Brackets	Score	Formula Weighting
Lake and Shoreline							
Natural Community	WDNR	Stream flow conditions and water temperature are used to predict the ecology of streams.	WDNR Natural Community Estimate	The biota and sustained flow of smaller, colder streams are more vulnerable to influence from changes landscape conditions.	Large River	1 (least sensitive)	3.00
					Mainstem: Cool-warm	2	
					Macro-invertebrate only	3	
					Headwater: Warm and Cool-Warm	4	
					Headwater: Cool-Cold	5	
					Coldwater	6 (most sensitive)	
Strahler Stream Order	WDNR	Strahler stream order expresses the watershed position and usually the size of streams. First order streams are headwater streams. Where two first order stream converge, a second order stream begins. Where two second order streams converge, a third order stream results.	Stream order rank/ dimensionless	Lower order streams are more sensitive to landscape change in the immediate area.	5th order	1 (least sensitive)	1.25
					3rd and 4th order	2	
					1st and 2nd order	3 (most sensitive)	
Rare Species and Trout	WDNR	Certain organisms are rare in the study area. This rarity is often related to degraded habitat conditions.	Number of rare species and trout	The presence of rare species and trout suggest the stream is vulnerable to change.	0 rare species	0 (least sensitive)	5.00
					1 rare species	1	
					2 rare species	2	
					3 or more rare species	3	
					Trout	4 (most sensitive)	
Predomi-nant Geology	United States Depart-ment of the Interior Geological Survey	Landscapes underlain by permeable soils are typically more conducive to stormwater infiltration. This reduces the volume and intensity of stormwater runoff and helps contribute water to streams during dry weather.	Sum of acres of very high and high recharge potential (based upon SEWRPC studies) divided by total watershed area/dimen-sionless percentage	Landscapes dominated by impermeable soil create more runoff and allow less water to recharge groundwater flow systems. Heavy runoff and little groundwater recharge makes streams in such landscapes very reliant on surface-water runoff and therefore changes in watershed conditions. Deep, laterally extensive granular sediments attenuate runoff, provide dry weather flow, and usually are associated with better stream health.	Outwash (sand and fine gravel). Limited runoff and rapid percolation.	1 (least sensitive)	1.00
					Ice-contact deposits (coarse gravel and boulders, sand and some silt). Moderate potential runoff and percolation, well or poorly drained	2	
					Sandy till (clay, silt, sand, gravel) moderate runoff, slow-moderate percolation, well drained	3	
					Organic deposit, moderate to high runoff, commonly artificially drained	4	
					Fine grained till with limited outwash (east of Fox River)	5	
					Silty-clay till, high runoff, very slow percolation	6 (most sensitive)	

Table C-1 (continued)

Sensitivity Criteria					Scoring		
Criterion	**Data Source**	**Description**	**Measured Value/Units**	**Lake Classification Significance**	**Value Brackets**	**Score**	**Formula Weighting**
Watershed (areas beyond 1,000 feet of lake shoreline)							
Wetland	USGS	Wetlands detain and slow runoff, and can help remove pollutants from runoff improving water quality.	Acres of wetland divided by total watershed area/dimensionless percentage	Streams with watersheds occupied by large amounts of wetlands are more able to attenuate pollutants, and are therefore less sensitive to changes in upland areas.	>12%	1 (least sensitive)	1.00
					>6% - 12%	2	
					<6%	3 (most sensitive)	

NOTE: The parameters are weighted differently for final scoring.

Source: SEWRPC.

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Table C-2

STREAM AND WATERSHED SENSITIVITY PARAMETERS AND VALUES

Stream Code	Stream Number	U.S. Geological Survey Hydrologic Unit Code (HUC) – Name	U.S. Geological Survey Hydrologic Unit Code (HUC) – 12-Digit Code	Named Streams	Reach-Scale Criteria – Natural Community (Percentage by Category) – Large River	Main-stem	Macro-inverte-brate	Warm Head-water	Cool-Warm Head-water	Cool-Cold Head-water	Cold-water	Strahler Stream Order	Number of Rare Species	Trout Present?	Predominant Geology	HUC-12-Scale Criterion – Wetlands (Percent of HUC-12 watershed)
Bas-01	1	Bassett Creek - Fox River	71200061006				40%				60%	2	0		Less permeable	15.72%
Bas-02	2										100%	1	0		More permeable	
Bas-03	3						100%					1	0		More permeable	
Bas-04	4						10%				90%	2	0		More permeable	
Bas-05	5						15%		60%		25%	2	0		More permeable	
Bas-06	6						30%		50%	20%		2	3		More permeable	
Bas-07	7			Bassett Creek			10%		10%	70%	10%	2	0		More permeable	
Bas-08	8						20%			10%	70%	1	0		More permeable	
Bri-01	9	Brighton Creek	71200060101	Brighton Creek (Lower Reaches)				100%				4	2		More permeable	12.23%
Bri-02	10						100%					2	0		Less permeable	
Bri-03	11						100%					1	0		Less permeable	
Bri-04	12						100%					1	0		Less permeable	
Bri-05	13						100%					1	0		Less permeable	
Bri-06	14			Salem Branch				100%				3	0		More permeable	
Bri-07	15			Salem Branch			10%	30%		20%	40%	2	1		Less permeable	

Table C-2 (continued)

Stream Code	Stream Number	U.S. Geological Survey Hydrologic Unit Code (HUC)		Named Streams	Reach-Scale Criteria											HUC-12-Scale Criterion
					Natural Community (Percentage by Category)											
		Name	12-Digit Code		Large River	Main-stem	Macro-inverte-brate	Warm Head-water	Cool-Warm Head-water	Cool-Cold Head-water	Cold-water	Strahler Stream Order	Number of Rare Species	Trout Present?	Predominant Geology	Wetlands (Percent of HUC-12 watershed)
Bri-08	16	Brighton Creek (continued)	71200060101	Brighton Creek (Upper Reaches)				35%	25%	40%		3	1		Less permeable	
Bri-09	17						30%		70%			2	0		Less permeable	
Bri-10	18						20%				80%	1	0		Less permeable	
Bri-11	19						20%			80%		1	0		Less permeable	
Bri-12	20						20%	80%				1	0		Less permeable	
Bri-13	21						100%					1	0		Less permeable	
Bri-14	22						20%		10%	70%		2	0		Less permeable	
Cha-01	23	Channel Lake	71200061005	Trevor Creek			20%	20%		50%	10%	2	2		Less permeable	15.34%
Cha-02	24						10%	90%				2	3		Less permeable	
Roo-01	25	East Branch Root River Canal	71200060202	East Branch Root River Canal			100%					1	0		Less permeable	2.22%
Des-01	26	Head-waters of Des Plaines River	71200060103	Des Plaines River						100%		1	0		Less permeable	4.92%
Des-02	27			Center Creek			5%			95%		1	0		Less permeable	
Des-03	28					100%						4	0		Less permeable	
Des-04	29						100%					1	0		More permeable	
Des-05	30						100%					1	0		Less permeable	

Table C-2 (continued)

Stream Code	Stream Number	U.S. Geological Survey Hydrologic Unit Code (HUC)		Named Streams	Reach-Scale Criteria											HUC-12-Scale Criterion
					Natural Community (Percentage by Category)											
		Name	12-Digit Code		Large River	Main-stem	Macro-invertebrate	Warm Head-water	Cool-Warm Head-water	Cool-Cold Head-water	Cold-water	Strahler Stream Order	Number of Rare Species	Trout Present?	Predominant Geology	Wetlands (Percent of HUC-12 watershed)
Des-06	31	Head-waters of Des Plaines River (continued)	71200060103	Des Plaines River						40%	60%	3	1		Less permeable	
Des-07	32						100%					1	0		Less permeable	
Des-08	33						25%			45%	30%	2	0		Less permeable	
Des-09	34						100%					2	0		Less permeable	
Des-10	35						100%					1	0		Less permeable	
Des-11	36						40%			60%		2	0		Less permeable	
Des-12	37						100%					2	0		Less permeable	
Des-13	38						95%				5%	1	0		Less permeable	
Des-14	39						20%				80%	1	0		Less permeable	
Des-15	40						100%					1	0		Less permeable	
Des-16	41						50%				50%	2	0		Less permeable	
Des-17	42						60%			40%		2	0		Less permeable	
Des-18	43						100%					1	0		Less permeable	
Des-19	44						25%			25%	50%	2	0		Less permeable	
Des-20	45			Des Plaines River						50%	50%	2	0		Less permeable	

Table C-2 (continued)

		U.S. Geological Survey Hydrologic Unit Code (HUC)			Reach-Scale Criteria											HUC-12-Scale Criterion
					Natural Community (Percentage by Category)											
Stream Code	Stream Number	Name	12-Digit Code	Named Streams	Large River	Main-stem	Macro-inverte-brate	Warm Head-water	Cool-Warm Head-water	Cool-Cold Head-water	Cold-water	Strahler Stream Order	Number of Rare Species	Trout Present?	Predominant Geology	Wetlands (Percent of HUC-12 watershed)
Hoo-01	46	Hoosier Creek	71200061001	Hoosier Creek Canal			10%	10%	35%	30%	15%	2	0		Less permeable	8.35%
Kil-01	47	Kilbourn Road Ditch	71200060102				100%					2	0		Less permeable	3.73%
Kil-02	48						100%					2	0		Less permeable	
Kil-03	49									100%		3	0		Less permeable	
Kil-04	50						100%					1	0		Less permeable	
Kil-05	51						90%			10%		2	0		Less permeable	
Kil-06	52						100%					1	0		Less permeable	
Nip-01	53	North Branch of Nipper-sink Creek	71200060802				5%				95%	1	2		More permeable	8.42%
Nip-02	54						100%					2	0		More permeable	
Nor-01	55	North Mill Creek	71200060201					100%				3	0		Less permeable	14.87%
Nor-02	56			North Mill Creek				100%				1	0		Less permeable	
Nor-03	57						100%					1	0		Less permeable	
Nor-04	58			Mud Lake Outlet & Dutch Gap Canal (North Mill Creek)			10%	80%	5%	5%		2	0		Less permeable	

Table C-2 (continued)

Stream Code	Stream Number	U.S. Geological Survey Hydrologic Unit Code (HUC)		Named Streams	Reach-Scale Criteria											HUC-12-Scale Criterion
					Natural Community (Percentage by Category)											
		Name	12-Digit Code		Large River	Main-stem	Macro-inverte-brate	Warm Head-water	Cool-Warm Head-water	Cool-Cold Head-water	Cold-water	Strahler Stream Order	Number of Rare Species	Trout Present?	Predominant Geology	Wetlands (Percent of HUC-12 watershed)
Pal-01	59	Palmer Creek-Fox River	71200061003	Palmer Creek			2%	10%	88%			2	0	Yes	More permeable	14.09%
Pal-02	60						20%	30%	35%	15%		2	0		More permeable	
Pal-03	61			Peterson Creek			5%	35%	15%	35%	10%	2	0		More permeable	
Pal-04	62			New Munster Creek			100%					1	0		More permeable	
Pal-05	63						100%					1	0		More permeable	
Pal-06	64						10%			90%		2	0		More permeable	
Dye-01	65	Spring Brook - Fox River	71200061002	Spring Brook (Dyer Creek)			10%			90%		2	0		More permeable	10.22%
Fox-01	66	N/A	N/A	Fox River	100%							5	0		More permeable	n/a

Source: SEWRPC.

Table C-3

STREAM AND WATERSHED SENSITIVITY SCORES

		U.S. Geological Survey Hydrologic Unit Code (HUC)			Stream Reach Factors					Sensitivity Scores	
Stream Code	Stream Number	Name	12-Digit Code	Named Streams	Natural Community	Strahler Stream Order	Rare Species and Trout	Predominant Geology	HUC-12 Scale Criterion	Total Score	Category
Factor Weights					3.00	1.20	5.00	1.00	1		
Bas-01	1	Bassett Creek - Fox River	71200061006		4.8	4	0	4.0	1	21.4	Medium
Bas-02	2				6.0	4	0	1.0		24.0	Medium
Bas-03	3				3.0	4	0	1.0		15.0	Low
Bas-04	4				5.7	4	0	1.0		23.1	Medium
Bas-05	5				4.4	4	0	3.0		19.8	Medium
Bas-06	6				3.9	4	3	1.5		32.9	Medium
Bas-07	7			Bassett Creek	4.8	4	0	2.0		20.8	Medium
Bas-08	8				5.3	4	0	2.0		22.3	Medium
Bri-01	9	Brighton Creek	71200060101	Brighton Creek (Lower Reaches)	4.0	2	2	2.5	1	26.1	Medium
Bri-02	10				3.0	4	0	5.0		16.2	Low
Bri-03	11				3.0	4	0	5.0		16.2	Low
Bri-04	12				3.0	4	0	5.0		16.2	Low
Bri-05	13				3.0	4	0	5.0		16.2	Low
Bri-06	14			Salem Branch	4.0	2	0	2.5		16.1	Low
Bri-07	15				4.9	4	1	6.0		27.1	Medium
Bri-08	16			Brighton Creek (Upper Reaches)	4.4	2	1	5.0		22.9	Medium
Bri-09	17				3.7	4	0	6.0		18.5	Medium
Bri-10	18				5.4	4	0	6.0		23.6	Medium
Bri-11	19				4.6	4	0	6.0		21.2	Medium
Bri-12	20				3.8	4	0	6.0		18.8	Medium
Bri-13	21				3.0	4	0	6.0		16.4	Medium
Bri-14	22				4.5	4	0	6.0		20.9	Medium
Cha-01	23	Channel Lake	71200061005	Trevor Creek	4.5	4	2	6.0	1	30.9	Medium
Cha-02	24				3.9	4	3	6.0		34.1	Medium
Roo-01	25	East Branch Root River Canal	71200060202	East Branch Root River Canal	3.0	4	0	6.0	3	28.5	Medium
Des-01	26	Head-waters of Des Plaines River	71200060103	Des Plaines River	5.0	4	0	6.0	3	38.9	High
Des-02	27			Center Creek	4.9	4	0	6.0		38.4	High
Des-03	28				2.0	2	0	5.0		18.6	Medium
Des-04	29				3.0	4	0	2.5		27.0	Medium
Des-05	30				3.0	4	0	5.0		28.1	Medium
Des-06	31			Des Plaines River	5.6	2	1	5.0		46.0	High
Des-07	32				3.0	4	0	5.0		28.1	Medium
Des-08	33				4.8	4	0	5.0		37.5	High

Table C-3 (continued)

Stream Code	Stream Number	U.S. Geological Survey Hydrologic Unit Code (HUC) Name	U.S. Geological Survey Hydrologic Unit Code (HUC) 12-Digit Code	Named Streams	Stream Reach Factors: Natural Community	Stream Reach Factors: Strahler Stream Order	Stream Reach Factors: Rare Species and Trout	Stream Reach Factors: Predominant Geology	HUC-12 Scale Criterion	Sensitivity Scores: Total Score	Sensitivity Scores: Category
Factor Weights					3.00	1.20	5.00	1.00	1		
Des-09	34	Head-waters of Des Plaines River (continued)	71200060103	Des Plaines River	3.0	4	0	5.0		28.1	Medium
Des-10	35				3.0	4	0	5.0		28.1	Medium
Des-11	36				4.2	4	0	5.0		34.4	Medium
Des-12	37				3.0	4	0	5.0		28.1	Medium
Des-13	38				3.2	4	0	5.0		28.9	Medium
Des-14	39				5.4	4	0	5.0		40.6	High
Des-15	40				3.0	4	0	5.0		28.1	Medium
Des-16	41				4.5	4	0	5.0		35.9	High
Des-17	42				3.8	4	0	5.0		32.3	Medium
Des-18	43				3.0	4	0	5.0		28.1	Medium
Des-19	44				5.0	4	0	5.0		38.5	High
Des-20	45				5.5	4	0	5.0		41.1	High
Hoo-01	46	Hoosier Creek	71200061001	Hoosier Creek Canal	4.5	4	0	6.0	2	29.6	Medium
Kil-01	47	Kilbourn Road Ditch	71200060102		3.0	4	0	6.0	3	28.5	Medium
Kil-02	48				3.0	4	0	6.0		28.5	Medium
Kil-03	49				5.0	2	0	6.0		34.6	Medium
Kil-04	50				3.0	4	0	6.0		28.5	Medium
Kil-05	51				3.2	4	0	6.0		29.5	Medium
Kil-06	52				3.0	4	0	6.0		28.5	Medium
Nip-01	53	North Branch of Nipper-sink Creek	71200060802		5.9	4	2	2.0	2	48.0	High
Nip-02	54				3.0	4	0	2.5		22.0	Medium
Nor-01	55	North Mill Creek	71200060201		4.0	2	0	6.0	1	16.9	Low
Nor-02	56			North Mill Creek	4.0	4	0	6.0		19.4	Medium
Nor-03	57				3.0	4	0	6.0		16.4	Low
Nor-04	58			Mud Lake Outlet & Dutch Gap Canal (North Mill Creek)	4.0	4	0	6.0		19.3	Medium
Pal-01	59	Palmer Creek-Fox River	71200061003	Palmer Creek	4.0	4	4	1.0	1	37.9	High
Pal-02	60				4.0	4	0	2.0		18.3	Medium
Pal-03	61			Peterson Creek	4.5	4	0	2.0		19.9	Medium
Pal-04	62			New Munster Creek	3.0	4	0	2.0		15.4	Low

Table C-3 (continued)

Stream Code	Stream Number	U.S. Geological Survey Hydrologic Unit Code (HUC)		Named Streams	Stream Reach Factors				HUC-12 Scale Criterion	Sensitivity Scores	
		Name	12-Digit Code		Natural Community	Strahler Stream Order	Rare Species and Trout	Predominant Geology		Total Score	Category
Factor Weights					3.00	1.20	5.00	1.00	1		
Pal-05	63	Palmer Creek-Fox River (continued)	71200061003	New Munster Creek	3.0	4	0	1.0		15.0	Low
Pal-06	64				4.8	4	0	1.5		20.6	Medium
Dye-01	65	Spring Brook - Fox River	71200061002	Spring Brook (Dyer Creek)	4.8	4	0	2.5	2	29.7	Medium
Fox-01	66	N/A	N/A	Fox River	1.0	1	0	3.0	1	6.0	Low

Note: The formulas used to derive scores use the abbreviations below:

NC - Natural Community, SSO - Strahler Stream Order, RST - Rare Species and Trout, PG - Water Predominant Geology, and W -Wetlands

Sensitivity Score = (NC Score*NC Weight)+(SSO Score*SSO Weight)+(RST Score*RST Weight)+(Square Root (PG Score)*PG Weight)+(Square Root (W Score)*W Weight)

Source: SEWRPC.

Table C-4

STREAM AND WATERSHED HUMAN INFLUENCE INPUT VARIABLES AND SCORING BRACKETS

Human Influence Criteria					Scoring		
Criterion	Data Source	Description	Measured Value/Units	Stream Classification Significance	Value Brackets	Score	Formula Weighting
Stream Reach							
Modified Channel	SEWRPC	Humans ditch straighten, pipe, and line stream channels to drain wetlands, hasten runoff, convey more water in less time, and create more developable land.	Visual inspection of aerial photographs and maps and evaluation of amount of channel modification. Both the amount and intensity of modification are considered.	Modified stream reaches loose much of their innate habitat value and are oftentimes unstable. Modified stream reaches often loose much of their ability to attenuate flooding and process/retain sediment and pollutants.	Unaltered	1 (least influence)	1.00
					< 1/3 of channel length modified	2	
					1/3 to 2/3 of channel length modified	3	
					> 2/3 of channel length modified	4 (most influence)	
HUC – 12 Watershed							
Impervious Surface	USGS	Humans build roads, buildings, parking lots, and many other features. Such features cover natural ground with surfaces that repel water (impervious surfaces). Impervious surface increase the amount of runoff and pollution entering a lake and decrease groundwater recharge.	The proportion of total watershed acreage covered by impervious features. Both 2010 and 2035 land use data were used, with double weight given to planned land use. Dimensionless.	Increasing proportions of impervious surface have been linked to declines in water quality, fisheries, and ecological health.	<4%	1 (least influence)	2.00
					4%-8%	2	
					>8%-12	3	
					>12%	4 (most influence)	
High Priority Pollutant Load	Kenosha County	Sediment, nutrients, and other pollutants are transported from upland areas into streams. While some sediment and nutrients enter all waterbodies, human activity can greatly increase loading, reaching levels that degrades water quality and waterbody ecology. Phosphorus is generally the nutrient limiting biological activity in Wisconsin streams, and is an indicator of pollution. Kenosha County evaluated HUC-12 watersheds throughout the County and identified those with the highest need for remedial action.	Type and number of factors needing corrective action.	High sediment, nutrient, and pollutant loads are related to streams highly influenced by human activity.	Not identified as a priority watershed	1 (least influence)	1.50
					Sediment or nitrogen priority watershed	2	
					Phosphorus priority watershed	3	
					Phosphorus and sediment priority watershed	4	
					Phosphorus, sediment, and nitrogen priority watershed	5 (most influence)	

Table C-4 (continued)

Human Influence Criteria					Scoring		
Criterion	Data Source	Description	Measured Value/Units	Stream Classification Significance	Value Brackets	Score	Formula Weighting
Watershed Index of Biotic Integrity (IBI)	WDNR	The presence and abundance of certain types of organisms are a good indicator of overall stream health. Several biological indices are commonly used, and data sets using both the Hilsenhoff biotic index (HBI) and the macroinvertebrate index of biotic integrity (MIBI) were used. It must be remembered that IBI may vary greatly between reaches of the same stream, and between different tributaries in the same watershed.	IBI scoring brackets	Low IBI scores are often related to human influenced ecological degradation.	Good HBI/MIBI	1 (least influence)	1.00
					Good to fair HBI/MIBI	2	
					No information	3	
					Fair HBI/MIBI	4	
					Fair to poor HBI/MIBI	5	
					Poor HBI/MIBI	6 (most influence)	

NOTE: The parameters are weighted differently for final scoring.

Source: SEWRPC.

Table C-5

STREAM AND WATERSHED HUMAN INFLUENCE PARAMETERS AND VALUES

Stream Code	Stream Number	U.S. Geological Survey Hydrologic Unit Code (HUC)		Named Streams[a]	Reach Scale Criterion	HUC-12 Scale Criterion				
		Name	12-Digit Code		Modified Channel	2010 Land Use	Planned 2035 Land Use	Composite 2010/2035 Land Use	High Priority Pollutant Load	Watershed Index of Biotic Integrity (MIBI/HBI)
Bas-01	1	Bassett Creek - Fox River	71200061006		Unmodified	4%	14%	10.7%	Not identified as a priority watershed	Fair/Good
Bas-02	2				< 1/3 Modified					
Bas-03	3				< 1/3 Modified					
Bas-04	4				1/3 to 2/3 modified					
Bas-05	5				Unmodified					
Bas-06	6				> 2/3 Modified					
Bas-07	7			Bassett Creek	< 1/3 Modified					
Bas-08	8				> 2/3 Modified					
Bri-01	9	Brighton Creek	71200060101	Brighton Creek (Lower Reaches)	1/3 to 2/3 Modified	3%	12%	9.0%	Not identified as a priority watershed	Fair/Fair
Bri-02	10				1/3 to 2/3 Modified					
Bri-03	11				1/3 to 2/3 Modified					
Bri-04	12				> 2/3 Modified					
Bri-05	13				> 2/3 Modified					
Bri-06	14			Salem Branch	< 1/3 Modified					
Bri-07	15			Salem Branch	< 1/3 Modified					
Bri-08	16			Brighton Creek (Upper Reaches)	< 1/3 Modified					
Bri-09	17				< 1/3 Modified					
Bri-10	18				< 1/3 Modified					
Bri-11	19				< 1/3 Modified					
Bri-12	20				1/3 to 2/3 Modified					
Bri-13	21				> 2/3 Modified					
Bri-14	22				1/3 to 2/3 Modified					

Table C-5 (continued)

Stream Code	Stream Number	U.S. Geological Survey Hydrologic Unit Code (HUC)		Named Streams[a]	Reach Scale Criterion	HUC-12 Scale Criterion				
		Name	12-Digit Code		Modified Channel	2010 Land Use	Planned 2035 Land Use	Composite 2010/2035 Land Use	High Priority Pollutant Load	Watershed Index of Biotic Integrity (MIBI/HBI)
Cha-01	23	Channel Lake	71200061005	Trevor Creek	< 1/3 Modified	5%	16%	12.3%	Not identified as a priority watershed	-/-
Cha-02	24				Unmodified					
Roo-01	25	East Branch Root River Canal	71200060202	East Branch Root River Canal	> 2/3 Modified	1%	1%	1.0%	Phosphorus, sediment, and nitrogen	Good/Good
Des-01	26	Head-waters of Des Plaines River	71200060103	Des Plaines River	> 2/3 Modified	1%	1%	1.0%	Not identified as a priority watershed	Fair/Fair-
Des-02	27			Center Creek	> 2/3 Modified					
Des-03	28				> 2/3 Modified					
Des-04	29				> 2/3 Modified					
Des-05	30				> 2/3 Modified					
Des-06	31			Des Plaines River	> 2/3 Modified					
Des-07	32				1/3 to 2/3 Modified					
Des-08	33				< 1/3 Modified					
Des-09	34				> 2/3 Modified					
Des-10	35				1/3 to 2/3 Modified					
Des-11	36				1/3 to 2/3 Modified					
Des-12	37				> 2/3 Modified					
Des-13	38				1/3 to 2/3 Modified					
Des-14	39				> 2/3 Modified					
Des-15	40				1/3 to 2/3 Modified					
Des-16	41				> 2/3 Modified					
Des-17	42				> 2/3 Modified					
Des-18	43				> 2/3 Modified					
Des-19	44				1/3 to 2/3 Modified					
Des-20	45				> 2/3 Modified					

Table C-5 (continued)

Stream Code	Stream Number	U.S. Geological Survey Hydrologic Unit Code (HUC) Name	U.S. Geological Survey Hydrologic Unit Code (HUC) 12-Digit Code	Named Streams[a]	Reach Scale Criterion Modified Channel	HUC-12 Scale Criterion 2010 Land Use	HUC-12 Scale Criterion Planned 2035 Land Use	HUC-12 Scale Criterion Composite 2010/2035 Land Use	HUC-12 Scale Criterion High Priority Pollutant Load	HUC-12 Scale Criterion Watershed Index of Biotic Integrity (MIBI/HBI)
Hoo-01	46	Hoosier Creek	71200061001	Hoosier Creek Canal	> 2/3 Modified	1%	1%	1.0%	Phosphorus and Sediment	Poor/-
Kil-01	47	Kilbourn Road Ditch	71200060102		1/3 to 2/3 Modified	2%	11%	8.0%	Not identified as a priority watershed	Fair/Fair
Kil-02	48				1/3 to 2/3 Modified					
Kil-03	49				Unmodified					
Kil-04	50				1/3 to 2/3 Modified					
Kil-05	51				> 2/3 Modified					
Kil-06	52				> 2/3 Modified					
Nip-01	53	North Branch of Nipper-sink Creek	71200060802		Unmodified	5%	25%	18.3%	Sediment	Poor/-
Nip-02	54				< 1/3 Modified					
Nor-01	55	North Mill Creek	71200060201		> 2/3 Modified	3%	7%	5.7%	Phosphorus	Good/-
Nor-02	56			North Mill Creek	> 2/3 Modified					
Nor-03	57				> 2/3 Modified					
Nor-04	58			Mud Lake Outlet & Dutch Gap Canal (North Mill Creek)	1/3 to 2/3 modified					
Pal-01	59	Palmer Creek-Fox River	71200061003	Palmer Creek	< 1/3 Modified	3%	6%	5.0%	Nitrogen	-/Fair+
Pal-02	60				1/3 to 2/3 Modified					
Pal-03	61			Peterson Creek	> 2/3 Modified					
Pal-04	62			New Munster Creek	> 2/3 Modified					
Pal-05	63				1/3 to 2/3 Modified					
Pal-06	64				1/3 to 2/3 Modified					

Table C-5 (continued)

Stream Code	Stream Number	U.S. Geological Survey Hydrologic Unit Code (HUC)		Named Streams[a]	Reach Scale Criterion	HUC-12 Scale Criterion				
		Name	12-Digit Code		Modified Channel	2010 Land Use	Planned 2035 Land Use	Composite 2010/2035 Land Use	High Priority Pollutant Load	Watershed Index of Biotic Integrity (MIBI/HBI)
Dye-01	65	Spring Brook - Fox River	71200061002	Spring Brook (Dyer Creek)	> 2/3 Modified	2%	5%	4.0%	Sediment	-/-
Fox-01	66	- -[b]	- -[b]	Fox River	- -[c]	- -[c]	- -[c]	6.9%[d]	- -[c]	-/-

[a]*Most streams evaluated as part of this study are unnamed.*

[b]*The Fox River in Kenosha County is substantially larger than a HUC-12 watershed.*

[c]*Unlike the other watersheds studied in this project, the Fox River watershed extends far upstream of Kenosha County. Therefore, estimated values or average watershed values were substituted for scoring the Fox River. The Fox River is also impaired by PCBs in Kenosha County*

[d]*This impervious surface value is the average of the HUC-12 watershed values determined as part of this study.*

Source: SEWRPC.

Table C-6

STREAM AND WATERSHED HUMAN INFLUENCE SCORES

Stream Code	Stream Number	U.S. Geological Survey Hydrologic Unit Code (HUC) Name	U.S. Geological Survey Hydrologic Unit Code (HUC) 12-Digit Code	Named Streams[a]	Reach Scale Criterion: Modified Channel	HUC-12 Scale Criterion: Composite 2010/2035 Land Use	HUC-12 Scale Criterion: High Priority Pollutant Load	HUC-12 Scale Criterion: Watershed Index of Biotic Integrity	Scores: Numeric Total	Scores: Management Category
Factor Weights					1.00	2.00	1.00	1.50		
Bas-01	1	Bassett Creek - Fox River	71200061006		1	3	1	2	3.16	Low
Bas-02	2				2				6.32	Low
Bas-03	3				2				6.32	Low
Bas-04	4				3				9.49	Medium
Bas-05	5				1				3.16	Low
Bas-06	6				3				9.49	Medium
Bas-07	7			Bassett Creek	2				6.32	Low
Bas-08	8				4				12.65	High
Bri-01	9	Brighton Creek	71200060101	Brighton Creek (Lower Reaches)	3	3	1	3	10.17	Medium
Bri-02	10				3				11.02	Medium
Bri-03	11				3				10.17	Medium
Bri-04	12				4				13.56	Medium
Bri-05	13				4				13.56	Medium
Bri-06	14			Salem Branch	2				6.78	Medium
Bri-07	15				2				6.78	Medium
Bri-08	16			Brighton Creek (Upper Reaches)	2				6.78	Medium
Bri-09	17				2				6.78	Medium
Bri-10	18				2				6.78	Medium
Bri-11	19				2				6.78	Medium
Bri-12	20				3				10.17	Medium

Table C-6 (continued)

Stream Code	Stream Number	U.S. Geological Survey Hydrologic Unit Code (HUC) Name	U.S. Geological Survey Hydrologic Unit Code (HUC) 12-Digit Code	Named Streams[a]	Reach Scale Criterion: Modified Channel	HUC-12 Scale Criterion: Composite 2010/2035 Land Use	HUC-12 Scale Criterion: High Priority Pollutant Load	HUC-12 Scale Criterion: Watershed Index of Biotic Integrity	Scores: Numeric Total	Scores: Management Category
Factor Weights					1.00	2.00	1.00	1.50		
Bri-13	21	Brighton Creek (continued)	71200060101	Brighton Creek (Upper Reaches) (continued)	4				13.56	High
Bri-14	22				3				10.17	Medium
Cha-01	23	Channel Lake	71200061005	Trevor Creek	2	4	1	3	6.78	Medium
Cha-02	24				1				3.39	Low
Roo-01	25	East Branch Root River Canal	71200060202	East Branch Root River Canal	4	1	5	1	11.66	Medium
Des-01	26	Head-waters of Des Plaines River	71200060103	Des Plaines River	4	1	1	4	12.00	Medium
Des-02	27			Center Creek	4				12.00	Medium
Des-03	28				4				12.00	Medium
Des-04	29				4				12.00	Medium
Des-05	30				4				12.00	Medium
Des-06	31			Des Plaines River	4				12.00	Medium
Des-07	32				3				9.00	Medium
Des-08	33				2				6.00	Low
Des-09	34				4				12.00	Medium
Des-10	35				3				9.00	Medium
Des-11	36				3				9.00	Medium
Des-12	37				4				12.00	Medium
Des-13	38				3				9.00	Medium
Des-14	39				4				12.00	Medium

Table C-6 (continued)

Stream Code	Stream Number	U.S. Geological Survey Hydrologic Unit Code (HUC)		Named Streams[a]	Reach Scale Criterion	HUC-12 Scale Criterion			Scores	
		Name	12-Digit Code		Modified Channel	Composite 2010/2035 Land Use	High Priority Pollutant Load	Watershed Index of Biotic Integrity	Numeric Total	Management Category
Factor Weights					1.00	2.00	1.00	1.50		
Des-15	40	Head-waters of Des Plaines River (continued)	71200060103	Des Plaines River	3				9.00	Medium
Des-16	41				4				12.00	Medium
Des-17	42				4				12.00	Medium
Des-18	43				4				12.00	Medium
Des-19	44				3				9.00	Medium
Des-20	45				4				12.00	Medium
Hoo-01	46	Hoosier Creek	71200061001	Hoosier Creek Canal	4	1	4	6	15.49	High
Kil-01	47	Kilbourn Road Ditch	71200060102		3	2	1	4	9.95	Medium
Kil-02	48				3				9.95	Medium
Kil-03	49				1				3.32	Low
Kil-04	50				3				9.95	Medium
Kil-05	51				4				13.27	High
Kil-06	52				4				13.27	High
Nip-01	53	North Branch of Nipper-sink Creek	71200060802		1	4	2	6	4.36	Low
Nip-02	54				2				8.72	Medium
Nor-01	55	North Mill Creek	71200060201		4	2	3	1	11.66	Medium
Nor-02	56			North Mill Creek	4				11.66	Medium
Nor-03	57				4				11.66	Medium
Nor-04	58			Mud Lake Outlet & Dutch Gap Canal (North Mill Creek)	3				8.75	Medium

Table C-6 (continued)

Stream Code	Stream Number	U.S. Geological Survey Hydrologic Unit Code (HUC)		Named Streams[a]	Reach Scale Criterion	HUC-12 Scale Criterion			Scores	
		Name	12-Digit Code		Modified Channel	Composite 2010/2035 Land Use	High Priority Pollutant Load	Watershed Index of Biotic Integrity	Numeric Total	Management Category
Factor Weights					1.00	2.00	1.00	1.50		
Pal-01	59	Palmer Creek-Fox River	71200061003	Palmer Creek	2	2	2	3	6.48	Low
Pal-02	60				3				9.72	Medium
Pal-03	61			Peterson Creek	4				12.96	High
Pal-04	62			New Munster Creek	4				12.96	High
Pal-05	63				3				9.72	Medium
Pal-06	64				3				9.72	Medium
Dye-01	65	Spring Brook - Fox River	71200061002	Spring Brook (Dyer Creek)	4	1	2	3	11.66	Medium
Fox-01	66	- -[b]	- -[b]	Fox River	2[c]	2[d]	4[c]	3[c]	7.07	Medium

Note: The formulas used to derive scores use the abbreviations below:

MC - Modified Channel, LU - Land Use, HPPL - High Priority Pollutant Load, IBI - Index of Biotic Integrity

Human Influence Score = (MC Score*MC Weight)*(Square Root ((LU Score*LU Weight)+(HPPL Score*HPPL Weight)+(IBI Score*IBI Weight))

[a]*Most streams evaluated as part of this study are unnamed.*

[b]*The Fox River in Kenosha County is substantially larger than a HUC-12 watershed.*

[c]*Unlike the other watersheds studied in this project, the Fox River watershed extends far upstream of Kenosha County. Therefore, estimated values or average watershed values were substituted for scoring the Fox River. The Fox River is also impaired by PCBs in Kenosha County*

[d]*This impervious surface value is the average of the HUC-12 watershed values determined as part of this study.*

Source: SEWRPC.

Appendix D

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

Managing the Water's Edge

Making Natural Connections

Problem Statement:

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

Southeastern Wisconsin Regional Planning Commission

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

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

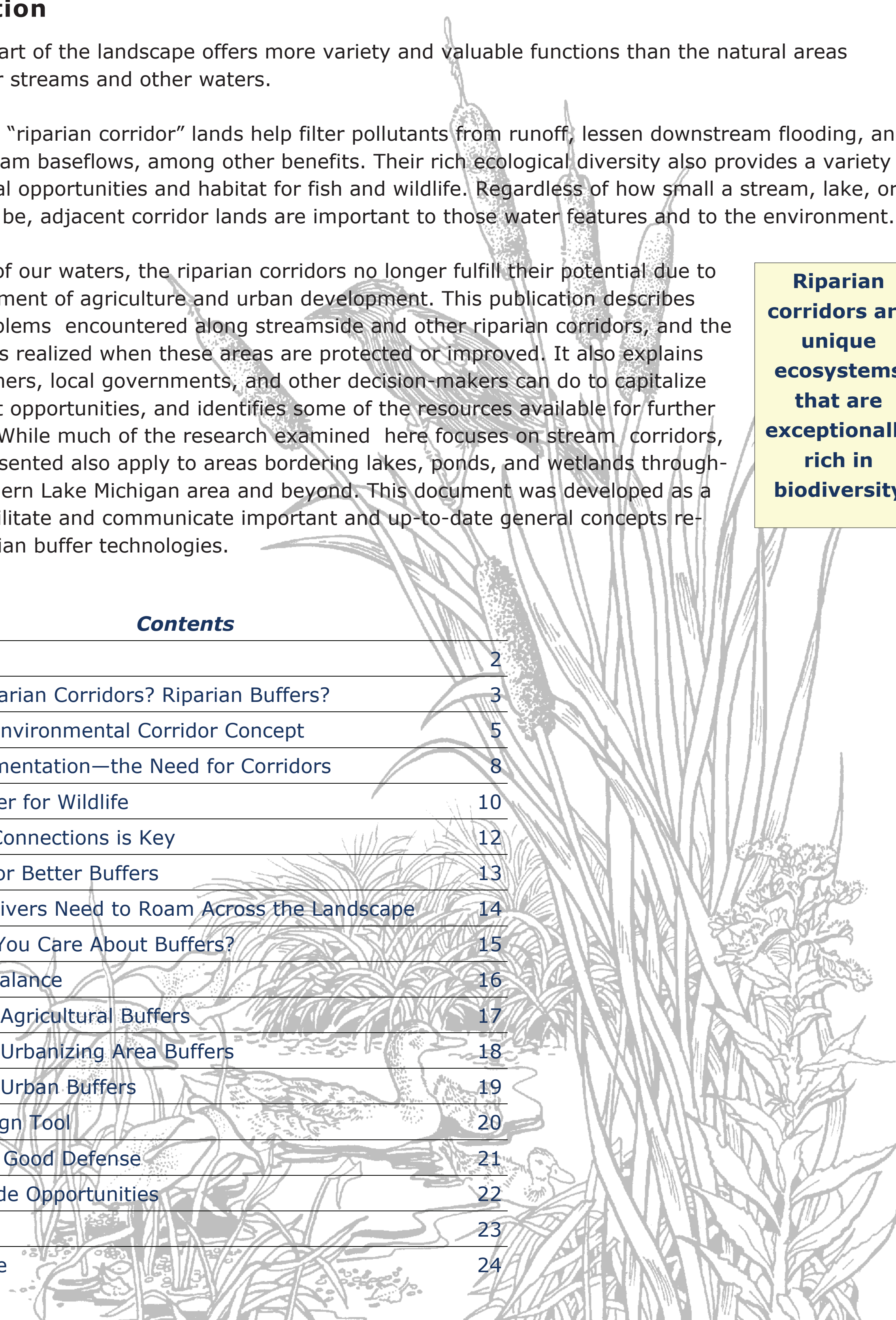
Introduction

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

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

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

Riparian corridors are unique ecosystems that are exceptionally rich in biodiversity

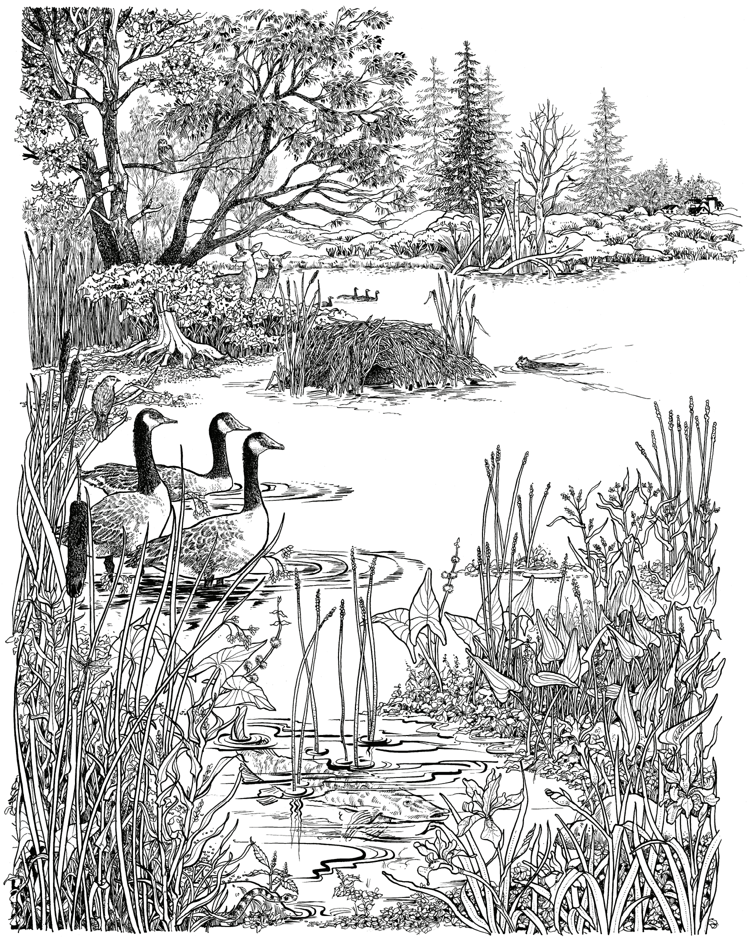


Contents

University of Wisconsin—Extension

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.



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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.

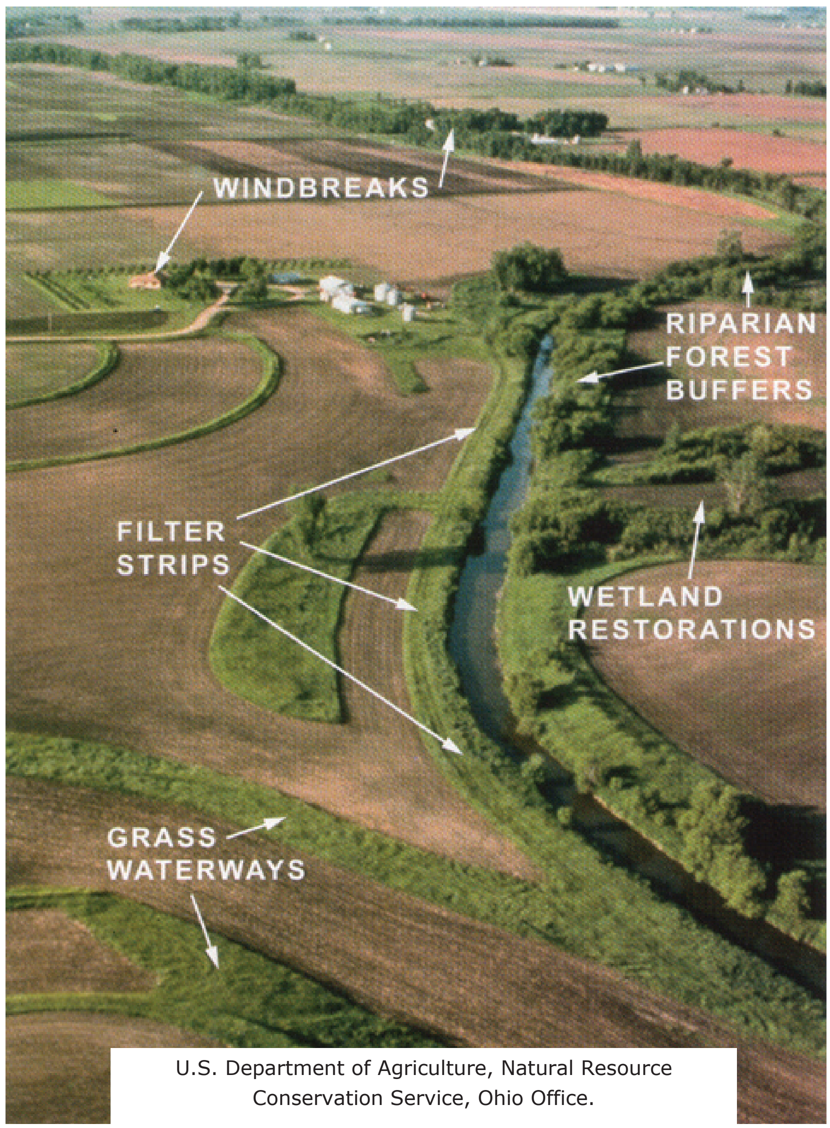
Riparian buffers are zones adjacent to waterbodies such as lakes, rivers, and wetlands that simultaneously protect water quality and wildlife, including both aquatic and terrestrial habitat. These zones minimize the impacts of human activities on the landscape and contribute to recreation, aesthetics, 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

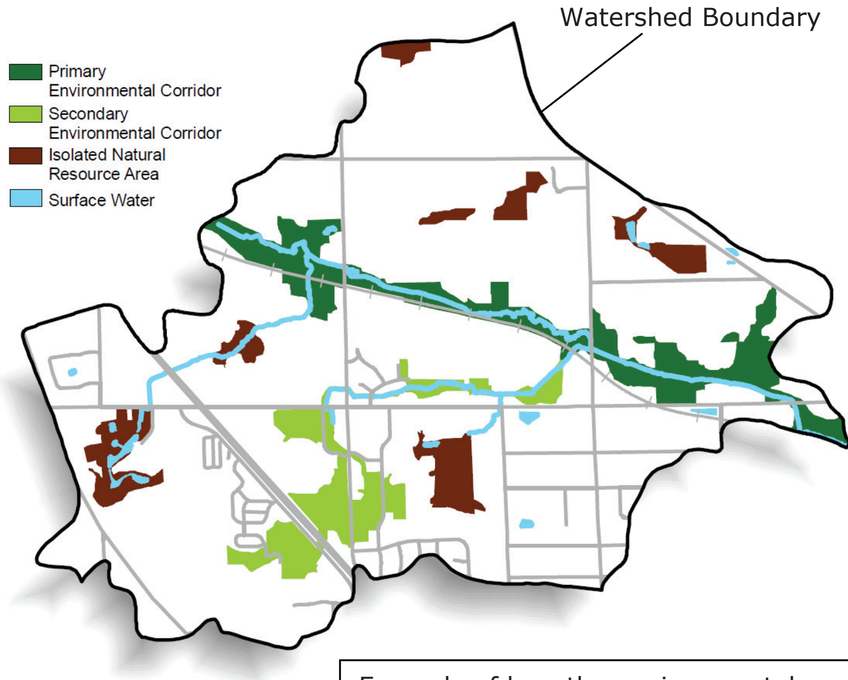
Environmental corridors are divided into the following three categories.

- **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

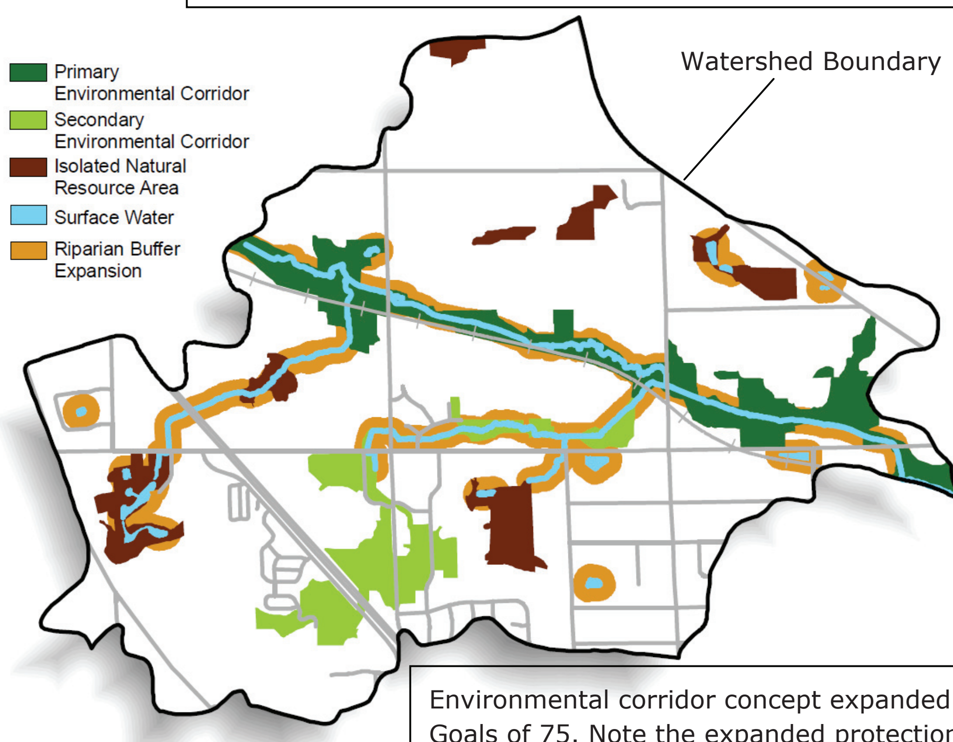


The Minimum Goals of **75** within a Watershed

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.

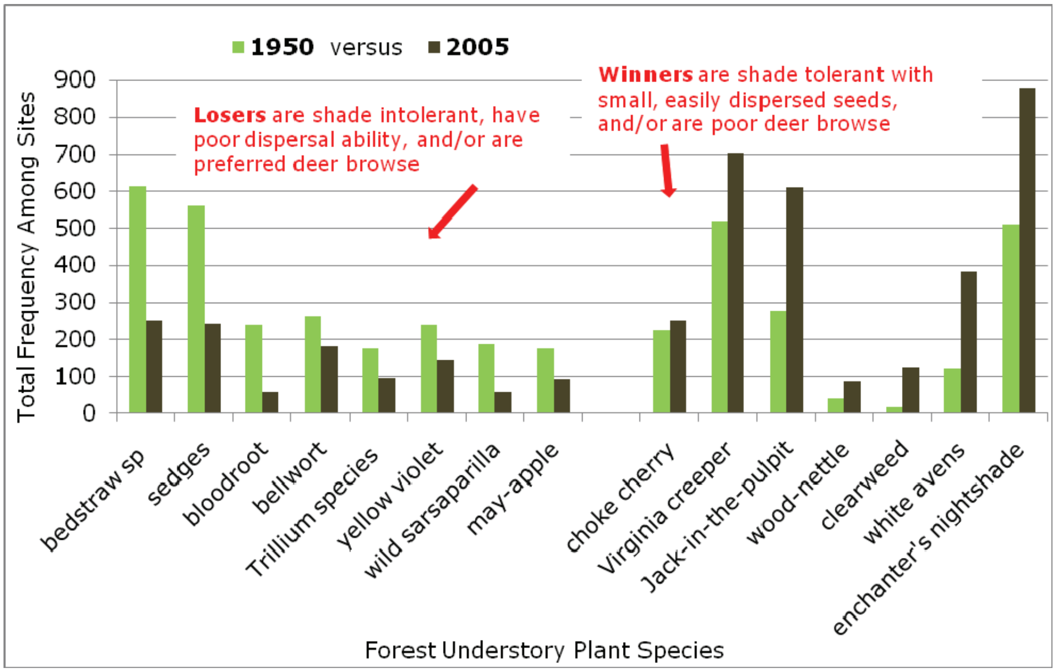
At the time of conversion of agricultural lands to urban uses, there are opportunities to re-create and expand riparian buffers and environmental corridors reconnecting uplands and waterways and restoring ecological integrity and scenic beauty locally and regionally. For example, placement of roads and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



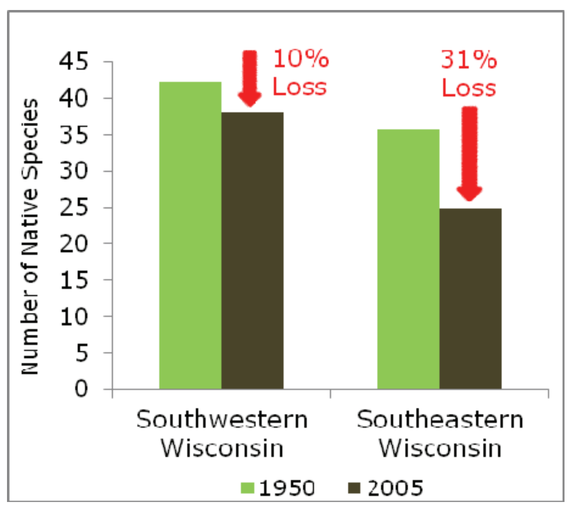
Forest fragmentation has led to significant plant species loss within Southern Wisconsin

(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

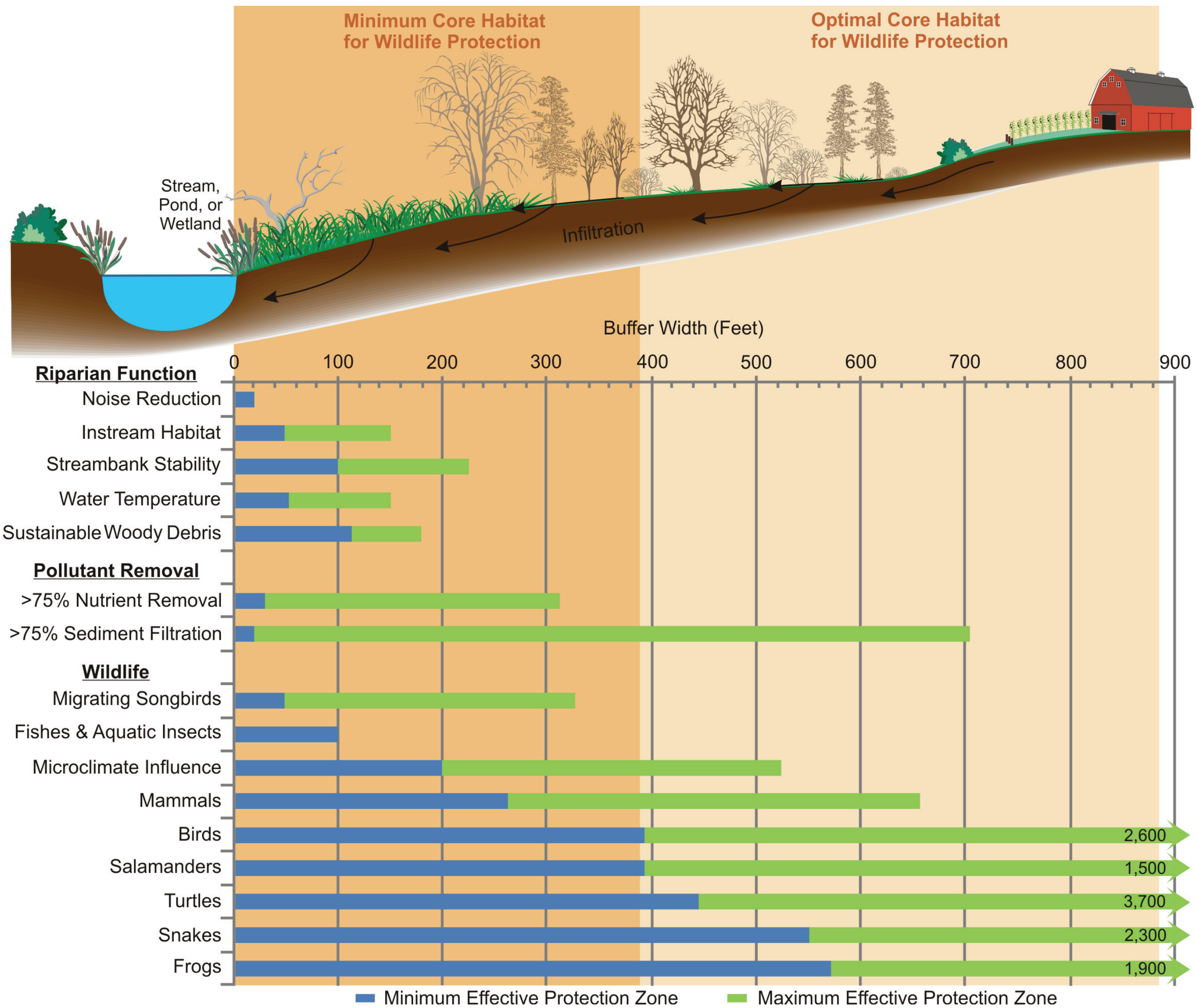
Since the 1950s, forests have increasingly become more fragmented by land development, both agricultural and urban, and associated roads and infrastructure, which have caused these forests to become isolated "islands of green" on the landscape. In particular, there has been significant loss of forest 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.

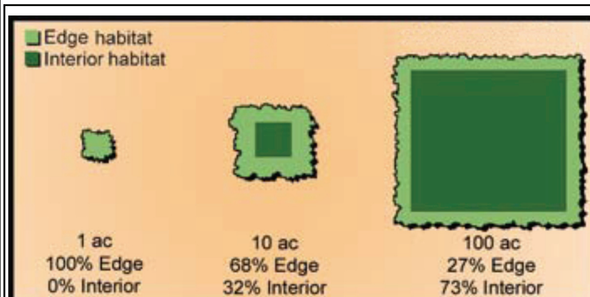
Wider is Better for Wildlife

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.**

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.

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.*



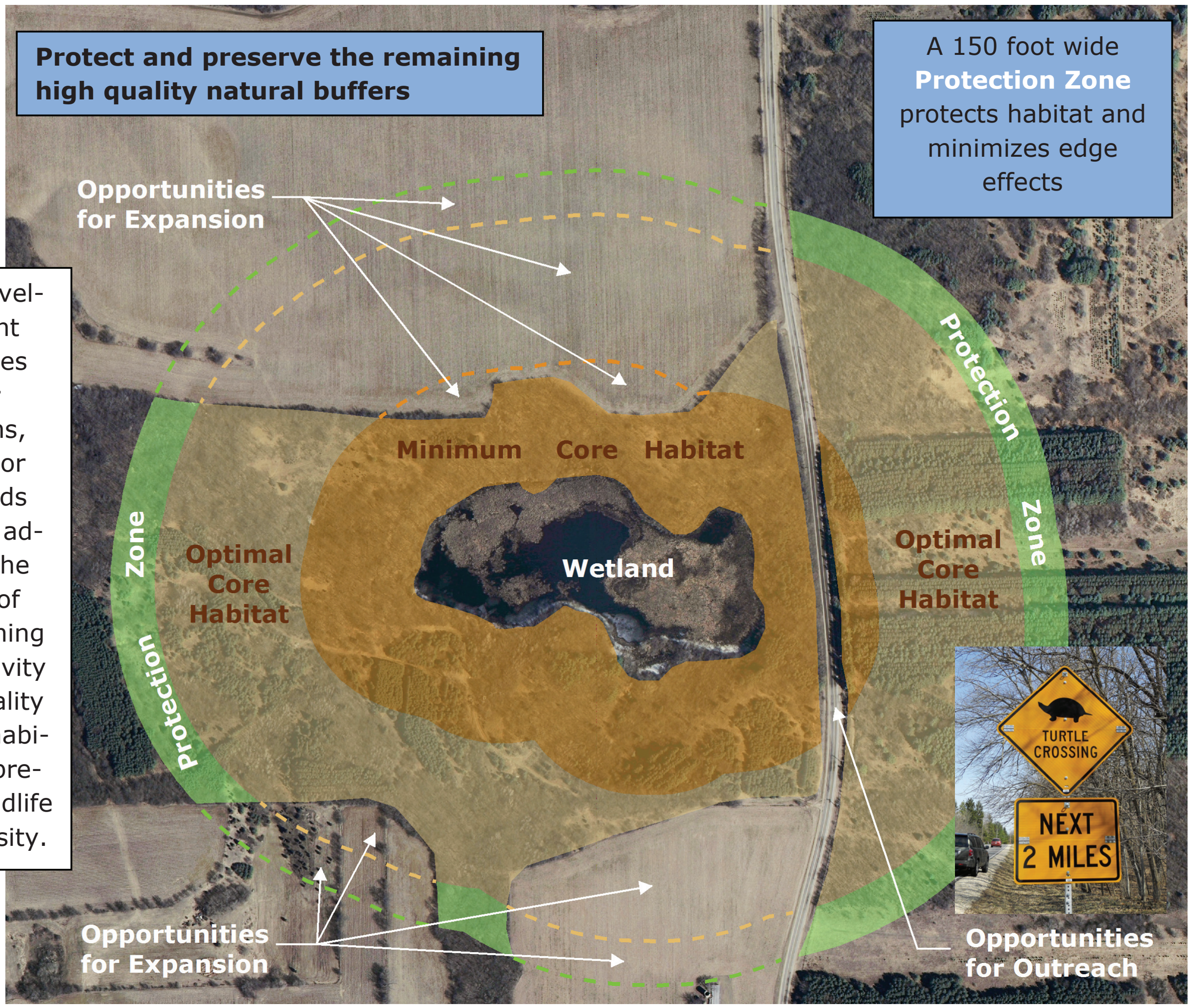
"***Large patches typically conserve a greater variety and quality of habitats, resulting in higher species diversity and abundance."*** *Larger patches contain greater amounts of interior habitat and less edge effects, which benefits interior species, by providing safety from parasitism, disease, and invasive species.*

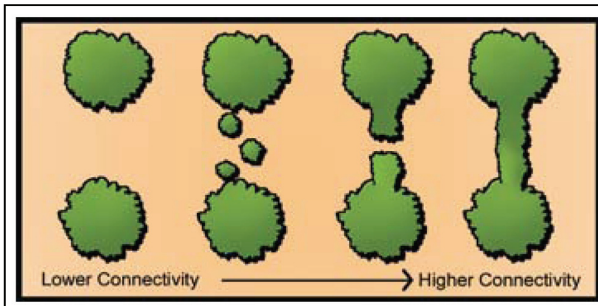
(Bentrup, G. 2008. Conservation buffers: design guidelines for buffers, corridors, and greenways. Gen. Tech. Rep. SRS-109. Asheville, NC: Department of Agriculture, Forest Service, Southern Research Station)

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

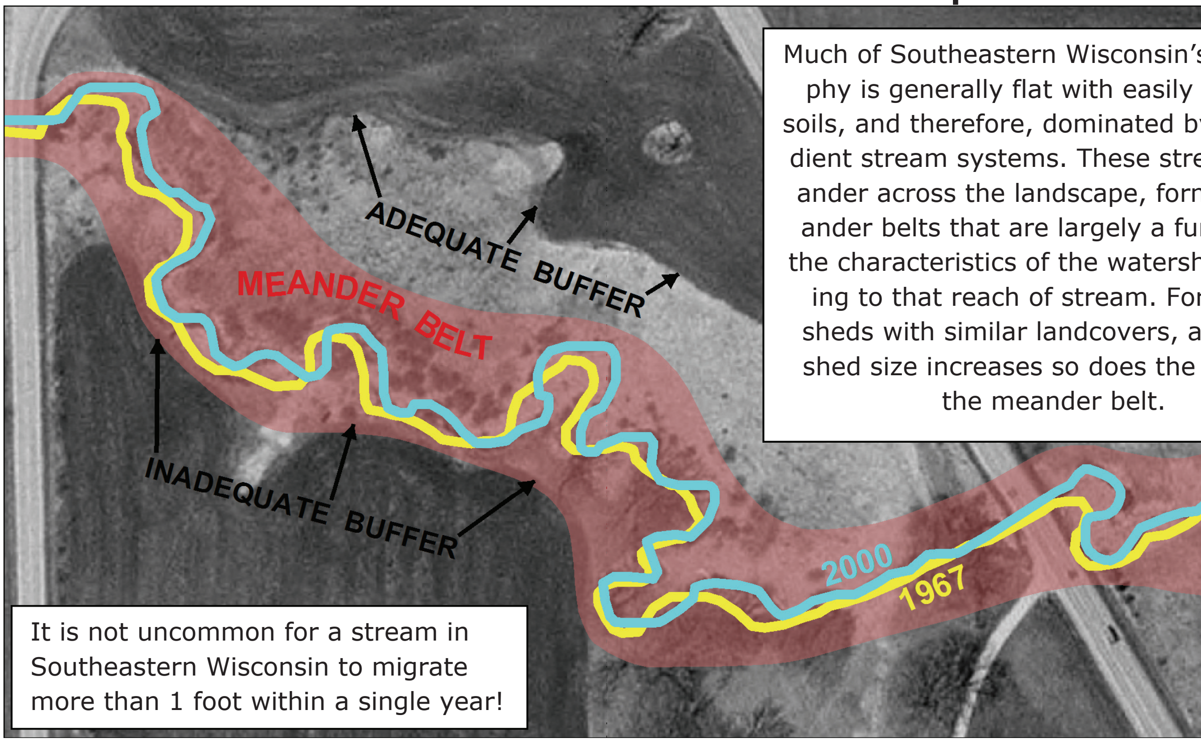
Protecting the integrity of native species in the region is an objective shared by many communities. The natural environment is an essential component of our existence and contributes to defining our communities and neighborhoods. Conservation design and open space development patterns in urbanizing 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:

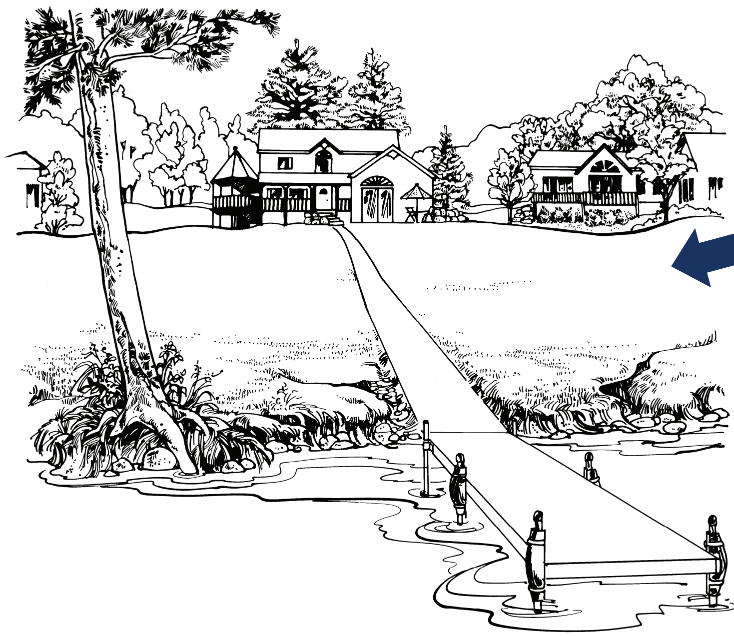
- Increased quality of the canoeing/kayaking experience
- Improved fishing and hunting quality by improving habitat
- Improved bird watching/wildlife viewing quality and opportunities
- Increased potential for expansion of trails for hiking and bicycling
- Opportunities made available for youth and others 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



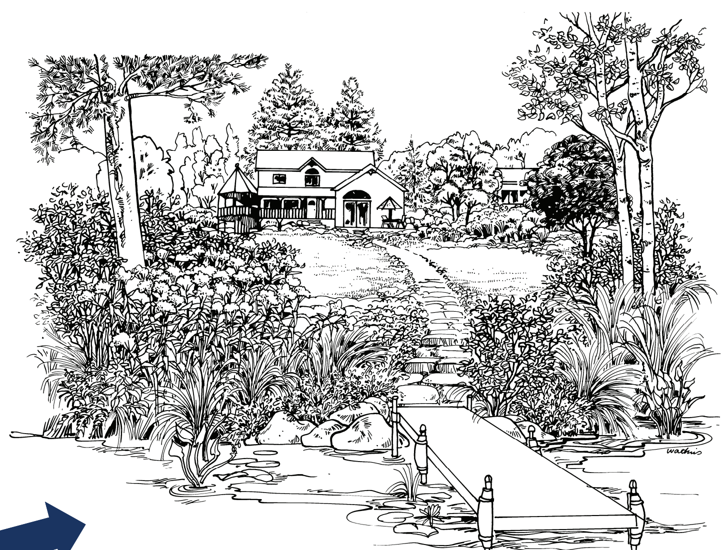
University of Wisconsin—Extension

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).

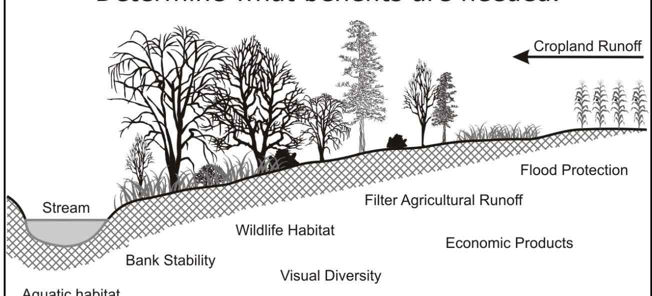
While it is true that riparian buffers alone may not always be able to reduce nutrient and sediment loading from agricultural lands, WBI researchers found that "…***riparian buffers are capable of reducing large percentages of the phosphorus and sediment that are currently being carried by Wisconsin 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:

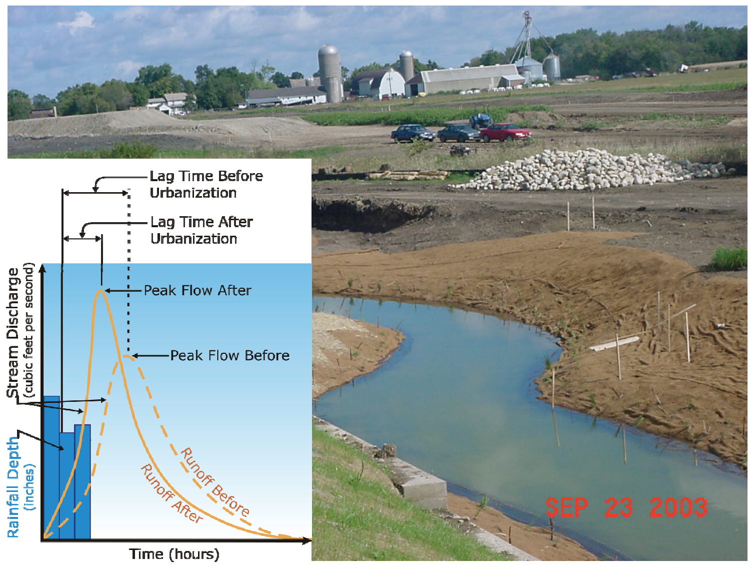
1-Determine what buffers functions are needed
2-Identify the best types of vegetation to provide the needed benefits
3-Determine the minimum acceptable buffer width to achieve desired benefits
4-Develop an installation and maintenance plan

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.

Mitigation of urban impacts may be as simple as not mowing along a stream corridor or changing land management and yard care practices, or as complex as changing zoning ordinances or widening riparian corridors through buyouts.

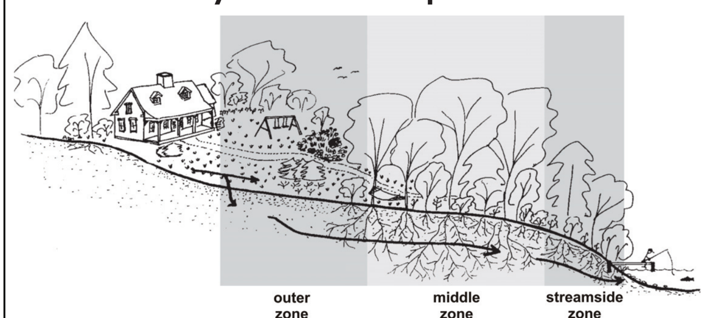


Comparison of hydrographs before and after urbanization. Note the rapid runoff and greater peak streamflow tied to watershed development. (Adapted from Federal Interagency Stream Restoration Working Group (FISRWG), Stream Corridor Restoration: Principles, Processes, and Practices, October 1998)

Challenge:
Urban development requires balancing flood protection, water quality protection, and the economic viability of the development.

Opportunities:
Buffers may offset costs by providing adequate space for providing long-term water quantity and water quality protection. In addition, they provide visual diversity on the landscape, wildlife habitat and connectedness, and help maintain property values.

Anatomy of an urban riparian buffer



The most effective urban buffers have three zones:

Outer Zone-Transition area between the intact buffer and nearest permanent structure to capture sediment and absorb runoff.

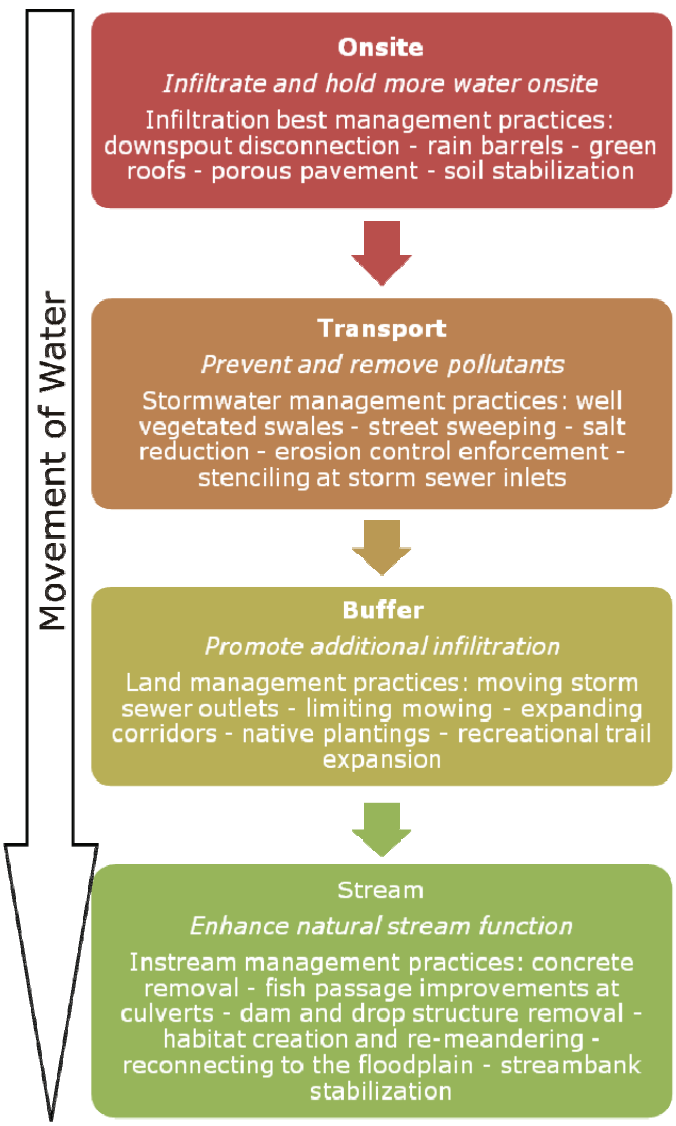
Middle Zone-Area from top of bank to edge of lawn that is composed of natural vegetation that provides wildlife habitat as well as improved filtration and infiltration of pollutants.

Streamside Zone-Area from the water's edge to the top of the bank or uplands that provides critical connection between water, wetland, and upland habitats for wildlife as well as protect streams from bank erosion

(Fact sheet No. 6 Urban Buffer in the series Riparian Buffers for Northern New Jersey)

Case Study—Urban Buffers

Placement of riparian buffers in established urban areas is a challenge that requires new and innovative approaches. In these areas, historical development along water courses limits options and requires balancing flood management protection versus water quality and environmental protection needs. Consequently, some municipalities have begun to recognize the connections between these objectives and are introducing programs to remove flood-prone structures and culverts from the stream corridors and allow recreation of the stream, restoring floodplains, and improving both the quality of life and the environment.



In urban settings it may be necessary to limit pollution and water runoff before it reaches the buffer.

Challenge:
There are many potential constraints to establishing, expanding, and/or managing riparian buffers within an urban landscape. Two major constraints to establishment of urban buffers include:

1) **Limited or confined space to establish buffers** due to encroachment by structures such as buildings, roadways, and/or sewer infrastructure;

2) **Fragmentation of the landscape** by road and railway crossings of creeks and rivers that disrupt the linear connectedness of buffers, limiting their ability to provide quality wildlife habitat.

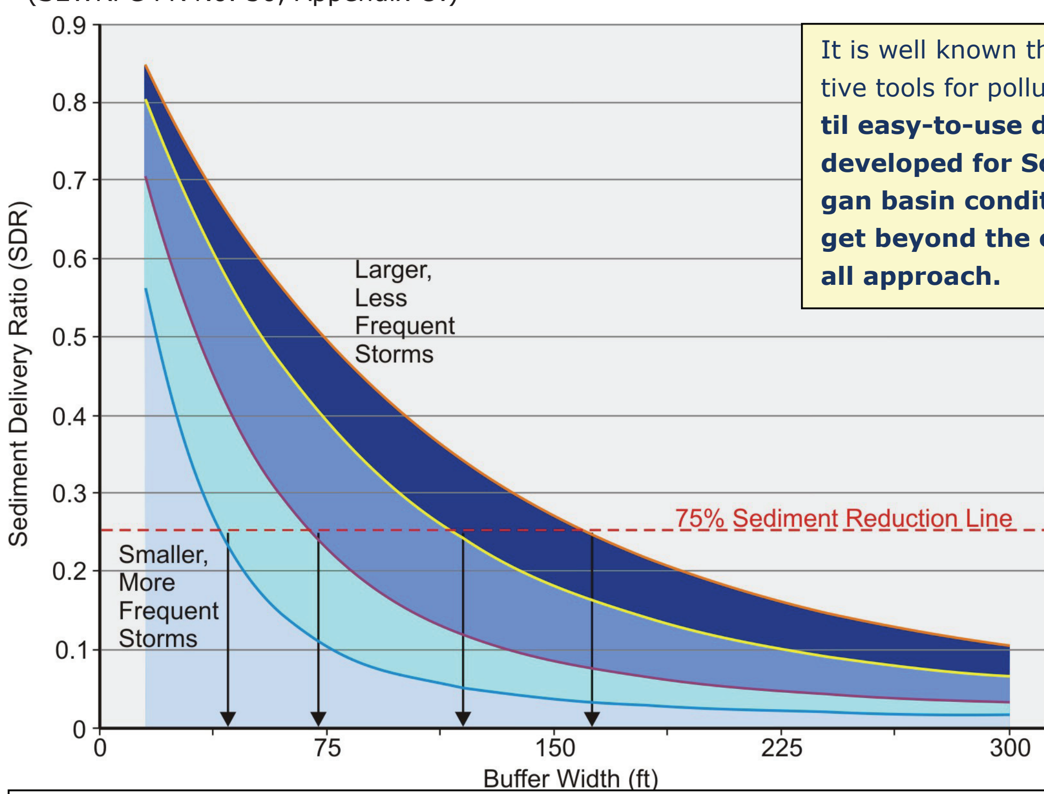
Much traditional stormwater infrastructure intercepts runoff and diverts it directly into creeks and rivers, bypassing any benefits of buffers to infiltrate or filter pollutants. This is important to consider in design of a buffer system for urban waterways, which begin in yards, curbsides, and construction sites, that are figuratively as close to streams as the nearest storm sewer inlet.

A Buffer Design Tool

Design aids are needed to help municipalities, property owners, and others take the "guesswork" out of determining adequate buffer widths for the purpose of water resource quality protection. While there are various complex mathematical models that can be used to estimate sediment and nutrient removal efficiencies, they are not easily applied by the people who need them including homeowners, farmers, businesses and developers.

To fill this gap, design aid tools are being developed using factors such as slope, soils, field length, incoming pollutant concentrations, and vegetation to allow the user to identify and test realistic buffer widths with respect to the desired percent pollutant load reduction and storm characteristics. By developing a set of relationships among factors that determine buffer effectiveness, the width of buffer needed to meet specific goals can be identified.

In the example below, 50-foot-wide buffers are necessary to achieve 75 % sediment removal during small, low intensity storms, while buffers more than 150 feet wide are necessary to achieve the same sediment reduction during more severe storms. Based on this information, decision-makers have the option of fitting a desired level of sediment removal into the context of their specific conditions. Under most conditions, a 75-foot width will provide a minimum level of protection for a variety of needs (SEWRPC PR No. 50, Appendix O.)



It is well known that buffers are effective tools for pollutant removal, but **until easy-to-use design aid tools are developed for Southern Lake Michigan basin conditions, we can never get beyond the current one size fits all approach.**

This generalized graph depicts an example of model output for an optimal buffer width to achieve a 75% sediment reduction for a range of soil and slope, vegetation, and storm conditions characteristic of North Carolina. *(Adapted from Muñoz-Carpena R., Parsons J.E.. 2005. VFSMOD-W: Vegetative Filter Strips Hydrology and Sediment Transport Modeling System v.2.x. Homestead, FL: University of Florida. 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.

Managing the Water's Edge

MORE TO COME

Future editions in a riparian buffer planning series are being explored with the intent of focusing on key elements of this critical land and water interface. Topics may include:

- Information sharing and development of ordinances to integrate riparian buffers into existing land management plans and programs
- Integration of stormwater management practices and riparian buffer best management practices
- Application of buffers within highly constrained urban corridors with and without brownfield development
- Installation of buffers within rural or agricultural lands being converted to urban uses
- Utilization of buffers in agricultural areas and associated drainage systems
- Integration of riparian buffers into environmental corridors to support resources preservation, recreation and aesthetic uses
- Preservation of stream courses and drainageways to minimize maintenance and promote protection of infrastructure
- Guidance for retrofitting, replacement, or removal of infrastructure such as dams and road crossings, to balance transportation, recreation, aesthetic, property value, and environmental considerations.
- Protection of groundwater recharge and discharge areas
- Protection of high quality, sensitive coastal areas, including preservation of recreational potential

MORE INFORMATION

This booklet can be found at http://www.sewrpc.org/RBMG-no1 . Please visit the website for more information, periodic updates, and a list of complementary publications.

* * *

W239 N1812 Rockwood Drive, Waukesha, WI, 53187-1607
262-547-6721.

www.sewrpc.org

Staff Acknowledgements:

Principal Author: Tom Slawski, PhD, Principal Planner

Michael Hahn, P.E., P.H., Chief Environmental Engineer
Laura Kletti, P.E., Principal Engineer
Gary Korb, Regional Planning Educator, UW-Extension/SEWRPC
Ed Schmidt, GIS Planning Specialist
Mike Scott, GIS Application Specialist
Sara Teske, Research Analyst
Jeff Thornton, PhD, Principal Planner

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Appendix E

A COMPREHENSIVE SOLUTION TO AQUATIC HABITAT FRAGMENTATION IN THE MILWAUKEE RIVER WATERSHED, OZAUKEE COUNTY, WISCONSIN

Source: Proceeding of the Environmental & Water Institute/American society of Civil Engineers Watershed Management Conference, August 2010, Madison Wisconsin

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A COMPREHENSIVE SOLUTION TO AQUATIC HABITAT FRAGMENTATION IN THE MILWAUKEE RIVER WATERSHED, OZAUKEE COUNTY, WISCONSIN

Dale J. Buser[1] and Andrew T. Struck[2]

[1] Principal Hydrologist, Bonestroo, Incorporated, 12075 Corporate Parkway, Suite 200, Mequon, Wisconsin 53092; Phone (262) 643-9170, Fax (262) 241-4901, email: dale.buser@bonestroo.com

[2] Director, Planning and Parks Department, Ozaukee County, 121 West Main Street, Post Office Box 994, Port Washington WI 53074-0994; Phone (262) 284-9411, FAX (262) 284-8278, email: astruck@co.ozaukee.wi.us

ABSTRACT

Anthropogenic land uses generally diminish biological integrity and interconnectivity of rivers, lakes, perennial and intermittent streams, and wetlands. Areas offering distinctly different physical and biological conditions become isolated, preventing many species from successfully utilizing remnant, high-quality, life-cycle-requisite habitat. This project identifes and restores full life-cycle access to naturally occurring refuge, spawning, and feeding habitat. Native potadramous fish species were the measure of habitat desirability and accessibility. Habitat ingress and egress were equally considered. Remedial work was supported by the NOAA, funded through the ARRA, and was carried out by a unique alliance of government agencies, non-profit organizations, volunteer and community service groups, and private industry. When completed in late 2010, the project will reconnect the Milwaukee River Estuary and nearshore waters of Lake Michigan to over 150 additional miles of rivers and major tributary streams, dozens of smaller streams, and 119,000 acres of watershed including over 14,000 acres of wetlands.

Introduction

Human-induced changes have compromised, or in some cases eliminated, the abundance and self-sustaining nature of many Great Lakes fish populations. The depredation of fish populations has caused financial and quality of life losses, including the factors listed below.

- Loss of a nationally significant commercial fishery for a long list of desirable species
- Significant depression of catch rates for most remaining commercial species
- Compromised subsistence and recreational fisheries
- Socioeconomic and ecological losses on many levels

Local, regional, national and international policies and doctrines call for action to be taken.

Many desirable lake resident fish species require access to rivers and streams for life-cycle critical functions (e.g., congregation, spawning, juvenile development). Dams on the Milwaukee River main stem in Ozaukee County impede and/or preclude upstream migration of some, and in some cases, all, lake resident adfluvial fish. Tributary streams that enter the Milwaukee River in Ozaukee County drain large areas of desirable, protected, naturally occurring aquatic habitat needed by adfluvial and river resident fish species. Though wetland and floodplain habitat is now commonly offered some degree of protection through State and Federal regulations restricting fill degradation, these policies do not always emphasize its importance in the larger watershed ecosystem. Consequently, even though desirable habitat is available, it is not always functionally accessible to fish ascending from the Lake Michigan, the Milwaukee River Estuary, and/or the Milwaukee River itself. Therefore, remaining natural habitat is not reaching its full ecological potential on a watershed scale.

Public Policy Overview

The Great Lakes Water Quality Agreement (GLWQA), an international agreement between Canada and the United States, sets forth a procedure to restore the socioeconomic and ecological vitality of the Great Lakes. The United States and Canada amended the GLWQA in 1987, agreeing to "... restore and maintain the chemical, physical and biological integrity of the waters of the Great Lakes Basin Ecosystem." An interesting and important facet of this agreement is that human habitation was a fully integrated component of the overall Great Lakes ecosystem. The Federal Interagency Ecosystem Management Task Force defines an ecosystem is defined as:

". . . an interconnected community of living things, including humans, and the physical environment with which they interact. As such, ecosystems form the cornerstones of sustainable economies. The goal of the ecosystem approach is to restore and maintain the health, sustainability, and biological diversity of ecosystems while supporting sustainable economies and communities. Based on a collaboratively developed vision of desired future conditions, the ecosystem approach integrates ecological, economic, and social factors that affect a management unit defined by ecological - not political - boundaries."

To achieve these goals, federal, state, provincial governments developed Lakewide Management Plans (LaMP) (EPA 2000) for open waters and Remedial Action Plans (RAP) for Areas of Concern (AOC). By design, the LaMP acknowledges and focuses on the interdependent balance between human well being, economic vitality, and environmental integrity. Sustainable actions can only result by properly balancing the needs from all three elements. The LaMP's ecosystem perspective requires a comprehensive approach focusing not only on contaminants, but also on quality of life, sustainability, biodiversity, invasive species, and a long list of other factors.

The Project Area

Ozaukee County, Wisconsin is located completely within the Lake Michigan Drainage Basin, and is considered part of the Milwaukee Metropolitan urbanized area for census purposes. The County's southern portion is rapidly urbanizing given its proximity to Milwaukee urban area. In contrast, the County's central and northern portions have large areas devoted to agricultural and natural uses. The Milwaukee River watershed drains approximately 75% of the County (See Figure 1).

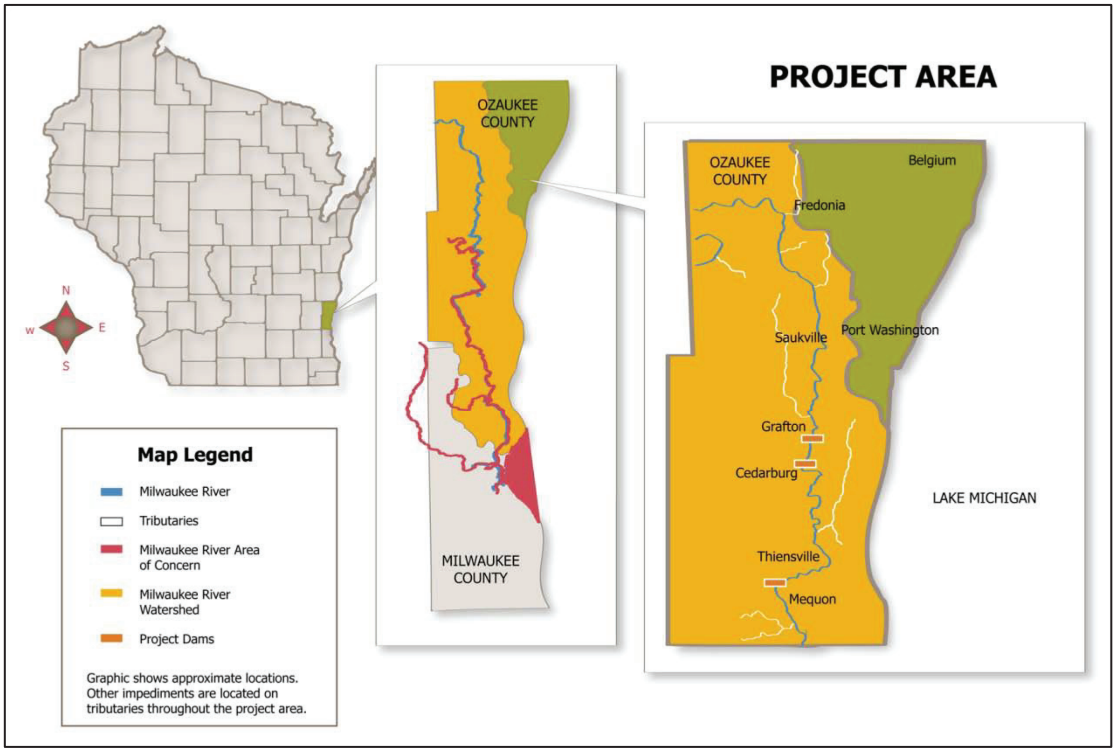

Figure 1. Project Area

The Milwaukee Estuary and its rivers are identified as one of the 43 Areas of Concern (AOC) in the United States and Canada. The Milwaukee Estuary AOC contains large distances of free-flowing streams including all of the Milwaukee River in the southern third of Ozaukee County (see Figure 1). The Milwaukee Estuary AOC Remedial Action Plan (RAP) identifies 11 beneficial uses as impaired (EPA 2008). These beneficial use impairments (BUIs) include:

- Restrictions on fish and wildlife consumption
- Eutrophication or undesirable algae
- Degradation of fish and wildlife populations
- Beach closings
- Fish tumors or other deformities
- Degradation of aesthetics
- Bird or animal deformities or reproduction problems
- Degradation of benthos
- Degradation of phytoplankton and zooplankton populations
- Restriction on dredging activities

- Loss of fish and wildlife habitat

The ultimate goal of the AOC process is to formally delist each BUI using measurable criteria or endpoints (DNR 2008).

Framing the Project

Ozaukee County has completed a number of projects that focus on its unique ecological role of being a Lake Michigan shoreline county adjacent to a major urban center. Many of these initiatives focus on maximizing the overall ecological value of remaining natural areas on a landscape scale, an initiative consistent with state, regional (i.e., Southeastern Wisconsin Regional Planning Commission (SEWRPC 2009) and county planning and resource management objectives.

The Milwaukee River watershed downstream of Ozaukee County is highly urbanized and essentially none of the formerly-abundant wetland and riparian habitat remains in its natural state. In-stream habitat has also been significantly altered in many (if not most) locations for navigation and drainage purposes. Efforts are underway in the lower Milwaukee River to address a litany of issues consistent with the AOC RAP, including restoration of a suite of desireable and/or imperiled fish species. This effort has had notable successes, including removal of a large dam that completely biologically isolated Lake Michigan from essentially all free-flowing stretches of the River (Kanehl, et. al 1997). Some species have naturally returned to the lower river, and stocking has augmented depleted natural fish stocks that do not have suitable habitat available to them at the present time. Ozaukee County does have significant tracts of relatively intact, and often protected, habitat remaining for all target species. Since many freshwater fish species move long distances for life-cycle functions (e.g., spawning), these areas would provide habitat suitable for spawning and juvenile development. The goal is to supplant stocking and re-establish a fishery that is self-sustaining and does not need significant human intervention.

Ozaukee County took positive action to foster this idea, and designed a project to review fish passage impediments on tributary streams. Grant funding was received for target streams, and a comprehensive inventory of such features was compiled during 2005 and 2006 (Buser, et. al 2007).

Remediating these obstacles became part of the County's Multi-Jursidictional Comprehensive Plan (SEWRPC and Ozaukee County, 2009). At the same time, work was underway to manage deteriorating and functionally obsolete former mill dams on the main stem of the Milwaukee River. Two dams were removed with State funding, and the 3 remaining dams came under close scrutiny by regulatory agencies and their municipal owners for a variety of reasons.

Funding was not readily or immediately available to address most of the tributary or main stem fish passage impediments. However, the long-standing definition and pursuit of this project made it an ideal candidate for American Recovery and Reinvestment Act (ARRA) funding. A portion of the ARRA funding pool was allocated to the National Oceanic and Atmospheric Administration (NOAA) for coastal restoration management work. Using the elements that had been completed and contemplated, Ozaukee County and its consultant developed a rigorous and comprehensive project that considered the entire watershed, providing access to a variety of habitat types for a wide spectrum of important fish species. Additionally, the action plan included addressing socioeconomic issues by incorporating an analog to the depression-era civilian conservation corps to address large portions of the project with the active physical engagement of disadvantaged urban youth in environmental restoration. NOAA awarded Ozaukee County $4.7 million to carry out the program, one of only three such awards in the entire Great Lakes region and the only award in the State of Wisconsin (Ozaukee County and Northern Environmental Technologies, Incorporated 2009)

Fish Migration and Human Influence

Fish migrate for a variety of reasons including spawning, refuge, and feeding. Migrations of commercially important and well-known anadromous (live in salt water, migrate to spawn in fresh water) species have attracted attention for generations. Human-induced changes can make critical habitat inaccessible or unsuitable and deplete migrating stocks over time. The commercial importance and popularity of many of these species make changes tangible to many and led to efforts to stabilize and/or replenish populations. Although these remedial activities sometimes yield mixed results, refining and improving performance of anadromous fish migration strategies has been an ongoing topic of research and development for generations.

Potamodromous fish (live in fresh water, migrate to spawn in fresh water) migrations have attracted far less attention than those occuring in saltwater coastal areas. Nevertheless, such migrations are equally critical to many species' survival and have also been adversely affected by degradation and destruction of habitat and blocked access to remaining critical areas. Many of the fish species native to the Great Lakes are adfluvial (live in lakes, migrate to flowing water), requiring unfettered access to specific habitat types not available in the lake itself, estuaries, or the commonly heavily developed lower reaches of major tribuary streams.

A number of common misconceptions exist regarding fish migration. Salmon are thought by many to be "typical" examples of migrating fish because of their popularity. Salmon are extremely powerful swimmers and leapers, have great affinity to the streams in which they were born, and require very specific conditions to successfully propogate. A long list of fish species exhibit some, but not all, of these tendencies. Native Great Lakes fish are generally not powerful swimmers, particularly over long distances, and many will not leap to pass obstacles. As opposed to many salmonids, most migrate in the spring of the year when water is cold and velocities are high, and the young of the year return to the lake when water levels are decreasing or low.

Many Great Lakes species spawn in wetlands, ditches, seasonally flooded areas, and very small streams, habitat types that can commonly be overlooked and under-appreciated. Others require sandy or gravelly stream bottoms, large cobbles, or creviced bedrock. Some species require one habitat type for spawning, and a very different type of habitat for young-of-the-year development. A large ***variety*** of accessible habitat is critically important to maintaining or restoring the rich species diversity originally present in the Great Lakes watershed. Moreover, many native Great Lakes fish exhibit great fidelity to their streams, including obscure, seasonal, and under-appreciated habitat areas.

Although excellent habitat abounds in the region, it is often biologically disfunctional, isolated, or physically inaccessible to lake-resident fish on account of migration impediments such as various sized and often functionally obsolete dams, biologically impassable stream crossings, debris, pervious fill, and deteriorated channel morphology. Restoring access to high-quality natural habitat generally costs less and is usually more productive than restoring severely degraded habitat or constructing artificial habitat. Reconnecting isolated portions of watersheds improves biological and genetic diversity of aquatic communities including river resident and adfluvial fish species, and other organism that depend upon these fish for part of their life cycles (e.g, mussels). Combined, such actions increase the sustainability of imperiled species, a large assemblage of popular game and forage fish, and other aquatic organisms.

What is a "Fish Passage Impediment"?

During the inventory phase, we purposely chose not to use the term "barrier" to describe features of interest for a number of reasons. The term barrier implies an impermeable boundary, a perfect separation. Very few barriers block all species at all times. "Barriers" to some species are nearly completely passable to other species in nearly all instances. For this reason, we used the term "impediment" to identify features that we believed could block the passage of some fish during a critical portion of their life cycle. Variables that influence the blocking action of a fish passage impediment include:

1. Species-specific swimming performance and behaviors
2. Size, age, and condition of the same species
3. Water temperature and other physicochemical variables
4. Seasonal variations in vegetation, hydrology, predator-prey relationships, and other factors
5. Water velocity versus the length of the obstacle needing to be ascended
6. Duration of impassable events

Habitat needs to be accessible for ***all*** critical life stages to be ecologically valuable to a sustainable fishery. For example, a spawning area may be accessible to adults during typical high-water spring flows and provide ideal habitat for juvenile fish to develop, but may become isolated during low water periods preventing young-of-the-year to migrate downstream during a critical period. Therefore, ingress and egress to critical habitat are equally important.

Various fish species have very different behaviors and physical abilities pass obstacles. Northern pike (*Esox lucius*) is a native potamodromous fish that inhabits nearshore waters of Lake Michigan, the Milwaukee River estuary, and is also a year-round resident of the river itself. These fish commonly enter very small, oftentimes intermittent, streams to access wetlands and seasonally flooded areas where they spawn. Even though this fish can swim very fast, it can do so only for short distances. In fact, northern pike are one of the weakest swimming native fish in passing long stretches of higher velocity water. In addition to its inability to transverse extended stretches of higher velocity water, it will not leap to pass cascading water features. For these reasons, northern pike were used as a surrogate to evaluate barriers for all species. In other words, if a feature was believed to inhibit northern pike passage at any point in its life cycle, it was identified as a potential impediment to other species and was labeled a fish passage impediment.

Quantifying the Issue

Over 100 fish passage impediments were identified as part of the 2005 – 2006 inventory study. The inventory included streams that for a variety of reasons were considered biologically significant. These streams were distributed throughout Ozaukee County. Factors that were considered when choosing project streams included those that:

- Have anecdotal evidence of current or past use by northern pike or other species
- Are perennial in their lower reaches and/or exhibit reliable baseflow
- Drain wetlands and/or larger watersheds
- Potentially enjoy better than average water quality and general habitat conditions
- Have been studied in the past and/or have benefitted from fish habitat projects

The project streams are definitely not the only streams that are likely used by our target species and other fish, but are believed to be typical of the better quality habitat available in the various portions of the County. We inventoried probable northern pike spawning habitat along the stream corridors, and took detailed notes regarding the nature of possible fish passage impediments. An interesting finding of our inventory was that rural areas and urban-fringe areas contained approximately the same density of fish passage impediments.

Tributary fish passage impediments were subdivided into three categories:

- Impediments directly resultant to human activities (see Figure 2)
- Impediments indirectly resultant to human activities (see Figure 3)
- Natural Impediments (see Figure 4)

Impediments directly resulting from humans include those that increase water velocities sufficiently to preclude fish passage, those that require leaping behavior to ascend, and those that decrease water depth of volume so as to preclude fish movement. Examples include dams, certain culverts and bridge abutments; straightened, armored, or otherwise "improved" stream channels; weirs and check dams; and pervious fill. Impediments indirectly created by humans include accelerated sediment delivery and/or accretion within stream segments, nuisance and invasive plants, and negatively modified stream morphology/hydrology. Fish passage impediments that are natural include natural waterfalls, extremely high gradient stream reaches, and influent (water losing) stream reaches that seasonally isolate upstream areas. The project did not suggest any changes to allow fish migration around natural fish passage impediments.

Figure 2. Impediment directly resulting from human activity

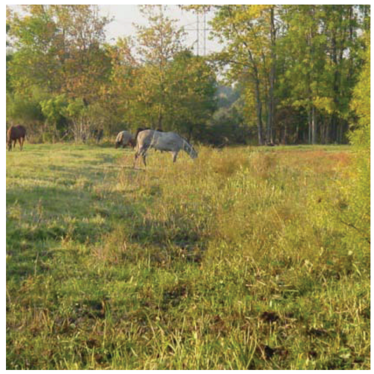

Figure 3. Impediment indirectly resulting from human activity

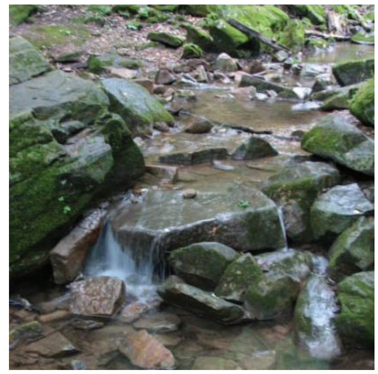

Figure 4. Natural impediment

Larger scale fish passage impediments on the Milwaukee River itself were functionally integrated into the overall project to enable smaller tributaries to benefit the lower Milwaukee River, its estuary, and nearshore waters of Lake Michigan. Three dams remain on the Milwaukee River in Ozaukee County. Providing fish passage around all three is a critical and vital element of the plan. A fishway was already proposed, but was insufficiently funded, at the lowermost dam (the Mequon-Thiensville Dam). A grant had previously been submitted to another federal funding source to remove the next upstream dam (the Grafton Lime Kiln Dam), but this dam was incorporated into the ARRA-funded project for logistical continuity and efficiency. Neither dam is formally considered a complete barrier. Some fish species can pass both dams during favorable conditions

Figure 5. Grafton Bridge Street Dam

and flood stages. Therefore, neither provided any form of invasive species migration control between Lake Michigan and upstream areas.

The Grafton Bridge Street Dam (see Figure 5) is the most upstream dam remaining in Ozaukee County and is considered to be a complete barrier for desirable and invasive species. A fishway was proposed at this location in the grant application, but the Village of Grafton thoroughly debated the concept of full dam removal as an alternate fish passage method. Ultimately, the Village decided to retain the dam and construct the fishway as originally proposed. Because it is the only fish migration impediment that is considered to be a complete migration barrier at all times, retaining the dam also allows some measure of control on upstream aquatic invasive species (AIS) migration in the watershed. The dam and fishway will be retrofitted with specific design elements to retain and enhance AIS control.

Implementation Strategy

From the outset of grant request preparation to shovel-in-the-ground implementation, this project has depended upon open communication, collaboration, stakeholder involvement, and a variety of methods to overcome compressed schedule and construction time requirements and technical challenges. Scores of partners have contributed funding, labor, cooperation, and support to the project including several towns and villages; county, state and federal government, non-governmental organizations, grass-roots organizations and conservation groups, universities and local schools, and private institutions such as technical consulting and construction companies. This collaborative approach was absolutely critical to securing funding, and remains just as critical to the project now in its implementation phase.

Fish passage impediments were divided into and were managed as three categories:

- Milwaukee River fishway construction and dam removal (3 projects)
- Tributary road/stream crossings and low-head dams (35+ projects)
- Tributary small-scale Conservation Corps projects (85 projects)

Dam removal and fishway design and construction were primarily delegated to technical consultants and private construction firms. Tributary road/stream crossing and low-head dam fish passage plans were largely completed by technical consultants, but construction was carried out by local resources, primarily the County highway department. Conservation corps projects were directed by project-funded and dedicated County staff, and were carried out by disadvantaged urban youth through the Milwaukee Community Service Corps, Incorporated (an Americorps-eligible non-governmental organization that provides career development through education and hands-on work) and volunteers.

Monitoring is integral to the project, with consideration given to help evaluate changes in species abundance and composition during the active life of the project. Monitoring has focused primarily on the presence and absence of species, larval migration, and creel surveys. Volunteers are anticipated to continue the monitoring program using equipment acquired as part of the grant-funded work after ARRA funding ends. We also hope to acquire supplemental funding to incorporate environmental DNA (eDNA) testing above and below the Grafton Bridge Street Dam. eDNA testing would be a cooperative venture with University of Notre Dame, South Bend, Indiana. eDNA samples are hoped to give a snapshot in time of any fish species of interest that can be preserved indefinitely for later detailed analysis.

Anticipated Benefits

When completed in late 2010, the project will reconnect the Milwaukee River Estuary and nearshore waters of Lake Michigan to over 150 additional miles of rivers and major tributary streams, dozens of smaller streams, and 119,000 acres of watershed including over 14,000 acres of wetlands. The goal of this project is creating more sustainable fish populations along the near-shore areas of Lake Michigan, the Milwaukee River, and its estuary by enabling isolated fish stocks to reach historical, more extensive and higher quality spawning and rearing habitats. In turn, the project will:

- Improve genetic and biological diversity of existing aquatic life communities, helping assure long-term vitality of remaining stocks
- Restore the biological function of protected, yet isolated, high-quality habitat throughout the watershed
- Help supplant the need for artificial stocking, habitat manipulation, and creation of artificial habitat in areas without access to certain habitat types
- Improve success of natural spawning and recruitment within existing habitat
- Help bolster the population of desirable recreational species and their accessibility to anglers along existing public access points
- Bolster mussel populations by allowing fish free access to previously isolated stream segments
- Develop strategies, skills and techniques that can be used to assist similar projects in other parts of the country, particularly comprehensive approaches on a watershed scale

The proposed project benefits delisting targets for four BUIs associated with the Milwaukee Estuary AOC. More specifically, the tremendously improved access to quality life-cycle dependent habitat type for fish and mussel species temporarily or permanently residing in, spawning in, or attempting to be restored to, the Milwaukee Estuary AOC benefits fish numbers and genetic diversity. Therefore the proposed project benefits delisting to the following BUI:

- Degraded fish and wildlife populations
- Loss of fish and wildlife habitat
- Degradation of benthos
- Degradation of aesthetics

Further, removing debris from streams in the project area reduces delivery of objectionable flotsam to the Milwaukee Estuary, which benefits the BUI delisting target for degradation of aesthetics.

Project activities are inherently self-sustaining. Removing the Lime Kiln Dam permanently restores fish movement and eliminates the negative impact that dams and their resultant impoundments have on water quality (e.g., dissolved oxygen levels, thermal regime and eutrophication) and navigation. The MT and Bridge Street Dams cannot be feasibly removed anytime in the near future. Fish passageways are therefore the best approach to restore ecological connectivity in these two instances. The construction of a fishway does not preclude removal of these dams in the future as they reach the end of their engineered life and as local preferences change. The proposed fish passage structures for the MT and Bridge Street Dams utilize designs that most closely emulate nature for restoring fish passage to the extent allowed by site constraints. The fish passages will require minimal maintenance, and should be able to help fish reach upstream habitat for generations based on the well documented history of operation for similar systems.

On the tributaries, stream crossings acting as fish migration impediments will be redesigned with sensitivity to the target species swimming abilities. The typical functional life of culverts and other stream crossings is anticipated to exceed 40 years. Proposed Wisconsin Administrative Code NR331 and Ozaukee County's planning documents incorporate design requirements for stream crossing fish migration; therefore, the improvements funded from this grant will be part of a long-term and sustainable plan.

The activities to be completed using the Conservation Corps are to some degree subject to the one-time funding provided by the grant, and may not be sustainable over the long term. In particular, some types of barriers are directly due to human intervention. However, while the paid Conservation Corps' direct project involvement will largely end after the grant-funded portion of the project, the training and processes generated by the Conservation Corps will benefit future volunteer efforts. The project also enjoys the support of a lengthy list of area organizations that have provided volunteer workers for these types of activities in the past. A permanent volunteer system may be established as part of this project to maintain connections within the targeted tributaries, as well as to expand the program to other tributaries that are not included within this project. The County has expressed an interest in coordinating these volunteer efforts.

The Milwaukee River Watershed in Ozaukee County is regionally unique in that detailed inventories of fish passage impediments have already been completed, evaluated, and prioritized. The project is expected to contribute significantly to achieving a major strategic goal of the WDNR, local governments, and other stakeholders – re-establishing self-sustaining potamodromous game fish populations within the Milwaukee River, its Estuary, and near-shore waters of Lake Michigan. The project is of regional significance as a consequence of the Milwaukee River Basin being the most populous basin in the State of Wisconsin, and the project's influence on Lake Michigan. The project is of national significance in that it proposes a comprehensive and watershed-based program restoring native potamodromous fish migration pathways. More specifically, the program focuses not only on large impediments on the main stem of the Milwaukee River, but also remedies smaller scale, nondescript fish passage problems on smaller tributary streams. Ingress and egress from these smaller streams is a function equally important for maintaining self-sustaining stocks of many fish.

Small-scale fragmentation of aquatic habitat is a problem throughout the nation. Although work has been completed to methodically identify and resolve fish passage impediment for diadromous species, very little attention has been focused on potamodromous species. The habitat needs, migration timing, and swimming/leaping ability of potamodromous fish are significantly different than trout and salmon; therefore, new strategies and new approaches need to be adapted, created, and recognized. This project has great potential to serve as a model for other watersheds that do or could sustain potamodromous fish throughout the United States.

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