Fredonia-Newburg Area Watershed-Based Plan

Including North Branch Milwaukee River, Town of Fredonia - Milwaukee River, & Village of Newburg - Milwaukee River watersheds

FINAL REPORT

October 2019

Applied Ecological Services, Inc.

Aqua Vitae

MMSD
PARTNERS FOR A CLEANER ENVIRONMENT

FREDONIA-NEWBURG AREA WATERSHED-BASED PLAN

Ozaukee, Sheboygan and Washington Counties, Wisconsin

A Strategy for Protecting and Restoring Watershed Health

FINAL REPORT

October 2019
(AES #18-0400)

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MMSD
PARTNERS FOR A CLEANER ENVIRONMENT
Milwaukee Metropolitan Sewerage District
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Contract No. M03059P11

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WISCONSIN
DEPT. OF NATURAL RESOURCES

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Milwaukee Metropolitan Sewerage District (MMSD) is a regional government agency that provides water reclamation and flood management services for more than one million people across the Greater Milwaukee region. MMSD is a leader in protecting public health and the drinking water through their wastewater treatment, flood management, and green infrastructure programs (MMSD 2019). Funding for this watershed planning process was made possible through a WDNR aid agreement with MMSD and is funded by a Great Lakes Restoration Initiative Nearshore Nonpoint Source grant. MMSD hired Applied Ecological Services, Inc. (AES) and AquaVitae (AV) in August 2018 to develop the plan. MMSD, AES, and AV used the funding to undergo a watershed planning effort and produce a "Watershed-Based Plan" for the Fredonia-Newburg Area watersheds that meets requirements as defined by the United States Environmental Protection Agency (USEPA).

Karen Nenahlo, Senior Project Planner, acted as Project Manager for MMSD. She worked closely with watershed stakeholders, AES, and AV to produce the watershed planning document. AES and AV conducted analysis, summarized results, and authored the Watershed-Based Plan. The stakeholder group representing the Fredonia-Newburg Area watersheds consisted of representatives from various municipal, governmental, private, and public organizations as well as local residents. These partners played an important role in providing input on watershed goals & objectives, various planning approaches, and input on the watershed plan content.

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(Note: All appendices are included on attached CD: Hard Copies Only)

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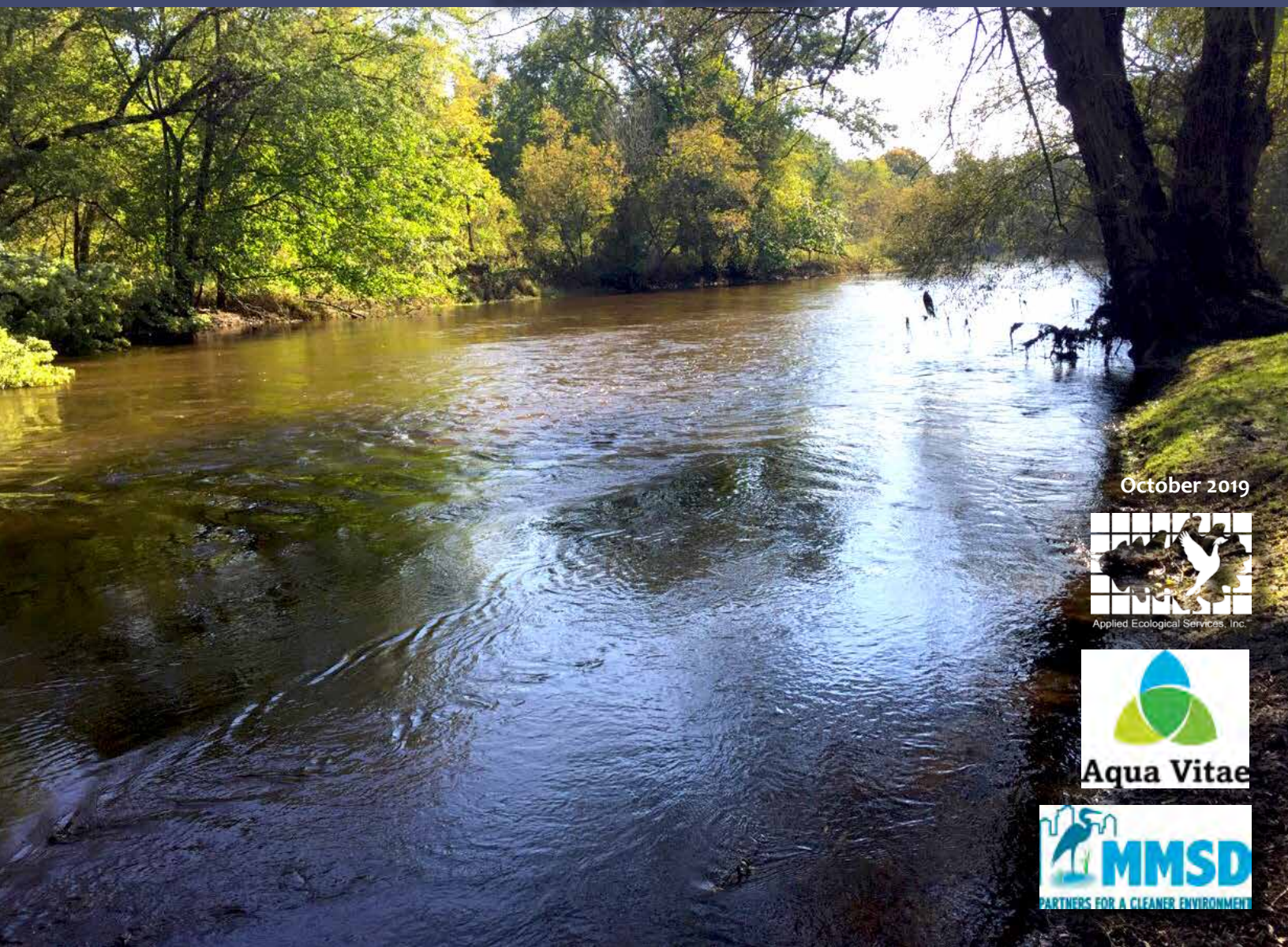
Fredonia-Newburg Area Watershed-Based Plan

Including North Branch Milwaukee River, Town of Fredonia - Milwaukee River, & Village of Newburg - Milwaukee River watersheds

EXECUTIVE SUMMARY



October 2019

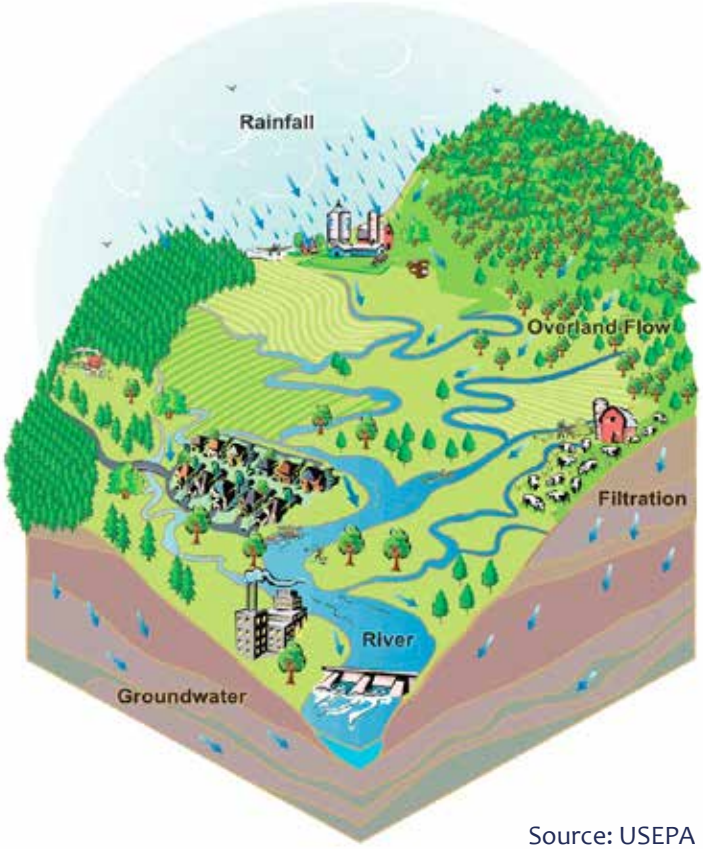
Applied Ecological Services, Inc.

Aqua Vitae

MMSD
PARTNERS FOR A CLEANER ENVIRONMENT

INTRODUCTION

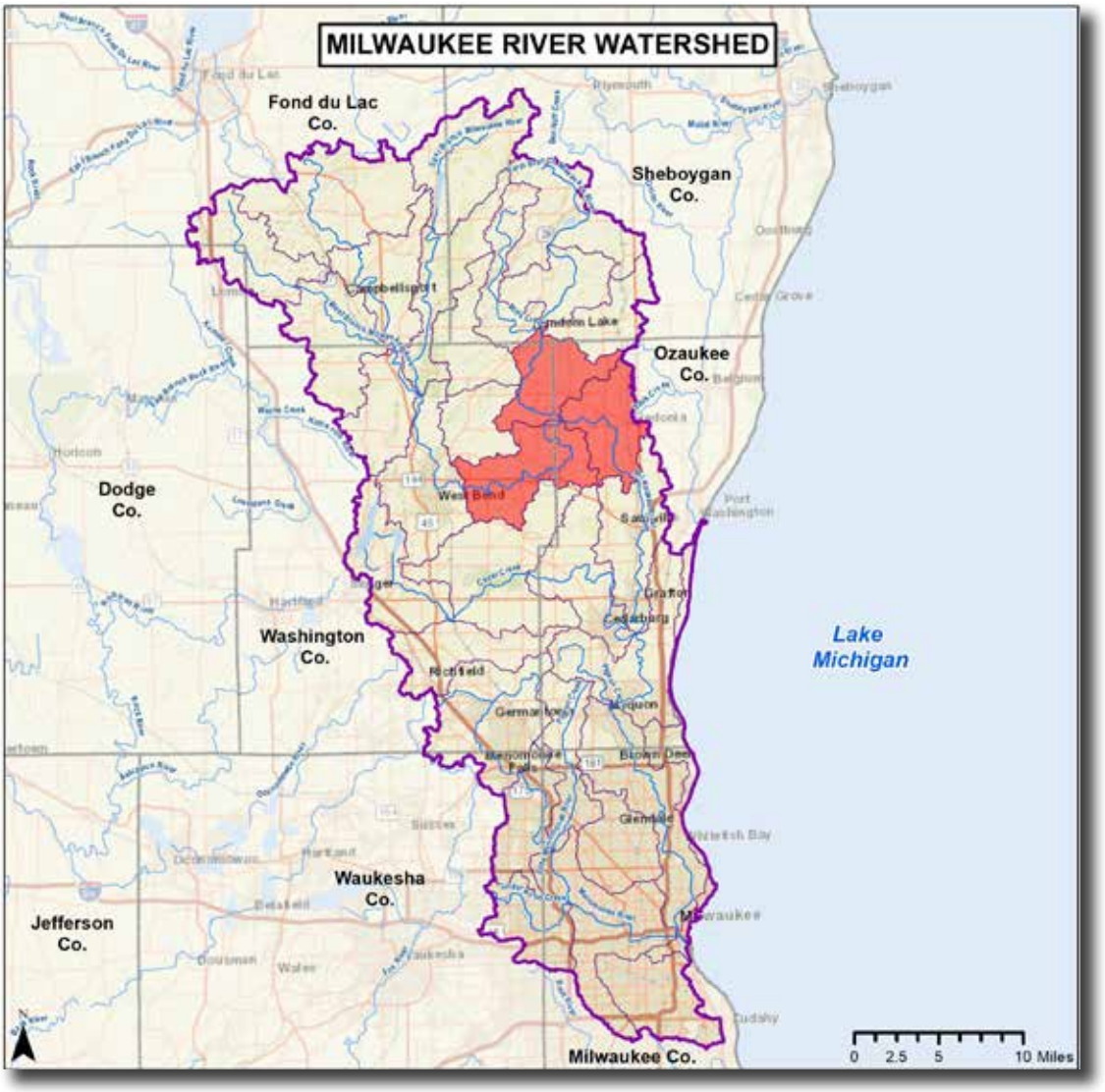
People live, work, and play in areas of land known as watersheds. A watershed is best described as an area of land where surface water drains to a common location such as a stream, river, or lake (see image, right). The source of groundwater recharge to aquifers, streams, and lakes is also considered part of a watershed. Watersheds are complex systems because there is interaction between natural elements such as climate, surface water, groundwater, and vegetation and human elements. Human influences can produce polluted stormwater runoff, increase impervious surfaces, alter stormwater flows, and degrade or fragment natural areas.



Source: USEPA

The Fredonia-Newburg Area watersheds planning area encompasses three HUC 12 watersheds: Town of Fredonia-Milwaukee River (HUC: 040400030602), Milwaukee River North Branch (HUC: 040400030107), and Village of Newburg-Milwaukee River (HUC: 040400030209). The planning area is located in southeast Wisconsin between Milwaukee and Sheboygan. Together, the three watersheds drain nearly 47,000 acres (73 square miles) of land surface.

Collectively, there are 378,341 linear feet or 71.6 miles stream miles and 8,441 acres of wetlands in the Fredonia-Newburg Area watersheds. Three counties and four municipalities comprise the watershed. The watershed is split almost evenly between Ozaukee and Washington Counties , with a small portion extending into Sheboygan County, and includes the Town of Fredonia, Village of Newburg, unincorporated Waubeka and the southeastern portion of West Bend.



WATERSHED PLANNING

Watershed planning is a collaborative approach to address natural resource issues and improve water quality protection. This approach allows stakeholders to share information, better target limited financial resources, and address common water-related challenges. These challenges can include improving water quality, preserving and protecting groundwater resources, managing stormwater, reducing flooding, conserving open space, protecting wildlife habitat, supporting opportunities for economic development, and other issues of concern.

Goals were drafted from the concerns expressed by watershed stakeholders during a May 7, 2019 workshop. Participants were given the opportunity to vote across eight goal topics as to which they felt were most important. Then, a facilitator led successive groups of stakeholders through questions and prompting around the mission statement and each goal, taking notes on stakeholder ideas and feedback. This information was then used to refine the mission, the goals, and the objectives of the plan.

MISSION

The communities of the Fredonia-Newburg Area watersheds are dedicated to the protection, preservation, and improvement of our area watersheds through planning, implementation, education and stewardship for shared health and area wellbeing.

GOALS

Goal 1: *Improve surface water quality to meet water quality standards.*

Goal 2: *Encourage agricultural techniques and soil conservation practices that will protect and conserve topsoil and bolster our water resources.*

Goal 3: *Increase stakeholder awareness of watershed issues through education and stewardship.*

Goal 4: *Protect groundwater quantity & quality.*

Goal 5: *Increase communication and coordination among stakeholders.*

Goal 6: *Manage and mitigate for existing and future structural flood problems.*

Goal 7: *Protect and manage natural and cultural components of the Green Infrastructure Network, including fish and wildlife habitat.*

Example of the pre-settlement landscape. Source: Riveredge.

THE WATERSHED OVER TIME

A diverse network of forests, prairies and wetlands remained intact in the Fredonia-Newburg Area watersheds until European settlers began to alter significant portions of the watershed's natural landscape, hydrology and wetland processes in the 1800s. Where it was feasible, trees were cleared, prairies were tilled under and wet prairie and marsh communities commonly found in floodplain areas were drained, streams channelized, and existing vegetation cleared to farm the rich soils. Today, the Fredonia-Newburg Area watersheds are collectively approximately 46% agricultural and 30% open space.

While these changes increased the agricultural productivity of the watershed, they created other problems resulting from the channelization of streams and removal of riparian buffers. Functional wetlands and riparian buffers do more for water quality improvement and flood reduction than any other natural resource. In addition, intact wetlands and riparian buffers typically provide habitat for a wide variety of plant and animal species. They also provide groundwater recharge, filter sediments and nutrients, and slowly discharge to streams thereby maintaining water levels in streams during drought periods.

Channelization is detrimental for the health of streams and rivers because it increases the speed and force of water through a channel, eliminates suitable in-stream habitat for fish and wildlife and limits the number of natural in-stream features such as pool-riffle sequences in the channel. In many locations, a berm comprised of historic side-cast dredge spoils cuts off the stream channels from the floodplain.

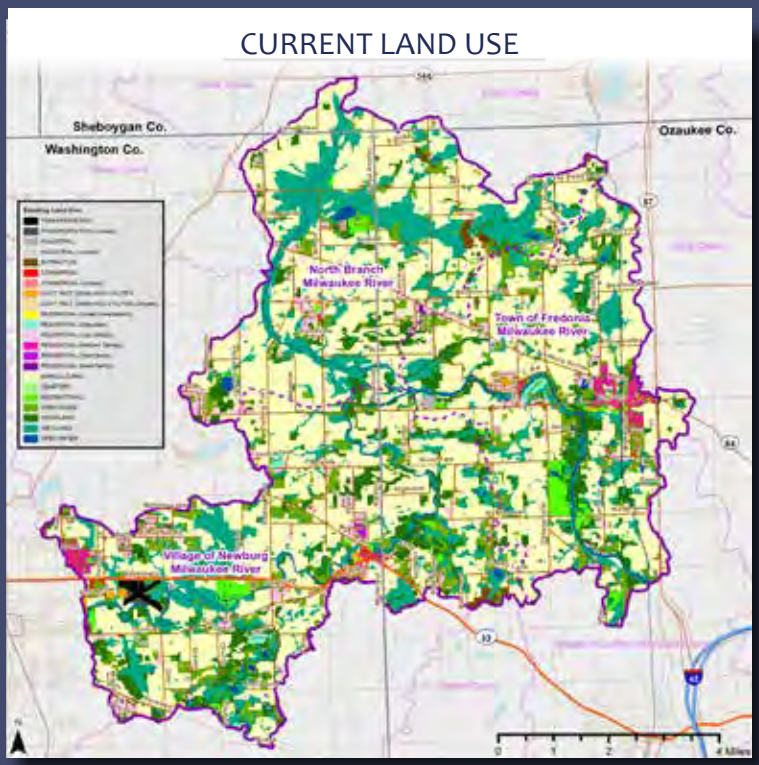
LAND USE

In all three watersheds agriculture is far and away the most prevalent land use. In the Village of Newburg, Town of Fredonia, and North Branch Milwaukee River watersheds this amounts to 8,390.6 acres (44.9%), 7,154.7 acres (50.7%), and 7,499.2 acres (53.1%) respectively. This includes row crop agriculture (largely corn and soybean) as well as livestock (largely dairy.)

Wetlands make up the next most abundant land use . The wetland areas are largely adjacent to the Milwaukee River and accompanying floodplain areas, as well as a large lowland area in the North Branch watershed. The Village of Newburg, Town of Fredonia, and North Branch Milwaukee River watersheds this amounts to 3,117.7 acres (16.7%), 1,929.9 acres (13.7%), and 3,392.9 acres (24.0%) respectively.

Within the Town of Fredonia and North Branch watersheds the third largest land use results from woodland areas. These account for 822.2 acres (5.8%) and 1,327.4 acres (9.4%) respectively. These woodland areas are also largely adjacent to the Milwaukee River. Woodlands are the fourth largest land use type within the Village of Newburg watershed spanning 1,877.2 acres (10.1%).

The third largest land use within the Village of Newburg is open land which makes up 1,980.9 acres (10.6%); this is generally defined as undeveloped land which has no discernable natural resource type. Open land is the fourth largest land use in both the Town of Fredonia and North Branch watersheds, covering 1,308.2 acres (9.3%) and 742.7 acres (5.3%) respectively.



CHALLENGES & THREATS

During the planning process a number of challenges and threats to water quality were identified in the Fredonia-Newburg Area watersheds. These challenges and threats were identified while documenting existing conditions and assessment of the watershed and by stakeholders throughout the planning process. They include:

- Degraded or missing riparian areas and management
- Agricultural runoff
- Channelization of tributaries
- Funding challenges for large scale water quality, habitat, and flood prevention projects
- Funding challenges for implementation of additional agricultural management practices
- There is a gap in science and knowledge on how to cost effectively monitor water quality using *E. coli* as the indicator for bacteria-based surface water impairments.

AGRICULTURAL LAND MANAGEMENT

While Wisconsin is known for its food production, how this land is managed can have a significant effect on water quality. According to the Environmental Protection Agency's National Water Quality Inventory, "agricultural nonpoint source (NPS) pollution was the leading source of water quality impacts on surveyed rivers and lakes… Agricultural activities that cause NPS pollution include poorly located or managed animal feeding operations; overgrazing; plowing too often or at the wrong time; and improper, excessive or poorly timed application of pesticides, irrigation water and fertilizer. "

Agricultural land can be a significant contributor of nutrients, sediment, and bacteria to local streams when practices such as filter strips, grass swales, no or reduced tillage, waste (manure) management, and fencing to restrict livestock access to streams are not in place. Some agricultural parcels within the watershed are already utilizing appropriate conservation practices, including no-till farming, vegetated swales, or cattle fencing in order to reduce nutrient and sediment loading to streams. Most farmers understand the inherent value in reducing soil and nutrient losses on their farms and consider it good business practice to do so. For those parcels where conservation practices appeared to be lacking, potential recommendations were noted during the watershed field inventory.

Since roughly half of the Fredonia-Newburg Area watersheds are used for agricultural purposes, the use of additional conservation practices on agricultural land is imperative to ensure the protection and improvement of water quality in the watershed. Selecting specific locations for agricultural BMPs is complicated and involves many considerations including owner willingness to participate, land configuration, and crop management practices already in place. Individual land owners are encouraged to work with NRCS and the Counties to appropriately manage nutrient and sediment loss on their lands.

The Watershed-Based Plan includes a list of general practices that should be implemented throughout the watershed where practicable.

Recommended agricultural BMPs include:

- Conservation crop rotation
- No-till or Conservation tillage
- Grass waterways
- Filter strips
- Fencing
- Injection
- Nutrient management plans
- Waste (manure) management

More information on all of these practices can be found in the full watershed plan document.

Images: Background - Conservation Tillage (no till) farming. Source: farmprogress.com.

Right, top to bottom - Stakeholders developing and prioritizing goals. Conservation crop rotation, and grass waterways.

Source: USDA NRCS

Source: USDA NRCS

GREEN INFRASTRUCTURE & YOUR BACKYARD

A Green Infrastructure Network is a connected system of natural areas and other open space that conserves natural ecosystem values and functions, sustains clean air and water, and provides a wide array of benefits to wildlife and people. The network is made up of hubs and linking corridors. Hubs generally consist of the largest and least fragmented areas such as Huiras Lake, Fellenz Woods, Kratzsch Conservancy, Mayhew Preserve, and Riveredge Nature Preserve. Corridors are generally formed by private agricultural or residential parcels along the Milwaukee River and its tributaries as well as along the primary SEWRPC Environmental Corridors. Corridors are extremely important because they provide habitat conduits between hubs. However, most parcels forming corridors are not ideal green infrastructure until landowners embrace the idea of managing stream corridors or creating backyard habitats.

Source: greeninfrastructure.net

Source: Appalachian Traveller.

Any property owner can improve green infrastructure. Create a safe place for wildlife by providing a few simple things such as food, water, cover, and a place for wildlife to raise their young. The National Wildlife Federation's Certified Wildlife Habitat® and the Conservation Foundation's Conservation@ Home programs can help you get started.

Creating a rain garden, or a small vegetated depression, to capture water is another way of promoting infiltration while beautifying your yard and providing additional habitat. Disconnecting your roof downspouts and capturing that runoff in rain barrels not only reduces the amount of runoff entering streams, but also serves as a great source of water for irrigating your yard.

Fellenz Woods (Source: OWLT)

Source: Rainbarrelsource.com.

RAIN BARREL

RAIN GARDEN

If a portion of a stream runs through your backyard, here are some tips to help properly manage your piece of the green infrastructure network:

1. **A NATURAL, MEANDERING STREAM IS A HAPPY STREAM**
   Work with experts to restore degraded streams.
2. **REMOVE NON-NATIVE SPECIES**
   Identify and remove plants that are out of place (see photo guide, right).
3. **PLANT NATIVE VEGETATION**
   Plants adapted to the Midwest climate can help control erosion by stabilizing banks.
4. **NO DUMPING**
   Avoid dumping yard waste and clear heavy debris jams.
5. **MANAGE CHEMICAL USE**
   Avoid over fertilizing or spilling/dumping chemicals near waterways.

RiverEdge Nature Center (Source: Riveredge)

Huiras Lake (Source: OWLT)

REMOVE THESE NON-NATIVE AND INVASIVE SPECIES

COMMON REED

BUCKTHORN

Source: Loras.edu.

REED CANARY GRASS

PURPLE LOOSESTRIFE

GARLIC MUSTARD

TEASEL

ACTION PLAN

The Fredonia-Newburg Area Watershed-Based Plan includes an Action Plan developed to provide stakeholders with recommendations to address plan goals. The Action Plan includes programmatic and site-specific recommendations. Programmatic recommendations are general watershed-wide remedial, preventatitve, and regulatory actions. Site-specific recommendations include actual locations where projects can be implemented to improve water quality, green infrastructure, and aquatic and terrestrial habitats.

Programmatic recommendations include...

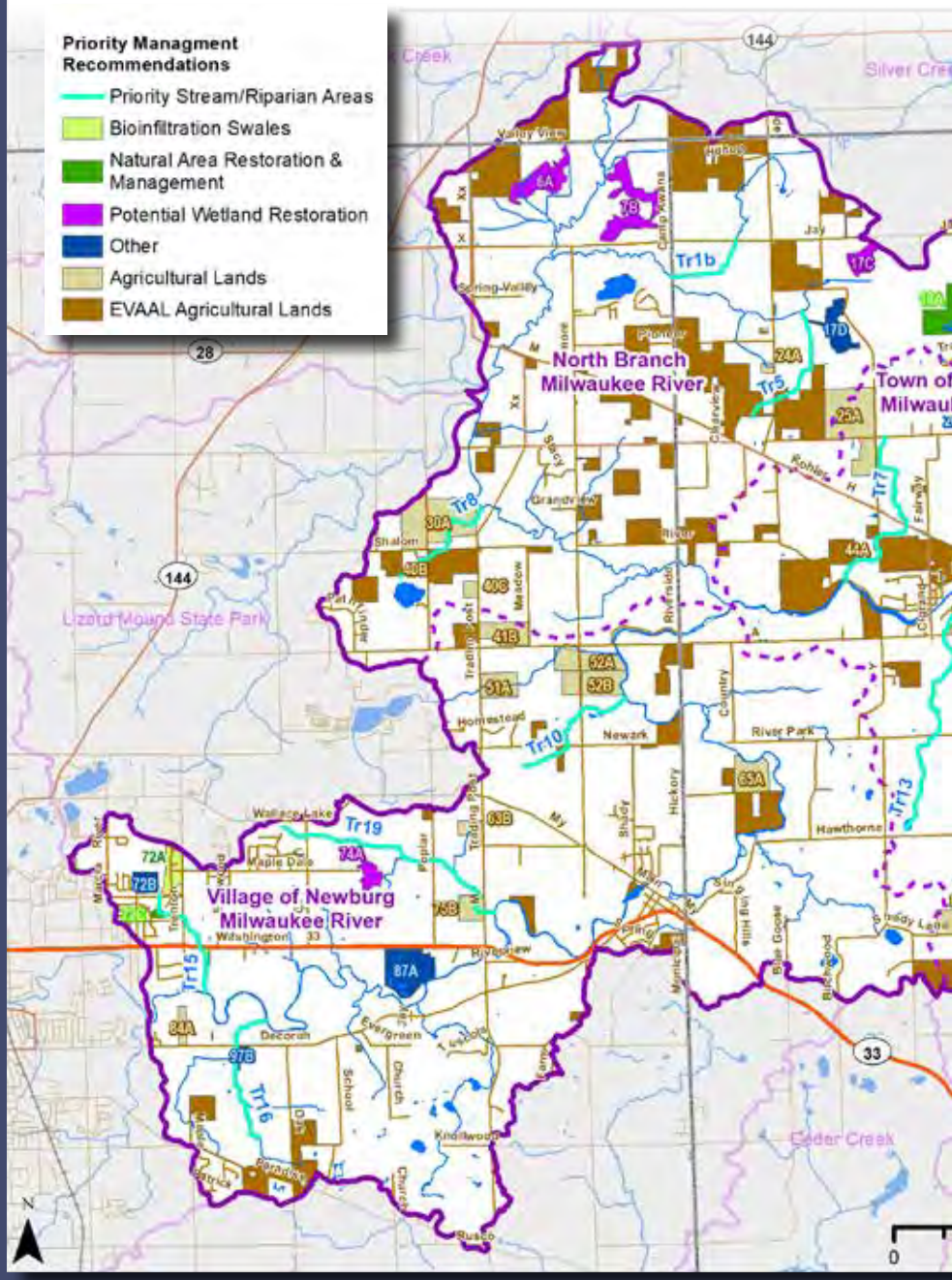
- Ordinance and Policy Recommendation
- Rainwater Harvesting & Re-use
- Native Landscaping
- Street Sweeping
- Septic System Maintenance
- Green Infrastructure Planning
- Conservation Design & Low Impact Development
- Water Quality Trading & Adaptive Management

Site-specific recommendations include...

- Stream & Riparian Area Restoration
- Agricultural Management Practices
- Other Management Measures:
  - Wetland Restoration
  - Natural Area Restoration
  - Bioinfiltration Swales
  - Golf Course Naturalization
  - Rain Gardens

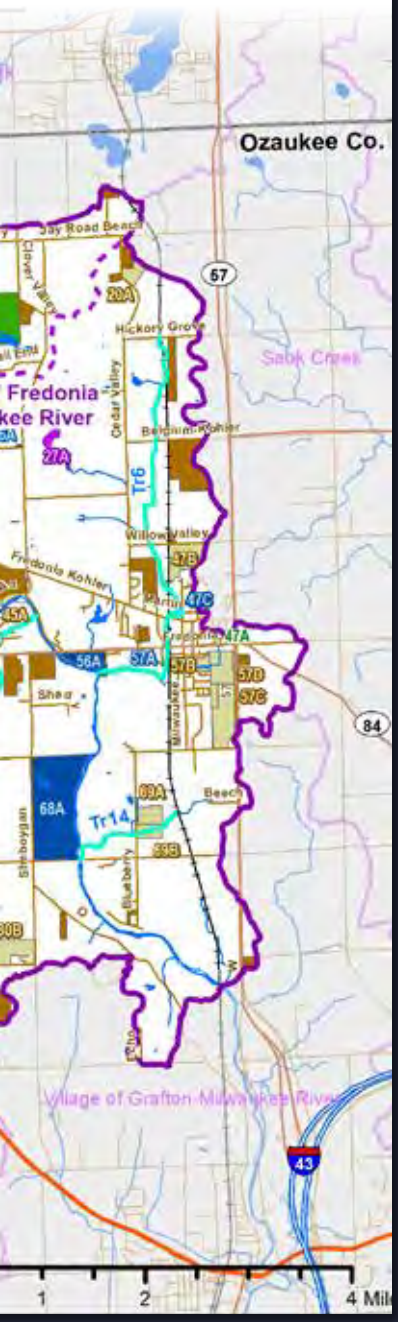
The recommended programmatic and site-specific management measures provide a solid foundation for protecting and improving watershed conditions over time but should be updated as projects are completed or other opportunities arise. Key implementation stakeholders are encouraged to organize partnerships and develop various funding arrangements to help delegate and implement the recommended actions. More details on the action plan and implementation can be found in the full waterhsed plan document.

PRIORITY AREAS



Stream & Riparian Area Restoration

Agricultural Manag



MILWAUKEE RIVER TOTAL MAXIMUM DAILY LOAD (TMDL) STUDY

For the Fredonia-Newburg Area watersheds, reduction targets for total phosphorus and total suspended solids were based on the Milwaukee River Total Maximum Daily Load (TMDL) pollutant load allocations for the corresponding watersheds within the Fredonia-Newburg watersheds, under the guidance of WDNR. In order to meet the Milwaukee River TMDL requirements, we need to reduce the total load of ...

Phosphorus by

- 45% for Newburg (MI-7)
- 33% for North Branch (MI-13)
- 51% for Fredonia (MI-15)

And total suspended solids by

- 68% for Newburg (MI-7)
- 66% for North Branch (MI-13)
- 57% for Fredonia (MI-15)

For fecal coliform, no percent reductions were developed under the TMDL, there was not enough existing water quality data to determine an annual load reduction target, and available models could not caluculate load reductions.

A water quality monitoring plan is an essential part of any watershed plan to evaluate plan implementation outcomes. Physical, chemical, and biological data will be collected over time to track progress towards acheiving the TMDL targets.

Water Quality Monitoring & Education

Source: D. Johnson

ement Practices

Natural Area Restoration

Wetland Restoration

WHERE DO WE GO FROM HERE?

Historical land uses have played a significant role in the degradation of water resources in the Fredonia-Newburg Area watersheds. Fortunately, there are actions outlined in the plan that can be taken to mitigate existing issues and prevent additional problems. The future health of the watershed is largely dependent on how the landscape and stormwater are managed. That includes implementing proven and environmentally-conscious landscape practices and approaches to stormwater management, such as those identified in this executive summary, to improve water quality and stream health in the watershed.

There is no single fix for the water quality and landscape challenges in the Fredonia-Newburg Area watersheds. These problems are the cumulative result of decisions made since people moved to the watershed in the 1800s. It will take all stakeholders and actions at every scale in order to positively impact watershed resources. This watershed-based plan is the first step in helping watershed residents and stakeholders understand what can be done to restore the valuable resources of the Fredonia-Newburg Area watersheds.

Milwaukee Metropolitan Sewerage District (MMSD) is a regional government agency that provides water reclamation and flood management services for more than one million people across the Greater Milwaukee region. MMSD is a leader in protecting public health and the drinking water through their wastewater treatment, flood management, and green infrastructure programs. Funding for this watershed planning process was made possible through a WDNR aid agreement with MMSD and is funded by a Great Lakes Restoration Initiative Nearshore Nonpoint Source grant. The findings and recommendations herein are not necessarily those of the funding agencies.

For more information on how you can help, contact the Counties:

Ozaukee County - Andy Holschbach
Land & Water Management Department
121 W. Main St, P.O. Boz 994, Port Washington, WI 53074
262-284-8271

Washington County - Paul Sebo
Land & Water Conservation Division
333 E. Washington St, Ste. 2300
P.O. Box 2003, West Bend WI 53095
262-335-4805

All photos by AES unless otherwise noted.

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MMSD PARTNERS FOR A CLEANER ENVIRONMENT

Aqua Vitae

Applied Ecological Services, Inc.™

1.0 INTRODUCTION

1.1 Fredonia-Newburg Area Watersheds Setting

People live, work, and recreate in areas of land known as "Watersheds". A watershed is best described as an area of land where surface water drains to a common location such as a stream, river, or lake (Figure 1). The source of groundwater recharge to streams, rivers, and lakes is also considered part of a watershed. Despite the simple definition for a watershed, they are complex systems with interaction between natural elements such as climate, surface water, groundwater, vegetation, and wildlife as well as human interactions. Urban development and agriculture can produce stormwater runoff, increase impervious surfaces thereby altering stormwater flows, and degrade or fragment natural areas. Other common names given to watersheds, depending on size, include basins, sub-basins, subwatersheds, and Subwatershed Management Units (SMUs).

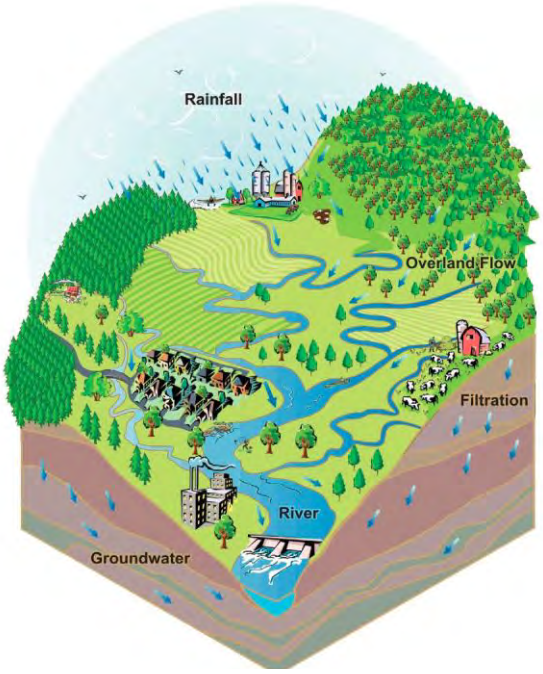


Figure 1. Hypothetical watershed setting (Source: USEPA)

The Fredonia-Newburg Area watersheds planning area encompasses three HUC 12 watersheds: Town of Fredonia- Milwaukee River (HUC: 040400030602), Milwaukee River North Branch (HUC: 040400030107), and Village of Newburg- Milwaukee River (HUC: 040400030209). The planning area is located in southeast Wisconsin in Washington, Ozaukee, and Sheboygan Counties (Figure 2). Together, the three watersheds drain nearly 47,000 acres (73 square miles) of land surface between Milwaukee and Sheboygan. Municipalities found in the watershed include Fredonia, Newburg, Waubeka, and West Bend. The watershed area lies across portions of Town of Fredonia, Town of Farmington, Town of Saukville, and Town of Trenton.

Prior to European settlement, the Fredonia-Newburg Area watersheds were ecologically intact, with clean water and a diversity of plant and wildlife populations. The area was a mosaic of southern mesic or dry-mesic forests and southern lowland forest or wetland communities and was shaped and maintained by frequent wildfires. During these times most of the water that fell as precipitation was absorbed in these forested and wetland areas. Southeast Wisconsin was inhabited by the Potawatomi Indian tribe until 1833 when the U.S. Government purchased 5 million acres of land and moved the Potawatomi to areas in the western United States.

Ecological conditions changed quickly and drastically following European settlement in the mid-1800s. Large scale fires no longer occurred, and bison and elk were extirpated. Significant portions of wooded communities and nearly all prairies were tilled, and tile systems were installed to drain wetland areas as farming became the primary land use by the early 1900s. Conversion from farmland to primarily residential and commercial uses followed, particularly over the past 30 years because of the close proximity to Milwaukee and Chicago, affordable land costs, and existing transportation.

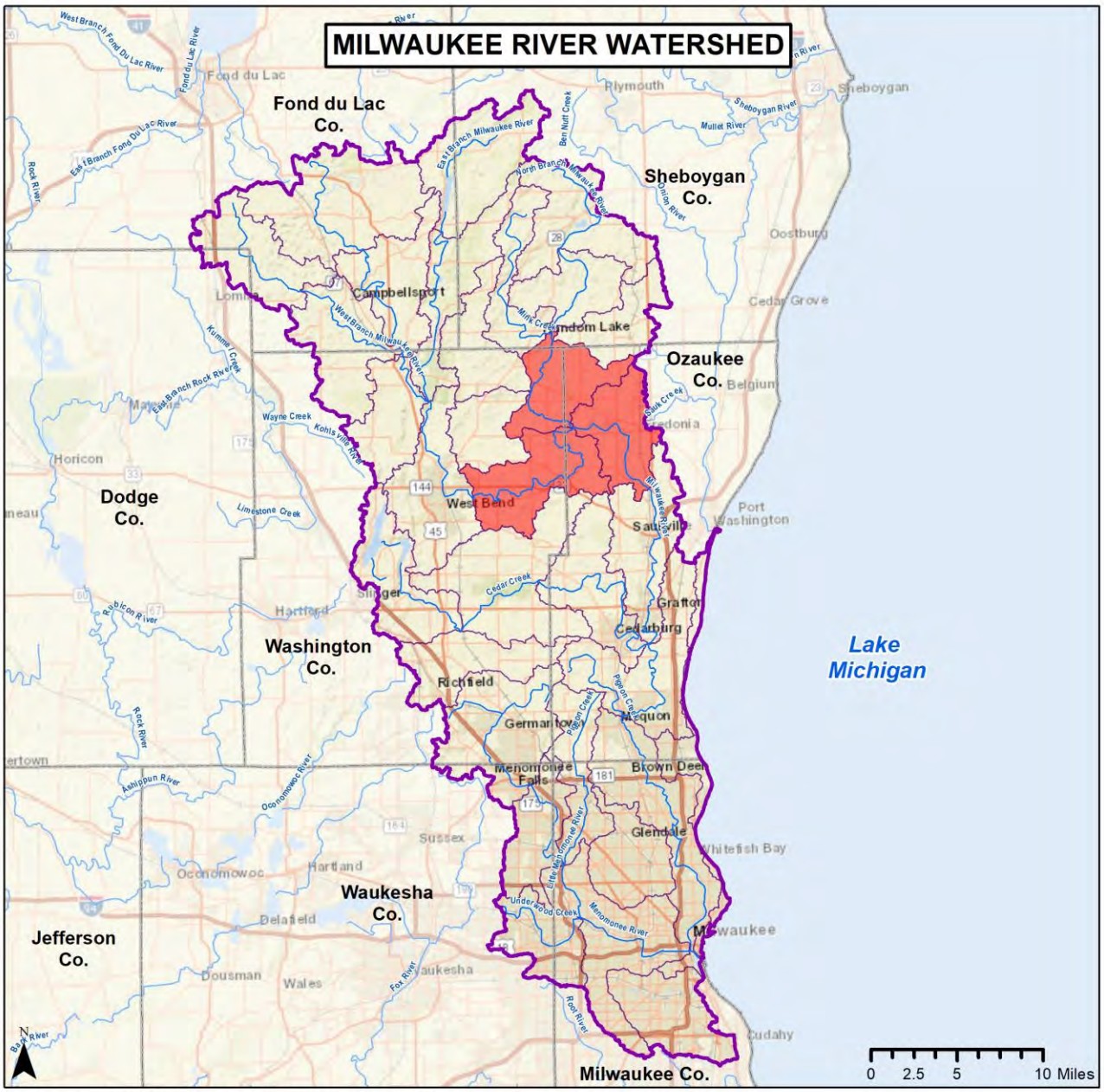
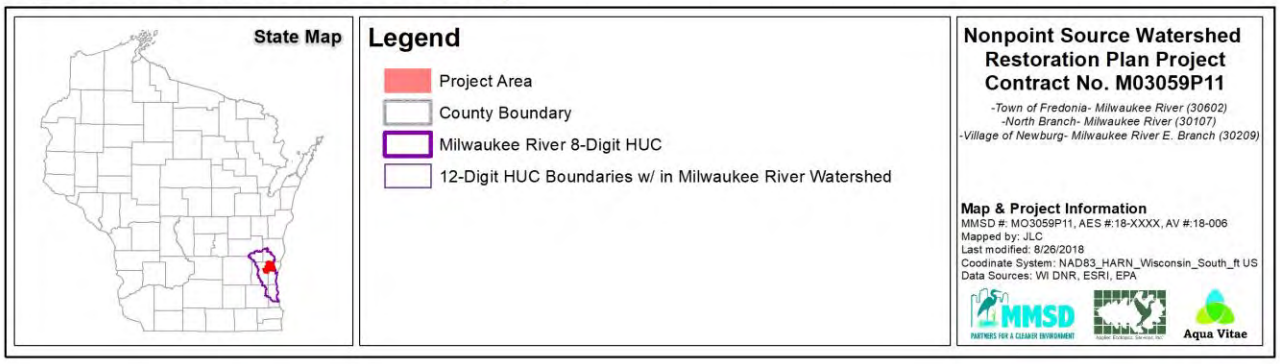


Figure 2. Watershed Locator Map



networks. The Fredonia-Newburg Area watershed is presently dominated by agricultural land, natural areas, and residential neighborhoods centered around few village centers.

While the Fredonia-Newburg Area watersheds have not experienced the levels of development seen in more urbanized areas, ongoing development and landscape change in the watershed has brought forth negative impacts to the environment. Increases in impervious surfaces greatly reduce the ability of precipitation to infiltrate into the ground. The channelization or straightening of streams has caused stormwater to run off of the land and in streams more quickly resulting in downcutting, widening, and moderate bank erosion, which in turn causes sediment and nutrient loading downstream. Meanwhile, invasive species established in adjacent floodplain wetlands are causing loss of wildlife habitat and reduced floodplain function. Discharged water from various sources that is not properly filtered is referred to as "non-point source pollution" and is the primary focus of this plan.

According to the Wisconsin Department of Natural Resources (WDNR) 2018 Water Quality Report and Section 303d List (WDNR 2018), the Milwaukee River, North Branch Milwaukee River, and Fredonia Creek within the Fredonia-Newburg Area watersheds are all listed as impaired. Under the Federal Clean Water Act, waterbodies that do not meet water quality standards are considered to be impaired. States are required to submit a list of impaired waterbodies to the U.S. Environmental Protection Agency every other year.

This section of the Milwaukee River is 303(d) listed because of an unknown pollutant and total phosphorus resulting in elevated water temperatures and an unknown impairment; this section was also 303(d) listed for PCBs at one time but was delisted in 2006. The North Branch Milwaukee River is 303(d) listed because of excessive amounts of phosphorus resulting in a degraded biological community. Finally, Fredonia Creek is 303(d) listed because of excessive amounts of phosphorus resulting in an unknown impairment.

Noteworthy- Watershed at a Glance

- Southern mesic, dry-mesic, lowland forests were common prior to European settlement in the 1830s.
- Tributaries in the watershed drain 73 square miles in Ozaukee, Washington, & Sheboygan Counties, WI.
- The dominant land uses in 2018 include agricultural land, open space, and residential areas.
- Municipalities include Fredonia, Newburg, and West Bend.
- The population of the watershed in 2010 was nearly 15,000 and is expected to increase to over 21,500 by 2050.
- Water quality is impacted by phosphorus and sediment.
- 56% of streams and tributaries are naturally meandering; 44% are moderately to highly channelized.
- 40% of streams exhibit no bank erosion; 60% are moderately eroded.
- 28% of the riparian areas are in "Good" ecological condition, 46% are "Average"; and 26% are "Poor".
- There were 18,171 acres of wetlands prior to European settlement; 8,441 acres or 46% remain in 2018.
- Open space parcels comprise approximately 44,656 acres or 78% of the watershed.
- 7 "Important Natural Areas" make up 600 acres and are home to number of important species.
- Shallow and deep groundwater aquifers provide the water supply for many private users and municipalities.
- Modeling indicates that agricultural land uses contribute the most to pollutant loading.
- Priority Area stream and riparian area restoration, agricultural management practice, and other management measures were identified for potential implementation across the watershed.

1.2 Project Scope & Purpose

Milwaukee Metropolitan Sewerage District (MMSD) is a regional government agency that provides water reclamation and flood management services for more than one million people across the Greater Milwaukee region. MMSD is a leader in protecting public health and the drinking water through their wastewater treatment, flood management, and green infrastructure programs (MMSD 2019). Funding for this watershed planning process was made possible through a WDNR aid agreement with MMSD and is provided via a Great Lakes Restoration Initiative Nearshore Nonpoint Source grant. MMSD hired Applied Ecological Services, Inc. (AES) and AquaVitae (AV) in August 2018 to develop the plan. MMSD, AES, and AV used the funding to conduct a watershed planning effort and produce a comprehensive "Watershed-Based Plan" for the Fredonia-Newburg Area watersheds that meets requirements as defined by the United States Environmental Protection Agency (USEPA). Ultimately, the intent is to develop and implement a Watershed-Based Plan designed to enable these waterbodies to achieve water quality standards/criteria.

The watershed planning process is a collaborative effort involving voluntary stakeholders who's primary intent is to restore impaired waters and protect unimpaired waters by developing an ecologically-based management plan. The Fredonia-Newburg Area watershed-based plan focuses on improving water quality by prioritizing cost effective projects in areas where progress in improving water quality can be achieved. Water quality improvement projects include protecting green infrastructure, creating protection policies, implementing ecological restoration, and educating the public. Another important outcome is to improve the quality of life for people in the watershed for current and future generations.

The primary purpose of this plan is to spark interest and give stakeholders a better understanding of the Fredonia-Newburg Area watersheds and to promote and initiate plan recommendations that will accomplish the goals and objectives of this plan. This plan was produced via a comprehensive watershed planning approach that involved input from stakeholders and analysis of complex watershed issues by watershed planners, ecologists, GIS specialists, water quality specialists, and environmental engineers. In addition, ideas and recommendations in this plan are designed to be updated through adaptive management that will strengthen the plan over time as additional information becomes available.

1.3 USEPA Watershed-Based Plan Requirements

In March 2008, the United States Environmental Protection Agency (USEPA) released watershed protection guidance entitled "Non-point Source Program and Grant Guidelines for States and Territories." The document was created to ensure that Section 319 funded projects make progress towards restoring waters impaired by non-point source pollution. Applied Ecological Services, Inc. consulted USEPA's "Handbook for Developing Watershed Plans to Restore and Protect Our Waters" (USEPA 2008) and subsequent guidance to create this watershed plan. Having a Watershed-Based Plan will allow Fredonia-Newburg Area watershed stakeholders to access 319 Grant funding and other funding for watershed improvement projects recommended in this plan. Under USEPA guidance, "Nine Elements" are required in order for a plan to be considered a Watershed-Based Plan.

Noteworthy- USEPA Nine Elements

Element A: Identification of the causes and sources or groups of similar sources of pollution that will need to be controlled to achieve the pollutant load reductions estimated in the watershed-based plan;

Element B: Estimate of the pollutant load reductions expected following implementation of the management measures described under Element C below;

Element C: Description of the BMPs (non-point source management measures) that are expected to be implemented to achieve the load reductions estimated under Element B above and an identification of the critical areas in which those measures will be needed to implement;

Element D: Estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon, to implement the plan;

Element E: Public information/education component that will be implemented to enhance public understanding of the project and encourage early and continued participation in selecting, designing, and implementing/maintaining non-point source management measures that will be implemented;

Element F: Schedule for implementing the activities and non-point source management measures recommended in the plan; identified in this plan that is reasonably expeditious;

Element G: Description of interim, measurable milestones for determining whether non-point source management measures or other control actions are being implemented;

Element H: Set of environmental or administrative criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made towards attaining water quality standards;

Element I: Monitoring component to evaluate the effectiveness of the implementation efforts over time.

1.4 Planning Process

The planning process for the Fredonia-Newburg Area watersheds was designed to be stakeholder-driven with assistance from MMSD and AES and other partner agencies. MMSD and AES facilitated meetings between October 2018 and November 2019. Feedback gathered at these meetings, best professional judgement, and the requirements outlined in USEPA's *Handbook for Developing Watershed Plans to Restore and Protect Our Waters* directed the development of the watershed-based plan. AES provided technical assistance for the watershed-based plan and drafted the report and AV provided technical assistance for the report, developed the GIS data/maps, and conducted the modeling for the plan.

MMSD, SEWRPC, Ozaukee and Washington Counties, WDNR, municipal representatives, and other active stakeholders played an important role in the early identification of watershed issues, stakeholder goals, and an overall vision for watershed improvements. Meetings were initiated by the Watershed Coordinator, Karen Nenahlo, and covered a wide range of topics specific to the Fredonia-Newburg Area watersheds. Meeting schedules and topics of those meetings are included in Table 1. Attendance lists and stakeholder meeting flyers are included in Appendix A.

Table 1. Meeting dates, agendas and summaries.

Meeting Date	Agenda	Summary
October 9, 2018	• Background context to the plan effort • Introduction to Watershed Planning Process • Overview of Field Inventory	MMSD presented the context for putting together a watershed plan for the Fredonia-Newburg Area and Applied Ecological Services detailed the planning process and what to expect. AES then detailed the results of the watershed field inventory.
November 13, 2018	• Watershed Characteristics Assessment, Part 1	AES detailed the geology, topology, soils, and subwatersheds as well as summarized the jurisdictions and demographics, existing and future land use, and impervious cover in the watershed. AES then gave an overview of the Code and Ordinance review process and its importance in the planning process.
January 15, 2019	• Watershed Characteristics Assessment, Part 2	AES detailed the watershed drainage network, highly productive agricultural lands, important natural areas and summarized groundwater conditions. Then AES walked stakeholders through the process and results of the open space inventory, prioritization and green infrastructure network.
March 12, 2019	• Water Quality Data Summary • Initial Pollutant Loading Model Results	Applied Ecological Services presented plan Section 4.0 (Water Quality & Pollutant Modeling Assessment). It was explained to the group that phosphorus and total suspended solids are the primary water quality threats in the watershed.
April 30, 0219	• Watershed Overview • Goal Building	MMSD and UW Extension Cooperative provided overview of plan, plan purpose and requested input from area farmers on their priorities for water quality
May 7, 2019	• Watershed Overview Presentation • Watershed Goal Prioritization • World Café Exercise - Goal Building	Applied Ecological Services first gave summary of the Fredonia-Newburg Area watershed conditions to prepare stakeholders for a visioning session. The mission and goal-setting session followed a World Café Exercise format whereby stakeholders provided valuable information about the group's goals for the watershed.
July 9, 2019	• Priority Areas • Programmatic Action Plan • Site Specific Action Plan	Applied Ecological Services presented plan Section 5.0 (Causes & Sources of Impairment & Reduction Targets) and 6.0 (Management Measures Action Plan). This also included a discussion of the Priority Areas within the watershed and potential project types.
August 1-20, 2019	• Plan Overview Presentations	MMSD presented an overview of the plan purpose and content at local board and plan commission meetings
September 10, 2019	• Executive Summary • Information & Education Plan • Future Water Quality Monitoring	Applied Ecological Services presented the Executive Summary. This was followed by an in-depth presentation of plan Section 7.0 (Information & Education Plan) by various partners. AES presented the Future Water Quality Monitoring Plan from plan Section 8.0.
November 12, 2019	• Present Final Watershed Plan • Discuss Implementation Phase	MMSD presented the Final Watershed Plan and discussed next steps with the stakeholder group.

1.5 Using the Watershed-Based Plan

The information provided in this Watershed-Based Plan is prepared so that it can be easily used as a tool by any stakeholder including elected officials, federal/state/county/municipal staff, and the general public to identify and take action related to watershed issues and opportunities. The pages below summarize what the user can expect to find in each major "Section" of the plan.

Section 2.0: Mission, Goals, and Objectives
Section 2.0 of the plan contains the Fredonia-Newburg Area watershed goals and objectives. Goal topics include Surface Water Quality, Agriculture, Education & Stewardship, Groundwater, Communication & Coordination, Flooding, and Species and Habitat, and the Green Infrastructure Network. In addition, "Measurable Objectives" were developed where possible for each goal so that the progress toward meeting each goal can be measured in the future by evaluating information included in Section 9.0 (Measuring Plan Progress & Success).

Section 3.0: Watershed Resource Inventory
An inventory of the characteristics, problems, and opportunities in the Fredonia-Newburg Area watersheds is examined in Section 3.0. Resulting analysis of the inventory data led to recommended watershed actions that are included in Section 6.0 (Management Measures Action Plan). Inventory results also helped identify causes and sources of watershed impairment as required under USEPA's *Element A*.

Section 3.0 includes summaries and analysis of the following inventory topics:

Watershed Resource Inventory Topics *Included* in the Plan

- 3.1 Geology & Climate
- 3.2 Pre-European Settlement Landscape & Present Landscape
- 3.3 Topography, Watershed Boundary, Subwatersheds
- 3.4 Soils
- 3.5 Jurisdictions, Roles & Protections
- 3.6 Existing Policies & Ordinance Review
- 3.7 Demographics
- 3.8 Transportation Network
- 3.9 Existing & Future Land Use/Land Cover
- 3.10 Impervious Cover Impacts
- 3.11 Open Space & Green Infrastructure
- 3.12 Highly Productive Agricultural Land
- 3.13 Important Natural Areas
- 3.14 Watershed Drainage System
  - Streams
  - Wetlands
  - Floodplain
- 3.15 Groundwater

Section 4.0: Water Quality & Pollutant Modeling Assessment
A summary and analysis of available water quality data for the watershed and pollutant modeling assessment is included in its own section because of its importance in the watershed planning process. This section includes a detailed summary of physical, chemical, and biological data available for the Fredonia-Newburg Area watersheds. Water quality data combined with pollutant loading data provides information needed for developing pollutant reduction targets and identifying Priority Areas, as outlined in Section 5.0 (Causes & Sources of Impairment & Reduction Targets).

Section 5.0: Causes & Sources of Impairment & Reduction Targets
This section of the plan includes a list of causes and sources of watershed impairment as identified in Section 3.0 (Watershed Resource Inventory) and by watershed stakeholders that affect Wisconsin DNR "Designated Uses" for water quality and other watershed features. As required by USEPA,

Section 4.0 also addresses all or portions of *Elements A, B, & C* including an identification of the Priority Areas, pollutant load reduction targets, and estimate of pollutant load reductions following implementation of recommended Priority Area Management Measures identified in Section 6.0.

Section 6.0: Management Measures Action Plan

A "Management Measures Action Plan" is included in Section 6.0. The Action Plan is divided into a Programmatic Action Plan and a Site-Specific Action Plan. Programmatic recommendations are described in paragraph format; site specific recommendations are presented in paragraph, figure, and table formats with references to entities that would provide consulting, permitting, or other technical services needed to implement specific measures. The site-specific tables also outline project priority, pollutant reduction efficiency, implementation schedule, sources of technical and financial assistance, and cost estimates. This section also contains a watershed-wide summary table of specific information for all recommended site-specific management measures combined including "Units," "Cost," and "Estimated Pollutant Load Reduction". This section addresses all or a portion of USEPA *Elements C & D*.

Section 7.0: Information & Education Plan

This section is designed to address USEPA *Element E* by providing an Information/Education component to enhance public understanding and to encourage early and continued participation in selecting, designing, and implementing recommendations provided in the Watershed-Based Plan. This is accomplished by providing a matrix that outlines each recommended education action, target audience, package or vehicle for implementing the action, who will lead the effort, what the expected outcomes or behavior change will be, and estimated costs to implement.

Sections 8.0 & 9.0: Plan Implementation & Measuring Plan Progress & Success

A list of key stakeholders and discussion about forming a Watershed Implementation Committee that forms partnerships to implement watershed improvement projects is in included in Section 8.0. Section 9.0 includes two monitoring components; 1) a "Water Quality Monitoring Plan" that includes specific locations and methods where future sampling should occur and a set of water quality "Criteria" that can be used to determine whether pollutant load reduction targets are being achieved over time and 2) "Report Cards" for each plan goal used to measure milestones and to determine if Management Measures are being implemented on schedule, how effective they are at achieving plan goals, and need for adaptive management if milestones are not being met. Sections 8.0 and 9.0 address USEPA *Elements F, G, H, and I.*

Sections 10.0 & 11.0: Literature Cited and Glossary of Terms

Section 10.0 includes a list of literature that is cited throughout the report. The Glossary of Terms (Section 11.0) includes definitions or descriptions for many of the technical words or agencies that the user may find useful when reading or using the document.

Appendix

The Appendix to this report is included on the attached CD located on the back cover (hard copies only). It contains watershed stakeholder attendance lists and stakeholder meeting flyers (Appendix A), Center for Watershed Protection local ordinance review results (Appendix B), map results of the watershed resource field inventory (Appendix C), a list of the public wells in the Fredonia-Newburg Area watersheds (Appendix D), the STEPL modelling results and assumptions used to develop pollutant loading estimates and reductions (Appendix E), County maps of potentially failing private onsite wastewater treatment systems (POWTS) (Appendix F), and a list of potential funding programs and opportunities (Appendix G).

1.6 Prior and Concurrent Studies and Projects

Various studies and other planning processes have been completed or are in progress describing and analyzing conditions within the Fredonia-Newburg Area watersheds. This Watershed-Based Plan uses existing data to analyze and summarize work that has been completed by others and integrates new data and information and has been developed concurrent to several other planning projects. A list of known studies and projects is summarized below.

1. Southeastern Wisconsin Regional Planning Commission (SEWRPC) developed a number of stormwater or drainage management plans, environmental reports, or watershed planning documents for various municipalities and contextual settings within the Fredonia-Newburg Area watershed beginning in the 1960s and continues to develop and updates these plans.
2. In 1970, SEWRPC created a comprehensive plan for the Milwaukee River watershed (Planning Report No.13). This report provides an overview of land and water resource quality and identifies challenges within this basin.
3. Between 1989 and 1991, the WDNR in partnership with the Wisconsin Department of Agriculture, Trade & Consumer Protection and county land conservation departments developed three priority watershed plans that each cover portions of the Fredonia-Newburg Area HUC-12s. These projects were designed to address nonpoint source pollution. The three plans were: Nonpoint Source Control Plan for the East and West Branches of the Milwaukee River Priority Watershed Project (1989), Nonpoint Source Control Plan for the North Branch Milwaukee River Priority Watershed Project (1989), Nonpoint Source Control Plan for the Milwaukee River South Priority Watershed Project (1991).
4. In 1999, SEWRPC developed a comprehensive land use plan for the Town of Fredonia. This was updated to a comprehensive plan through 2035 in March of 2009.
5. In 2002, SEWRPC completed a study of groundwater entitled Groundwater Resources of Southeastern Wisconsin (Technical Report No. 37). This report provides an overview of the current extent and conditions of both deep and shallow aquifers in Southeastern Wisconsin.
6. In 2007, SEWRPC issued an update to the regional water quality management plan for the greater Milwaukee watershed, including the Milwaukee River watershed. This plan was accompanied by a technical report on water quality and sources of water pollution for the watersheds addressed. SEWRPC set forth limited revisions to this plan update in a 2013 plan amendment."
7. In 2008, SEWRPC and the Ozaukee County Planning and Parks Department developed a county comprehensive plan called *A Multi-Jurisdictional Comprehensive Plan for Ozaukee County: 2035*. This plan followed a "Smart Growth" framework and guidelines and was amended in 2009 and 2013.
8. In 2008, SEWRPC and the Washington County Planning and Parks Department Planning Division developed a county comprehensive plan called *A Multi-Jurisdictional Comprehensive Plan for Washington County: 2035*. This plan followed a "Smart Growth" framework and guidelines and was adopted that same year. This plan is being updated to 2050 and a preliminary draft was released in January 2019.
9. In 2009, SEWRPC and the Washington County Planning and Parks Department developed A Park and Open Space Plan for Washington County. An update for this plan is in progress.

10. In 2011, SEWRPC and the Ozaukee County Planning and Parks Department developed A Park and Open Space Plan for Ozaukee County. An update for this plan is in progress.
11. In 2012, SEWRPC developed a comprehensive land use plan for the City of West Bend.
12. The Milwaukee Metropolitan Sewerage District created a plan in 2013 to implement widespread green infrastructure throughout their planning region.
13. In 2013, SEWRPC and Ozaukee County developed A Farmland Preservation Plan for Ozaukee County that extends to 2035. This plan is designed to preserve economically viable agriculture and the rural character of the County.
14. In 2015, Ozaukee County developed a Land and Water Resource Management Plan (2011-2015). The mission of this plan is "to protect, preserve and enhance natural resources, local ecology and the quality of life in Ozaukee County." An update for this plan is in progress.
15. In 2015, Ozaukee County developed a GIS-based Fish and Wildlife Decision Support Tool that addresses the role of wetland protection and restoration within the larger context of landscape-based fish and wildlife habitat conservation.
16. Wisconsin has also utilized Section 208, or the Priority Watershed Program, to develop a nonpoint pollutant source program, the most recent of which was approved by EPA in 2015. WDNR identified watersheds and lakes in most need of nonpoint pollution abatement and encouraged the use of nonpoint source controls to improve water quality.
17. In 2016, SEWRPC completed its Vision 2050: A Regional Land Use and Transportation System Plan for Southeastern Wisconsin which forecasts various demographic, land use, and transportation data for the planning area through 2050.
18. In 2016, Ozaukee County completed the Ozaukee County Coastal Resources Ecological Prioritization Master Plan. The Plan is a parcel-level prioritization and planning effort for preservation and restoration of critical land and water resources in the County.
19. The Community Rivers Program works to with communities in the Upper Milwaukee River Watershed to create healthier ecosystems. In 2017, they completed a Report Card for the Milwaukee River Basin that summarizes the water quality conditions within the planning area.
20. As a stipulation of MMSD's new WPDES permit, a Water Quality Improvement Plan (WQIP) is due to WDNR by March 1, 2020. The WQIP is intended to be a holistic plan to address water quality issues and stream impairments, to build the framework behind an Intergovernmental Cooperation Agreement to prioritize and implement cost-effective water quality improvement measures, collaboratively between and across watershed stakeholders. The WQIP will recommend a monitoring system that will measure and document water quality, and when streams can be removed from the WDNR Section 303(d) list of impaired waterbodies ("delisting streams").
21. Approved by the USEPA in March 2018, the Milwaukee River Basin Total Maximum Daily Load (MRB TMDL) Report provides documentation of the sources, loads, and required reductions for three pollutants (total phosphorus, total suspended solids, and fecal coliform) in the Milwaukee, Menomonee, and Kinnickinnic River Watersheds, as well as in the Milwaukee Harbor Estuary. The MRB TMDL was a third-party TMDL (not created by WDNR) commissioned by MMSD and produced by a consultant team led by CDM Smith, with input from WDNR and SEWRPC.

2.0 MISSION, GOALS, AND OBJECTIVES

2.1 Fredonia-Newburg Area Watershed-Based Plan Mission

The Watershed Coordinator and stakeholders of the Fredonia-Newburg Area watersheds developed a mission statement to guide the watershed plan. That mission is as follows:

"The communities of the Fredonia-Newburg Area watersheds are dedicated to the protection, preservation, and improvement of our area watersheds through planning, implementation, education, and stewardship for shared health and area wellbeing."

Scenic view of the Fredonia-Newburg Area landscape

2.2 Places-of-the-Heart

During a May 7, 2019 meeting devoted to gathering feedback from the community on the development of the plan and goals, stakeholders were given the opportunity to participate in an exercise called Places-of-the-Heart. Participants were asked to place heart-shaped stickers on a map of the watershed to indicate places they felt a connection to and to explain to the group why they placed their stickers where they did. Figure 3 depicts where participants placed their hearts and Table 2 summarizes what participants shared with the group (note: not all participants shared a description of why they placed a heart where they did).

Table 2. Location and description of Places-of-the-Heart group exercise.

Heart #	Description
7	"I see lots of wild life there and hope to keep their wild land home into the future (birds, deer, turtles, turkeys, ducks, etc.)"
8	"I've seen many snapping turtles killed on County Road W crossing the road"
9	"Riveredge – 379 acres of restored farmland and Hardwood forest – beautiful"
16	"Agricultural land and management. The Ag Component is a strong vibrant part of the watershed, maintain the ag component, improve the vibrancy and management of the land"
17	"I see this is a problem flooding area where I live"
18	"My home"
19	"Home, Waubeka runoff erosion brown water vs clean water/ *opened up a 10 acre wetland north of our farm -> not closed back to past level (destroyed owl habitat in Hames Woods) *Woodbank was compromised in 1970s/ Floodwater force through woods and our land."
20	"This is where I cross the River when the cops are after me"
21	"Pioneer Rd South, South parcel – neighboring farmer dug ditch (a new ditch) right on our property line in January within less than 1,000 feet of our pond. DNR first objected to his clearing his own ditch but later said his ditching was for ag reasons (the new ditch was never there before)"
22	"North Branch – our original family homestead pre-Civil War has had other owners since. Neighbor to west built a pond right on the north branch within "feet" of the north branch.
24	"A small wetland I own into which people throw tires and other junk to get rid of it."
25	"The area where I am responsible for the quality of effluent that enters the river."
26	"River is great for canoeing and kayak trips"
27	"Beautiful natural areas and a great park for community"

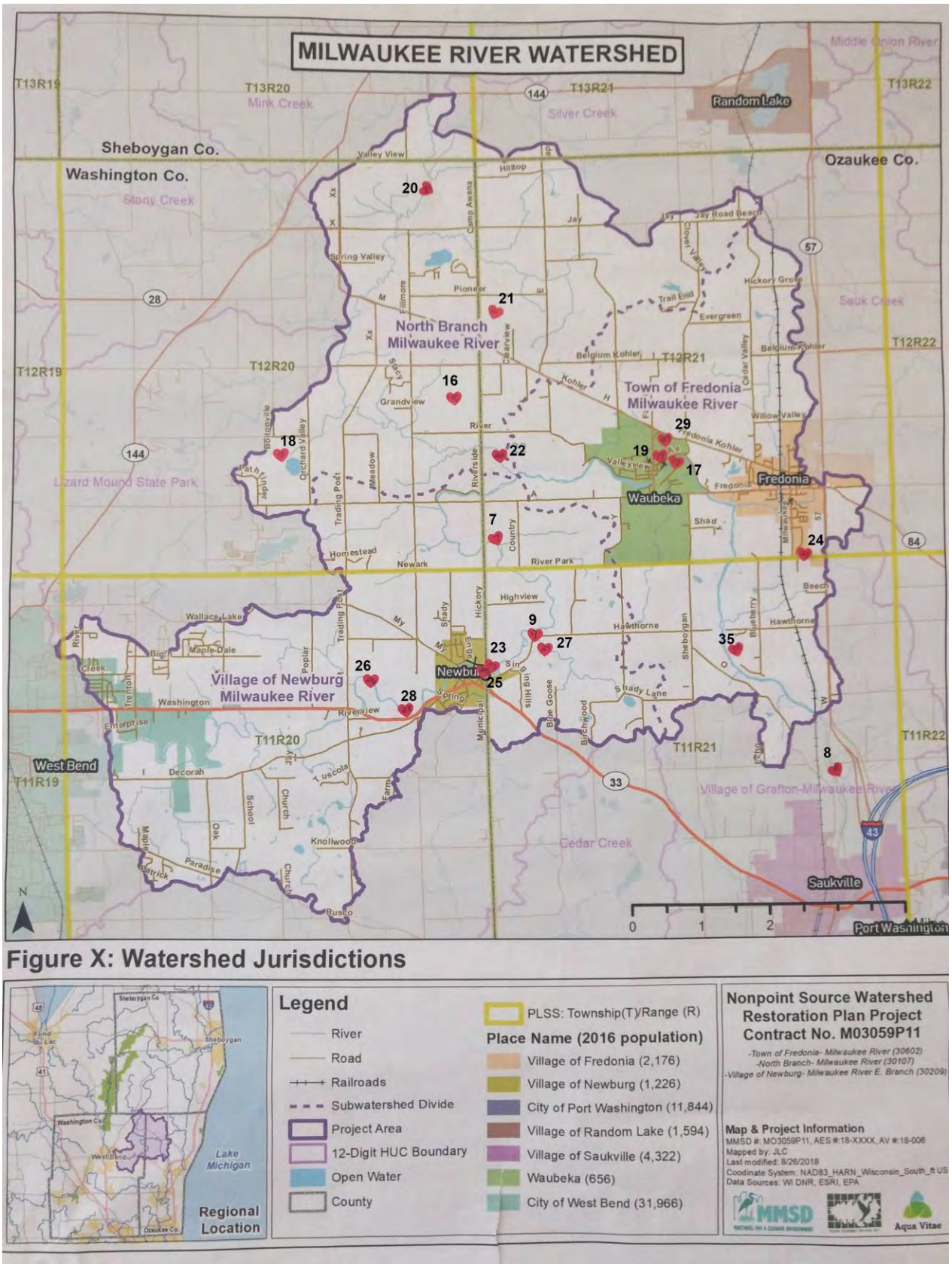


Figure X: Watershed Jurisdictions

Figure 3. Places-of-the-Heart mapping exercise results.

2.3 Goals & Objectives

Watershed stakeholders were first presented with information about the character, existing conditions, and quality of watershed resources over the course of several meetings prior to developing goals. Eight general goal topics that address issues that were brought up during those meeting as important in the Fredonia-Newburg watershed were selected. Stakeholders were then given the opportunity to vote on goals they felt were most important as a way of prioritizing those goals.

The voting process occurred during the Goals meeting held on May 7, 2019. Each stakeholder was given five votes. Each person was allowed to use up to two votes on a single goal if he or she felt strongly about it. The voting process helped focus on goals that need to be adequately addressed in the planning process and within this watershed plan report. Tallied votes by goal topic were as follows:

1) Surface Water Quality – *21 votes*
2) Agriculture – *20 votes*
3) Education & Stewardship – *15 votes*
4) Groundwater – *13 votes*
5) Communication & Coordination – *9 votes*
6) Flooding – *8 votes*
7) Species & Habitat – *5 votes*
8) Green Infrastructure Network – *4 votes*

Finally, stakeholders that attended the Goals meeting participated in a World café exercise dedicated to a facilitated brainstorming session around the watershed plan mission statement and goals. Facilitators led successive groups of stakeholders through questions and prompting around each goal and the mission statement, taking notes on stakeholder ideas and feedback. This information was then used to refine the mission, the goals, and the objectives of the plan, as well as incorporated into the plan document where appropriate.

Objectives for each goal were further refined to be specific where appropriate and designed to be measurable so that future progress toward meeting goals can be assessed. Goals and objectives ultimately lead to the development of action items and project recommendations. The Management Measures Action Plan section of this report is geared toward addressing watershed goals by recommending programmatic and site-specific Management Measure actions to address each goal. The goals and objectives are examined in more detail in the discussion of the measurement of plan progress and success via milestones and "Report Cards" given in Section 9.2.

Goal 1: *Improve surface water quality to meet water quality standards.*

Objectives:

1) Restore 152,621 linear feet of riparian areas buffers and spot stream stabilization along High Priority and Medium Priority stream reaches.
2) Implement 1,589 acres of other management measures recommended in this plan.
3) Implement agricultural best management practices on 5,052 acres of agricultural land identified in the plan.
4) Continue existing water quality monitoring programs and implement the Water Quality Monitoring Plan targeting assessment of Total Phosphorus, Total Nitrogen, Total Suspended

Solids, and *E. coli* at identified locations. Other parameters are identified for additional monitoring within the water quality monitoring plan.

5) Track changes in water quality over time as related to the Milwaukee River TMDL and make adaptive management changes to the plan as necessary to ensure water quality improvements toward meeting the TMDL reductions.

Goal 2: *Encourage agricultural techniques and soil conservation practices that will protect and conserve topsoil and bolster our water resources.*

Objectives:

1) Encourage landowner to utilize existing programs and agencies such as the Natural Resource Conservation Service (NRCS), the University of Wisconsin-Division of Extension, and the land conservation departments of Ozaukee, Sheboygan, and Washington Counties to install conservation practices that protect soil loss and water quality.
2) Educate and inform landowners about federal and state cost-share programs, which provide incentives for landowners to enroll in conservation programs and implement conservation practices.
3) Increase support for and develop additional financial assistance programs targeted at increasing the installation of conservation practices.
4) Encourage landowners and farmers to leave adequate buffers between agricultural land and waterways.
5) Implement agricultural best management practices on 5,052 acres of agricultural land identified in the plan.

Goal 3: *Increase stakeholder awareness of watershed issues through education and stewardship.*

Objectives:

1) Increase environmental stewardship opportunities and encourage stakeholders to participate in watershed plan implementation and restoration campaigns to increase activism in the watershed.
2) Implement the Fredonia-Newburg Watershed-Based Plan Information & Education Campaign.
3) Inform public officials of the benefits of conservation and low impact development and the importance of ordinance language changes that promote these developments.
4) Create targeted educational information for riparian land owners.
5) Install watershed interpretation signage at public access points and major roads.
6) Develop recommendations and alternatives for the use of fertilizer and road salt and the disposal of pet waste.

Goal 4: *Protect groundwater quantity and quality.*

Objectives:

1) Encourage county health departments or other appropriate entities to monitor the extent and current condition of septic tanks in the watershed and to educate septic tank owners on how to properly maintain their systems.
2) Educate stakeholders about potential groundwater contamination issues and encourage private well testing.
3) Implement model groundwater recharge policies for development in all “High” and “Very High” groundwater recharge potential areas.
4) Encourage landowners to install downspout disconnection practices such as rain gardens and rain barrels and utilize pavement alternatives.

5) Encourage use of Stormwater Treatment Train, Conservation Developments, or Low Impact Designs within new and redevelopment.
6) Encourage additional studies and stakeholder education on connections between well-abandonment and groundwater quality.

Goal 5: *Increase communication and coordination among stakeholders.*

Objectives:

1) Inform public officials on the benefits of conservation, low impact development, and the importance of ordinance language changes.
2) Encourage adoption of the Fredonia-Newburg Area Watershed-Based Plan by local municipalities in the watershed.
3) Leverage existing outreach programs and develop additional programs and vehicles dedicated to conducting water quality outreach and grass roots communication within the Fredonia-Newburg Area watersheds.
4) Increase awareness of surface water quality issues among the general public and agricultural community.
5) Encourage amendments to municipal comprehensive plans, codes, and ordinances to include watershed plan goals and objectives where necessary.

Goal 6: *Manage and mitigate for existing and future structural flood problems.*

Objectives:

1) Implement impervious reduction measures into development that is predicted to occur within Subwatershed Management Units 3, 8, 11, 12, 25, 33, 34, and 35, which are "Highly Vulnerable" to future development changes and associated impervious cover.
2) Mitigate for identified flood problem areas on a case by case basis where feasible.
3) Limit development in the identified FEMA 100-year floodplain.
4) Restore 489 acres of potential wetland restoration sites and maintain existing wetland connectivity to streams.

Goal 7: *Protect and manage natural and cultural components of the Green Infrastructure Network, including fish and wildlife habitat.*

Objectives:

1) Include the identified Green Infrastructure Network in all county and municipal comprehensive plans and development review maps.
2) Encourage private land owners with parcels within the Green Infrastructure Network to manage their land for ecological and water quality benefits.
3) Increase the width of and restore riparian buffers along 11 stream reaches identified as critical stream reaches and reconnect the stream to the floodplain where possible.
4) Improve habitat in degraded stream reaches using natural design approaches.
5) Develop and implement restoration and management plans for all Natural Area Restoration sites.
6) Implement conservation or low impact design standards where new or redevelopment occurs.
7) Incorporate natural landscaping into golf courses.

3.0 WATERSHED RESOURCE INVENTORY

3.1 Geologic History & Climate

Geologic History

The terrain of the Midwestern United States is shaped by several significant features and processes including The Niagara Escarpment and the Late Wisconsin Glaciation. The Niagara Escarpment is a 650-mile (1,050 km) long discontinuous bedrock ridge that runs from western New York near Niagara Falls, through southern Ontario and the Upper Peninsula of Michigan into eastern Wisconsin (Luczaj 2013). The ancient Niagara Escarpment has had a lot to do with creating the familiar landscape of eastern Wisconsin. During the last ice age, this erosion-resistant rock ridge caused the vast glacier to split into two lobes, which carved out Green Bay, Lake Winnebago and Lake Michigan. It continues to lend a special sense of place to the region, as it snakes through the countryside, affording a dramatic backdrop here or a spectacular view there (Kluessendorf 2010).

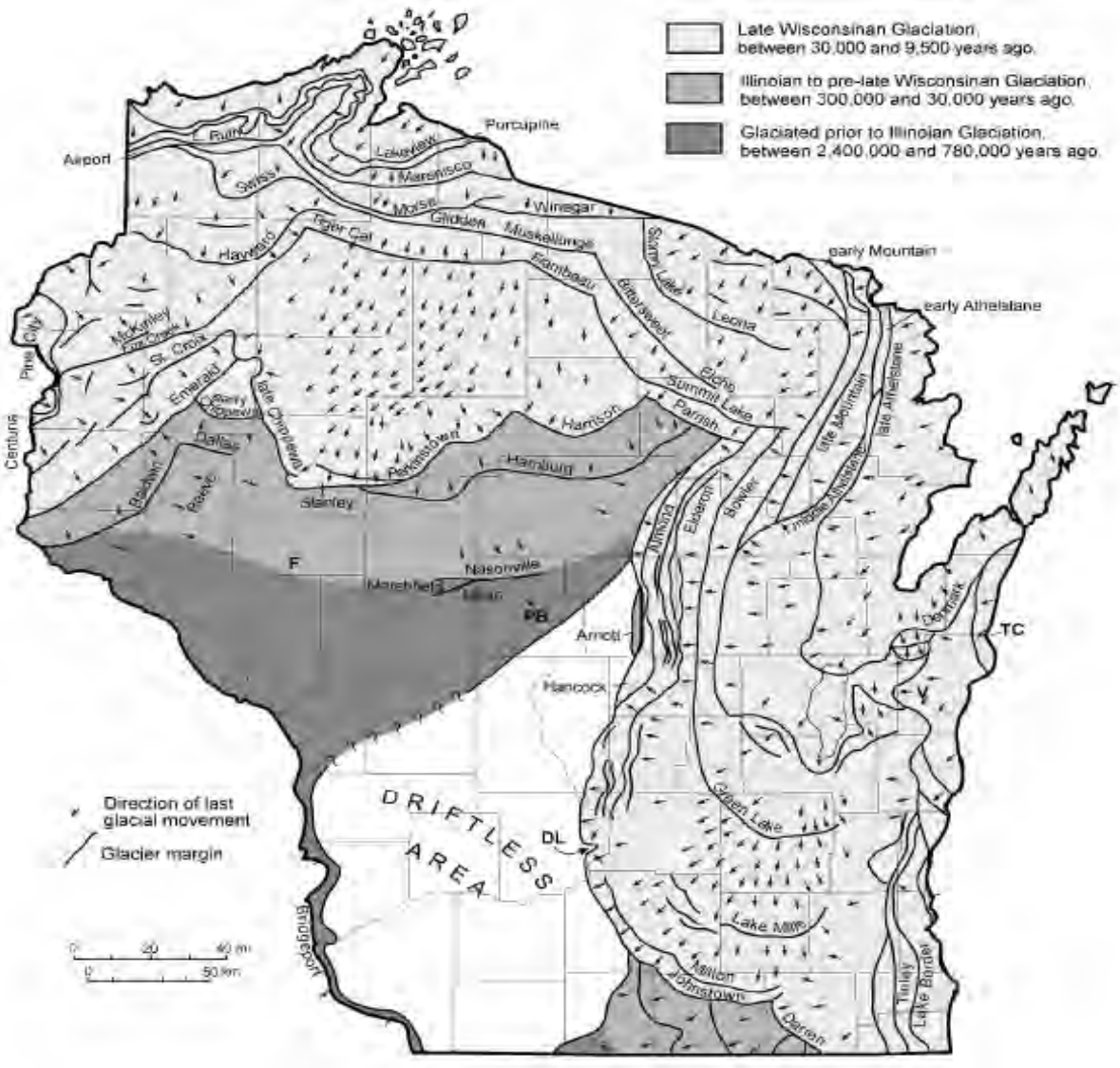


Figure 4. Phases of glaciations in Wisconsin. Source: Syverson & Colgan.

After the 400-million-year-old Niagara Escarpment established the foundation, the subsequent process of shaping the terrain we see now took thousands of years as glaciers advanced and retreated during the Pleistocene Era or "Ice Age". Some of these glaciers were a mile thick or more. The area of east central Wisconsin where the Fredonia-Newburg Area watersheds now lie was covered by the most recent glacial event known as the Late Wisconsin Glaciation that began approximately 30,000 years ago and ended around 9,500 years ago (Figure 4). During this period the earth's temperature warmed and the ice slowly retreated leaving behind moraines and glacial ridges where it stood for long periods of time (Hansel 2005). As the glaciers from this period receded, they scoured out what have become the Great Lakes and left behind a nearby terminal moraine known as the Kettle Moraine. The Kettle Moraine geology defines the character of these watersheds and the communities within them. Massive amounts of meltwater from the melting and receding glacier also carved out many of the ravines found along the coastline.

The composition of the soil in the watershed area is also a remnant of the ancient ice movement. Above the bedrock lies a layer of deposits left behind from the glaciers, consisting of clay, silt, sand, and limestone cobble. A somewhat tundra-like environment covered by spruce forest was the first ecological community to colonize after the glaciers retreated. As temperatures continued to rise, cool moist deciduous forests dominated by maple, basswood, and beech trees developed along Lake Michigan coastal areas and oak-hickory forests, oak savannas, marshes, and prairies developed more inland. Black ash, relict cedar, and tamarack swamps were also part of the landscape.

Climate

The southeast Wisconsin climate can be described as temperate with cold winters and warm summers where great variation in temperature, precipitation, and wind can occur on a daily basis. Surges of polar air moving southward or tropical air moving northward cause daily and seasonal temperature fluctuations. The action between these two air masses fosters the development of low-pressure centers that generally move eastward and frequently pass over the study area, resulting in abundant rainfall. Prevailing winds are generally from the west but are more persistent and blow from a northerly direction during winter. Lake Michigan significantly influences the study area as it reduces the heat of summer and buffers (warms) the cold of winter by several degrees on average.

The Weather Channel website (www.weather.com) provides an excellent summary of climate statistics including monthly averages and records for most locations in Southeast Wisconsin. Data for West Bend, WI was selected to represent the climate and weather patterns experienced across the three watersheds (Figure 5). The average temperature in West Bend ranges from a high of 81 °F (July) to a low average temperature of 11 °F (January). Record high and low temperatures are 107 °F and -30 °F, respectively. The average annual rainfall is 33.2 inches. The average annual snow measures 44.7 inches. (Sperling's, 2018).

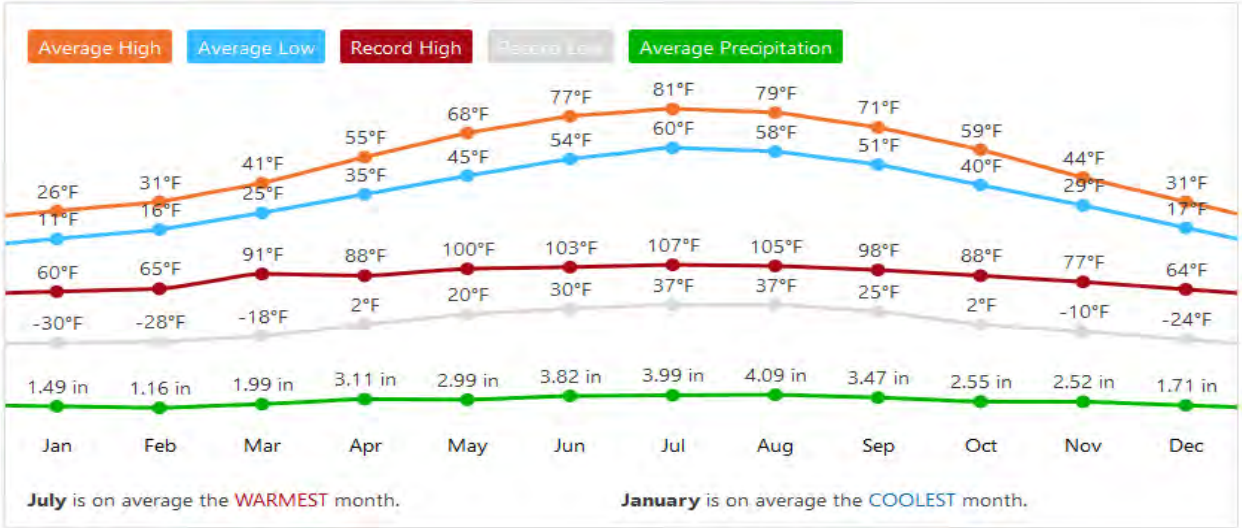


Figure 5. Monthly averages, highs and lows for temperature and precipitation in West Bend, WI (Source: the Weather Channel).

According to Wisconsin Initiative on Climate Change Impacts (WICCI) Wisconsin's climate is changing. On average, Wisconsin has become warmer and wetter over the past 60 years. Future projections for Wisconsin created by University of Wisconsin-Madison suggest Wisconsin's warming trend will continue and increase considerably. By the middle of the century, statewide annual average temperatures are likely to warm by 6-7 ° F.

3.2 Pre-European Settlement Landscape Compared to Present Landscape

The last Native American Indian tribe to call the area home was the Potawatomie. Per old historical accounts: "The Milwaukee River was the boundary line between the Chippewas and the Pottawatomies, the former holding all lands south of the entire length of the Milwaukee River, while the latter occupied everything north of that stream" (Cigrand 1916). These people lived in relative harmony with the environment until they signed a land cession treaty with the United States in 1816 at Prairie du Chien, Wisconsin. By the early 1830's, Wisconsin and Illinois lands were rapidly dwindling and pressure on natural resources by incoming white settlers on adjacent lands severely affected supplies and game (Cigrand 1916). A subsequent treaty in 1833 resulted in their removal from the land by the U.S. Government.

This treaty further paved the way for European settlement in the area that began with surveys of the land. The original public land surveyors that worked for the office of U.S. Surveyor General in the early and mid-1800s mapped and described natural and man-made features and vegetation communities while creating the township, range, and section ("Rectangular Survey System") for mapping and sale of western public lands of the United States (Daly & Lutes et. al., 2011). Ecologists know by interpreting survey notes and hand drawn Federal Township Plats of Wisconsin (1833-1866) and from documents written by the earliest settlers in the area that a complex interaction existed between several ecological communities including creeks, rivers, oak savannas, forests, and wetland prior to European settlement in the 1830s (Figures 6 - 8).

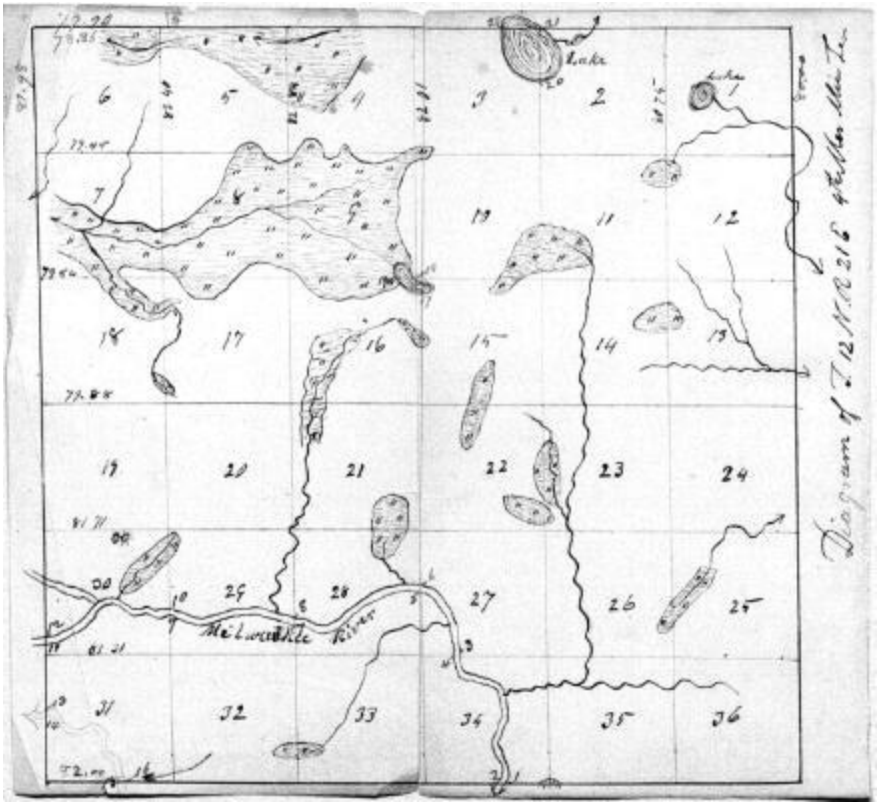


Figure 6. Sketch map for T12N R21E, Fredonia, WI and area to NW (Source: Wisconsin Board of Commissioners of Public Lands).

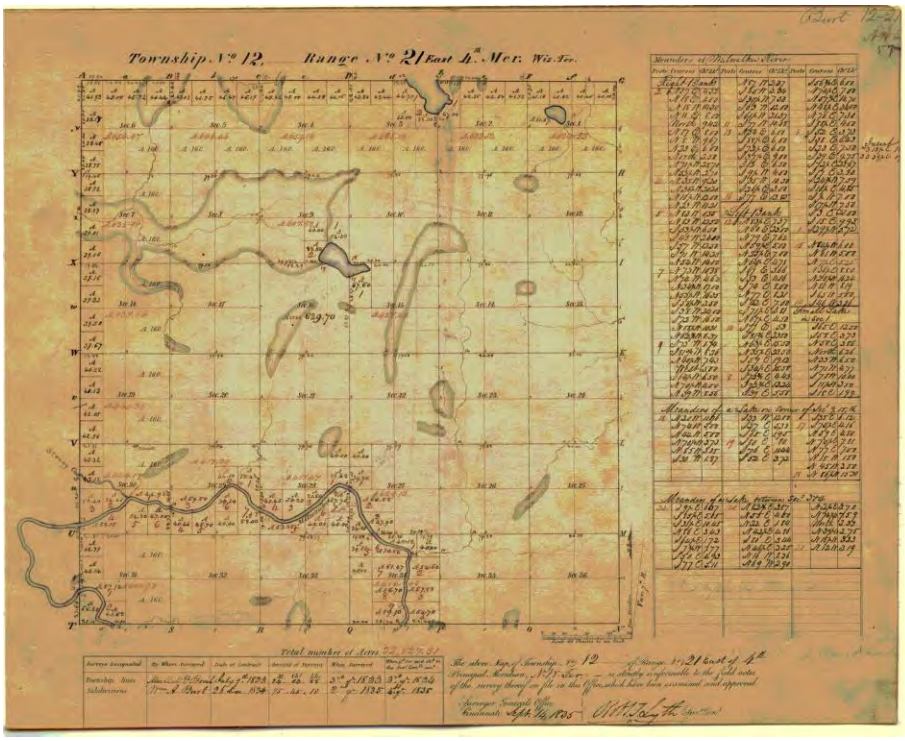
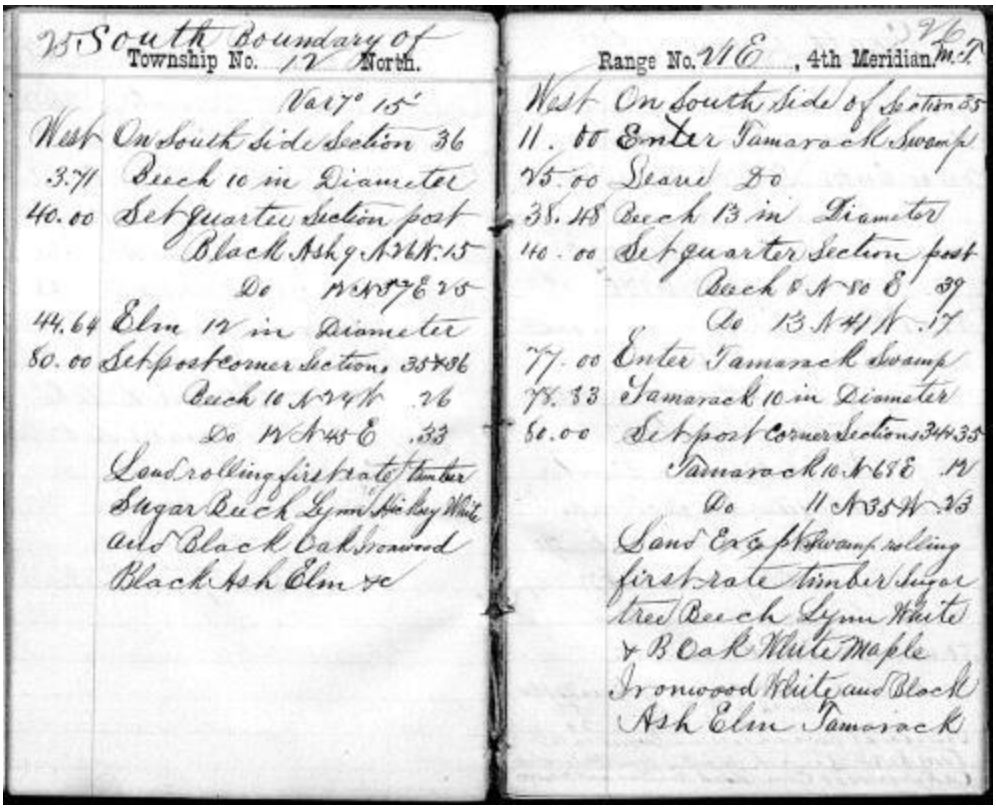


Figure 7. 1835 plat map of land features along the Upper Milwaukee River T12N R21E (Source: Wisconsin Board of Commissioners of Public Lands).


25 South Boundary of Township No. 12 North.
Var 7° 15'
West On South side Section 36
3.71 Beech 10 in Diameter
40.00 Set Quarter Section post
Black Ash 9 N 24 W. 15
Do N 45 W 26
44.64 Elm 12 in Diameter
80.00 Set post corner Sections 35 & 36
Beech 10 N 24 W .26
Do N 45 E .33
Land rolling first rate timber
Sugar Beech Lynn White
and Black Oak Ironwood
Black Ash Elm &c

Range No. 21 E, 4th Meridian. M.T.
West On South side of Section 35
11.00 Enter Tamarack Swamp
25.00 Leave Do
35.48 Beech 13 in Diameter
40.00 Set Quarter Section post
Beech 8 N 80 E 39
Do 13 N 41 W .17
77.00 Enter Tamarack swamp
78.33 Tamarack 10 in Diameter
80.00 Set post Corner Sections 34 & 35
Tamarack 10 N 68 E 12
Do 11 N 35 W 23
Land Exc. for Swamp rolling
first rate timber Sugar
tree Beech Lynn White
& B Oak White Maple
Ironwood White and Black
Ash Elm Tamarack

Figure 8. 1835 surveyor's notes for plat map T12N R21E Sec. 36 (Source: Wisconsin Board of Commissioners of Public Lands).

The surveyors described the large majority of the area of the Fredonia -Newburg Area watersheds as forested with a variety of tree species (Figure 9). Forested areas were comprised of three primary sub-communities as described by Curtis (1959). Southern mesic forest dominated by maple, basswood, and beech trees was likely the most common in the watershed. Southern dry-mesic forest, dominated by a variety of oak and hickory species, was also common, particularly on the slopes that are well-drained and derived from glacial till. Southern lowland forest was also probably common in the area and these wet areas contained black ash and alder.

European settlement beginning in the 1830s resulted in drastic changes to the fragile ecological communities as most of the old growth forests were cleared by settlers who used the wood for fuel, to build their homes, sold it to sawmills, and farmed the cleared land. This area's relatively proximity to the explosive growth occurring just south in Chicago, put tremendous strain on resources. Wetland complexes in the valleys and hillslopes of tributaries and the riparian area of the Fredonia-Newburg Area watersheds were also cleared and drained for farmland. The majority of streams were channelized and ditched to further drain water off the land. The earliest aerial photographs taken in 1937 (Figure 10) depict Fredonia-Newburg Area watersheds when row crop farming was the primary land use but before much of the residential, commercial, and industrial development seen today. By 1937, very few forested areas that once dominated the watershed remained.

Figure 11 shows a 2015 aerial photograph of the Fredonia -Newburg Area watersheds. One can see that large portions of agricultural land are replaced by residential, commercial, and industrial development, specifically near the cities, towns, and villages within the watershed. Newer residential

development is common in the western portion of the Village of Newburg-Milwaukee River watershed near the city of West Bend. Industrial land uses are more common along the transportation corridors of State Highway 33 and WI Highway 57 near the city of West Bend and Town of Fredonia. There is also an airport in the city of West Bend just south of State Highway 33. Most of the watershed is still used for agricultural purposes, with natural areas interspersed throughout owned by local conservation groups.

Depiction of what the pre-settlement landscape might have looked like (Source: Riveredge)

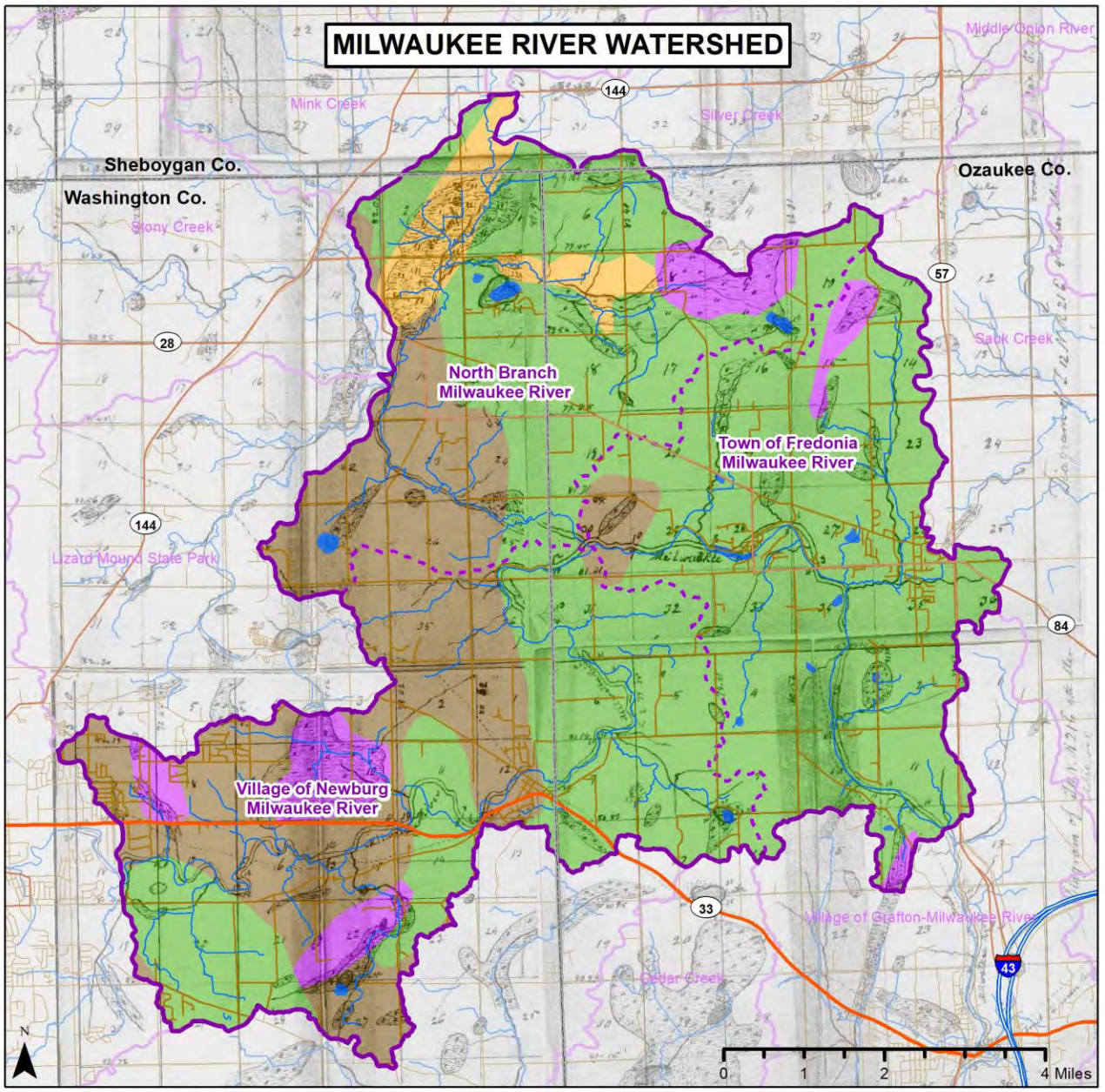
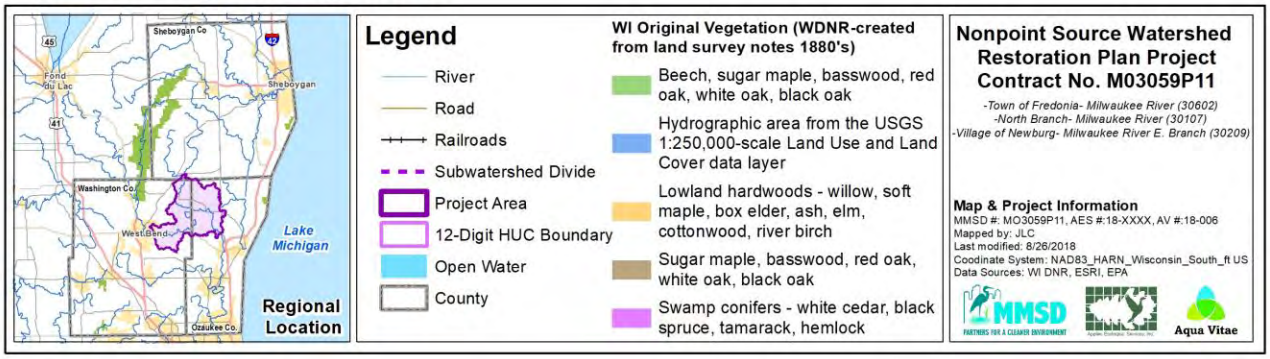


Figure 9. Original Vegetation



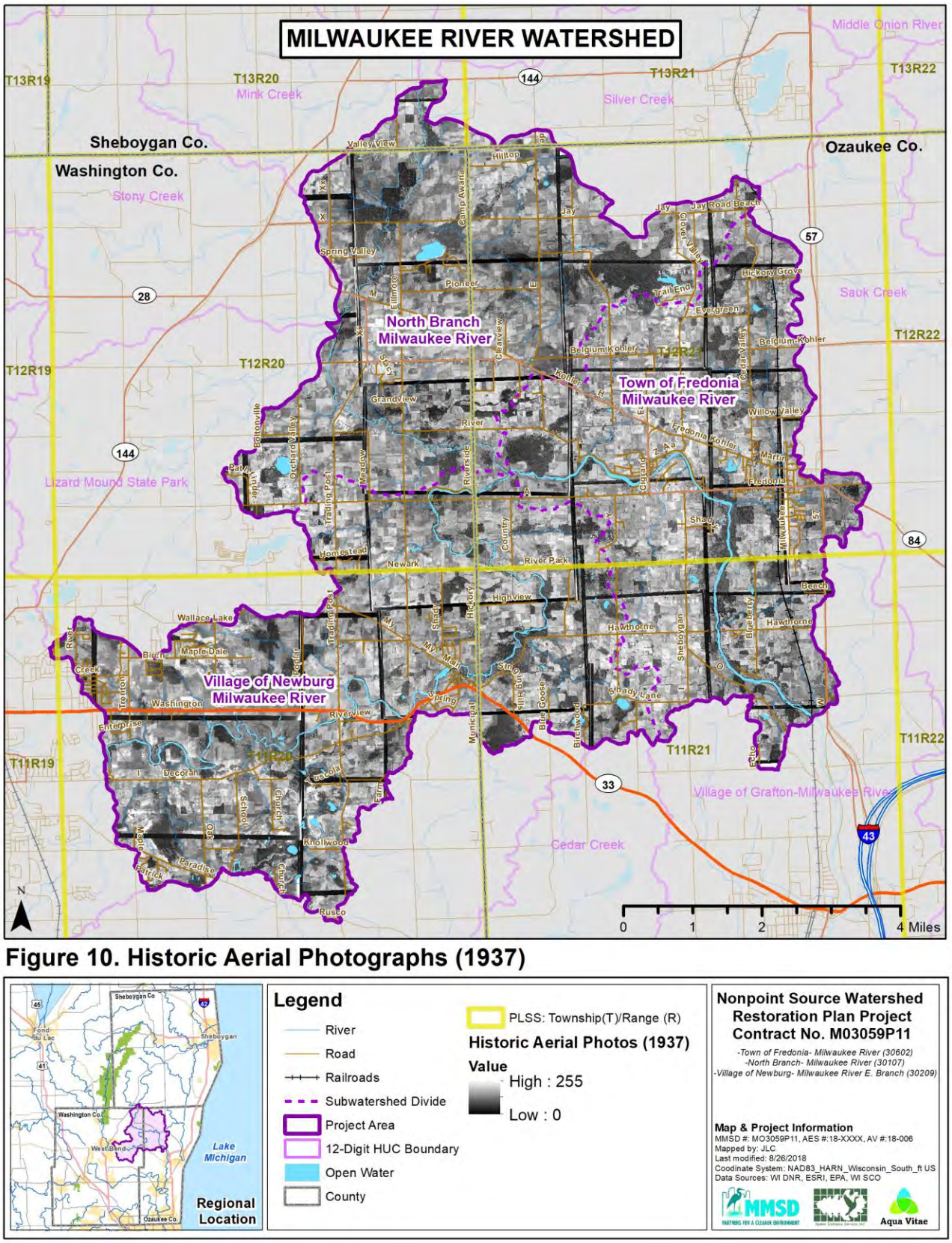


Figure 10. Historic Aerial Photographs (1937)

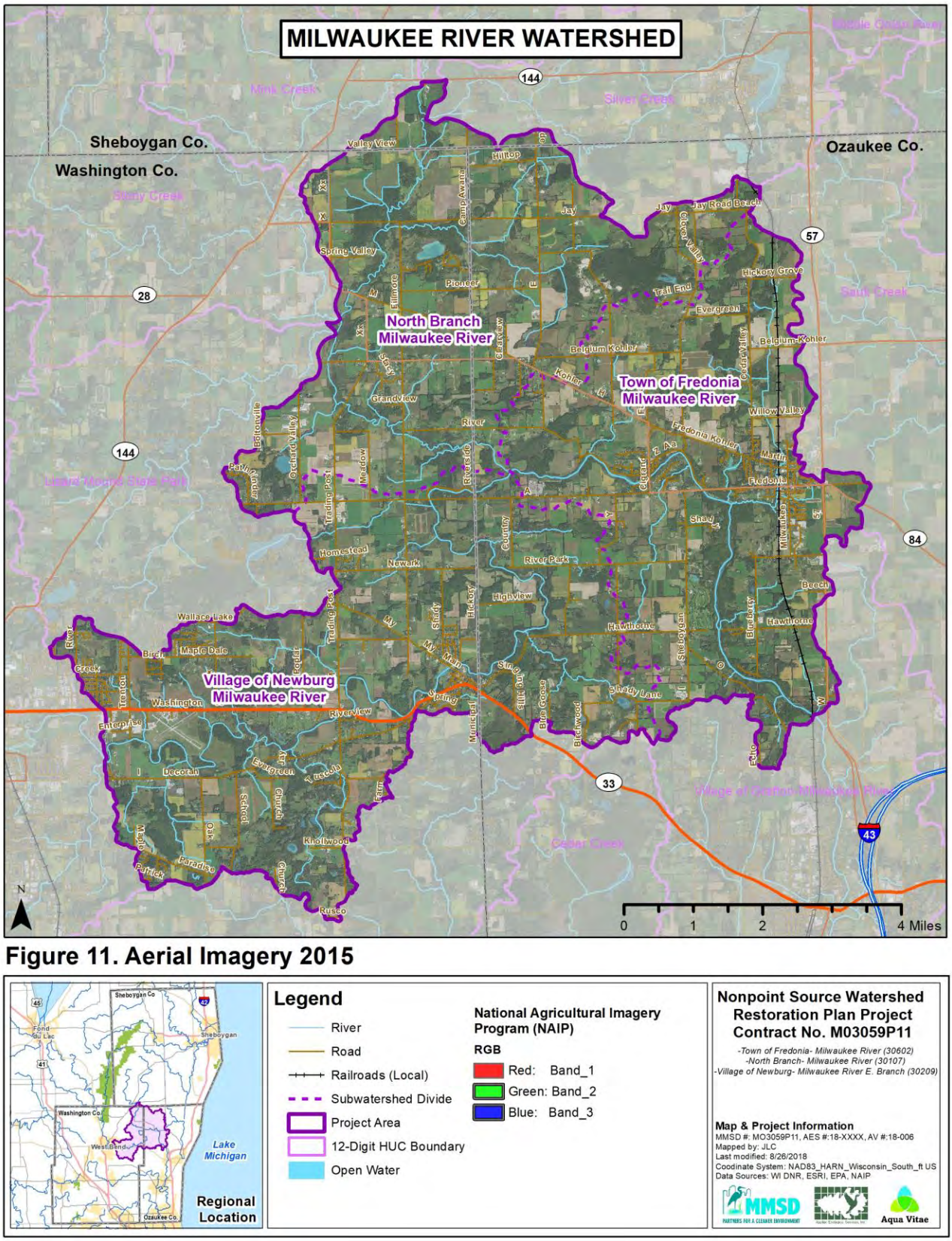


Figure 11. Aerial Imagery 2015

Legend

- River
- Road
- Railroads (Local)
- Subwatershed Divide
- Project Area
- 12-Digit HUC Boundary
- Open Water

National Agricultural Imagery Program (NAIP)

RGB

- Red: Band_1
- Green: Band_2
- Blue: Band_3

Nonpoint Source Watershed Restoration Plan Project Contract No. M03059P11

-Town of Fredonia- Milwaukee River (30602)
-North Branch- Milwaukee River (30107)
-Village of Newburg- Milwaukee River E. Branch (30209)

Map & Project Information

MMSD #: MO3059P11, AES #:18-XXXX, AV #:18-006
Mapped by: JLC
Last modified: 8/26/2018
Coodinate System: NAD83_HARN_Wisconsin_South_ft US
Data Sources: WI DNR, ESRI, EPA, NAIP

MMSD PARTNERS FOR A CLEANER ENVIRONMENT
Aqua Vitae

With degraded ecological conditions comes the opportunity to implement ecological restoration to improve the condition of these three watersheds. Present day knowledge of how pre-European settlement ecological communities formed and evolved provides a general template for developing present day natural area restoration and management plans and projects. One of the primary goals of this watershed plan is to identify, protect, restore, and manage remaining natural areas.

Noteworthy- Old Stone Foundations

Old stone foundations and stone fences are common sights around many of the old farmsteads within all three watersheds. Before tilling the land, farmers had to remove and pile the rocks or repurpose them. This reflects the rocky geology of glacial till in this area of Kettles and Moraines. Removing rocks and plowing the land was backbreaking labor done by horses and by hand (Note: old relict steel Horse Drawn Walking Plow sits in foreground).

3.3 Topography, Watershed Boundary, & Subwatershed Management Units

Topography & Watershed Boundary

The Wisconsin glacier that retreated about 10,000 years ago following formation of the Niagara Escarpment (described previously in this document) formed much of the topography and defined the watershed catchment boundaries of today. Topography refers to elevations of a landscape that describe the configuration of its surface and ultimately defines watershed boundaries. And, the specifics of watershed planning cannot begin until a watershed boundary is clearly defined.

The watershed boundaries used in this study are a combination of boundaries provided by both Wisconsin Department of Natural Resources (WDNR) and Southeastern Wisconsin Regional Planning Commission (SEWRPC). Small discrepancies noted during field inventories were also used to alter the boundary where appropriate. Topographic data was derived from a DEM (Digital Elevation Model) dataset at 2' resolution. This detailed LiDAR (Light Detection and Ranging) data was provided by SEWRPC for Ozaukee and Washington Counties. Sheboygan County contour data were converted into a DEM and mosaiced to create a seamless high-resolution DEM for the entire watershed. ArcSWAT was then used to generate SMUs (Sub Management Units) based on the DEM (Figure 12).

Intertwined land uses of agriculture and wildlife/natural areas characterize the Fredonia-Newburg watersheds.

Collectively, the Village of Newburg, Town of Fredonia, and North Branch- Milwaukee River Watersheds span 46,923 acres, or about 73.3 square miles. The entire watershed drains from north and west to south and eventually to Lake Michigan at Milwaukee, WI. Elevation within the watersheds range from a high of 1048 feet above mean sea level (AMSL) to a low of 754 feet AMSL on the Milwaukee River just upstream of Grafton, WI for a total relief of 294 feet (Figure 12). The highest point is found just east of West Bend along a ridge south of Decorah Road.

Natural areas such as this oak savanna restoration at Riveredge Nature Center (left) illustrate potential opportunities to restore parcels for water quality, wildlife habitat and useable open space.

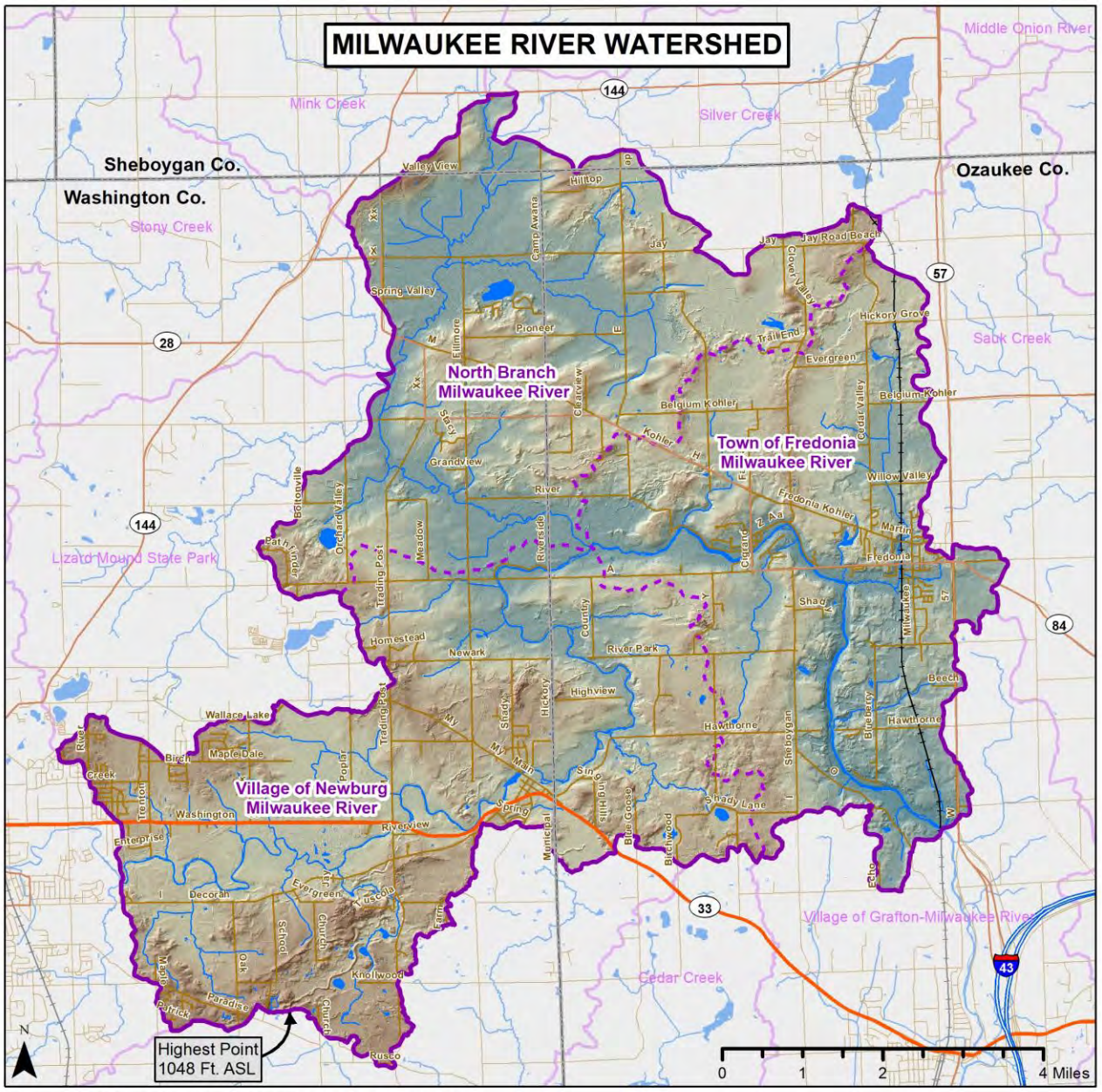
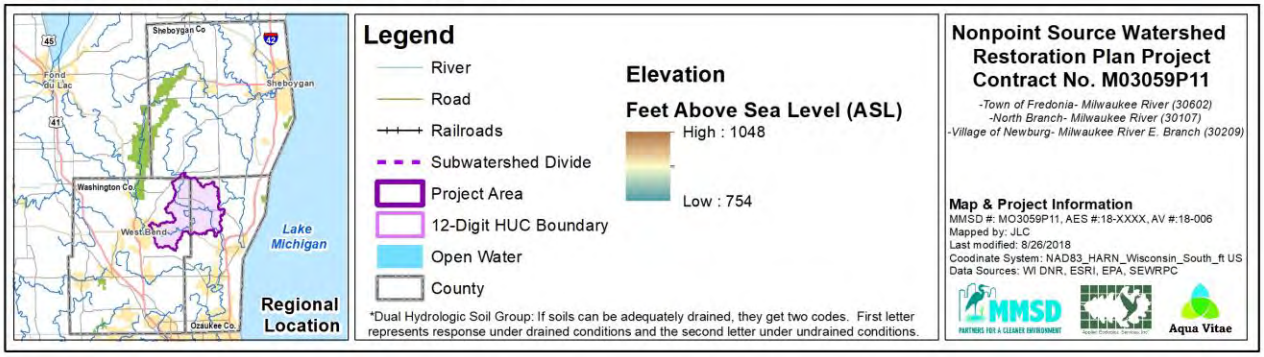


Figure 12. Digital Elevation Model



Rolling hills of the Fredonia-Newburg area watersheds

Subwatershed Management Units (SMUs)

The Center for Watershed Protection (CWP) is a leading watershed planning agency and has defined watershed and subwatershed sizes appropriate to meet watershed planning goals. In 1998, the CWP released the "Rapid Watershed Planning Handbook" (CWP 1998) as a guide to be used by watershed planners when addressing issues within urbanizing watersheds. The CWP defines a watershed as an area of land that drains anywhere from 10 to 100 square miles. Broad assessments of conditions such as soils, wetlands, and water quality are generally evaluated at the watershed level and provide some information about overall conditions. As mentioned, the combined watershed area is about 73.3 square miles and therefore this plan allows for a detailed look at watershed characteristics, problem areas, and management opportunities. However, an even more detailed look at smaller drainage areas must be completed to find site specific problem areas or Priority Areas that require immediate attention.

A watershed can be divided into subwatersheds called Subwatershed Management Units (SMUs) to address issues at a smaller scale. The North Branch, Town of Fredonia, and Village of Newburg-Milwaukee River watersheds were delineated into 10, 12, and 13 SMUs respectively using the Digital Elevation Model (DEM) information (Table 3; Figure 13). All SMUs contribute directly to the Milwaukee River, or to a tributary within the SMU. All SMUs have a single outlet point where the tributary or river flow from one SMU into the next downstream. Information obtained at the SMU scale allows for detailed analysis and better recommendations for site specific "Management Measures" otherwise known as Best Management Practices (BMPs). Delineation into SMUs also allows for better identification of areas contributing to water quality problems as summarized in Section 4.0. No internally drained areas were found within the subwatershed management units.

Table 3. Subwatershed management units, acreages and square miles.

Watershed/SMU	Acres	Sq. Miles
Town of Fredonia-Milwaukee River		
SMU 1	1,643	2.6
SMU 2	536	0.8
SMU 3	775	1.2
SMU 4	1,157	1.8
SMU 5	1,349	2.1
SMU 6	985	1.5
SMU 7	486	0.8
SMU 8	1,041	1.6
SMU 9	1,098	1.7
SMU 10	1,668	2.6
SMU 11	475	0.7
SMU 12	2,909	4.5
Total	**14,122**	**22.1**
North Branch Milwaukee River		
SMU 13	678	1.1
SMU 14	1,476	2.3
SMU 15	1,070	1.7
SMU 16	1,542	2.4
SMU 17	2,144	3.4
SMU 18	1,041	1.6
SMU 19	624	1.0
SMU 20	1,088	1.7
SMU 21	2,646	4.1
SMU 22	1,821	2.9
Total	**14,131**	**22.1**
Village of Newberg-Milwaukee River		
SMU 23	1,301	2.0
SMU 24	901	1.4
SMU 25	986	1.5
SMU 26	607	1.0
SMU 27	1,442	2.3
SMU 28	2,788	4.4
SMU 29	1,571	2.5
SMU 30	545	0.9
SMU 31	1,521	2.4
SMU 32	1,870	2.9
SMU 33	2,237	3.5
SMU 34	1,407	2.2
SMU 35	1,492	2.3
Total	**18,669**	**29.2**
Total all 3 Watersheds	**46,922**	**73.3**

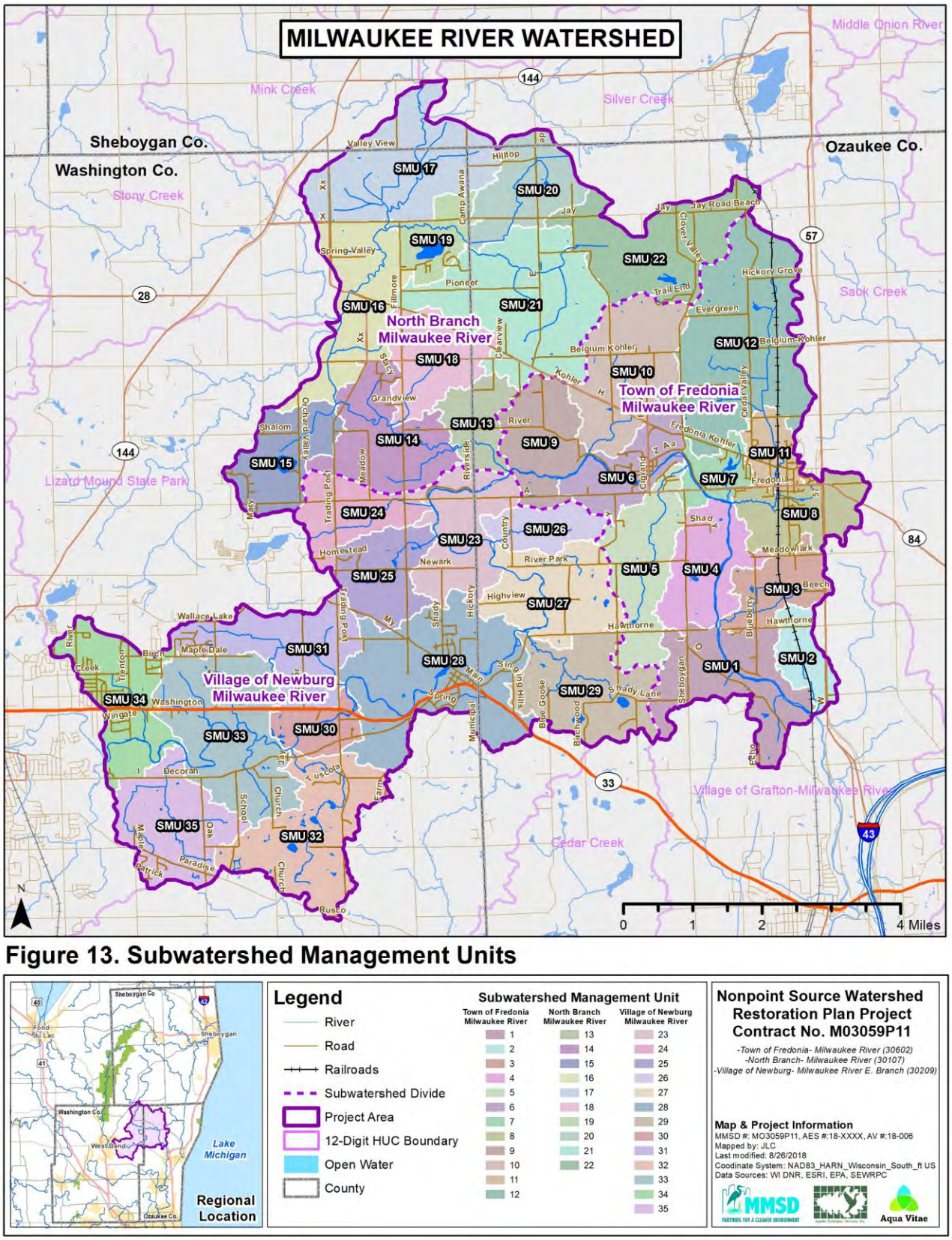


Figure 13. Subwatershed Management Units

3.4 Hydric Soils, Soil Erodibility, & Hydrologic Soil Groups

Soils

Deposits left by the Wisconsin glaciation 10,000 years ago are the raw materials of present soil types in the watershed. These raw materials include till (debris) and outwash. A combination of physical, biological, and chemical variables such as topography, drainage patterns, climate, and vegetation, have interacted over centuries to form the complex variety of soils found in the watershed. Most soils formed under wetland, woodland, and prairie vegetation. The most up to date soils mapping provided by the Wisconsin DNR (WDNR), United States Environmental Protection Agency (EPA), and United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) for Washington, Ozaukee, and Sheboygan Counties was used to summarize the extent of hydric soils, soil susceptibility to erosion, and infiltration capacity of soils in the North Branch, Town of Fredonia, and Village of Newburg Milwaukee River HUC 12 watersheds (Tables 4-7; Figures 14-16).

Hydric Soils

Wetland or "Hydric Soils" generally form over poorly drained clay material associated with wet prairies, marshes, and other wetlands and from accumulated organic matter from decomposing surface vegetation. Hydric soils are important because they indicate the presence of existing wetlands or drained wetlands where restoration may be possible. Most of the wetlands in the North Branch, Town of Fredonia, and Village of Newburg Milwaukee River HUC 12 watersheds were intact until settlers began to alter significant portions of the watershed's natural hydrology and wetland processes. Where it was feasible wet areas were cleared of vegetation and drained to farm the rich soils. The location of hydric, partially hydric, and upland soils in the watershed is summarized and depicted on Table 4 and Figure 14, respectively.

Within the North Branch- Milwaukee River watershed, hydric soils comprise 3,964 acres or 28% of the watershed, in the Town of Fredonia- Milwaukee River watershed, hydric soils comprise 1,883 acres or 13% of the watershed, and in the Village of Newburg- Milwaukee River watershed, hydric soils comprise 3,261 acres or 17% of the watershed. Most of these soils are located in the Milwaukee River floodplain areas of the North Branch of the Milwaukee River watershed and the floodplain areas directly east of West Bend in the Village of Newburg-Milwaukee River watershed. Vegetation mapping developed by the WDNR from 1880's land survey notes suggests the areas surrounding the hydric soils in the North Branch watershed were dominated mostly by lowland hardwoods and swamp conifers; while those in the Village of Newburg watershed are largely split between swamp conifers as well as sugar maple, basswood, and red, white and black oak.

Within the North Branch, Town of Fredonia, and Village of Newburg Milwaukee River watersheds, partially hydric soils occur over 1,931 (14%) acres, 3,642 (26%) acres, and 3,491 (19%) acres respectively. Partially hydric soils exhibit some, but not all, of the characteristics of hydric soils. These soils are scattered throughout the watershed, typically found adjacent to hydric soils in floodplains, but there is also a concentration of partially hydric soils on the eastern boundary of the Town of Fredonia watershed. These soils likely did not support true wetland communities.

Additionally, the North Branch, Town of Fredonia, and Village of Newburg Milwaukee River watersheds, contain non-hydric soils spanning 8,236 (58%) acres, 8,598 (61%) acres, and 11,972 (64%) acres respectively.

Table 4. Percent coverage of hydric soil classes within the watersheds.

HUC 12 Name/Erosion Rating	Acres	PCT of HUC 12
North Branch Milwaukee River	**14,130.6**	**100%**
Not Hydric	8,235.9	**58%**
Partially Hydric	1,930.8	**14%**
Hydric	3,964.0	**28%**
Town of Fredonia-Milwaukee River	**14,123.1**	**100%**
Not Hydric	8,598.2	**61%**
Partially Hydric	3,641.9	**26%**
Hydric	1,883.0	**13%**
Village of Newburg-Milwaukee River	**18,669.1**	**100%**
Not Hydric	11,917.8	**64%**
Partially Hydric	3,490.7	**19%**
Hydric	3,260.6	**17%**

Soil Erodibility

Soil erosion is the process whereby soil is removed from its original location by flowing water, wave action, wind, and other factors. Sedimentation is the process that deposits eroded soils on other ground surfaces or in bodies of water such as streams and lakes. Soil erosion and sedimentation reduces water quality by increasing total suspended solids (TSS) in the water column and by carrying attached pollutants such as phosphorus, nitrogen, and hydrocarbons. When soils settle in streams and lakes they often blanket rock, cobble, and sandy substrates needed by fish and aquatic macroinvertebrates for habitat, food, and reproduction.

A highly erodible soils map was created based on soil information provided by the WDNR, EPA, and USDA NRCS (Figure 15). Highly erodible soils have attributes that when located on slopes are susceptible to erosion. It is important to know the location of highly erodible soils because these areas have the highest potential to degrade water quality during farm tillage, development, or other factors such as bluff failures.

Based on mapping, soils with the North Branch-Milwaukee River watershed classify as "severely erodible" across 2,949 (21%) acres, "moderately erodible" 4,413 (31%) acres, "slightly erodible" 6,489 (46%) acres, and "not rated" 279 (2%) acres.

Within the Town of Fredonia-Milwaukee River watershed, soils classify as "severely erodible" across 3,905.70 (28%) acres, "moderately erodible" 5,502 (39%) acres, "slightly erodible" 4,459 (32%) acres, and "not rated" 256 (2%) acres.

The Village of Newburg-Milwaukee River watershed soils consist of "severely erodible" across 3,812 (20%) acres, "moderately erodible" 6,255 (34%) acres, "slightly erodible" 8,251 (44%) acres, and "not rated" 351 (2%) acres (Table 5).

Table 5. Percent coverage of soil erodibility ratings in the watersheds.

HUC 12 Name/Erodibility Rating	Acres	PCT of HUC 12
North Branch Milwaukee River	**14,130.6**	**100%**
Slight	6,489.2	46%
Moderate	4,413.4	31%
Severe	2,948.9	21%
Not rated	279.2	2%
Town of Fredonia-Milwaukee River	**14,123.1**	**100%**
Slight	4,459.1	32%
Moderate	5,502.0	39%
Severe	3,905.7	28%
Not rated	256.3	2%
Village of Newburg-Milwaukee River	**18,669.1**	**100%**
Slight	8,251.4	44%
Moderate	6,255.2	34%
Severe	3,811.9	20%
Not rated	350.6	2%

Fortunately, much of the highly erodible areas are currently stabilized by existing land uses/cover. However, others are located adjacent to areas of urban expansion near Newburg, Fredonia, and West Bend; or near farming in the form of dairy pastureland, and row crop farmland where erosion following annual tilling is a possibility.

One option for farmers is to convert highly erodible areas to vegetative cover under the USDA NRCS's Conservation Reserve Program (CRP). Under this program farmers receive an annual rental payment for the term of the multi-year contract.

To combat erosion due to the expansion of urban areas and the subsequent increase in impermeable surfaces, municipalities can explore options which limit the peak flow from areas of impermeability into areas of severe erodibility, such as stormwater pond retrofits, bioinfiltration basins, and permeable pavement.

Hydrologic Soil Groups

Soils also exhibit different infiltration capabilities and have been classified to fit what are known as "Hydrologic Soil Groups" (HSGs). HSGs are based on a soil's infiltration and transmission (permeability) rates and are used by engineers and planners to estimate stormwater runoff potential. Knowing how a soil will hold water ultimately affects the type and location of recommended infiltration Management Measures such as wetland restorations and detention basins. More importantly however is the link between hydrologic soil groups and groundwater recharge areas. Groundwater recharge is discussed in detail in Section 3.15.

HSG's are classified into four primary categories; A, B, C, and D, and three dual classes, A/D, B/D, and C/D. Dual classes represent soils which can be adequately drained, with the first letter representing the soil under drained conditions, and the second letter representing the soil under undrained conditions. Figure 16 depicts the location of each HSG in the watershed. The HSG categories and their corresponding soil texture, drainage description, runoff potential, infiltration

rate, and transmission rate are shown in Table 6 while Table 7 summarizes the acreage and percent of each HSG.

Within the North Branch Milwaukee River watershed, Group B soils are most prevalent throughout the watershed at about 27% or 3,878 acres and are found in most upland areas. Group B/D soils make up 1,731 acres or 12% of the watershed and are generally found within floodplain areas. Group C soils make up 3,167 acres (22%) and C/D soils 106 acres (1%). Group A soils account for 82 acres (1%) and A/D 2,010 (14%) acres within the watershed. Group D soils comprise 2,960 acres or another 21% of the watershed; group D soils are located centrally within the watershed and are associated with areas most susceptible to erosion. Group A/D and B/D soils generally line up with areas dominated by hydric soils within areas adjacent to the Milwaukee River and tributaries.

In the Town of Fredonia-Milwaukee River watershed the soil groups are dominated by group B which accounts for 52% or 7,375 acres of the watershed area. This largely corresponds with non-hydric, moderately-erodible upland. Soil group C accounts for 2,952 acres (21%) of the watershed; soil group D makes up 1,748 (12%) acres. Though largely spread out through the watershed, soil groups C and D are concentrated along the eastern border of the watershed and near Fredonia. This area is of interest as the land use is dominated by row crops, and Fredonia is one of the areas in the region with projected population growth and expansion over the next 30 years.

The Village of Newburg-Milwaukee River watershed is very similar in make-up to that of the Town of Fredonia-Milwaukee river watershed. The landscape is predominantly soil group B with 10,701 acres (57%). The next largest group is C with 3,231 acres (17%) which combines with soil group A/D 1,633 (9%) and B/D 1,540 (8%) to span most of the hydric and partially hydric land directly east of West Bend. Highly erodible group D soils cover 1,203 acres (6%) of the watershed and are clustered in the upland areas northeast of Newburg which are largely used for agriculture.

Table 6. Hydrologic Soil Groups and their corresponding attributes.

HSG	Soil Texture	Drainage Description	Runoff Potential	Infiltration Rate	Transmission Rate
A	Sand, Loamy Sand, or Sandy Loam	Well to Excessively Drained	Low	High	High
B	Silt Loam or Loam	Moderately Well to Well Drained	Moderate	Moderate	Moderate
C	Sandy Clay Loam	Somewhat Poorly Drained	High	Low	Low
D	Clay Loam, Silty Clay Loam, Sandy Clay Loam, Silty Clay, or Clay	Poorly Drained	High	Very Low	Very Low

Table 7. Hydrologic Soil Groups including acreage and percent of watershed.

HUC 12 Name/Hydrologic Soil Group	Acres	PCT of HUC 12
North Branch Milwaukee River	**14,130.6**	100%
A	81.7	1%
A/D	2,010.0	14%
B	3,877.7	27%
B/D	1,730.5	12%
C	3,167.2	22%
C/D	105.6	1%
D	2,960.4	21%
Not Classed	197.5	1%
Town of Fredonia-Milwaukee River	**14,123.1**	100%
A	33.7	0%
A/D	1,038.8	7%
B	7,374.5	52%
B/D	691.6	5%
C	2,952.2	21%
C/D	54.0	0%
D	1,748.4	12%
Not Classed	230.0	2%
Village of Newburg-Milwaukee River	**18,669.1**	100%
A	17.2	0%
A/D	1,632.8	9%
B	10,701.1	57%
B/D	1,540.1	8%
C	3,231.2	17%
C/D	10.5	0%
D	1,202.9	6%
Not Classed	333.4	2%

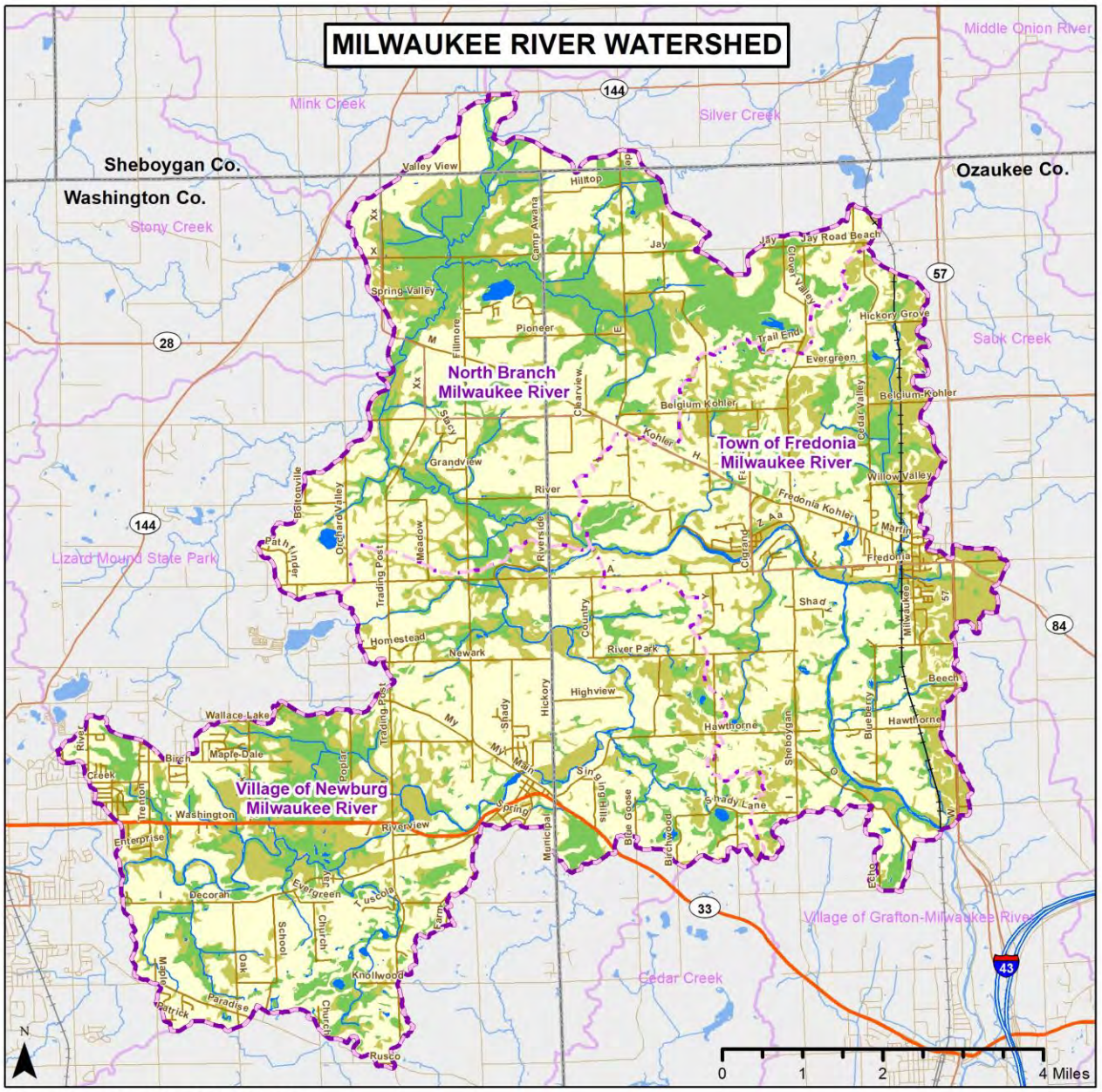


Figure 14. Hydric Soils

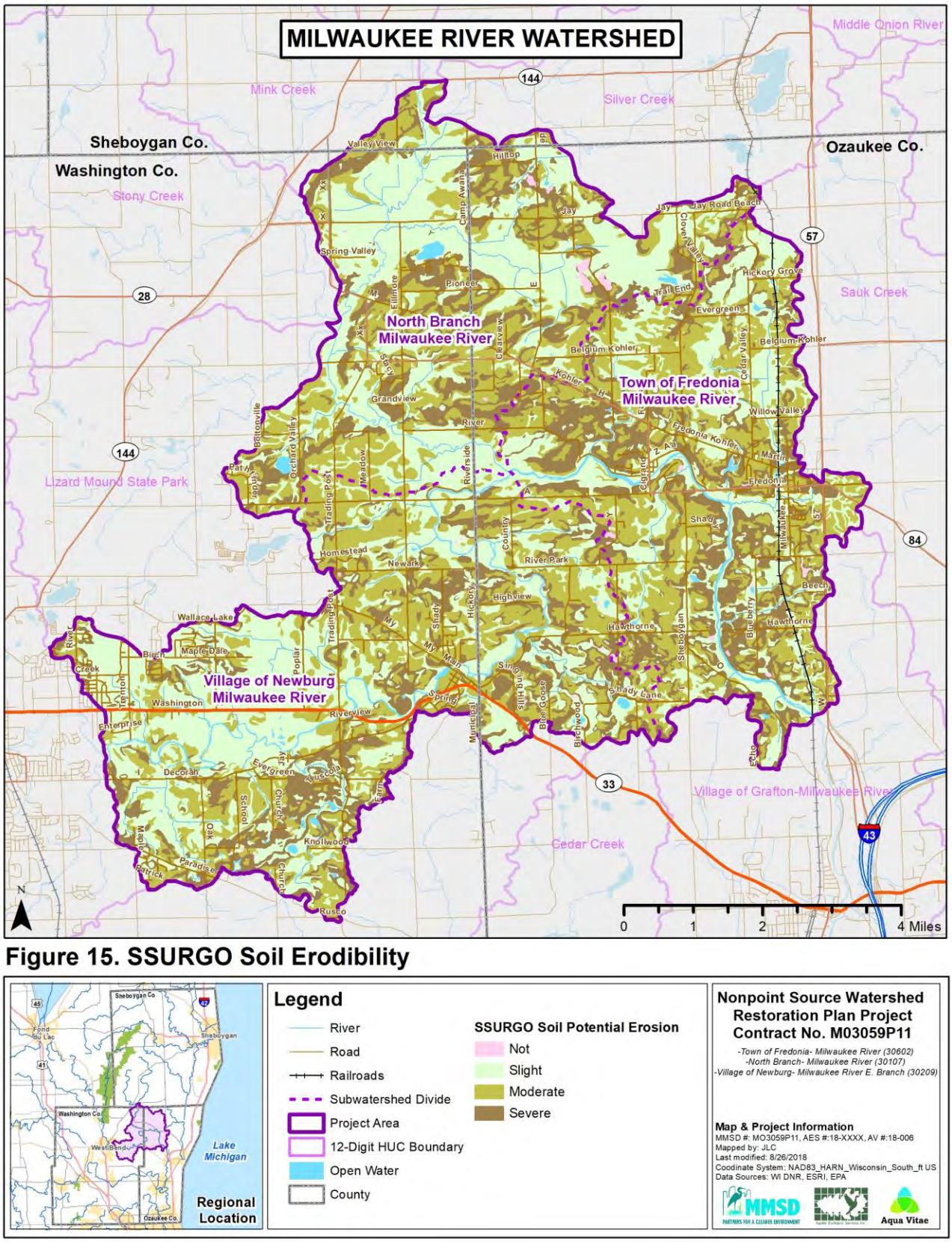


Figure 15. SSURGO Soil Erodibility

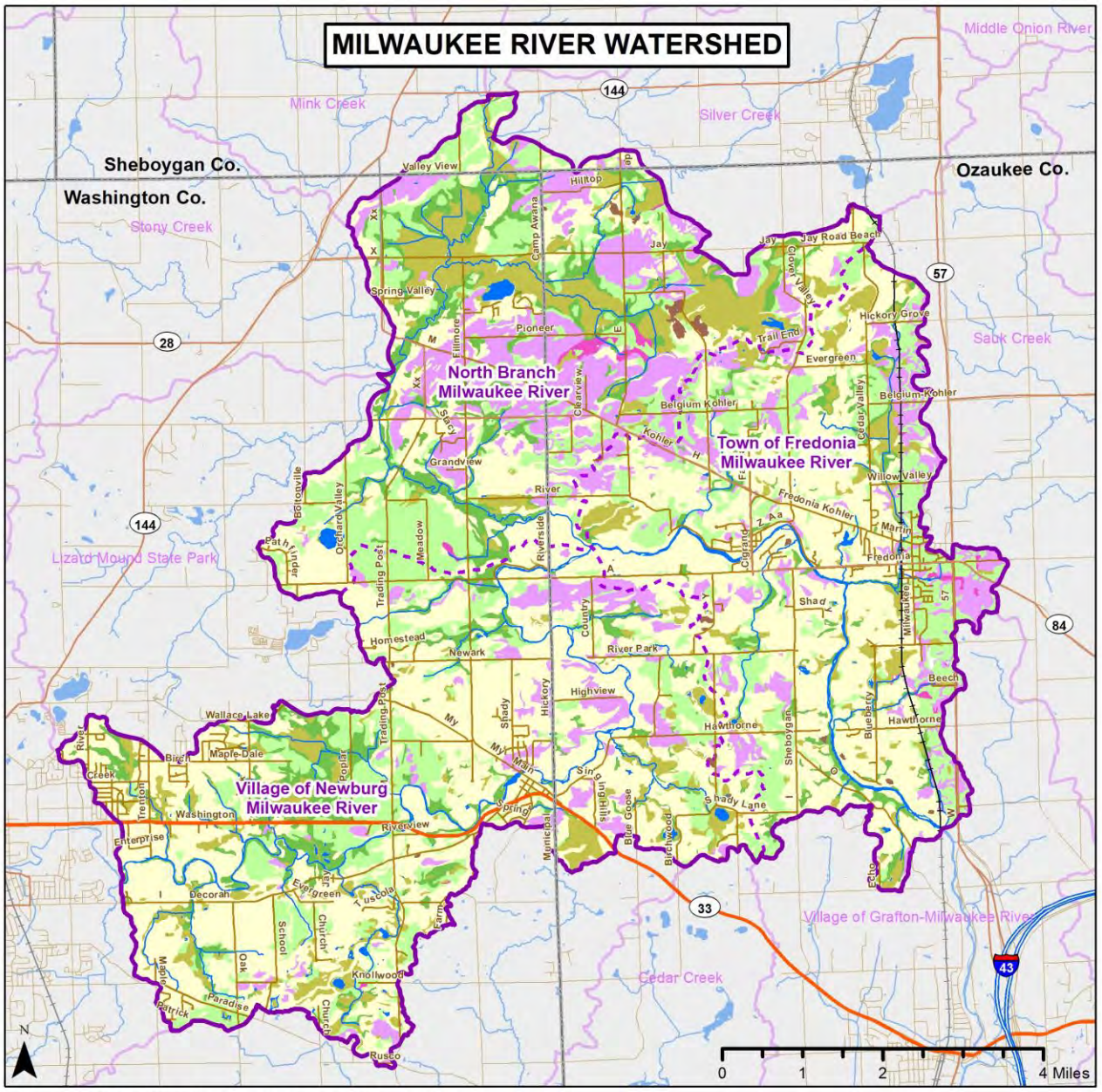
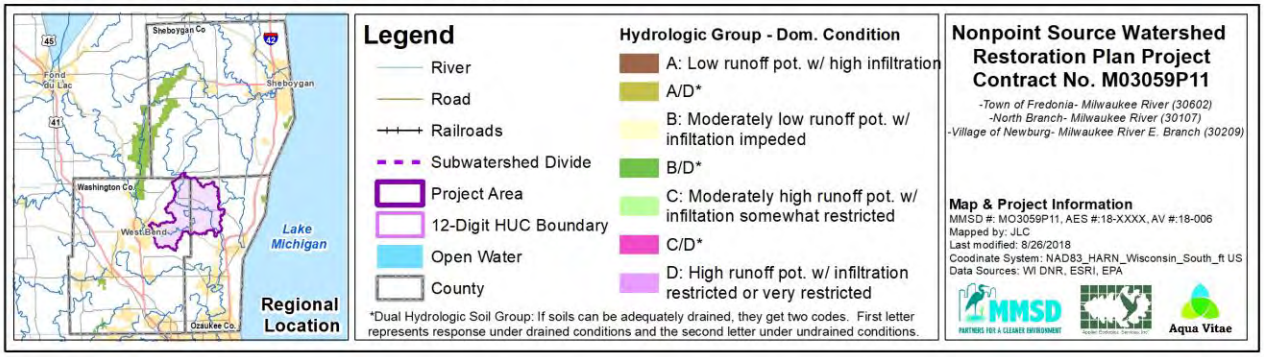


Figure 16. Hydrologic Soil Groups



3.5 Jurisdictions, Roles & Protections

The HUC-12 watersheds of the North Branch of the Milwaukee River, Town of Fredonia-Milwaukee River, and Village of Newburg-Milwaukee River are subwatersheds within the much larger, HUC-8 Milwaukee River watershed. Individually, the North Branch of the Milwaukee River watershed spans three counties, 14,130.6 acres, and no municipalities, the Town of Fredonia-Milwaukee River watershed covers one county, 14,123.1 acres, and one municipality, and the Village of Newburg-Milwaukee River watershed spans two counties, 18,669.1 acres, and two municipalities (Table 8, Figure 17).

The northernmost tip of the North Branch Milwaukee River watershed (698.4 acres, 5%) is in Sheboygan County, though the majority is split down the middle with Washington County (7,655.7 acres, 54%) in the west, and Ozaukee County (5776.5 acres, 41%) in the east. There are no municipalities located within the boundaries of the North Branch Milwaukee River watershed. The Town of Fredonia-Milwaukee River watershed is entirely within Ozaukee County, and 7% of the land cover is municipal, with the Village of Fredonia covering 975.9 acres. The Village of Newburg-Milwaukee River watershed is split with 13,927.6 acres (75%) lying in Washington County, and 4,741.5 acres (25%) lying in Ozaukee County; and of this area, 8% is covered by a municipality. The easternmost borders of West Bend extend in the west lobe of the watershed covering 1,012.6 acres (5%) with its population making it the largest and most rapidly growing municipality in the watershed. Newburg is the next largest municipality at 562.4 acres (3.0%).

There are also several unincorporated towns that have all assumed Village powers for the purposes of general zoning. These include the Towns of Fredonia, Saukville and Waubeka in Ozaukee County, Scott and Sherman in Sheboygan County, and Farmington and Trenton in Washington County.

Note: For clarity throughout the remainder of this report, when referring to "Fredonia", in every case this refers to *the Village* of Fredonia, not *the Town* of Fredonia.

Table 8. County and municipal jurisdictions.

HUC 12 Name/Place Name	Acres	PCT of HUC 12
North Branch Milwaukee River	**14,130.6**	**100%**
Ozaukee County	5,776.5	41%
Sheboygan County	698.4	5%
Washington County	7,655.7	54%
Town of Fredonia-Milwaukee River	**14,123.1**	**100%**
Ozaukee County	14,123.1	100%
Village of Newburg-Milwaukee River	**18,669.1**	**100%**
Ozaukee County	4,741.5	25%
Washington County	13,927.6	75%
Town of Fredonia-Milwaukee River	**975.9**	**7%**
Fredonia	975.9	7%
Village of Newburg-Milwaukee River	**1,575.0**	**8%**
Newburg	562.4	3%
West Bend	1,012.6	5%

Source: Washington County, Ozaukee County, SEWRPC

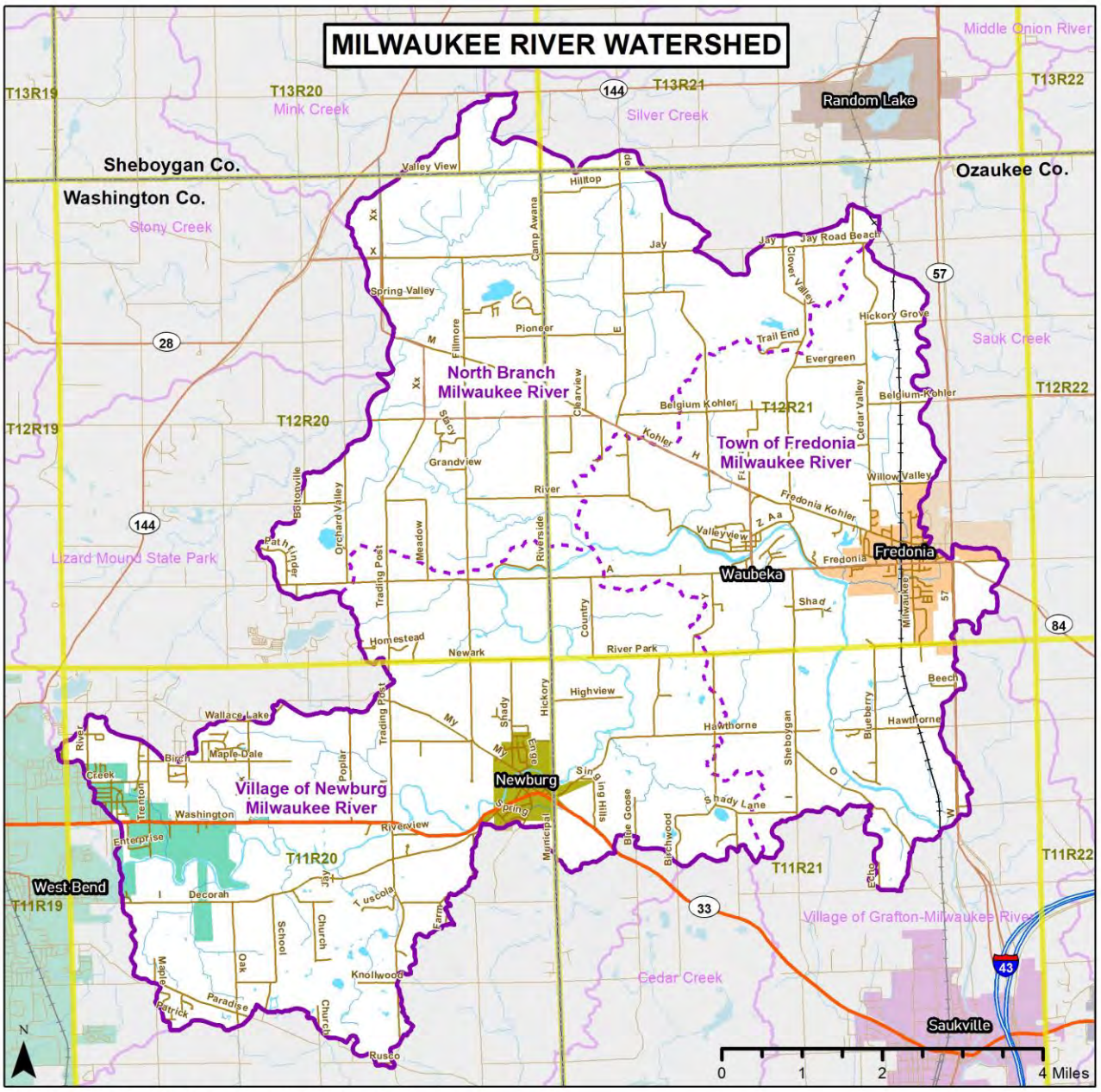
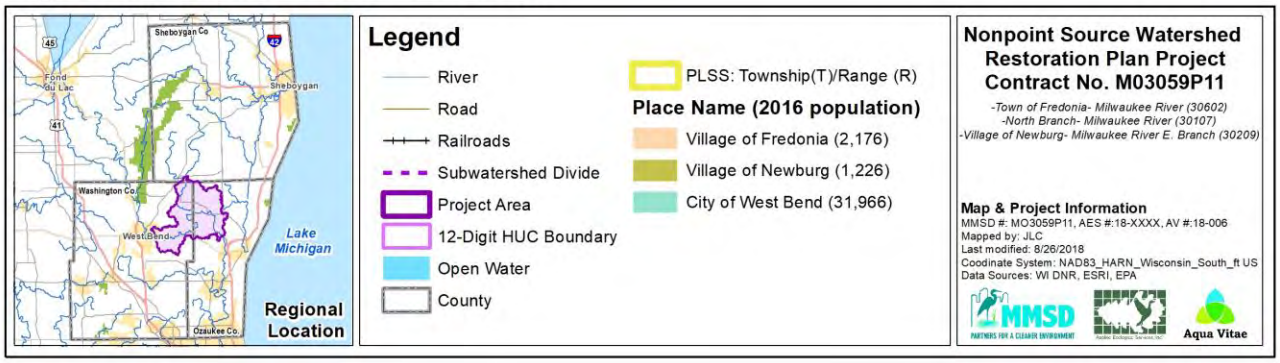


Figure 17. Watershed Jurisdictions



Jurisdictional Roles and Protections

Water quality and land protection throughout the United States are protected to some degree under federal, state, and/or local law.

Water Quality Protection

At the federal level, the Clean Water Act (CWA) is the strongest tool in protecting water resources. Within the state of Wisconsin, the authority to administer the provisions of the CWA has been delegated to the Wisconsin Department of Natural Resources (WDNR). Section 402 of the CWA establishes the National Pollution Discharge Elimination System (NPDES), while Section 319 Nonpoint Source Management Program was created in order to further support state and local nonpoint pollutant source efforts not addressed by NPDES permits. Section 319 permits states to receive grant money towards activities such as technical assistance, financial assistance, education, training, technology transfer, demonstration projects, and monitoring to assess the success of nonpoint pollutant source implementation projects. Section 303 of the CWA requires states to catalogue impaired waters, prioritize them, and calculate Total Maximum Daily Loads (TMDLs) of pollutants a waterbody can receive and still safely meet the water quality standards. Wisconsin has also utilized Section 208, or the Priority Watershed Program, to develop a nonpoint pollutant source program. WDNR identified watersheds and lakes in most need of nonpoint pollution abatement and encouraged the use of nonpoint source controls to improve water quality (Kent, 2001).

Lake Twelve, one of 28 preserves owned and managed by the Ozaukee-Washington Land Trust (OWLT)

The Safe Drinking Water Act also plays a role in protecting surface and groundwater resources. In Wisconsin, the Wellhead Protection Program includes both mandatory and voluntary initiatives aimed at protecting groundwater resources.

Additionally, Wisconsin is part of three interstate compact agreements that also have jurisdiction over Lake Michigan. The first is the Great Lakes Basin Compact which established the Great Lakes Commission and gave it the authority to research and make recommendations regarding water use and development in the Great Lakes. The Council of Great Lakes Governors established the Great Lake Protection Fund to finance projects used to protect and restore the Great Lakes. Finally, the Great Lakes Charter, signed by the Council of Great Lakes Governors, regulates water transfers out of the Great Lakes Drainage basin in excess of 100,000 gallons per day.

The Wisconsin Coastal Management Program, established under the Federal Coastal Zone Management Act, also serves to protect the Lake Michigan coast and manage this valuable resource.

Land Protection
The U.S. Fish and Wildlife Service (USFWS) and WDNR protect various dedicated natural areas and threatened and endangered species. Local government agencies such as the Washington County Land and Water Conservation Division and local conservation groups such as the Ozaukee Washington Land Trust and Riveredge Nature Center also serve in a similar capacity by working to protect and restore natural areas.

The U.S. Army Corps of Engineers (USACE), with approval of WDNR, regulates wetlands through Sections 401 and 404 of the Clean Water Act (CWA). Land development affecting water resources (rivers, streams, lakes, wetlands, and floodplains) is regulated by the USACE when "Waters of the U.S." are involved. These types of waters include any wetland or stream/river that is hydrologically connected to navigable waters. The USACE primarily regulates filling activities and requires buffers or wetland mitigation for developments that impact jurisdictional wetlands. Village of Newburg, Town of Fredonia, and North Branch Milwaukee River watersheds fall within USACE's Detroit District of the Great Lakes & Ohio River Division.

Land development in the watershed is regulated by county and municipal ordinances. Washington Ozaukee, and Sheboygan Counties each have a Subdivision Ordinance and Zoning Ordinance as well as dedicated regulating ordinances for both stormwater and erosion control.

Beyond county-level regulations, each municipality has its own applicable regulations. Municipalities in the watershed may or may not provide additional watershed protection above and beyond existing local municipal codes. Most municipal codes provide ordinances covering businesses regulations, building regulations, zoning regulations, new subdivision regulations, stormwater management, streets, utilities, landscaping/restoration, tree removal, etc. None of the unincorporated towns within the watersheds have additional codes and ordinances.

Municipal codes and ordinances include:

- *Village of Fredonia*: Land development is regulated under both subdivision and zoning codes. Dedicated ordinances include Subdivision Controls, Shoreland Zoning, Erosion Control and Stormwater Management, Floodplain Zoning.

- *Village of Newburg*: Land development is regulated under both subdivision and zoning codes. Dedicated ordinances include Subdivision Controls, Shoreland-Wetland Zoning, Erosion Control and Stormwater Management, Floodplain Zoning.

- *Village of Waubeka*: As a census designated place within the Town of Fredonia, Waubeka is subject to the zoning regulations defined by the Town of Fredonia.

- *City of West Bend*: Municipal codes in West Bend include chapters on: Zoning, Subdivision, Erosion Control, and Stormwater Management.

Other governments and private entities with watershed jurisdictional or technical advisory roles include the Federal Emergency Management Agency (FEMA), the USDA's Natural Resources Conservation Service (NRCS), and Southeastern Wisconsin Regional Planning Commission

(SEWRPC). County Boards are also important because they oversee decisions made by respective county governments and therefore have the power to override or alter policies and regulations.

Noteworthy- NPDES/WPDES Program

The Wisconsin Department of Natural Resources (WDNR) has delegated authority to administer the National Pollutant Discharge Elimination System (NPDES) program, as the Wisconsin Pollutant Discharge Elimination System (WPDES). The NPDES program was initiated under the federal Clean Water Act to reduce pollutants to the nation's waters. This program requires permits for discharge of: 1) treated municipal effluent; 2) treated industrial effluent; and 3) stormwater from municipal separate stormsewer systems (MS4's) and construction sites.

The NPDES Phase I Stormwater Program began in 1990 and applies only to large and medium-sized municipal separate stormsewer systems (MS4's), several industrial categories, and construction sites hydrologically disturbing 5 acres of land or more.

The NPDES Phase II program began in 2003 and differs from Phase I by including additional MS4 categories, additional industrial coverage, and construction sites hydrologically disturbing greater than 1 acre of land. Under NPDES Phase II, all municipalities with small, medium, and large MS4's are required to complete a series of Best Management Practices (BMPs) and measure goals for six minimum control measures:

1) Public education and outreach
2) Public participation and involvement
3) Illicit discharge detention and elimination
4) Construction site runoff control
5) Post-construction runoff control
6) Pollution prevention and good housekeeping

The Phase II Program also covers all construction sites over 1 acre in size. For these sites the developer or owner must comply with all requirements such as completing and submitting a Notice of Intent (NOI) before construction occurs, developing a Stormwater Pollution Prevention Plan (SWPPP) that shows how the site will be protected to control erosion and sedimentation, completing final stabilization of the site, and filing a Notice of Termination (NOT) after the construction site is stabilized.

There are two municipal permits located in the Fredonia-Newburg watersheds for their respective wastewater treatment plants- the Fredonia Municipal Sewer and Water Utility in Fredonia and Newburg Village in Newburg.

Planning, Policy and Regulation

Planning, policy, and regulation are the foundation of watershed protection as the process sets the minimum standards for development that occurs or is proposed to occur in the vicinity of water resources. It is hoped that recommendations from this watershed plan would be referenced in future comprehensive plans and implemented in ordinances. In many cases, municipal codes also lay the foundation for the types of trees that can be removed from sites as well as what types of plant

communities and species that can be replanted. County stormwater ordinances are the primary preventative measure that can be used to standardize for the respective county the requirements that proposed developments must meet. Monitoring and enforcement of implemented municipal codes and county regulations falls in the hands of local municipalities or County agencies. It is up to these enforcing bodies to communicate effectively and discuss often the problems with how ordinance language is interpreted and amendments that may help clarify certain regulations.

Planning/zoning guidance provides another level of watershed and natural resource protection. Most planning and zoning guidance is in the form of local floodplain or zoning ordinances that regulate onsite land use practices to ensure adequate floodplain, wetland, stream, lake, pond, conservancy soil, and other natural resource protection. Zoning ordinances and overlay districts in particular define what type of development is allowed and where it can be located relative to natural resources. For example, the Village of Newburg's Shoreland-Wetland zoning ordinance defines acceptable and prohibited uses and other regulations that apply within the designated "Shoreland-Wetland" zoning area. Other examples of how planning and zoning can provide resource protection include making recommendations or instituting requirements to establish and maintain riparian and wetland buffers, reduce impervious area, dedicate land to open space and greenways, establish conservation easements, and implement conservation and/or low-density development.

To improve the impact of planning/zoning guidance on water resource protection, there needs to be improved coordination and communication between county and local government. Watershed development regulations should be made very clear to local enforcement officers; local planners and zoning boards should consider revisions to local ordinances that address watershed, subwatershed, and/or site-specific natural resource issues. For example, communities with less impervious development now should revise their zoning ordinances sooner rather than later in order to adequately prevent the types of development that contribute to flooding, degrade wildlife habitat, and reduce water quality.

3.6 Existing Policies and Ordinance Review

Protection of natural resources and green infrastructure during future urban growth will be important for the future health of these Milwaukee River watersheds. To assess how future growth might further impact the watershed, an assessment of local municipal ordinances was performed to determine how development is regulated in each municipality. In this way, potential improvements to local ordinances can be identified. As part of the assessment, municipal governments were asked to compare their local ordinances against model policies outlined by the Center for Watershed Protection (CWP) in a publication entitled "*Better Site Design: A Handbook for Changing Development Rules in Your Community*" (CWP 1998).

CWP's recommended ordinance review process involves assessments of three general categories including "Residential Streets & Parking Lots", "Lot Development" and "Conservation of Natural Areas". Various questions with point totals are examined under each category. The maximum score is 100. CWP also provides general rules based on scores. Scores between 60 and 80 suggest that it may be advisable to reform local development ordinances. Scores less than 60 generally mean that local ordinances are not environmentally friendly and serious reform may be needed. Of the municipalities queried for ordinance review (Ozaukee County, Washington County, the Village of Fredonia, Newburg, Waubeka, and West Bend) two responded: Washington County and the Village of Fredonia (Figure 18). Their scores were 32% and 16% respectively. Although these scores are

low, it should be noted that this assessment is meant to be a tool to local communities to help guide development of future ordinances. Various policy recommendations are included in the Action Plan section of the report to address general ordinance deficiencies. Completed ordinance review worksheets can be found in Appendix B.

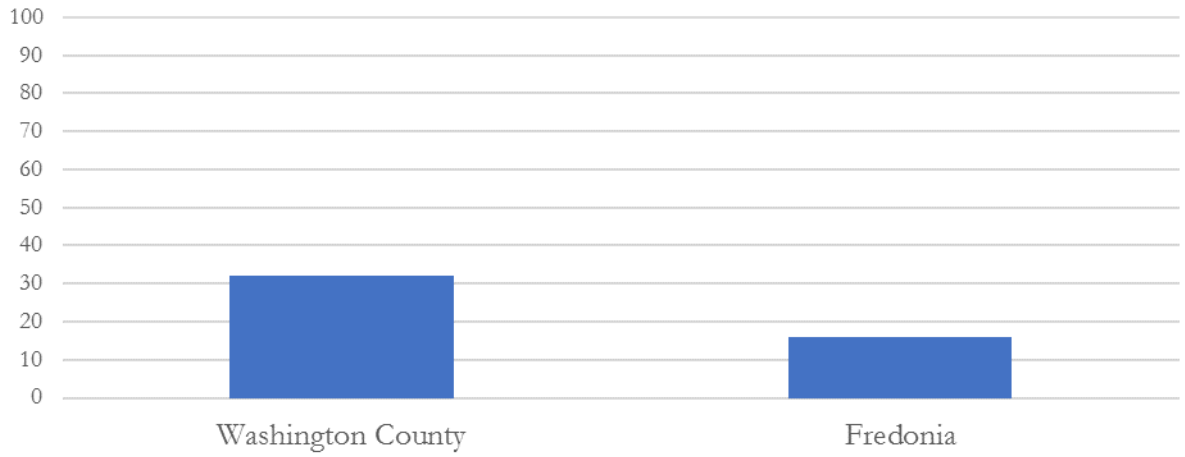


Figure 18. Center for Watershed Protection ordinance review results for local municipalities.

3.7 Demographics

The Southeastern Wisconsin Regional Planning Commission (SEWRPC) developed multi-jurisdictional comprehensive plans for both Ozaukee and Washington Counties which project regional changes out to 2050 at the county level and provide reliable growth forecasts. These were produced as part of the "Smart Growth Initiative" in 2009 which also led to the development of comprehensive plans for the municipalities in the watershed. SEWRPC also predicts demographics data extending to 2050 and converted the data to quarter-section data in 2015. The County data is published in SEWRPC Technical Reports No. 10 and 11 (fifth edition), available on SEWRPC's website.

SEWRPC's 2010 to 2050 forecasts of population, households, and employment were used to project how these attributes will impact the North Branch Milwaukee River, Town of Newburg, and Village of Fredonia watersheds. These forecasts were created under the guidance of SEWRPC's Advisory Committee on Regional Population and Economic Forecasts (SEWRPC 2013). The Committee utilized the cohort-component method to develop their population projections; used the projection of the population in households, the projection of average household size, and the application of the projected household size to the projected household population to achieve household projections; and used a disaggregate approach to the preparation of employment projects that took into account the explicit consideration of employment in selected industry groups and the preparation of projections for those groups.

Table 9 showss SEWRPC's forecasts of changes in population, households, and employment forecast changes between 2000 and 2050 for the combined area of the Fredonia-Newburg Area watersheds. The data is generated by Township, Range, and quarter Section and is depicted on Figures 19-21. Note: AquaVitae and AES used GIS to overlay the combined watershed boundaries

onto SEWRPC's quarter Section data. If any part of a quarter Section fell inside the watershed boundary, the statistics for the entire quarter Section were included in the analysis.

The combined population of the watershed is expected to increase from 14,980 in 2010 to 21,522 by 2050, a 44% increase. The highest population increase is expected in the western portion of the watershed within the City of West Bend. Much of this area is currently agricultural land and multiple residential developments are currently in progress.

Some high to moderate population growth is expected in the eastern portion of the watershed within the Town of Fredonia. Some of this growth is already occurring or is anticipated in areas that are currently farmed or vacant. Similarly, projected household change generally follows change in population. The combined number of households in the watershed is expected to increase from 5,608 in 2010 to 8,572 by 2050, a 53% increase.

Employment is expected to increase greatly from 4,374 jobs in 2010 to 6,915 jobs by 2050, a 58% decrease. Employment growth is projected to be highest in the west area of the watershed nearest to West Bend and the eastern area of the watershed near the Town of Fredonia. Despite the large projection of regional growth in employment, much of the areas within the watershed are projected to see decreased employment opportunities or very slight growth.

Table 9. SEWRPC 2010 data and 2050 forecast data.

Data Category	2010	2050	Change (2010-2050)
Population	14,980	21,522	6,542
Household	5,608	8,572	2,964
Employment	4,374	6,915	2,541

Source: Southeastern Wisconsin Regional Planning Commission 2050 Forecasts

Socioeconomic Status

The communities within the watershed can best be described as middle class. Active growth slowed beginning in 2007 due to an economic downturn. However, the region did experience a mixture of residential, industrial, and commercial growth over the past 20 years and offers amenities such as parks, shopping, conservation areas, schools and libraries, and is in somewhat close proximity to interstate highway access.

Within the watershed, the 2010 U.S. Census Bureau only has data for the City of West Bend, and Washington and Ozaukee Counties. Economic countywide data is not representative of the communities within the watershed area, it is greatly skewed by exurban communities in the southern portion of the counties. So, census data from the City of West Bend is used as a basis for profiling the socioeconomic status of the three watersheds. To summarize, the area is comprised of a mostly white population (~95%). The median household income is about $56,000 with around 8% of the population in West Bend below poverty level. In addition, approximately 64% of housing units are owner occupied; the remainder are rented. Owner occupied units are valued at about $164,000 on average in West Bend.

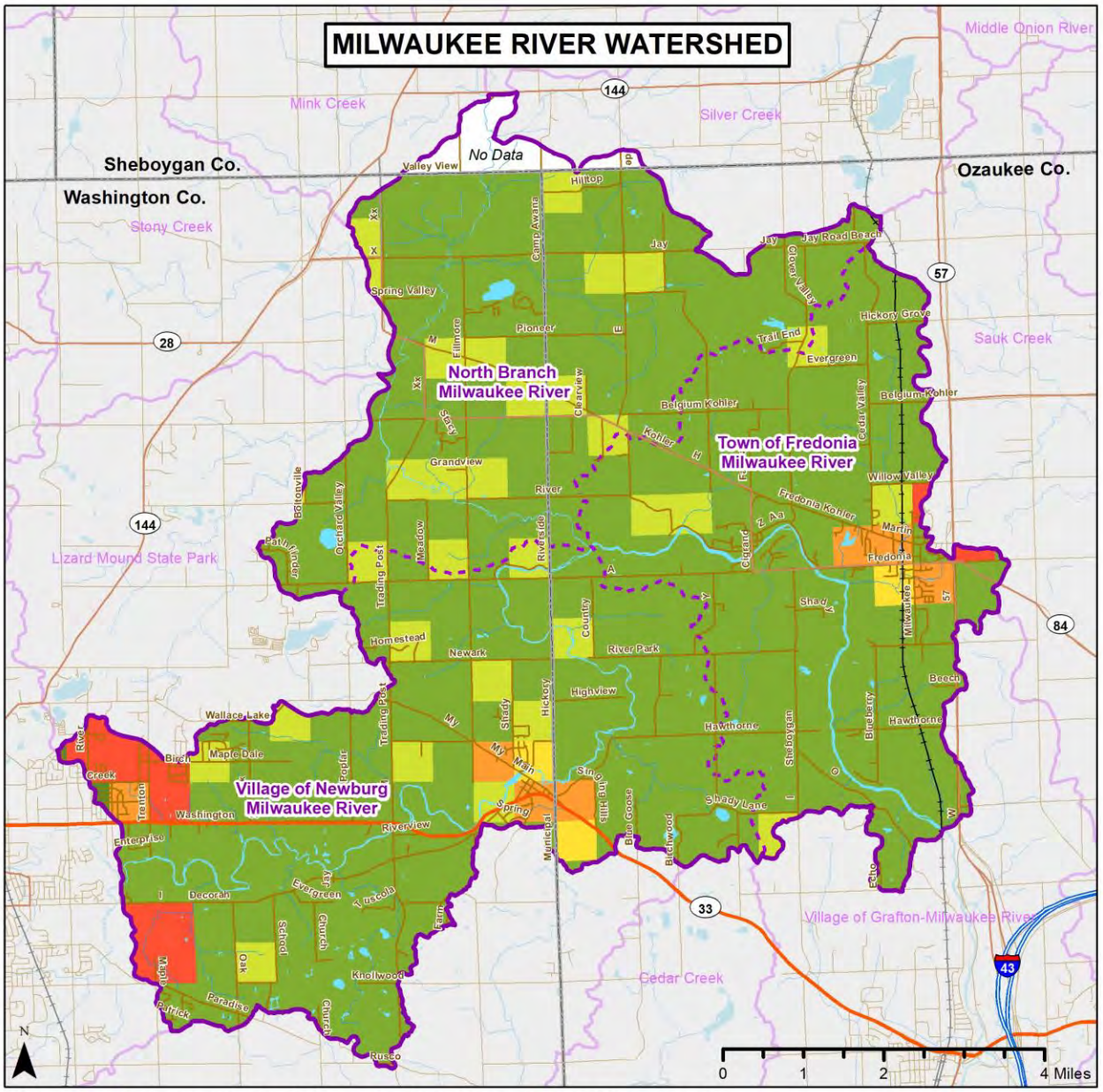
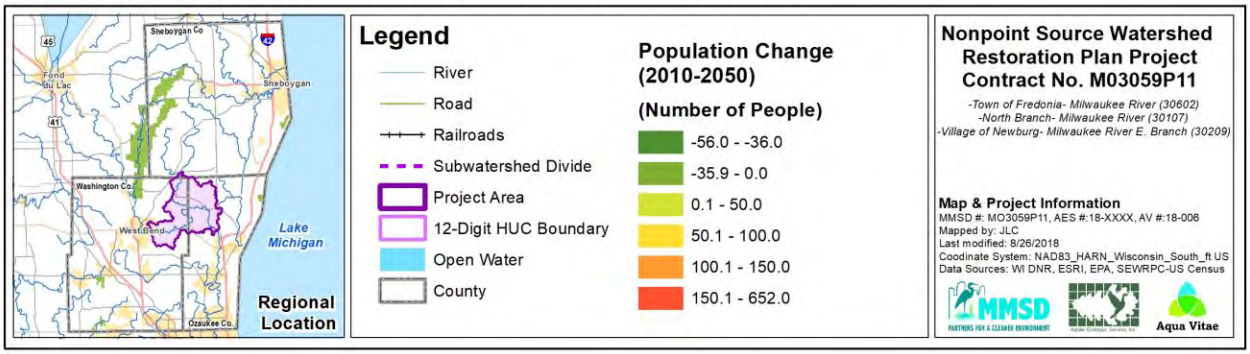


Figure 19. Forecasted Population Change (2010-2050)



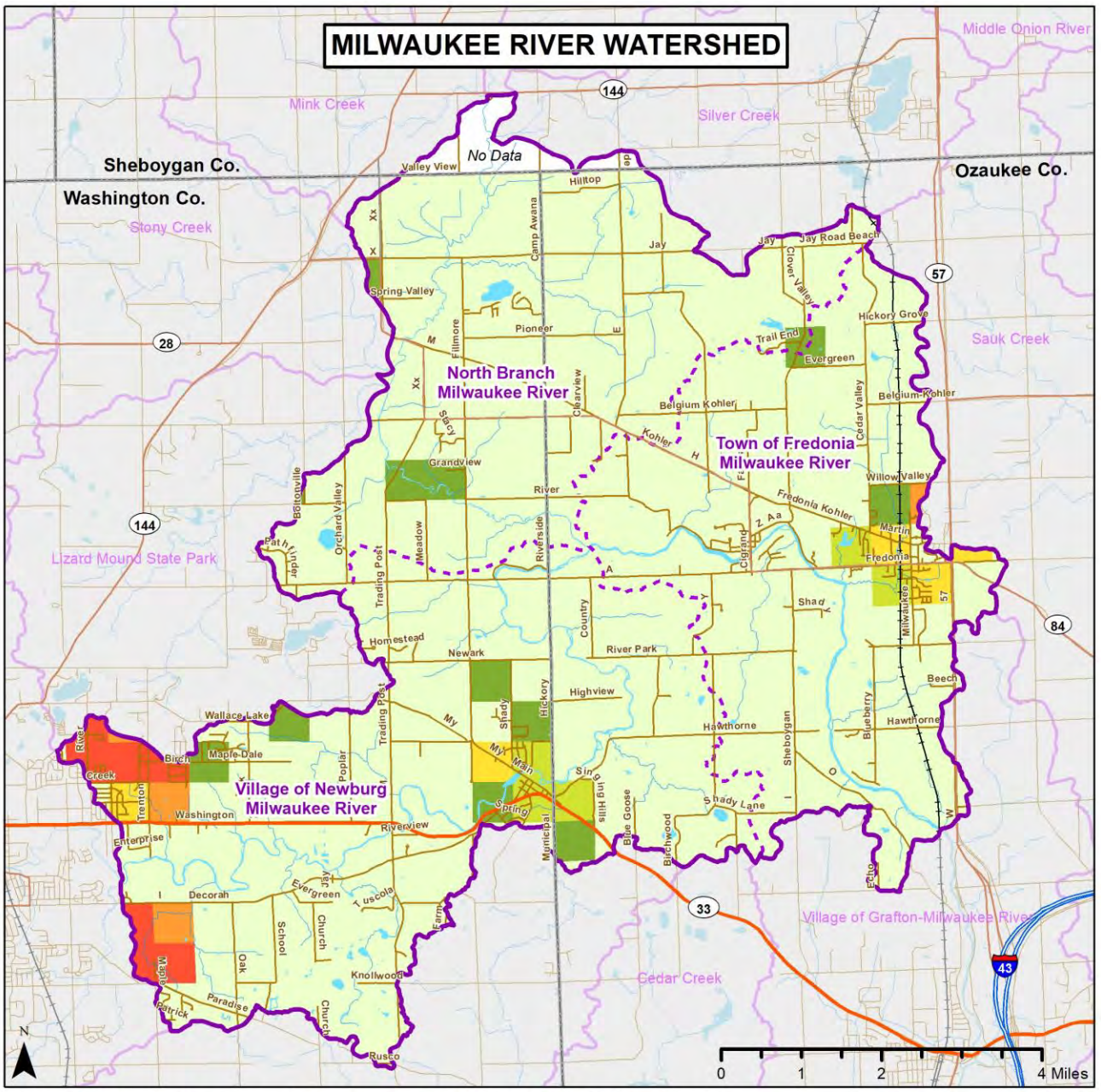
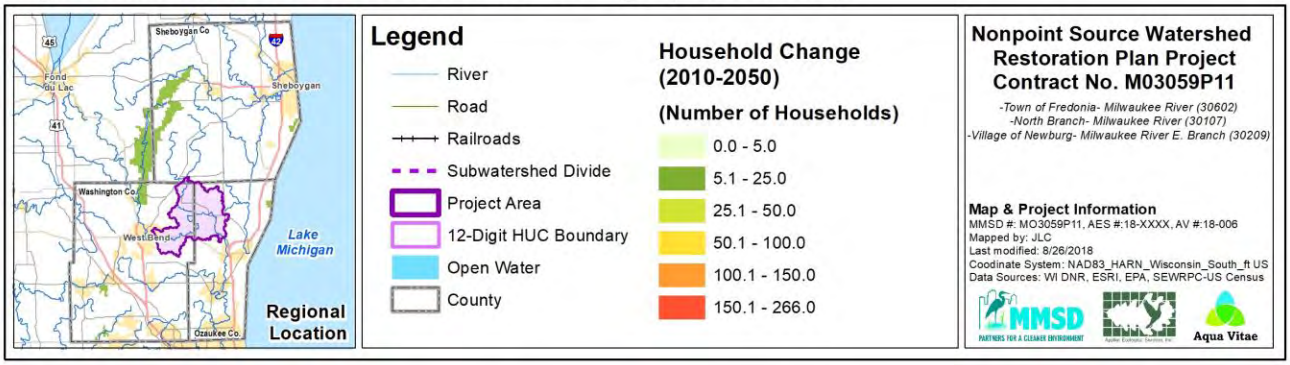


Figure 20. Forecasted Household Change (2010-2050)



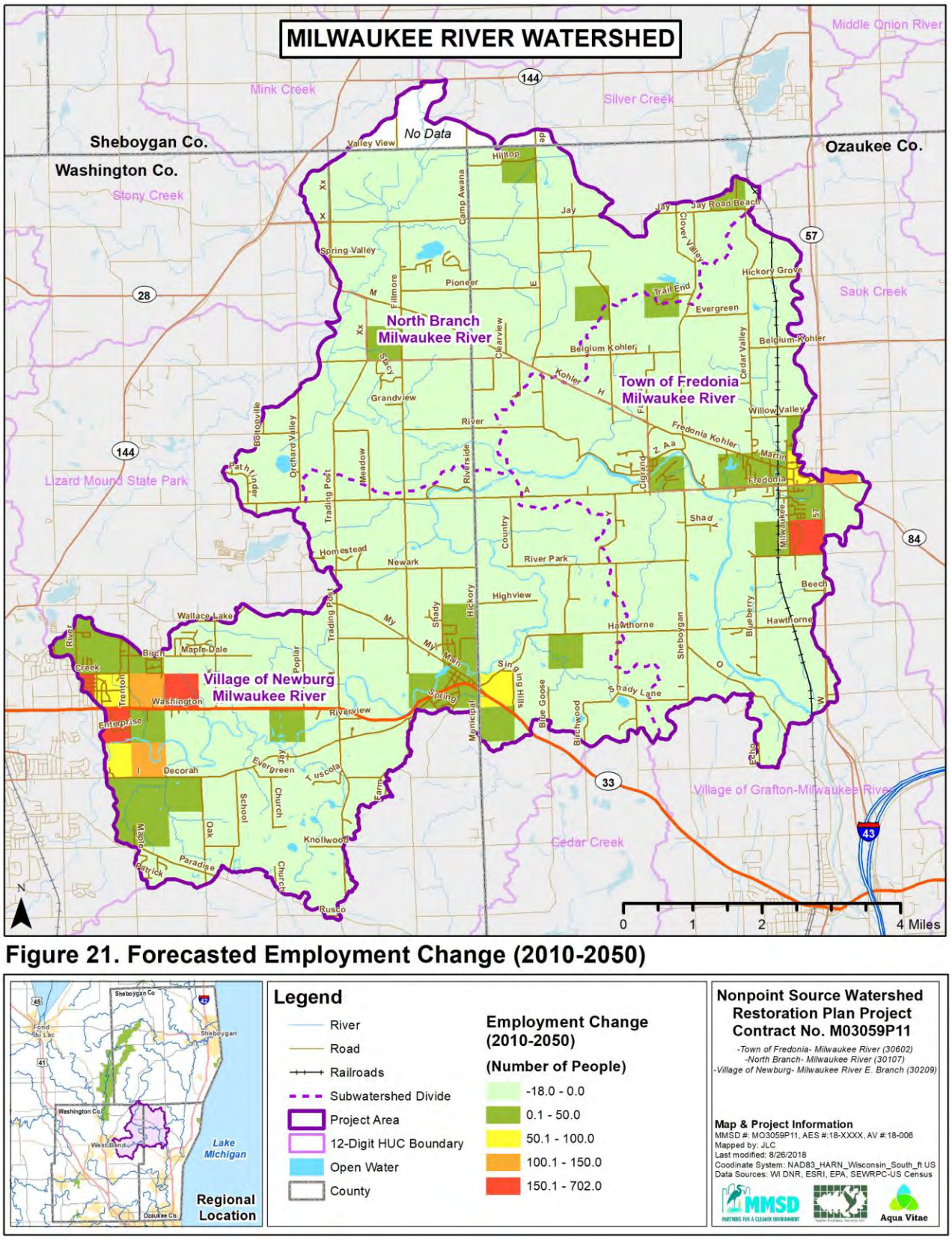


Figure 21. Forecasted Employment Change (2010-2050)

3.8 Transportation Network

Roads

A grid of mostly small, low-traffic roads spans the Fredonia-Newburg Area watersheds (Figure 22). Wisconsin State Highway 33 only passes through the Village of Newburg watershed, but the east-west running road is the most traveled road in the watershed; seeing 7,600-23,000 annual travelers, a number which is expected to grow to 8,700-28,300 by 2030 (WisDOT 2009). Another, smaller connector route, Wisconsin Highway 57, briefly runs north-south through the Town of Fredonia-Milwaukee River watershed, connecting I-43 and the Town of Fredonia. Fredonia-Kohler Road (or County Highway H) runs east-west through the North Branch Milwaukee river watershed into the Town of Fredonia Milwaukee River watershed and connects these areas to State Highway 57.

Railroads

Within the Town of Fredonia- Milwaukee River watershed, the Plymouth Line of the Wisconsin and Southern Railroad publicly owned railroad runs north and south through the Town of Fredonia. The railroad is headquartered from Madison, WI and operates on tracks formerly owned by the Milwaukee Road which were abandoned in the late 1970's and became state owned. The rails are freight-only and transport a variety of commodities, most frequently chemicals and transload products. According to the WISDOT 2030 Long-Range Multimodal Transportation Plan, rail freight corridors are to be maintained and preserved, but expansion is not anticipated (WisDOT 2009).

Airports

West Bend Municipal Airport is located on 430 acres of land in the City of West Bend (Figure 22) and provides services to corporate, business, private, freight, and military aircraft. In 2016, the airport saw 46,000 operations (take offs and landings), and as of October 2018, there are 95 aircraft based out of the air field. The terminal is classified by FAA as a regional reliever airport facility and is complete with pilot lounge, weather office and a refueling depot. The airport was founded in 1928 as a grass landing field, and remained as such until the 1950's when the first concrete runway was installed.

West Bend Airport

Trails/Bike Paths

There are no designated single or shared-use bicycle/pedestrian trails within the watershed area.

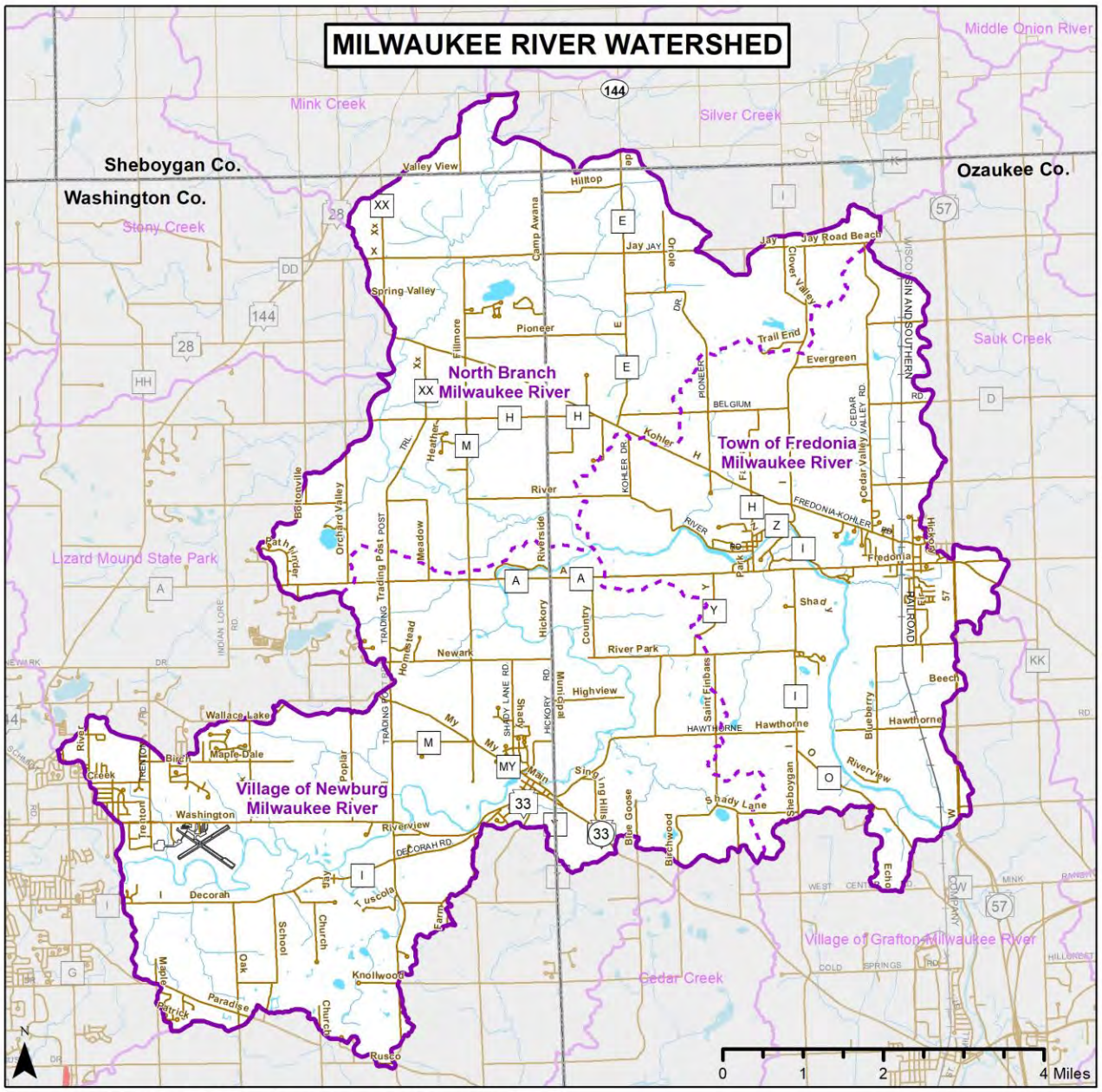
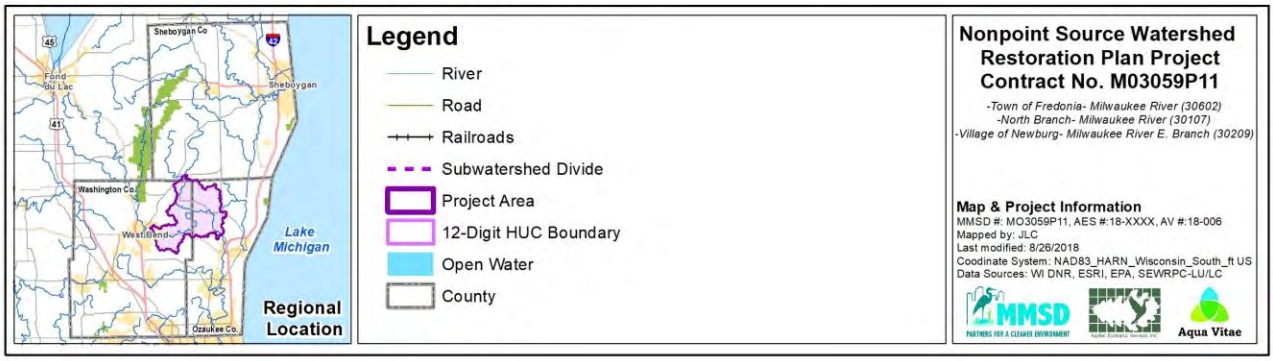


Figure 22. Existing Transportation Network



3.9 Existing & Future Land Use/Land Cover

2015 Land Use/Land Cover

Highly accurate land use/land cover data was produced for the Village of Newburg, Town of Fredonia, and North Branch Milwaukee River watersheds using several sources of data. First, the most recent land use/land cover data from Southeastern Wisconsin Regional Planning Commission (SEWRPC) was used as a base layer. No base layer was available for Sheboygan County. Recent aerial photography of the watershed was also overlaid on SEWRPC land use data in GIS so that additional discrepancies could be corrected, including for the missing portion of Sheboygan County. 2015 land use/land cover data and map for the tri-watershed area is included in Table 10 and depicted on Figure 23.

In all three watersheds agriculture is far and away the most prevalent land use. In the Village of Newburg, Town of Fredonia, and North Branch Milwaukee River watersheds this amounts to 8,390.6 acres (44.9%), 7,154.7 acres (50.7%), and 7,499.2 acres (53.1%) respectively. This includes row crop agriculture (largely corn and soybean) as well as livestock (largely dairy.) As seen in Figure 23, this acreage is spaced evenly throughout the watersheds.

Wetlands make up the next most abundant land use within all three watersheds. The wetland areas are largely adjacent to the Milwaukee River and accompanying floodplain areas, as well as a large lowland area in the North Branch watershed. The Village of Newburg, Town of Fredonia, and North Branch Milwaukee River watersheds this amounts to 3,117.7 acres (16.7%), 1,929.9 acres (13.7%), and 3,392.9 acres (24.0%) respectively.

Roadway flooding observed in lowland areas within North Branch-Milwaukee River watershed.

Table 10. 2015 land use/land cover classifications and acreage.

Watershed/Description	Acres	Pct of 12-Digit HUC
North Branch Milwaukee River		
AGRICULTURAL	7,499.2	53.1%
WETLANDS	3,392.9	24.0%
WOODLAND	822.2	5.8%
OPEN LANDS	742.7	5.3%
RESIDENTIAL	721.0	5.1%
TRANSPORTATION	419.9	3.0%
OPEN WATER	220.3	1.6%
RECREATIONAL	140.1	1.0%
EXTRACTIVE	132.4	0.9%
COMMERICAL	13.1	0.1%
INDUSTRIAL	8.6	0.1%
GOVT, INST, COMM AND UTILITIES	6.4	0.0%
CEMETERY	4.8	0.0%
Total	**14,123.6**	**100.0%**
Town of Fredonia-Milwaukee River		
AGRICULTURAL	7,154.7	50.7%
WETLANDS	1,929.9	13.7%
WOODLAND	1,327.4	9.4%
OPEN LANDS	1,308.2	9.3%
RESIDENTIAL	992.6	7.0%
TRANSPORTATION	589.8	4.2%
RECREATIONAL	336.9	2.4%
OPEN WATER	283.2	2.0%
INDUSTRIAL	109.1	0.8%
GOVT, INST, COMM AND UTILITIES	41.2	0.3%
COMMERICAL	34.7	0.2%
EXTRACTIVE	8.0	0.1%
CEMETERY	6.7	0.0%
Total	**14,122.5**	**100.0%**
Village of Newburg-Milwaukee River		
AGRICULTURAL	8,390.6	44.9%
WETLANDS	3,117.7	16.7%
OPEN LANDS	1,980.9	10.6%
WOODLAND	1,877.2	10.1%
RESIDENTIAL	1,554.1	8.3%
TRANSPORTATION	881.4	4.7%
OPEN WATER	400.1	2.1%
RECREATIONAL	229.8	1.2%
GOVT, INST, COMM AND UTILITIES	72.8	0.4%
EXTRACTIVE	71.8	0.4%
INDUSTRIAL	45.7	0.2%
COMMERICAL	37.6	0.2%
CEMETERY	9.5	0.1%
Total	**18,669.2**	**100.0%**

Within the Town of Fredonia and North Branch watersheds the third largest land use results from woodland areas. These account for 822.2 acres (5.8%) and 1,327.4 acres (9.4%) respectively. These woodland areas are also largely adjacent to the Milwaukee River. Woodlands are the fourth largest land use type within the Village of Newburg watershed spanning 1,877.2 acres (10.1%).

The third largest land use within the Village of Newburg is open land which makes up 1,980.9 acres (10.6%); this is generally defined as undeveloped land which has no discernable natural resource type. Open land is the fourth largest land use in both the Town of Fredonia and North Branch watersheds, covering 1,308.2 acres (9.3%) and 742.7 acres (5.3%) respectively.

Another important land use within the three watersheds is combined residential land use; meaning a combination of low density, medium density, multi-family, suburban, and two-family residential types. Within the Village of Newburg, Town of Fredonia, and North Branch Milwaukee River watersheds this is currently the 5th highest land use total with amounts of 1,554.1 acres (8.3%), 992.5 acres (7.0%), and 721.0 acres (5.1%) respectively. These percentages are projected to double, as we see relatively high rates of population growth within the watersheds.

Noteworthy: North Branch Milwaukee River Wildlife and Farming Heritage Area

Established in 2009, this project includes 13 parcels of state owned-land totaling 765 acres and two privately owned properties - totaling 171 acres - with easements that allow for public use. Within the area, other conservation partners own land open to some public uses, including 407 acres that are federally owned under the waterfowl production area program and 134-acre parcel owned by the Ozaukee-Washington County Land Trust and open for passive uses and limited hunting opportunities.

This project area is one of the largest blocks on undeveloped land in southeastern Wisconsin, yet within 20 miles of the Milwaukee metropolitan area. Although located just outside of the largest urban area in the state, the project area is predominantly open and rural with large wetland complexes, riparian corridors and agriculture dominating the landscape.

The project area includes nine miles of the North Branch Milwaukee River and five tributary streams, expansive areas of floodplain forest, coniferous swamps, other wetlands, three small lakes and large blocks of agricultural lands. Because of its location and natural resource features, the property has potential for preserving farmland or "stabilizing the rural landscape" while providing low impact, nature-based, outdoor recreational opportunities. The property is located within the "Southeast Glacial Plains" ecological landscape, which is characterized as one of the landscapes with the highest wetland and river productivity for plants, insects and invertebrates in the state (WI DNR, 2017).

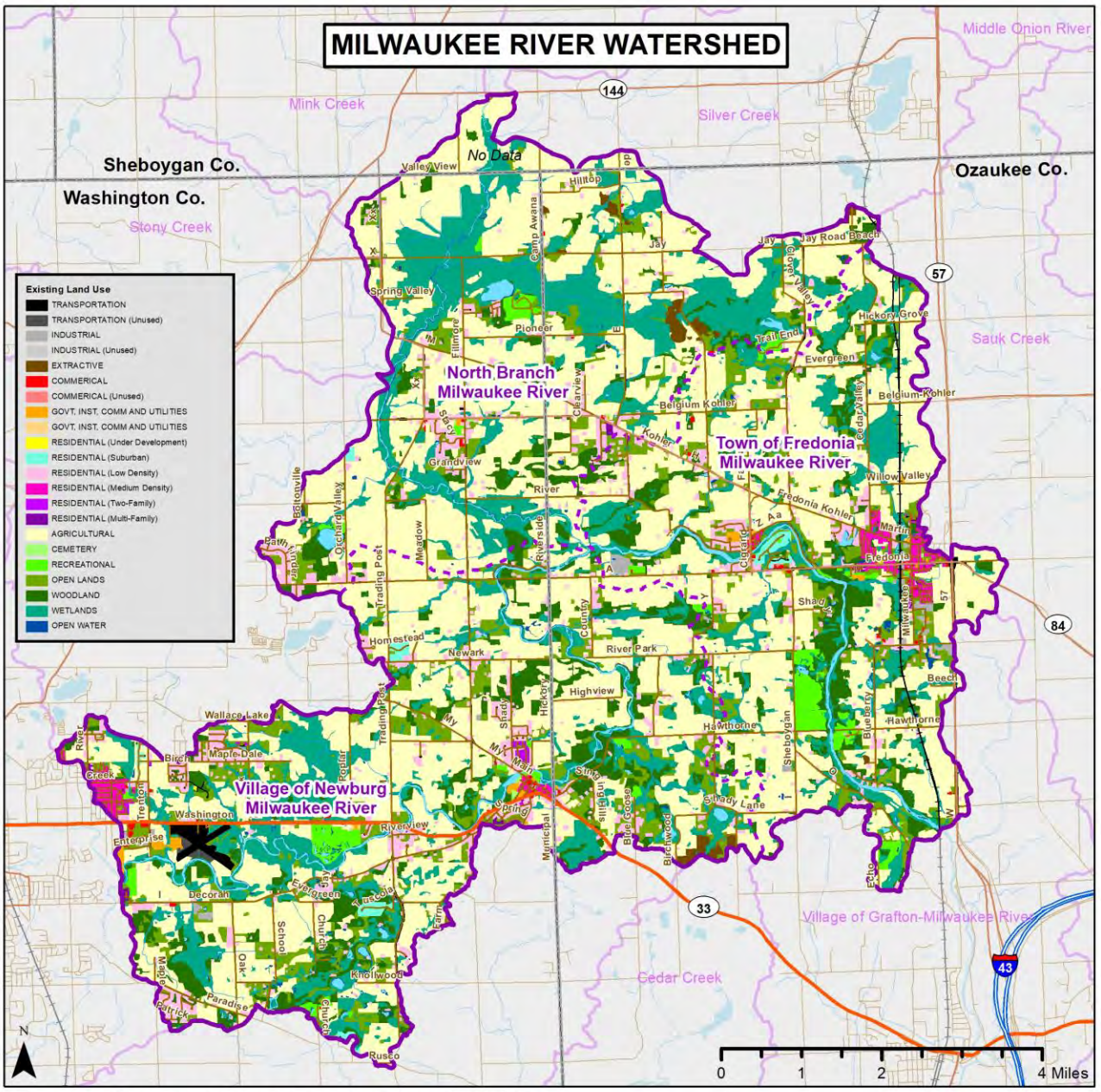


Figure 23. Land Use/ Land Cover (2015)

Noteworthy-Land Use/Land Cover Definitions:

Agricultural: Land use that includes out-buildings and barns, row & field crops and fallow field farms and pasture, includes dairy and other livestock agricultural processing. Also includes nurseries, greenhouses, orchards, tree farms, and sod farms.

Cemetery: Local and regional cemeteries of any size and related administration buildings, maintenance areas, and landscaped areas within the cemetery ownership.

Commercial/Retail: Land use that includes food and drug stores, eating and drinking places, general merchandise stores, legal, insurance, and real estate offices, doctors' offices, personal services, business services, shopping malls and their associated parking, single structure office/hotels.

Extractive: Land use utilized for the extraction of products from the earth, including stone, sand, and minerals, have been identified as extractive use areas.

Government/Institutional: Land use that includes administration, safety, assembly, group quarters, medical facilities, educational facilities, government buildings, religious facilities, and others.

Industrial: Land use that includes manufacturing and processing, industrial, warehousing and wholesale trade, such as mineral extraction, associated parking areas, truck docks, etc.

Open Lands: Land cover that includes rural non-cultivated land.

Open Water: Land cover that includes rivers, streams and canals, lakes, reservoirs, and lagoons.

Recreational: Land use that includes parks, playgrounds, athletic fields, museums, zoos, historic sites, amphitheaters, stadiums, race tracks, conference centers, fairgrounds, and amusement parks.

Residential-Suburban: Land use that includes single family homes and farmhouses and immediate residential area around them with lot sizes ≥ 1.44 ac ≤ 5.0. ac and impervious cover less than 20%.

Residential-Low Density: Land use that includes single family homes and farmhouses and immediate residential area around them with lot sizes ≥ 0.45 ac ≤1.43 ac and impervious cover less than 20%.

Residential-Medium Density: Land use that includes single family homes and farmhouses and immediate residential area around them with lot sizes ≥ 0.16 ac ≤0.44 ac and impervious cover around 30%.

Residential-Multifamily: Land use that includes multifamily residences of more than one family per residence. These include duplex and townhouse units, apartment complexes, condominiums, and associated parking.

Transportation: Land use that includes railroads, rail rapid transit and associated stations, rail yards, linear transportation such as streets and highways, and airport transportation.

Wetlands: Land cover that includes all wetlands on public and private land characterized by both hydric soils and the growth of hydrophytes. Note: wetland mapping is based off SEWRPC 2000 land use data and not 2005 wetland inventory.

Woodland: Land cover generally consisting of remnant or second growth forest.

Future Land Use/Land Cover Predictions

Table 11 shows the forecasted 2035 land use/land cover acreage that was determined from available municipal comprehensive plans and SEWRPC data. Figure 24 compares data shown in Table 11 to existing 2015 land use/land cover, showing those areas where the type of land use is forecast to change. Within the North Branch, Town of Fredonia, and Village of Newburg watersheds, the largest loss of current land use/land cover acreage is expected to occur on areas considered open land, woodland, and wetland.

These land uses collectively are expected to see decreases of 966 acres (6.8%), 1,236 acres (8.8%), and 1,347 acres (7.2%) respectively. Just as significant are the losses of cropland and pastureland where losses of 499 acres (3.5%), 141 acres (1.0%), and 1,005 acres (5.4%) are expected across the respective watersheds. This anticipated loss of open space is contributed to by the expectation of housing growth within the North Branch, Fredonia, and Newburg watersheds. Parcel land use of suburban to medium density housing is expected to increase by 615 acres (4%), 980 acres (7%), and 2,504 acres (11%) across the respective watersheds.

This development is largely localized in the surrounding areas of Fredonia, Newburg, Waubeka, and West Bend. The loss of open lands and subsequent development expansion means it will be important to develop around these using conservation/low impact development design standards.

Table 11. Projected future land use (2035) across the Fredonia-Newburg Area watersheds.

Watershed/Description	Acres	Pct of 12-Digit HUC
North Branch Milwaukee River		
AGRICULTURAL	6,999.9	49.6%
OPEN LANDS	3,951.3	28.0%
RESIDENTIAL	1,313.2	9.3%
No Data	701.0	5.0%
TRANSPORTATION	403.1	2.9%
EXTRACTIVE	279.0	2.0%
RECREATIONAL	218.0	1.5%
OPEN WATER	203.5	1.4%
WETLANDS	40.6	0.3%
GOVT, INST, COMM AND UTILITIES	7.8	0.1%
COMMERICAL	6.3	0.0%
Total	**14,123.7**	**100.0%**
Town of Freedonia-Milwaukee River		
AGRICULTURAL	7,013.5	49.7%
OPEN LANDS	3,329.0	23.6%
RESIDENTIAL	1,976.5	14.0%
TRANSPORTATION	581.8	4.1%
RECREATIONAL	467.9	3.3%
INDUSTRIAL	428.7	3.0%
OPEN WATER	255.9	1.8%
COMMERICAL	39.3	0.3%
GOVT, INST, COMM AND UTILITIES	27.8	0.2%
EXTRACTIVE	2.1	0.0%
Total	**14,122.5**	**100.0%**
Village of Newburg-Milwaukee River		
AGRICULTURAL	7,385.9	39.6%
OPEN LANDS	5,583.8	29.9%
RESIDENTIAL	3,593.8	19.2%
TRANSPORTATION	1,026.3	5.5%
OPEN WATER	373.9	2.0%
RECREATIONAL	363.3	1.9%
INDUSTRIAL	151.4	0.8%
COMMERICAL	116.4	0.6%
WETLANDS	44.8	0.2%
GOVT, INST, COMM AND UTILITIES	29.6	0.2%
Total	**18,669.1**	**100.0%**

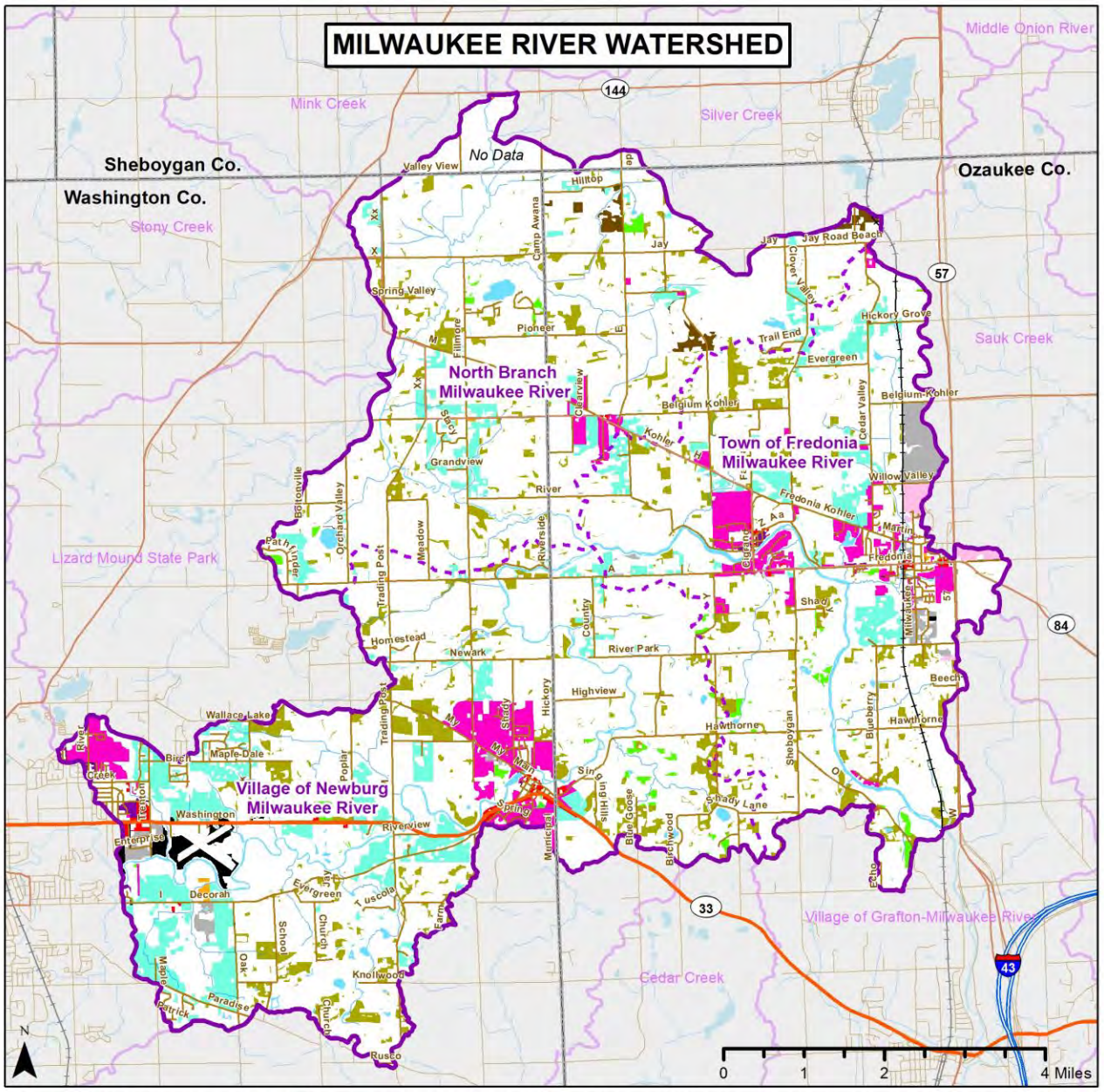
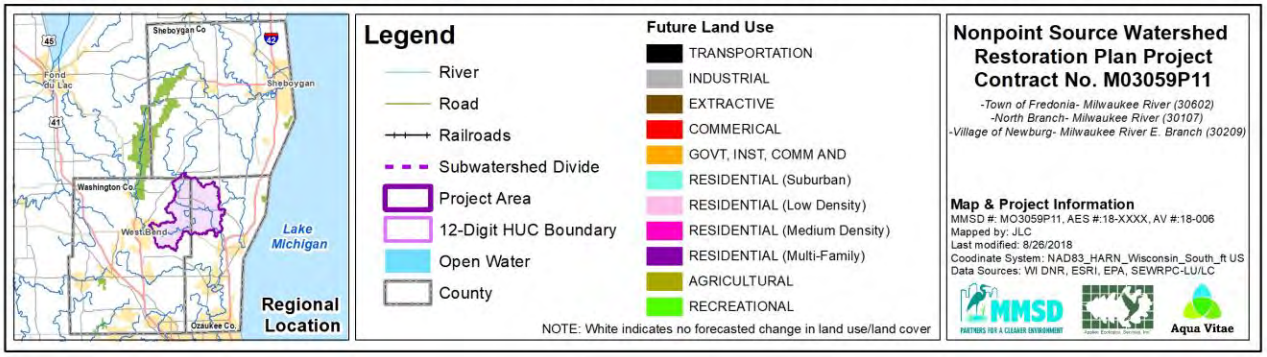
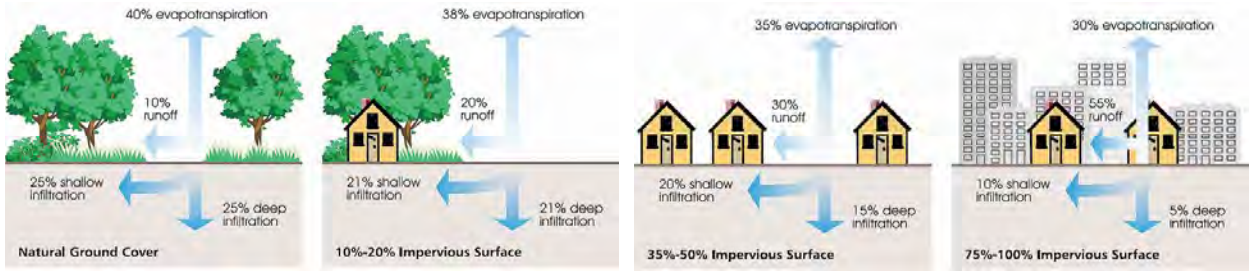


Figure 24. Forecasted Changes in Land Use/Land Cover between 2015 and 2035



3.10 Impervious Cover Impacts

Impervious cover is defined as surfaces of an urban landscape that prevent infiltration of precipitation (Schueler 1994). Imperviousness is an indicator used to measure the impacts of urban land uses on water quality, hydrology and flows, flooding/depressional storage, and habitat related to streams (Figure 25). Based on studies and other background data, Scheuler (1994) and the Center for Watershed Protection (CWP) developed an Impervious Cover Model used to classify streams within subwatersheds into three quality categories: Sensitive, Impacted, and Non-Supporting (Table 12). In general, Sensitive subwatersheds have less than 10% impervious cover, stable stream channels, good habitat, good water quality, and diverse biological communities. Impacted subwatersheds have between 10% and 25% impervious cover, somewhat degraded streams, altered habitat, and decreasing water quality. Non-Supporting subwatersheds generally have greater than 25% impervious cover, highly degraded streams, degraded habitat, poor water quality, and poor-quality biological communities. In addition, runoff over impervious surfaces collects pollutants and warms the water before it enters a stream resulting in negative biological impacts.



Source: The Federal Interagency Stream Restoration Working Group, 1998 (Rev. 2001).

Figure 25. Relationship between impervious surfaces, evapotransporation, & infiltration.

Table 12. Impervious category & stream condition via the Impervious Cover Model.

Category	% Impervious	Stream Condition within Subwatershed
Sensitive	<10%	Stable stream channels, excellent habitat, good water quality, and diverse biological communities
Impacted	>10% but <25%	Somewhat degraded stream channels, altered habitat, decreasing water quality, and fair-quality biological communities.
Non-Supporting	>25%	Highly degraded stream channels, degraded habitat, poor water quality, and poor-quality biological communities.

Source: (Zielinski 2002)

Sensitive Stream

Impacted Stream

Non-Supporting Stream

The following paragraphs describe the implications of increasing impervious cover:

Water Quality Impacts
Imperviousness affects water quality in streams and lakes by increasing pollutant loads and water temperature. Impervious surfaces accumulate pollutants from the atmosphere, vehicles, roof surfaces, lawns and other diverse sources. During a storm event, pollutants such as nutrients (nitrogen and phosphorus), metals, oil/grease, and bacteria (*E. coli*) are delivered to streams and lakes. According to monitoring and modeling studies, increased imperviousness is directly related to increased urban pollutant loads (Schueler 1994). Furthermore, impervious surfaces can increase stormwater runoff temperature as much as 12 degrees compared to vegetated areas (Galli, 1990). Water temperatures exceeding 90°F (32.2°C) can be lethal to aquatic fauna and can generally occur during hot summer months.

Hydrology and Flow Impacts
Higher impervious cover translates to greater runoff volumes thereby changing hydrology and flows in streams. If unmitigated, high runoff volumes can result in higher floodplain elevations (Schueler 1994). In fact, studies have shown that even relatively low percentages of imperviousness (5% to 10%) can cause peak discharge rates to increase by a factor of 5 to 10, even for small storm events. Impervious areas come in two forms: 1) disconnected and 2) directly connected. Disconnected impervious areas are represented primarily by rooftops, so long as the rooftop runoff does not get funneled to impervious driveways or a storm sewer system. Significant portions of runoff from disconnected surfaces usually infiltrate into soils more readily than directly connected impervious areas such as parking lots that typically end up as stormwater runoff directed to a storm sewer system that discharges directly to a waterbody.

Flooding and Depressional Storage Impacts
Flooding is an obvious consequence of increased flows resulting from increased impervious cover. As stated above, increased impervious cover leads to higher water levels, greater runoff volumes, and high floodplain elevations. Higher floodplain elevations usually result in more flood problem areas. Furthermore, as development increases, wetlands and other open space decrease. A loss of these areas results in increased flows because wetlands and open space typically soak up rainfall and release it slowly via groundwater discharge to streams and lakes. Detention basins can and do minimize flooding in highly impervious areas by regulating the discharge rate of stormwater runoff, but detention basins do not reduce the overall increase in runoff volume.

Habitat Impacts
A threshold in habitat quality exists at approximately 10% to 15% imperviousness (Booth and Reinelt 1993). When a stream receives more severe and frequent runoff volumes compared to historical conditions, channel dimensions often respond through the process of erosion by widening, downcutting, or both, thereby enlarging the channel to handle the increased flow. Channel instability leads to a cycle of streambank erosion and sedimentation resulting in physical habitat degradation (Schueler 1994). Streambank erosion is one of the leading causes of sediment suspension and deposition in streams leading to turbid conditions that may result in undesirable changes to aquatic life (Waters 1995). Sediment deposition alters habitat for aquatic plants and animals by filling interstitial spaces in substrates important to benthic macroinvertebrates and some fish species. Physical habitat degradation also occurs when high and frequent flows result in loss of riffle-pool complexes.

Impervious Cover Estimate & Future Vulnerability

In 1998, the Center for Watershed Protection (CWP) published the Rapid Watershed Planning Handbook. This document introduced rapid assessment methodologies for watershed planning. The CWP released the Watershed Vulnerability Analysis as a refinement of the techniques used in the Rapid Watershed Planning Handbook (Zielinski 2002). The vulnerability analysis focuses on existing and predicted impervious cover as the driving forces impacting potential stream quality within a watershed. It incorporates the Impervious Cover Model described at the beginning of this subsection to classify Subwatershed Management Units (SMUs). SMUs are defined and examined in more detail in Section 3.3.

AES used a modified Vulnerability Analysis to compare each SMU's vulnerability to predicted land use changes across Fredonia-Newburg Area watersheds, detailed in the following paragraphs. Three steps were used to generate a vulnerability ranking of each SMU. The results were used to make and rank recommendations in the Action Plan related to curbing the negative effects of predicted land use changes on the watershed. The three steps are listed below and described in detail on the following pages:

Step 1: Classify SMUs relative to existing impervious cover based on 2015 land use/land cover

Step 2: Classify SMUs relative to forecasted impervious cover based on forecasted 2035 land use/land cover

Step 3: Assign each SMU a vulnerability ranking based on forecasted changes in impervious cover and classification

Step 1: Existing Impervious Cover Classification

Step 1 in the Vulnerability Analysis is an existing classification of each SMU based on 2015 land use/land cover and measured impervious cover. 2015 impervious cover was calculated by assigning an impervious cover percentage for each land use/land cover category based upon the United States Department of Agriculture's (USDA) Technical Release 55 (TR55) (USDA 1986). Highly developed land such as commercial/retail for example is estimated to have over 70% impervious cover while a typical medium density residential development exhibits around 25% impervious cover. Open space areas generally have less than 5% impervious cover. GIS analysis was used to estimate the percent impervious cover for each SMU in the watershed using 2015 land use/land cover data. Each SMU then received an initial classification (Sensitive, Impacted, or Non-Supporting) based on percent of existing impervious cover (Table 13; Figure 26).

To summarize, 27 SMUs (SMUs 1-5, 9-10, 12-14, 16-27, 29, 31-33, and 35) were classified as Sensitive, eight as Impacted (SMUs 6-8, 11, 15, 28, 30, and 34), and zero as Non-Supporting based on 2015 impervious cover estimates. Sensitive SMUs are spaced evenly throughout the watersheds. Most of the Impacted SMUs are found around municipal areas West Bend (SMU 34), Newburg (28, 30), Fredonia/Waubeka (6-8, 11) and in areas of residential development.

Table 13. 2015 & predicted (2035) future impervious cover by Subwatershed Management Unit.

SMU #	Step 1: Existing Impervious %	Existing (2015) Impervious Classification	Step 2: Predicted Impervious %	Predicted (2035) Impervious Classification	Percent Change	Step 3: Vulnerablity
SMU 1	6.8%	Sensitive	7.1%	Sensitive	0.3%	Low
SMU 2	8.9%	Sensitive	9.0%	Sensitive	0.2%	Medium
SMU 3	8.8%	Sensitive	11.4%	Impacted	2.6%	High
SMU 4	3.8%	Sensitive	4.4%	Sensitive	0.6%	Low
SMU 5	6.1%	Sensitive	7.5%	Sensitive	1.5%	Low
SMU 6	12.3%	Impacted	17.6%	Impacted	5.3%	Medium
SMU 7	13.0%	Impacted	17.4%	Impacted	4.4%	Medium
SMU 8	16.1%	Impacted	26.3%	Non-Supporting	10.2%	High
SMU 9	8.0%	Sensitive	9.8%	Sensitive	1.8%	Medium
SMU 10	6.4%	Low	8.5%	Low	2.1%	Low
SMU 11	20.5%	Impacted	27.8%	Non-Supporting	7.3%	High
SMU 12	5.8%	Sensitive	13.0%	Impacted	7.2%	High
SMU 13	6.0%	Sensitive	6.7%	Sensitive	0.7%	Low
SMU 14	7.0%	Sensitive	7.7%	Sensitive	0.7%	Low
SMU 15	10.9%	Impacted	11.9%	Impacted	1.0%	Low
SMU 16	5.6%	Sensitive	6.3%	Sensitive	0.7%	Low
SMU 17	3.7%	Sensitive	4.0%	Sensitive	0.3%	Low
SMU 18	8.1%	Sensitive	9.7%	Sensitive	1.6%	Medium
SMU 19	5.5%	Sensitive	5.7%	Sensitive	0.2%	Low
SMU 20	5.0%	Sensitive	5.8%	Sensitive	0.8%	Low
SMU 21	6.2%	Sensitive	7.5%	Sensitive	1.2%	Low
SMU 22	5.4%	Sensitive	6.3%	Sensitive	0.8%	Low
SMU 23	6.5%	Sensitive	7.3%	Sensitive	0.9%	Low
SMU 24	8.4%	Sensitive	8.8%	Sensitive	0.4%	Low
SMU 25	8.0%	Sensitive	10.7%	Impacted	2.7%	High
SMU 26	3.0%	Sensitive	3.5%	Sensitive	0.5%	Low
SMU 27	6.2%	Sensitive	6.4%	Sensitive	0.2%	Low
SMU 28	10.3%	Impacted	17.0%	Impacted	6.7%	Medium
SMU 29	4.8%	Sensitive	5.2%	Sensitive	0.4%	Low
SMU 30	10.2%	Impacted	12.9%	Impacted	2.7%	Low
SMU 31	7.6%	Sensitive	9.2%	Sensitive	1.5%	Medium
SMU 32	5.4%	Sensitive	6.0%	Sensitive	0.6%	Low
SMU 33	9.0%	Sensitive	14.1%	Impacted	5.0%	High
SMU 34	17.6%	Impacted	35.5%	Non-Supporting	17.9%	High
SMU 35	7.5%	Sensitive	13.4%	Impacted	5.9%	High

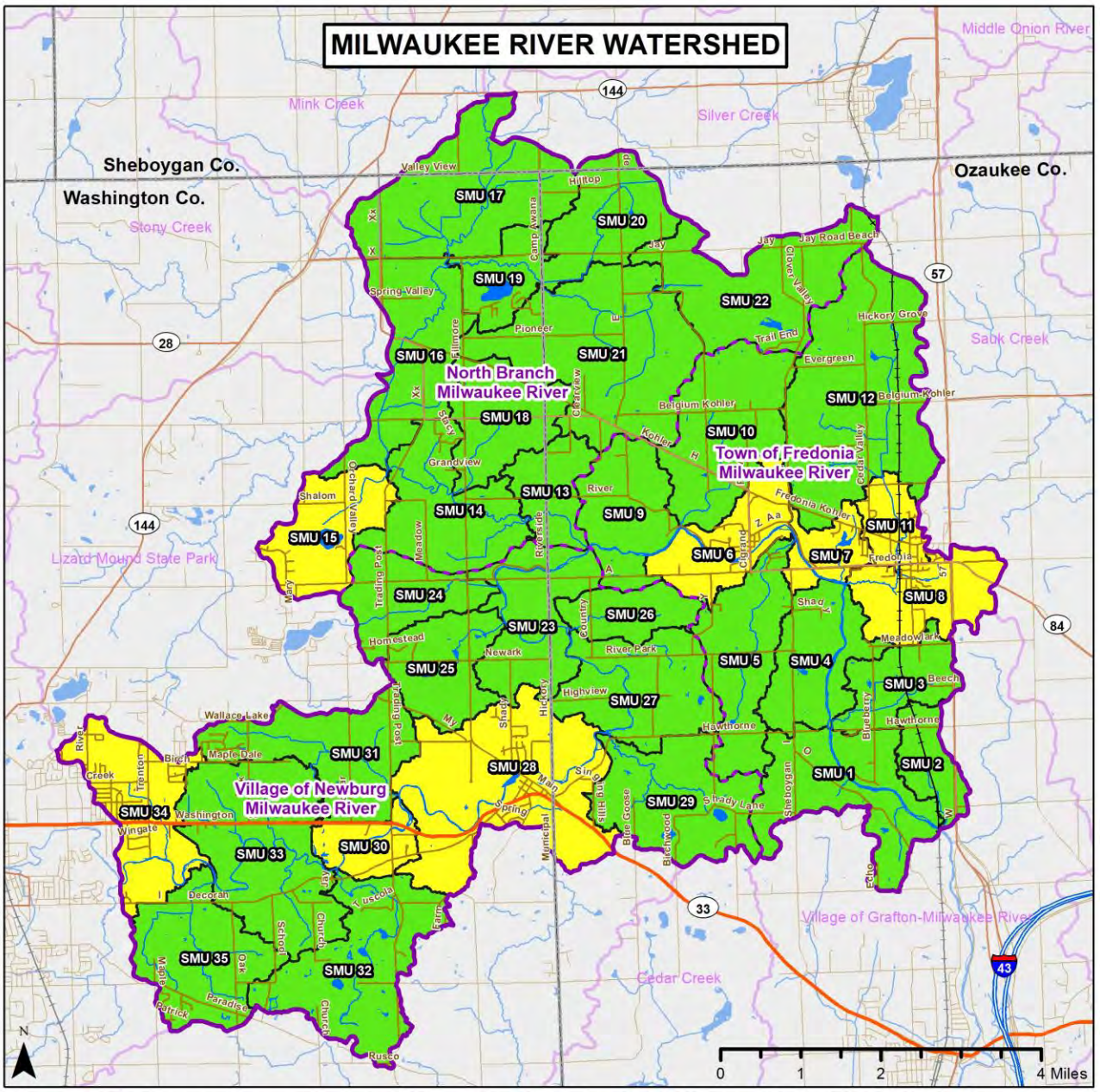


Figure 26. Impervious Cover Classification by SMU Based On 2015 LULC

Legend

- River
- Road
- Railroads
- Subwatershed Divide
- Project Area
- 12-Digit HUC Boundary
- Open Water
- County

Subwatershed Management Unit Impervious Cover by SMU (2015)

- Sensitive (0 to 10% Impervious)
- Impacted (10 to 25% Impervious)
- Non-Supporting (25 to 100% impervious)

Nonpoint Source Watershed Restoration Plan Project Contract No. M03059P11

-Town of Fredonia- Milwaukee River (30602)
-North Branch- Milwaukee River (30107)
-Village of Newburg- Milwaukee River E. Branch (30209)

Map & Project Information
MMSD #: MO3059P11, AES #:18-XXXX, AV #:18-006
Mapped by: JLC
Last modified: 8/26/2018
Coordinate System: NAD83_HARN_Wisconsin_South_ft US
Data Sources: WI DNR, ESRI, EPA, SEWRPC

MMSD PARTNERS FOR A CLEANER ENVIRONMENT
Aqua Vitae

Step 2: Predicted Future Impervious Cover Classification
Predicted future impervious cover (2035) was evaluated in Step 2 of the vulnerability analysis by classifying each SMU as Sensitive, Impacted, or Non-Supporting based on predicted land use changes. Table 13 and Figure 27 summarize and depict predicted future impervious cover classifications for each SMU. This step identifies Sensitive and Impacted SMUs that are most vulnerable to future development pressure. SMUs 3, 12, 25, 33, and 35 are predicted to change from Sensitive to Impacted while SMUs 8, 11, and 34 change from Impacted to Non-Supporting. These changes are attributed to mostly predicted medium density and suburban residential as well as industrial development localized near West Bend and Fredonia. It is also interesting to note that much of the medium impacted SMUs are localized around the county highway H corridor through the Village of Fredonia and North Branch watersheds.

Step 3: Vulnerability Ranking
The vulnerability of each SMU to predicted future land use changes was determined by considering the following questions:

1. Will the SMU classification change?
2. Does the SMU classification come close to changing (within 2%)?
3. What is the absolute change in impervious cover from existing to predicted conditions?

Vulnerability to future development for each SMU was categorized as Low, Medium, or High:
Low = no change in classification; <5% change in impervious cover
Medium = classification close to changing (within 2%) and/or 5-10% change in impervious cover
High = classification change or close to changing (within 2%) and/or >10% change in cover

The vulnerability analysis resulted in 8 High, 7 Medium, and 20 Low ranked SMUs (Table 13; Figure 28). SMUs 3, 8, 11, 12, 25, 33, 34, and 35 are ranked as highly vulnerable to future problems associated with impervious cover because each is expected to change classification from Sensitive to Impacted or Impacted to Non-Supporting. Predicted medium density and suburban residential as well as industrial development largely concentrated east of West Bend, as we all around Fredonia in areas that are currently agricultural are the largest source of increased impervious cover.

SMUs 2, 6, 7, 9, 18, 28, and 31 are ranked as moderately vulnerable to predicted land use changes. SMUs 6 and 28 exhibit between 5 and 10 percent increases in impervious cover while SMUs 2, 9, 18, and 31 are Sensitive but nearly reach Impacted status. Again, a shift from agricultural, woodland, wetland, and open land use to residential contribute most to increased impervious cover.

The remaining SMUs are not vulnerable to predicted future land use changes based on the Center for Watershed Protection's methodology.

The results of this analysis clearly point to the potential negative impacts of traditional development. It will be important to consider developing these areas using Conservation/Low Impact Development standards that incorporate the most effective and reliable Stormwater Treatment Train practices whereby stormwater is routed through various water quality and infiltration Management Measures prior to being released from the development site. The use of Conservation/Low Impact Development is discussed in the Programmatic Action Plan section of this report.

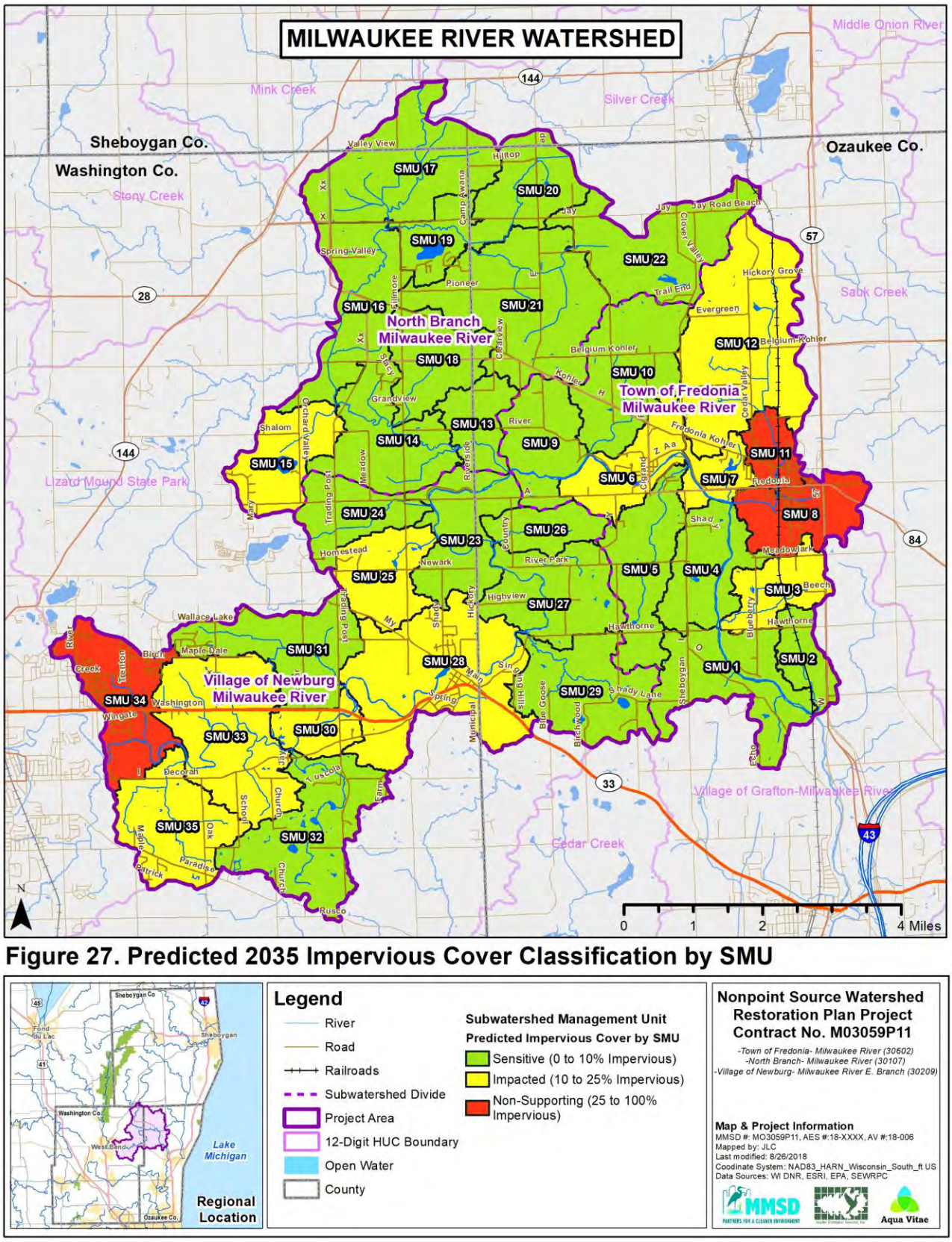


Figure 27. Predicted 2035 Impervious Cover Classification by SMU

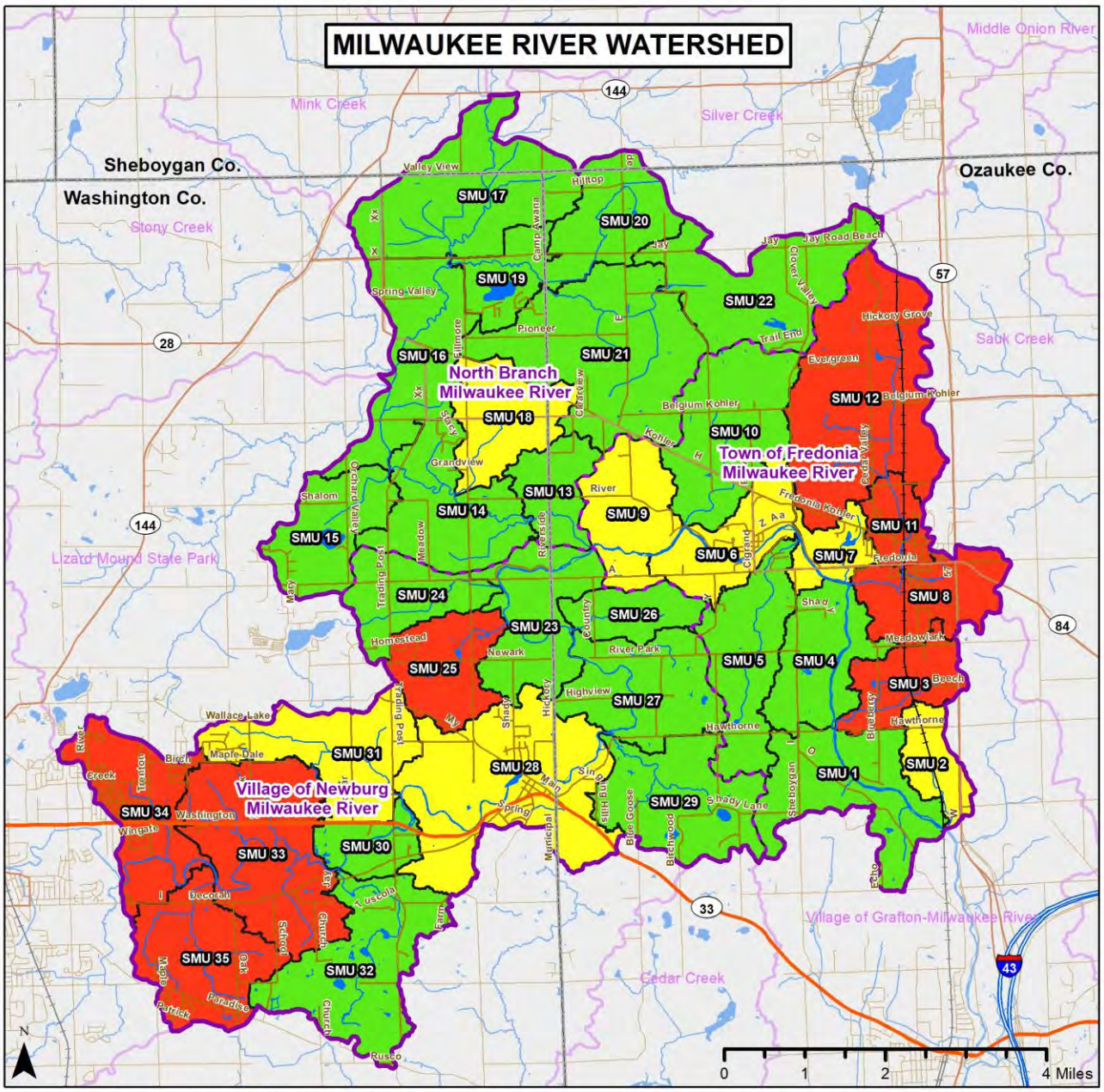
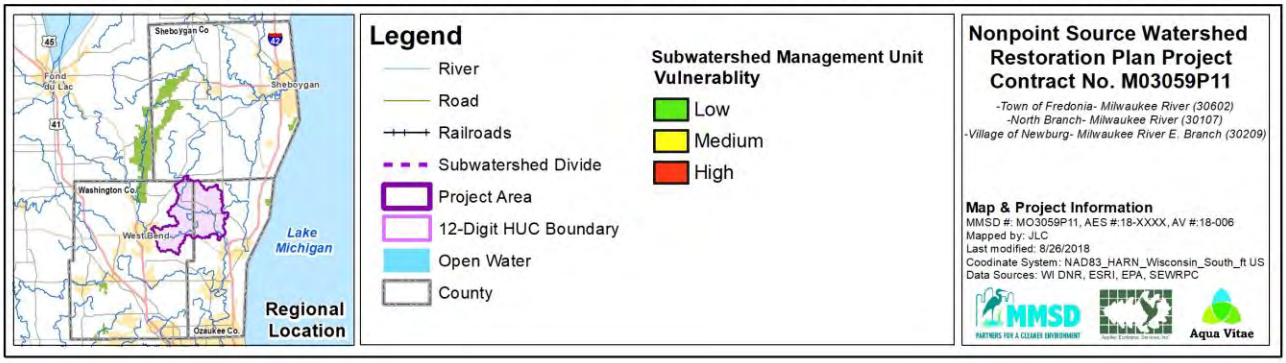


Figure 28. Vulnerability Ranking of SMUs Based on Predicted Land Cover Change: 2015-2035



3.11 Open Space Inventory, Prioritization, & Green Infrastructure Network

A major component of watershed planning includes an examination of open space to determine how it best fits into a "Green Infrastructure Network". Green infrastructure is best defined as an interconnected network of natural areas and other open space that conserves natural ecosystem values and functions, sustains clean air and water, and provides a wide array of benefits to people and wildlife (Benedict 2006). Natural features such as stream corridors, wetlands, floodplain, woodlands, and grassland are the primary components of green infrastructure. Working lands such as farms parks/ball fields, golf courses, school grounds, detention basins, and large residential parcels can also be considered green infrastructure components. A three-step process was used to create a parcel-based Green Infrastructure Network for the Fredonia-Newburg Area watersheds:

Step 1: All parcels of land in the watershed were categorized as open space, partially open space, or developed.
Step 2: All open and partially open parcels were prioritized based on a set of criteria important to green infrastructure.
Step 3: Prioritized open and partially open parcels and some developed but linking parcels were combined to form a Green Infrastructure Network.

For this watershed plan, an "open space" parcel is generally defined as any parcel that is not developed such as a protected natural area or agricultural field. "Partially open" parcels have been developed to some extent, but the parcels still offer potential green infrastructure opportunities. Examples of partially open parcels include some school grounds, residential lots generally greater than two acres with minimal development, vacant industrial areas, and portions of airports. Parcels that are mostly built out such as medium and high-density residential development, transportation, and commercial/retail areas are considered "developed". Public versus private and protected versus unprotected status of open and partially open space parcels are other important green infrastructure attributes that are discussed in more detail below.

Open, Partially Open, & Developed Parcels

Step 1 in creating a Green Infrastructure Network was completed by categorizing all parcels in the watershed as "open", "partially open", or "developed" as described above. Figures 29 and 32 summarize and depict Step 1 results. Open space parcels (defined as less than 10% developed) within the Village of Newburg, Town of Fredonia, and North Branch Milwaukee River watersheds largely dominate the landscape and comprise approximately 44,656 acres or 78% of the watershed. Open parcels range from less than 1 acre to 286 acres with a 24-acre average. Partially open parcels (10-50% developed) make up another 9,681 acres or 17% of the watershed. Partially open parcels range from less than 1 acre to 347 acres with a 8.6-acre average. Developed parcels account for the remaining 3,229 acres or 6% of the watershed, hence the rural feel of the watershed. Most open and partially open parcels are located on agricultural land, County preserves, an airport, and large residential lots.

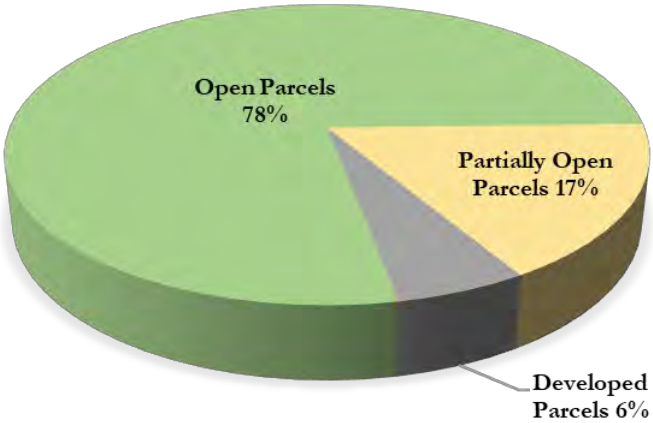


Figure 29. Distribution of open, partially open, and developed parcels (2015).

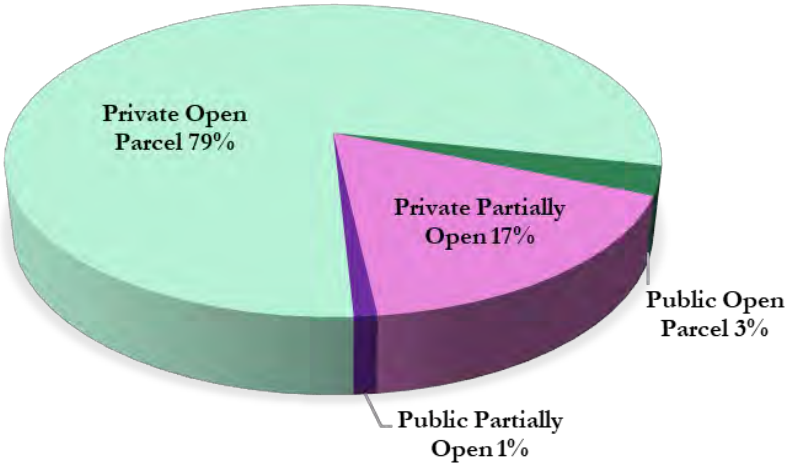


Figure 30. Distribution of private vs. public open and partially open parcels (2015).

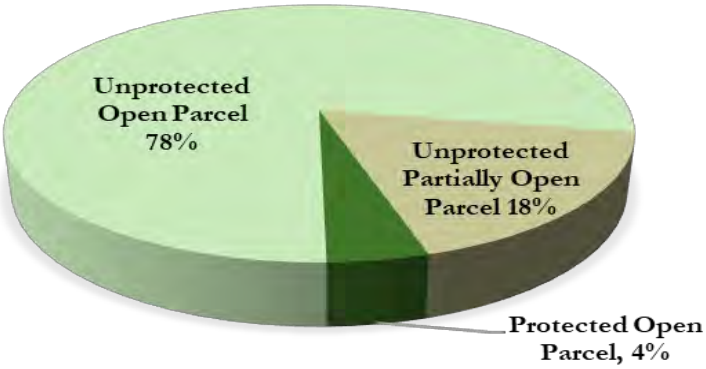


Figure 31. Distribution of protected vs unprotected open and partially open parcels (2015).

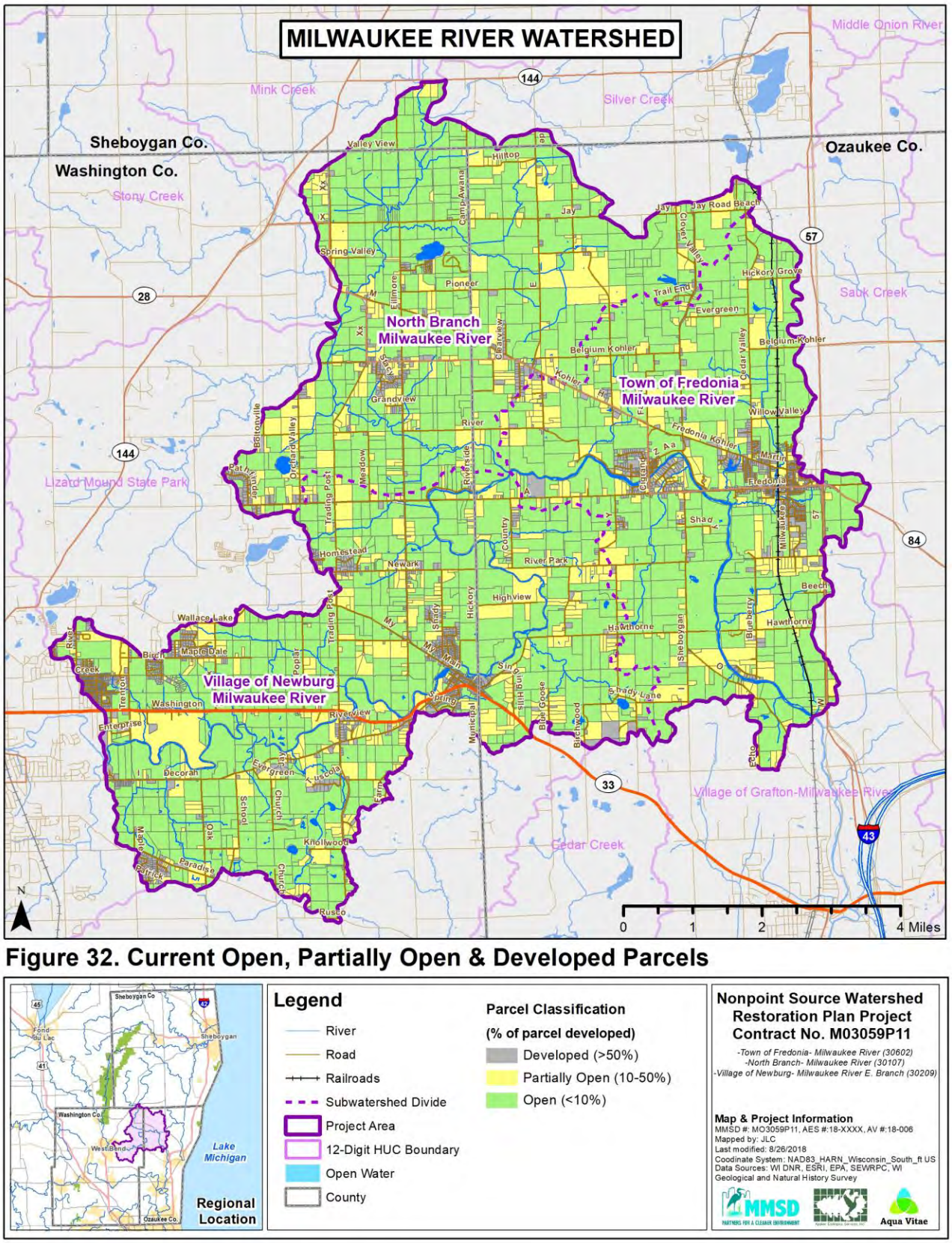


Figure 32. Current Open, Partially Open & Developed Parcels

Public/Private Ownership of Open and Partially Open Parcels

The public or private ownership of each open and partially open parcel was determined from available parcel data. Developed parcels are not included in this summary. Publicly owned parcels generally include those owned by state, county, municipal government, school districts, and park districts. Public open and partially open parcels account for 3% and 1% of the open and partially open acreage respectively (Figures 30 & 33). Private ownership types include residential, businesses, commercial, industrial, non-profit, agricultural, etc. Private open parcels comprise 79% of the open and partially open acreage whereas private partially open parcels comprise 17%. Public open and partially open parcels are mostly owned by counties and municipalities.

Protected Status of Open and Partially Open Parcels

Preservation of open space is critical to maintaining and expanding green infrastructure and is an important component of sustaining water quality, hydrological processes, ecological function, and the general quality of life for both wildlife and people. Without preservation, open space can be converted to other less desirable land uses in the future. Typically, parcels that are protected from future development are considered protected, while those open to development changes if the property changes hands are considered unprotected. Protected open and partially open parcels account for about 4% of the open and partially open parcel acreage in the watershed while unprotected open and partially open parcels account for the remaining 96% at 78% and 18% respectively (Figures 31 & 34). Most protected open or partially open parcels are owned by counties, municipalities, homeowner associations, and non-profit groups such as Ozaukee-Washington Land Trust.

The most crucial unprotected open and partially open parcels are agricultural lands. Most agricultural areas will likely be developed to residential unless agricultural preservation tools are leveraged. Utilizing the Wisconsin Working Lands Initiative and future development that incorporates conservation design or low impact development will be extremely important in many of these areas to improve water quality and reduce stormwater runoff volume.

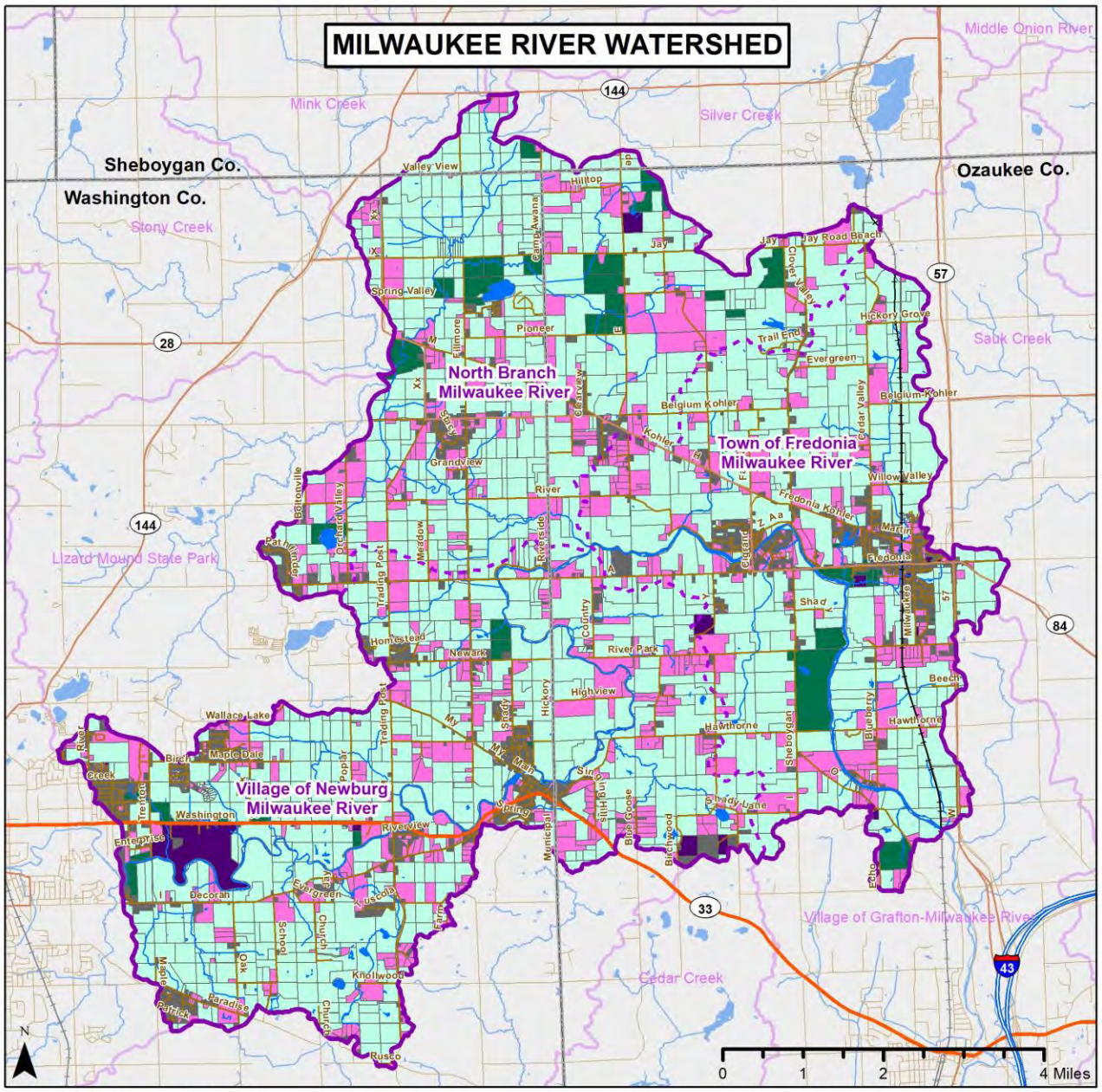
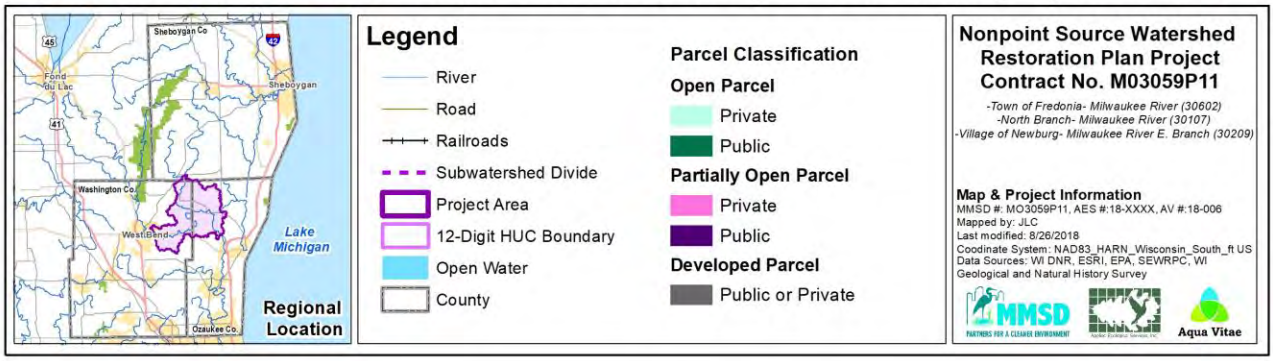


Figure 33. Public Versus Private Ownership of Open and Partially Open Parcels



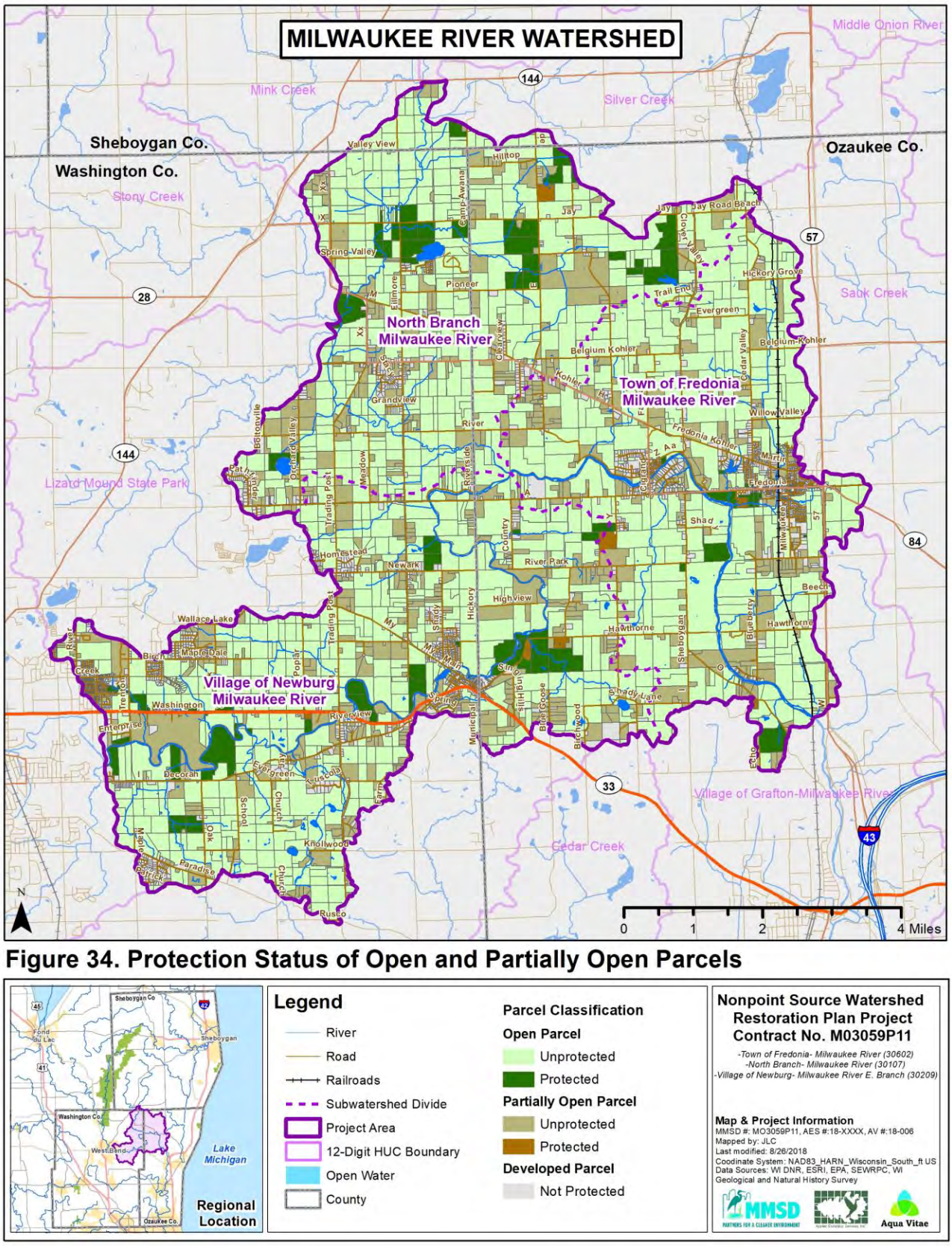


Figure 34. Protection Status of Open and Partially Open Parcels

Open Space Parcel Prioritization

Step 2 in creating a Green Infrastructure Network for the Fredonia-Newburg Area watersheds was completed by prioritizing open and partially open parcels. For this step, 10 prioritization criteria important to green infrastructure were examined via a GIS analysis (Table 14). If an open or partially open parcel met a criterion it received one point. If the parcel did not meet that criterion, it did not receive a point. This process was repeated for each open and partially open parcel and for all criteria. Due to the extent to which additional planning work around threatened and endangered species are being looked at in the watershed, those parcels meeting Criteria 11 were given 2 points. The prioritization process was not completed for developed parcels. The total points received for each parcel were summed to determine parcel importance for developing the Green Infrastructure Network; parcels with the highest number of points are more important to green infrastructure than parcels that met fewer criteria.

The combined possible total of points any one parcel could accumulate was 12 (11 of 11 total criteria met, with one extra point if it met Criteria 11). The highest total value received by a parcel in the weighting process was 12 (having met 11 of 11 criteria). After completion of the prioritization, parcels were mapped according to their score (Figure 35) and reviewed as a whole.

Table 14. Criteria used to prioritize parcels for a Green Infrastructure Network.

Green Infrastructure Criteria
1. Open/partially open parcels that include the FEMA 100-year floodplain
2. Open/partially open parcels within 0.25 miles of a headwater stream
3. Open/partially open parcels that include a wetland (WI Wetland Inventory)
4. Open/partially open parcels that include an ADID wetland (SEWRPC)
5. Open/partially open parcels that are within 100 feet of a stream or open water
6. Open/partially open parcels in a "Highly Vulnerable" Land Use/Land Cover SMU
7. Open/partially open parcels adjacent to or including private or public protected open space
8. Open/partially open parcels that include an existing or planned trail
9. Open/partially open parcels that include SEWRPC environmental corridors
10. Open/partially open parcels that include "Highly Productive Agricultural Land"
11. Open/partially open parcels that include "Historic or Potential Areas for Threatened and Endangered Species".

Green Infrastructure Network

The final step (Step 3) in creating a Green Infrastructure Network for the Fredonia-Newburg Area watersheds involves laying out the network by using prioritized open space results from Step 2 as the base layer that includes all prioritized parcels and adding back in developed parcels along streams, wetlands and open space corridors if they provided *links*, expanded existing green infrastructure, or connected isolated sites such as protected parks. In this watershed, parcels that scored 6 or higher were kept in the Green Infrastructure Network and then additional parcels were added/included where individual parcels were needed to link all portions of the network to form a whole.

County and regional green infrastructure plans generally focus on natural features such as stream corridors, wetlands, floodplain, buffers, and other natural components. The Green Infrastructure Network created for the Fredonia-Newburg Area watersheds captures all the natural components

including the majority of SEWRPC's environmental corridors and other green infrastructure such as recreational parks, large residential lots, and school grounds at the parcel level. Parcel level green infrastructure planning is important because land purchases, acquisitions, and land use changes almost always occur at the parcel level. The Green Infrastructure Network for the Fredonia-Newburg Area watersheds is illustrated on Figure 36. In total, the Green Infrastructure Network covers 33,520 acres, only 2,521 acres of which are currently protected.

Perhaps the most important aspect of green infrastructure planning is that it helps communities identify and prioritize conservation opportunities and plan development in ways that optimize the use of land to meet the needs of people and nature (Benedict 2006). Green infrastructure planning provides a framework for future growth that identifies areas not suitable for development, areas suitable for development but that should incorporate conservation or low impact design standards, and areas that do not affect green infrastructure. The Action Plan section of this report includes various programmatic and site-specific green infrastructure recommendations.

Noteworthy: Green Infrastructure Network

A Green Infrastructure Network is a connected system of *Hubs* and linking *Corridors*. Hubs generally consist of the largest and least fragmented areas. Corridors are generally formed by smaller private/unprotected parcels along swales and streams. Corridors are extremely important because they provide biological conduits between hubs. However, most parcels forming corridors are not ideal green infrastructure until residents, businesses, industries, and farmers embrace the idea of naturalizing stream corridors. Unique to the three Fredonia-Newburg watersheds in this plan, are very undeveloped riparian corridors. The main branches of these rivers are still currently wooded, diverse and have limited development impacts and limited agricultural encroachments.

Source: greeninfrastructure.net

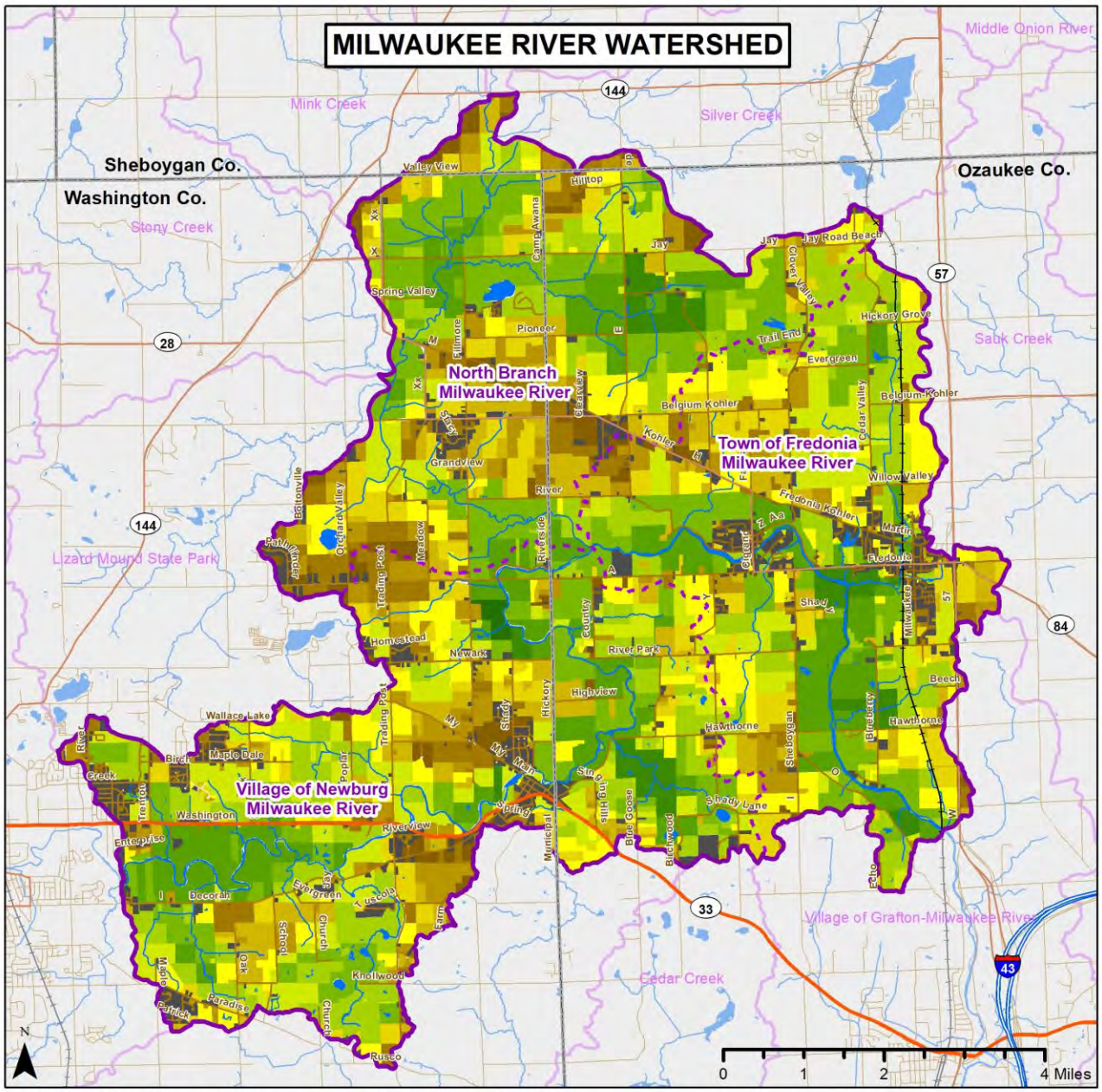


Figure 35. Open Space Parcel Prioritization

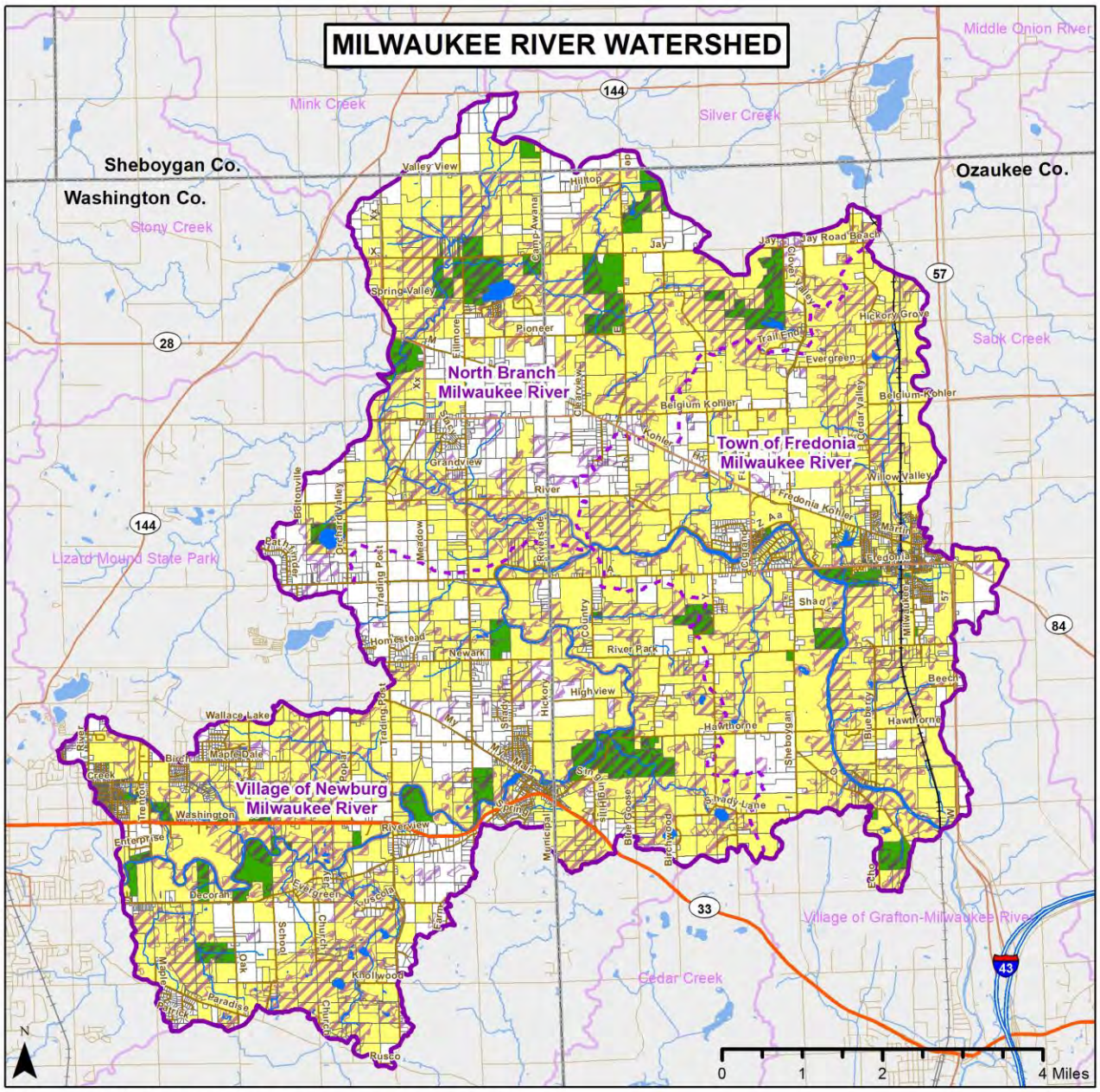
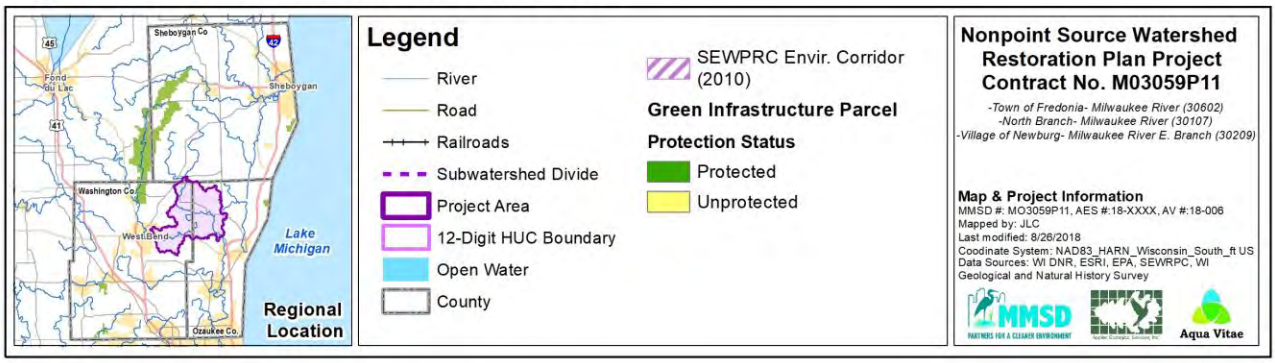


Figure 36. Green Infrastructure Network



3.12 Highly Productive Agricultural Land

The preservation of agricultural land in the Fredonia-Newburg Area watersheds can play a crucial role in retaining valuable open space as part of the green infrastructure network. These areas allow for greater groundwater infiltration than those lands that have been converted to urban land uses. Southeastern Wisconsin Regional Planning Commission's (SEWRPCs) 2016 *Vision 2050: One Region, Focusing on Our Future,* calls for the preservation of as much of the most productive farmland as practicable.

SEWRPC defines the most productive farmland (National Prime Farmlands) according to the agricultural capability of the soils on that land – specifically those classified by the U.S. Natural Resources Conservation Service (NRCS) as Class I and Class II soils. Agricultural land classified as Class III soils are categorized as Farmland of Statewide Importance. In the Fredonia-Newburg Area watersheds, 17,514 acres have been classified as National Prime Farmlands (worthy of preservation. Farmlands of Statewide Importance account for 8,470 acres. Figure 37 depicts the location of the National Prime Farmlands, as well as Farmlands of Statewide Significance. The breakdown of each of the three watersheds farmland data is as follows: North Branch Milwaukee River has 4,886 acres of National Prime Farmlands with 2,856 acres of Statewide Importance; Town of Fredonia-Milwaukee River has 6,836 acres of National Prime Farmlands with 1,636 acres of Statewide Importance and Village of Newburg-Milwaukee River has 5,792 acres of National Prime Farmlands with 3,978 acres of Statewide Importance.

Rolling hills and corn along Hwy M near Filmore

Farmland and rolling hills coexist and define these three watersheds but as more and more family farms give way to development pressure and aggregate to larger agricultural operations in the near future, the rural character of this area will change. The 2009 Wisconsin Working Lands Initiative was an effort introduced which includes the Farmland Preservation Program, Agricultural Enterprise Area Program, and the Purchase of Agricultural Conservation Easement Program. An opportunity may exist to expand agricultural preservation within the Fredonia-Newburg Area watersheds.

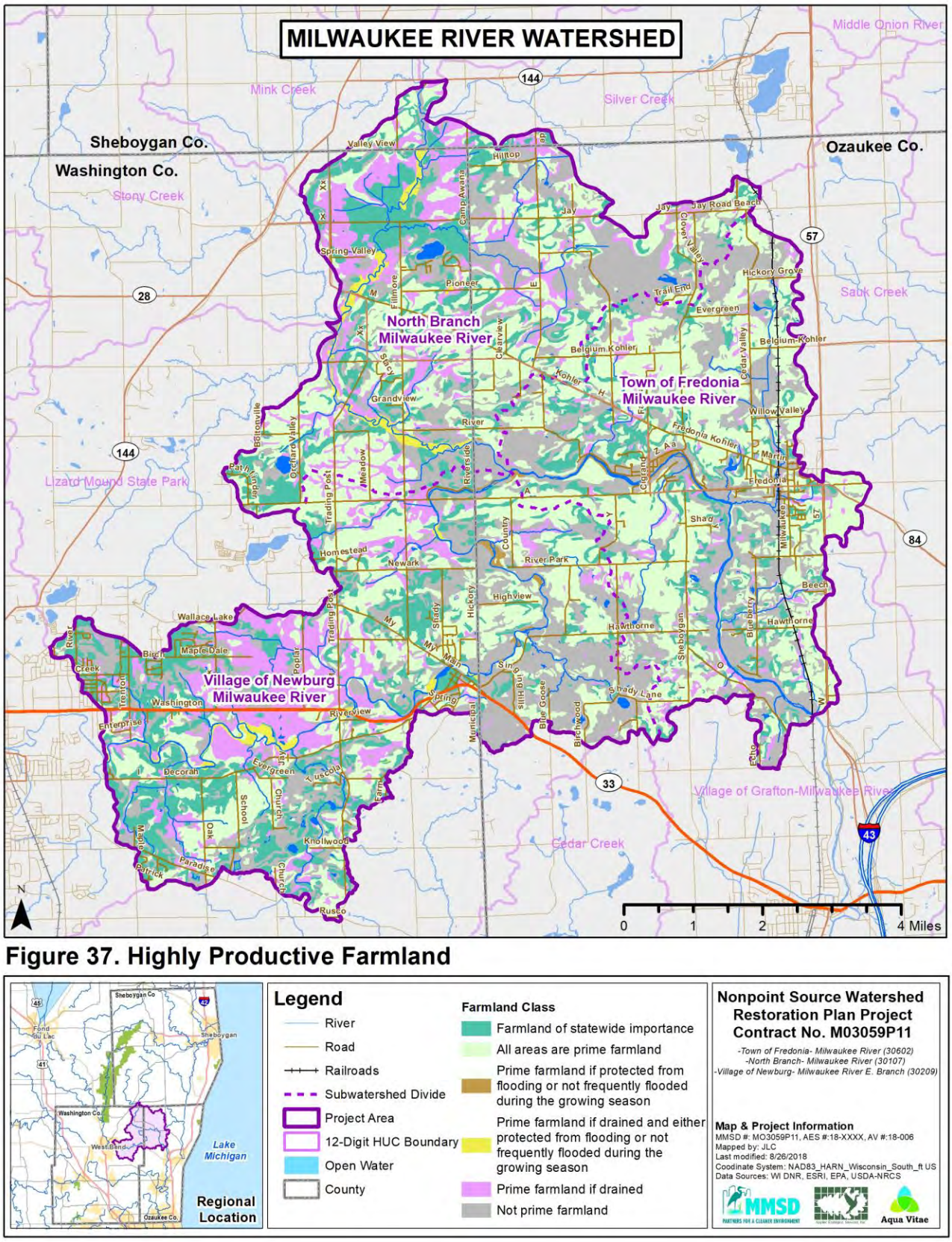


Figure 37. Highly Productive Farmland

3.13 Important Natural Areas

Wetlands, woodlands, stream corridors and other natural features that fall within concentrated corridors of the natural resource base are all considered "Important Natural Areas" within the Fredonia-Newburg Area watersheds. Many of these areas are public and owned/managed by local county, non-profit, or municipal entities. Important Natural Areas often provide high quality habitat for and harbor uncommon or even threatened and endangered (T&E) species. These areas also provide large greenway corridors that interconnect land and waterways, support native species, maintain natural ecological processes, and contribute to the quality of life for communities of people. For this plan, SEWRPC Environmental Corridors were adopted as Important Natural Areas. SEWRPC Environmental Corridors total 46,215 acres and data layers are broken down and expressed by acreage and percentage of each of the three watersheds (Table 15). ADID designated wetlands areas total 7,325 acres, the three watersheds had the following ADID wetlands totals: North Branch Milwaukee River 3,060 acres, Town of Fredonia-Milwaukee River 1,616 acres and Village of Newburg-Milwaukee River 2,649 acres. There are also 595 acres in other Natural Areas are located in the watershed (Table 16; Figures 38 & 39).

Table 15. SEWRPC Environmental Corridors by type, acreage and percent of watershed.

Watershed/Corridor Type	Acres	Percent of HUC 12
North Branch Milwaukee River	**13,423.6**	**95%**
Water	12.9	0%
Primary	3,602.1	25%
Primary Water	163.8	1%
Secondary	147.1	1%
Secondary Water	37.9	0%
Isolated Natural Area	330.6	2%
Water in INRA	5.3	0%
OUT	9,123.8	65%
Town of Freedonia-Milwaukee River	**14,123.1**	**100%**
Water	22.2	0%
Primary	2857.7	20%
Primary Water	243.2	2%
Secondary	102.7	1%
Secondary Water	5.5	0%
Isolated Natural Area	340.3	2%
Water in INRA	13.1	0%
OUT	10,538.4	75%
Village of Newburg-Milwaukee River	**18,669.1**	**100%**
Water	23.8	0%
Primary	4,524.4	24%
Primary Water	360.3	2%
Secondary	137.3	1%
Secondary Water	7.8	0%
Isolated Natural Area	538.1	3%
Water in INRA	13.1	0%
OUT	13,064.3	70%

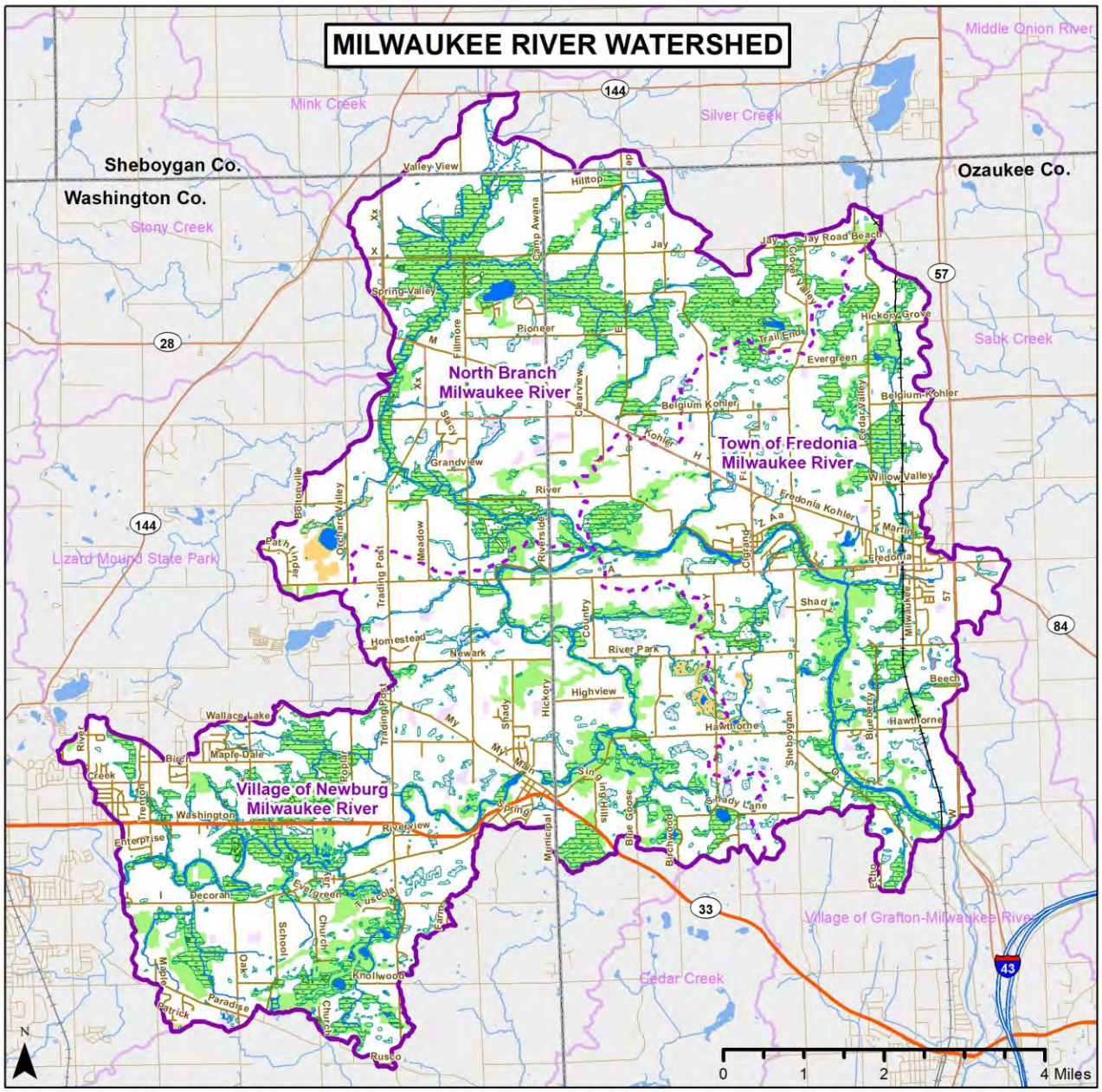
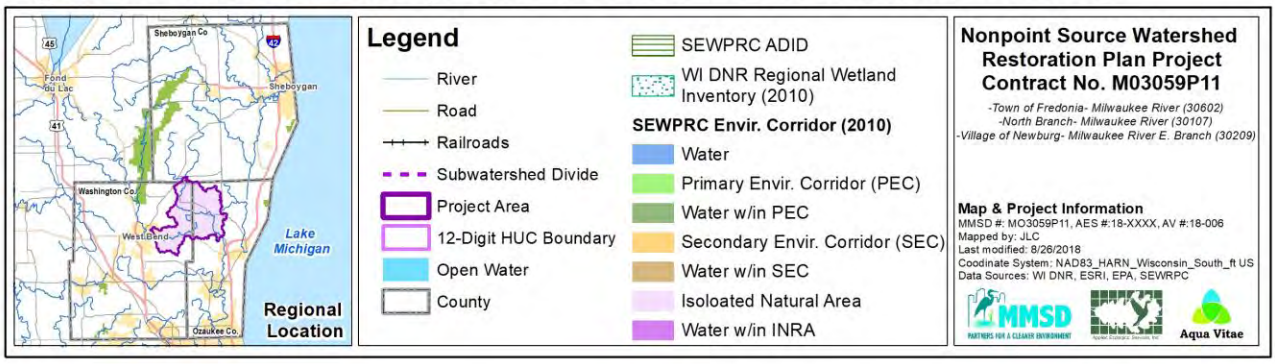


Figure 38. Wetlands, Lakes, Ponds & SEWRPC Environmental Corridors



SEWRPC Environmental Corridors

As part of their regional planning efforts, Southeastern Wisconsin Regional Planning Commission (SEWRPC) identified primary and secondary environmental corridors within southeastern Wisconsin. These environmental corridors were designated to identify and protect important natural resources in the area. The Environmental Corridors for the Fredonia-Newburg Area watersheds serve as an important catalogue of important natural areas within the watershed and form the backbone of the Green Infrastructure Network. The SEWRPC 2005 Environmental Corridors within the Fredonia-Newburg Area watersheds are mapped on Figure 38.

Native Jewelweed (Impatiens capensis) thrives along a creek bank on the North Branch-Milwaukee River.

SEWRPC's Environmental Corridors were determined based on the presence of water bodies, watercourses, wetlands, remnant plant communities, wildlife habitat areas, areas containing hydric or partially hydric soils, and areas of rugged terrain or high-relief topography. Additionally, the corridors take into account the relation of open space, historic sites, scenic areas, natural areas, and critical species habitat sites within the area. Primary and Secondary Environmental Corridors, as well as Isolated Natural Resource Areas were delineated for the planning area. Primary Environmental Corridors are defined as being at least 400 acres in size, two miles long, and 200 feet in length. Secondary Corridors are at least 100 acres in size and one mile long, unless they connect primary environmental corridors. Isolated Natural Resource Areas include those from 200 feet wide down to a 5-acre minimum (SEWRPC 2000).

ADID Wetlands, Lakes, & Ponds

The United States Environmental Protection Agency (USEPA) has a planning process known as advanced identification of disposal areas (ADID) in place that is used to identify wetlands and other waters that are unsuitable for the discharge of dredged and fill materials (USEPA 2009). For the Fredonia-Newburg Area watersheds, these identifications were made by the USEPA in conjunction with the United States Army Corps of Engineers (USACOE) and Wisconsin Department of Natural Resources (WDNR). The ADID wetland inventory was completed for Washington and Ozaukee Counties in 2005. SEWRPC provided technical assistance in producing these maps by combining this data with their Primary Environmental Corridors. These inventories identify wetlands where special protection should be implemented and enforced. There are 7,325 acres of ADID wetlands as shown on Figure 38.

Other Important Natural Areas

The Wisconsin Department of Natural Resources (WDNR) manages the State Natural Areas Program (SNA) which works to identify ecological communities that remain predominantly undisturbed from pre-European settlement times. These areas have been assessed according to field inventories conducted by WDNR staff and account for the quality, diversity, extent of past disturbance, context within the greater landscape, and rarity of features. Areas that meet these qualifications and have also been identified as areas of statewide significance are designated as State Scientific Areas. Within the Fredonia-Newburg Area watersheds, there are two SNAs, Riveredge Creek & Ephemeral Pond (SNA No. 197) and Huiras Lake (SNA No. 353). There are an additional five sites of high-quality natural areas, most are owned by Ozaukee Washington Land Trust (OWLT). There are also a number of other sites that serve as critical species habitat for plants or wildlife that lie just outside the boundary of these three HUC12 Milwaukee River watersheds (Figure 39).

North Branch Milwaukee River Wildlife and Farming Heritage Area

WDNR in conjunction with Ozaukee, Sheboygan, and Washington Counties has designated an area covering 25 square miles as the North Branch Milwaukee River Wildlife and Farming Heritage Area. According to WDNR, "This unique project seeks to preserve the strong agricultural farming tradition of the area while maintaining wildlife habitat, restoring plant communities and wetlands and providing recreational opportunities. A policy of 'passive' management is used in some self-sustaining community types such as lowland forests, with the exception of where invasive species control is necessary. Over the years, many wetlands have been degraded, filled or destroyed. One primary effort will be to manage and restore wetlands on the property, including the reestablishment of vegetative and riparian buffers to protect the watershed, improve wildlife habitat and reduce soil erosion. Where open areas are to be maintained, several management systems will be used - prescribed burning, brush cutting, herbicide treatments and sharecropping or grazing - to facilitate habitat health. Ponds, lakes, rivers and streams will be managed to improve water quality and wildlife habitat through a variety of best management practices. (WDNR, 2009)"

Ozaukee County has included three easements/acquisitions as identified in the project as a goal in their Land & Water Plan and the project has identified other project areas, many of which fall within the Fredonia-Newburg Area watersheds. The goals of the project are in line with the goals of the Fredonia-Newburg Area watershed-Based Plan and the action plan recommendation found in Section 6 of this plan. More detailed information regarding the North Branch Milwaukee River Wildlife and Farming Heritage Area, including maps of the project areas, can be found online at https://dnr.wi.gov/topic/lands/WildlifeAreas/northbranch.html.

Table 16. Important Natural Area summary data.

Natural Area	Size (acres)	Description
SEWRPC Environmental Corridors		
Primary Environmental Corridors	7,382	≥ 400 acres in size, two miles long, and 200 feet in length
Secondary Environmental Corridors	387	≥ 100 acres in size and one mile long, unless they connect primary environmental corridors
Isolated Natural Resource Area	1,209	200 feet wide down to a 5-acre minimum
ADID Wetlands, Lakes, & Ponds		
ADID Wetlands, Lakes, & Ponds	7,325	As delineated by USEPA, USACOE, & WDNR, with assistance provided by SEWRPC, in 2005
Other Important Natural Areas		
Riveredge Creek & Ephemeral Pond (SNA No. 197)	61	Unique State Natural Area (SNA) containing a low velocity, cold, hard water stream of exceptionally high water quality. Supports ecologically conservative aquatic insect community including *Molanna spp* and *Glossosomatid caddis*. Seasonally dry pond with fen-like areas surrounded by northern wet-mesic forest. Owned and managed by Riveredge Nature Center.
Huiras Lake (SNA No. 353)	198	Woodland and high-quality natural area SNA with 26AC pristine, hardwater seepage lake. Open water of the bog is surrounded by sphagnum moss and a ring of tamarack, eastern white cedar and black ash. The undeveloped shoreline and woods have marsh ferns, yellow blue-bead lily and other uncommon species. Hiking, birding and hunting with a boardwalk. Owned by OWLT and WDNR.
Fellenz Woods	160	High quality woodland with some undeveloped Milwaukee River frontage. Prairie restoration and tree plantings. Hiking, birding, fishing, hunting and xc skiing. Owned by OWLT.
Hepburn Woods	20	Hardwood forest located in the City of West Bend. Hiking and birding. Owned and managed by OWLT.
Kratzsch Conservancy	73	Grasslands, wetlands and woodlands on this farm to natural areas restoration. Hiking, birding, boating, fishing, hunting, xc skiing. Managed and owned by OWLT.
Lake Twelve	12	Partially forested kettle lake ringed by yellow birch and tamarack. Birding, fishing and hunting, public access for non-motorized boats.
Mayhew Preserve	71	Upland forests, lowland hardwood, conifer plantings, shrub- carr and wetlands. Sandhill cranes can be observed seasonally as are fish such as longear sunfish, greater redhorse, lake sturgeon and northern pike. Owned by OWLT.

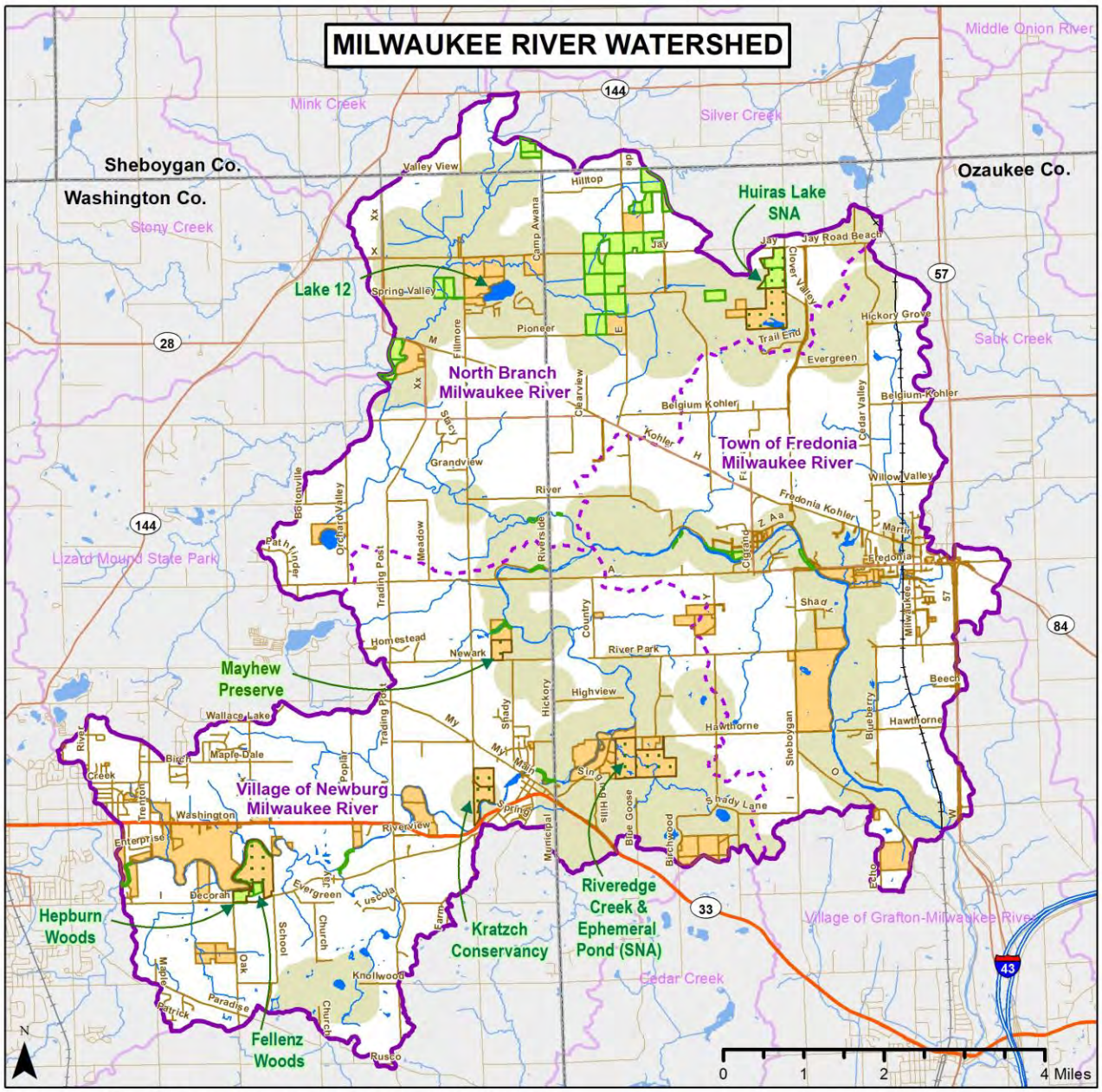
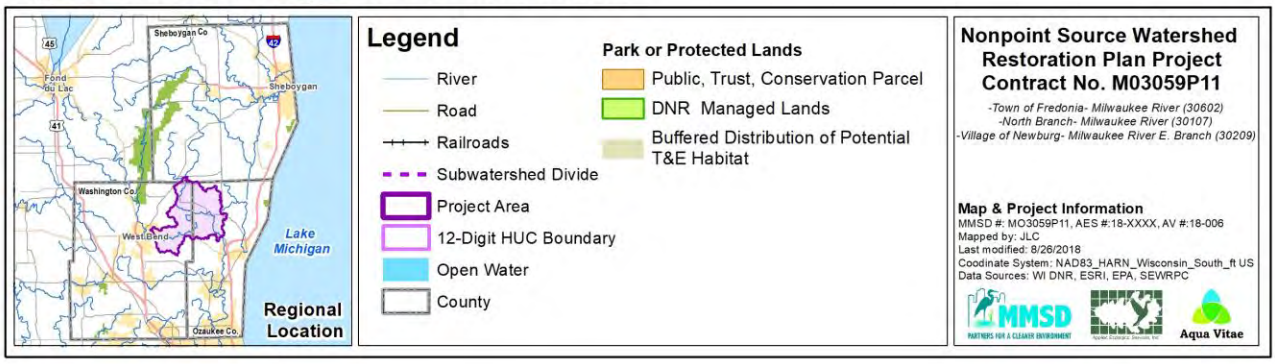


Figure 39. Other Important Natural Areas



Lake Twelve owned and managed by OWLT has a rich composition of native flora and fauna.

Lake Twelve has access for nonmotorized boats.

Riveredge Creek & Ephemeral Pond (SNA No. 197)

Riveredge Creek and Ephemeral Pond contains a slow, cold, hard water stream of exceptionally high water quality which supports a stable, diverse invertebrate community. Riveredge Creek's upper reach, consisting of three branches, has an invertebrate fauna dominated by the caddisfly (Molanna); the lower reach is dominated by Glossoma caddisflies; and the middle reach exhibits a diverse, extremely well-balanced fauna including at least five other species of caddisfly, stoneflies, mayflies, beetles, true bugs, flies (including blackflies), scuds, aquatic sow bug, and snails. This aquatic assemblage appears to be stable. The leaf litter is well processed, reflecting the productivity of shredders. The stream has a flow of 4 cubic feet per second, a dissolved oxygen content of 12 ppm (exceptionally high), and a temperature not known to exceed 65F. Two fen-like areas are associated with this complex. The forest is second-growth northern wet-mesic. The ephemeral pond is rich in plant and animal species including caddisflies, fairy shrimp, predacious diving beetles, backswimmers, and diptera (midges and true flies). The pond shrinks annually but dries up completely only during extreme droughts. Riveredge Creek and Ephemeral Pond is owned by Riveredge Nature Center, Inc (a nonprofit, privately owned environmental education facility) and was designated a State Natural Area in 1985 (WDNR 2018).

Riveredge Creek & Ephemeral Pond SNA #197 has beautiful stands of mature mixed hardwoods.

Boardwalk at Riveredge Nature Center (Source: Riveredge Nature Center)

Huiras Lake (No. 353)

Huiras Lake features a 26-acre pristine, hardwater seepage lake with an undeveloped shoreline contained within a larger wooded matrix. Plant communities include dry-mesic forest, mixed conifer and hardwood swamp, and a relict kettle bog. Located within a lowland hardwood swamp of black ash, the open water of the bog is surrounded by a narrow band of sphagnum moss and cattails and grades into shrub-carr and a tamarack-white cedar swamp. Several white pines are present and poison sumac is scattered throughout. Species include round-leaved sundew, pitcher plant, leather-leaf, huckleberry, small cranberry, round-leaved shinleaf, bog St. John's wort, and bogbean. Surrounding the eastern edge of the lake are extensive forested wetlands dominated by black ash, green ash, red maple, silver maple, yellow birch, paper birch, and basswood. Near the lake large tamarack and white cedar are co-dominant and the ground layer is patchy to continuous with a good diversity of both southern and northern species including Canada mayflower, yellow blue-bead-lily, jack-in-the-pulpit, and marsh fern. Pockets of mature mesic hardwoods with sugar maple, beech, red oak, basswood, and white pine are found to the south. The lush growth of emergent vegetation and partial seclusion make this an excellent waterfowl nesting and migration site. Additionally, the undeveloped nature of the site and its location within a rapidly urbanizing area make this site a highly valuable waterfowl and wildlife habitat site in the southeastern portion of Wisconsin. Huiras Lake is owned by the Ozaukee Washington Land Trust (OWLT) and DNR. It was designated a State Natural Area in 2002 (WDNR 2018, OWLT 2019).

Huiras Lake SNA #353 is tucked away in the hills of Town of Fredonia-Milwaukee River (Source: OWLT)

Fellenz Woods

Fellenz Woods is owned and managed by Ozaukee Washington Land Trust. Located in West Bend, it is 160 acres and includes virgin floodplain forest, lowland forest, and undeveloped riparian areas along the Milwaukee River in the Newburg watershed. Natural springs can be found within the preserve and it serves as valuable habitat for amphibians, birds and waterfowl. Ozaukee Washington Land Trust has been working to restore the portions of the property since 2002, including prairie restoration and ongoing management of invasive species (OWLT 2019).

Path within Fellenz Woods (Source: OWLT)

Kratzsch Conservancy

The Kratzsch Conservancy is a restored farm in Newburg that is owned and managed by Ozaukee Washington Land Trust. The preserve includes 73 acres of grasslands, woodlands, and wetlands, as well as some riparian areas along the Milwaukee River and includes examples of glacial remnant topography such as eskers, kettle depressions and kames. Various work has been done to restore this property and it is also home to OWLT's stewardship program and tree nursery (OWLT 2019).

Trails and topography of Kratzsch Conservancy (Source: OWLT)

Other Natural Areas

Located just north of Newburg and recently acquired by OWLT, Mayhew Preserve includes 71 acres of upland forests, lowland hardwood forests, conifer plantations, upland meadows, shrub carr, and wetlands, as well as riparian areas along the Milwaukee River (OWLT 2019). Hepburn woods in West Bend is also owned by OWLT and includes 20 acres highlighting glacial remnant topography such as glacial ridges and kettles. The hardwood forest is undergoing restoration and control of invasive species (OWLT 2019). Also owned by OWLT, Lake Twelve in the North Branch watershed consists of a 53-acre lake and 12 acres of land partially forested with yellow birch and tamarack (OWLT 2019).

3.14 Watershed Drainage System

3.14.1 Streams and Tributaries

Waterways such as streams and tributaries are a barometer of the health of their watersheds. The story of waterways, as with so many natural resources, has been one of exploitation and lack of understanding. Few waterways throughout the world have escaped pollution, channel modifications, and increased flooding as a result of mismanagement of development in the watershed (Apfelbaum & Haney 2010). Fortunately, many waterways can be restored if stressors in the watershed can be mitigated.

Streams in the three Fredonia-Newburg Area watersheds have seen many changes since European settlement in the mid-1800s. The results of the watershed field inventory suggest that alterations to streams and stream conditions have been subtle but also chronic and continual, from streams flowing through woodlands and wetlands and other high-quality natural areas to that of a highly agricultural setting. Some of these changes can be observed by looking at the pre-settlement stream mapping depicted on Figure 9 in Section 3.1.

<u>Stream Inventory</u>

In summer 2018, Applied Ecological Services, Inc. (AES) completed a field inventory of each of the primary streams in the Fredonia-Newburg Area watersheds. There are also numerous smaller secondary tributaries branching off many of the primary tributaries. However, mapping and describing all secondary tributaries is beyond the scope of this project.

Two important observations were made during the August/September 2018 field reconnaissance and inventory: 1) many streams in the watershed are intermittent and 2) the southern half of Wisconsin had just received an unprecedented amount of rainfall (~>500-year event). In intermittent stream systems, the stream may dry up entirely during dry periods that usually occur in summer and early fall. This was not the case during the sampling and while the water had come down significantly during the subsequent September 2018 site visits, the water was still very high. This concerned the field team for fear of sampling bias at first but the high water had an added benefit of seeing what streams looked like when they were "all online" and in some cases flooded/beyond bankfull, though it may have masked some of the channelization, erosion and headcutting damage (it would have been underwater at the time or concealed by vegetation), potentially under-portraying some of these issues.

All primary tributary streams were assessed based on divisions into "Stream Reaches" (Table 17; Figure 40). Reaches are defined as stream segments having similar hydraulic, geomorphic, riparian condition, and adjacent land use characteristics.

Methodology used in the stream inventory included walking portions of each stream reach, collecting measurements, taking photos, and noting channel, streambank, and riparian corridor conditions on Stream Inventory/BMP Data Forms. Detailed notes were also recorded related to potential Management Measure recommendations and their corresponding priority for eventual inclusion into the Action Plan section of this report. Results of the inventory can be found in Appendix C and in the Fredonia-Newburg Area watersheds GIS dataset.

Thirty (30) stream and tributary reaches (including distinct reaches of main branches) were identified, totaling 378,341 linear feet or 71.6 miles of stream were identified within the Fredonia-

Newburg Area watersheds (Table 17; Figure 40). This includes distinct reaches of the main stems of the Milwaukee River and the North Branch of the Milwaukee River. Each stream and tributary was assigned a unique stream reach code. The main stem of the Milwaukee River was divided into 7 reaches, 4 of which fall in the Village of Newburg watershed, with the remaining 3 falling in the Town of Fredonia watershed. These reaches range is size from 10,766 to 32,682 linear feet. The North Branch Milwaukee River was divided into 3 reaches, ranging in size from 15,430 to 19,980 linear feet.

Of the 20 tributaries, Tr6 (also called Fredonia Creek) which is located in the eastern portion of the watershed, is the longest at approximately 24,441 linear feet or about 4.6 miles. Tributaries Tr13 and Tr19, the second and third longest streams in the watershed, are 16,208 linear feet (3.07 miles) and 14,218 linear feet (2.69 miles) respectively. The remaining 17 streams account for a total of 139,917 linear feet or 26.5 miles. Stream conditions vary greatly depending on their location, surrounding land uses, ownership, etc.

Table 17. Summary of stream and tributary reaches and length.

Stream Reach Name	Stream Reach Code	Linear Feet	HUC 12
North Branch Milwaukee River, Reach 1	NBR1	15,430	North Branch
North Branch Milwaukee River, Reach 2	NBR2	19,980	North Branch
North Branch Milwaukee River, Reach 3	NBR3	18,620	North Branch
Tributary 1a	Tr1a	8,513	North Branch
Tributary 1b	Tr1b	4,727	North Branch
Tributary 2	Tr2	8,273	North Branch
Tributary 3	Tr3	13,542	North Branch
Tributary 4	Tr4	8,253	North Branch
Tributary 5	Tr5	7,413	North Branch
Tributary 8	Tr8	6,746	North Branch
Milwaukee River, Reach 5	MR5	13,137	Fredonia
Milwaukee River, Reach 6	MR6	19,309	Fredonia
Milwaukee River, Reach 7	MR7	10,766	Fredonia
Tributary 13	Tr13	16,208	Fredonia
Tributary 14	Tr14	6,600	Fredonia
Tributary 6, Fredonia Creek	Tr6	24,441	Fredonia
Tributary 7	Tr7	12,031	Fredonia
Milwaukee River, Reach 1	MR1	32,682	Newburg
Milwaukee River, Reach 2	MR2	18,953	Newburg
Milwaukee River, Reach 3	MR3	19,693	Newburg
Milwaukee River, Reach 4	MR4	14,985	Newburg
Tributary 9	Tr9	3,146	Newburg
Tributary 10	Tr10	7,845	Newburg
Tributary 11	Tr11	7,605	Newburg
Tributary 12	Tr12	12,056	Newburg
Tributary 15	Tr15	6,939	Newburg
Tributary 16	Tr16	8,474	Newburg
Tributary 17	Tr17	11,810	Newburg
Tributary 18	Tr18	3,765	Newburg
Tributary 19	Tr19	14,218	Newburg
Tributary 20	Tr20	2,180	Newburg

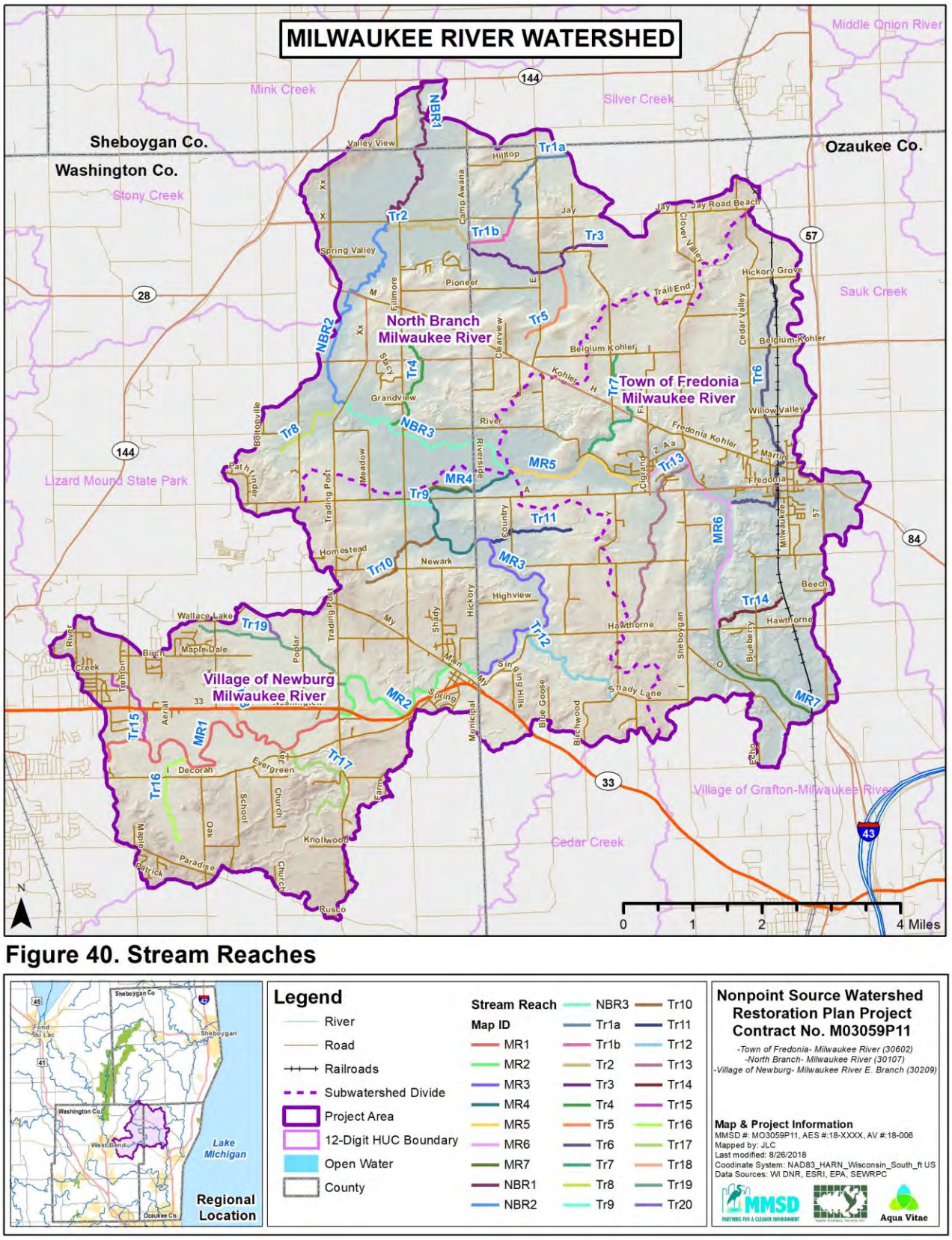


Figure 40. Stream Reaches